World Armaments and Disarmament

SIPRI *yearbook* 1978

Stockholm International Peace Research Institute

World Armaments and Disarmament
SIPRI Yearbook 1978

sipri

Stockholm International Peace Research Institute

Sveavägen 166, S-113 46 Stockholm, Sweden

Cable: Peaceresearch, Stockholm

Telephone: 08-15 09 40

World Armaments and Disarmament

SIPRI Yearbook 1978

sipri

Stockholm International Peace Research Institute

Taylor & Francis Ltd
London
1978

First published 1978 by Taylor & Francis Ltd
10-14 Macklin St, London WC2B 5NF

Distributed in the United States of America by
Crane, Russak & Company, Inc.
347 Madison Avenue, New York, N.Y. 10017
and in Scandinavia by
Almqvist & Wiksell International,
26 Gamla Brogatan,
S-101 20 Stockholm, Sweden

ISBN 0 85066 134 X

Printed and bound in the United Kingdom by
Taylor & Francis (Printers) Ltd, Rankine Road,
Basingstoke, Hampshire RG24 0PR

Previous volumes in this series:

SIPRI Yearbook of World Armaments and Disarmament 1968/69
SIPRI Yearbook of World Armaments and Disarmament 1969/70
World Armaments and Disarmament, SIPRI Yearbook 1972
World Armaments and Disarmament, SIPRI Yearbook 1973
World Armaments and Disarmament, SIPRI Yearbook 1974
World Armaments and Disarmament, SIPRI Yearbook 1975
World Armaments and Disarmament, SIPRI Yearbook 1976
World Armaments and Disarmament, SIPRI Yearbook 1977

PREFACE

The ninth issue of the *SIPRI Yearbook* continues our analysis of the world's arms races, and the attempts to stop them, up to 31 December 1977. As in all SIPRI publications, information has been obtained from open sources only.

This Yearbook will be published unusually early in the year to be in time for the United Nations General Assembly's special session devoted to disarmament, which begins on 23 May 1978. It is hoped that the information in the Yearbook will be of use to those participating in the special session and to those interested in the proceedings.

Attributions

Those responsible for the preparation of the *SIPRI Yearbook 1978* are as follows: Frank Barnaby (Chapters 1 and 15), Richard Booth (Chapter 6, section I, and Appendix 6A), Joseph Coffey (Chapter 14 and Appendix 14A), Jozef Goldblat (Chapters 13 and 16), Ronald Huisken (Chapter 10), Carl-Magnus Hyltenius (Chapter 1), Bhupendra Jasani (Chapters 4 and 7, and Appendices 7A and 7B), Andrzej Karkoszka (Chapter 11 and Appendix 14B), Signe Landgren-Bäckström (Chapter 8 and Appendix 8A), Milton Leitenberg (Chapter 6, section II), Sverre Lodgaard (Chapter 2), Karlheinz Lohs (Chapter 12), Arthur Westing (Chapter 3), and Owen Wilkes (Chapter 5).

Ragnhild Ferm and Carol Stoltenberg-Hansen assisted the researchers in preparing the material.

The editorial staff were Felicity Roos, Connie Wall and Rajesh Kumar.

Acknowledgements

The Yearbook team wish to thank the Institute's librarians, Gunnel von Döbeln and Janet Meurling; the press cutters, Michal Lucki and Ernst Falta; and the secretarial staff for their assistance in preparing the Yearbook.

March 1978

Frank Barnaby
Director

CONTENTS

Part II. Developments in World Armaments

Part III. Developments in Arms Control and Disarmament

TABLES AND FIGURES

Chapter 2. The nuclear fuel cycle and nuclear proliferation

TABLES

Chapter 3. The military impact on the human environment

TABLES

Chapter 4. Military satellites

TABLES

Chapter 7. World arms production

TABLE

FIGURE

Chapter 8. The trends in the arms trade with the Third World

TABLES

Appendix 8A. Register of the arms trade with Third World countries, 1977

TABLES

Chapter 10. Disarmament and development

TABLES

FIGURES

Chapter 11. The comprehensive test ban

TABLE

FIGURE

Chapter 14. Mutual force reductions: status and prospects

TABLES

Appendix 14B. NATO and WTO nuclear weapons and delivery vehicles deployed in Europe, 1977

TABLES

Chapter 15. The strategic arms limitation talks

TABLES

FIGURES

ABBREVIATIONS, CONVENTIONS AND CONVERSIONS

Abbreviations

cm	centimetre	mi	mile
CY	calendar year	m	metre
eV	electronvolt	mm	millimetre
FY	fiscal year	mn	million
h	hour	Mt	megaton
ha	hectare	MW(e)	million watts of electricity
Hz	hertz	MW(th)	million watts of thermal power
kg	kilogram	nm	nanometre
km	kilometre	s	second
kt	kiloton	t	tonne (1 000 kg)
MeV	mega-electronvolt		

Conventions

Particular conventions used in certain tables are given in footnotes to the respective tables. The conventions used in Part II are given in chapter 9.

..	Data not available
–	Nil or less than half the final digit shown; negligible; not applicable
( )	Greater degree of uncertainty about estimate
[ ]	Crude estimate

Conversions

Units of length

1 millimetre = 0.039 inch
1 inch = 25.4 millimetres
1 metre = 1.1 yards = 3.28 feet
1 foot = 30.480 centimetres
1 yard = 3 feet = 36 inches = 0.91 metre
1 kilometre = 0.62 statute mile = 1 094 yards
1 statute mile = 1.61 kilometres = 1 760 yards
1 nautical mile = 6 076 feet = 1 852 metres

Units of mass

1 ton = 1 000 kilograms (tonne) = 2 205 pounds, avoirdupois = 0.98 long ton = 1.1 short tons
1 short ton = 2 000 pounds = 0.91 ton = 0.89 long ton
1 long ton = 2 240 pounds = 1.1 tons = 1.12 short tons
1 kiloton = 1 000 tons
1 megaton = 1 000 000 tons
1 kilogram = 2.2 pounds
1 pound = 0.45 kilogram

Part I. 1977, developments of the year

1. Recent developments in armaments and disarmament

Square-bracketed numbers, thus [1], *refer to the list of references on page 15.*

I. Growing militarization

In 1977, world military expenditure was about $360 thousand million. Of this total, NATO and the Warsaw Treaty Organization (WTO)—the major alliances of industrialized countries—spent about 70 per cent, and the Third World spent about 18 per cent. But an important feature of world military spending is that the Third World share is steadily increasing. In 1957 this share (excluding China) accounted for 4 per cent of total military expenditures; in 1977 the Third World accounted for 14 per cent. The increase in military spending, however, varies considerably from region to region (see chapter 6).

Nearly all the wars fought since World War II have involved Third World countries. The weapons used in these wars have been mostly acquired through the international trade in arms. In fact, about 75 per cent of the current world arms trade is with the Third World (see appendix 8A); and increasing amounts of money are being invested by the industrialized countries in the co-production of weapons with underdeveloped countries. The volume of military transfers to the Third World has increased more than 15-fold over the past 25 years, and the 1970s show a marked increase over the 1960s.

There is also a qualitative change—in the 1950s large numbers of second-hand weapons were sent to Third World countries, often without any supplementary equipment, such as spares and support equipment, or training agreements. Today, the arms market is a buyer's rather than a seller's market, and any importer able to pay is likely to find a seller of even the most sophisticated armaments.

Increasingly, national as well as international attention is being devoted to the problem of the arms trade. Authorities in the supplier countries have begun to question the wisdom of providing unlimited amounts of sophisticated weapons. And some importers are beginning to doubt the wisdom of importing large amounts of military technology from the industrialized world, involving many military advisers, and huge investments in the military sector at the expense of the civilian sector of the economy.

II. Nuclear weapon developments

The need for progress towards nuclear disarmament is particularly emphasized by recent developments in nuclear weapons. In both the USA and the USSR, groups who are thinking in terms of the feasibility of fighting a nuclear war may be gaining political influence. Certain qualitative developments in offensive and defensive strategic weapons and in tactical nuclear weapons may enhance perceptions that a nuclear war is both fightable and "winnable". The fact that these perceptions will, if ever put to the test, be proved wrong is cold comfort.

The most dangerous current developments in nuclear weapons include: the continuous improvement of the accuracy of warhead delivery; the development of mobile land-based missiles to carry these accurate warheads; cruise missiles; and miniaturized tactical nuclear weapons, including enhanced-radiation reduced-blast weapons—the so-called neutron bombs.

Some of the strategic nuclear weapons now being developed or deployed are very destabilizing—in particular, very accurate warheads for ballistic missiles, such as the Mark-12A 200-m Circular Error Probability (CEP),[1] 370-kt warheads for the US Minuteman III (now being deployed); mobile intercontinental ballistic missiles (ICBMs), which have been developed by the USSR and are in the initial stages of development in the USA for deployment in the 1980s; and long-range, land- or sea-based modern cruise missiles (being developed by the United States).

Future land-based mobile ICBMs may be awesome weapons. For example, the US M-X, a \$30–50 thousand million weapon system, will probably carry between seven and fourteen 200-kt manœuvrable re-entry vehicles (MARVs) with terminal guidance giving CEPs of a few tens of metres. The missile, designs for which were called for by the US Air Force in October 1977, would move along an underground tunnel about 25 km long. The number of M-Xs in each tunnel could not be discovered by the use of reconnaissance satellites. The missile would, therefore, not only destabilize whatever strategic balance is perceived to exist between the USA and the USSR, but would also seriously complicate the negotiation of future strategic arms limitation agreements just as the cruise missile complicates the current negotiations of a SALT II treaty (see chapter 15).

Mark-12A, let alone M-X, warheads are first-strike weapons capable of destroying enemy ICBMs in their silos. The deployment of such first-strike weapons may stimulate the other side to deploy a launch-on-

[1] Circular Error Probability (CEP) is the radius of a circle, centred on the target, within which 50 per cent of the weapons or munitions aimed at the target will fall.

warning system, to launch its land-based ICBMs when enemy missiles cross the horizon. Such a system would be provocative and dangerous. In any case, the large-scale deployment of first-strike weapons is likely to escalate the arms race.

In the USA, the development of MARVs is under way—also for future submarine-launched ballistic missiles (SLBMs), such as the 6 000-nautical mile range Trident D-5. This missile, in the first stages of development, is planned for eventual deployment in Trident strategic nuclear submarines. Two of these ships, to be equipped with 24 SLBMs each, are under construction. Initially, Trident submarines will be armed with the 4 000-nautical mile range C-4 SLBM now being tested, each carrying up to eight 100-kt multiple independently targetable re-entry vehicles (MIRVs). The C-4 will have nearly double the range of the current Poseidon C-3 SLBM and a CEP of about 500 m.

The Soviet Union is also increasing the accuracy of its strategic nuclear warheads and has developed a mobile ICBM, the SS-X-16. A mobile intermediate-range ballistic missile (the SS-20), armed with MIRVs, is already being deployed. According to US sources, a new generation of Soviet ICBMs for possible deployment in the 1980s is under development. A three-MIRV SLBM, the SS-NX-18, is being tested as a replacement for the 4 200-nautical mile range SS-N-8, to be deployed on "Delta"-class strategic nuclear submarines.

Neutron bombs and fuel air explosives

The present debate over new enhanced-radiation reduced-blast weapons has re-focused attention on low-yield nuclear weapons. The W-70 mod. 3 enhanced-radiation warhead is being developed as an alternative warhead for the US Lance 130-km range surface-to-surface missile. It is planned that a total of 92 Lance launchers will be deployed in Europe.

Neutron bombs rely mainly on fusion as the explosive mechanism, a more efficient explosive process than fission. The complete fusion of, for example, about 12 g of deuterium and tritium would produce an explosion of 1 kt. To obtain the same explosive yield from fission would require, for example, about 56 g of plutonium-239.

The neutrons produced during fusion have much greater energies than those produced by fission. A deuterium–tritium fusion event produces, on average, 14 million electronvolts (MeV) of free neutron energy, compared with about 3 MeV for a fission event. A pure fusion explosive device would thus produce, at the point of detonation, a given total neutron energy for about 20 times less explosive power than a fission bomb. In practice, some fission must be used to provide the high temperature necessary for fusion and some of the neutrons will be absorbed in the bomb material itself. A workable enhanced-radiation weapon would probably have the same radiation killing capability, at a given range, as a fission nuclear weapon of about five times the explosive power. People could be incapacitated by radiation from an enhanced-radiation weapon at distances at which blast and heat effects were relatively small.

The greatest significance of the deployment of enhanced-radiation weapons may be the indication of the growing influence of thinking in terms of nuclear war fighting. But another aspect of their deployment which should be emphasized is that it may encourage the proliferation of nuclear weapons to countries which, at present, do not have them. This danger has been admitted by the White House. In the Arms Control Impact Statement about enhanced-radiation weapons sent to the US Senate by the National Security Council, it is said that some governments may couple a decision to deploy enhanced-radiation weapons with perceptions that US doctrine has changed to make the use of nuclear weapons more likely in a tactical situation. Such a coupling, the statement goes on, could have adverse effects on US efforts to prevent further nuclear proliferation [1].

The gap between conventional and nuclear weapons, in terms of explosive power, may be narrowed from the other direction by the deployment of new types of conventional weapons. The attention given to nuclear weapons tends to obscure the considerable advances being made in conventional weapons. One such is the fuel air explosive (FAE). (President Carter refused, earlier this year, to supply these weapons to Israel. Israel could, however, probably produce FAEs itself if it chose to do so.)

A typical FAE is the 45-kg BLU-73—containing highly volatile ethylene oxide, which burns spontaneously without oxygen. BLU-73s were used by the USA in Viet Nam to detonate mines and defoliate trees over areas greater than 700 square metres.

The CBU-55 is essentially a cluster of three BLU-73s. The 225-kg bomb, normally dropped by helicopter or slow aircraft from a height of about 500 m, is opened after a pre-set time by a time-fuse to disperse the three bomblets. Each bomblet—35 cm in diameter, 53 cm long, and containing 33 kg of ethylene oxide—falls by parachute so that it does not hit the ground too hard. The cloud of ethylene oxide vapour produced (each bomblet produces a cloud about 15 m across and 2.5 m high) is detonated by a delayed action igniter, normally about 150 milliseconds after impact with the ground [2].

The CBU-55 has been further developed into the CBU-72 FAE for delivery by fast (though subsonic) aircraft; and an FAE weapon for delivery by aircraft flying at supersonic speeds is under development.

The blast-wave effect of 1 kg of an FAE-like ethylene oxide is equivalent to the explosive effect of up to 5 kg of TNT [2]. Current efforts aim at substantially increasing the TNT equivalent of FAEs. They would then make formidable warheads for cruise missiles, for example. A 100-kg FAE warhead may be made equivalent to a tonne of TNT, and a helicopter-borne dispenser containing, say, 24 45-kg FAE bombs could produce the same blast effects as 10 t of TNT. Very much larger FAEs are feasible.

III. The CCD in 1977

A comprehensive test ban

By the end of 1977 the Conference of the Committee on Disarmament (CCD) had two priority matters on its agenda—the comprehensive test ban (CTB) and a ban on chemical weapons. A ban on radiological weapons was also on the agenda. Discussions were held, on Soviet initiative, regarding the prohibition of new types and systems of weapons of mass destruction.

In an attempt to break the deadlock in the talks on a comprehensive nuclear test ban treaty, the Swedish delegation to the CCD tabled a draft treaty on 3 March 1977. This is the most recent draft CTB treaty put before the CCD. According to the Swedish proposal, any nuclear weapon test explosion or any explosion of other nuclear devices, in any environment, should be prohibited. Peaceful nuclear explosions (PNEs) would, however, be permitted, provided that they be carried out under strict international supervision and control, and that satisfactory procedures can be devised to ensure that the PNEs in question do not yield any information of significance for nuclear weapon development or maintenance. The proposal relies heavily on the international exchange of seismological data for the technical supervision of compliance with the treaty. A global network of seismological stations for detecting violations of the treaty is envisaged to function both as a deterrent to potential violators and as a defence against unfounded suspicions and accusations. (Deliberations have been held in an *ad hoc* group of experts to consider international co-operative measures to detect and identify seismic events. The group is expected to submit its report to the CCD in March 1978 and to propose a world-wide network of seismographic stations.) (See chapter 11.) The proposal also provides for a system of "inspections by invitation", that is, on-site inspections at the invitation of the party accused of violating the treaty. It is proposed that a consultative committee be established to ensure the full observance and implementation of the treaty. It is also envisaged that a conference should be convened five years after the entry into force of the proposed treaty in order to review its operation.

According to the draft, the treaty will not enter into force until a certain number of governments, including those of the USA and the USSR, have deposited their instruments of ratification. It is suggested that under the treaty the two powers might be allowed a transitional period before having to stop all nuclear weapon testing. According to the proposal, if the treaty has not been adhered to by all nuclear weapon states a specified number of years after its entry into force, each party will then have the right to withdraw from the treaty.

The deliberations between the Soviet Union and the United States on a comprehensive test ban treaty entered a new phase in the summer of 1977, when real negotiations started with the participation also of the United Kingdom. These trilateral negotiations were still going on by the end of 1977. It appeared that the problem of verification was by then causing less difficulty than the problem of peaceful nuclear explosions. However, the fact that General Secretary Brezhnev, in a speech on 2 November 1977 [3], indicated a willingness on the part of the Soviet Union to accept a moratorium on PNEs inspires some hope that this particular difficulty in the negotiations on a CTB treaty will be overcome in the near future, although it seems that the moratorium must be formally linked to the treaty, for example in a protocol. Furthermore, the Soviet Union now seems willing to agree in principle to a CTB treaty that would not necessarily include all nuclear weapon states as a provision for the entry into force of the treaty. As an indication of the more constructive atmosphere it is worth noting that it was possible for the General Assembly to adopt a resolution which was accepted also by the USA and the USSR according to which the result of the trilateral negotiations should be transmitted to the CCD for its urgent consideration "with a view to the submission of a draft treaty to the General Assembly at its special session" [4].

A ban on chemical weapons

Bilateral talks have been held in the CCD between the United States and the Soviet Union in preparation for a joint initiative on concluding a convention banning chemical weapons (see chapter 12). The convention is expected to be comprehensive, that is, to prohibit the development, production and stockpiling of chemical weapons (CWs) and to prescribe the destruction of CW agents. Several exemptions, however, are likely to be made; for example, riot- or crowd-control agents and herbicides, which also have peacetime uses. The problem of verification of a CW treaty is particularly complex and difficult to solve, since effective verification is important to the national security of many countries. One possibility that has been suggested in the CCD is to institute a consultative committee along similar lines to those applied under the ENMOD Convention (see chapter 13).

A ban on radiological weapons

Discussions were held in 1977 between the United States and the Soviet Union on the prohibition of radiological weapons, and a joint proposal for a convention is expected to be presented in early 1978. However, the military value of such weapons, were they to be produced, seems questionable. Since, as far as is known, no radiological weapons have hitherto been produced, such a convention would not, in fact, be a disarmament measure.

The expected agreement on the prohibition of radiological weapons should be seen in the context of the Soviet initiative regarding the prohibition of the development, production and manufacture of new types and systems of weapons of mass destruction. Apart from steps towards the possible conclusion of a convention on radiological weapons, little progress has been made in this area during 1977. The discussions still focus mainly on the problem of arriving at a satisfactory definition of new types and systems of weapons of mass destruction. Several members of the CCD have supported a British proposal according to which the Committee would be given the task of monitoring technological developments which may produce such weapons and, if the need arises, would draft conventions without delay banning the development and production of these weapons.

The role of the CCD

The CCD did not conclude any arms control or disarmament treaty in 1977, but by the end of the year diplomatic observers considered it possible that agreements on a CTB and on a ban on radiological weapons could be achieved before the convening in May 1978 of the UN General Assembly special session devoted to disarmament. It seemed to be a widespread opinion among members of the CCD that it is essential for concrete results to be achieved on the priority matters on its agenda before the opening of the special session, if the Committee is to maintain its credibility as a negotiating body. Although the atmosphere among the nuclear weapon member states seemed to improve, the bilateral and trilateral negotiations between them did not reach a stage at which they considered the issues ripe for multilateral negotiations in the Committee. This was a cause of considerable disappointment to many of the member countries. The lack of real progress and results, and the fact that other member countries are repeatedly faced with ready-made draft agreements between the two leading nuclear powers, the substance of which they cannot significantly influence, resulted in severe criticism and concern, especially among the small-power members of the CCD. Although it can be argued that the bilateral and trilateral approaches may have some advantages in facilitating agreement between the leading powers, and although there is a possibility for other countries to make their views known to these powers through bilateral contacts, there is no guarantee that their views are actually taken into account. If the CCD is to function as a truly multinational negotiating body, the practice of the USA and the USSR of not including other member countries in the negotiations until a late stage must be stopped.

Another expression of the dominating role of the USA and the USSR is their co-chairmanship in the CCD. This is still one of the main reasons why another nuclear weapon power, France, does not take part in the work of the Committee. It is hard to see that the co-chairmanship is in any way indispensable to the two countries concerned. By virtue of their indisputable leadership in terms of military might and technology they will play a leading role under any circumstances.

The Sea-Bed Treaty

A Review Conference of the Sea-Bed Treaty took place from 20 June to 1 July 1977 with 42 countries participating. From the point of view of arms limitation, the treaty is of very little significance, and the outcome of the Review Conference yielded meagre results. The Conference noted that the provisions of the treaty had been observed and recommended that the CCD establish an *ad hoc* committee to supervise technological developments in this field. It was decided that a new Review Conference should be held in 1982.

IV. The laws of war

The Final Act of the Diplomatic Conference on the Reaffirmation and Development of International Humanitarian Law in Armed Conflict was signed in Geneva on 10 June 1977 [5]. After six years of deliberations, delegates representing 124 countries unanimously agreed on two Additional Protocols to the Geneva Conventions of 1949 on the protection of victims of armed conflicts. The Additional Protocols were essentially based on two such protocols drafted by conferences of experts in Geneva in 1971 and 1972, although these rather elaborate drafts had to be amended in order to be adopted. Compromises were worked out in which the humanitarian aspects had to yield partly to military considerations. However, some progress towards development of the humanitarian laws of war was undoubtedly made. The protection of the civilian population was thus enhanced, and it is particularly noteworthy that the earlier prohibition of indiscriminate attacks was extended also to aerial war. Area bombing was expressly prohibited, probably at least partly due to the fact that this method of warfare is now deemed less effective from the military point of view. It is also noteworthy that starvation of civilians as a method of warfare is prohibited, as well as attacks against dams, dykes and nuclear power plants. Guerrilla soldiers are, under certain circumstances, granted the right to be considered prisoners of war whereas mercenaries are expressly denied the right of being considered either combatants or prisoners of war.

Protocol I contains an article prohibiting ecological warfare, and also provisions improving the protection of civil defence personnel in the event of war.

As far as the prohibition of dubious weapons is concerned, the Conference did not manage to reach agreement, apart from the general prohibition in Protocol I of weapons causing unnecessary injury or suffering. The two leading military blocs resisted efforts to reach agreement on the prohibition of incendiary weapons. Nor was it possible to agree to prohibit high-velocity or fragmentation weapons. The Conference, however, unanimously passed a resolution calling upon the United Nations to convene a Special Governmental Conference, not later than 1979, with the aim of reaching a formal agreement on the prohibition of particularly cruel weapons.

The treatment of these questions in the UN General Assembly in the autumn of 1977 indicates that considerable difficulties are likely to arise in the continued work on the improvement of the laws of war.

V. The UN special session on disarmament

Arms control negotiations have failed to halt the arms race between the USA and the USSR, let alone lead to nuclear disarmament. This failure has stimulated a search for new approaches to disarmament. Most observers now realize that the pace of piecemeal arms control negotiations is outstripped by the rate of innovation in military technology. It is widely felt that a comprehensive approach to disarmament, in which each measure is part of an agreed plan, might be more successful. One way of engaging the entire world community in an effort to evolve such a comprehensive disarmament programme may be a world disarmament conference (WDC). This idea has, however, been opposed by some countries. China, for example, asserts that all nuclear weapon countries—and particularly the Soviet Union and the United States—should first undertake never to be the first to use nuclear weapons, and never to use nuclear weapons against non-nuclear weapon countries and nuclear-free zones. Moreover, China maintains that the nuclear weapon powers should dismantle all nuclear bases on the territories of other countries and withdraw all nuclear armed forces and nuclear weapons from abroad. The United States argues that a WDC could play an important role at an appropriate time but, because of the present lack of political agreement, such a conference would hinder rather than assist the efforts to reach concrete arms control and disarmament agreements. In view of this, a majority of the member states of the United Nations considered it unlikely that a WDC with adequate participation of all relevant countries—especially all nuclear weapon countries—could be held. On 21 December 1976, the thirty-first General Assembly unanimously adopted a resolution calling for the convening of a special session of the General Assembly devoted to disarmament.

The idea of a special session had been put forward by Yugoslavia and endorsed by the Conference of Heads of State or Government of Non-Aligned Countries in Colombo in August 1976. On this occasion reference was made to the convening of a WDC, but in the resolution put forward by the non-aligned countries in the UN General Assembly a WDC was not mentioned.

The Western countries have regarded the convocation of a WDC as desirable, provided that all nuclear weapon states would be likely to participate. As they considered this prerequisite unlikely to be fulfilled in the near future those countries also voted for convening a special session.

The Soviet Union and other socialist countries in Eastern Europe, which have particularly actively pursued the idea of a WDC, did not vote against the convocation of a special session in the General Assembly, but maintained that they merely regard it as a step—although an important one—towards a world disarmament conference. In their view the special session should provide an opportunity to exchange views on approaches to disarmament, to identify the main areas of priority where states should concentrate their efforts, and also to decide on, and make preparations for, the convocation of a subsequent disarmament conference.

The operative part of the relevant General Assembly resolution [6] states among other things that the special session should take place in New York in May/June 1978, that a Preparatory Committee composed of 54 member states should be appointed by the President of the Assembly on the basis of equitable geographical distribution, and that all member states should be invited to communicate their views on the special session agenda not later than 15 April 1978 to the Secretary-General.

The Preparatory Committee consists of representatives of the following countries in (*a*) *Africa:* Algeria, Benin, Burundi, Egypt, Ethiopia, Liberia, Libyan Arab Republic, Mauritius, Morocco, Nigeria, Sudan, Tunisia, Zaire, Zambia; (*b*) *Asia:* Bangladesh, Cyprus, India, Iran, Iraq, Japan, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka; (*c*) *Europe:* German Democratic Republic, Hungary, Poland, Romania, Soviet Union, Yugoslavia; (*d*) *Latin America:* Argentina, Bahamas, Brazil, Colombia, Cuba, Guyana, Mexico, Panama, Peru, Venezuela; and (*e*) *Western Europe and other states:* Australia, Austria, Belgium, Canada, France, Federal Republic of Germany, Italy, Norway, Spain, Sweden, Turkey, United Kingdom, United States. The Preparatory Committee held three sessions in New York during 1977, namely, on 28–30 March, 9–20 May and 31 August–9 September.

Several states, non-members of the Committee, attended the sessions as observers and made statements to the Committee. Specialized agencies concerned with disarmament, as well as the International Atomic Energy Agency (IAEA), were also invited. It was, however, not until the second session that a consensus was reached to allow non-governmental organizations (NGOs) to be present at the sessions of the Committee and to have lists of their documents distributed via the UN Secretariat. A number of NGOs then attended the third session.

Extensive activities are being planned by the NGOs to focus worldwide attention on the preparation of the special session on disarmament.

The rules of procedure of the Committee are the same as those of the General Assembly, but special efforts have been made to ensure, as far as possible, that decisions are adopted by consensus. In fact, in 1977 the Committee managed to reach consensus on all decisions taken.

During the first three sessions the Preparatory Committee dealt mainly with procedural matters and practical arrangements for the special session. It decided to recommend, among other things, that the special session should be held from 23 May to 28 June 1978 in New York; and that the rules of procedure of the General Assembly should apply in the special session without amendments, on the understanding that, regarding the adoption of decisions by the special session, every effort should be made to ensure that, as far as possible, decisions on matters of substance will be adopted by consensus.

The Preparatory Committee further agreed to recommend the following provisional agenda for the special session:

1. Opening of the session in accordance with rule 30 of the rules of procedure of the General Assembly
2. Minute of silent prayer or meditation
3. Credentials of representatives to the eighth special session of the General Assembly:
   (a) Appointment of the Credentials Committee
   (b) Report of the Credentials Committee
4. Election of the President
5. Organization of the session

6. Report of the Preparatory Committee to the special session
7. Adoption of the agenda
8. General debate
9. Review and appraisal of the present international situation in the light of the pressing need to achieve substantial progress in the field of disarmament, the continuation of the arms race and the close interrelationship between disarmament, international peace and security and economic development
10. Adoption of a declaration on disarmament
11. Adoption of a programme of action on disarmament
12. Review of the role of the United Nations in disarmament and of the international machinery for negotiations on disarmament, including, in particular, the question of convening a world disarmament conference [7].

In connection with the provisional agenda, the Preparatory Committee recommended the Thirty-Second General Assembly to request the CCD to submit to the special session a report on the various questions under consideration by that Committee. A recommendation was made to request a report from the *ad hoc* Committee on the WDC to be submitted to the special session.

In 1977, the Preparatory Committee was thus able to devote very little attention to drafting the substantial documents of the forthcoming special session. However, a few working papers were submitted, namely, by Sri Lanka (on behalf of the non-aligned group of countries), Mexico, Mauritius and Romania, and joint working papers by Bulgaria, Czechoslovakia, Hungary, the German Democratic Republic, Mongolia, Poland and the Soviet Union.

On the proposal of Denmark, Finland, Norway and Sweden the Committee recommended the General Assembly to initiate a study on the problem of disarmament and development (see chapter 10). Although the topic has been the subject of earlier UN studies, this proposal recommended that a further in-depth study should focus on the basic conditions for a successful redeployment of military resources to civilian purposes. Special emphasis should be given to the utilization of strategic raw materials no longer needed for military purposes but of great importance for the exports of underdeveloped countries, and to mechanisms for transferring released human and material resources to development efforts in accordance with the needs of the underdeveloped countries. The conclusions should, to the greatest extent possible, be made in the form of concrete suggestions.

This Nordic initiative should be seen as part of the effort to attain a new international economic order.

The Committee reached consensus, in principle, that the main elements of the principal document or documents of the special session should be an introduction or preamble, a declaration on disarmament, a programme of action, and the machinery for disarmament negotiations.

A follow-up of the special session, for instance through a second special session, is necessary to ensure that its decisions and recommendations be fully implemented and that these matters continue to receive attention among the general public as well as among their governments.

It therefore seems essential that the proposals contained in a programme of action be of such a nature that they can realistically be implemented within a relatively short period of time in order to allow an assessment after a few years. An obvious first priority of such a programme should be to achieve nuclear disarmament, and the first step towards that end should be a comprehensive nuclear test ban treaty.

VI. Conclusions

The nuclear weapons currently in the world's arsenals (there are tens of thousands of them) probably have a total explosive power equivalent to that of about one million Hiroshima-type atomic bombs. If all, or a significant fraction, of these weapons were used, the consequences would be unimaginable (see chapter 3). Most of the cities in the Northern Hemisphere would be destroyed in a flash, and the bulk of their inhabitants would be killed instantly.

And then there are the after-effects of a nuclear world war. These are unpredictable. We do not know what global climatic changes would be induced by such a war. Nor do we know what damage would be done to the ozone layer, the stratospheric shield which helps protect life on Earth from ultra-violet radiation. The long-term consequences of the genetic damage done to the human race by the radiation from the resulting world-wide radioactive fall-out are also unknown. This genetic damage could, over many generations, decimate the human race. It is to be hoped that the UN General Assembly special session on disarmament will really achieve progress towards nuclear disarmament. The failure to do so would set back the prospects for nuclear disarmament for a long time.

References

1. Department of Defense, *Arms Control Impact Analysis; Program Title: W-70 Mod. 3 (Lance) Warhead*, Supplied to the Senate Foreign Relations Committee, 13 July 1977.
2. *International Defense Review*, Vol. 9, No. 6, December 1976, p. 992.
3. Tass press release, 2 November 1977.
4. UN General Assembly Resolution 32/78.
5. *Anti-Personnel Weapons* (Taylor & Francis, London, 1978, Stockholm International Peace Research Institute), chapter 9.
6. UN General Assembly Resolution 31/189 B.
7. UN document A/AC.187/R.1.

2. The nuclear fuel cycle and nuclear proliferation

Square-bracketed numbers, thus [1], *refer to the list of references on page 34.*

I. The contest over the plutonium economy

If nuclear programmes become significantly based on the plutonium economy, the problem of controlling the proliferation of nuclear weapons will become much more difficult. Strongly emphasized by the present US Administration, the time and cost needed to convert some parts of civilian programmes to weapons acquisition could be much reduced. Already, the gap between the countries which could produce nuclear weapons rapidly and those which already possess nuclear weapons is small.

The main elements of the non-proliferation policy of the US Administration are contained in President Carter's statement of 7 April 1977 on domestic nuclear power policy, in the Nuclear Non-Proliferation Policy Act sent to Congress on 27 April, and in the additional policy decisions released by the White House the same day. In his 7 April statement, the President announced that commercial reprocessing and recycling of plutonium would be deferred indefinitely. The breeder research and development (R&D) programme would be restructured to give greater priority to designs not dependent on plutonium, and commercial use of breeders would be deferred (see the planned liquid metal fast breeder reactor at Clinch River, in table 2.2). Research and development of more proliferation-resistant nuclear fuel cycles would be accelerated: ERDA (the Energy Research and Development Agency) is now reviewing some 60–70 reactor types and concepts as possibly having better non-proliferation characteristics than the reactors currently on the market.

The non-proliferation policy bill establishes for the first time a statutory requirement forbidding the Nuclear Regulatory Commission from granting a licence to export nuclear materials or facilities until it has been notified by the executive branch (Departments of State, Defense, and Commerce; the Arms Control and Disarmament Agency; and ERDA) that issuance "will not be inimical to the common defense and security". In making its judgements, the executive branch will adhere to the Presidential policy decisions of 27 April, that is, continue to embargo the export of enrichment and reprocessing plants, avoid new commitments to export significant amounts of separated plutonium and highly enriched uranium, identify projects and facilities which might be converted to the use of low- rather than highly enriched uranium, and take steps to minimize inventories of weapon-usable materials abroad. The bill requires, furthermore, that reprocessing and retransfer of materials be subject to prior consent and that this shall apply not only to materials of US origin, but also to all special (fissionable) material produced through the use of US equipment.

The US policy is a veritable challenge to nuclear industries and governments which have for a long time wanted to reprocess irradiated fuels, recycle plutonium in light water reactors (LWRs), and construct plutonium breeders. The world is already a long way down the plutonium road: apart from those of the USA, the USSR and China, reprocessing capabilities on a commercial scale exist in Belgium, France, FR Germany, India, Japan and the UK. New commercial-scale facilities are planned in France, FR Germany, Pakistan and the UK. Special facilities for the reprocessing of breeder fuels are in operation in France, FR Germany, India and the UK, and are planned in FR Germany and India (see table 2.1). Experimental recycling of plutonium in LWRs has taken place in several countries, and has proved technologically feasible. In FR Germany, the fuel cycle has been closed for a number of reactors (VAK, MZFR, KWL, KWO, KRB-A). These reactors operate on mixed plutonium and uranium oxide fuel (Mox fuel) made from self-generated plutonium reprocessed at WAK, Karlsruhe. Ten breeder reactors in seven countries are operational, seven of which are experimental and the others prototypes. Another six are under construction, three of which are prototypes. Altogether, 10 countries have 23 breeder reactors in operation, under construction or planned (in addition to a number of reactors with zero or close to zero power capacity in countries with advanced breeder programmes). Except for the Indian experimental reactor under construction at Kalpakkam and the Soviet BN-350, they are all plutonium-based. The first full-sized commercial breeder—the French Super Phénix 1—is already under construction, and is planned for operation in 1981 (see table 2.2).

The most advanced breeder programmes seem to be those of the Soviet Union and Western Europe. In 1977, the European Commission, as well as the Nuclear Energy Agency of the Organization for Economic Co-operation and Development (OECD), urged that the reprocessing and breeder programmes go ahead. Close co-operation between France and FR Germany and the existence of a number of other agreements indicate a strong West European commitment to breeders (see table 2.3).

While the economics of using plutonium fuel appear debatable today, there are strong political as well as industrial stakes involved. For industrialized countries poor in natural energy resources, uranium may offer no more security than oil, while the plutonium breeder route can relieve them of burdensome dependence relationships. The question is therefore whether the world has travelled too far down the plutonium

Table 2.1. Fuel reprocessing capabilities, as of 31 December 1977[a]

Country	Facility	Type of fuel	Year available	Design capacity *Tons of U/year*
Existing capabilities, commercial scale				
Belgium (Eurochemic Multinational)[b]	Eurochemic-Mol	Metal and UO_2, low enrichment, and metal, high enrichment		70 (plant closed down in 1974)
France (COGEMA)[c]	La Hague	Either metal, natural; or UO_2, low enrichment		2 000; start-up at 60 in 1976, increasing to 800 by 1980, by extension of existing capacity
	Marcoule	Metal, natural		1 000
FR Germany (GWK)[d]	WAK, Karlsruhe	Breeder, UO_2		40
India (IAEC)[e]	Trombay	Metal, natural		50
India (IAEC)	Tarapur	Metal and UO_2, low enrichment		125
Japan (PNC)[f]	Tokai Mura	UO_2, low enrichment		210; limited by agreement with the USA to 99 over the first 2 years (for the scheduled period of the International Nuclear Fuel Cycle Evaluation)
UK (BNFL)[g]	Windscale Works	Metal, natural		2 500
Breeder fuel reprocessing facilities in operation				
France (COGEMA)	La Hague	Breeder (U-Pu oxide)		0.25 (pilot plant)
UK (BNFL)	Dounreay	Mixed oxide fuels (from the PFR, see table 2.2)		5 (pilot plant)
Country	**Facility**	**Type of fuel**	**Year available**	**Design capacity *Tons of U/year***
Planned capabilities, commercial scale				
France (COGEMA)	La Hague	UO_2, low enrichment	1985	1 000
	La Hague	UO_2, low enrichment	1989	1 000
FR Germany (DWK)[h]	. .	UO_2, low enrichment	1988–90	1 400
Pakistan (AECP)[i]	Chashma	UO_2, natural, low enrichment	. .	100
UK (BNFL)	Windscale	UO_2, low enrichment	1984	1 000; pending outcome of enquiry
UK (BNFL)	Windscale	UO_2, low enrichment	1987	1 000; pending outcome of enquiry
Planned breeder fuel reprocessing facilities				
FR Germany (GWK)	WAK, Karlsruhe	Breeder	. .	Cf. *Existing capabilities* above
India (IAEC)	Reactor Research Centre, Kalpakkam	Breeder (mixed oxide), thorium oxide	. .	Laboratory-scale; cf. FBTR being constructed at Kalpakkam (see tables 2.2 and 2.3(c))

Country	Facility	Type of fuel	Status
Small-scale plants and laboratory-scale facilities built in countries other than those mentioned above[j]			
Argentina	Ezeiza Nuclear Center	UO_2, natural	Closed down
Canada	Chalk River	UO_2, natural	Dismantled
Egypt[k]	..	..	Unknown
Israel	Dimona	Metal, natural	Unknown
Italy	EUREX-1, Saluggia	UO_2, and metal	Pilot plant (10 t of U/year), currently closed down for modification
	ITREC-Rotondella	Thorium/uranium	Pilot plant (2 t of U/year), in operation
Norway	Kjeller	Metal, natural	Closed down
Spain[l]	Juan Vigon Center	Metal, natural	Closed down
Taiwan	Institute for Nuclear Energy Research, Lung Tau	Metal, natural	Dismantled
Yugoslavia[l]	Boris Kidric Institute	Metal, natural	Closed down

[a] The WTO countries, the USA and China are not included. The only non-military US plant that has ever been in operation was closed down in 1972, and its owners (Nuclear Fuel Services, Inc., of West Valley, N.Y.) have since withdrawn their application to reopen. The Allied General Nuclear Services plant in Barnwell County, South Carolina, with a capacity for reprocessing 1 500 t of oxide fuel per year, has so far not received the licence for operation. The reprocessing capacities of the USSR and China are not known.
[b] The plant was in operation from 1966 to 1974. Due to reprocessing of many different types of fuels, actual throughput has varied between 40 and 60 t of U/year. Transfer to Belgian ownership is being negotiated. Modification under Belgian ownership is being considered, raising the capacity to 60–80 t of U/year. A second line for reprocessing oxide fuel (300 t of U/year) has also been considered.
[c] COGEMA=Compagnie Générale de Matériaux Nucléaires, Commissariat à l'Energie Atomique (CEA).
[d] Twenty per cent of the shares of GWK are taken up by the DWK (Deutsche Gesellschaft für Wiederaufarbeitung von Kernbrennstoffen GmbH), which will acquire all shares on 1 January 1979.
[e] IAEC=Indian Atomic Energy Commission. Will be modified and expanded to handle spent fuel from a 100-MW(e) research reactor (Super-Cirus) at Trombay.
[f] PNC=Power Reactor and Nuclear Fuel Development Co. Built by the French company Saint-Gobain Techniques Nouvelles. Following agreement with the USA, Japan intends to defer the construction of the plutonium conversion facility scheduled to be attached to the plant. The parties to the agreement do not intend to undertake any major moves regarding additional reprocessing facilities for plutonium separation during the two-year period of the INFCE.
[g] A head-end facility for oxide fuel (LWR type) operated from 1970 to 1973 when it was shut down after a small release of radioactivity. Refurbishment of the oxide head-end is uncertain at the moment.
[h] DWK=Deutsche Gesellschaft für Wiederaufarbeitung von Kernbrennstoffen GmbH, a joint undertaking of electricity utilities, previously Kernbrennstoff-Wiederaufarbeitungsgesellschaft GmbH (KEW), a joint undertaking of chemical industries.

[i] France gave a pledge in 1977 to proceed with the sale of the reprocessing plant. Ninety-five per cent of the plans for the plant have reportedly been delivered to Pakistan by Saint-Gobain Techniques Nouvelles. Pakistan has already started to build a laboratory-scale reprocessing plant on its territory.
[j] The list is likely to be incomplete. It is included for what it indicates about the spread of reprocessing technologies to date. The technology transfer for the reprocessing plant to be built in Brazil as part of the West German–Brazilian deal (UO_2, low enrichment, 0.5–1 t of U/year) has already been licensed by the West German government.
[k] Design capacity may be in the range of 0.5–1 t of U/year. Operability and current status unknown.
[l] Express interest in future construction of reprocessing plants on their territories.

Sources: Atomwirtschaft, Vol. 22, January–December 1977; *Applied Atomics*, Nos. 1106–1157, January–December 1977; *Nuclear Engineering International*, Vol. 22, January–December 1977, in particular No. 258; *Nucleonics Week*, Vol. 18, January–December 1977; and *Nuclear Proliferation and Safeguards* (Congress of the United States, Office of Technology Assessment, Washington, 1977)

Table 2.2. World breeder reactor developments as of 31 December 1977

Country, name of reactor	Type of reactor[a]	Year of operation[b]	Power capacity[c]	Site	Status
Brazil					
Cobra	Experimental	–	0	–	Planned; see table 2.3(c)
France					
Rapsodie-Fortissimo	Experimental	1967	(40)	Cadarache	Operational; converted from Rapsodie, which went into operation in 1967
Phénix	Prototype	1974	250	Marcoule	Operational; a 450-MW(e) version has been designed and offered for sale; see table 2.3(c)
Super Phénix 1	Commercial	1981	1 200	Creys-Malville	Under construction; multinational; see table 2.3(b)
Super Phénix 2	Commercial	Mid-1980s	1 200–1 800	–	Planned
Super Phénix 3	Commercial	Mid-1980s	1 200–1 800	–	Planned
FR Germany					
KNK II	Experimental	1977	21	Karlsruhe	Operational; converted from the research reactor KNK into a fast breeder reactor
SNR-1	Prototype	1981	300	Kalkar	Under construction; multinational; see table 2.3(b)
SNR-2	Commercial	1986–88	1 300–1 500	Kalkar	Planned; multinational; see table 2.3(b)
India					
Purnima	Experimental	1972	0	–	Operational; used to provide data on the use of plutonium in fast breeder reactors
FBTR	Experimental	1979	15	Kalpakkam	Under construction; see table 2.3(c)
Iraq					
–	Prototype	–	–	–	Planned; see table 2.3(c)
Italy					
PEC	Experimental	1979	(120)	Brasimone	Under construction

Table 2.2 contd.

Country, name of reactor	Type of reactor[a]	Year of operation[b]	Power capacity[c]	Site	Status
Japan					
Joyo	Experimental	1977	(50)	Oarai	Operational
Monju	Prototype	1985	300	Shiraki	Planned
UK					
DFR	Experimental	1963	15	Dounreay	Closed down 1977
PFR	Prototype	1976	250	Dounreay	Operational
CFR	Commercial	Mid-1980s	1 300	–	Planned; probably subject to inquiry similar to the Windscale reprocessing inquiry
USA					
Enrico Fermi	Experimental	1963	60	Monroe	Closed down 1972
EBR-2	Experimental	1965	20	Idaho Falls	Operational
SEFOR	Experimental	1971	(20)	Fayetteville	Closed down 1972
FFTF-1	Experimental	1979	(400)	Richland	Under construction
CRBR	Prototype	1982	350	Clinch River, Oak Ridge	Planned; no federal funding yet
USSR					
BR-5	Experimental	1958	12	Obninsk	Operational; upgraded in 1972 from a capacity of 5 MW(e)
BOR-60	Experimental	1973	12	Dimitrovgrad	Operational
BN-350	Prototype	1973	350	Shevchenko	Operational
BN-600	Prototype	1979	600	Beloyarsk	Under construction
BN-1500	Commercial	1985	1 500	–	Planned

[a] The reactors are grouped in three categories: *experimental* reactors built for investigation of new technologies; *prototypes* for demonstrating the feasibility of the concepts; and full-scale *commercial* power reactors. Experimental reactors of 0 or close to 0 power capacity are not included for countries with advanced breeder programmes, such as Masurca (France), SNEAC (FR Germany), Zebra (UK), EBR 1 and ZPPR (USA), and Arbus and BFS (USSR).
[b] Year when the reactor began generating power, mostly based on data from the IAEA (see sources to this table) giving year of full power.
[c] Gross electrical power. Figures in parentheses are for thermal energy. The power-generating capacity of reactors are either expressed in millions of watts of electricity (MW(e)) or, for reactors which are not used to produce electricity, in millions of watts of thermal power (MW(th)).

Sources: See sources to table 2.1. See also *LMFBR Plant Parameters*, International Working Group on Fast Reactors, International Atomic Energy Agency, December 1976 (IWGFR/14); and "Superphenix: A Full-Scale Breeder Reactor", *Scientific American*, Vol. 236, No. 3, March 1977.

Table 2.3(a). Agreements on breeder reactor co-operation between Common Market countries

Co-operating countries	Project/facilities	Site	Comments
Belgium, FR Germany, Netherlands	SNR-1	Kalkar	R&D co-operation, industrial co-operation and co-operation between electrical utilities
Belgium, France, FR Germany, Italy, Netherlands	SNR-2	Kalkar	Co-operation between electrical utilities with a view to building Super Phénix 1 and SNR-2
	Super Phénix 1	Malville	
France, Italy	Involving in principle all facilities in the countries concerned	..	R&D and industrial co-operation
Bilateral agreement between FR Germany and France, with the participation of Belgium, Italy and the Netherlands	Rapsodie-Fortissimo Phénix Super Phénix KNK-II SNR-1	Cadarache Marcoule Malville Karlsruhe Kalkar	R&D co-operation, industrial co-operation and co-operation between electrical utilities[a]

[a] Agreement signed in 1977 containing, among others, the following sub-agreements:
1. A research and development agreement between GfK and Interatom, FR Germany and CEA, France. The facilities involved are the French-based reactors Rapsodie-Fortissimo, Phénix and Super Phénix, and the West German-based reactors KNK II and SNR-1.
2. An agreement between KVG (Kenntnisverwertungsgesellschaft Schnelle Brutreaktoren GmbH) and CEA/Novatome on the foundation of SERENA, a company entrusted with the delivery of FBR licences. The shares in SERENA are distributed as follows: CEA/Novatome (France), 65 per cent; and KVG 35 per cent (in which Interatom holds 51 per cent; GfK, 19 per cent; Belgo-Nucléaire of Belgium, 15 per cent; and Neratom of the Netherlands, 15 per cent), during the first phase.
3. An agreement to improve the industrial co-operation between INB (Internationale Natrium-Brutreaktor-Baugesellschaft), FR Germany and Novatome, France.

Table 2.3(b). Governmental and industrial shares in the multinational breeder projects SNR-1, SNR-2 and Super Phénix

1. SNR-1 (SNR-300)

Governments

FR Germany 70% Netherlands 15% Belgium 15%

Owner-operator SBK			
RWE (FRG) 68.85%	SEP (Netherl.) 14.75%	SYNATOM (Belg.) 14.75%	CEGB (UK) 1.65%

Manufacturer INB		
INTERATOM (FRG) 70%	NERATOM (Netherl.) 15%	BELGO-NUCLEAIRE (Belg.) 15%

2. SNR-2

Owner-operator ESK		
SBK (FRG, Netherl., Belg.) 51%	ENEL (Italy) 33%	EdF (France) 16%

Manufacturer	
INB (FRG., Netherl., Belg.)	KWU (FRG)

Table 2.3(b) contd.

3. Super Phénix

Owner-operator NERSA		
EdF (France) 51%	ENEL (Italy) 33%	SBK (FRG., Netherl., Belg.) 16%

Engineering design, manufacturer	
NOVATOME (France)	NIRA (Italy)
Acting jointly	

Industrial ownership NOVATOME:
36%: Creusot-Loire
15%: Neyrpic (65% owned by Creusot-Loire)
34% CEA
15% Alsthom-Atlantique

Industrial ownership NIRA:
AGIP Nucleare
Ansaldo
Franco Tosi
IRI

Abbreviations:

CEGB – Central Electricity Generating Board
EdF – Electricité de France
ENEL – Ente Nazionale per l'Energie Electrica
ESK – Europäische Schnell-Brüter Kernkraftwerksgesellschaft GmbH
INB – Internationale Natrium-Brutreaktor-Baugesellschaft GmbH
IRI – Istituto Ricostruzione Industriale
KWU – Kraftwerk Union AG
NERSA – Groupement Centrale Nucléaire Européene de Neutrons Rapides
NIRA – Nucleare Italiana Reattori Avanzati
RWE – Rheinisch-Westfälisches Elektrizitätswerk AG
SBK – Schnell-Brüter-Kernkraftwerkgesellschaft GmbH
SEP – Samenwerkende Electriciteits Productiebedrijven

Sources: See sources to table 2.1.

Table 2.3(c). French, West German and British breeder co-operation with countries outside of Euratom as of 31 December 1977

Euratom country	Collaborating country	Comment
France	USA	Agreement between CEA (Commissariat à l'Energie Atomique) and ERDA (Energy Research and Development Agency) of January 1977; co-operation on physics and safety of FBRs through exchange of data and personnel
	USSR	Agreement on R&D overall activities, especially the exchange of documentation concerning Phénix and BN 350, of June 1977; further exchange of information and close co-operation on Super Phénix and BN 600 is planned
	Spain	Research co-operation; the Spanish government has discussed the possibility of joint liquid metal fast breeder reactor development with France; participation in a multinational project is also being considered
	Brazil	Construction of an experimental fast breeder power reactor; agreement signed in July 1975

Euratom country	Collaborating country	Comment
	India	Experimental fast breeder test reactor under construction at Kalpakkam, to operate on the thorium U-233 cycle; design drawn up by an Indian team working in France 1969–70; technologically, the reactor is close to the technology of the Rapsodie-Fortissimo reactor; see table 2.2
	Iraq	Bilateral agreement with France signed in November 1975, including the eventual construction of a liquid metal fast breeder reactor
	Japan, UK, FR Germany	Agreement on a common programme for FBR safety studies using the CABRI reactor at Cadarache
FR Germany	USA	Bilateral agreement between Bundesministerium für Forschung und Technik (BMFT), FR Germany, and ERDA, USA, of June 1976, on exchange of information and technical personnel
	USSR	Exchange delegations since 1973, contacts between the German Kraftwerk Union (KWU) and the USSR since 1974; INB participation in visits to the USSR for exchange of scientific know-how
	Spain	Co-operation in the field of peaceful uses of nuclear energy between GfK (Gesellschaft für Kernforschung GmbH), and JEN (Junta de Energia Nuclear) according to agreement of July 1973, containing the supply of a neutron generator and a Na loop to JEN; co-operation concerning the use of LMFBRs by electrical facilities between SBK (FR Germany, Netherlands, Belgium) and Union Electrica S.A. since 1971
	Brazil	Contract on research and development between GfK and Brazilian AEC of October 1971; exchange of delegations concerning fast reactor research and development since 1972
	Japan	Several contracts and agreements have been made, including: - Exchange of research and development results between GfK and PNC, 1971–77 - Agreement on safety studies using the CABRI reactor at Cadarache (see Japan, UK, FR Germany, above). The reactor is designed and rebuilt under a co-operation agreement with GfK to provide controlled simulation of accidents in fast reactors of the Phénix type: - Agreements on exchanging results on fission product loop and sodium boiling experiment of 1974, and on further exchange of 1976 - Consulting contract between INTERATOM and Fuji Electric on design of LMFBR 1972. At present, activities are reportedly insignificant - Transfer of know-how on SNR-300. At present, activities are reportedly insignificant
UK	USA	Bilateral agreement between British AEA and ERDA, of June 1976, involving exchange of information and technical personnel
	France, FR Germany, Japan	Agreement on safety studies (see above)

road to afford laborious industrial and economic planning for more proliferation-resistant fuel cycles, and whether there are acceptable substitutes for plutonium which would contribute to greater national energy independence.

II. The International Fuel Cycle Evaluation

On 7 April 1977, President Carter proposed an International Fuel Cycle Evaluation (INFCE), inviting the international community to re-examine the basic assumptions of the plutonium economy. The proposal was endorsed by the seven-nation Western summit in London on 7–8 May, and the first organizational meeting of INFCE took place in Washington on 19–21 October, with representatives of 40 nations present. The scope of the evaluation is defined by the eight working groups set up: (*a*) fuel and heavy water availability; (*b*) enrichment availability; (*c*) assurances of long-term supply of technology, fuel, heavy water and related services; (*d*) reprocessing, plutonium handling and recycling, including safeguards aspects specific to recycling; (*e*) fast breeders, including various reprocessing modes and safeguards aspects specific to breeders; (*f*) spent fuel management, focusing on storage strategies and the special needs of underdeveloped countries; (*g*) waste management and disposal; and (*h*) advanced reactor and fuel cycle concepts, including the thorium–U-233 cycle, light water, and thorium-breeder concepts, and high temperature reactors.

The evaluation is defined as a technical and analytical inquiry rather than as a negotiation. It may nevertheless serve to restrain further plutonium developments in the coming two years, while the possibilities for more proliferation-resistant fuel cycles are explored. It can be used to check and delay controversial steps toward a plutonium economy, as was actually the case in the US–Japanese negotiations over the Tokai Mura reprocessing facility. For an initial period of two years (as concomitant with INFCE and following the joint communiqué issued on 12 September 1977), the facility will process up to 99 tonnes of US-origin spent fuel (design capacity is 210 tonnes of uranium per year), and the construction of an attached facility for plutonium conversion[1] is deferred for the same period. Experimental co-processing[2] will be undertaken, the results of which will be made available to INFCE, and Tokai will be promptly converted from conventional reprocessing to full-scale co-processing at

[1] The lack of conversion facility means that the plutonium appears in the form of liquid nitrate: in order for it to be used as a reactor fuel, it has to be converted into powder. For use in nuclear explosives, plutonium is usually converted to metallic form.
[2] Unlike conventional reprocessing, co-processing implies that only the fission products are separated: the uranium and plutonium are left in a mixture.

the end of the two-year period if the parties agree that such co-processing is technically feasible and effective. Pending the outcomes of INFCE, the parties do not intend to undertake any major moves regarding additional reprocessing facilities for plutonium separation.

The Tokai issue was an important test case for the US Administration's non-proliferation policy. With the aforementioned restraints, Japan was allowed to operate just the kind of facility the Carter Administration wishes to avoid. The decision to allow even limited reprocessing increases the pressure to allow reprocessing elsewhere. On the other hand, Japan endorsed the view that plutonium should not yet be used commercially in LWRs, and will defer the intended large-scale reprocessing plant. (The term "major moves" as used in the communiqué, however, is somewhat ambiguous: some preparations for the plant might not violate the agreement.) The parties will co-operate with the International Atomic Energy Agency (IAEA) in testing safeguards instrumentation, but no determination is made of whether safeguards can effectively be applied to Purex reprocessing plants[3] in general.

III. Commercial restraints and tightening of safeguards

Following the French–West German summit meeting in Bonn on 16–17 June, the West German government announced that, for the time being, it would not allow sales of reprocessing technology. Existing agreements (in particular that with Brazil) would not be affected. The declaration is virtually identical to the one issued by the French Council for External Nuclear Policy on 16 December 1976. Since there were no immediate sales prospects for reprocessing plants and since the duration of the embargo was not specified, it was no costly decision. Both embargoes are likely to remain valid at least for the period of the INFCE. No major supplier is now ready to sign export contracts for reprocessing technology.

On 25 August the Australian government declared its readiness to reopen uranium mining and exports, under strictly controlled conditions. Australia, Canada and the USA—accounting for about 70 per cent of the uranium supplies of the Western countries—are discussing common safeguards requirements for natural uranium exports. Among the agreed conditions are prior consent on reprocessing, enrichment above 20 per cent, and retransfer of exported materials or materials originating there-

[3] The Purex process for recovering uranium and plutonium for light water reactors is the most widely used process today. By this process the fuel is dissolved in acid and the resulting solution undergoes a series of chemical separations by solvent extraction. Most of the fission products are first removed, followed by the separation of the uranium from the plutonium. Subsequent steps remove residual fission products from the uranium and plutonium which leave a concentrated solution ready for conversion to other forms.

from. The Australian re-entrance on the uranium market may to some extent be reassuring to importers. On the other hand, frequent changes of export conditions and tightening of safeguards may make uranium buyers look toward South Africa (commanding about 20 per cent of Western supplies) and others demanding less stringent safeguards.

Mainly due to West German and French reluctance, the London group of supplier countries has not yet agreed to prohibit sales of material and equipment on the trigger list (items triggering international safeguards; for the trigger list of the London Club, see reference [1a]) to countries not willing to submit all nuclear facilities on their territories to IAEA safeguards. Canada applies this rule unilaterally. The Soviet Union and others are known to prefer the same principle, but are willing to apply it only upon universal acceptance in the group. The US non-proliferation policy bill demands that the rule be observed in new bilateral agreements for co-operation, and that existing agreements be renegotiated to meet the same standards (for bilateral agreements for the peaceful utilization of nuclear energy, see reference [1b]). In the meantime, nuclear exports to countries not submitting to full-scope safeguards continue: in 1977, both the USA and the USSR thus made transfers to India—of heavy water and enriched uranium, respectively—while pressing for stricter safeguards.

Outside of the five nuclear weapon states recognized by the Non-Proliferation Treaty (NPT), 12 significant nuclear facilities in five countries were not subject to IAEA or bilateral safeguards as of 31 December 1977. Facilities for the production of heavy water, which are included in the trigger list of the London Club, but not in the list of the Zangger Committee set up to interpret the safeguards clause of the NPT (incorporated in 1974 in IAEA document INFCIRC/209, and widely applied), are not included in this number (see table 2.5).

IV. Discrimination in the nuclear fuel cycle business

Beyond the five nuclear weapon states recognized by the NPT, a significant reprocessing capability exists in four non-nuclear weapon state members of the treaty: Belgium (the plant is shut down for the time being), FR Germany, Italy and Japan. Furthermore, a significant capability exists in two non-member states which are both likely to have a nuclear explosive capability: India and Israel. Two other non-members, Pakistan and Brazil (for a pilot plant), have import contracts which seem to be honoured. This is, in short, the dam which today's embargo of reprocessing technology actually attempts to hold.

Enrichment plants exist or are planned in Brazil, Canada, Japan, the

Netherlands (Urenco, together with FR Germany and the UK) and South Africa (see table 2.4). (Belgium, Iran, Italy and Spain participate in the French-based Eurodif and Coredif plants.) Three are members of the NPT, two are not, and one of them might already possess nuclear explosives. For how long can reprocessing and enrichment capabilities be confined to such heterogeneous groups of nations, striking across the boundaries of NPT membership?

The fear of nuclear proliferation certainly does not extend to all nations to the same degree or in equal fashion. Today, the sense of discrimination is so pervasive, however, that states which are not privileged by the rules of the game might insist on keeping open the options to reprocess, enrich and store weapon-usable materials. The discrimination between nuclear and non-nuclear weapon states still accounts to a large extent for the limited support for the NPT. Discrimination within the category of non-nuclear weapon states—along lines which seem both artificial and illegitimate—is most likely to prove counter-productive.

V. Non-proliferation strategies

So far, the non-proliferation strategies of major suppliers have largely focused on the two-pronged approach of technology denials and tightening of safeguards. The Soviet Union has always strictly controlled the utilization of nuclear energy within Eastern Europe. It takes complete responsibility for supplying manufactured fuel to other members of the WTO, and the irradiated fuel is returned: fuel cycle facilities do not exist on the territory of other WTO countries. The US non-proliferation bill provides that no nuclear export shall be granted to any non-nuclear weapon state that (*a*) detonates a nuclear explosive device, (*b*) terminates or abrogates IAEA safeguards, or (*c*) is found by the President to have materially violated an IAEA agreement or any other guarantee it has given under an agreement for co-operation with the USA. Largely brought about by the French–Pakistani reprocessing deal, the USA in 1977 cancelled the delivery of 110 A-7 aircraft planned for Pakistan. Generally, the great powers have, until now, largely relied on negative sanctions in trying to achieve their non-proliferation goals [2].

History testifies to the limits of the strategy of technology denials. In 1944, US denials of Anglo–Canadian access to plutonium technology engendered the launching in Canada of an independent research programme which led to the discovery of a new reprocessing method similar in principle to the one universally adopted today (the Purex process). The agenda of the Geneva conference of 1955 covered the whole field of fuel cycle technologies except enrichment. Already in the late 1950s, 13

European countries took part in preparations for the multinational Eurochemic reprocessing plant in Belgium. The Indian government claims to have built the reprocessing plant at Trombay—where the fissile material for the 1974 explosion was extracted—at a cost of $7 million. Today, large-scale reprocessing capabilties exist or are planned in 10 nations (including the USA, the USSR and China), while small-scale facilities have been built in at least nine more countries (see table 2.1). Table 2.4 indicates the spread of enrichment technologies: the secrecy surrounding this field has probably limited the extension of enrichment capabilities, but has also contributed to the variety of techniques which now exist. If South Africa actually prepared for a nuclear test in the Kalahari Desert in mid-1977, the fissile material is likely to have been produced at the pilot enrichment plant in Valindaba—constructed on a co-operative basis with the West German firm STEAG, drawing upon the principles of the jet nozzle technique developed in FR Germany and the vortex tube technique developed in the United States (see chapter 4).

Table 2.4. Current and anticipated enrichment production capacities, excluding the USSR and China, as of 31 December 1977[a]

		Time schedule		
Country/company	Technology	1977 *Mn SWU*	1980	1985
Brazil (cf. agreement with FR Germany)	Jet nozzle	..	..	0.2–2.5
Canada (exploratory stage)[b]	Gaseous diffusion			
Coredif (France, Italy, Iran, Spain, Belgium)[c]	Gaseous diffusion	..	..	5
Eurodif (France, Italy, Iran, Spain, Belgium)[d]	Diffusion		6	11
France (CEA)[e]	Diffusion	0.4	0.4	0.4
Japan (PNC)[f]	Gas centrifuge			0.1–6
South Africa (UCOR)[g]	South African process, similar to the jet nozzle technique			0.01–5
UK (AEA)[h]	Gaseous diffusion	0.4	0.4	0.4
Urenco (FRG, UK, Netherlands)[i]	Gas centrifuge	0.4		2–5
USA				
Existing plants (ERDA)[j]	Gaseous diffusion	17	21	27
New plants:[k]				
ERDA	Gas centrifuge			9
Uranium Enrichment Associates	Gaseous diffusion			9
Exxon Nuclear Co.	Gas centrifuge			3
Centar Associates	Gas centrifuge	0.3–3 from 1982–89		
Garret Nuclear Corp.	Gas centrifuge	0.3–3 from 1982–89		

[a] Total Soviet capacity (in Siberia) has been estimated at 7–10 mn SWU, of which 1 mn SWU may be available for export. No estimate of Chinese capacity (at Lanchow) is available.
[b] Indicated site: James Bay, Quebec; schedule uncertain.

[c] Site: Tricastin, France. Financed 51 per cent by Eurodif, 29 per cent by COGEMA and 20 per cent by the Atomic Energy Organization of Iran. Since Iran keeps a 10 per cent share in Eurodif through Sofidif, its total share in Coredif is 25 per cent.

The decision to build the plant was announced on 13 September 1976. It is scheduled to start production by 1983/84, and reach a capacity of 5 mn SWU by 1985. Subsequent increase of total annual capacity to 10 mn SWU is indicated.

[d] Site: Tricastin, France. Shareholders in Eurodif are as follows: AGIP Nucleare (Italy), 12½ per cent; Comitato Nazionale per l'Energia Nucleare, CNEN (Italy), 12½ per cent; Cie Générale de Materiaux Nucléaires, COGEMA (France), 27.8 per cent; Empresa Nacional de Uranio S.A., ENUSA (Spain), 11.1 per cent; Société Belge pour l'enrichissement de l'uranium, SIBESI (Belgium), 11.1 per cent; and Société franco-iranienne de diffusion gazeuse, SOFIDIF, 25 per cent (COGEMA owning 60 per cent and the Atomic Energy Organization of Iran 40 per cent).

The plant is scheduled to start production by December 1978, and to be run at full capacity (11 mn SWU) from 1982 onwards.

[e] Site: Pierrelatte. Primarily for military purposes.

[f] Site: Tokai Mura. Construction and operation of pilot centrifuge plant is planned for 1981. Subsequent construction of a commercial plant is subject to many uncertainties.

[g] Site: Valindaba. A pilot enrichment has been operating since 1975. The commercial project is in an early phase of development. Schedule uncertain.

[h] Site: Capenhurst. Primarily for military purposes.

[i] Sites: Almelo, the Netherlands and Capenhurst, UK. At the end of 1976, two 0.2 mn-SWU/year plants started to operate. The capacities of the plants will be increased according to requirements, with a stipulated full production rate altogether of 10 mn SWU in 1986.

[j] ERDA = Energy Research and Development Administration. Sites: Oak Ridge, Tenn., Paducah, Ky., and Portsmouth, Ohio. The previous annual capacity of the three plants—17 mn SWUs—is being increased by cascade improvement and uprating, aiming at a maximum capacity of 28 mn SWU/year in the early 1980s; the US Congress has authorized ERDA to build another enrichment plant (at Portsmouth, Ohio) with a maximum capacity of 9 mn SWU/year to be reached in 1985. The decision is now to use gas centrifuge technology.

[k] In 1975, the government initiated an industrial participation programme, giving potential suppliers access to classified technology and the results of government-sponsored R&D efforts, with the intention of turning enrichment into a competitive commercial industry. The programme has resulted in proposals from four companies: from Uranium Enrichment Associates (UEA), to reach a maximum capacity of 9 mn SWU/year at Dothan, Ala., in 1984; from Exxon Nuclear, to develop a capacity from 1 to 3 mn SWU/year over the years 1982–86; from Center Associates; and from Garret Nuclear. As part of its non-proliferation policy, the Carter Administration has committed itself to increasing US production for enriched uranium, to be in a better position to provide fuel supplies on a timely, adequate, reliable and economic basis.

Sources: Nuclear Proliferation and Safeguards (Congress of the United States, Office of Technology Assessment, Washington, 1977); Vanstrum, P. R. and Levin, S. A. (Union Carbide Corporation, Nuclear Division, Oak Ridge, Tennessee), *New Processes for Uranium Isotope Separation*, Paper presented at the International Conference on Nuclear Power and Its Fuel Cycle, Salzburg, Austria, 2–13 May 1977; *Nuclear Fuel Cycle Requirements and Supply Considerations through the Long Term* (OECD, Paris, January 1978); see also sources to table 2.1.

Recently, greater emphasis has been directed at incentives or so-called positive sanctions. In the long run, these are more likely to pay off. To encourage other nations to forgo plutonium fuel cycles, the USA has stressed the need for an assured supply of non-sensitive nuclear fuels on a timely, adequate, reliable and economic basis, and for sufficient spent fuel and nuclear waste storage capacity. To fulfil its commitments to supply reactor fuel, the USA is expanding its enrichment capacity. Plans to that effect were initiated by earlier Administrations, and the USA may soon be able to reopen its order books for enrichment service for the first time since mid-1974. The non-proliferation policy bill aims, furthermore, at prompt and predictable issuance of licences once statutory requirements are met. In order to help with nuclear fuel waste disposal, the USA seems willing to store more irradiated fuel from abroad.[4] The decision to defer commercial reprocessing and recycling indefinitely and to cease considering plutonium extraction as indispensable has, however, negative implications for the ability to fulfil fuel supply and storage promises: the amounts of uranium and enrichment services needed for a given power programme will increase, and large long-term storage capacities will be required.

The best way of preventing a sudden reversal of a nuclear programme from peaceful to military ends is to make sure that the country has no weapon-usable material on its territory and possesses neither enrichment nor reprocessing plants to produce such material. In a sense, it would therefore be a natural solution to limit the siting of enrichment plants, reprocessing plants and storage facilities to existing nuclear weapon states. In other words, Western nuclear weapon states could deal with their clients the way the Soviet Union does with its—and the USA is taking some steps in that direction. Should development of reprocessing capabilities and plutonium breeders proceed in countries now having advanced programmes in these fields—despite opposition from the USA and other countries—irradiated fuels could be sent to Britain, France and the USSR in return for new fuel elements. Again, the Soviet Union is in effect doing this already with its East European customers. Today's enrichment, reprocessing and breeder programmes extend, however, far beyond the five nuclear weapon states recognized by the NPT. To limit the siting of fuel cycle facilities in such a way would, moreover, add to the favoured status already enjoyed by the established nuclear weapon states. Therefore, while accentuating the problems associated with the plutonium economy, efforts in this direction could easily prove counter-productive.

Another way to dissuade non-nuclear weapon states from creating their own enrichment or reprocessing plants would be to establish an open market for these services, characterized by diversity and competition. This could eliminate unacceptable economic and political dependence on a single supplier or group of suppliers, and it could give the necessary guarantees for the long-term viability of nuclear energy programmes and eliminate excuses for establishing national fuel cycle programmes.

[4] "We are very eager to help solve the problem of the disposal of spent nuclear fuel itself. We cannot provide storage for the major portion of the world's spent fuel, but we are willing to cooperate. And when a nation demonstrates to us [its] need for the spent fuel storage, we hope to be prepared to accept that responsibility." (President Carter at the opening of INFCE in Washington on 19 October 1977.)

Table 2.5. Operating nuclear facilities not subject to IAEA or bilateral safeguards, as of 31 December 1977[a]

Country	Facility	Indigenous or imported	First year of operation
Egypt	Inshas	Imported (USSR)	1961
India	Apsara research reactor	Indigenous	1956
	Cirus research reactor	Imported (Canada/USA)	1960
	Purnima research reactor	Indigenous	1972
	Fuel fabrication plant at Trombay	Indigenous	1960
	Fuel fabrication plant at the Nuclear Fuel Cycle Complex at Hyderabad	Indigenous	1977
	Reprocessing plant at Trombay	Indigenous	1964
	Reprocessing plant at Tarapur	Indigenous	1977
Israel	Dimona research reactor	Imported (France)	1963
	Reprocessing plant	Indigenous (in collaboration with France)[b]	..
South Africa	Pilot enrichment plant	Indigenous (in collaboration with FR Germany)[c]	1975
Spain	Vandellos power reactor	Jointly operated with France	1972

[a] Significant nuclear activities outside of the five nuclear weapon states recognized by the NPT. Laboratory-scale activities are not included. The list is based on the best information available to SIPRI.
[b] Assistance by Saint Gobain Techniques Nouvelles.
[c] Co-operation between STEAG (FR Germany) and UCOR (South Africa).

Finally, international solutions to the storage, enrichment and reprocessing problems have recently received considerable attention. The USA has suggested the establishment of an international fuel bank, so that if there is a temporary breakdown in the bilateral supply of nuclear fuel, an international reservoir could be drawn upon. The IAEA has published a study of regional fuel cycle centres. If plutonium fuel is made use of, the fuel centre proposal implies that the plutonium would be outside the centres in mixed plutonium and uranium oxide (Mox) form. Mox fuel lends itself more easily, however, to chemical separation than do irradiated fuel elements. The warning time could be reduced to a few weeks. International fuel cycle centres are integral parts of proposals for more proliferation-resistant fuel cycles as well, such as the denatured U-233–thorium cycle.[5] Here, international centres are conceived of to reprocess fuel from national reactors and undertake all the fabrication and denaturing of fresh fuel assemblies. Some additional source of U-233

[5] Uranium-233, bred from thorium, can be diluted with the abundant isotope 238 to such an extent as to make the mixture unsuitable for weapons without isotope separation. No comparable "denaturant" exists for plutonium.

would also be needed. INFCE will probably explore a broad variety of possible international arrangements to reduce the proliferation danger.

The greatest catalyst of nuclear proliferation is the spread of national autarchic fuel-cycle programmes. In the long run, the spread of such programmes can best be avoided in an atmosphere of international trust. This implies that present dependencies on nuclear suppliers must be reduced, that the conditions of international nuclear transactions are made more stable and predictable, that the long-term viability of nuclear reactor programmes is guaranteed through a combination of national and multinational measures at both the front and the back ends of the fuel cycle, and that discrimination is halted.

From a non-proliferation point of view, nuclear energy probably ought to be a short parenthesis in the history of mankind. Regardless of the fate of nuclear power, however, the dissemination of nuclear technologies will continue. This means that for the cause of non-proliferation, there is no substitute for measures devaluing the military and political utility of nuclear weapons.

References

1. *World Armaments and Disarmament, SIPRI Yearbook 1977* (Almqvist & Wiksell, Stockholm, 1977, Stockholm International Peace Research Institute).
   (a) —, appendix 1A.
   (b) —, chapter 2.
2. *Postures for Non-Proliferation* (Taylor & Francis Ltd, London, 1978, Stockholm International Peace Research Institute).

Appendix 2A

Nuclear-export guidelines of the London Club

1. The following fundamental principles for safeguards and export controls should apply to nuclear transfers to any non-nuclear-weapon state for peaceful purposes. In this connection, suppliers have defined an export trigger list and agreed on common criteria for technology transfers.

Prohibition on Nuclear Explosives

2. Suppliers should authorize transfer of items identified in the trigger list only upon formal governmental assurances from recipients explicitly excluding uses which would result in any nuclear explosive device.

Physical Protection

3. (a) All nuclear materials and facilities identified by the agreed trigger list should be placed under effective physical protection to prevent unauthorized use and handling. The levels of physical protection to be ensured in relation to the type of materials, equipment and facilities, have been agreed by suppliers, taking account of international recommendations.

(b) The implementation of measures of physical protection in the recipient country is the responsibility of the government of that country. However, in order to implement the terms agreed upon amongst suppliers, the levels of physical protection on which these measures have to be based should be the subject of an agreement between supplier and recipient.

(c) In each case special arrangements should be made for a clear definition of responsibilities for the transport of trigger list items.

Safeguards

4. Suppliers should transfer trigger list items only when covered by IAEA safeguards, with duration and coverage provisions in conformance with the GOV/1621 guidelines. Exceptions should be made only after consultation with the parties to this understanding.

5. Suppliers will jointly reconsider their common safeguards requirements, whenever appropriate.

Safeguards Triggered by the Transfer of Certain Technology

6. (a) The requirements of paragraphs 2, 3 and 4 above should also apply to facilities for reprocessing, enrichment, or heavy water production, utilizing technology directly transferred by the supplier or derived from transferred facilities, or major critical components thereof.

(b) The transfer of such facilities, or major critical components thereof, or related technology, should require an undertaking (1) that IAEA safeguards apply to any facilities of the same type (i.e. if the design, construction or operating processes are based on the same or similar physical or chemical processes, as defined in the trigger list) constructed during an agreed period in the recipient country and (2) that there should at all times be in effect a safeguards agreement permitting the IAEA to apply Agency safeguards with respect to such facilities identified by the recipient, or by the supplier in consultation with the recipient, as using transferred technology.

Special Controls on Sensitive Exports

7. Suppliers should exercise restraint in the transfer of sensitive facilities, technology and weapons-usable materials. If enrichment or reprocessing facilities, equipment or technology are to be transferred, suppliers should encourage recipients to accept, as an alternative to national plants, supplier involvement and/or other appropriate multinational participation in resulting facilities. Suppliers should also promote international (including IAEA) activities concerned with multinational regional fuel cycle centres.

Special Controls on Export of Enrichment Facilities, Equipment and Technology

8. For a transfer of an enrichment facility, or technology therefor, the recipient nation should agree that neither the transferred facility, nor any facility based on such technology, will be designed or operated for the production of greater than 20 per cent enriched uranium without the consent of the supplier nation, of which the IAEA should be advised.

Controls on Supplied or Derived Weapons-Usable Material

9. Suppliers recognize the importance, in order to advance the objectives of these guidelines and to provide opportunities further to reduce the risks of proliferation, of including in agreements on supply of nuclear materials or of facilities which produce weapons-usable material, provisions calling for mutual agreement between the supplier and the recipient on arrangements for reprocessing, storage, alteration, use, transfer or retransfer of any weapons-usable material involved. Suppliers should

endeavour to include such provisions whenever appropriate and practicable.

Controls on Retransfer

10. (a) Suppliers should transfer trigger list items, including technology defined under paragraph 6, only upon the recipient's assurance that in the case of:

(1) retransfer of such items, or (2) transfer of trigger list items derived from facilities originally transferred by the supplier, or with the help of equipment or technology originally transferred by the supplier; the recipient of the retransfer or transfer will have provided the same assurances as those required by the supplier for the original transfer.

(b) In addition the supplier's consent should be required for: (1) any retransfer of the facilities' major critical components, or technology described in paragraph 6: (2) any transfer of facilities or major critical components derived from those items: (3) any retransfer of heavy water or weapons-usable material.

SUPPORTING ACTIVITIES

Physical Security

11. Suppliers should promote international co-operation on the exchange of physical security information, protection of nuclear materials in transit, and recovery of stolen nuclear materials and equipment.

Support for Effective IAEA Safeguards

12. Suppliers should make special efforts in support of effective implementation of IAEA safeguards. Suppliers should also support the Agency's efforts to assist member states in the improvement of their national systems of accounting and control of nuclear material and to increase the technical effectiveness of safeguards.

Similarly, they should make every effort to support the IAEA in increasing further the adequacy of safeguards in the light of technical developments and the rapidly growing number of nuclear facilities, and to support appropriate initiatives aimed at improving the effectiveness of IAEA safeguards.

Sensitive Plant Design Features

13. Suppliers should encourage the designers and makers of sensitive equipment to construct it in such a way as to facilitate the application of safeguards.

Consultations

14. (a) Suppliers should maintain contact and consult through regular channels on matters connected with the implementation of these guidelines.

(b) Suppliers should consult, as each deems appropriate, with other Governments concerned on specific sensitive cases, to ensure that any transfer does not contribute to risks of conflict or instability.

(c) In the event that one or more suppliers believe that there has been a violation of supplier/recipient understandings resulting from these guidelines, particularly in the case of an explosion of a nuclear device, or illegal termination or violation of IAEA safeguards by a recipient, suppliers should consult promptly through diplomatic channels in order to determine and assess the reality and extent of the alleged violation.

Pending the early outcome of such consultations, suppliers will not act in a manner that could prejudice any measure that may be adopted by other suppliers concerning their current contacts with that recipient.

Upon the findings of such consultations, the suppliers, bearing in mind Article XII of the IAEA Statute, should agree on an appropriate response and possible action which could include the termination of nuclear transfers to that recipient.

15. In considering transfers, each supplier should exercise prudence having regard to all the circumstances of each case, including any risk that technology transfers not covered by paragraph 6, or subsequent retransfers, might result in unsafeguarded nuclear materials.

16. Unanimous consent is required for any changes in these guidelines, including any which might result from the reconsideration mentioned in paragraph 5.

ANNEX: CLARIFICATIONS OF ITEMS ON THE TRIGGER LIST

A. Complete nuclear reactors (Item 2.1.1 of the Trigger List):

1. A "nuclear reactor" basically includes the items within or attached directly to the reactor vessel, the equipment which controls the level of power in the core, and the components which normally contain or come in direct contact with or control the primary coolant of the reactor core.

2. The export of the whole set of major items within this boundary will take place only in accordance with the procedures of the guidelines. Those individual items within this functionally defined boundary which will be exported only in accordance with the procedures of the Guidelines are listed in paragraphs 2.1.1 to 2.1.5.

The Government reserves to itself the right to apply the procedures of the guidelines to other items within the functionally defined boundary.

3. It is not intended to exclude reactors which could reasonably be capable of modification to produce significantly more than 100 grams of plutonium per year. Reactors designed for sustained operation at significant power levels, regardless of their capacity for plutonium production, are not considered as "zero energy reactors".

B. Pressure vessels (Item 2.1.2 of the Trigger List):

4. A top plate for a reactor pressure vessel is covered by item 2.1.1 as a major shop-fabricated part of a pressure vessel.

5. Reactor internals (e.g. support columns and plates for the core and other vessel internals, control rod guide tubes, thermal shields, baffles, core grid plates, diffuser plates, etc.) are normally supplied by the reactor supplier. In some cases, certain internal support components are included in the fabrication of the pressure vessel. These items are sufficiently critical to the safety and reliability of the operation of the reactor (and, therefore, to the guarantees and liability of the reactor supplier), so that their supply, outside the basic supply arrangements for the reactor itself, would not be common practice. Therefore, although the separate supply of these unique, especially designed and prepared, critical, large and expensive items would not necessarily be considered as falling outside the area of concern, such a mode of supply is considered unlikely.

C. Reactor control rods (Item 2.1.4 of the Trigger List):

6. This item includes, in addition to the neutron absorbing part, the support or suspension structures therefor if supplied separately.

D. Fuel reprocessing plants (Item 2.3.1 of the Trigger List):

7. A "plant for the reprocessing of irradiated fuel elements" includes the equipment and components which normally come in direct contact with and directly control the irradiated fuel and the major nuclear material and fission product processing streams. The export of the whole set of major items within this boundary will take place only in accordance with the procedures of the Guidelines. In the present state of technology, the following items of equipment are considered to fall within the meaning of the phrase "and equipment especially designed or prepared therefor":

(a) Irradiated fuel element chopping machines: remotely operated equipment especially designed or prepared for use in a reprocessing plant as identified above and intended to cut, chop or shear irradiated nuclear fuel assemblies, bundles or rods; and

(b) Critically safe tanks (e.g. small diameter, annular or slab tanks) especially designed or prepared for use in a reprocessing plant as identified above, intended for dissolution of irradiated nuclear fuel and which are capable of withstanding hot, highly corrosive liquid, and which can be remotely loaded and maintained.

8. The Government reserves to itself the right to apply the procedures of the Guidelines to other items within the functionally defined boundary.

E. Fuel fabrication plants (Item 2.4.1 of the Trigger List):

9. A "plant for the fabrication of fuel elements" includes the equipment:

(a) Which normally comes in direct contact with, or directly processes, or controls, the production flow of nuclear material, or

(b) Which seals the nuclear material within the cladding.

10. The export of the whole set of items for the foregoing operations will take place only in accordance with the procedures of the Guidelines. The Government will also give consideration to application of the procedures of the Guidelines to individual items intended for any of the foregoing operations, as well as for other fuel fabrication operations such as checking the integrity of the cladding or the seal, and the finish treatment to the solid fuel.

F. Isotope separation plant equipment (Item 2.5.1 of the Trigger List):

11. "Equipment, other than analytical instruments, especially designed or prepared for the separation of isotopes of uranium" includes each of the major items of equipment especially designed or prepared for the separation process. Such items include:

— gaseous diffusion barrier
— gaseous diffuser housings
— gas centrifuge assemblies, corrosion-resistant to UF_6
— jet nozzle separation units
— vortex separation units
— large UF_6 corrosion-resistant axial or centrifugal compressors
— special compressor seals for such compressors

ANNEX B: CRITERIA FOR LEVELS OF PHYSICAL PROTECTION

1. The purpose of physical protection of nuclear materials is to prevent unauthorized use and handling of these materials. Paragraph 3(a) of the Guidelines document calls for agreement among suppliers on the levels of protection to be ensured in relation to the type of materials, and equipment and facilities containing these materials, taking account of international recommendations.

2. Paragraph 3(b) of the Guidelines document states that implementation of measures of physical protection in the recipient country is the responsibility of the Government of that country. However, the levels of physical protection on which these measures have to be based should be the subject of an agreement between supplier and recipient. In this context these requirements should apply to all states.

3. The document INFCIRC/225 of the International Atomic Energy Agency entitled "The Physical Protection of Nuclear Material" and similar documents which from time to time are prepared by international groups of experts and updated as appropriate to account for changes in the state of the art and state of knowledge with regard for physical protection of nuclear material are a useful basis for guiding recipient states in designing a system of physical protection measures and procedures.

4. The categorization of nuclear material presented in the attached table [omitted] or as it may be updated from time to time by mutual agreement of suppliers shall serve as the agreed basis for designating specific levels of physical protection in relation to the type of materials, and equipment and facilities containing these materials, pursuant to paragraphs 3(a) and 3(b) of the Guidelines document.

5. The agreed levels of physical protection to be ensured by the competent national authorities in the use, storage and transportation of the materials listed in the attached table [omitted] shall as a minimum include protection characteristics as follows:

CATEGORY III

Use and Storage within an area to which access is controlled.

Transportation under special precautions including prior arrangements among sender, recipient and carrier, and prior agreement between entities subject to the jurisdiction and regulation of supplier and recipient states, respectively, in case of international transport specifying time, place and procedures for transferring transport responsibility.

CATEGORY II

Use and Storage within a protected area to which access is controlled, i.e., an area under constant surveillance by guards or electronic devices, surrounded by a physical barrier with a limited number of points of entry under appropriate control, or any area with an equivalent area of physical protection.

Transportation under special precautions including prior arrangements among sender, recipient and carrier, and prior agreement between entities subject to the jurisdiction and regulation of supplier and recipient states, respectively, in case of international transport, specifying time, place and procedures for transferring transport responsibility.

CATEGORY I

Materials in this Category shall be protected with highly reliable systems against unauthorized use as follows:

Use and Storage within a highly protected area, i.e., a protected area as defined for Category II above, to which, in addition, access is restricted to persons whose trustworthiness has been determined, and which is under surveillance by guards who are in close communication with appropriate response forces. Specific measures taken in this context should have as their objective the detection and prevention of any assault, unauthorized access or unauthorized removal of material.

Transportation under special precautions as identified above for transportation of Category II and III materials and, in addition, under constant surveillance by escorts and under conditions which assure close communication with appropriate response forces.

6. Suppliers should request identification by recipients of those agencies or authorities having responsibility for ensuring that levels of protection are adequately met and having responsibility for internally co-ordinating response/recovery operations in the event of unauthorized use or handling of protected materials. Suppliers and recipients should also designate points of contact within their national authorities to co-operate on matters of out-of-country transportation and other matters of mutual concern.

3. The military impact on the human environment[1]

Square-bracketed numbers, thus [1], *refer to the list of references on page 67.*

I. Introduction

This chapter examines the adverse effects of warfare and other military activities on the human environment. Such effects are largely incidental to the multifarious activities associated with maintaining armies both in peace and in war. In some instances of warfare, however, they can be an intentional and integral component of the military strategy being employed. Indeed, there is a discernible trend for modern warfare to become ever more destructive of the environment. Moreover, the weapons of mass destruction available today could be employed so as to have a catastrophic environmental impact. Finally, there is the suggestion that man will soon attain the technological sophistication to permit the manipulation of certain forces of nature, such as hurricanes, tsunamis and earthquakes. If these abilities were to be employed for hostile purposes, their environmental impact could be truly widespread, long-lasting and severe.

Section II of this chapter describes the environmental impact of specific forms of feasible modern warfare, reviewing in turn conventional, nuclear, chemical, biological and geophysical means of attack. Section III examines the same problem from the standpoint of the ecological vulnerability of the several major global habitats, both terrestrial and oceanic. The terrestrial habitats are separated into five large categories: temperate, tropical, desert, arctic and insular. The major emphasis is on natural ecosystems, although some attention is also paid to the anthropogenic ones, especially in the case of temperate habitats.

II. Warfare of today and tomorrow

Conventional warfare

The environmental impact of conventional warfare derives primarily from the disruption of the theatre of operations by high-explosive munitions. Ever greater amounts of these munitions are being employed in modern warfare. Paradoxically, although their use has become more profligate, munition effectiveness as measured in terms of the number of

[1] This chapter draws freely upon three SIPRI publications: references [1–3]. The reader is also referred to three further SIPRI publications: references [4–6]. The most useful introduction to the scattered literature on the subject is provided by a UNESCO bibliography [7].

enemy killed has been declining. This is because an increased proportion of these munitions is being directed against ill defined area targets, a form of use associated with fewer casualties but with greater ecological disruption.

This anti-ecological trend can be illustrated by munition expenditures by the USA during its three most recent wars. Thus, during World War II the USA expended 1 100 kg of munitions for each enemy soldier killed; during the Korean War the amount increased to 5 600 kg and during the Second Indo-China War to fully 17 800 kg. Considering these expenditures in terms of the size of the respective theatres of operation, the USA expended only about 26 kg per hectare during World War II as opposed to 120 kg per hectare during the Korean War and 190 kg per hectare during the Second Indo-China War. Additionally, during World War II perhaps 30 per cent of aerial munitions were directed by the USA against area targets (primarily urban or industrial), during the Korean War this proportion approached 75 per cent (largely rural) and during the Second Indo-China War it was in excess of 85 per cent (and almost entirely rural).

The Second Indo-China War serves as an example of the character and amount of ecological disruption that can be associated with high-explosive munitions, especially in the manner in which these were expended in South Viet Nam, a region representing one-fourth of Indo-China. A total of over 14 million tonnes of munitions was directed against the whole of Indo-China by the USA, more than 70 per cent of this being directed against the 17 million hectares of rural South Viet Nam. The result of this onslaught against South Viet Nam was the creation of some 10 million more-or-less permanent craters that average about 67 cubic metres in size. The total surface area of South Viet Nam that has been converted to craters adds up to more than 100 000 hectares. Beyond the area of complete obliteration is a very small zone of severe blast damage and a much larger one that had been subjected to flying metal fragments, the so-called shrapnel. If one considers the zone subjected to such abuse at an intensity sufficient to be lethal to 50 per cent or more of exposed personnel (and thus of wildlife as well), then the combined area in question amounts to almost 5 million hectares. This huge area is one in which many of the trees would have been injured by shrapnel, an event that in turn leads to fungal decay, inevitably followed by significant tree mortality.

Much of the heavy expenditure of high-explosive munitions in South Viet Nam and elsewhere in Indo-China was in the form of pattern bombing, a tactic in which several hundred bombs were dropped in concert from a group of high-flying aircraft onto a rural area of perhaps 300 hectares. The high degree of vegetational destruction throughout this target area would lead to reduced transpiration, a raising of the water table and thus further vegetational damage, and more rapid run-off. Moreover, depending upon local conditions, some fraction of the craters could become either intermittent or permanent ponds.

Damage from the high-explosive munitions to the forest resource of South Viet Nam has been immense. Millions of trees were destroyed directly by the initial blast and millions more were damaged by flying metal. The entry wounds have in turn led to fungal decay and further commercial losses. The profusion of craters has made logging operations more difficult. The embedded shrapnel has ruined saw blades, both in the woods and at the sawmill, often to the point of financial ruin. In addition, the residuum of unexploded munitions remaining hidden in the forest—1 to 2 per cent or often even more of original expenditures—has made forest work a highly hazardous occupation.

Thus, the Second Indo-China War has made it clear that the massive and repeated use of conventional high-explosive munitions for purposes of harassment, interdiction or area denial of large contested regions for long periods is both militarily feasible and ecologically objectionable. On the other hand, perhaps the future will witness a trend towards improved means of discrete target identification coupled with more accurate means of munition delivery, and thus possibly towards reduced munition expenditures. Environmental damage would be alleviated to the extent that such a reversal in strategy was adopted, through a reduction in wide-area habitat debilitation and because of a reduced drain on the world's non-renewable natural resources.

Finally, high-explosive munitions are by no means the only ecological insult attributable to conventional warfare. To provide one good illustration, during the Second Indo-China War the USA carried out highly disruptive large-scale land-clearing operations with giant tractors (so-called Rome ploughs) for purposes of denying its enemy the advantages of forest concealment (for details, see reference [1a]).

Nuclear warfare

The two small nuclear bombs that the USA exploded over the cities of Hiroshima and Nagasaki during World War II resulted in awesome carnage and devastation, but they do no more than hint at the environmental impact that could result from a nuclear war today.

A 0.91-Mt thermonuclear bomb (that is, one that has an energy yield of 4×10^{15} joules) exploded at the surface will blast out a deep crater with a surface area of perhaps 12 hectares (see table 3.1). The blast wave, thermal pulse and initial nuclear radiation will kill all exposed plants and animals over a huge area, the dimensions of which will depend upon the terrain and the weather, but which will be of the order of several thousand hectares. It will initiate wildfires over an even larger area. The initial fury

Table 3.1. Damage to biota from a nuclear bomb exploded at the surface

Type of damage	Area suffering the given type of damage (*hectares*) 18-kt atomic (fission) bomb	0.91-Mt hydrogen (fission/fusion) bomb	9.1-Mt hydrogen (fission/fusion) bomb
Craterization by the blast wave	1	12	57
Trees blown down by the blast wave	362	9 040	52 500
Trees killed by nuclear radiation	148	12 800	63 800
All vegetation killed by nuclear radiation	43	2 830	12 100
Dry vegetation ignited by thermal radiation	749	21 300	117 000
Vertebrates killed by the blast wave	24	332	1 540
Vertebrates killed by nuclear radiation	674	36 400	177 000
Vertebrates killed by thermal radiation	1 000	26 900	150 000

Source: Reference [2a].

of a tropospheric burst will produce no crater but will result in a somewhat more predictable and greater area of devastation (see table 3.2). A full-scale nuclear war could involve an exchange of several or more thousand such bombs. Although the primary targets would presumably be military, urban and industrial, the large area of devastation associated with each bomb (as well as some faulty aiming) would ensure that enormous agricultural and other rural areas were concurrently decimated.

The vast areas rendered desolate by the initial events of the nuclear explosions and by the associated wildfires would experience substantial site degradation during the period before the eventual re-establishment of a pioneer vegetative cover. This degradation would result from greatly accelerated soil erosion by wind and water and from so-called nutrient dumping (that is, the rapid loss by the soil of minerals in solution). Subsequent ecological (successional) recovery of these debilitated areas could

Table 3.2. Damage to biota from a nuclear bomb exploded in the troposphere

Type of damage	Area suffering the given type of damage (*hectares*) 18-kt atomic (fission) bomb	0.91-Mt hydrogen (fission/fusion) bomb	9.1-Mt hydrogen (fission/fusion) bomb
Craterization by the blast wave	0	0	0
Trees blown down by the blast wave	565	14 100	82 000
Trees killed by nuclear radiation	129	648	1 250
All vegetation killed by nuclear radiation	18	312	759
Dry vegetation ignited by thermal radiation	1 170	33 300	183 000
Vertebrates killed by the blast wave	43	591	2 740
Vertebrates killed by nuclear radiation	318	1 080	1 840
Vertebrates killed by thermal radiation	1 570	42 000	235 000

Source: Reference [2b].

take many decades or even centuries, depending upon the habitat and the size of the area of contiguous damage.

Surface explosions would inject vast amounts of fine dust into the atmosphere—up to 50 000 t by a 1-Mt bomb. A substantial fraction of this particulate aerosol would enter the stratosphere, where it would have a residence time of several years. The aerosol would supply condensation nuclei, thereby creating clouds. Moreover, it would reflect solar energy back into space more efficiently than it would reflect terrestrial infra-red energy back to Earth. Several thousand such bombs might thereby lower global temperatures by a tenth of a degree Celsius or more, for up to several years. Such a temperature depression would have subtle ecological and agricultural effects, the latter probably being adverse.

About one-third of the nuclear radiation generated by a nuclear bomb is dissipated during the first minute and adds its lethal impact to the zone of initial devastation. The residual radiation is dispersed far more widely in both space and time, impinging upon ecosystems both near and far in the form of radioactive fall-out (more so from surface bursts than atmospheric bursts). This long-term nuclear radiation provides a stress to the ecosystems of the world, exacerbating the various pollutional stresses to which they are already being subjected. The global human population would be exposed to increased radioactivity, both directly and through contaminated food and water intake. The result would be a slight increase in the incidence of malignancies, leukaemia, mental retardation and other somatic and genetic maladies.

Atmospheric nuclear bursts generate immense amounts of nitrogen oxides that are capable of catalytically destroying atmospheric ozone (which is to some extent concentrated in an ozone layer in the lower stratosphere). Atmospheric ozone depletion permits a greater fraction of solar ultra-violet radiation to reach the Earth's surface. Several thousand 1-Mt bombs exploded in the troposphere of, say, the Northern Hemisphere would destroy perhaps 10 per cent of the atmospheric ozone in that hemisphere which, in turn, would approximately double the ultra-violet radiation dose reaching the Earth there. Normal atmospheric ozone levels would become re-established over a period of about a decade. Such transient ultra-violet enrichment is not likely to have any discernible effect on natural ecosystems, either terrestrial or aquatic. Among exposed humans it might result in a modest transient increase in skin cancer frequency.

It thus appears that the ecological concern associated with nuclear detonations derives primarily from the initial wide-area devastation resulting from the blast wave, thermal pulse and early nuclear radiation, together with the damage caused by the wildfires initiated; it derives secondarily from a number of more subtle long-term impacts of the residual nuclear radiation, the augmentation of stratospheric dust, the depletion of stratospheric ozone, and perhaps other factors. Clearly, a nuclear war would result not only in dreadful human losses and societal disruption, but in terrible environmental destruction as well, both agricultural and natural.

The possibility exists that tactical nuclear weapons (relatively low-yield devices perhaps with enhanced neutron flux) will find future battlefield use and, if so, possibly on a large scale. Even if these bombs are detonated at an altitude sufficient to reduce greatly their blast and thermal effects, the initial pulse of nuclear radiation from each bomb will kill exposed humans, wildlife, trees and other plants with great efficiency over an area of tens of hectares. But perhaps the greatest ecological concern associated with such weapons is that their use could escalate into a full-scale nuclear war.

Chemical warfare

Chemical warfare—which could involve any of a wide spectrum of harassing or lethal agents—is here exemplified by the highly lethal nerve agent VX (*S*-[2-diisopropylaminoethyl] *O*-ethyl methyl phosphonothiolate).

VX is an essentially colourless, odourless and non-volatile liquid that lends itself well to military aerosol dispersion. Entry is especially hazardous for humans via inhalation, but is also possible and highly dangerous via the skin (with a dermal application of less than 10 mg said to be lethal). The primary mode of the toxic action of VX is the rapid inhibition of the cholinesterase enzymes, such as acetylcholinesterase, essential for the transmission of nerve impulses. Depending upon formulation, method of dispersal and weather, one tactical missile could disseminate a debilitating-to-lethal dose of VX over an area of several hundred hectares and a single aircraft could do the same over several thousand hectares.

Information available on organophosphorus insecticides, such as parathion, with which VX shares anti-cholinesterase activity, makes it clear that if VX were used in an attack at levels lethal to personnel, it would simultaneously destroy exposed non-human vertebrates also, including mammals, birds and reptiles. It would also kill many of the invertebrates, especially various of the insects and other arthropods. On the other hand, the exposed vegetation, although it would absorb the agent, would largely be spared. However, the exposed plants would for a time act as a secondary source of contamination for the herbivores feeding on them, in some instances being dangerous for at least three weeks. Moreover, insectivorous birds entering an attacked area would, for a time, ingest lethal levels of VX by preferentially feeding on the readily available dead and weakened arthropods. Long-term environmental persistence of VX would, however, not appear to become a problem.

It is unquestionable that a wide-area attack with VX, although probably not having a long-term residual effect *per se*, would result in an immediate zoological catastrophe. This could become a matter of serious concern if the attack extended over thousands of hectares, as well it might. In short, the major ecological danger from a wide-area attack with VX or other biologically active chemical agent would derive from the resultant decimation of selected categories of fauna or flora. The affected ecosystems would thereby be drastically unbalanced or upset. A recent military example of such ecological upset has, in fact, been provided by the chemical attack on the trees of South Viet Nam by the USA during the Second Indo-China War (for details of which, see reference [1b]). Major ecological disturbance would also result from the hostile employment of dioxin (TCDD; 2,3,7,8-tetrachlorodibenzo-*p*-dioxin; for details of which, see reference [5]).

Biological warfare

Biological warfare could take a variety of bizarre forms. A biological attack could be directed against humans or livestock and it could be overt or covert. Potential agents, which range from harassing to lethal, include diverse bacteria, rickettsia, viruses, fungi and protozoans. Presented here is the military employment of *Bacillus anthracis* (Bacillaceae) as an illustration of what might be the outcome of a biological attack.

The highly virulent bacterium *B. anthracis* is the causative agent of the febrile and septicaemic disease known as anthrax. This exceedingly infectious disease of most mammals and a variety of other animals is often fatal if left to run its course. Among the groups that are known to contract anthrax are a variety of mammals, birds, amphibians and fish. Normal dissemination is via the bacterial spores, which are transmitted and gain entry in a multiplicity of ways. The pulmonary form of the disease, contracted by spore inhalation, is nearly always rapidly fatal, at least to humans (for whom the lethal dose is less than 1 μg of spores).

The spores of *B. anthracis* are easy to mass-produce, are extraordinarily resistant to the vicissitudes of the environment and lend themselves well to military aerosol dispersion. A single aircraft would easily be able to deliver a dose of spores initially lethal to three-quarters of the humans over an area of at least several thousand hectares. The same application would debilitate, if not destroy, many of the populations of mammals throughout the attacked region and would have at least some impact on numerous other animal groups as well.

B. anthracis appears capable of establishing itself in a wide range of climates. Thus, in many parts of the world a biological attack with these bacteria would establish them in the local ecosystems, thereby providing permanent reservoirs of the disease. Occasional outbreaks could be expected to occur from then on. Even in regions not conducive to permanent naturalization, spores in the soil could remain alive and continue to be a focus of infection for many years or decades.

Thus, as with a chemical attack, the ecological danger from a wide-area biological attack would derive from the resultant decimation of selected categories of fauna and flora which, in turn, would drastically unbalance the affected ecosystems. However, a biological attack could present a number of grave additional problems. For one thing, the likelihood exists that its deleterious impact would be multiplied by contagious spread. Secondly, a dangerous new disease or pest organism could become permanently established in an area that had previously been free of it.

Geophysical warfare

So-called geophysical warfare (also known as environmental warfare) refers to the manipulation of natural forces for hostile purposes. It can involve modifications of the atmosphere, of the land and its associated fresh waters, or of the ocean. Many of the suggested geophysical manipulations are not as yet possible to carry out.

A number of hostile modifications of the atmosphere have been suggested as useful military possibilities for the future. These include rainfall modification, the manipulation of the electrical properties of the ionosphere or troposphere, the initiation or redirection of hurricanes, the control of cloud-to-ground lightning and the destruction of the stratospheric ozone layer. The reasons for wishing to alter the rainfall patterns would include the disruption of ground traffic, the improvement or the impairment of visibility, and the disruption of agriculture. The purpose of altering the electrical properties of the atmosphere would be to interfere with some forms of enemy communication, remote sensing, navigation and missile guidance systems. The purpose of wanting to disrupt the ozone layer above enemy territory would be to permit harmful amounts of solar ultra-violet radiation to reach the ground.

Hostile manipulations of the land that are already feasible or have been suggested are for the most part highly dependent for their success on the local site factors. Large-scale wildfires can be initiated and abetted if the vegetation and the weather are suitable. Some local land-forms or man-made structures might well lend themselves to disruption that would lead to flooding or to avalanches or landslides. In enemy tundra regions it might be feasible during the summer season to destroy the vegetational ground cover. This would result in the lowering of the permafrost level, which, in turn, would reduce the trafficability of the area. If an enemy region happens to be tectonically unstable, it might become possible in the future to trigger an earthquake there. Similarly, quiescent volcanoes in enemy territory could perhaps be stimulated into destructive activity.

Among the hostile ocean modifications that have been suggested as military possibilities for the future are physical or chemical manipulations that would disrupt the acoustic (sonar) or electromagnetic properties of the attacked waters. Again, the purpose of such attack would be the disruption of some forms of enemy underwater communication, remote sensing, navigation and missile guidance systems. A second possibility involving the ocean habitat is the generation of tsunamis for the purpose of destroying coastal cities and other nearshore facilities.

Man has had much experience with wildfires, floods, hurricanes, tsunamis, earthquakes and other natural forces. Their environmental impacts and ecological effects are thus for the most part well known, as are their agricultural consequences. In many respects it would, of course, make little difference whether the forces set in motion were of natural origin or the result of human intervention. On the other hand, it must be stressed that in so far as these forces would be initiated during abnormal seasons and especially in so far as they would be directed against ecosystems not accustomed to their fury, they would be inordinately ecologically disruptive. Moreover, once man achieves the ability to manipulate natural forces (especially those that normally change little) on a grand scale, it is possible that these in turn will set in motion unpredictable and presumably undesirable environmental changes that are both long-lasting and widespread.

III. The Earth and its habitats

Ecosystems of the Earth

The Earth as a whole, with its interacting living and non-living components, should be thought of as one huge integrated life-support system. Wind and ocean currents travel ceaselessly around the globe, laden with matter that is thereby passively distributed and redistributed. Moreover, numerous sorts of living organisms actively move between widely divergent and separated ecosystems at different times during their development or during different seasons of the year. All of the countless local ecosystems on Earth share the Sun as their common ultimate source of energy; and, at least potentially, each local ecosystem is connected to all the others by its hydrological, carbon dioxide, oxygen and other biogeochemical cycles. The continuing and seasonal patterns of wind, precipitation and temperature—which are interconnected throughout the world—are crucial in determining the character of all the local ecosystems.

In short, it is clear that the global ecosystem is, indeed, an interconnected world-wide system of which any part is more or less sensitive to perturbations anywhere else in the system. Nevertheless, the Earth—with its surface area of 510 million square kilometres—is a huge and diverse structure (see tables 3.3 and 3.4). It thus becomes highly useful to divide the global ecosystem into a number of major climatically and geomorphically determined habitats, with temperate, tropical, desert, arctic, insular and oceanic sufficing for present purposes (see table 3.5). These entities can be considered as operational ecosystems (either *in toto* or in subunits determined by the quirks of geography) as long as their ultimate interconnections are kept in mind. A number of further ecosystems, based on human manipulations, can also be recognized, including those resulting from various agricultural, horticultural and silvicultural activities, as well as urban and suburban areas.

Table 3.3. Major global land masses

Region[a]	Area[b] $10^6\ km^2$	Population[b] 10^6	Nations[c]	Armed forces[d] 10^6
North America	21.8	315	9	2.3
South America	17.8	216	12	1.0
Africa	29.7	391	45	1.4
Europe	10.0	479	28	7.6
Asia	41.5	2 216	30	12.3
Australia	7.7	14	1	0.1
Antarctica	13.0	0	0	0
Islands	7.2	434	34	1.8
Atlantic Ocean	0.7	88	15	0.5
Pacific Ocean	3.7	337	13	1.2
Indian Ocean	0.6	10	6	0.0
Arctic Ocean	2.2	0	0	0
Total	**148.8**	**4 065**	**159**	**26.5**
Northern Hemisphere	101.4	3 636	124	25.1
Southern Hemisphere	47.4	429	35	1.4

[a] The regions are strictly geographic and the continents are exclusive of islands. The division between North and South America is taken to be the eastern border of Panama. The division between Africa and Asia is taken to be the Suez Canal. The division between Europe and Asia is taken to be the crest of the Ural Mountains and the Ural River; the crest of the Caucasus Mountains; and the Dardanelles and the Bosporus. Mediterranean islands are included with Atlantic islands.
[b] Areas and populations are from the *UN Demographic Yearbook*, being summations of the individual nations and colonies (with overlapping territories apportioned appropriately).
[c] The following 159 territories are considered *de facto* nations for present purposes: the 147 United Nations of September 1977 (with Byelorussia, the Ukraine, and the USSR being treated as one unit; and with China being treated exclusive of Taiwan) plus Andorra, North Korea, South Korea, Liechtenstein, Monaco, Nauru, Rhodesia, San Marino, Switzerland, Taiwan, Tonga, and Vatican City. The numbers refer to those nations wholly or primarily in the given region.
[d] Armed forces are from reference [8], being summations of the individual nations (with overlapping nations apportioned appropriately).

Table 3.4. Major global ocean basins

Basin	Area 10^6 km^2	Average depth m	Volume 10^{15} m^3
Atlantic	82.0	3 700	300
Pacific	181.0	4 300	780
Indian	73.0	3 400	250
Arctic	14.0	1 400	20
Miscellaneous	11.3	1 800	20
Total	**361.3**	**3 800**	**1 370**
Northern Hemisphere	153.7	..	..
Southern Hemisphere	207.6	..	..

Table 3.5. Major global habitats[a]

Habitat	Area 10^6 km^2	Population 10^6	Nations	Armed forces 10^6
Land	148.8	4 065	159	26.5
Temperate	56.2	2 360	56	18.7
Tropical	42.2	1 586	80	6.1
Desert	26.7	102	22	1.6
Arctic[b]	23.7	18	1	0
Ocean[b]	361.3	–	–	–
Total	**510.1**	**4 068**	**159**	**26.5**
Island	7.2	433	34	1.8

[a] For explanations regarding area, population, nations, and armed forces, see the notes to table 3.3.

[b] Permanently ice-covered land amounts to about 17 million square kilometres; permanently ice-covered ocean amounts to about 7 million square kilometres.

When the operational ecosystems enumerated above are subjected to military disruption, this leads to greater tragedy for some and lesser for others. This is the case because different ecosystems are differently vulnerable to upset. Insular or desert ecosystems, for example, can be exceedingly species-poor and are thus intrinsically fragile. On islands especially, some of the species themselves are ill equipped to cope with adversity. Some ecosystems, including arctic and alpine ones, are very slow to recover from disruption owing to the harshness of the climate or terrain, or to other factors, such as soil fragility. The vulnerability of other ecosystems hinges upon their overall limited global extent or upon their degree of geographic fragmentation. Many individual species of plants and animals require relatively large contiguous areas of habitat for survival. The ecosystems associated with them are thereby vulnerable to the extent that important biotic components are unable to survive such fragmentation. In fact, some ecosystems are of particular concern since they constitute the habitat for species in special need of protection because of a danger of extinction or for some other reason. Finally, numerous ecosystems—either natural or managed to different degrees—are of importance inasmuch as human populations derive food, shelter, clothing and other amenities from them.

In the sections to follow, the military abuse of the global environment is, as previously indicated, divided for convenience into six broad categories, five terrestrial and one oceanic.

Temperate regions

The temperate terrestrial regions of the world can, as an approximation, be thought of as falling between the Arctic Circle and the Tropic of Cancer on the one hand and between the Antarctic Circle and the Tropic of Capricorn on the other. The temperate lands within these two global bands—temperate with respect to both temperature and rainfall—comprise an area of about 56 million square kilometres, thereby representing about 38 per cent of the global land area or about 43 per cent if one excludes the permanently frozen lands (see table 3.5). These temperate lands support an estimated 58 per cent of the world population, that is, almost 2 400 million people. Included within this region are 56 nations, including all of the great powers as well as the other highly developed and industrialized nations of the world. It is also the region of the world whose natural environment has been most extensively and drastically modified to suit the needs of man. Much of the land has for millennia been given over to increasingly intensive agricultural and high-density urban uses and the remainder—terrain permitting—to silvicultural and other extensive uses.

With the truly natural environment playing a more subsidiary role in temperate regions, the processes of natural ecological recovery from environmental damage—whether civil or military—are relevant to only a limited extent. Instead, the character and speed of recovery and rehabilitation are determined largely by the form and extent of human intervention. In the present section, therefore, a brief analysis is made of the rate of recovery from the devastation that results from large-scale conventional warfare. It is based on recovery in Europe and Japan from the damage of World War II and examines the two major anthropogenic ecosystems, the agricultural one and the urban/industrial one, in terms of production data.

Despite the potential availability of various means of rehabilitating war-disrupted sites, obstacles are likely to exist that could all but overwhelm most reconstruction efforts, at least during the war and in the immediate post-war period. These obstacles might include the extensiveness of the disruption and the paucity of available human and material resources. Moreover, the available population can be enfeebled for a time by disease, malnutrition and war trauma. The question of how long recovery might take is complicated by such further variables and uncertainties as a nation's pre-war condition, the character and severity of its wartime damage and the amount of post-war foreign aid it might receive (to say nothing of the criteria of damage and recovery, or of the reliability of the data used).

Examined and compared here in brief are the rates of post-war agricultural and industrial recovery exhibited by a group of 10 nations that were subjected to damage during World War II (see table 3.6). This group had at the time a combined population of perhaps 300 million and a combined area of about 260 million hectares, of which roughly 95 million were under cultivation and an additional 93 million devoted to forestry.

Table 3.6. Impact of and recovery from World War II

Nation	Proportion killed (military + civil) *Per cent*	Post-war agricultural production[a] *Per cent of pre-war*	Rate of agricultural recovery[a] *Per cent per year*	Post-war industrial production[a] *Per cent of pre-war*	Rate of industrial recovery[a] *Per cent per year*
Austria	5.4	60	5.9	0	26.5
Czechoslovakia	3.1	52	7.5	64	12.0
Finland	2.3	70	9.7	91	14.1
France	1.6	71	6.9	54	16.1
Germany, FR	9.3[b]	54	8.8	10	18.5
Greece	6.1	55	14.6	43	14.9
Italy	1.5	78	6.3	82	5.5
Japan	2.8	67	5.5	22	10.5
Netherlands	2.5	75	9.7	43	22.9
Poland	17.5	42	7.8	50	30.7
Composite[c]	**5.7**	**62**	**8.3**	**46**	**17.2**

[a] Derived from *UN Statistical Yearbook* data.
[b] This value refers to the whole of Germany.
[c] The composite nation (the average of the 10) has an area of 26 million hectares, of which 9.5 million hectares are under cultivation and 9.3 million hectares are forested. It had a mid-war population of 30 million.

World War II appears to have been responsible for a 38 per cent depression in agricultural production for that group as a whole (see table 3.6). Recovery from this set-back during the post-war years was essentially linear with time, progressing at an average annual rate of 8.3 per cent. As a result, the pre-war level of agricultural production was regained after an average of 4.6 years. With respect to industrial production, the post-war depression for the group averaged 54 per cent, and was thus by this criterion rather more severe than agricultural production. As with agriculture, post-war industrial recovery was essentially linear with time, but in fact, proceeded twice as rapidly, averaging 17.2 per cent per year. Indeed, the pre-war level of industrial production was regained by the group after an average of only 3.2 years. It was thus regained 1.4

years earlier than agricultural production, despite the greater initial setback. It thus appears that the restoration of war-damaged agricultural ecosystems is a slow and presumably arduous process.

Finally, war-damaged forest and other more or less natural temperate-zone ecosystems can also be expected eventually to recover their former status. Indeed, the disrupted area will be invaded by a pioneer community of plants and animals that will arrest erosional and soluble-nutrient losses (although it is unlikely to possess either the ecological or commercial value of the original stand). In time, this stage will be replaced by the first of a number of intermediate communities, a succession that over a period of decades or perhaps centuries is likely to culminate in a community that resembles the original one.

The tropics

The tropical regions of the world straddle the Equator, being situated at the lower altitudes more or less between the Tropics of Cancer and Capricorn. The three major regions are in northern South America, central Africa and south-east Asia. These hot and frequently also rainy and humid tropical lands have a combined area of roughly 42 million square kilometres and thus comprise about 28 per cent of the Earth's land surface (or about 32 per cent of those lands not permanently ice-covered) (see table 3.5). About 39 per cent of the world population lives in the tropics, that is, of the order of 1 600 million people, many of these in south Asia. Most of the 80 nations within the tropics are poor and underdeveloped, and make up a substantial fraction of the so-called Third World.

Almost four-fifths of the tropical lands are today forested. Somewhat more than half of the forest can be referred to as open or clear forest and the remainder as closed, dense or rain forest. This latter tropical rain forest—of which only about 750 million hectares remains—must be considered as one of the world's great biological resources. For the past 50 million years (that is, since Tertiary times) the tropical rain forests of the world have had the opportunity to grow, develop and evolve under benign and rather constant conditions. The outcome has been an enormously complex and efficient, albeit fragile, ecosystem. Even during the past several million years, with small numbers of ancestral and primitive man upon the scene, the added perturbations have been inconsequential or perhaps even beneficial. A number of aboriginal groups live in the tropical forests of the world to this day. It is only in the past several centuries, since the intrusion of civilized man, that this great gift of nature has been threatened. The tropical rain forest is simply no match for man equipped with chain saws, tractors, herbicides and other tools or weapons.

At first glance these tropical rain forest regions, with their biotic luxuriance, appear to stand ready to provide man with his final major terrestrial frontier: offering a supply of timber for the world market, agricultural lands to feed a growing population, and living space as well. Unfortunately, the unbelievably rich biota of the unsullied tropical rain forest is a most misleading indicator of either the robustness of the ecosystem or the potential productivity of the habitat. Major disturbance of tropical rain forest—whether by civil or military means—results in the immediate massive loss to the area of mineral nutrients. Part of this site debilitation is through soil erosion, especially in hilly terrain, but it is largely the result of nutrient dumping, that is, of the rapid loss of soluble nutrients from a soil that cannot hold them. The climatic and geomorphic stability of the humid tropical environment through tens of millions of years has simply not prepared the plants and animals—or, more specifically, the obligatorily interacting community they form—to cope with sudden and drastic changes on a large scale (upsets of a sort that the temperate-zone biota have, in fact, learned in large part to live with). The result is long-term and partly irreversible damage.

The civil assault on the tropical forests of the world is currently destroying an estimated 10 million hectares per year. It is thus a particular tragedy that certain military strategies, especially some that are most applicable to local warfare in the Third World, involve the large-scale destruction of forest lands. The Second Indo-China War provides an example. The USA was faced with a dispersed and elusive guerrilla enemy in South Viet Nam that was able to use the forest to excellent advantage for cover and sanctuary. It adopted as a major strategy the conceptually simple and straightforward expedient of eliminating the forest. A variety of mechanical and chemical means were applied from both the ground and the air, including the employment of high-explosive munitions, herbicides and large tractors. By the end of the war, of the order of 5.6 million hectares of South Vietnamese forest lands, some 54 per cent of the total, had been damaged, much of it severely. Indeed, some 600 000 hectares (5 per cent) had been totally obliterated.

In summary, destroying tracts of tropical rain forest anywhere in the world can be condoned only if the local long-term benefit of such action demonstrably outweighs the resultant long-term loss. Any unnecessary or capricious destruction must be condemned unequivocally. By destroying tropical rain forest communities one is degrading the site and destroying the irreplaceable end product of millions of years of evolution. At the same time one is eliminating the progenitors from which most present-day terrestrial plants and animals, both tropical and temperate, have evolved. Such destruction will also preclude the study of many thousands of as yet undescribed plants and animals and their ecological relationships. Moreover, the widespread destruction of the tropical rain forest may possibly result in some global climatic repercussions, presumably adverse. Finally, the destruction of tropical forest is placing in jeopardy the very existence of the remaining primitive cultural groups in the Amazon basin, equatorial Africa and south-east Asia, whose way of life depends upon this habitat.

Deserts

The desert regions of the world cover roughly 27 million square kilometres of the Earth's subarctic surface, that is, some 18 per cent of the Earth's total land area (see table 3.5). They are among the most hostile regions on Earth and are only sparsely populated with plants, animals and especially humans. Yet their locations, oil and other mineral resources or quirks of history endow some of these arid lands with enormous economic and military significance. All of the continents except for Europe contain substantial areas of desert, the single largest being the Sahara of north Africa (9 million square kilometres) and the next two being the central Australian desert and the desert occupying the Arabian peninsula. Twenty-two of the world's nations are considerably more than half covered by desert. Although the combined population of this group of nations exceeds 100 million, the number of true desert dwellers—those living a traditional nomadic existence—probably comes to less than one million.

The central environmental feature of the desert habitat is its dearth of water, the result of little rain and high evaporation, the latter caused by cloudless skies, low humidity, windy conditions (in many cases) and high daytime temperatures (in some cases). The sparse desert flora and fauna are highly specialized and unique. The desert ecosystem has a very modest biomass and low primary productivity. However, life flourishes locally in desert regions, at oases, where water is available. In the Sahara, for example, roughly 15 per cent of the overall area is in the oasis category, some 70 per cent is very sparsely vegetated and the remaining 15 per cent is barren of any vegetation. The greatest civil abuse today of the desert and semi-desert margin is over-use by livestock, which destroys the already sparse vegetation—and thus the entire ecosystem—by overgrazing and overbrowsing, trampling and soil compaction. This enlarges the barren area and also increases the number and severity of damaging duststorms, which further extends the damage.

The principal peace-time military abuse of the desert is its employment as a nuclear weapon test site. Beginning with man's first nuclear detonation, in the Sonoran Desert of New Mexico, USA, in July 1945, many hundreds of nuclear devices have been exploded under, on and above at least four major deserts on as many continents. A surface detonation blasts out a huge crater (often tens of hectares in extent) and obliterates all life over a large perijacent area (often hundreds of hectares in extent) (see table 3.1). The subsequent process of ecological (successional) recovery of such a denuded desert habitat takes many, many decades.

Desert regions have also served as theatres of war on numerous occasions from biblical times to the present. Prominent recent examples include the north African campaign of World War II and the Arab–Israeli Wars of 1948–49, 1956, 1967 and 1973. The major effect of desert battle is the destruction of vegetation and disruption of the soil surface. These are brought about by the mechanical disturbance associated with tank and other vehicular traffic, with bombing and shelling and so forth. Again, the disturbed areas give rise to a far greater number of damaging duststorms, the problem persisting for the years that it takes for the re-establishment of a soil-stabilizing vegetational cover.

In summary, the desert ecosystem is easy to disrupt and its recovery is slow. Large areas of the world's desert and semi-desert ecosystems are currently being degraded owing to agricultural over-utilization and other forms of cultural mismanagement, and the plight of the local human populations is serious. Damage to the desert brought about by military activities thus exacerbates an already adverse situation.

Arctic regions

The arctic regions of the world, far northern as well as far southern, are becoming ever more important in both economic and military terms. The resultant increasingly heavy use of these regions by man is to a great extent incompatible with their ecological fragility. Discussed below are those 24 million square kilometres of treeless land that are ice- and snow-covered (see table 3.5), either permanently (17 million) or seasonally (7 million), for reasons of either latitude (22 million) or altitude (2 million). Moreover, for some considerations, these areas could well be enlarged through the inclusion of the permanently ice-covered portions of the ocean, which amount to some 7 million square kilometres. The 24 million square kilometres of arctic lands represent 16 per cent of the total land area of the Earth. On the other hand, the 18 million or fewer permanent inhabitants of these cold regions, some fraction of them living a traditional nomadic existence, represent only a minute portion of the world population, about 0.4 per cent. Antarctica (13 million square kilometres) constitutes by far the largest single expanse of the permanently ice-covered lands, indeed, almost three-quarters of the world total. The two largest expanses of tundra (the treeless, seasonally frozen arctic regions) are found in Canada and the USSR and together represent about three-quarters of the world total of tundra.

The tundra ecosystem is characterized by a cool and brief growing season, windy conditions, rather scanty precipitation, a unique photoperiod and a so-called permafrost soil system. Its soil is frozen permanently except for a surface horizon that thaws each summer. The upper active layer is insulated by a mat of low-growing vegetation of which lichens are a prominent component. Primary productivity of this ecosystem is low, its biogeochemical cycling is sluggish, the food-chains are short and population densities of the fauna are subject to violent oscillations. Ecological recovery from disturbance is exceedingly slow. In short, the rigours of the local climate—inhospitable in summer and forbidding in winter—are a major cause of the precarious foothold that living things must contend with on arctic lands.

The strategic significance of the northern Arctic today hinges upon its location between the world's two major powers, the USSR and the USA. Polar great-circle routes provide the shortest distances between these two nations, whether by air or sea. Military facilities are located in the North American and Eurasian Arctics, serving as warning stations and first lines of defence. The tactical significance of arctic regions depends upon their inclusion within the territorial limits of a number of nations and upon their oil and other exploitable natural resources.

The establishment and maintenance of radar stations, airfields, naval bases and other military installations, as well as the carrying out of military manœuvres all involve the construction of diverse facilities and lines of communication with inevitable habitat destruction, from which it takes incredibly long to recover under arctic conditions; and the devastation associated with battle seems to remain unchanged indefinitely.

Radioactive contamination of arctic regions is almost entirely of military origin and needs to be singled out because of special problems associated with this habitat. Some fraction of this pollution has been the result of readily identifiable local testing and other incidents, but most has arrived as stratospheric fall-out usually originating from distant subarctic nuclear weapon testing. Radioactive fall-out onto arctic tundra is held especially well and long by the lichen flora that forms such an important component of the diet of caribou or reindeer, particularly in winter. Strontium-90 and caesium-137 are among the radioactive nuclides that are transferred to these animals as a result. In turn the animals constitute part of the diet of the indigenous humans, especially of Eskimos and Lapps leading traditional lives. The result of this short and pernicious food-chain has been that many of the native peoples of far northern North America and Eurasia have been subjected to body burdens of these biologically dangerous nuclides far in excess of any other populations in the world, exclusive of the residents of Hiroshima and Nagasaki of August

1945. Any future atmospheric testing or wartime use of nuclear weapons will, of course, exacerbate the dilemma of these bystanders.

To recapitulate, the harsh arctic environment places the tundra ecosystem among the most labile and slowly developing and recovering of any on Earth. Human activities, both civil and military, should thus be carried out in a manner that respects this fragility.

Islands

The oceanic islands of the world have in common a physical habitat that is undeniably finite, indeed, often severely circumscribed. The inevitable consequences of this limitation become especially pronounced on small and isolated islands. Although large numbers of islands exist, many of which are heavily populated (see table 3.3), the general focus here is on some several thousand islands with a combined area of perhaps 3 million square kilometres and a combined population of the order of 10 million (a small fraction of whom live traditional lives). It is, however, those islands that can be thought of as being relatively small, relatively isolated and relatively undisturbed that are of particular concern.

A relatively small and remote island forms an ecological microcosm that can be of considerable scientific interest. The total number of species of plants and animals on such an island is limited in comparison with a mainland of equal size. Moreover, a relatively high proportion of insular species is endemic to a single island. Interspecific competition is usually less severe on an island than on a mainland, with the result that bizarre and ill adapted forms have a higher likelihood of survival—barring, of course, alien intrusions. From these traits it becomes apparent why island biotas have played such an enormously important role in the development of theoretical biology, especially in the fields of ecology, population genetics and evolution. They also suggest the reasons for the characteristic vulnerability of island ecosystems and why the ecological damage is partly irreversible.

The major military use of islands is as a site for bases of one sort or another. Some islands are fortified and defended by the inhabitants because the islands constitute a sovereign nation (34 island nations exist) and others are fortified and defended by absentee owners because of their natural resources or other intrinsic value. Still others are defended by a non-resident nation because of their strategic location as part of the overall military posture of the foreign power. For these reasons, scores of islands throughout the world ocean have located upon them combinations of one or more army garrisons, naval bases (for both surface and submarine fleets), air bases, missile and satellite tracking stations, and military communication and intelligence gathering facilities. Needless to say, installations of this sort are likely to invite the wrath of some belligerent power in time of war.

Weapon testing and training exercises are among the major military abuses to which islands are subjected. Some islands have been employed as test or training grounds for conventional high-explosive munitions, others for testing biological warfare agents and still others for the hostile use or testing of nuclear weapons. Indeed, islands have been among the favoured locations for nuclear explosions, having provided sites for one-fourth of all such detonations to date. During the past three decades, four different nations have exploded hundreds of nuclear devices on or over at least 11 separate islands. Some of the damage from nuclear explosions results in local geomorphological modifications of an essentially permanent nature. For example, surface bursts on Bikini and Enewetak (Eniwetok) Atolls in the Marshall Islands have blasted out huge, now water-filled, craters. The much larger concentric zone in which the biota has been obliterated perijacent to the crater becomes, depending upon the local terrain, subject to massive soil erosion, from which even minimal recovery could take centuries.

Island testing has provided the opportunity to examine the medical impact of nuclear contamination. A large fission/fusion device was detonated at Bikini on 1 March 1954 that accidentally exposed more than 100 persons (23 on a fishing vessel and 89 on Rongelap Atoll) to roughly 0.2 kiloröntgen of nuclear radiation from early fall-out. Several deaths, as well as a substantial number of tumours, some of them malignant, are attributable to this exposure. Included are an especially high incidence of thyroid tumours among those who were *in utero* or youngsters at the time. The number of these cases continues to rise.

Many islands throughout the world have been the scene of combat on one or more occasions. Indeed, several islands in the Mediterranean Sea have had prominent battles fought upon them many times during the past few thousand years, among them Cyprus, Rhodes and Malta. Much of the combat in the Pacific theatre of operations during World War II occurred on islands. As a result, Tarawa in the Gilbert Islands, Iwo Jima in the Volcano Islands and more than a dozen other Pacific Ocean islands were subjected to heavy bombardment and intense combat, with concomitant high loss of life and severe habitat disruption leading to social and ecological upheaval. The war was even responsible for the extinction of a number of the indigenous insular bird species.

In conclusion, the abuse of islands is becoming an increasingly important cause for concern. Various of the factors responsible for island abuse—both civil and military—are becoming ever more pronounced, frequent or likely. Island categories can no longer be considered safe simply by virtue of numbers nor can individual islands be considered safe simply by virtue of remoteness. Substantial disruption of any island is unfortunate at least to the extent that its ecology differs from that of others. Once such an island has been substantially disrupted and a fraction of its endemic plant and animal species perhaps driven to extinction, its ecosystem has been harmed irretrievably.

The ocean

The five previous sections have covered the several terrestrial habitats of the Earth that together, however, account for only 149 million square kilometres (or 29 per cent) of the global surface. The remaining 361 million square kilometres (or 71 per cent) of the global surface is covered by ocean—the subject of the present section (see table 3.4). The world ocean—a vast, continuous body of salt water with a total volume of perhaps 1.37×10^{18} cubic metres—is distributed primarily within a number of major basins: one large (the Pacific), two medium-sized (the Atlantic and the Indian) and several lesser ones (the Arctic, and so on). Between 18 and 27 million square kilometres (or 5 to 7 per cent) of the world ocean is covered at any one time by a layer of ice.

The world-wide hydrological cycle plays an indispensable role in the global ecosystem, its series of pathways serving to link all the local ecosystems on Earth. The ocean is the great reservoir for this cycle, representing over 97 per cent of the entire world supply of water (and more than 99 per cent of the world supply of unfrozen water). It is thus crucially involved in the global water balance and thereby in global mineral nutrient cycling and in global climate.

The ocean provides suitable niches for an amazing diversity of living things, plant and animal, large and small, sessile and mobile. Taxonomic diversity is substantially greater in the ocean than on land. Although some life can be found in almost any area of the ocean and at any depth, most by far of the marine biomass is within the shallow regions that overlie the continental shelves or is in the vicinity of islands, that is, within about 10 per cent of the ocean in terms of surface area. Some ocean habitats are highly productive. These include certain close-inshore areas endowed with a continuing supply of nutrients from terrestrial run-off (such littoral zones as estuaries and mangrove swamps) as well as regions of upwelling, where sunken nutrients are brought up from the lower reaches of the ocean. Continental-shelf waters are about twice as productive as the open ocean, regions of upwelling about 5 to 10 times as productive, and estuaries and mangrove swamps about 10 to 20 times as productive. Estuaries and mangrove swamps are further important because at least three-quarters of all species of marine fishes require this inshore habitat during at least one critical stage in their life cycle.

The military use of the ocean is growing rapidly in importance and complexity. It can be either defensive or offensive, either in territorial waters or on the high seas, either on the surface or below it. Military use of the ocean by a nation is generally in support of its direct terrestrial interests, although an increasing fraction is in support of its direct ocean interests. The navies of the world—some 50 of them—together maintain on the high seas almost 2 500 fighting ships, with the fleets of the USA and the USSR dwarfing all of the others.

A number of military abuses of the ocean are comparable to civil ones and even merge into them, whereas others are more readily separable from the civil ones. To begin with, some fraction (perhaps 6 per cent) of the pollutants that are continually introduced into the ocean via stream flow and atmospheric fall-out has its origin in munition factories and other military facilities and activities of all sorts. A rather specialized military abuse of the ocean ecosystem can be noted by way of contrast, that of employing marine mammals for military purposes. Although very little is known about some aspects of such naval operations, it has been suggested that dolphins and sea-lions are being trained for various underwater missions, among them the suicidal one of delivering warheads.

Underwater explosions associated with military activities can occur: (*a*) in conjunction with undersea warfare and other hostile actions; (*b*) during military training exercises; (*c*) when sea-mines are set off by unintentional and other civil actions; and (*d*) when unwanted explosive munitions are disposed of at sea. The actual dimensions of the lethal zone of an underwater explosion are determined by the size of the charge in conjunction with several other factors. The explosion of a typical (100-kg) depth-charge could be expected to be lethal to most marine animals within a radius of 77 metres and thus within an area of about 2 hectares and a volume of about 2 million cubic metres. For fish possessing air-bladders, that is, for most fish, these values would have to be multiplied by 4, 16 and 64, respectively: a radius of 310 metres, an area of 30 hectares and a volume of 120 million cubic metres.

Radioactive contamination of the ocean associated with military activities occurs as a result of: (*a*) nuclear weapon manufacture; (*b*) nuclear weapon testing and training exercises; (*c*) the hostile use of nuclear weapons; (*d*) routine emissions from nuclear-powered naval vessels; (*e*) the accidental or intentional destruction of nuclear-powered ships and military satellites; and (*f*) accidental introductions of all sorts. Indeed, almost all of the present global burden of radioactive pollution is of military origin. Of the various sources of such contamination to date, nuclear weapon testing has been by far the worst offender. The USA, the USSR and several other nations have during the past three decades detonated six nuclear devices beneath the surface of the ocean, 35 on its surface and several hundred in the atmosphere above it.

The potential for massive radioactive releases associated with the intentional destruction during wartime of enemy nuclear-powered ships, both military and civil, is a cause for serious concern. There exist today some 259 nuclear-powered submarines, seven such cruisers and five such merchant vessels. A nuclear-powered submarine might have a 35-MW(th) reactor and a nuclear-powered cruiser one of 140 MW(th). Their reactors would thus be producing about 22 g and 90 g, respectively, of mixed fission products during each day of operation. The short-lived component of this conglomerate decays almost as fast as it is being produced, whereas the long-lived component builds up in almost direct proportion to the number of days of operation. Thus, if a nuclear-powered submarine at sea were to be destroyed, it could at essentially any time release just over 22 g of mixed fission products (disintegrating, after 100 days, at the rate of about 15 kilocuries). These fission products, composed primarily of short-lived isotopes, are equivalent in amount to the release of a 0.38-kt atomic bomb. The long-lived component, on the other hand, would be derived from an additional 670 g of original fission products for every month at sea. As a result, after about 50 days of operation they would build up to the equivalent of what a 18-kt atomic bomb would release.

The ocean can be contaminated with oil as the result of military activities in at least two ways: (*a*) oil tankers can be sunk by hostile actions; and (*b*) offshore oil facilities can be similarly destroyed. More than 5 000 oil tankers are currently plying the high seas. Together they transport about 1.5×10^9 cubic metres per year of oil across the ocean, that is, roughly half of annual world production. At least 32 of the tankers have capacities in excess of 400 000 cubic metres, of which seven exceed 500 000 cubic metres. In time of war, enemy oil tankers could become prime naval targets of opportunity, owing to the crucial importance of this commodity to the functioning of most sorts of sustained military effort. (Other bulk carriers carrying ecologically dangerous cargoes are coming into ever greater use and could be similarly destroyed.)

A massive oil spill of the sort that might result from the sinking of an enemy oil tanker could have a dramatic local ecological impact, especially if it occurred along the coast or in some other biotically rich area and all the more so if the area were partially isolated from the main body of the ocean. One of the most immediately obvious effects of such a spill is marine bird mortality. Commercial finfish and shellfish present in the area become "tainted" and unusable. Substantial ecological recovery of a locally oil-decimated area takes of the order of several years, perhaps as many as six. Moreover, it has been suggested with sufficient authority to provide cause for concern that a major oil spill in the Arctic Ocean could conceivably initiate a chain of events leading to extensive ice melting of long duration. Such an occurrence would, in turn, modify global albedo, perhaps sufficiently to alter the global climate.

Military activities can damage inshore ocean habitats in various ways. For example, the mangrove habitat in South Viet Nam suffered especially heavy damage during the Second Indo-China War. An estimated 124 000 hectares of true mangrove (41 per cent of that entire subtype) plus another 27 000 hectares of rear (back) mangrove (13 per cent of that subtype) were subjected to military herbicide spraying. The result was virtual annihilation of the vegetation and severe coastal erosion. There resulted significant decreases in the number and variety of planktonic and benthic forms (diatoms, copepods, and so on) as well as in fish eggs and in molluscs. Moreover, declines in the offshore fishery, involving both finfish and shellfish, could be attributed to the disruption of these breeding and nursery grounds. It is expected that substantial habitat recovery will take a century or more.

In summary, the world ocean is an inextricable and indispensable component of the global system of nature or world ecosystem. It is, moreover, an essential and increasingly important source of both living and non-living natural resources for man. Besides, the ocean is also the immediate or ultimate sump for most of man's wastes—wastes that continue to grow in both quantity and complexity. Despite the immensity and ecological resilience of the world ocean, there is a growing concern that it is being abused to a degree that is approaching the point where natural self-renewal will not be able to offset the anthropogenic insults. Military sources represent a significant component of ocean abuse. In time of war, this military component could reach catastrophic proportions as a result of massive oil contamination of inshore waters through the destruction of supertankers and especially as a result of radioactive contamination through the destruction of nuclear-powered ships and in other ways.

IV. Conclusions

The human environment is both immense and resilient. Nevertheless, the human population continues to increase and man's attack on the environment becomes ever more varied and intense. The result is that the natural global processes of environmental renewal will soon not be able to keep up with this growing human onslaught. Indeed, this point has already been passed in any number of local habitats. It should thus be obvious that in the long run it is in man's own interest to protect his already much abused environment. It is from this environment that the human race ultimately—and in many instances, rather more immediately—derives its sustenance. Moreover, this environment is also the source of a host of more or less crucial economic and cultural amenities, not least of which are the aesthetic and spiritual ones.

Military activities make up a relatively small, although significant, fraction of all human activities and therefore contribute their share to the global burden of environmental abuse. This occurs during both peace and war and is in many instances qualitatively indistinguishable from the civil fraction, but, of course, adds to it. Especially in time of war, however, the military abuses have the potential of reaching very substantial, not to say spectacular, proportions. Indeed, experience, particularly from the Second Indo-China War, suggests that hostile environmental disruption, both incidental and intentional, has in fact already become a significant component of modern warfare.

Hostile environmental disruption is open to *a priori* criticism since its effect, although more or less subtle, is unavoidably indiscriminate, uncontainable and long-lasting. The impact is thus felt not only by the enemy military forces, but probably by the civil sector also, by third parties and by future generations. Moreover, all living things on Earth deserve at least some measure of respect and protection in their own right. Humans must think of themselves less as owners of the land and lords of the birds and beasts, and more as temporary residents and guardians of the land and what it supports. A concern over ecological consequences of war does not preclude the direct traditional anthropocentric concerns. It may, in fact, enhance such concerns via a civilizing influence and also perhaps by awakening a new constituency to war-related concerns. That is to say, a respect for the environment should reinforce the incentive to attain a disarmed world.

References

1. *Ecological Consequences of the Second Indochina War* (Almqvist & Wiksell, Stockholm, 1976, Stockholm International Peace Research Institute).
   (a) —, chapter 4, pp. 46–50.
   (b) —, chapter 3, pp. 24–45.
2. *Weapons of Mass Destruction and the Environment* (Taylor & Francis, London, 1977, Stockholm International Peace Research Institute).
   (a) —, p. 17.
   (b) —, p. 16.
3. *Warfare and the Human Environment* (Taylor & Francis, London, Stockholm International Peace Research Institute), in preparation.
4. "Environmental and Ecological Warfare", in *World Armaments and Disarmament, SIPRI Yearbook 1976* (Almqvist & Wiksell, Stockholm, 1976, Stockholm International Peace Research Institute), chapter 4, pp. 72–101.

5. "Dioxin: A Potential Chemical Warfare Agent" in *World Armaments and Disarmament, SIPRI Yearbook 1977* (Almqvist & Wiksell, Stockholm, 1977, Stockholm International Peace Research Institute), chapter 4, pp. 86–102.
6. *Environmental Weapons* (Taylor & Francis, London, Stockholm International Peace Research Institute), in preparation.
7. *The Dangers to Man and his Environment Inherent in Modern Armaments and Techniques of Warfare: An Introduction and Descriptive/Annotated Bibliography* (UNESCO, Paris), in press.
8. *World Military Expenditures and Arms Transfers 1966–1975*, Publication No. 90 (US Arms Control and Disarmament Agency, Washington, 1976), table II, pp. 19–55.

4. Military satellites

Square-bracketed numbers, thus [1], *refer to the list of references on page 103.*

I. Introduction

Two decades ago, on 4 October 1957, the first artificial Earth satellite was launched. Ten years later, in October 1967, the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space (Outer Space Treaty) came into force. It was hoped that the treaty would establish outer space as a zone of peace, but in fact, it was then too late; outer space was already being exploited for military uses. Since then the treaty has done nothing to check the proliferation of US, Soviet and other countries' military satellites in Earth orbit; some 75 per cent of the total number of satellites launched by the end of 1977 were military-oriented.

A great variety of satellites are being used by members of the military space club—that is, China, France, NATO, the United Kingdom, the United States and the Soviet Union. Their types range from reconnaissance, navigation, tactical and strategic communications, geodetic, early-warning and meteorological, to the satellite interceptor/destructor system that has probably been tested by the Soviet Union [1]. Methods for "killing" satellites are increasingly being investigated by the United States.

This chapter first discusses the reconnaissance satellites which the USA and the USSR continue to launch to observe each other's territories, to check their compliance with the provisions of the SALT (Strategic Arms Limitation Talks) agreements. In addition, these satellites are used by both sides to observe other countries. It appears that these reconnaissance satellites may have had a role in the discovery in 1977 of possible South African preparations for a nuclear test, and as such, may illustrate another positive aspect of space technology. The South African nuclear programme and the evidence for the reports of such nuclear preparations are described in section II.

Another useful function of reconnaissance satellites is that of monitoring developments in the space programmes of various countries. Here the particular example given is that of the US and Soviet satellites which appear to have monitored an area in Zaire being used by FR Germany as a rocket test and launch site. The significance of this is discussed more fully in section III.

But more sinister developments in space technology can also be discerned. Among other things, the USA is working on exotic kill mechanisms which would use an ion-beam to encourage the build-up of static electricity on an enemy satellite, causing damage to it by arcing [2].[1]

Other weapons, such as high-energy lasers and charged particle beam systems, are also being seriously considered. Placing such weapons in orbit will become practicable once the Space Shuttle system becomes operational. It has been suggested that the Soviet Union is developing a re-usable Space Shuttle system, but no details of this are available. Section IV briefly describes the US Space Shuttle system and discusses its potential military uses as a typical example of man's relentless drive towards the increasingly effective militarization of space.

Finally, the tables of all the military-oriented satellites launched in 1977 are given in section VI.

II. The possible prevention of a South African nuclear test

Before considering whether reconnaissance satellites were used to detect preparations for a possible nuclear test by South Africa, it may be useful to determine the extent of South Africa's nuclear capabilities.

A nuclear explosive requires relatively pure forms of either uranium-233, uranium-235 or plutonium-239. Uranium-233 and plutonium-239 do not exist in nature and must therefore be produced artificially in nuclear reactors. Naturally occurring uranium contains 0.711 per cent by weight of fissile uranium-235. Theoretically it is possible to make a nuclear weapon which uses as small a concentration of uranium-235 as 10 per cent. In practice, however, the uranium for a nuclear weapon is enriched to at least 50 per cent and it is generally assumed that the fissile material used by the nuclear weapon powers in their uranium weapons contains uranium enriched to at least 90 per cent. If, therefore, South Africa was indeed preparing to test a nuclear device in the Kalahari Desert, what type of nuclear device was it and how could South Africa have obtained the required fissile material? To answer these questions, one may consider South Africa's nuclear programme.

South Africa's nuclear programme

The South African Atomic Energy Board (AEB) was formed in 1949, and is responsible for research activities in such fields as chemistry, extraction

[1] In principle, such a technique is feasible, since many satellites in synchronous orbits have, in fact, been affected by electrostatic charges that build up as a result of higher electron density around the dark side of the Earth.

The US Air Force (USAF) is planning to send up a satellite called Scatha (Spacecraft Charging At High Altitude) in early 1979 into a synchronous orbit. The purpose of this satellite is to show that the charge built up on the outer surface of a satellite can be neutralized by a beam of opposite charge generated from an ion gun [2]. During this experiment, charge will be built up on to the structure of the satellite to measure its response.

metallurgy, isotopes and radiation, physical metallurgy, physics and reactor development. In fact, South Africa has two research reactors. One, the Safari-1, designed by a US firm, has been in operation since 1964 at the National Nuclear Research Centre at Pelindaba, near Pretoria. It is a light water-moderated reactor which uses highly enriched uranium (about 90 per cent uranium-235) supplied by the USA. After operating for three years at a 6-MW(th) output, the reactor was converted to operate at 20 MW(th). The second research reactor, Pelinduna Zero, is also located at Pelindaba. The reactor, designed and built by the AEB, uses slightly enriched uranium (2 per cent uranium-235) and has a negligible power output. The construction of the reactor started at the end of 1966, and it became critical a year later.

In August 1976, a contract for the construction of the Koeberg power station, situated some 30 km north of Cape Town, was signed by the South African Electricity Supply Commission (ESCOM) and a French consortium [3]. The power station will have two pressurized water reactor units each with an electrical output of 922 MW(e). The first unit will be commissioned at the end of 1982 and the second a year later.

It is clear that South Africa could not have obtained plutonium from any of the above research reactors. Safari-1 uses highly enriched uranium (about 93 per cent enriched uranium supplied by the USA initially, and again in 1974–75) and is therefore not very suitable for plutonium production. In any case, spent fuel from the reactor is sent either to the USA or to the UK for reprocessing under International Atomic Energy Agency (IAEA) supervision. It must be noted here that if low enrichment uranium is used in the reactor, it is possible to produce some two kilograms per year of plutonium from the reactor. The Pelinduna Zero reactor produces no plutonium. Since, in addition, the new power reactors have yet to be built, the most likely fissile material for a possible nuclear test seems to be enriched uranium.

South Africa has the third largest deposits of uranium in the world (see table 4.1), and is the third largest producer (2 700 tonnes/year) [4]. The existence of radioactivity in gold ores was known as long ago as 1915 but the mineral was not identified as a variety of uranite until 1923. The first plant to extract uranium oxide (U_3O_8) from gold ore began production in 1952.

With the availability of uranium, the easiest way for South Africa to acquire a nuclear weapon capability would be by uranium enrichment. The development of an enrichment facility would not only give South Africa the required fissile material for a nuclear explosive, but it would also make the country independent of overseas sources of nuclear fuel for its future power reactors, as well as opening up an opportunity for a sizeable share in the enriched uranium supply business. It is therefore no

Table 4.1. South African uranium resources, nuclear reactors and enrichment facilities

	Uranium resources	
	Tonnes of U at $15/lb	*Tonnes of U at $15–30/lb*
Reasonably assured resources	186 000	90 000
Estimated additional resources	6 000	68 000

	Research reactors	Power reactors
Name and location	Power output and date of criticality	Power output and date of criticality
Safari 1 Pelindaba	20 MW(th): 1964	–
Pelunduna Zero Pelindaba	Negligible power output; 1967	–
Koeberg Power Station ~30 km north of Cape Town	–	Two 922-MW(e) units; 1982

	Enrichment facilities	
Name and location	Capacity: *mn SWU/year*	In operation
UCOR Valindaba	0.006	Pilot plant in operation in 1970
UCOR Valindaba	5	Planned to operate by 1986–87

Sources: On uranium resources, see reference [4].
On enrichment facilities, see references [6, 21].

coincidence that South Africa has been interested in enrichment technologies for some time, and indeed has been investigating enrichment processes since around 1968, about the same time as the emergence of the West German jet nozzle process and the vortex tube process patented by a US firm [5].

In August 1970 South Africa announced that it had perfected a "new and unique process" which would enrich uranium at a much lower cost than existing techniques, and in October of that year it was confirmed that the Valindaba plant was operational. The method used to enrich uranium is similar to that used in the West German jet nozzle process, in that it is based on the principle that a stream of atoms of different masses travelling in a curved path will be affected by different centrifugal forces and will therefore be separated. It differs from the West German method in the technology of producing the required centrifugal force. According to the chairman of both the AEB and the South African Uranium Enrichment

Corporation (UCOR), Dr A. J. A. Roux, the South African process is related to the West German, but is derived more from development of the so-called US vortex tube concept, in which centrifugal force in a gas stream is obtained by making it swirl aerodynamically in a fixed tube.

Recently, South Africa has indicated its willingness to build a large-scale commercial enrichment plant on an international collaboration basis [6].

With such an advanced nuclear programme, it is not surprising that many have speculated that South Africa was within two to four years of acquiring a nuclear bomb.

Observation of a possible South African nuclear test

Speculations seemed to have become a reality when it was reported that, on 6 August 1977, the Soviet Union had informed the United States that South Africa was in fact secretly preparing to detonate an atomic explosion in the Kalahari Desert. France, FR Germany and the UK were similarly informed. After considerable diplomatic activity, it was announced that South Africa had promised that "no nuclear explosive test will be taken . . . now or in the future" [7].

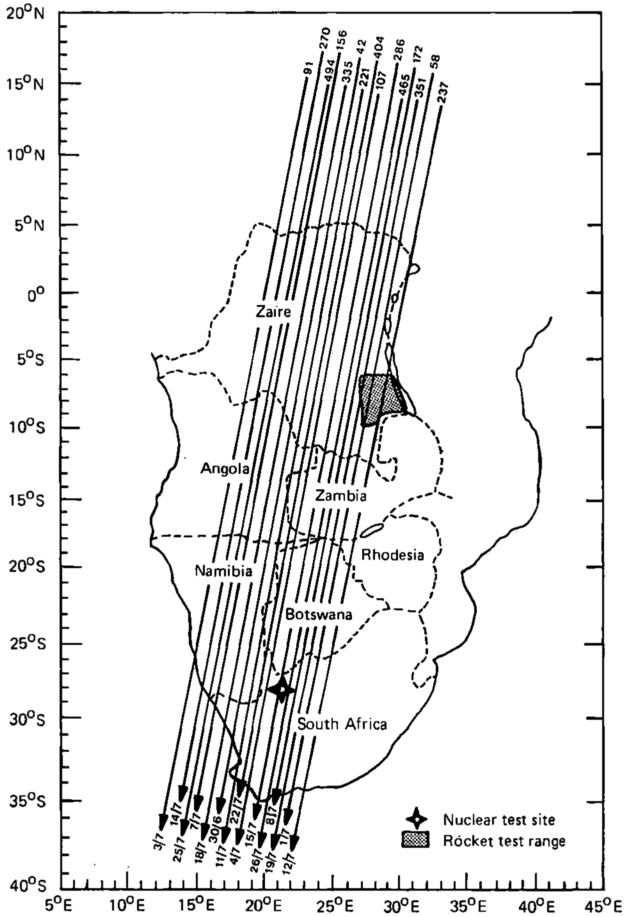
Incidentally, with regard to the South African "promises", the Finance Minister, Owen Horwood, said on 30 August 1977 that the South African government reserved the right to depart from its assurances that its nuclear programme was for peaceful purposes only. Subsequently, even Prime Minister Vorster stated: "I am not aware of any promise that I gave . . . I repeated a statement which I have made very often that, as far as South Africa is concerned, we are only interested in peaceful development of nuclear facilities".

Although the Soviet Union did not disclose the source of its information, it is very likely that reconnaissance satellites were involved. It can be seen from tables 4.6 and 4.12 (see section VI, below) that both the USA and the USSR launched a number of photographic reconnaissance satellites during 1977. It is difficult to ascertain which particular satellites were used to observe the possible South African nuclear test site since it is not known when such observations were carried out. However, the behaviour during July and August of three satellites—one US Big Bird, and two Soviet Cosmos—was analysed by computing their ground tracks.[2]

The Big Bird satellite (1977-56) was launched from the Vandenberg Air Force Base or the Western Test Range (WTR) on 27 June 1977. Figure 4.1 shows the ground tracks made by the satellite during the day through the month of July 1977. It can be seen that the satellite made four passes over

[2] The ground track is defined as the projected path traced out by a satellite over the surface of the Earth.

Figure 4.1. Ground tracks of the US 1977-56A Big Bird satellite over South Africa and Zaire, July 1977[a]



[a] The date and orbit number are indicated for each ground track.

the presumed nuclear test site region on 4, 8, 15 and 26 July 1977. Analysis of the cloud cover over the region when the satellite made these passes showed that the sky was mainly either free of cloud or only lightly clouded (see table 4.2). Moreover, the satellite was launched in a Sun-synchronous orbit at an inclination of 97°. This meant that the satellite passed over the test site at the same time each day, so that any photograph taken would refer to the same local time and changes in activity in the region would be comparable. It is possible, therefore, that the USA already had some knowledge of the activities in the Kalahari Desert.

Figure 4.2 shows the ground tracks made by the Big Bird during August 1977. Again only the ground tracks made during the day are shown in the

Table 4.2. Cloud coverage over South Africa when the US and Soviet reconnaissance satellites passed over the possible nuclear test site

Date	Time *GMT*	Regions: Latitude	Regions: Longitude	Total cloud *oaktas*[a]	Low cloud: Amount *oaktas*[a]	Low cloud: Height *m*
3 Jul 1977	06	28° 24′ S	21° 16′ E	3	–	1 500
		30° 21′ S	21° 41′ E	2	–	1 500
4 Jul 1977	06	26° 28′ S	20° 37′ E	2	–	
		30° 21′ S	21° 41′ E	2	–	
15 Jul 1977	00	26° 32′ S	18° 07′ E	–		
		28° 24′ S	21° 16′ E	–		
	06	26° 32′ S	18° 07′ E	–		
		28° 24′ S	21° 16′ E	–		
		26° 28′ S	20° 37′ E	–		
		29° 08′ S	19° 23′ E	–		
		29° 40′ S	22° 45′ E	–		
		24° 01′ S	21° 53′ E	–		
21 Jul 1977	06	26° 32′ S	18° 07′ E	–		
		28° 24′ S	21° 16′ E	–		
		26° 28′ S	20° 37′ E	–		
		29° 08′ S	19° 23′ E	–		
		29° 36′ S	17° 52′ E	–		
		29° 40′ S	22° 45′ E	–		
		30° 21′ S	21° 41′ E	–		
		24° 01′ S	21° 53′ E	–		
		26° 03′ S	22° 27′ E	–		
22 Jul 1977	06	26° 32′ S	18° 07′ E	1	–	
		28° 24′ S	21° 16′ E	–		
		29° 08′ S	19° 23′ E	–		
		29° 40′ S	22° 45′ E	–		
		30° 21′ S	21° 41′ E	–		
		24° 01′ S	21° 53′ E	–		
		30° 21′ S	21° 41′ E	–		
26 Jul 1977	06	26° 28′ S	20° 37′ E	–		
		29° 08′ S	19° 23′ E	5	5	1 000
		29° 36′ S	17° 52′ E	8	8	600
		29° 40′ S	22° 45′ E	–		
		24° 01′ S	21° 53′ E	–		
		30° 21′ S	21° 41′ E	2	2	1 000
30 Jul 1977	06	30° 21′ S	21° 41′ E	–		
		24° 01′ S	21° 53′ E	–		
		26° 03′ S	22° 27′ E	–		
		29° 40′ S	22° 45′ E	–		
		26° 28′ S	20° 37′ E	–		
		29° 08′ S	19° 23′ E	Fog (sky obscured)		
		26° 32′ S	18° 07′ E	4	3	300
30 Jul 1977	12	28° 32′ S	18° 07′ E	–		
		28° 24′ S	21° 16′ E	1	–	
		30° 21′ S	21° 41′ E	–		
		26° 03′ S	22° 27′ E	1	–	
		29° 36′ S	17° 52′ E	–		
		29° 40′ S	22° 45′ E	–		
		26° 28′ S	20° 37′ E	–		

Date	Time GMT	Regions Latitude	Longitude	Total cloud oaktas[a]	Low cloud Amount oaktas[a]	Height m
2 Aug 1977	06	26° 32′ S	18° 07′ E	-		
		28° 24′ S	21° 16′ E	-		
		29° 36′ S	17° 52′ E	-		
		29° 40′ S	22° 45′ E	1	1	600
		26° 28′ S	20° 37′ E	-		
		29° 08′ S	19° 23′ E	-		
		30° 21′ S	21° 41′ E	1	-	
6 Aug 1977	06	26° 32′ S	18° 07′ E	-		
		28° 24′ S	21° 16′ E	-		
		30° 21′ S	21° 41′ E	1	-	
		26° 28′ S	20° 37′ E	-		
		29° 08′ S	19° 23′ E	-		
		29° 36′ S	17° 52′ E	-		
	12	26° 32′ S	18° 07′ E	-		
		30° 21′ S	21° 41′ E	-		
		26° 28′ S	20° 37′ E	-		
		29° 08′ S	19° 29′ E	-		
		29° 36′ S	17° 52′ E	-		
		29° 40′ S	22° 45′ E	-		
		26° 03′ S	22° 27′ E	-		
13 Aug 1977	06	26° 32′ S	18° 07′ E	7	7	600
		28° 24′ S	21° 16′ E	2	1	1 500
		29° 40′ S	22° 45′ E	6	5	600
		30° 21′ S	21° 41′ E	1	-	
		29° 36′ S	17° 52′ E	1	1	600
		24° 01′ S	21° 53′ E	8	6	600

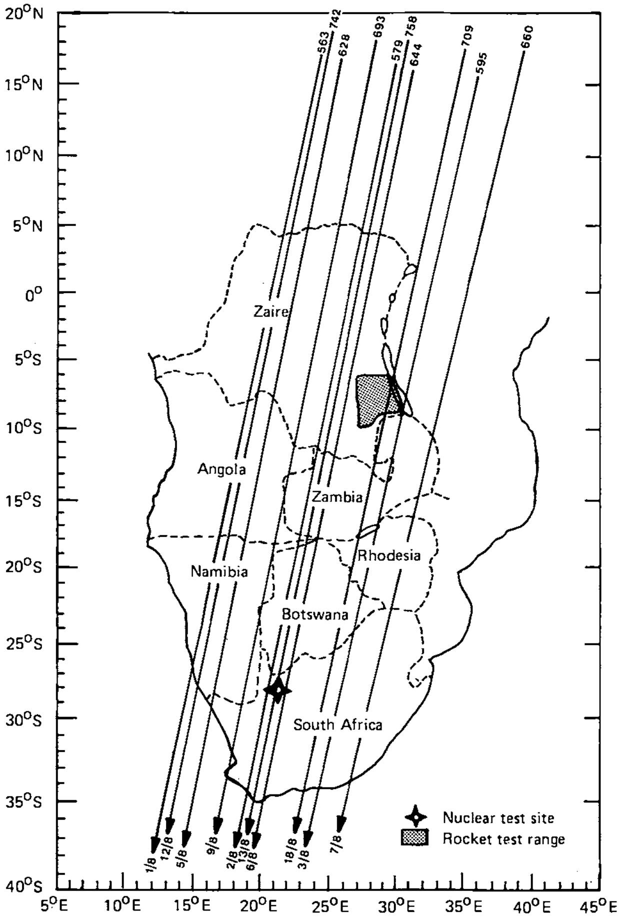
[a] Unit used to measure the cloud cover. One oaktas is equivalent to one-eighth of the sky covered with cloud.

Source: Based on information supplied by the British Meteorological Office.

figure. It is usually difficult to know when a Big Bird satellite manœuvres specially to observe a particular region on the Earth, since the satellite is periodically manœuvred to prolong its lifetime. However, a close examination of the mean motion (that is, revolutions per day) of the satellite given in the orbital elements (published by the National Aeronautics and Space Administration [NASA]) can indicate when manœuvres over and above the normal ones are made. Such an analysis showed that the Big Bird was manœuvred just before its first pass in August (figure 4.2) over the nuclear test site. The satellite subsequently made three passes over the test area on 2, 6 and 13 August. On 6 August the USA was informed by the Soviet Union of its findings so that the USA may have checked the test area on 13 August. Again a study of the weather shows that the sky over the area was mostly cloud-free during this period (see table 4.2).

The ground tracks shown in the two figures are those which correspond to the times when the inclination of the Sun was between 20° and 25°, that is, the time of day at which objects in the desert would cast long shadows, thus facilitating the interpretation of the photographs. Objects

Figure 4.2. Ground tracks of the US 1977-56A Big Bird satellite over South Africa and Zaire, August 1977[a]

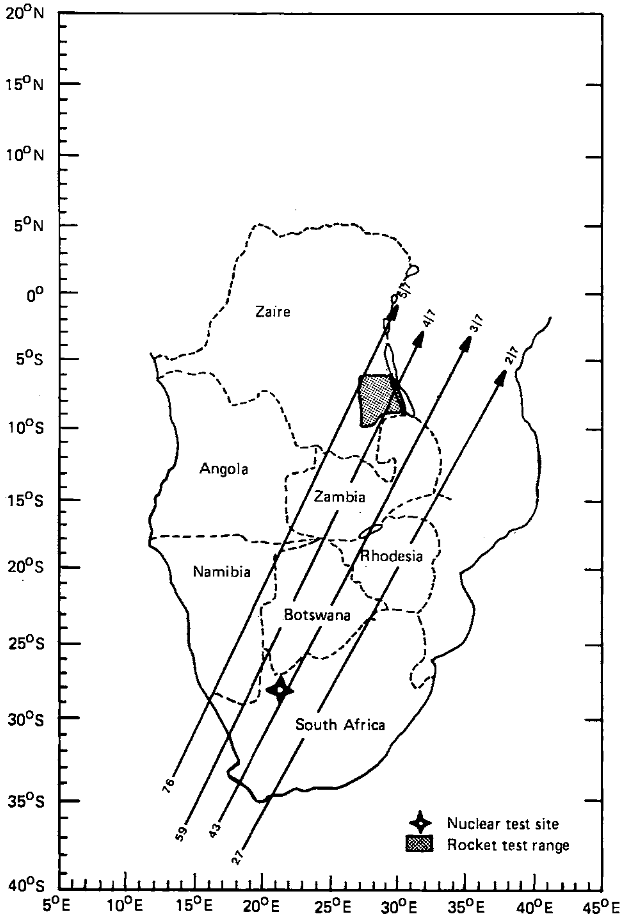


[a] The date and orbit number are indicated for each ground track.

such as a drilling rig used to make a hole in the ground for placing a nuclear charge underground would be easily recognized.

Cosmos 922 was launched from Plesetsk at an orbital inclination of 63° on 30 June 1977. The satellite was an area-surveillance type. The ground tracks of the satellite over South Africa are shown in figure 4.3. It can be seen that the satellite made two passes over the nuclear test site on 3 and 4 July. It is possible that this satellite first detected South Africa's preparations for a nuclear explosion. Table 4.2 shows that the sky was virtually cloud-free. The satellite was in orbit for 13 days. A week after its recovery, another Cosmos, Cosmos 932, was launched from Plesetsk at a 63° inclination on 20 July. This was a manœuvrable close-look type satellite. The ground tracks for this satellite are shown in figure 4.4. On 22 July,

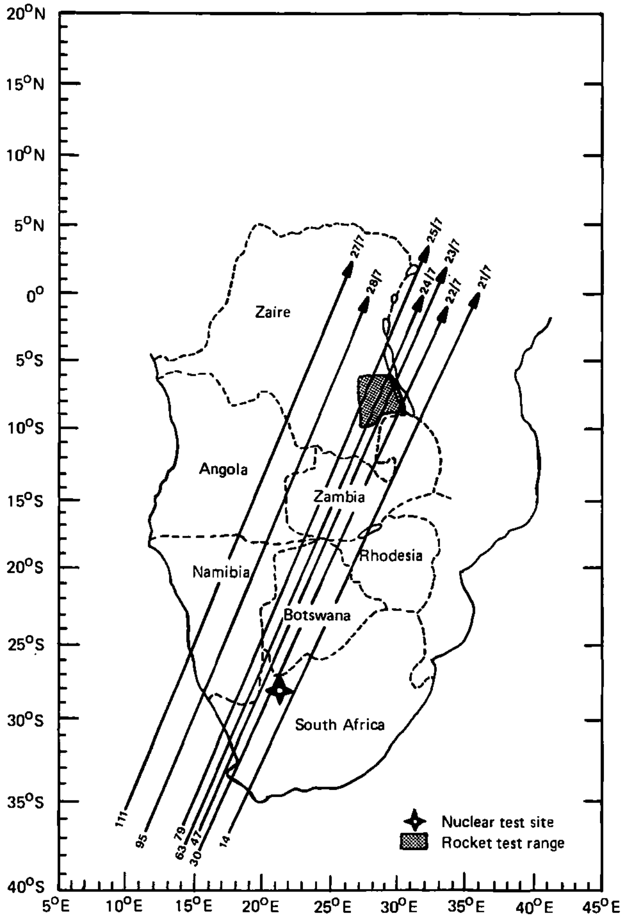
Figure 4.3. Ground tracks of the Soviet Cosmos 922 satellite over South Africa and Zaire, July 1977[a]



[a] The date and orbit number are indicated for each ground track.

during the 27th revolution, the satellite was manœuvred and its perigee lowered just before passing over the test area for the first time. This gave four good passes over the test site between 21 and 24 July. Just before the last of these four passes during the 75th revolution, the apogee of the satellite was raised. This manœuvre enabled the satellite to preserve its 13-day mission [8]. Again the weather conditions were such that the sky was practically free of clouds (see table 4.2), and this satellite too passed over the region when the Sun was low in the sky. Cosmos 932 was recovered on 2 August, which presumably gave the Soviet experts time to analyse the material and to inform the USA on 6 August. It may be speculated here that the time taken for analysis of the photographs could not have taken four days since most of this time was probably taken up in deciding how

Figure 4.4. Ground tracks of the Soviet Cosmos 932 satellite over South Africa and Zaire, July 1977[a]



[a] The date and orbit number are indicated for each ground track.

and when the West should be informed about the Cosmos findings. This indicates that the reaction time can be extremely short, particularly if the satellite data are transmitted by radio to the ground station.

If South Africa were about to test a nuclear device, then indeed, the timely detection of the preparations for such a test by reconnaissance satellites has, at least temporarily, halted the test. This can only be described as a positive aspect of reconnaissance satellite activities.

III. Observation of the West German test site in Zaire

The possible South African nuclear test was not the only event being observed by these US and Soviet satellites. Figures 4.1 to 4.4 show that during the period, all three satellites passed over Shaba, in the south-eastern region of the Republic of Zaire, when the Sun's inclination was at least 50° and the sky practically cloud-free.

This area has been of particular interest recently because of the launch in May 1977 of the first rocket from African soil for about a decade. (Between 13 February 1959 and 1 July 1967, France launched a number of rockets and satellites from its Sahara Test Centre in Algeria.)

In 1976, Orbital Transport-Und Raketen-Aktiengesellschaft (OTRAG), a West German firm, signed with the West German government an agreement to establish a rocket test and launch site. OTRAG has rented an area of about 100 000 square kilometres, an area one-tenth the total area of Zaire or about one-half the total area of FR Germany [9]. It is planned that by 1981, reconnaissance, Earth Resources and communications (in synchronous orbits) satellites will be launched from this site.

The rocket launched in 1977 was obviously part of a longer-term project eventually to launch satellites. OTRAG has so far spent some $30 million on the development of this rocket, which is based on a building-block system. The basic model consists of a relatively small tank and an engine. A number of such modules will eventually be combined to form a larger vehicle. The cost of the rocket system is kept low by using as many mass-produced and off-the-shelf components as possible.

This development is particularly interesting in that it points to the probability of satellite technology becoming increasingly available to many more countries than hitherto. The West German system is relatively cheap and will therefore be an attractive alternative for launching observation and communications satellites.

However, once a country can launch a satellite, it has also developed the potential for having missiles. The present members of the military space club developed their missiles first, which were then used to launch their military satellites. Could it be that this trend is now being reversed? If there is a connection between the peaceful applications of space and military potentials, then it may be useful to know which countries with peaceful civilian space programmes have developed the capability to launch their own satellites. The status of the peaceful space programmes of all the countries outside the military space club is shown in table 4.3. It can be seen that a total of 76 satellites were launched by or on behalf of the countries listed. By the end of December 1977, a total of 1 957 satellites were launched world-wide, and of these, some 1 480 were military-oriented satellites belonging to members of the military space club. This means that some 15 per cent of all the civilian satellites launched belonged to the non-space club countries listed in the table. This number will no doubt grow once cheap rockets become available.

Following this discussion of the less debatable "watchdog" role of some

Table 4.3. National and international civilian satellites launched during 1962–77

Country or organization	Launching country	Number	Type	First successful launch	Comments
Australia	Australia/ USA	2	Scientific; amateur communications satellite, Oscar-5	29 Nov 1967	Only one satellite launched by Australia; a series of sounding rockets have been launched
Canada	USA	8	Scientific and communications	29 Sep 1962	Has a sounding rocket launching facility
ELDO[a]	UK	–	–	–	11 attempts to launch satellites were made using Blue Streak but all were unsuccessful; first attempted 5 Jun 1964
ESRO[b]	USA	8	Scientific		Extensive sounding rocket programme
ESA[c]	USA	2	Scientific	9 Aug 1975	
ESA[c]/Canada	USA	2	Communications, meteorological	17 Jan 1977	
FR Germany	USA	5	Scientific	8 Nov 1969	FR Germany participating in the production of several satellites in co-operation with other countries; has acquired a launch range in Zaire and developing own rockets
FR Germany/ France	France	3	Scientific and communications	10 Mar 1970	
Italy	USA	10	Scientific and communications	15 Dec 1964	
Japan	Japan	11	Scientific	11 Feb 1970	Includes the first synchronous satellite launched on 23 Feb 1977
Japan/USA	USA	1	Meteorological	14 Jul 1976	Synchronous satellite launched by the USA
India	USSR	1	Communications	19 Apr 1975	Sounding rockets launched
Netherlands	USA	1	Scientific	30 Aug 1974	
Spain	USA	1	Scientific	15 Nov 1974	
WTO countries	USSR	21	Scientific	19 Dec 1968	

[a] European Launcher Development Organization.
[b] European Space Research Organization.
[c] European Space Agency.

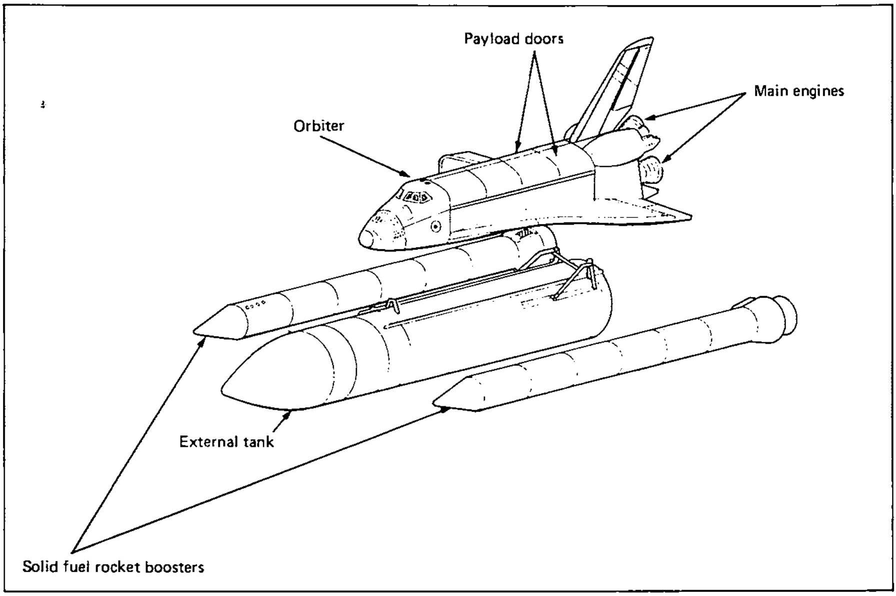
satellites, it may be pointed out that some recent developments in the technology are a reminder of more negative trends in space technology. The year 1977 has seen the beginnings of tests of the Space Shuttle system, which development will now be discussed.

IV. The Space Shuttle system

In the past, satellites and deep space probes have been launched into space using non-recoverable multi-stage rockets. The Space Shuttle system, on the other hand, is designed as a partially or fully re-usable system.

The origin of the Space Shuttle may be traced back to 1962, when the two-man Dyna-Soar programme was launched. The Dyna-Soar was a delta-winged Orbiter with aerodynamic re-entry. The programme was cancelled in December 1965. The design of the present system began in 1972 and consists of an aeroplane-like vehicle capable of gliding flight, called an Orbiter, an external fuel tank and two booster rockets (see figure 4.5). The Orbiter and the two solid fuel rocket boosters are re-usable, while the external tank which contains the ascent propellant to be used by the Orbiter's main engines can either be jettisoned before the Orbiter goes into an orbit or be placed in an orbit and used as a space platform. The Shuttle will be launched vertically.

Figure 4.5. The Space Shuttle system



The Orbiter

The Orbiter is designed to carry a crew of up to seven as well as to deliver payloads of up to 29 000 kg into Earth orbit. The payload bay of the Orbiter is 18 m long and 5 m in diameter. The Orbiter has three main propulsion rocket engines to be used during launch and there are smaller orbiter rocket engines for orbital manœuvring and control during space flight. These latter units provide thrust for orbit insertion, orbit change, rendezvous and return to Earth. The Orbiter will be launched from the NASA Kennedy Space Center (ETR) in Florida and, later on, also from the WTR in California. Acceleration during the climb does not exceed 3 *g* and is less than 1.5 *g* during re-entry.[3] This is only about one-third of what previous astronauts had to endure. Such low acceleration is one of the most novel features of the new space vehicle since it means that even people with no special training will be able to travel to Earth orbits.

The two solid fuel rocket boosters and the Orbiter's main engine will fire in parallel at lift-off. After the large external tank is jettisoned, the orbital manœuvring system of the Orbiter is used to attain the desired orbit and to make any subsequent manœuvres which may be required during the mission. Payloads of up to 29 000 kg can be launched due east from ETR into an orbit as high as 104° inclination. Polar-orbiting capabilities up to 18 000 kg can be achieved from WTR [10].

The payload bay of the Orbiter has four massive doors, nine metres in length, permitting deployment and recovery of very large payloads such as satellites. Retrieval is accomplished using two remotely controlled manipulator arms, which enable the payload to be moved in and out of the Orbiter payload bay. This ability of the Orbiter to retrieve friendly, and therefore, by implication, also hostile satellites from orbit is unique to the US space programme.

Normally the Orbiter will remain in orbit for seven days. When the mission is accomplished, the pilot will fire the Orbiter rockets to slow it down and enter the Earth's atmosphere. In the lower, more dense atmosphere, altitude control is provided by the aerodynamic surfaces on the Orbiter's wings and its vertical stabilizers. The Orbiter is designed to land like a normal jet aircraft at a speed of 95 m/s [10]. It is expected that it will take 14 days or about 160 hours of work to prepare the Orbiter between flights.

The external tank and solid fuel rocket boosters

Apart from the Orbiter, the Space Shuttle system consists of two other elements: two solid fuel rocket boosters and an external tank.

[3] Stresses on bodies undergoing acceleration are measured in gravity (*g*), 1 *g* being equal to the force exerted by the Earth's gravitational field on a body at sea level.

During a normal mission, the solid fuel rocket boosters, each weighing about 584 000 kg, burn for about two minutes in parallel with the Orbiter's main propulsion system. At an altitude of about 45 km, eight rockets built in each of the two solid fuel rocket boosters are fired to separate the boosters from the Orbiter/external tank. The booster rockets continue to fall through a 67-km apogee and at 5.8 km pilot parachutes are deployed to stabilize the rockets. The three main parachutes on each of the boosters are then deployed at an altitude of 2.7 km and are fully extended at one kilometre. The rockets fall into the sea some 300 km from the launch site, and are recovered by ships and returned to the base.

The external tank contains the fuel for the Orbiter main engines. This fuel is made up of liquid hydrogen (1 523 m^3) and liquid oxygen oxidizer (552 m^3) contained in a separate compartment. At lift-off the external tank contains 703 000 kg of propellant. After the solid fuel rocket boosters have been separated, the Orbiter's main propulsion system continues to burn until the Orbiter achieves a velocity slightly less than that required for its orbit. The external tank is then separated and falls into a remote area of the ocean or it stays in space in an orbit round the Earth.

This latter possibility was rejected in the past, but has now been resurrected. The idea is to use the external tank as a space platform to accommodate man's continuing presence in space. It is proposed that some of the liquid oxygen be removed to provide a separate compartment of about 57 m^3 which could be equipped to house a crew in orbit. Once the external tank is placed in an orbit, a second Shuttle would carry into this orbit a Skylab Airlock Module and a Multiple Docking Adopter together with a wing of solar cells. The crew brought by the Shuttle would then fix these to the external tank and construct additional crew quarters in the remaining space of the fuel tank. Using this concept, a permanent space platform could be placed in a three- to five-year orbit. It is planned to carry out such a programme in 1983 [11].

Military applications of the Space Shuttle

There has been a considerable amount of information on the possible widespread civilian benefits of the Space Shuttle programme. The most obvious advantage of the Space Shuttle is that it will bring down the costs of space operations by replacing the expensive single use of older launch vehicles with a re-usable system. This very fact, however, also increases the military attractiveness of space, a situation that is all the more serious in that relatively little is known about military plans for the Shuttle.

It has been reported that the US Department of Defense (DoD) space payloads under development or in the planning stage will be defined so that they can be placed into Earth orbit using the Orbiter [12]. A number of experimental payloads have been planned for orbiting during the first ten Orbiter flights, including Defense Support Program (DSP) early-warning satellites; the USAF Defense Satellite Communications System (DSCS-3); the Fleet SatCom Satellite Communications System; meteorological satellites; Space Test Program (STP) multi-purpose satellites, including laser communications; laser weapon development from the Space Laser Experiment Definition (SLED) studies now under consideration to counter enemy ICBMs; and long-wavelength infra-red surveillance sensors to be used to detect low-flying aircraft [11]. The DoD will invest $1 500–2 000 million to support its share of the Shuttle programme [12]. The Office of Management and Budget approved NASA's estimates for development of the Shuttle at $5 200 million in 1972. The latest projections put the total R&D cost at about $6 800 million.

An average of about 60 launches per year using the Space Shuttle system are planned starting in 1985. One payload will be launched from the ETR and the other from the WTR. Two of several tests under consideration are the US Navy's (USN) remote ocean-surface surveillance and the USAF's laser communications tests [13]. Initially six Space Shuttle flights are planned. During the third flight, in September 1979, the basic purpose of the mission will be to test the Shuttle's remote manipulator system, and the unit will manœuvre a payload into space [13]. The Orbiter will orbit at 296 km with an orbital inclination of 57° [14].

Of the currently envisaged military satellites to be launched by the Space Shuttle system, one carrying sensors designed to detect movements of strategic aircraft is already under development [15]. A satellite designated P-80-1 will be stabilized and have a pair of solid-fuel rocket motors. One of the motors will be used to boost the satellite from a Shuttle parking orbit up to about 740 km and the other will adjust the satellite's orbital inclination to at least 75° [16]. The satellite carrying such sensors will weigh about 900 kg and will be launched during the fifth Shuttle flight in 1980. It will require about half of the Shuttle's payload bay. The satellite will contain an infra-red sensor system called Teal Ruby to demonstrate that weak infra-red radiation from aircraft or cruise missiles can be detected against the background of radiation originating from the Earth's surface and its atmosphere [16].

In addition, the Defense Advanced Research Projects Agency (DARPA) has begun a study of the technology for a large space-based multi-mission surveillance system to satisfy strategic and tactical needs. The system would be capable of detecting and tracking ballistic and cruise missiles and military aircraft. The project is called HALO (High Altitude, Large Optics) and the system would require some six Space Shuttle payloads to place its structure and equipment in orbit [16–17].

One extremely important Space Shuttle payload already under development is the NavStar satellite being built under a $102.6 million contract from the USAF. Twenty-four satellites will make up the NavStar Global Positioning System. The satellites will be in 12-hour orbits at altitudes of about 16 000 km. There will be eight satellites in each of three orbital planes inclined at 60° to the equator. It is estimated that the system will enable a navigator to determine his position to within 10 m along longitude, latitude and altitude. The satellite clock will be accurate to one second in about 30 years and the satellite will give a navigator's speed to within about 10 centimetres per second, also in three dimensions [18]. The system will be used to deliver weapons accurately to their targets, and navigate spacecraft, aircraft, missiles, ships and submarines. Navigation instruments to be used with the NavStar system have recently been successfully tested using the NTS-2 satellite launched on 23 June 1977 (see table 4.9). The satellite carried a pair of caesium atomic clocks [19].

Another item that is being investigated for testing is a manœuvrable television camera which could travel short distances from the Shuttle for satellite inspection. In addition the mechanisms for retrieval of satellites from space will be tested.

Table 4.4 shows some of the milestones in the Space Shuttle programme.

Table 4.4. Some milestones in the Space Shuttle programme

Date	Test
15 Feb 1977	Taxi trials of Shuttle Orbiter OV-101 on Boeing 747 carrier aircraft made on runway.
18 Feb 1977	Orbiter made captive first flight on Boeing 747.
2 Mar 1977	Fifth and final unmanned captive flight of Orbiter on Boeing 747 completed; previous flights took place on 18, 22, 25 and 28 February 1977.
13 Mar 1977	Space Shuttle's main engine successfully tested.
18 Jun 1977	Orbiter made first captive flight on Boeing 747 with astronauts aboard; the aircraft flew at 4 572 m for a series of tests such as control stick steering checks, deployment of Orbiter speed breaks and Tactical Air Navigation System range and bearing tests at speeds of less than 333 km/h.
28 Jun 1977	During the second captive flight of Orbiter on Boeing 747 with astronauts, the crew performed operational checks and systems monitoring.
18 Jul 1977	First static firing of Space Shuttle rocket booster.
26 Jul 1977	Third and final captive flight during which the astronauts simulated full sequence of operations short of actual separation; the flight took place up to altitude of 7 895 m.
12 Aug 1977	First free flight of Orbiter successfully conducted; Boeing 747 with the Orbiter climbed to an altitude of 8 230 m and at an altitude of 7 345 m the two crafts separated and astronauts took over.
9 Sep 1977	First Space Shuttle external propellant tank left assembly line.
13 Sep 1977	Second free flight of Orbiter made at a speed of more than 530 km/h. It performed several manœuvres to test aerodynamics.

V. Conclusions

By the end of September 1977, some 75 per cent of all satellites launched were military-oriented satellites launched by members of the military space club, particularly the United States and the Soviet Union (see tables 4.6–4.19). During the first nine months of 1977, a total of 105 satellites of several countries were launched and 82 of these—belonging to the Soviet Union and the United States and one to NATO—were military satellites. Of these military satellites, the Soviet Union has continued to test its inspector/destructor satellites while the USA has accelerated its programmes to develop anti-satellite systems. The Department of Defense in FY 1972 spent $1 407 million on its space programmes, which was some 30 per cent of the total US space budget. It is estimated that this will increase to a little more than 40 per cent in 1977 (see table 4.5).

Table 4.5. US space budgets, 1972–77

Fiscal year	DoD space *$ mn*	Total space *$ mn*	DoD budget as percentage of total
1972	1 407	4 600	*31*
1973	1 623	4 800	*34*
1974	1 827	5 000	*37*
1975	1 892	..	..
1976	1 985	(5 000)	*40*
1977	(2 336)	(5 800)	*40*

Source: NASA Authorization for Fiscal 1974, Hearing on S. 880, US Senate Committee on Aeronautical and Space Sciences, 93rd Congress, First Session, 3, 4, 8 and 10 April 1973 US Government Printing Office, (Washington, 1973), Part 3, p. 1377.

The continuing trend of militarizing space is further emphasized by the initial testing of the Space Shuttle system in 1977. This system is potentially ideal for installing weapons such as laser and ion beam weapons in orbit round the Earth. It is interesting to note that the Space Shuttle budget has increased from less than $100 million to more than $1 300 million per year. And this increase appears to have been at the expense of several other scientific projects. For example, the High Energy Astronomy Observatory programme has been cut back (the first satellite was launched in August 1977) and the Large Space Telescope project has been deferred [20].

There is no doubt that satellites are playing a useful role in verifying arms control agreements such as SALT. In addition to this role, however, it appears that military reconnaissance satellites are playing a more subtle, and possibly more positive role, in their function as watchdogs of the world. Both the United States and the Soviet Union appear to be using their satellites continuously to observe the Earth, and their exposure in 1977 of a possible South African nuclear test in the Kalahari Desert was certainly useful. In fact, it has been suggested that these preparations for a nuclear test were a hoax, since there has been no proof that the South Africans were actually planning to explode a nuclear device, and that the Kalahari facility was created only to let the world know that South Africa is capable of becoming a nuclear weapon power. It is often very difficult in nuclear politics to discover the truth, but one thing is clear: whatever the purpose of the activities in the Kalahari Desert, these satellites were quickly able to detect them.

In addition to the satellite observations of South Africa discussed in this chapter, the ground tracks passing over the West German rocket site in Zaire are of considerable interest. Developments here, where rockets are being developed cheaply using readily available components, clearly illustrate the way in which the militarization of space could proliferate. It is true that it is argued that the West German programme is for launching Earth observation and communications satellites for civilian purposes. However, once a nation can launch a satellite, it has developed the potential for possessing missiles. This development is all the more alarming when one considers how easy it is for a private firm to begin to exploit space, merely by associating itself with a national government. All Article 6 of the Outer Space Treaty requires is "authorization and continuing supervision" by a state party to the treaty on activities in outer space of non-governmental organizations. In addition, membership of the treaty is relatively limited. By 31 December 1977, only 77 countries were parties to it. Zaire signed the treaty in 1967, but has not yet ratified it.

In March 1977, the USA suggested that the two powers should agree to ban the arming and destruction of each other's Earth satellites. The Soviet Union is said to have responded positively. However, even if the two powers were to come to such an agreement, it would help to eliminate only part of the arms race in space. This has been shown by the limitations placed on hostile space activities by the existing three outer space-related agreements. An international telecommunications agreement forbids interference with communications. However, this includes communications satellites implicitly and therefore does not prohibit the military use of such satellites. The two US–Soviet strategic arms agreements prohibit interference with "national technical means of verification" which includes reconnaissance satellites but does not indicate which types of reconnaissance satellite. Both these agreements prohibit interference with certain types of satellite only and do not include such satellites as the early-warning, navigation, communications, weather and geodetic satellites. The third agreement, the Outer Space Treaty, has not helped to check the proliferation of military satellites. The treaty only prohibits placing "in orbit around the Earth any objects carrying nuclear weapons or any other kind of weapons of mass destruction". In Article 4 of the treaty, "the establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military manœuvres" are prohibited only on celestial bodies. It might have helped to check the proliferation of military satellites in Earth orbit—such as inspector/destructor, navigation, communications, weather and geodetic—and hence the arms race in space, if this provision had been extended to artificial satellites also.

VI. Tables of military satellites

Conventions

..	Information not available
–	None
?	Uncertainty about the satellite designation or other data

Abbreviations and acronyms

US launchers:

A	Atlas
A-D	Agena D
Bu II	Burner II
T-3B	Titan-3B
T-3C	Titan-3C
T-3D	Titan-3D
TAT	Thrust Augmented Thor
Th	Thor

Soviet launchers:

A-1	One and one-half stage booster with first-generation upper stage (Vostok vehicle)
A-2	Vostok up-rated second stage
A-2-e	One and one-half stage booster with second-generation upper stage plus escape stage
C-1	Skean intermediate-range missile plus upper stage
D-1-e	Proton booster plus upper and escape stages
F-1-m	SS-9 Scarp missile with orbital and manœuvrable stages

US launch sites:

ETR	Eastern Test Range (Cape Kennedy, Florida)
WTR	Western Test Range (Vandenberg AFB, California)

Soviet launch sites:

PL	Plesetsk
TT	Tyuratam

Other:

DSCS	Defense Satellite Communications System
GOES	Geostationary Operational Environmental Satellite
Intelsat	International Telecommunications Satellite Consortium
NASA	National Aeronautics & Space Administration
NTS	Navigation Technology Satellite
PDM	Pulse Duration Modulation
SDS	Satellite Data System
USAF	US Air Force

Table 4.6. US photographic reconnaissance satellites launched in 1977

Satellite name and designation[a]	Launch site and vehicle	Launch date and time *GMT*	Orbital inclination *deg*	Period *min*	Perigee height *km*	Apogee height *km*	Lifetime	Whether capsule recovered	Comments
USAF (1977-19A)	WTR T-3B/A-D	13 Mar 1843	96.40	89.25	124	348	74 days	..	Low-resolution search and find
USAF (1977-56A)	WTR T-3D	27 Jun 1829	97.02	88.47	155	239	5 months	..	Big Bird satellite
USAF (1977-94A)	WTR T-3B/A-D	23 Sep 1843	96.49	89.30	125	352	70 days	..	Low-resolution search and find

[a] The designation of each satellite is recognized internationally and is given by the World Warning Agency on behalf of the Committee on Space Research.

Table 4.7. US early-warning satellites launched in 1977

Satellite name and designation[a]	Launch site and vehicle	Launch date and time *GMT*	Orbital inclination *deg*	Period *min*	Perigee height *km*	Apogee height *km*	Lifetime *years*	Comments
USAF (1977-07A)	ETR T-3C	6 Feb ..	0.5	1 433.3	35 620	35 862	$>10^6$	Satellite equipped with infra-red detector and system to detect interference from other satellites

[a] See footnote *a* to table 4.6.

Table 4.8. US communications satellites launched in 1977

Satellite name and designation[a]	Launch site and vehicle	Launch date and time *GMT*	Orbital inclination *deg*	Period *min*	Perigee height *km*	Apogee height *km*	Lifetime *years*	Comments
USAF DSCS-7 (1977-34A)	ETR T-3C	12 May 1438	2.44	1 426.7	35 438	35 762	$>10^6$	Two military satellites, equipped with anti-jamming systems; one placed over Atlantic and the other over Pacific
USAF DSCS-8 (1977-34B)	ETR T-3C	12 May 1438	2.43	1 436.7	35 781	35 792	$>10^6$	
USAF SDS-4 (1977-38A)	ETR Atlas/A-D	23 May 0126	0.2	1 435.1	35 679	35 855	$>10^6$	
Intelsat 4A (1977-41A)	ETR Atlas Centur	28 May 2150	0.28	1 424.2	35 346	35 755	$>10^6$	Satellite's final position will be over Atlantic; three more are scheduled to be launched over next two years

[a] See footnote *a* to table 4.6.

Table 4.9. US weather satellites launched in 1977

Satellite name and designation[a]	Launch site and vehicle	Launch date and time *GMT*	Orbital inclination *deg*	Period *min*	Perigee height *km*	Apogee height *km*	Lifetime *years*
AMS-2 (1977-44A)	WTR Th/Bu II	5 Jun 0307	99.20	101.74	811	869	80
NASA GOES 2 (1977-48A)	ETR Delta	16 Jun 1048	0.88	1 436.03	35 266	36 304	10^6

[a] See footnote *a* to table 4.6.

Table 4.10. US navigation satellites launched in 1977

Satellite name and designation[a]	Launch site and vehicle	Launch date and time *GMT*	Orbital inclination *deg*	Period *min*	Perigee height *km*	Apogee height *km*	Lifetime *years*	Comments
USAF NTS2 (1977-53A)	WTR Atlas	23 Jun 0058	63.18	351.87	160	20 106	10^6	To be used to test highly accurate caesium-type atomic clock which will be component of NavStar Global Positioning System

[a] See footnote *a* to table 4.6.

Table 4.11. US ocean-surveillance satellites launched in 1977

Satellite name and designation[a]	Launch site and vehicle	Launch date and time *GMT*	Orbital inclination *deg*	Period *min*	Perigee height *km*	Apogee height *km*	Lifetime *years*
USN NOSS (1977-112A)	WTR Atlas	8 Dec	63.4	107.5	1 056	1 116	..

[a] See footnote *a* to table 4.6.

Table 4.12. Soviet photographic reconnaissance satellites launched in 1977

Satellite name and designation[a]	Launch site and vehicle	Launch date and time *GMT*	Orbital inclination *deg*	Period *min*	Perigee height *km*	Apogee height *km*	Lifetime *days*	Whether recovered	Comments
Cosmos 888 (1977-01A)	TT A-2	6 Jan 0950	64.97	89.45	170	325	12.85	Yes	Manœuvrable satellite; two-tone
Cosmos 889 (1977-03A)	TT A-2	20 Jan 0838	71.38	89.84	202	329	11.92	Yes	About three such satellites are launched each year; area-surveillance satellite; PDM
Cosmos 892 (1977-09A)	PL A-2	9 Feb 1131	72.86	89.66	171	343	12.7	Yes	Manœuvrable satellite; two-tone
Cosmos 896 (1977-16A)	PL A-2	3 Mar 1033	72.89	89.72	177	343	12.8	Yes	Manœuvrable satellite; two-tone
Cosmos 897 (1977-17A)	PL A-2	10 Mar 1102	72.85	89.63	171	340	12.79	Yes	Capsule ejected; manœuvrable satellite; two-tone
Cosmos 898 (1977-20A)	PL A-2	17 Mar 0838	81.35	88.99	216	230	12.8	Yes	Capsule ejected; PDM; also scientific mission
Cosmos 902 (1977-26A)	PL A-2	7 Apr 0907	81.39	89.00	168	279	12.8	?	Launched in spring and autumn each year to survey Arctic ice conditions
Cosmos 904 (1977-28A)	PL A-2	20 Apr 0907	71.37	89.83	203	328	13.9	?	About three such satellites are launched each year; area-surveillance satellite; PDM
Cosmos 905 (1977-30A)	PL A-2	26 Apr 1453	67.12	89.60	171	339	29.5	?	Fourth-generation long-lived satellite
Cosmos 907 (1977-33A)	PL A-2	5 May 1410	62.80	89.93	181	364	10.6	?	Manœuvrable satellite; two-tone
Cosmos 908 (1977-35A)	TT A-2	17 May 1019	51.79	89.06	174	288	13.83	Yes	Manœuvrable satellite; two-tone
Cosmos 912 (1977-40A)	PL A-2	26 May 0712	81.35	89.00	217	231	12.8	?	First unmanned satellite characterized by USSR as Earth Resources satellite
Cosmos 914 (1977-43A)	TT A-2	31 May 0735	65.00	89.59	203	306	12.9	?	PDM; also scientific mission

Cosmos 915 (1977-45A)	PL A-2	8 Jun 1410	62.80	89.10	173	289	12.6	?	Manœuvrable satellite; two-tone
Cosmos 916 (1977-46A)	PL A-2	10 Jun 0810	62.80	89.94	246	246	11.6	?	Manœuvrable satellite; two-tone
Cosmos 920 (1977-52A)	TT A-2	22 Jun 0810	64.99	89.65	173	342	12.8	Yes	Manœuvrable satellite; two-tone
Cosmos 922 (1977-58A)	PL A-2	30 Jun 1410	62.81	89.53	205	299	12.61	?	Area-surveillance satellite; PDM
Cosmos 927 (1977-63A)	PL A-2	12 Jul 0907	72.87	89.65	153	361	12.8	?	Manœuvrable satellite; two-tone
Cosmos 932 (1977-69A)	TT A-2	20 Jul 0735	65.02	89.09	149	311	12.80	?	Manœuvrable satellite; two-tone
Cosmos 934 (1977-62A)	PL A-2	27 Jul 1814	62.81	89.35	231	255	12.62	Yes	Manœuvrable satellite; two-tone
Cosmos 935 (1977-73A)	PL A-2	29 Jul 0813	81.33	89.20	217	251	12.88	?	Area-surveillance satellite; PDM
Cosmos 938 (1977-78A)	PL A-2	24 Aug 1438	62.81	89.37	156	332	12.63	Yes	Manœuvrable satellite; two-tone
Cosmos 947 (1977-81A)	PL A-2	27 Aug 1019	72.89	89.75	203	321	12.77	Yes	Manœuvrable satellite; two-tone
Cosmos 948 (1977-83A)	PL A-2	2 Sep 0907	81.36	89.04	217	235	12.8	?	Possible Earth Resources satellite; capsule ejected
Cosmos 949 (1977-85A)	AL A-2	7 Sep 1731	62.80	89.89	177	364	29.5	?	Fourth generation long-lived satellite; all such satellites have previously been launched in 67° orbit
Cosmos 950 (1977-86A)	AL A-2	13 Sep 1522	62.81	89.36	205	282	13.6	?	Manœuvrable satellite; two-tone
Cosmos 953 (1977-89A)	PL A-2	16 Sep 1438	62.81	89.00	151	300	12.6	Yes	Manœuvrable satellite; two-tone
Cosmos 957 (1977-98A)	TT A-2	30 Sep 0950	64.95	89.51	150	351	12.9	?	Manœuvrable satellite; two-tone
Cosmos 958 (1977-100A)	PL A-2	11 Oct 1522	62.81	90.59	257	351	12.6	?	Interlaced ground track to get complete photographic coverage; similar to Cosmos 867[b]

Satellite name and designation[a]	Launch site and vehicle	Launch date and time *GMT*	Orbital inclination *deg*	Period *min*	Perigee height *km*	Apogee height *km*	Lifetime *days*	Whether recovered	Comments
Cosmos 964 (1977-110A)	PL A-2	4 Dec ..	72.9	89.8	180	391	13	Yes	High-resolution manœuvrable satellite; two-tone
Cosmos 966 (1977-115A)	TT A-2	12 Dec ..	65	89.5	210	316	12	?	Area-surveillance satellite; PDM; also scientific mission
Cosmos 969 (1977-120A)	PL A-2	20 Dec ..	62.8	89.5	188	340	14	?	High-resolution manœuvrable satellite; two-tone
Cosmos 973 (1977-124A)	TT A-2	27 Dec ..	71.4	89.8	210	348	..	?	Area-surveillance satellite; PDM; also scientific mission

[a] See footnote *a* to table 4.6.
[b] See reference [8].

Table 4.13. Possible Soviet electronic reconnaissance satellites launched in 1977

Satellite name and designation[a]	Launch site and vehicle	Launch date and time *GMT*	Orbital inclination *deg*	Period *min*	Perigee height *km*	Apogee height *km*	Lifetime
Cosmos 899 (1977-22A)	PL C-1	24 Mar 2219	74.05	95.15	503	547	104 years
Cosmos 901 (1977-25A)	PL C-1	5 Apr 1033	70.99	95.54	269	820	17 months
Cosmos 919 (1977-51A)	PL C-1	18 Jun 1033	71.02	95.56	269	822	7 months
Cosmos 924 (1977-60A)	PL C-1	4 Jul 2219	74.02	95.28	513	550	10 years
Cosmos 960[b] (1977-103A)	PL C-1	25 Oct 0531	74.04	95.13	502	546	10 years

[a] See footnote *a* to table 4.6.
[b] Cosmos 913, 930 and 965 had similar orbital parameters to those in this series but the period was 94.4 min. These satellites are possibly new programmes.

Table 4.14. Possible Soviet early-warning satellites launched in 1977

Satellite name and designation[a]	Launch site and vehicle	Launch date and time *GMT*	Orbital inclination *deg*	Period *min*	Perigee height *km*	Apogee height *km*	Lifetime
Cosmos 903 (1977-27A)	PL A-2-e	11 Apr 0141	62.84	725.88	603	40 153	10
Cosmos 917 (1977-47A)	PL A-2-e	16 Jun 0210	62.90	718.74	586	39 818	10
Cosmos 931 (1977-68A)	PL A-2-e	20 Jul 0448	62.96	724	604	40 065	12

[a] See footnote *a* to table 4.6.

Table 4.15. Possible Soviet ocean-surveillance satellites launched in 1977

Satellite name and designation[a]	Launch site and vehicle	Launch date and time *GMT*	Orbital inclination *deg*	Period *min*	Perigee height *km*	Apogee height *km*	Lifetime *years*
Cosmos 937 (1977-77A)	TT F-1-m	24 Aug 0712	65.04 0712	93.31	424	444	6
Cosmos 952 (1977-88A)	TT F-1-m	16 Sep 1424	64.97 64.97	89.65 104.13	251 910	265 998	600
Cosmos 954 (1977-90A)	TT F-1-m	18 Sep 1355	64.98	89.65	251	265	7 months

[a] See footnote *a* to table 4.6.

Table 4.16. Possible Soviet communications satellites launched in 1977

Satellite name and designation[a]	Launch site and vehicle	Launch date and time *GMT*	Orbital inclination *deg*	Period *min*	Perigee height *km*	Apogee height *km*	Lifetime *years*
Molniya 2-17 (1977-10A)	PL A-2-e	11 Feb 1507	62.81	735.35	464	40 756	10
Molniya 1-36 (1977-21A)	PL A-2-e	24 Mar 0014	63.87	717.49	465	39 879	10
Molniya 3-7 (1977-32A)	PL A-2-e	28 Apr 0922	62.75	736.03	436	40 817	12
Molniya 1-37 (1977-54A)	TT A-2-e	24 Jun 0546	62.93	699.66	447	39 011	12
Statsionar 2 (Raduga 3) (1977-61A)	TT D-1-e	23 Jul 2122	0.21	1 436.30	42 170	35 730	10^6
Cosmos 939 (1977-79A)	PL C-1	24 Aug 1814	74.02	114.88	1 435	1 464	8 000
Cosmos 940 (1977-79B)	PL C-1	24 Aug 1814	74.02	114.46	1 397	1 464	6 000
Cosmos 941 (1977-79C)	PL C-1	24 Aug 1814	74.02	114.67	1 416	1 464	7 000
Cosmos 942 (1977-79D)	PL C-1	24 Aug 1814	74.02	115.98	1 464	1 535	10 000
Cosmos 943 (1977-79E)	PL C-1	24 Aug 1814	74.02	115.08	1 453	1 464	9 000
Cosmos 944 (1977-79F)	PL C-1	24 Aug 1814	74.02	115.30	1 464	1 473	9 000
Cosmos 945 (1977-79G)	PL C-1	24 Aug 1814	74.02	115.52	1 464	1 493	10 000

Cosmos 946 (1977-79H)	PL C-1	24 Aug 1814	74.02	115.73	1 464	1 512	10 000
Molniya 1-38 (1977-82A)	PL A-2-e	30 Aug 1814	62.83	735.58	445	40 785	10
Stationar T (Ekran 2) (1977-92A)	TT D-1-e	20 Sep 1731	0.04	1 426.55	35 580	35 622	10^6
Molniya 3-8 (1977-105A)	PL A-2-e	28 Oct 0141	62.77	736.21	420	40 842	12

[a] See footnote *a* to table 4.6.

Table 4.17. Possible Soviet navigation satellites launched in 1977

Satellite name and designation[a]	Launch site and vehicle	Launch date and time *GMT*	Orbital inclination *deg*	Period *min*	Perigee height *km*	Apogee height *km*	Lifetime *years*
Cosmos 890 (1977-04A)	PL C-1	20 Jan 2010	82.97	105.17	983	1 020	1 200
Cosmos 894 (1977-13A)	PL C-1	21 Feb 1717	82.94	105.00	972	1 014	1 200
Cosmos 911 (1977-39A)	PL C-1	25 May 1102	82.95	104.87	970	1 004	1 200
Cosmos 926 (1977-62A)	PL C-1	8 Jul 1731	82.94	105.13	976	1 022	1 200
Cosmos 928 (1977-64A)	PL C-1	13 Jul 0502	82.96	104.79	956	1 011	1 200
Cosmos 951 (1977-87A)	PL C-1	14 Sep 1955	82.97	104.98	968	1 017	1 200
Cosmos 962 (1977-107A)	PL C-1	28 Oct 1550	82.96	104.93	968	1 012	1 000
Cosmos 971 (1977-122A)	PL C-1	23 Dec ..	83	105.00	993	1 021	..

[a] See footnote *a* to table 4.6.

Table 4.18. Possible Soviet weather satellites launched in 1977

Satellite name and designation[a]	Launch site and vehicle	Launch date and time *GMT*	Orbital inclination *deg*	Period *min*	Perigee height *km*	Apogee height *km*	Lifetime *years*	Comments
Meteor 2-02 (1977-02A)	PL A-1	6 Jan 2317	81.27	102.97	890	906	500	
Meteor 27 (1977-24A)	PL A-1	5 Apr 0210	81.25	102.50	854	897	500	
Meteor 28 (1977-57A)	PL A-1	29 Jun 1843	97.91	97.46	601	670	60	First Soviet satellite to use Sun-synchronous retrograde orbit; it has been reported that satellite also carried multi-spectral sensor for Earth Resources applications
Cosmos 925 (1977-61A)	PL A-1	7 Jul 0726	81.21	97.16	609	934	60	
Cosmos 955 (1977-91A)	PL A-1	20 Sep 0112	81.24	97.46	630	641	60	
Meteor 2-3 (1977-117A)	PL A-1	14 Dec ..	81.2	102.5	864	904	..	

[a] See footnote *a* to table 4.6.

Table 4.19. Possible Soviet inspector/destructor satellites launched in 1977

Satellite name and designation[a]	Launch site and vehicle	Launch date and time *GMT*	Orbital inclination *deg*	Period *min*	Perigee height *km*	Apogee height *km*	Lifetime	Comments
Cosmos 909 (1977-36A)	PL C-1	19 May 1634	65.87	117.02	990	2 109	4 000 years	Target satellite
Cosmos 910 (1977-37A)	TT F-1-m	23 May 1229	65.86	99.56	300	1 774	0.05 day	Inspector/destructor satellite probably intended to pass close to Cosmos 909; the satellite entered atmosphere before completing first orbit
Cosmos 918 (1977-50A)	TT F-1-m	17 Jun 0726	65.11	88.18	128	243	1 day	Inspector/destructor satellite which may have temporarily entered orbit passing close to Cosmos 909 in new "pop-up" technique
Cosmos 959 (1977-101A)	PL C-1	21 Oct 1005	65.84	94.57	146	850	42 years	Target satellite
Cosmos 961 (1977-104A)	TT F-1-m	26 Oct 0517	66.0 66.40	88.76 101.80	125 269	302 1 421	0.78 day	Inspector/destructor satellite—"pop-up" type—which fired propulsion system to climb to the higher orbit of Cosmos 959; orbits are provisional
Cosmos 967 (1977-116A)	PL C-1	13 Dec ..	65.8	105	973	1 013	..	Target satellite
Cosmos 970 (1977-121A)	TT F-1-M	21 Dec ..	65.1	..	144	854	..	Inspector/destructor satellite; approached Cosmos 967 in co-orbital type interception and exploded

[a] See footnote *a* to table 4.6.

Table 4.20. Possible Soviet geodetic satellite launched in 1977

Satellite name and designation[a]	Launch site and vehicle	Launch date and time *GMT*	Orbital inclination *deg*	Period *min*	Perigee height *km*	Apogee height *km*	Lifetime *years*
Cosmos 963 (1977-109A)	PL C-1	24 Nov 1424	82.93	109.35	1 182	1 210	3 000

[a] See footnote *a* to table 4.6.

Table 4.21. NATO communications satellite launched in 1977

Satellite name and designation[a]	Launch site and vehicle	Launch date and time *GMT*	Orbital inclination *deg*	Period *min*	Perigee height *km*	Apogee height *km*	Lifetime *years*
NATO 3B (1977-05A)	ETR TAT/Delta	28 Jan 0058	2.60	1 436.20	35 777	35 797	$> 10^6$

[a] See footnote *a* to table 4.6.

References

1. *Outer Space—Battlefield of the Future?* (Taylor & Francis, London, 1978, Stockholm International Peace Research Institute).
2. Baker, D., "Killer Satellites", *Flight International*, Vol. 112, No. 3579, 15 October 1977, pp. 1129–35.
3. Purvis, G., "Koeberg's Cooling Water Marine Basin Next on Agenda", *Nuclear Engineering International*, Vol. 22, No. 262, September 1977, pp. 47–48.
4. *Uranium Resources, Production and Demand*, Joint Report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency, December 1975, pp. 22–24.
5. "New Enrichment Process?", *Nuclear Engineering International*, Vol. 15, No. 171, August 1970, p. 551.
6. Marshall, P., "Buoyant Uranium Market Brings South African Mining Bonanza", *Nuclear Engineering International*, Vol. 22, No. 262, September 1977, p. 50.
7. Marder, N. and Oberdorfer, D., "How West, Soviets Acted to Defuse S. African A-Test", *Washington Post*, 28 August 1977.
8. Perry, G. E., private communication.
9. Ropelewski, R. R., "Low-Cost Satellite Launcher Developed", *Aviation Week and Space Technology*, Vol. 107, No. 11, 12 September 1977, pp. 42–47.
10. *Space Shuttle* (Scientific and Technical Information Office, NASA, Washington, 1976).
11. *Interavia Air Letter*, No. 8713, 14 March 1977, p. 7.
12. Brownlaw, C., "Defense Configures Orbiter Payloads", *Aviation Week and Space Technology*, Vol. 105, No. 19, 8 November 1976, p. 142.
13. "Space Shuttle Priorities Set for Payloads", *Aviation Week and Space Technology*, Vol. 106, No. 20, 16 May 1977, p. 13.
14. Covault, C., "Shuttle Test Goal Studies Accelerated", *Aviation Week and Space Technology*, Vol. 106, No. 26, 27 June 1977, pp. 20–21.
15. Lenorovitz, J. M., "USAF Defining Shuttle Sensor Payload", *Aviation Week and Space Technology*, Vol. 106, No. 11, 14 March 1977, pp. 44–46.
16. Miller, B., "Aircraft Detection System Advances", *Aviation Week and Space Technology*, Vol. 106, No. 25, 20 June 1977, pp. 22–23.
17. *Aviation Week and Space Technology*, Vol. 106, No. 13, 28 March 1977, p. 11.
18. *Interavia Air Letter*, No. 8787, 30 June 1977, p. 6.
19. *Aviation Week and Space Technology*, Vol. 107, No. 4, 25 July 1977, p. 22.
20. Norman, C., "Re-usability is the Catchword", *Nature*, Vol. 266, No. 5602, 7 April 1977, pp. 489–90.
21. Kovan, D., "Enrichment Plants—A Survey of Major New Uranium Enriching Projects", *Nuclear Engineering International*, Vol. 21, No. 250, November 1976, p. 50.

5. The arms race in space

Square-bracketed numbers, thus [1], *refer to the list of references on page 129.*

I. Introduction

Chapter 4 and chapters in previous *SIPRI Yearbooks* have documented the increasing role that space-based systems are playing in preparations for fighting wars on Earth. As space-based systems become more important, there are increasing incentives to develop weapon systems—characterized in the United States by the acronym ASATs (Anti-Satellite weapons)—directed against these space-based systems. Both the United States and the Soviet Union are developing such weapons. It is thus likely that future wars will be fought in space as well as on Earth.

This chapter describes, first, the anti-satellite weapon systems which have been deployed or are under development and, second, the surveillance systems used to maintain surveillance over foreign satellite launches and to provide targeting data for anti-satellite weapons.

This new emphasis on development of capabilities for each of the great powers to destroy the satellites belonging to the other, and the resulting countermeasures, might be termed an arms race in space. It is likely to lead to further expansion of arms budgets and to strategic destabilization. As satellite technology becomes more accessible to more nations, and displaces ground-based technology in more fields, some way of controlling war in space will have to be found.

The 1967 Outer Space Treaty is of little assistance here, as it bans only "nuclear weapons or any other kinds of weapons of mass destruction in earth orbit", and nuclear weapons and military activities in general on the Moon and other celestial bodies. Nuclear explosions in space are banned by the 1963 Partial Nuclear Test Ban Treaty. These two treaties leave space wide open for a range of other military functions such as weapon guidance and intelligence collection, and for the stationing in orbit of non-nuclear weapon systems, including anti-satellite weapons.

To illustrate the extent to which the conduct of war is becoming dependent on the use of satellites, one might consider a hypothetical war occurring sometime in the near future. The early stages of such a war will be monitored by both the United States and the Soviet Union using surveillance satellites. The USA will adjust the orbit of its current Big Bird satellite to obtain high-resolution photographs of the conflict area at frequent intervals and the Soviet Union may launch one or more "quick look" Cosmos satellites specifically to photograph the conflict. Both sides will pay particular attention to the data collected by "ferret" satellites on the various radar and other electromagnetic emissions from the conflict area, in order to tailor the countermeasures that will be used to protect their own weapon systems, particularly aircraft. These ferret satellites may also intercept short-wave communications from one or other of the warring parties.

Detailed topographical maps, aeronautical charts and so on will have been prepared long in advance using photography from higher-altitude, lower-resolution "area-coverage" photographic satellites and Earth Resource satellites. Geodetic control for these maps, and for the calculation of medium- and long-range missile trajectories, will have been calculated long in advance using the accumulation of data from many years of tracking geodetic satellites.

After each of the two great powers has entered the conflict, its air sorties and other operations will be planned on the basis of predictions from weather satellites photographing cloud cover. The weather satellites will also be used to plan further spy satellite manœuvres, and satellite measurements of atmospheric water vapour content will be used in calculating propagation corrections for the Loran C radio-navigation system, used for blind precision bombing.

The United States and the Soviet Union will exercise control over distantly deployed forces via the thousands of channels available on the US Defense Satellite Communications System satellites in equatorial synchronous orbits and Soviet satellites in high-inclination elliptical, as well as synchronous orbits. Data relay satellites will be used to forward intelligence information from satellite control stations back to command headquarters. Within the conflict area, tactical communications satellites will handle communications between aircraft and their bases, between ships and shore stations, and between ground forces and their command posts. Moreover, all these deployed forces will be able to communicate with each other via the same satellites.

Ocean-surveillance satellites will monitor naval movements, and the early-warning satellites of each side will keep watch for the volley of intercontinental ballistic missile (ICBM) launches that will signify that the other side has escalated to total nuclear war. If ICBMs are used, then nuclear burst detection sensors will determine that the warheads are indeed getting through to their intended targets.

If this hypothetical war takes place after 1984 then US forces at least will to a large extent be dependent on the NavStar satellite Global Positioning System. Amongst users of NavStar will be: aircraft or blind precision-bombing missions, submarines fixing their positions precisely so that they can launch their missiles accurately, and infantry with back-pack receivers. Missiles will obtain mid-course corrections to their trajectories using

NavStar, and it will be used to direct artillery fire. If NavStar is not available for this future war, then some US forces, in particular the missile submarines, will be relying on Transit Navy Navigation satellites. Soviet forces will rely on the more abundant Soviet navigation satellites to an even greater extent, because of the lesser spread of Soviet ground-based navigation aids.

II. US anti-satellite systems

In the current controversy about the destabilizing effects of Soviet anti-satellite systems, the existence of a US anti-satellite system between 1963 and 1975 is often ignored. This was supposedly developed as a form of deterrent against Soviet attempts to destroy US reconnaissance satellites. These satellites had come to take the place of reconnaissance overflights, and it was feared that the Soviet Union might be tempted to destroy the satellites for much the same reasons as they had earlier shot down the U-2 plane piloted by Gary Powers. There seemed to be no feasible way of protecting these satellites against attack, and it seemed easier to deter attack by threatening to attack equivalent Soviet satellites.

The US anti-satellite weaponry included, under Program 505, Nike-Zeus anti-ballistic missiles at Kwajalein Atoll in the western Pacific, which were adapted to an anti-satellite role in 1963, and deactivated in about 1968 [1]. Another programme—Program 437—was based on Thor intermediate-range ballistic missiles (IRBMs) at Johnston Island in the central Pacific, which were adapted to an anti-satellite role in 1964, and deactivated in 1975.

During its lifetime, the 437 system underwent considerable evolution. In latter years it was fitted with the Burner II upper stage, which had a precise payload-manœuvring capacity. No official information is available on the capabilities of the 437 system but certain conclusions can be reached. The Thor was originally designed as a 2 000 plus-km range IRBM and had the ability to lift several hundred kilograms into low orbit. This would have been ample for even a crude nuclear warhead. It is reasonable to assume that even the earliest version of the 437 would have been effective at reconnaissance altitudes within a horizontal range from Johnston Island of at least 1 000 km. At the longitude of Johnston Atoll, this is equivalent to about 11° of longitude. Owing to the rotation of the Earth, each successive orbit of a satellite at reconnaissance altitudes is displaced 22.5° west of the previous orbit. Thus even the earliest version of 437, without assistance from the Kwajalein missiles, would have been capable of destroying any satellites in reconnaissance orbits, simply by waiting for the rotation of the Earth to bring the orbit within range of Johnston Island. The Johnston

Island missiles continued to be fitted with nuclear warheads up until their retirement [2]. Air Force Secretary J. L. McLucas was reported as saying in 1974 that the 437 system was still in existence, but was not usable in a practical sense because the USA was a signatory of the treaty banning the use of nuclear weapons in space [3].

The accuracy of these anti-satellite systems is unknown, but with nuclear warheads high accuracy would not have been essential. Although there are no shock waves from nuclear blasts in space, a nuclear warhead can be effective over moderate distances—the burst of powerful X-rays, unimpeded by atmosphere, plus the electromagnetic pulse, would destroy the optical, electronic and solar power components of satellites. A 1.5- to 2-megaton charge will destroy a satellite less than 5 km away and will severely damage satellites at a distance of up to 25 km [4].

Current developments in US anti-satellite weaponry

Although the US Air Force (USAF) is currently without an anti-satellite capability, it is evident that there is considerable interest in acquiring a more sophisticated capability than that provided formerly by the Johnston Island missiles.

From the late 1960s onwards, sporadic reports have attested to a continuous programme for investigating non-nuclear methods of satellite destruction and terminal homing guidance systems to achieve the accuracy necessary for non-nuclear kill mechanisms to be successful.

Currently there are two projects under way which are intended to result in a design for a new direct ascent system. One relies on non-explosive miniature vehicles designed to destroy a satellite by impact; the other is to be armed with non-nuclear explosives. Either weapon would home on its target using long-wavelength infra-red or radar sensors [5].

In March 1977 President Carter announced that he had initiated moves towards a US–Soviet agreement to ban anti-satellite weapons [6]. News reports in late 1977 suggest, however, that the USAF is still proceeding with development of its new anti-satellite capability.

Lasers and charged-particle beams are now seen as feasible anti-satellite kill mechanisms although there are considerable technical problems to be solved with each. According to a Defense Advanced Research Projects Agency testimony, the high mass efficiency and ability to produce laser power without a large electrical power supply make the hydrogen fluoride chemical laser potentially suitable as a space-borne weapon, particularly for defence against interceptor attack rather than as an offensive weapon [7a]. Studies have shown that the USA could have a high-energy laser in orbit within six years. Laser components would be placed in orbit by the Space Shuttle and be assembled in space. Electrically excited lasers at ultra-violet and visible wavelengths have been proposed to destroy optical sensors and solar cells aboard low-orbit satellites from ground level. However, ground-based lasers are subject to serious limitations in that a laser beam powerful enough to inflict damage tends to heat the column of air through which it passes, thus altering the refractive index and effectively defocusing the beam.

III. The Soviet interceptor programme

The first hint of a Soviet interest in destroying hostile satellites came after the 1960 shooting down of a U-2 spy plane, when Premier Khrushchev warned that reconnaissance satellites could also be "paralysed". A 1962 Soviet text on space law proclaimed the "indisputable" right of a state to destroy another state's spy satellite.

In 1963 the Soviet Union reached agreement in principle with the United States on the banning of weapons of mass destruction in space, and this agreement was formalized in the 1967 Outer Space Treaty. There is some evidence of an internal discussion in this period about the need for and feasibility of space weapons. The 1965 Soviet *Dictionary of Basic Military Terms* described a special anti-space unit called Protivo Kosmicheskaya Oborona. According to the dictionary, "The main purpose of anti-space defense is to destroy space systems used by the enemy for military purposes. . . . The principal means of anti-space defense are special spacecraft and vehicles." There is no evidence that such "means of anti-space defense" actually existed at the time [8].

Interceptor tests

Since the Outer Space Treaty was signed, there have been two series of satellite experiments, one running between October 1968 and December 1971 and the other starting in February 1976 and perhaps still under way. These tests were described in the *SIPRI Yearbook 1977* and the satellites involved were listed there in table 5.18 [9]. There appeared to have been four different kinds of intercepting technique: (*a*) perigee matching, in which the interceptor makes a rapid swoop past the target at the perigee of its own highly eccentric orbit; (*b*) co-orbiting, in which the interceptor makes a more gradual approach while in a circular orbit similar to that of the target; (*c*) apogee matching, in which the interceptor passes by the target at the apogee of its own first orbit; and (*d*) the "pop-up" system, in which the interceptor enters an orbit much lower than the target, is accelerated to target altitude, and immediately re-enters without completing a full orbit.

There have been three tests the nature of which is not clear. Cosmos satellites 839 and 909, both in high orbits, were followed by one and two satellites respectively which achieved only low orbits for brief periods before re-entering.

In general, the test series indicates a limited and inflexible capability. Most of the intercepts have taken place at altitudes of about 500 km, and all have been at orbital inclinations of between 62° and 66°. At most there have been nine target satellites subjected to 13 intercepts, but in view of the anomalous behaviour of interceptors 843, 910 and 918 it would be safer to conclude that seven targets have been subjected to 10 intercepts of four different kinds over a period of nine years.

The most important limitation exhibited in the tests is that it appears to be necessary for the interceptors to be launched at the same orbital inclination (the angle between the satellite orbital plane and the Earth's equatorial plane) as the target, which limits the chances of intercepting hostile targets once they have been adequately located with respect to Soviet launching sites.

It is still not clear whether the interceptor series represents a destructive capability at all. No target satellites have been destroyed, but it is possible that this may have been because they were needed for re-use (two or three satellites have on occasion been launched against a single target). The fact that both the co-orbiting interceptors were commanded to re-enter for recovery could be interpreted to mean that an inspection role is more likely than a destructor role, for these satellites at least. Possibly the entire series of satellites was involved in trying out various ways of using satellites to inspect other satellites for the same reasons as the USA carries out Space Object Identification (SOI) from the ground. It is worth noting that the tests began at about the time the Outer Space Treaty was signed, indicating perhaps that the USSR was developing a "national technical means of verification" for that treaty.

Table 5.1 summarizes these tests. If only orbital altitudes are considered, the target satellites appear to be simulating the US satellite types shown in column three. However, if account is also taken of orbital inclination, as is done in figures 5.1, 5.2 and 5.3, it becomes obvious that such conclusions are not valid. Figure 5.1 indicates that US satellites of military value occupy a much greater variety of orbits than have yet been simulated by Soviet target satellites.

Figure 5.2 compares the interceptor orbits with those of other Soviet satellites. A greater degree of coincidence is obvious. This suggests that the interceptors may be intended to inspect or destroy any US satellites launched into orbits "occupied" by Soviet military satellites—implying that the interceptors were intended to defend Soviet military satellites against US interceptors, or destroy US satellites jamming or spoofing Soviet ones.

Table 5.1. Soviet interceptor satellite test series

"Target" satellites			"Interceptor" satellites	
Cosmos number	Launch date	Type of US satellite corresponding to altitude of target	Cosmos number	Type of intercept
248	19 Oct 1968	Electronic "ferret"	249	Perigee matching
			252	Perigee matching
373	20 Oct 1970	Electronic "ferret"	374	Perigee matching
			375	Perigee matching
394	9 Feb 1971	Electronic "ferret"	397	Perigee matching
400	18 Mar 1971	Transit navigation	404	Co-orbiting
459	29 Nov 1971	Photographic reconnaissance	462	Perigee matching
803	12 Feb 1976	Electronic "ferret"	804	Co-orbiting
			814	Apogee matching
839	9 Jul 1976	No US equivalent	843	Failed "pop-up"
880	9 Dec 1976	Electronic "ferret"	886	Perigee matching
909	19 May 1977	No US equivalent	910	Failed "pop-up"
			918	"Pop-up"
959	21 Oct 1977	..	961	"Pop-up"
967	13 Dec 1977	No US equivalent	970	"Co-orbiting"

Table 5.2. Soviet satellites sometimes attributed to the interceptor test series

Cosmos number	Launch date	Probable function
85	27 Oct 1967	Precursor target?
217	24 Apr 1968	Precursor target?
291	6 Aug 1969	Failed target?
316	23 Dec 1969	FOBS[a]
516	21 Aug 1972	Test of interceptor manœuvring system?
520	19 Sep 1972	Unknown
521	29 Sep 1972	Fourth generation reconnaissance
752	24 Jul 1975	Unknown[b]
758	5 Sep 1975	Fourth generation reconnaissance
805	20 Feb 1976	Fourth generation reconnaissance
816	28 Apr 1976	Unknown[b]
844	22 Jul 1976	Fourth generation reconnaissance
885	17 Dec 1976	Unknown[b]
891	2 Feb 1977	Unknown[b]

[a] Fractional Orbital Bombardment System.

[b] Cosmos 752, 816, 885 and 891 were put into orbits similar to the most common type of target—the 500-km altitude type—and have been assumed to be targets, the interceptors of which failed on the launch pad. However these four all had an orbital period of 94.6 min whereas the targets all had 96.4-min periods and must be considered to constitute a distinct class with some as yet unexplained function.

Figure 5.1. Comparison of orbits of US satellites of military value with those of Soviet target satellites

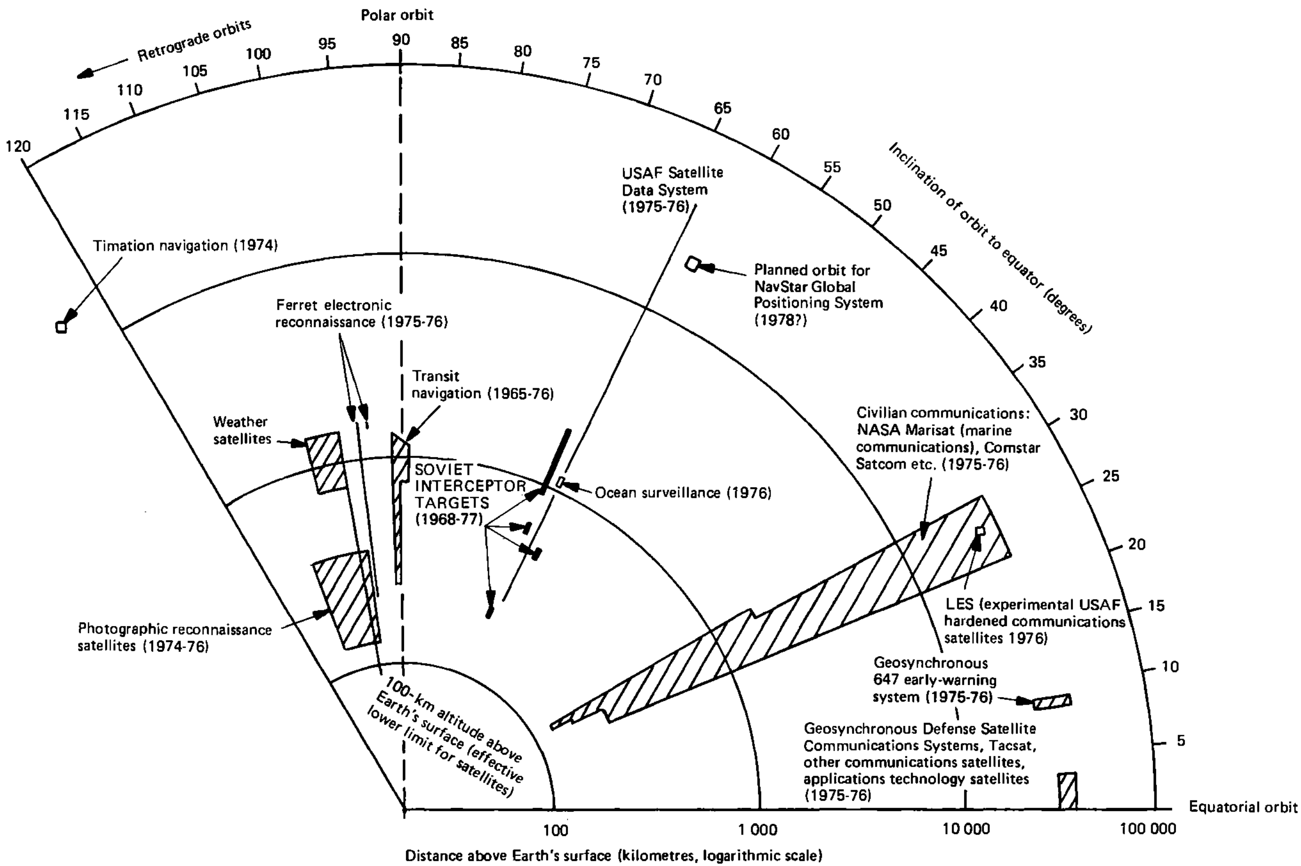


Figure 5.2. Comparison of orbits of interceptors with those of other Soviet satellites

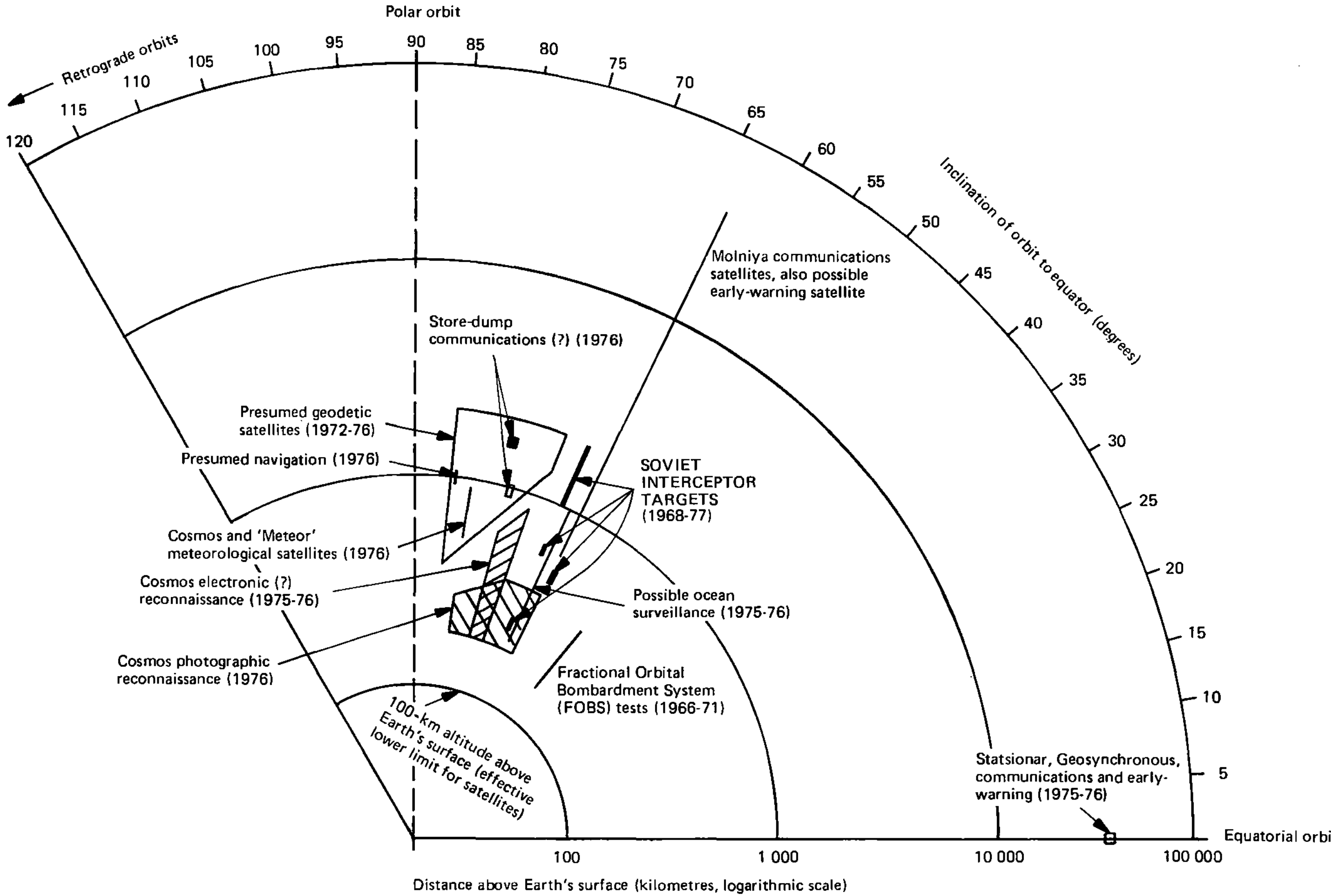
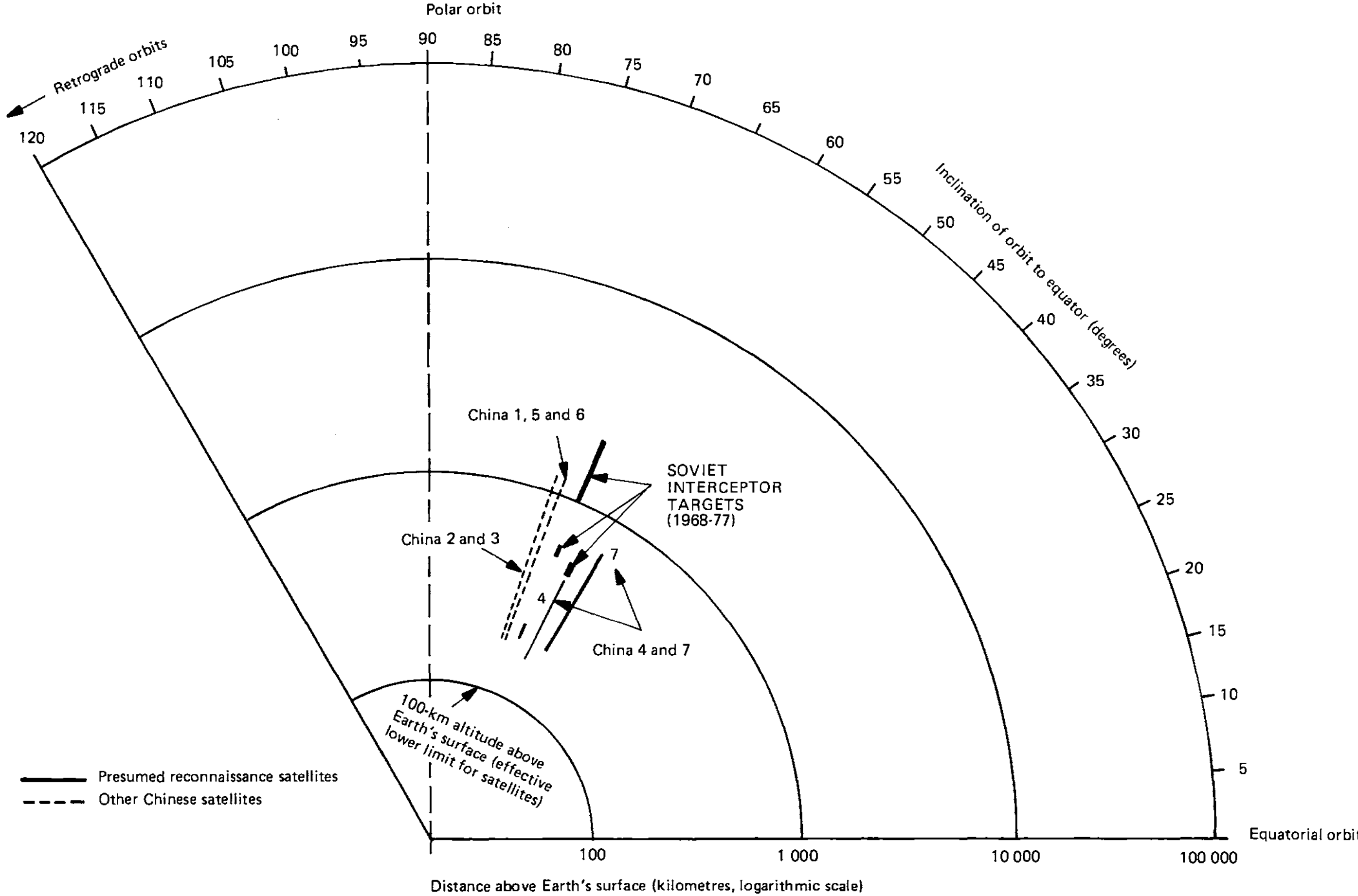


Figure 5.3. Comparison of orbits of Soviet interceptor targets with those of Chinese military satellites



It is also possible that the interceptors are intended to be used in connection with Chinese satellites. Figure 5.3 illustrates the degree of coincidence between Soviet interceptor targets and Chinese military satellites. The timing is also suggestive—Soviet interceptor tests have tended to follow Chinese satellite launches.

Some press commentary has indicated that many more interceptor tests have occurred than are listed in table 5.1. In some cases, the higher figures are arrived at by summing the numbers of targets *and* of interceptors, but there are also a number of other satellites which at one time or another have been considered to be part of the interceptor series. These are listed in table 5.2, together with more probable explanations of their functions.

It has been suggested that the very important US satellites in geosynchronous orbit will be particularly vulnerable to Soviet interceptors, but this seems unlikely in view of the Soviet Union's limited experience in achieving this extremely high orbit. It would be impossible to achieve the element of surprise—it takes about six to eight hours to reach geosynchronous orbit.

Even the new NavStar navigation satellites at 19 300-km altitude orbits are regarded as safe. A USAF spokesman pointed out that these satellites will also "be proliferated around the entire globe so that you could knock a few down and still have a relatively integrated system" [10a].

Much alarm has also been expressed about the possibility of the Soviet Union having made a breakthrough in the use of "directed energy" weapons—that is, beams of high-energy sub-atomic particles (protons, electrons, ions and so on), or high-energy laser beams. Such beams would have the great advantage of travelling at (or almost at) the speed of light. There has also been a good deal of publicity given to the claims of USAF General G. J. Keegan that the Soviet Union is within two years of being ready to operate a particle-beam weapon [11]. If such a weapon is indeed being built, it would be very effective against satellites. However, Keegan's claims have been rejected by the Central Intelligence Agency, the Department of Defense (DoD) and President Carter, and there appear to be fundamental physical reasons why such accelerators cannot yet be built [12]. Reports that US early-warning satellites had been "blinded" by Soviet lasers have been categorically denied by US DoD spokesmen [13].

IV. US surveillance of orbiting objects[1]

Having a capability to destroy hostile satellites presupposes having a capability to monitor all satellites in order to be able to (*a*) identify those

[1] The description of SPADATS is compiled from references [3, 14–20].

which are hostile; (*b*) assign priority for destruction; and (*c*) prepare targeting data which will enable them to be shot down. SPADATS, the Space Detection and Tracking System of the US Air Force, performs these functions in the course of maintaining a general surveillance of all man-made objects orbiting the Earth.

When Sputnik 1 went into orbit in 1957 the USA had only a rudimentary global system for tracking its own satellites. Sputnik prompted the Air Force to set up Project Spacetrack, responsible for "cataloging of all earth satellites and space vehicles" [14]. This evolved into SPADATS which became operational in July 1961 at the Colorado headquarters of the North American Air Defense Command (NORAD).

Among the sources supplying information to SPADATS in the early 1960s were the Navy's Space Surveillance system (SPASUR), the radars of the Ballistic Missile Early Warning System (BMEWS), Minitrack, Moonwatch, the Mercury Man-in-Space tracking network, several FPS-17 radars, the missile ranges and their tracking radars, and a world-wide network of Baker-Nunn cameras.

From the start there appears to have been a clear distinction between SPADATS and other satellite-tracking systems. SPADATS had the mission of cataloguing *all* objects—US, Soviet and any others—in orbit, but it catalogued US satellites only so that they could be distinguished from possibly hostile ones. SPADATS was not intended to monitor, interrogate, or in any way support US satellites, although it did undertake specific tracking operations on a "no interference" basis at the request of other agencies. Other US tracking networks were dedicated to the needs of US satellites.

In succeeding years, the term SPADATS continued to be applied to the overall network of space surveillance sensors and the central data-processing and catalogue facility, while the name Spacetrack was used to denote all those sensors operated by the USAF primarily for space surveillance. Thus SPADATS comprises Spacetrack plus other contributing systems, including the sensors described below.

Phased array radars

Phased array radars as used for satellite tracking consist of several thousand individual transmitters arranged in a physically enormous array. Whereas in a conventional radar a beam is swept across the sky by mechanically rotating the radar antenna, in a phased array the times of emission of radio pulses from the individual transmitters are varied in a systematic pattern across the face of the array to form a beam which can be electronically swept across the sky in millionths of a second. The agility thus imparted to the beam allows the radar to search for unknown objects across 120° of azimuth,[2] from horizon to zenith,[3] while simultaneously tracking up to 200 already acquired targets. In a typical 24-hour period such a radar will make 10 000 separate observations. The capabilities are classified but it is believed that satellites can be tracked at distances of 6 500 km, and it is said that this radar can detect "a basketball sized object" up to 3 000 km away. Recent advances may have made it possible to detect large satellites in geosynchronous orbit [21].

At present SPADATS includes two phased array radars. One was built at Eglin Air Force Base in Florida in 1967 and consists of 5 000 transmitters and 4 000 receivers. It is as high as a 13-storey building, and as long as a city block. Its beam is directed southwards, and most satellites pass through the beam twice a day. About 30 per cent of the radar capability is used for surveillance (that is, search), 50 per cent is for tracking specific satellites, and 20 per cent is for early warning of sea-launched ballistic missile attack.

In 1975 a second phased array radar, called Cobra Dane, became operational at Shemya Island, in the Aleutian group. The array here includes 15 360 transmitters and has a peak power output of 15.4 MW and an average output of 920 kW. Specifications called for the accuracy to be within 0.05° of arc and within five metres range on a single measurement. Special wave-forms were used to correct for ionospheric propagation errors and different wave-forms can be generated simultaneously for optimum tracking of different objects. Coverage extends northwards over an arc from Khamchatka to the Bering Strait, allowing it to be used (*a*) for tracking satellites in polar and near-polar orbits; (*b*) for observing Soviet missile test re-entry vehicles; and (*c*) as a supplementary ballistic missile early-warning system radar, in which mode it can simultaneously predict impact points for up to 200 warheads [22].

A third phased array radar, called Cobra Judy, is currently under consideration. It will be mounted on a ship which will be on patrol in the north Pacific Ocean to supplement the coverage of Cobra Dane, particularly of Soviet missile tests.

SPASUR

SPASUR is one of the oldest components of SPADATS. It consists of a "fence" of radio transmitters across the southern part of the USA which directs radio energy upwards in a fan-shaped beam. Satellites passing through this beam reflect some of this energy back to Earth, where it is detected by several arrays of dipole antennas—a form of cheap, un-

[2] Arc of the heavens extending from the point directly above the observer to the horizon, which it cuts at right angles.
[3] Point of the heavens which is directly above the observer.

sophisticated antenna not unlike a television receiving aerial. The distance to the satellite is determined by measuring the time taken for a radio pulse to be reflected and the direction of the satellite is determined by comparing the times of arrival of reflected pulses at adjacent stations.

BMEWS

The BMEWS consists of three large radar installations located in Alaska, Greenland and the UK so as to allow detection of missiles launched from the Soviet Union across the Arctic towards the United States. When these radars became operational between 1960 and 1963, satellites were tracked for calibration purposes and subsequently the system mission was expanded to include detection and tracking of satellites as part of SPADATS. By 1970 the BMEWS was generating about 70 per cent of the 400 000 satellite observations per month being made by SPADATS. Each BMEWS site consists of stationary AN/FPS-50 antennas directing a fan of radio energy into space for detection, and steerable AN/FPS-49 dish antennas within radomes to track targets acquired by the fans. The three sites provide overlapping coverage. BMEWS radars originally allowed tracking out to a range of about 1 300 km, later increasing to about 5 000 km. Accuracy is less than for other radars, however.

Other radars

Originally SPADATS included a large number of other radars of lesser capability than those described above. Many of these have now been closed down, or no longer function as part of SPADATS. One site is said to be particularly important—the FPS-16 radar fans located in Diyarbakır in Turkey—closed down in the aftermath of the 1974 Cyprus War. This fan detects satellite launches and missile test launches from Tyuratam. An important AN/GPS-10 tracking radar at Ko Kha in Thailand was also closed down at the request of the Thai government.

The two main US missile test ranges also contribute to SPADATS. The Eastern Test Range extends south-east from Florida into the south Atlantic and Indian Oceans, while the Western Test Range extends from California westwards across the Pacific Ocean to Kwajalein. Missile-tracking radars are located on islands along both these ranges, and these contribute to SPADATS on a "no-interference" basis.

A further world-wide network of tracking radars operates as part of the USAF Satellite Control System (SCS), reponsible for tracking, controlling and interrogating US military satellites. Originally the SCS had ground stations in Alaska, California, Greenland and New Hampshire—all located well to the north because military satellites are mostly in near-polar orbits and high-latitude stations thus have a better chance of being within useful range of a satellite for a greater proportion of passes. More recently, the SCS has acquired ground stations in the Seychelles (Indian Ocean), and on Guam, while one of the secrecy-shrouded stations in Australia is also believed to be part of the SCS.

One important function of these radars is that they allow transmitting satellites to be tracked many thousands of kilometres beyond the range of other radars. This allows satellites at geosynchronous altitudes and beyond to be "acquired" so that "look angles" can be generated for the Baker-Nunn cameras which provide the only way of tracking those satellites when their beacon transmitters are, for one reason or another, not operating.

Optical sensors

The principal optical sensor in SPADATS is the Baker-Nunn camera. This type of camera was originally designed at the request of the Smithsonian Astrophysical Observatory in the mid-1950s in preparation for International Geophysical Year satellite launchings. Twelve of these cameras were then deployed world-wide for tracking US satellites. They are still in use today, mainly for high accuracy tracking of geodetic satellites. The USAF bought a further six cameras at about the same time and these are today operated in Italy, New Zealand, California, South Korea and at two Canadian sites.

A Baker-Nunn camera is basically a three-ton telescope whose design has been optimized to collect the maximum amount of light from faint objects. The positions of satellites can be determined to a high degree of accuracy by measuring the positions of their photographic images relative to the star background. The Baker-Nunn is "the most sensitive and precise satellite tracking instrument in the Space Defense System" [23] and has successfully photographed the light reflected from an object "the size of a football" at a height of over 4 000 km. This sensitivity allows it to photograph satellites as far away as 40 000 km—well beyond the range of the radars. This long range is vital to SPADATS because many important military satellites operate at geosynchronous altitudes of about 35 000 km.

Amongst important geosynchronous satellites are the 647 early-warning and the Defense Satellite Communications System. Other satellites of military interest may have perigees of only a few hundred kilometres, but have highly elliptical orbits extending out to many thousands of kilometres, so that they spend most of the time beyond the reach of radar. Included in this category are many military research satellites collecting data on the magnetosphere (of importance in communications systems), and the Molniya series of Soviet communications satellites.

Molniya satellites are maintained in very distinctive orbits, of 63° orbital inclination, perigees of about 500 km in the Southern Hemisphere, and apogees of about 40 000 km over the Soviet Union. Such orbits are chosen because the apogees remain fixed over particular longitudes and drift only very slowly from north to south. The resulting stable configuration allows the Soviet Union to maintain communications links over its entire territory with only three satellites, although in practice four are currently used. The high apogees make each satellite usable over a very wide area, from the Arctic Ocean to south of the equator.

The same features of the Molniya orbit make it difficult for the USA to track. While over the Northern Hemisphere, it is outside the range of SPADATS radars. In the Southern Hemisphere there are no suitable radars, and in such a highly ellipsoidal orbit a satellite being tracked from near sub-perigee has a large velocity component along rather than across the line of sight, thus requiring high angular resolution by the tracker. The siting of a Baker-Nunn near the southern apex of New Zealand was an economical and efficient way of solving the problem.

The other important attribute of the Baker-Nunn is the accuracy with which satellite positions can be determined using Baker-Nunn data. This high accuracy is obtainable because satellite altitude/azimuth is determined by measuring satellite position relative to star background, thus eliminating errors due to atmospheric refraction.

Limitations of the Baker-Nunn are (*a*) that it operates only in clear weather and during those hours of darkness when satellites are still illuminated by the Sun; (*b*) that it has a slow data acquisition rate (several minutes to get a fix on one satellite); and (*c*) that it has a slow response time (typically 60 minutes or more to process film and measure image positions).

Other sensors

The National Aeronautics and Space Administration (NASA) and various other civilian sensors are also listed officially as contributing to SPADATS. It also seems probable that the 647 early-warning satellites would pass on notifications of detected satellite launches.

The accuracy of these SPADATS sensors is illustrated by the standard deviation figures shown in table 5.3.

The Space Defense Center

The data from the above sensors is transmitted to the Space Defense Center (SDC), a part of NORAD's Combat Operations Center, located at Cheyenne Mountain beneath 350 m of granite mountain and sealed off by blast-proof doors. The SDC processes something like 10 500 data inputs

Table 5.3. Accuracy of SPADATS sensors[a]

Sensor	Range *m*	Azimuth	Elevation
Diyarbakır	100	0.091°	0.084°
Shemya (old)	74	0.035°	0.041°
Shemya (new)	5	0.005°	0.005°
SPASUR	1 200	-	0.005°
Baker-Nunn (precision mode)	17	0.001°	0.001°

[a] The Cobra Dane figures are unofficial and represent design goals rather than achieved performance.

per day to yield a catalogue of all artificial objects in orbit (currently about 4 000) together with continuously updated orbital elements.

The functions of SPADATS

The catalogue of orbiting objects has a number of uses:

1. It forms the only body of US-compiled information about the total population of orbiting objects. NASA and other satellite-tracking networks compile information only about the particular classes of satellites they themselves support. Some of the space catalogue data are provided to NASA, which publishes them in the form of a fortnightly *Satellite Situation Report* and as a daily computer print-out of orbital elements. These are publicly available, but there is much information about US satellites that is withheld. Data on the size, shape, and presumed function of satellites are not recorded, and the orbital elements of some US satellites, particularly the early-warning satellites, are withheld altogether.

2. SPADATS monitors and predicts the orbital decay of satellites and space waste. This allows identification of any space debris which survives re-entry and impacts on the Earth's surface.

3. SPADATS, together with some other data sources to be described below, constitutes the principal source of intelligence on the status and development of Soviet space programmes. Such intelligence is vital in estimating the threat potential of satellite systems and in monitoring compliance with the Outer Space Treaty.

4. SPADATS, together with the other data sources, acts as an early-warning system against attack by space-borne weaponry. Although the possibility of this kind of warfare seemed to be one of the main declared reasons for building an anti-satellite capability and a space detection and tracking system, it is generally acknowledged that such a form of attack is unlikely.

5. SPADATS helps to reduce the false alarm rate in the other warning systems such as BMEWS, by allowing identification of low-flying or re-entering objects which might otherwise be mistaken by warning sensors for incoming ballistic missiles.

6. SPADATS provides the targeting data for the Project 437 anti-satellite missile system, and any other anti-satellite systems that might be operational.

This link between SPADATS and anti-satellite weaponry has been denied on occasion, but is officially documented. A 1970 report to the Senate Committee on Aeronautical and Space Sciences, for example, referring to the Johnston Island missiles, said: "This program, an anti-satellite system employing the Thor missiles which can reach into space to effect an intercept . . . uses SPADATS tracking data to predict time and location of intercept" [24]. John Foster, then Director of Defense Research and Engineering, told the House Government Operations Committee in 1966 that both the Johnston Island and the Kwajalein missiles used SPADATS for targeting data [25].

Space Object Identification

The data sources described so far are mostly those used for the relatively straightforward determination of satellite orbits. It is inconceivable, however, that the USAF would rest content with simply knowing where Soviet satellites were or will be, without also trying to find out what sort of satellites they are. Much can, of course, be guessed about function from the orbital parameters—the various types of military satellite all have different optimum altitudes, inclinations, and so on. But to know more definitely the functions and capabilities of a satellite, one needs to monitor its telemetry, and to estimate its size and shape. Some of the data sources for what the USAF calls Space Object Identification (SOI) are described in the sections below.

Electro-optical sensors

The USAF maintains facilities at Cloudcroft, New Mexico and at Haleakala, Hawaii for electro-optical observation of spacecraft. Among the devices experimented with is the AN/FPS-2 "optical radar" which uses electronic detectors rather than photographic film to record the light collected by a telescope to yield an "optical signature" of any particular satellite. The surface nature of the satellite can be determined from spectral analysis, and such characteristics as tumbling rate and shape can be determined from the time-varying intensity of the reflected light. Another instrument, called LARIAT (Laser Radar Intelligence Acquisition

Technology), is equipped with a laser which can be used to determine whether any particular satellite has an optical surveillance capability by reflections from any camera lenses aboard the satellite. The laser also allows the satellites to be observed at times when they are not illuminated by sunlight. LARIAT is operated at Cloudcroft and at the Haleakala site. The Baker-Nunns also contribute to SOI.

Interception of telemetry

The other obvious way of obtaining information about a satellite is by eavesdropping on its telemetry signals. The network of SCS stations have telemetry reception antennas and presumably spend some of their time attempting to intercept telemetry from foreign satellites. The National Security Agency (NSA) is reputed to have 2 000 listening posts around the world for intercepting the electronic communications of other nations. These posts are mostly located within US military bases and are operated by uniformed personnel. Satellite telemetry equipment, which need not be very complex, is undoubtedly operated at these listening posts. One defecting NSA operator who worked at an NSA post in Turkey has claimed that at that post the NSA recorded "everything" about the Soviet space programme [26], while another has said that NSA installations in Iran and Australia monitor missile telemetry from Tyuratam test missile launches [27]. Satellite telemetry would involve similar techniques and equipment.

Radar analysis

The radio energy reflected from a satellite can be recorded as a radar signature which can be analysed by techniques similar to those for the optical signature to yield information about the nature of the satellite. The Eglin phased array radar can determine "considerable information on the size, shape, and general configuration of each object in space" so that the radar can distinguish between various types of payloads, rockets and fragments. The Shemya phased array radar will also contribute to SOI by determining "precise size measurements and target signatures in the form of coherent narrow band and wide cross-section measurements" [22]. SOI analysis is undertaken at the Space Defense Center [15]. SPADATS provides SOI threat analyses to National Command authorities, the Joint Chiefs of Staff, and the US intelligence community.

Upgrading US space surveillance

Along with moves towards an upgraded satellite destruction capability for the USA, there are moves towards upgrading the capabilities of SPADATS. According to fiscal 1976 and 1977 testimony, geographic gaps in coverage must be eliminated, and, more importantly, real-time surveillance out to geosynchronous altitudes must be achieved.

Donald Rumsfeld, in his fiscal 1977 report, wrote:

> As space technology matures, space-based systems will play an even more important role in support of US and Soviet military operations. In the future, dependence on these systems may increase to the point where their loss could materially influence the outcome of a conflict. Consequently, it is important to know of any threat to US space activities and remain alert to Soviet activities. Defense is continuing R&D efforts to develop technologies for detecting, tracking, and identifying objects out of geostationary orbit and for enhancing survivability of satellite systems, at the same time abiding by the provisions of the various space treaties [28].

These goals are being approached from two directions: (*a*) by attempting to give optical sensors the real-time and area-search capabilities of the radars, and (*b*) by attempting to extend the detection range of the radars out to the geosynchronous distances currently covered only by the optical sensors.

The principal improvement in optical sensing involves replacing photographic film with electro-optical devices. This has resulted in a system called GEODSS—the Ground Based Electro-Optical Detection and Surveillance System—which uses fibre optics and low-light level television to enable it to act as a real-time surveillance sensor, operating in either search or tracking modes similar to those of the radars, but retaining the long-range sensitivity and accuracy of an optical system. GEODSS will automatically detect any new objects not stored in the star field catalogue or which are not moving in synchronization with the star field. Orbital parameters are calculated automatically for real-time transmission to SPADATS computers. The telescopes are also expected to provide imagery useful for identification of space objects [29]. The Air Force has allocated about $20 million for replacing the Baker-Nunns with GEODSS at five sites spaced at equal intervals of longitude around the globe in the vicinity of the equator [76].

The large phased-array radar concept is being refined to enable radar coverage out to geosynchronous altitudes. The principal obstacle hitherto has been the high cost of increasing the size of the antenna array to enable detection of small passive objects at geosynchronous altitudes. New techniques recently developed will allow the transmitter units to be built much more cheaply.

Another problem is that of improving SOI capabilities. Here also improvements to both optical and radar sensors are envisaged. Optical images are subject to distortion produced by rapid variation in the atmosphere's refractive index and other optical properties—the same phenomena which make stars "twinkle". To counteract this, compensated imaging systems are being developed in which servo-operated deformable optics compensate in real time for the atmospheric distortions. The imaging properties of radar are also being improved, by using shorter wavelengths to improve the resolution and information content of images. A more advanced concept involves combining data from two co-located radars operating at different frequencies to classify satellites by shape.

Meanwhile geographic coverage is being extended. A still classified programme called Seek Sail will fill a "critical gap" in SPADATS coverage in the Pacific [30].

In the long term, SPADATS is also likely to develop a space-borne surveillance capability, according to M. Currie:

For the more distant future we are seeking a solution which does not require foreign basing and provides rapid surveillance coverage. We believe the best approach is the use of satellite borne long-wave infra-red (LWIR) sensors. We are therefore emphasizing the development of components critical to this approach such as LWIR sensors and cryogenic coolers. The launching of an experimental satellite ... [is] planned [10b].

The long-wavelength approach is intended to solve the "dark satellite" problem. At present it is possible to hide a satellite from optical sensors by painting it non-reflective black. Such a light-absorbing satellite will, however, heat up and radiate energy in the LWIR portion of the electromagnetic spectrum [7c]. The feasibility of radars in space for satellite tracking is also being investigated.

V. Soviet surveillance of orbiting objects

Virtually nothing is known about Soviet systems for maintaining surveillance over non-Soviet space vehicles. This section is therefore much briefer than the previous one, but this should not be taken to indicate that Soviet surveillance of space is less important than is US surveillance.

Some Soviet capabilities can be inferred. It is known for instance that the Soviet Union has optical sensors which, superficially at least, resemble the US Baker-Nunn cameras. It is known that they monitor their own space probes at distances of 250 000 km and more.

The ability to operate the Galosh missiles around Moscow in an ABM mode implies a capability to track non-cooperative targets, including foreign satellites. The antenna arrays for this purpose are designated "Hen House" in the West.

Exceptionally large fixed array tracking antennas, some apparently more than 3 000 feet in length, at least one approaching 6 000 feet, have been observed near Russian space and missile launch sites. Other large phased array radars, including a 400 foot long array called Doghouse, are part of the Russian ABM system. A large VHF phased array radar centred in the 150 to 200 Mc range is at Sary Shagen bordering

Lake Balkhash. These facilities employ complicated signal processing, otherwise perhaps one of the weakest links in the Soviet radar spectrum [31].

The main deep-space tracking site (for interplanetary missions and so on) at Yevpatoriya in the Crimea uses two sets of steerable dishes which can move along rail tracks so as to function as an interferometer, thus allowing very accurate distance measurements. Another deep-space site is located near Vladivostok. These facilities may also be used for monitoring foreign satellites (as Britain's Jodrell Bank was formerly used by SPADATS) [32].

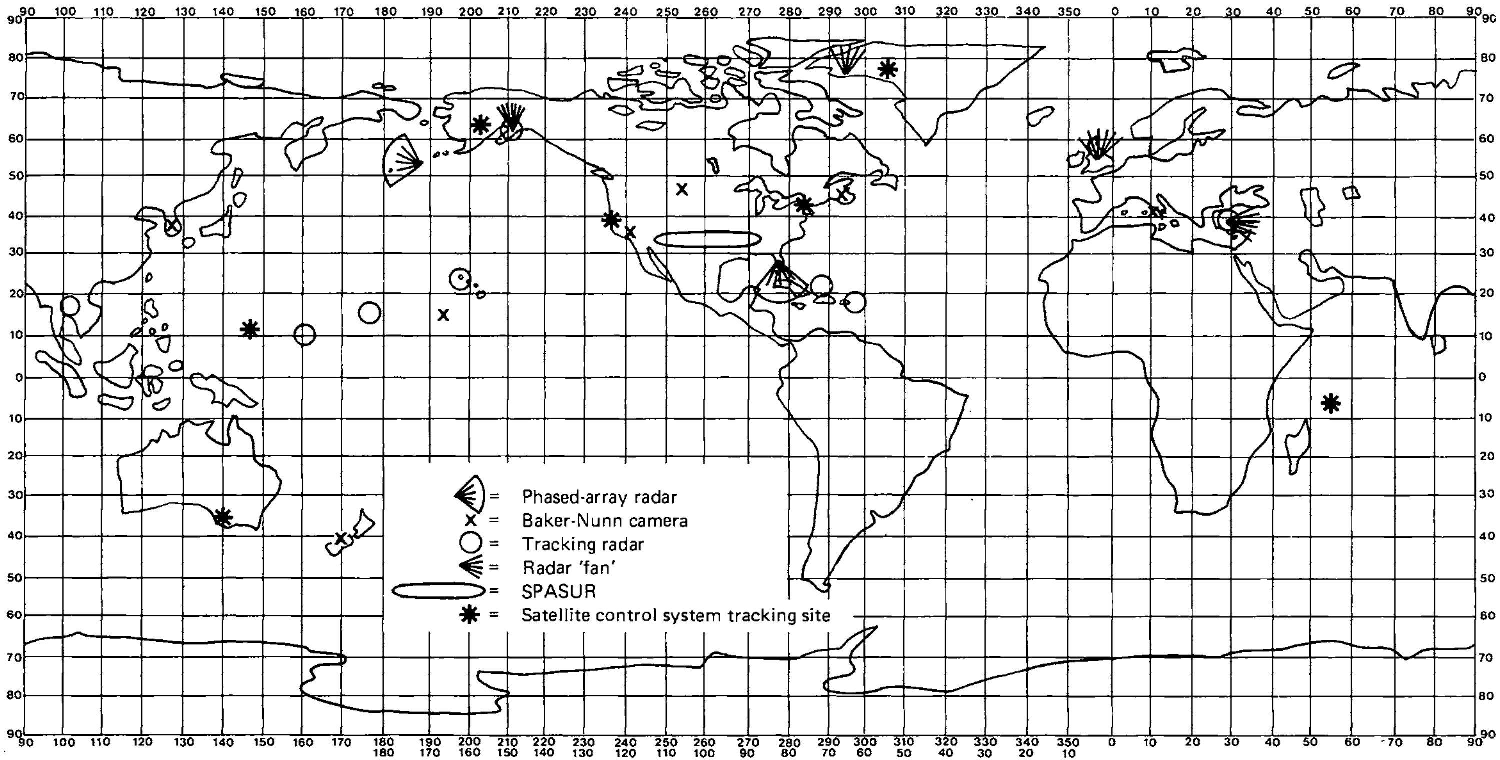
The Soviet Union has one possible space-tracking advantage in that, with territory stretching over two and a half times as many degrees of longitude as the USA, a Soviet domestic tracking system can be more effective than its US equivalent. However, the USA has more than compensated for this disadvantage by the construction of tracking stations overseas.

From figure 5.4 it can be seen that the USA has about 24 radar sensors scattered fairly evenly in all longitudes. If each sensor is assumed to be limited by the Earth's curvature to an operational range of about 800 km for satellites at reconnaissance altitudes, then the current distribution would allow even a low-altitude satellite to be tracked at least twice on each orbit. The Soviet Union by contrast has the potential for longitudinal coverage over about 180° of longitude with domestic tracking sites alone, allowing low-altitude satellites to be monitored on only 10 orbits out of every 16. The USSR has attempted to improve this situation with overseas sites and tracking ships.

Overseas facilities have been much more limited than those of the USA, but have at various times included sites in Chad, Cuba, Guinea, Mali, the United Arab Republic and other countries. Sites in north Africa would principally be of value during the recovery of domestic vehicles, which approach the landing area on a north-eastward path across Africa. A tracking site in Cuba would be valuable for monitoring US launches from Cape Kennedy and for controlling the injection of deep space probes from parking orbits into escape trajectories (such as to other planets). Moreover, Cuba, at 80°W, forms an imperfect triangle with the Vladivostok and Crimea sites, and together these three sites would have the potential for monitoring all geosynchronous satellites, US or other. Tracking may also be done in the Sudan, Somalia, the French island of Kerguelen (South Indian Ocean), and at Mirnyy, in Antarctica. It is probable that the Soviet Union is interested in having a more dispersed network, and it is known that it wanted to track from Indonesia, Chile and Australia. An Australian site would be particularly valuable for tracking its own satellites and approaches to the Australian government have been made on at least three occasions—in 1962, in 1971 and in 1974.

The USSR has partially overcome its lack of widely distributed ground

Figure 5.4. US surveillance tracking sites, excluding those of NASA



tracking stations by building an impressive fleet of space tracking ships. Twenty-two such vessels are listed in *Jane's Fighting Ships 1976–77* [33]. These appear to be used mainly for tracking Soviet space vehicles, especially manned vehicles, and for down-range tracking of missile tests.

One group of big vessels, equipped with large radomes and numerous antennas and optical devices, is located in the Pacific with the mission of monitoring Soviet missile tests impacting in the North Pacific. From the Pacific they could also monitor Soviet satellites on their first revolutions. These ships are operated by the military.

Space-tracking ships in the Atlantic appear to be operated by the Soviet Academy of Sciences. Formerly they were much less well equipped than the Pacific ships, but now they are equally sophisticated. They also operate in the Indian Ocean to support particular Soviet missions. The largest tracking ship displaces 45 000 tons, and has 120 laboratories and over 100 antennas.

Analysis of the movements, port calls and so on, of the Soviet tracking ships suggests that they are concerned principally with tracking and command of, and telemetry reception from, Soviet space missions, rather than surveillance of US satellites. They have, however, been observed monitoring US launchings from both Kennedy and Vandenberg, and have been present at Apollo splashdowns [34]. It might very tentatively be concluded from this that the Soviet Union has a more restricted capability than the USA for detection and tracking of both its own and foreign satellites.

VI. Conclusions

At the beginning of the space age, in the late 1950s and early 1960s, it appeared that "space war" was just over the technological horizon. However in the following 10 years or so, both sides seemed to show a degree of restraint in their military use of space. Each side made use of space for missions such as reconnaissance. It is true that, early on, the USA deployed a system for destroying Soviet satellites, and towards the end of the period the Soviet Union apparently worked on the development of an equivalent system. But overall, military use of space tended to be what might be described as "passive". Initially these passive functions were related mainly to strategic war-fighting capability and this gave the satellites a degree of immunity.

At present it appears that a new arms race in space is under way. The existence of the Soviet interceptor programme and the alleged Soviet development of directed-energy weapons are being cited in the West as a reason for complementary efforts of its own. Evidence that the Soviet Union has used satellites for tactical purposes in recent limited wars (and no doubt the certain knowledge that the USA has done the same), and the alleged use of satellites for missile guidance are also given as reasons why the USA must be able to destroy Soviet satellites.

Much of the recent research has been directed towards development of non-nuclear kill mechanisms. This may be in recognition of the limited destructiveness of a nuclear explosion in the vacuum of space where there are no blast effects, or it may be to make it more feasible and politically simpler to destroy hostile satellites during future limited wars—in other words, to lower the threshold for initiating space warfare.

Because of the fuzzy distinction between the tactical and strategic usefulness of satellites, it would be easy for an attack against satellites as a move in a limited war to be interpreted by the satellites' owners as the opening move in escalating a local conflict into a general and strategic conflict.

It is conventionally stated or implied that anti-satellite weapons are "defensive". It is argued, for instance, that US anti-satellite weaponry will defend US space systems against Soviet attack. This is not purely defensive, however. For one thing, many of those supposedly threatened space systems are themselves part of offensive systems—Transit satellites are part of the guidance system for Polaris/Poseidon missiles, for example, and NavStar satellites could provide hard target accuracy to Trident missiles. Secondly, ground-launched anti-satellite weapons directed against already launched anti-satellite weapons are not a feasible way of defending against anti-satellite attack. All the advantages lie with the offensive anti-satellite weapon in such an encounter. In particular any such weapon would be so far on its way towards its target before its mission could be deduced from tracking its trajectory or orbit that a defensive anti-satellite weapon would not be able to catch up with it. This would be particularly true if the Soviet Union has, as alleged, acquired a first-orbit intercept capability.

The logical way of defending satellites against hostile interference is to mount passive and/or active defences on board the satellites to be defended, and this in fact is what the USA is currently doing. The aerospace press contains numerous references to satellites being "hardened" against nuclear-induced electromagnetic impulses (EMP), to the development of proximity warning devices and on-board defensive weapons, and to the survivability of satellites being enhanced through redundancy. The USA is also contemplating more use of very high altitude orbits, thought to be safer from attack, and is considering keeping "dark/silent" satellites in orbits ready to take over when active satellites are disabled. For the particularly important early-warning function, the USA is considering developing small, cheap, short-lifetime versions of the present very complicated satellites which could be launched "in an unconventional manner" from previously unused launch sites so as to escape detection and tracking. These would then take over from the more easily identified and located operating early-warning satellites.

References

1. "Space Intercept Programs 437, 505, 706, 922", *DMS Market Intelligence Report*, DMS Inc., Greenwich, Conn., January 1968.
2. "Satellite Killers", *Aviation Week and Space Technology*, Vol. 104, No. 25, 21 June 1976, p. 13.
3. Ulsamer, E., "Strategic Warning, Cornerstone of Deterrence", *Air Force Magazine*, Vol. 57, No. 5, May 1974, pp. 40–47.
4. Anureyev, I. I., "Antimissile and Space Defense Weapons", JPRS 57378, US National Technical Information Service, p. 234. Translated excerpts from *Oruzhiye Protivoraketnoy i Protivokosmicheskoy Oborony*, Moscow, 1971.
5. Kempster, N., "New Secret Satellite-Killer Project is Revealed", *International Herald Tribune*, 31 March 1977.
6. "Satellite Proposal", *Aviation Week and Space Technology*, Vol. 106, No. 11, 14 March 1977, p. 24.
7. *Department of Defense Appropriations, Fiscal Year, 1977*, Hearings before the Committee on Appropriations, US House of Representatives, 94th Congress (US Government Printing Office, Washington, 1976.)
   (a) —, Part 4, p. 929.
   (b) —, Part 4, p. 349.
   (c) —, Part 4, p, 926.
8. Freedman, L., "The Soviet Union and 'Anti-Space Defence' ", *Survival*, Vol. 19, No. 1, January/February 1977, pp. 16–23.
9. *World Armaments and Disarmaments, SIPRI Yearbook 1977* (Almqvist & Wiksell, Stockholm, 1977, Stockholm International Peace Research Institute), pp. 103–79.
10. *Authorization For Military Procurement, Fiscal Year 1977*, Hearings on S.2965 before the Committee on Armed Services, US Senate, 94th Congress (US Government Printing Office, Washington, 1976).
    (a) —, p. 3750.
    (b) —, Part 4, p. 2110.
11. Robinson, C. A., "Soviets Push for Beam Weapon", *Aviation Week and Space Technology*, Vol. 106, No. 18, 2 May 1977, pp. 16–23.
12. Walgate, R., "Russia's Incredible Beam Weapons", *New Scientist*, Vol. 74, No. 1052, 19 May 1977.
13. "Denial Renewal", *Aviation Week and Space Technology*, Vol. 105, No. 22, 29 November 1976, p. 11.
14. North American Air Defense Command, "SPADATS Sensor Tasking Manual", *NORAD Manual 55–13*, 1975.
15. North American Air Defense Command, *NORAD Fact Sheet*, 1 July 1974.
16. "Keeping Track of Earth Satellites", *Spaceflight*, Vol. 12, No. 1, January 1970, pp. 2–7.
17. Klass, P. J., "Spadats Network Relies on Varied Sensors", *Aviation Week and Space Technology*, Vol. 78, No. 7, 18 February 1963, pp. 89–97.
18. North American Air Defense Command, "Operations: SPADATS Sensor Tasking", *NORAD Regulation 53–13*, Vol. 1, May 1975.
19. Thomas, S., *Satellite Tracking Facilities: Their History and Operation* (Holt Rinehart & Winston, New York, 1973).
20. "Baker–Nunn Cameras in the USAF Spacetrack System", Fourteenth Aerospace Force, System Brochure: 14AFP 55-28, 1972.

21. Klass, P. J., "FPS-85 Radar Expands to Cover SLBMs", *Aviation Week and Space Technology*, Vol. 98, No. 8, 19 February 1973, pp. 61–66.
22. Klass, P. J., "USAF Tracking Radar Details Disclosed", *Aviation Week and Space Technology*, Vol. 105, No. 17, 25 October 1976, pp. 41–46.
23. "Aerospace Defense: Background Information", *SAFOI Pamphlet 69-6*, Secretary of the Air Force, Office of Information (US Air Force, Washington, 1969).
24. *Report on NASA Authorization for Fiscal Year 1971*, Senate Committee on Aeronautical and Space Sciences (US Government Printing Office, Washington, 1970), p. 98.
25. *Missile and Space Ground Support Operations*, Hearings before the Committee on Government Operations, US House of Representatives (US Government Printing Office, Washington, 1966), p. 49.
26. "US Electronic Intelligence: A Memoir", *Ramparts Magazine*, August 1972.
27. "Uncle Sam and His 40,000 Snoopers", *Nation Review* (Australia), 5–11 October 1973.
28. Rumsfeld, D., *Annual Report of the Department of Defense, Fiscal Year 1977*, presented to Congress 27 January 1976, p. 74.
29. *Authorization for Military Procurement, Fiscal Year 1976*, Hearings on S.920 before the Committee on Armed Services, US Senate, 94th Congress (US Government Printing Office, Washington, 1975), Part 6, p. 2704.
30. *NASA Authorization for Fiscal Year 1977*, Hearings before the US Committee on Aeronautics and Space Sciences, US Senate (US Government Printing Office, Washington, 1976), Part 3, p. 2031.
31. Miller, B., "Soviet Radar Expertise Expands", *Aviation Week and Space Technology*, Vol. 94, No. 7, 15 February 1971, pp. 14–16.
32. Sheldon, C. S., *Soviet Space Programs, 1971–75*, Staff Report Committee on Aeronautical and Space Sciences, US Senate (US Government Printing Office, Washington, 1976), p. 66.
33. *Jane's Fighting Ships 1976–77* (Macdonald, London, 1977).
34. Oberg, J., "Soviet Tracking From the Sea", *Flight International*, Vol. 104, No. 3375, 15 November 1973, pp. 828–29.

Part II. Developments in world armaments

6. Military expenditure

Square-bracketed numbers, thus [1], *refer to the list of references on page 140.*

I. The world-wide trends

In 1977 world military expenditure continued the gradual rise which since 1968 has averaged less than 1 per cent per year, although over a longer period it has increased at a much larger average annual rate in real terms (see appendix 6A for the tables of world military expenditure for the period 1957–77).[1]

In 1976, for example, the world spent on the military about $325 thousand million (in current prices),[2] that is, as much as it spent on health and more than it spent on education. This was in spite of the facts that about 570 million people in the world are undernourished, about 2 800 million people are without safe water (water-borne diseases actually kill some 25 000 people per day), about 1 000 million lack adequate housing, about 1 500 million lack effective medical care, about 250 million children do not attend school, and 800 million people are totally illiterate [1].

World military expenditure is equivalent to nearly two-fifths of the combined gross domestic product (GDP) of all Third World countries. It is about equal to the combined income of three-quarters of the poorest inhabitants of the Third World. It is roughly the same as the total GDP of Latin America, and twice that of all the countries in Africa. It is 14 times the development aid from industrialized countries to the Third World.

While in the past decade military expenditure (in constant 1973 dollars), has risen by some 13 per cent world-wide, its distribution has been changing. Ten years ago, NATO and the Warsaw Treaty Organization (WTO)—the major alliances of industrialized countries—spent 81 per cent, and the Third World (excluding China) spent about 6 per cent. By 1977 expenditure by NATO and the WTO, although the same in absolute terms, accounted for 71 per cent of the world total, while the share of the Third World had steadily increased to over 14 per cent.

[1] See also chapter 10, page 301.

[2] If the US intelligence estimate of the dollar-cost in the USA of 1976 Soviet defence activities ($126 000 mn) is used instead of the SIPRI estimate of Soviet military expenditure ($61 100 mn) then total world military expenditure in 1976 would approach $400 000 mn.

SIPRI adjusts the defence expenditure figure in the budget of the Soviet Union to reflect its view that the costs of some Soviet defence activities are probably not covered or not wholly covered by the budget allocation to defence, and uses a SIPRI-estimated exchange rate to convert the adjusted figure into dollars (for details of the SIPRI methodology see reference [7]). The US intelligence figure is an estimate "of the costs in the United States of producing and manning a military force of the same size and with the same inventory of weapons as that of the Soviets and of operating that force as the Soviets do" [18].

For the Third World (excluding China) as a whole, military expenditure between 1967 and 1977 increased 2.7 times. This increase, however, varied considerably from region to region. Over the period 1967 to 1977, for example, military expenditure in the Middle East increased by a factor of 4.8; in Africa (excluding Egypt) by 3.8; and in the rest of Asia (excluding China) and in Latin America by about 1.7. In Africa, the increase was mainly due to Libya, Nigeria and South Africa. If these three countries are excluded, military spending in Africa increased 2.4 times instead of 3.8 times.

Another indication of the rise in Third World expenditure is that in 1976 Iran and Saudi Arabia were the seventh and eighth highest spenders in the world, exceeded only by the five permanent members of the UN Security Council and the Federal Republic of Germany. Ten years earlier they occupied twenty-fifth and thirty-third places, respectively.

Military spending thus varies greatly from one country to another. In 1976, for example, the top three spenders of the nearly 100 Third World countries were Iran, Saudi Arabia and Israel which spent (in current prices) $9 430 million, $8 930 million and $4 060 million, respectively. These three countries accounted for 37 per cent of Third World military expenditure. Egypt spent $4 000 million, and India spent $2 860 million. Together, these five countries accounted for half of Third World expenditure. Each of another 11 countries (Argentina, Brazil, Indonesia, Iraq, Kuwait, Libya, Nigeria, North Korea, South Korea, South Africa and Taiwan) also spent over $1 000 million. These top 16 countries—six of them in the Middle East—together accounted for 77 per cent of Third World military expenditure.

An example of the burden that military spending can become is given by the fact that Israel's gross domestic product per capita (in current dollars) in 1976 was about $3 600, out of which about $1 170 was spent on the military; for Egypt the figures are $320 and $140, for Kuwait $10 950 and $1 960, and for Saudi Arabia $4 440 and $970, respectively. In comparison, the US per capita military expenditure (the highest of all developed countries) in 1976 was about $425.

II. Military expenditures of underdeveloped countries as a proportion of state budgets

Researchers in political and social sciences are prone to use various indices of a nation's military burden or expenditure as evidence or argumentation on a particular point. The general indicators often used are: (*a*) military expenditure *per se*; (*b*) military expenditure as a percentage of a nation's gross national product (GNP) or, occasionally, of its gross domestic product; (*c*) per capita military expenditure (the military expenditure divided by the nation's population); (*d*) military expenditure as a percentage of a nation's gross fixed capital formation; (*e*) number of personnel in the nation's armed forces; (*f*) number of military personnel as a percentage of the nation's population; and (*g*) military expenditure as a percentage of a nation's federal budget.

Of these indicators, the most widely used one is military expenditure as a percentage of GNP. However, for some purposes this is a less than satisfactory indicator because by far the largest proportion of GNP is most often not available for direct allocation by national leaders and policy-makers, and thus the particular "per cent of GNP" measure cannot demonstrate the priorities of these policy-makers. In addition, for nations with sizeable GNPs, it takes quite large changes in military expenditure to appear as anything more than a change of a few tenths of 1 per cent in such an index. At best, except in case of wartime, time series data on a country's military expenditure as a percentage of GNP usually show only relatively small changes. These can perhaps be examined for year-to-year changes, but they can just as easily be obscured by any sizeable change in GNP.

Researchers should consider whether or not the last of the indicators in the above list—military expenditure as a percentage of a nation's federal budget—is, when studying the Third World, the most useful. Table 6.1 presents a comprehensive set of these data for 93 Third World countries for the consideration of researchers. The utility of this indicator lies in its focus precisely on the priorities of a nation's policy-makers. It has perhaps been the least used heretofore and is rarely found in the literature. Since such data were not readily available for underdeveloped nations, it was necessary to derive them.[3]

World military expenditure is now running at roughly $360 thousand million per year. Nearly two-thirds of this total—about 60 per cent—is made up of the military expenditure of two nations, the USA and the USSR. The purpose of this section is not to obscure this fact. It is also of interest, however, in the context of development goals, to see what the priorities of particular underdeveloped countries are.[4]

The data aggregated in table 6.1 are for 1974, the most recent year for which the two necessary component figures of national budget and military expenditure could be obtained for most of the countries of interest.

[3] Annual data on military expenditure can be found in several sources, for example references [2–5]. In addition, several recent publications have treated the question of military expenditure in general, its definition, or its possible reduction: references [6–11].

[4] A single table of defence budgets as percentages of government expenditure in 1967 for 32 African nations [12] indicates that the data for the table is derived from reference [13]. However, this is something of a puzzle, since the latter book contains only figures for national defence budgets and for defence expenditure as percentages of GNP, as did a subsequent edition in 1971.

Table 6.1. Military expenditure as a percentage of national budget, 1974[a]

Country	National budget[b] US $ mn		Military expenditure[c] US $ mn	Percentage of national budget for military expenditure
Afghanistan	189.3[d]		42.8	*22.6*
Algeria	3 545.9[e]		211.6	*6.0*
Argentina (1972)	4 699.2[e]		694.8	*14.8*
Bahrain (1975)	339.6[e]		14.2	*4.2*
Bangladesh	1 025.5[d]	(RE)[f]	86.5	*8.4*
Barbados	84.3[d]		1.0	*1.2*
Benin	61.1[e]		6.0	*9.8*
Bolivia	261.2[d]		39.4	*15.1*
Botswana	201.7[d]		–	–
Brazil	7 875.7[d]		1 198.6	*15.2*
Burma (1972)	394.4[d]	(DE)[f]	107.6	*27.3*
Burundi	33.4[e]		8.1	*24.0*
Cameroon	335.3[e]		39.7	*11.8*
Central African Empire	77.5[d]	(E)[f]	7.0	*9.0*
Chad	90.0[e]		22.7	*25.2*
Chile (1973)	848.2[d]		450.4	*53.1*
Colombia	1 155.2[d]		112.0	*9.7*
Congo	118.0[d]		19.3	*16.4*
Costa Rica	270.6[e]		8.0	*3.0*
Cyprus	107.1[d]	(RE)[f]	20.1	*18.8*
Dominican Republic	494.5[d]		47.6	*9.7*
Ecuador	473.8		70.5	*14.9*
Egypt	2 350.0[d]		3 136.0[o]	..[o]
El Salvador	197.2[d]		26.1	*13.2*
Ethiopia	372.4[d]		65.7	*17.6*
Fiji	111.0[d]	(E)[f]	1.1	*1.0*
Gabon	79.7[d]	(E)[f]	10.7	*13.4*
Gambia	1.9[d]		–	–
Ghana	642.2[d]		67.8	*10.6*
Guatemala	322.9[d]		26.0	*8.1*
Guyana	150.6[d]	(RE)[f]	6.5	*4.3*
Haiti	33.3[d]		8.5	*25.4*
Honduras	147.6[d]	(E)[f]	16.7	*11.3*
India	10 273.3[d]		2 539.6	*24.7*
Indonesia	2 805.5[d]		857.8	*30.6*
Iran	10 819.9[d]	(E)[f]	4 730.8	*43.7*
Iraq (1975)	12 303.2[e]	(Est)[f]	1 884.2	*15.3*
Israel	6 166.3[d]		4 624.0	*75.0*
Ivory Coast (1973)	539.1[e]	(Est)[f]	26.6	*4.9*
Jamaica	449.1[d]		17.6	*3.9*
Jordan	515.2[e]		137.8[g]	*26.8*
Kenya	639.2[e]		42.8	*6.7*
Korea, North (1973)	8 321.4[e]	(Est)[f]	510.6	*6.1*
Korea, South	2 547.4[d]		712.0	*27.9*
Kuwait	1 135.7[e]		631.6	*55.6*
Laos	47.4[d]	(E)[f]	25.1[h]	*53.0*
Lebanon	532.6[e]		129.4	*24.3*
Lesotho	23.1[d]		–	–
Liberia	124.5[d]		3.7	*3.0*
Libya	3 545.8[i]		1 030.4	*29.1*
Malagasy	420.3[e]		20.9	*5.0*
Malawi	109.5[d]		4.2	*3.8*
Malaysia	2 322.2[d]	(RE)[f]	311.3	*13.4*
Mali	62.2[e]		8.9	*14.2*
Mauritania	70.3[e]	(Est)[f]	8.9	*12.7*
Mauritius	94.2[e]		1.0	*1.1*

Country	National budget[b] *US $ mn*		Military expenditure[c] *US $ mn*	Percentage of national budget for military expenditure
Mexico (1975)	27 732.7[e]		581.0	*2.1*
Morocco	1 966.0[e]		196.4	*10.0*
Nepal	124.9[d]	(RE)[f]	9.4	*7.5*
Nicaragua	285.9[d]		22.0	*7.8*
Niger (1973)	70.5[e]		4.6	*6.6*
Nigeria (1973)	2 156.0[j]	(Est)[f]	380.0	*17.6*
Oman (1975)	1 466.1[e]		730.0	*49.8*
Pakistan	1 709.0[d]		567.0	*33.2*
Panama	392.6[d]		2.1	*0.5*
Paraguay	115.5[d]		21.1	*18.3*
Peru	4 503.9[e]	(RE)[f]	256.6	*5.7*
Philippines	1 842.2[d]		356.3	*19.3*
Rwanda	40.5[d]		7.9	*19.4*
Saudi Arabia	6 425.4[d]		1 671.0	*26.0*
Senegal	256.7[d]		21.9	*8.5*
Sierra Leone	86.0[e]	(Est)[f]	4.4	*5.1*
Singapore	912.3[d]		243.7	*26.7*
Somalia (1973)	62.9[k]	(Est)[f]	16.1	*25.5*
Sri Lanka	817.6[d]		25.6	*3.1*
Sudan	639.6[d]	(PR)[f]	114.6	*17.9*
Syria	1 300.0[d]	(PR)[f]	554.0	*42.6*
Taiwan	2 269.7[e]		855.3	*37.7*
Tanzania	626.1[d]	(E)[f]	50.7	*8.1*
Thailand	1 700.4[d]		361.9	*21.3*
Togo	73.2[d]	(E)[f]	6.7	*9.2*
Trinidad & Tobago (1973)	281.1[d]		4.2	*1.5*
Tunisia	923.2[l]		35.1	*3.8*
Uganda (1973)	318.0[d]		51.3	*16.1*
United Arab Emirates	424.9[d]	(DE)[f]	72.0	*17.0*
Upper Volta	52.8[e]	(Est)[f]	7.0	*13.2*
Venezuela	9 228.3[d]		457.9	*5.0*
Viet Nam, North (1975)	2 583.1[e,m]		520.0	*20.1*
Viet Nam, South (1973)	791.2[e]		512.8	*64.8*
Yemen	73.5[d]		49.2	*66.9*
Yemen, Democratic	65.8[d]	(RE)[f]	36.8	*55.9*
Zaïre (1973)	729.2[e]		130.0	*17.8*
Zambia	677.5[n]		96.5	*14.2*

[a] All budget and military expenditure figures are for 1974, unless otherwise indicated. All other military expenditure figures are for current, rather than constant, expenditure for the year indicated. For all 1974 military expenditure figures, 1974=100.

[b] All national budget figures were originally expressed in local currency. The exchange rates for Bahrain, the Republic of China (Taiwan), Iraq, North Korea, Mexico, Oman, North Viet Nam and South Viet Nam are derived from: *Europa Year Book, 1976, Vol. II: Africa, The Americas, Asia, Australasia* (Europa Publications Ltd., London, 1976). All other exchange rates are from: *UN Statistical Yearbook, 1975* (United Nations, New York, 1976), table 194, Exchange Rates, pp. 703–704.

[c] All military expenditure figures are from: *World Armaments and Disarmament, SIPRI Yearbook 1977* (Almqvist & Wiksell, Stockholm, 1977, Stockholm International Peace Research Institute), pp. 221–45. They are presented here at 1974 exchange rates.

[d] National budget figures are derived from: *UN Statistical Yearbook, 1975* (United Nations, New York, 1976), table 201, Budget Accounts and Public Debt, pp. 728–821.

[e] National budget figures are derived from: *Europa Year Book, 1976, Vol. II: Africa, The Americas, Asia, Australasia* (Europa Publications Ltd., London, 1976).

[f] (RE)=Revised Estimates (E)=Voted Estimates
(PR)=Provisional Remittances (DE)=Draft Estimates, submitted to Parliament.
The above breakdown is valid only for budget figures from the *UN Statistical Yearbook, 1975*.

(Est) is used to denote estimates from all other sources of budgetary data. All other figures are for closed accounts.
[g] Unreliable figure.
[h] Figures for the Force Armée Royale.
[i] National Budget figures for Libya are taken from: *African Statistical Yearbook, 1975, Part I: North Africa* (UN, Economic Commission for Africa, Addis Ababa, 1976), pp. 3–18.
[j] National Budget figures for Nigeria are taken from: *African Statistical Yearbook, 1974, Part II: West Africa* (UN, Economic Commission for Africa, Addis Ababa, 1975), pp. 16–19.
[k] National Budget figures for Somalia are taken from: *African Statistical Yearbook, 1974, Part III: East Africa* (UN, Economic Commission for Africa, Addis Ababa, 1975), pp. 28–40.
[l] National Budget figures for Tunisia are taken from: *African Statistical Yearbook, 1975, Part I: North Africa* (UN, Economic Commission for Africa, Addis Ababa, 1976), pp. 6–20.
[m] National Budget figure for North Viet Nam is unofficial.
[n] National Budget figures for Zambia are taken from: *African Statistical Yearbook, 1974, Part IV: Central Africa, Others in Africa* (UN, Economic Commission for Africa, Addis Ababa), pp. 41–49.
[o] According to ACDA, the military expenditure figure for Egypt is $1 550.0 mn and the percentage of the national budget is 65.9 per cent. SIPRI's figures, based on subsequent data received for military expenditure but not for the national budget, give $3 136.0 mn for military expenditure. This results in a percentage of national budget of 7 100 per cent, indicating that the figure for the national budget must be revised upwards.

The data show that, of the 93 underdeveloped countries:

20 (21.5 per cent) spent between 0 and 5 per cent of their budget on military expenditure;

19 (20.4 per cent) spent between 5 and 10 per cent of their budget on military expenditure;

11 (11.8 per cent) spent between 10 and 15 per cent of their budget on military expenditure;

14 (15.1 per cent) spent between 15 and 20 per cent of their budget on military expenditure;

6 (6.5 per cent spent between 20 and 25 per cent of their budget on military expenditure; and

23 (24.7 per cent) spent over 25 per cent of their budget on military expenditure.

The same figures indicate that:

nearly 25 per cent spent over 25 per cent of their budget on military expenditure;

over 30 per cent spent over 20 per cent of their budget on military expenditure; and

57 per cent spent over 10 per cent of their budget on military expenditure.

There are several reasons for assuming that the figures in the table should only be taken as close approximations and not as precise percentages of national budget for several of the countries. A serious and growing qualification is that for an important group of countries—particularly those involved in conflict—though the figures may more or less closely represent outlays from their own resources, they may not represent all the funds allocated for military expenditure. Additional moneys are also donated by other nations for military expenditure by the country concerned. These donations are grant and transfer payments and are not paid out of the budget of the nation in question. However, in order to derive the *total* expenditure for military purposes by underdeveloped nations, or by any particular underdeveloped nation, these transferred sums must be included.

The various factors that qualify the data in table 6.1 are enumerated below:

1. At least some of these countries substantially raised their military expenditure in the years since 1974, for example, several of the countries in the Middle East. Military expenditure in Mauritania rose sharply in 1976–77 [14], reaching perhaps 60 per cent of total expenditure.

2. There is always the general question of whether the publicly stated figure for military expenditure reflects real outlay for this function. This consideration again seems to apply most to several Middle Eastern countries for which there is strong evidence of secret or unstated outlays for military expenditure. In addition, military aid from the USA or the USSR, either free grant aid or on credit, to various Middle Eastern states (and perhaps to others as well) is usually not accounted for in the national budget of the recipient state [15]. More recently, Saudi Arabia and Libya have been new suppliers of unstated military grant funds to numerous countries, some in the Middle East but some elsewhere [16–17]. Saudi Arabia is now paying for US arms purchases by Egypt, Syria, Jordan, Pakistan, Mauritania, Yemen, Morocco and perhaps Tunisia, and several other nations may soon be added to this list. The transfer of military assistance of one sort or another between underdeveloped countries is becoming a reasonably widespread activity. In addition, donations or extensions of military aid may be in forms other than cash grants, such as the loan or extended assignment of jet aircraft pilots, tank operators, or other specially trained military personnel.[5]

It is also questionable whether such grants or transfers are really "a free good", or whether there may not be a national cost attached to them, particularly in subsequent years. Most immediately this would refer to the subsequent burden of supporting the weapon system acquired. But two political considerations may also incur subsequent costs: first, the effect on the nation's own military; and second, the question of whether

[5] It is useful to remember that "military assistance" takes a wide range of forms: arms trade; arms aid; supplying money with which to purchase weapons; building logistical infrastructure such as air bases, naval bases, and so on; paramilitary construction, aid or training, such as harbours, railways, rolling stock, roads, border police, internal security forces (the categorization depends on the usage); training officers and troops in the recipient country; training officers and troops in the donor country; supplying active duty military personnel such as advisers, "special forces", pilots, radar operators, air defence system operators for operations in recipient countries, and so on; and, finally, supplying mercenaries.

such transfers and grants may not involve the nation in political relationships and conflicts that it may later regret.

3. A constant underlying consideration is whether the category of national expenditure has a consistent definition, that is, whether federal expenditure is larger or smaller in countries with a primarily socialist economy than in those which do not have such economies. However, in any underdeveloped country, irrespective of economic system, a relatively larger part of the economy is likely to be in the public sector.

In summary, these figures indicate that military expenditure is a very sizeable fraction of the government expenditure of many underdeveloped nations. SIPRI data have also indicated the relatively sharper rise—from very much lower absolute levels—of the rate of increase of military expenditure in the underdeveloped nations.

References

1. McHale, J. and McHale, M., *Meeting Basic Human Needs, A Feasibility Study for UNEF* (Houston, 1977, Center for Integrative Studies, University of Houston).
2. *World Armaments and Disarmament, SIPRI Yearbooks 1968/69 . . . 1977* (Almqvist & Wiksell, Stockholm, 1969 . . . 1977, Stockholm International Peace Research Institute).
3. *World Military Expenditures and Arms Trade, 1963–1973, 1965–1974* and *1966–1975* (US Government Printing Office, Washington, 1975, 1976 and 1976, US Arms Control and Disarmament Agency).
4. Sivard, R. L., *World Military and Social Expenditures* (WMSE Publications, Leesburg, Va., 1974 and 1976, Institute for World Order).
5. *The Military Balance* (London, annual, International Institute for Strategic Studies).
6. *The Meaning and Measurement of Military Expenditure*, SIPRI Research Report No. 10 (Almqvist & Wiksell, Stockholm, 1973, Stockholm International Peace Research Institute).
7. *World Armaments and Disarmament, SIPRI Yearbook 1974* (Almqvist & Wiksell, Stockholm, 1974, Stockholm International Peace Research Institute), pp. 172–204.
8. *World Armaments and Disarmament, SIPRI Yearbook 1975* (Almqvist & Wiksell, Stockholm, 1975, Stockholm International Peace Research Institute), pp. 103–18.
9. *Reduction of the Military Budgets of States Permanent Members of the Security Council by 10 Percent and Utilization of the Funds thus Saved to Provide Assistance to Developing Countries, Report of the Secretary-General* (United Nations, New York, 1975).
10. Becker, A. S. and Ysander, B.-C., *International Limitation of Military Expenditures, Issues and Problems*, RAND Report R-1911-ACDA (RAND Corporation, Santa Monica, Calif., April 1976).
11. *Reduction of Military Budgets, Measurement and International Reporting of Military Expenditures, Report prepared by the Group of Experts on the*

Reduction of Military Budgets, Report of the Secretary-General, 20 October 1976, mimeographed.

12. Morrison, D. G., *et al.*, *Black Africa, A Comparative Handbook* (Free Press, New York, 1972).
13. Sellers, R. C. (Ed.), *Armed Forces of the World, A Reference Handbook*, 2nd ed. (Praeger, New York, 1968).
14. "Mauritania, Not Our War", *The Economist*, 16 April 1977, p. 71.
15. Mallman, W., "The Arab-Israel Arms Build-up Since the June War 1967", Outline of a research project and of a forthcoming book, private communication, 1 October 1976.
16. "Saudi Arabia's Schizophrenia", *Business Week*, 1 September 1977.
17. Howe, M., "Qaddafi's Prophetic Vision Goes Well Beyond Libya", *New York Times*, section 4, 7 September 1977.
18. *A Dollar Cost Comparison of Soviet and US Defense Activities, 1967–77*, US Central Intelligence Agency National Foreign Assessment Center, Research Paper SR 78-10002, January 1978.

Appendix 6A

World military expenditure, 1977

For sources and methods, see chapter 9. For conventions, see page 293.

Table 6A.1. World summary: constant price figures

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
USA	69 584	69 622	70 004	68 130	70 937	76 943	75 824	73 326	72 928	86 993
Other NATO	29 817	27 301	29 830	31 050	32 241	35 397	36 697	37 241	37 157	37 325
Total NATO	**99 401**	**96 923**	**99 834**	**99 180**	**103 178**	**112 340**	**112 521**	**110 567**	**110 085**	**124 318**
USSR	31 300	30 500	33 000	32 700	40 800	44 600	48 900	46 700	44 900	47 000
Other WTO[a]	2 700	2 900	3 000	2 958	3 250	4 147	4 469	4 471	4 598	4 833
Total WTO	**34 000**	**33 400**	**36 000**	**35 658**	**44 050**	**48 747**	**53 369**	**51 171**	**49 498**	**51 833**
Other Europe	3 160	3 225	3 300	3 300	3 546	3 867	3 999	4 226	4 256	4 422
Middle East	1 025	1 225	1 325	1 340	1 450	1 620	1 810	2 090	2 400	2 875
South Asia	1 100	1 100	1 075	1 090	1 150	1 494	2 317	2 287	2 364	2 313
Far East (excl China)	2 900	3 100	3 300	3 400	3 550	3 783	3 977	4 304	4 838	4 929
China	[9 750]	[9 000]	[10 000]	[10 000]	[11 800]	[13 700]	[15 500]	[18 400]	[19 400]	[21 800]
Oceania	974	976	1 024	1 018	1 006	1 039	1 166	1 356	1 559	1 779
Africa (excl Egypt)	300	275	325	390	575	855	967	1 163	1 338	1 397
Central America	350	375	400	435	458	512	548	583	574	617
South America	2 000	2 060	1 700	1 725	1 680	1 727	1 810	1 793	2 193	2 179
World total	**154 960**	**151 659**	**158 283**	**157 536**	**172 443**	**189 684**	**197 984**	**197 940**	**198 505**	**218 462**

[a] At current prices and Benoit-Lubell exchange rates.

Table 6A.2. NATO: constant price figures

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
North America:										
Canada	2 903	2 703	2 524	2 512	2 584	2 689	2 502	2 604	2 325	2 386
USA	69 584	69 622	70 004	68 130	70 937	76 943	75 824	73 326	72 928	86 993
Europe:										
Belgium	806	799	807	824	834	888	920	981	957	977
Denmark	379	370	361	404	411	502	508	524	556	548
France	7 929	7 321	7 469	7 699	7 935	8 229	8 087	8 311	8 446	8 688
FR Germany	5 566	4 141	6 611	7 148	7 535	9 562	10 749	10 301	10 180	9 869
Greece	247	242	251	266	258	262	268	279	302	327
Italy	1 991	2 033	2 121	2 204	2 279	2 500	2 787	2 853	2 961	3 204
Luxembourg	17	17	16	10	11	14	13	17	17	17
Netherlands	1 352	1 190	1 060	1 168	1 360	1 447	1 466	1 595	1 554	1 515
Norway	373	348	368	350	381	421	438	444	515	512
Portugal	223	229	257	266	427	485	474	517	517	545
Turkey	375	387	445	469	506	532	541	585	621	603
UK	7 656	7 521	7 530	7 730	7 720	7 866	7 944	8 230	8 206	8 134
Total NATO	**99 401**	**96 923**	**99 834**	**99 180**	**103 178**	**112 340**	**112 521**	**110 567**	**110 085**	**124 318**
Total NATO (excl USA)	**29 817**	**27 301**	**29 830**	**31 050**	**32 241**	**35 397**	**36 697**	**37 241**	**37 157**	**37 325**
Total NATO Europe	**26 914**	**24 598**	**27 306**	**28 538**	**29 657**	**32 708**	**34 195**	**34 637**	**34 832**	**34 939**

US $ mn, at 1973 prices and 1973 exchange rates (Final column, X, at current prices and exchange rates)

1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1976X
100 363	103 077	98 698	89 065	82 111	82 469	78 358	77 383	75 102	71 019	76 412	*91 008*
38 980	37 795	37 633	38 381	40 412	42 619	43 326	44 577	45 683	46 854	47 047	*59 891*
139 343	**140 872**	**136 331**	**127 446**	**122 523**	**125 088**	**121 684**	**121 960**	**120 785**	**117 873**	**123 459**	*150 899*
50 800	58 600	62 200	63 000	63 000	63 000	63 000	61 900	61 100	61 100	60 400	*61 100*
5 252	6 387	7 012	7 498	7 974	8 240	8 808	9 444	10 263	10 848	11 300	*10 848*
56 052	**64 987**	**69 212**	**70 498**	**70 974**	**71 240**	**71 808**	**71 344**	**71 363**	**71 948**	**71 700**	*71 948*
4 420	4 560	4 740	4 864	4 983	5 288	5 382	5 752	5 967	5 907	5 970	*8 264*
3 735	4 425	5 225	6 175	6 900	9 843	13 480	16 558	18 560	21 525	17 750	*32 796*
2 101	2 176	2 312	2 403	2 856	3 082	2 745	2 591	2 835	3 315	3 240	*3 850*
5 442	6 086	6 531	7 061	7 746	8 163	8 181	8 264	8 825	9 000	9 600	*12 869*
[23 500]	[25 500]	[27 500]	[29 300]	[30 000]	[27 500]	[27 500]	[27 500]	[27 500]	[27 500]	[27 500]	*[27 500]*
1 937	2 101	2 129	2 125	2 125	2 131	2 102	2 177	2 174	2 158	2 124	*2 749*
1 733	2 012	2 422	2 567	2 843	2 996	3 362	4 728	5 223	6 210	[6 500]	*8 621*
663	742	724	761	783	799	820	839	974	1 150	[1 200]	*1 396*
2 614	2 549	2 662	2 807	3 301	3 364	3 808	3 378	3 879	4 160	4 510	*4 520*
241 540	**256 010**	**259 788**	**256 007**	**255 034**	**259 494**	**260 872**	**265 091**	**268 085**	**270 746**	**273 553**	*325 412*

US $ mn, at 1973 prices and 1973 exchange rates (Final column, X, at current prices and exchange rates)

1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1976X
2 562	2 415	2 276	2 392	2 403	2 409	2 408	2 582	2 546	2 718	2 887	*3 640*
100 363	103 077	98 698	89 065	82 111	82 469	78 358	77 383	75 102	71 019	76 412	*91 008*
1 019	1 055	1 062	1 132	1 152	1 215	1 259	1 311	1 417	1 504	1 572	*2 100*
547	584	574	563	617	613	583	638	693	683	684	*940*
9 155	9 164	8 738	8 835	8 947	9 173	9 513	9 471	9 888	10 353	10 608	*13 369*
10 264	9 112	9 992	10 108	10 823	11 576	12 027	12 558	12 496	12 379	12 533	*15 458*
422	492	557	603	638	680	679	650	1 043	1 197	1 447	*1 561*
3 128	3 187	3 124	3 293	3 726	4 114	4 107	4 110	3 825	3 807	3 727	*4 335*
14	12	12	13	13	14	15	17	18	19	19	*25*
1 677	1 659	1 732	1 788	1 871	1 933	1 967	2 053	2 158	2 140	2 193	*2 957*
528	559	590	592	607	606	611	627	681	697	722	*977*
669	705	653	714	747	737	681	816	561	439	388	*624*
608	643	631	675	790	821	862	943	1 563	1 916	1 647	*2 775*
8 387	8 208	7 692	7 673	8 078	8 728	8 614	8 801	8 794	9 002	8 620	*11 130*
139 343	**140 872**	**136 331**	**127 446**	**122 523**	**125 088**	**121 684**	**121 960**	**120 785**	**117 873**	**123 459**	*150 899*
38 980	**37 795**	**37 633**	**38 381**	**40 412**	**42 619**	**43 326**	**44 577**	**45 683**	**46 854**	**47 047**	*59 891*
36 418	**35 380**	**35 357**	**35 989**	**38 009**	**40 210**	**40 918**	**41 995**	**43 137**	**44 136**	**44 160**	*56 251*

Table 6A.3. NATO: current price figures

	Currency	1957	1958	1959	1960	1961	1962	1963	1964	1965
North America:										
Canada	*mn dollars*	1 829	1 740	1 642	1 654	1 716	1 810	1 712	1 813	1 659
USA	*mn dollars*	44 159	45 096	45 833	45 380	47 808	52 398	52 295	51 213	51 827
Europe:										
Belgium	*mn francs*	19 232	19 254	19 658	20 209	20 641	22 341	23 596	26 241	26 606
Denmark	*mn kroner*	1 012	988	986	1 113	1 180	1 551	1 651	1 764	1 974
France	*mn francs*	15 600	16 569	17 926	19 162	20 395	22 184	22 849	24 280	25 300
FR Germany	*mn marks*	8 962	6 853	11 087	12 115	13 175	17 233	19 924	19 553	19 915
Greece	*mn drachmas*	4 477	4 469	4 735	5 110	5 034	5 102	5 385	5 647	6 290
Italy	*thous mn lire*	611	647	667	710	749	861	1 031	1 118	1 212
Luxembourg	*mn francs*	439	429	402	263	290	355	348	462	477
Netherlands	*mn guilders*	1 845	1 656	1 505	1 728	2 013	2 186	2 307	2 661	2 714
Norway	*mn kroner*	1 049	1 024	1 107	1 058	1 179	1 371	1 465	1 570	1 897
Portugal	*mn escudos*	2 391	2 485	2 820	3 023	4 922	5 744	5 724	6 451	6 680
Turkey	*mn lire*	1 266	1 470	2 153	2 410	2 718	2 980	3 157	3 443	3 821
UK	*mn pounds*	1 568	1 593	1 595	1 657	1 709	1 814	1 870	2 000	2 091

Table 6A.4. NATO: military expenditure as a percentage of gross domestic product

	1957	1958	1959	1960	1961	1962	1963	1964	1965
North America:									
Canada	*5.6*	*5.2*	*4.6*	*4.3*	*4.3*	*4.2*	*3.7*	*3.6*	*3.0*
USA	*9.9*	*10.0*	*9.4*	*8.9*	*9.0*	*9.2*	*8.7*	*8.0*	*7.5*
Europe:									
Belgium	*3.8*	*3.7*	*3.7*	*3.6*	*3.4*	*3.5*	*3.4*	*3.4*	*3.2*
Denmark	*3.1*	*2.9*	*2.6*	*2.7*	*2.6*	*3.0*	*3.0*	*2.8*	*2.8*
France	*7.3*	*6.8*	*6.6*	*6.4*	*6.2*	*6.0*	*5.6*	*5.3*	*5.2*
FR Germany	*4.1*	*3.0*	*4.4*	*4.0*	*4.0*	*4.8*	*5.2*	*4.6*	*4.3*
Greece	*5.1*	*4.8*	*4.9*	*4.9*	*4.2*	*4.0*	*3.9*	*3.6*	*3.5*
Italy	*3.5*	*3.4*	*3.3*	*3.3*	*3.1*	*3.2*	*3.3*	*3.3*	*3.3*
Luxembourg	*1.9*	*1.9*	*1.8*	*1.0*	*1.2*	*1.3*	*1.2*	*1.4*	*1.4*
Netherlands	*5.2*	*4.7*	*4.0*	*4.1*	*4.5*	*4.5*	*4.4*	*4.3*	*3.9*
Norway	*3.6*	*3.5*	*3.6*	*3.2*	*3.3*	*3.6*	*3.5*	*3.4*	*3.7*
Portugal	*4.0*	*4.0*	*4.3*	*4.2*	*6.4*	*7.0*	*6.5*	*6.7*	*6.2*
Turkey	*4.1*	*3.8*	*4.5*	*5.1*	*5.5*	*5.1*	*4.7*	*4.8*	*5.0*
UK	*7.2*	*7.0*	*6.7*	*6.5*	*6.3*	*6.4*	*6.2*	*6.0*	*5.9*

Table 6A.5. WTO: current price figures

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Bulgaria	133	149	141	154	187	222	256	224	198	207
Czechoslovakia	1 094	1 047	1 035	1 033	1 119	1 276	1 274	1 202	1 191	1 275
German DR	..	487	..	295	295	796	826	855	914	944
Hungary	110	..	144	179	194	283	374	355	332	301
Poland	634	704	898	937	1 069	1 154	1 300	1 374	1 461	1 584
Romania	405	381	365	360	386	416	439	461	502	522
USSR[a]	31 300	30 500	33 000	32 700	40 800	44 600	48 900	46 700	44 900	47 000
Total WTO	**[34 000]**	**[33 400]**	**[36 000]**	**35 658**	**44 050**	**48 747**	**53 369**	**51 171**	**49 498**	**51 833**

[a] At SIPRI estimated exchange rates (see *SIPRI Yearbook 1974*, pp. 191 ff.).

Local currency, current prices

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1 766	1 965	1 927	1 899	2 061	2 131	2 238	2 405	2 862	3 127	3 589	4 133
63 572	75 448	80 732	81 443	77 854	74 862	77 639	78 358	85 906	90 948	91 008	104 226
28 169	30 396	32 319	33 754	37 388	39 670	44 140	48 941	57 395	69 936	81 055	91 350
2 080	2 249	2 591	2 640	2 757	3 195	3 386	3 520	4 439	5 281	5 680	6 255
26 732	28 912	30 264	30 696	32 672	34 907	37 992	42 284	47 878	55 873	63 899	71 830
20 254	21 408	19 310	21 577	22 573	25 450	28 720	31 908	35 644	37 589	38 922	40 890
7 168	9 390	11 003	12 762	14 208	15 480	17 211	19 866	24 126	43 917	(57 090)	(77 070)
1 342	1 359	1 403	1 412	1 562	1 852	2 162	2 392	2 852	3 104	3 608	4 199
497	413	374	391	416	442	517	601	710	836	983	1 044
2 790	3 200	3 280	3 682	3 968	4 466	4 974	5 465	6 254	7 246	7 817	8 588
1 947	2 097	2 300	2 502	2 774	3 022	3 239	3 505	3 938	4 771	5 333	6 076
7 393	9 575	10 692	10 779	12 538	14 699	16 046	16 736	25 108	19 898	18 845	21 094
3 996	4 596	5 159	5 395	6 237	8 487	9 961	12 192	15 831	(31 510)	(44 550)	(47 960)
2 153	2 276	2 332	2 303	2 444	2 815	3 258	3 512	4 160	5 165	6 162	6 823

Per cent

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2.8	*2.9*	*2.6*	*2.4*	*2.4*	*2.2*	*2.1*	*1.9*	*1.9*	*1.9*	*1.9*
8.4	*9.4*	*9.3*	*8.7*	*7.9*	*7.1*	*6.6*	*6.0*	*6.1*	*6.0*	*(5.4)*
3.1	*3.1*	*3.1*	*2.9*	*2.9*	*2.8*	*2.8*	*2.8*	*2.8*	*3.1*	. .
2.7	*2.7*	*2.8*	*2.5*	*2.4*	*2.5*	*2.3*	*2.1*	*2.4*	*2.6*	*2.4*
5.0	*5.0*	*4.8*	*4.2*	*4.2*	*4.0*	*3.9*	*3.8*	*3.7*	*3.9*	*(3.9)*
4.1	*4.3*	*3.6*	*3.6*	*3.3*	*3.3*	*3.4*	*3.4*	*3.6*	*3.6*	*(3.4)*
3.6	*4.3*	*4.7*	*4.8*	*4.8*	*4.7*	*4.6*	*4.1*	*4.2*	*6.5*	*7.1*
3.4	*3.1*	*3.0*	*2.7*	*2.7*	*2.9*	*3.1*	*2.9*	*2.9*	*2.8*	*(2.6)*
1.4	*1.2*	*1.0*	*0.9*	*0.8*	*0.8*	*0.9*	*0.8*	*0.8*	*1.0*	. .
3.7	*3.9*	*3.7*	*3.6*	*3.5*	*3.4*	*3.4*	*3.3*	*3.3*	*3.5*	*3.4*
3.5	*3.5*	*3.6*	*3.6*	*3.5*	*3.4*	*3.3*	*3.1*	*3.1*	*3.2*	*3.1*
6.3	*7.3*	*7.4*	*6.8*	*7.0*	*7.4*	*6.9*	*6.0*	*7.4*	*5.3*	. .
4.4	*4.5*	*4.6*	*4.4*	*4.3*	*4.5*	*4.3*	*4.1*	*3.9*	*6.1*	*(6.9)*
5.7	*5.7*	*5.4*	*5.0*	*4.8*	*5.0*	*5.2*	*4.9*	*5.1*	*5.0*	*5.1*

US $ mn, at Benoit-Lubell exchange rates

1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
213	228	260	279	305	337	364	416	472	453	556
1 457	1 552	1 679	1 755	1 876	1 976	2 071	2 126	2 271	2 400	2 146
1 062	1 711	1 858	2 006	2 124	2 242	2 457	2 625	2 821	3 019	3 251
313	381	440	567	570	543	547	609	680	707	757
1 661	1 905	2 105	2 142	2 312	2 324	2 538	2 745	2 990	3 166	3 392
546	610	670	749	787	818	831	923	1 029	1 103	1 198
50 800	58 600	62 200	63 000	63 000	63 000	63 000	61 900	61 100	61 100	60 400
56 052	**64 987**	**69 212**	**70 498**	**70 974**	**71 240**	**71 808**	**71 344**	**71 363**	**71 948**	**71 700**

Table 6A.6. WTO: current price figures

	Currency	1957	1958	1959	1960	1961	1962	1963	1964	1965
Bulgaria	*mn leva*	154	173	163	179	217	258	297	260	230
Czechoslovakia	*mn korunas*	9 300	8 900	8 800	8 783	9 512	10 845	10 829	10 217	10 125
German DR	*mn marks*	..	1 650	..	1 000	1 000	2 700	2 800	2 900	3 100
Hungary	*mn forints*	1 912	..	2 500	3 100	3 376	4 913	6 500	6 163	5 757
Poland	*mn zlotys*	10 100	11 200	14 300	14 920	17 019	18 378	20 695	21 881	23 255
Romania	*mn lei*	3 817	3 597	3 446	3 392	3 639	3 924	4 143	4 346	4 735
USSR	*mn roubles*	9 672	9 400	9 370	9 300	11 600	12 700	13 900	13 300	12 800

Table 6A.7. WTO: military expenditure as a percentage of net material product

	1957	1958	1959	1960	1961	1962	1963	1964
Bulgaria	*4.8*	*5.0*	*3.9*	*4.0*	*4.6*	*5.0*	*5.2*	*3.1*
Czechoslovakia	*6.6*	*6.0*	*5.8*	*5.4*	*5.6*	*6.2*	*6.3*	*6.1*
Hungary	*1.8*	..	*2.0*	*2.2*	*2.3*	*3.1*	*3.9*	*3.6*
Poland	*3.4*	*3.5*	*4.1*	*4.0*	*4.1*	*4.3*	*4.5*	*4.4*
USSR[a]	*8.6*	*7.4*	*6.9*	*6.4*	*7.6*	*7.7*	*8.2*	*7.3*

[a] An alternative series for the Soviet Union shows the SIPRI estimates of the dollar-equivalent of Soviet military expenditure as a percentage of official Soviet estimates of the dollar-equivalent of Soviet National Income for 1962–75:

	1957	1958	1959	1960	1961	1962	1963	1964
						22.5	*23.4*	*20.2*

Table 6A.8. Other Europe: constant price figures

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Albania[a]	..	..	..	..	58	65	66	68	70	66
Austria	157	180	178	165	160	168	205	259	214	245
Finland	109	113	134	141	163	229	181	179	182	180
Ireland	43	42	44	47	49	50	51	57	58	56
Spain	552	494	463	548	558	651	670	681	675	797
Sweden	1 157	1 169	1 218	1 198	1 258	1 352	1 441	1 516	1 608	1 622
Switzerland	518	556	536	503	587	648	676	732	738	776
Yugoslavia	580	623	674	642	713	704	709	734	711	680
Total Other Europe	**[3 160]**	**[3 225]**	**[3 300]**	**[3 300]**	**3 546**	**3 867**	**3 999**	**4 226**	**4 256**	**4 422**

[a] At current prices and 1973 exchange rate.

Table 6A.9. Other Europe: current price figures

	Currency	1957	1958	1959	1960	1961	1962	1963	1964	1965
Albania	*mn leks*	..	..	..	..	[240]	[270]	[275]	282	288
Austria	*mn schillings*	1 714	1 986	1 989	1 893	1 890	2 076	2 608	3 408	2 957
Finland	*mn markkaa*	184	206	246	267	314	460	383	417	446
Ireland	*mn pounds*	8.1	8.3	8.6	9.2	9.9	10.5	10.8	12.9	14.0
Spain	*mn pesetas*	10 881	11 067	11 115	13 375	13 935	17 173	19 218	20 920	23 471
Sweden	*mn kronor*	2 557	2 706	2 820	2 898	3 107	3 500	3 839	4 173	4 646
Switzerland	*mn francs*	930	1 009	972	924	1 096	1 264	1 362	1 521	1 586
Yugoslavia	*mn new dinars*	1 590	1 785	1 956	2 077	2 477	2 701	2 862	3 321	4 305

Local currency, current prices

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
240	247	264	302	324	354	391	422	483	548	525	645
10 841	12 385	13 189	14 268	14 919	15 943	16 800	17 600	18 071	19 300	20 400	18 240
3 200	3 600	5 800	6 300	6 800	7 200	7 600	8 328	8 900	9 564	10 233	11 020
5 219	5 433	6 611	7 644	9 848	9 891	9 430	9 489	10 564	11 811	12 275	13 150
25 213	26 438	30 332	33 519	34 100	36 800	37 000	40 400	43 700	47 600	50 400	54 000
4 927	5 146	5 751	6 319	7 067	7 424	7 710	7 835	8 700	9 700	10 400	11 300
13 400	14 500	16 700	17 700	17 900	17 900	17 900	17 900	17 600	17 400	17 400	17 200

Per cent

1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
3.5	*3.3*	*3.1*	*3.1*	*3.2*	*3.1*	*3.4*	*3.5*	*3.5*	*3.7*	*3.8*
5.9 I	*5.5*	*5.3*	*5.1*	*4.9*	*4.8*	*5.0*	*4.9*	*4.9*	*4.7*	*4.8*
3.4	*2.8*	*2.6*	*2.9*	*3.0*	*3.6*	*3.4*	*3.0*	*2.7*	*2.9*	*3.0*
4.4	*4.4*	*4.4*	*4.5*	*4.8* I	*4.6*	*4.3*	*3.9*	*3.8*	*3.6*	*3.5*
6.6	*6.5*	*6.4*	*6.8*	*6.8*	*6.2*	*5.9*	*5.7*	*5.3*	*5.0*	*4.8*

18.1	..	*17.3*	*18.0*	*17.4*	*16.5*	*15.4*	*14.8*	*13.1*	*11.6*	*10.7*

US $ mn, at 1973 prices and 1973 exchange rates (Final column, X, at current prices and exchange rates)

1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1976X
66	81	105	115	140	143	142	147	153	189	194	*191*
249	249	257	254	244	260	263	294	327	313	349	*433*
175	201	183	194	211	241	244	249	268	251	232	*402*
57	58	61	69	76	90	95	107	103	107	110	*132*
862	893	927	945	977	1 062	1 161	1 261	1 311	1 289	1 303	*1 782*
1 580	1 583	1 667	1 711	1 739	1 786	1 791	1 806	1 846	1 823	1 737	*2 432*
757	721	769	791	823	838	812	809	763	811	850	*1 216*
674	764	771	785	773	868	874	1 079	1 196	1 124	(1 195)	*1 676*
4 420	**4 560**	**4 740**	**4 864**	**4 983**	**5 288**	**5 382**	**5 752**	**5 967**	**5 907**	**5 970**	*8 264*

Local currency, current prices

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
272	272	335	435	475	580	590	589	610	635	783	805
3 474	3 661	3 775	4 006	4 135	4 166	4 712	5 130	6 277	7 567	7 776	9 100
456	471	589	549	597	692	847	956	1 148	1 455	1 555	1 632
13.7	14.4	15.5	17.3	21.3	25.5	33.1	38.8	51.1	59.2	73.0	85.2
29 407	33 850	36 780	39 016	42 067	47 019	55 368	67 467	84 749	103 064	119 223	147 764
4 990	5 072	5 176	5 596	6 150	6 714	7 306	7 823	8 666	9 726	10 595	11 450
1 746	1 770	1 726	1 889	2 014	2 232	2 426	2 556	2 795	2 813	3 040	3 238
5 070	5 382	6 406	6 980	7 864	8 948	11 716	14 108	21 100	29 495	30 500	(37 500)

Table 6A.10. Other Europe: military expenditure as a percentage of gross domestic product

	1957	1958	1959	1960	1961	1962	1963	1964	1965
Austria	*1.3*	*1.5*	*1.4*	*1.2*	*1.0*	*1.1*	*1.3*	*1.5*	*1.2*
Finland	*1.5*	*1.6*	*1.7*	*1.7*	*1.8*	*2.4*	*1.9*	*1.8*	*1.7*
Ireland	*1.5*	*1.5*	*1.4*	*1.4*	*1.4*	*1.4*	*1.3*	*1.4*	*1.4*
Spain	*2.2*	*1.9*	*1.8*	*2.2*	*2.0*	*2.1*	*2.0*	*1.9*	*1.8*
Sweden	*4.6*	*4.7*	*4.6* |	*4.0*	*4.0*	*4.1*	*4.2*	*4.1*	*4.1*
Switzerland	*3.0*	*3.2*	*2.9*	*2.5*	*2.7*	*2.8*	*2.7*	*2.8*	*2.7*
Yugoslavia[a]	*7.9*	*9.0*	*8.0*	*7.2*	*7.4*	*7.2*	*6.2*	*5.4*	*5.4*

[a] Percentage of gross material product.

Table 6A.11. Middle East: constant price figures

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Bahrain	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Cyprus	. .	. .	. .	. .	. .	. .	. .	10	12	10
Egypt	314	[293]	[297]	[320]†	[353]	[400]	447	560	607	625
Iran	203	326	364	290	290	287	292	323	434	598
Iraq	140	150	176	201	210	224	261	299	366	374
Israel	122	137	153	182	182	205	254	332	363	461
Jordan	(69)	(80)	(100)	(93)	(91)	(98)	(98)	(97)	(98)	(116)
Kuwait	. .	. .	. .	. .	[32]†	[35]	41	38	58	61
Lebanon	22	25	23	24	29	41	34	37	43	50
Oman	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Saudi Arabia	. .	. .	. .	. .	[143]	[183]	230	224	235	428
Syria	56	[100]	98	98	101	114	119	131	143	117
United Arab Emirates[b]	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Yemen	. .	. .	. .	. .	. .	[2]	5	4	5	5
Yemen, Democratic[a]	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Total Middle East	[1 025]	[1 225]	[1 325]	[1 340]	[1 450]	[1 620]	[1 810]	[2 090]	[2 400]	[2 875]

[a] 1975.
[b] At current prices and 1973 exchange rates.

Table 6A.12. Middle East: current price figures

	Currency	1957	1958	1959	1960	1961	1962	1963	1964	1965
Bahrain	*mn dinars*	. .	. .	. .	. .	. .	. .	. .	. .	. .
Cyprus	*mn pounds*	. .	. .	. .	. .	. .	. .	. .	2.7	3.3
Egypt	*mn pounds*	78	[73]	[74]	[80]	[89]	[98]	110	143	178
Iran	*mn rials*	7 960	12 771	15 699	13 756	14 183	14 156	14 487	16 606	22 826
Iraq	*mn dinars*	29.7	31.0	35.8	42.4	44.8	48.2	58.3	66.1	80.6
Israel	*mn pounds*	183	212	243	294	313	386	511	700	825
Jordan	*mn dinars*	13.4	15.9	20.1	19.1	18.9	20.6	21.0	21.1	21.5
Kuwait	*mn dinars*	. .	. .	. .	. .	6.1	6.8	7.9	7.1	10.9
Lebanon	*mn pounds*	39.1	45.6	43.0	47.8	56.4	80.6	68.9	76.6	90.1
Oman	*mn riyals*	. .	. .	. .	. .	. .	. .	. .	. .	. .
Saudi Arabia	*mn rials*	. .	. .	. .	. .	331	428	541	531	561
Syria	*mn pounds*	140	[234]	237	251	261	279	297	346	365
United Arab Emirates	*mn dirhams*	. .	. .	. .	. .	. .	. .	. .	. .	. .
Yemen	*mn rials*	. .	. .	. .	. .	. .	5.3	10.6	10.6	11.7
Yemen, Democratic	*mn dinars*	. .	. .	. .	. .	. .	. .	. .	. .	. .

Per cent

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1.3	*1.3*	*1.2*	*1.2*	*1.1*	*1.0*	*1.0*	*1.0*	*1.0*	*1.2*	*1.1*
1.6	*1.6*	*1.7*	*1.4*	*1.4*	*1.5*	*1.5*	*1.4*	*1.4*	*1.5*	*1.4*
1.3	*1.3*	*1.2*	*1.2*	*1.3*	*1.4*	*1.5*	*1.5*	*1.8*	*1.7*	*(1.7)*
2.0	*2.1*	*2.0*	*1.9*	*1.6*	*1.6*	*1.6*	*1.6*	*1.7*	*1.7*	*1.7*
4.1	*3.8*	*3.7*	*3.6*	*3.6*	*3.7*	*3.7*	*3.6*	*3.5*	*3.4*	*3.3*
2.7	*2.6*	*2.4*	*2.3*	*2.2*	*2.2*	*2.1*	*2.0*	*2.0*	*2.0*	*2.1*
5.1	*5.2*	*5.7*	*5.3*	*5.0*	*4.4*	*4.8*	*4.6*	*5.2*	*5.9*	..

US $ mn, at 1973 prices and 1973 exchange rates (Final column, X, at current prices and exchange rates)

1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1976X
..	..	..	..	5†	5	5	6	10	..	..	*14*[a]
11	10	9	10	11	10	10	16	19	..	..	*22*[a]
838	816	946	1 343	1 756	1 719	3 171	3 502	3 403	2 957	3 139	*3 997*
752	852	759	959	1 245	2 107	3 691	4 498	5 556	6 712	4 636	*9 430*
361	439	536	548	557	538	667	2 037	1 573	1 261	1 172	*1 665*
710	1 228	1 715	1 949	1 930	3 735	3 781	3 545	3 052	3 017	2 496	*4 062*
121	170	185	143	136	118	131	114	127	117	(117)	*177*
94	106	202	236	217	221	238	[527]	[722]	[1 534]	[1 282]	[*2 018*]
55	62	60	60	61	87	95	104	(87)	(71)	[37]	*113*
..	..	..	40	51	77	122	310	(573)	(621)	(581)	*834*
624	465	505	570	634	839	1 079	1 324	2 784	3 974	(3 342)	*8 933*
130	201	208	253	219	301	394	468	516	584	584	*882*
..	..	..	..	..†	16	24	41	71	544	(211)	*550*
10	14	20	25	29	37	35	39	37	..	..	*58*[a]
..†	[31]	(31)	31	32	33	37	27	30	..	..	*41*[a]
[3 735]	[4 425]	[5 225]	[6 175]	[6 900]	**9 843**	**13 480**	**16 558**	**18 560**	[21 525]	[17 750]	*32 796*

Local currency, current prices

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
..	..	..	..	..	(1.8)	(1.8)	1.8	2.8	5.6	..	..
2.8	3.1	2.7	2.6	3.0	3.5	3.4	3.5	6.6	(8.1)	..	..
200	270	273	327	482	650	650	1 250	1 530	1 631	1 564	1 845
31 365	40 030	45 734	42 160	54 120	73 215	131 875	253 950	353 420	492 285	662 180	592 430
83.9	83.8	104.1	134.3	143.2	150.8	153.3	199.4	659.4	557.9	(493.0)	491.5
1 131	1 772	3 129	4 481	5 399	5 990	13 080	15 879	20 810	24 950	32 400	38 860
26.0	27.4	38.4	45.2	37.4	37.0	34.5	42.4	44.2	55.2	(58.7)	(77.1)
12.5	19.4	22.6	42.1	48.7	53.3	61	71	[178]	[265]	[590]	[530]
105.9	121.9	135.9	139.1	138.4	142.3	212.9	246.7	300.2	314.9	327.0	211.7
..	..	..	..	12.4	16	25	42	118	241	288	297
1 050	1 579	1 224	1 396	1 655	1 925	2 657	3 983	5 932	16 790	31 535	31 670
316	366	587	600	763	691	960	1 505	2 061	2 640	3 430	3 930
..	..	..	..	..	..	64	96	164	285	2 175	(845)
12.7	25	39	57	74	92	121	162	228	265	..	..
..	..	[8.2]	8.1	8.1	8.9	9.6	(13.1)	(11.4)	(14.1)	..	..

Table 6A.13. Middle East: military expenditure as a percentage of gross domestic product

	1957	1958	1959	1960	1961	1962	1963	1964	1965
Cyprus	..	..	..	..	..	..	..	*2.4*	*2.4*
Egypt	..	..	..	*5.6*	*6.0*	*6.1*	*6.2*	*7.0*	*7.7*
Iran	..	..	..	*4.2*	*4.2*	*3.9*	*3.7*	*3.9*	*4.7*
Iraq	*6.5*	*6.0*	*6.7*	*7.1*	*6.9*	*6.9*	*8.3*	*7.9*	*8.8*
Israel	*5.9*	*5.9*	*5.9*	*6.4*	*5.7*	*5.8*	*6.5* |	*7.8*	*7.7*
Jordan	..	..	*21.5*	*19.4*	*15.7*	*17.3*	*16.3*	*14.2*	*12.8*
Kuwait	..	..	..	..	..	..	*1.2*	*1.0* |	*1.5*
Lebanon	..	..	..	..	..	..	..	*2.4*	*2.6*
Oman	..	..	..	..	..	..	..	..	..
Saudi Arabia	..	..	..	..	..	..	*5.6*	*5.4*	*5.1*
Syria	..	..	..	..	..	..	*7.5*	*7.5*	*7.9*
Yemen	..	..	..	..	..	..	..	..	..
Yemen, Democratic[a]	..	..	..	..	..	..	..	..	..

[a] Percentage of net domestic product.

Table 6A.14. South Asia: constant price figures

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Afghanistan	..	..	..	..	..	[43]	[55]	46	44	43
Bangladesh	..	..	..	..	..	..	..	..	..	..
India	914	905	844	848	911	1 256	2 055	2 011	1 961	1 852
Nepal	..	..	..	[4]	[4]	[5]	5	4	4	5
Pakistan	144	150	176	184	182	173	188	212	341	398
Sri Lanka	12	16	18	18	18	17	14	14	14	15
Total South Asia	**[1 100]**	**[1 100]**	**[1 075]**	**[1 090]**	**[1 150]**	**1 494**	**2 317**	**2 287**	**2 364**	**2 313**

[a] 1975.

Table 6A.15. South Asia: current price figures

	Currency	1957	1958	1959	1960	1961	1962	1963	1964	1965
Afghanistan	*mn afghanis*	..	..	..	[628]	[650]	[650]	[810]	909	1 023
Bangladesh	*mn taka*	..	..	..	..	..	..	..	..	..
India	*mn rupees*	2 665	2 797	2 699	2 774	3 046	4 336	7 306	8 084	8 651
Nepal	*mn rupees*	..	..	..	[16.2]	[19.4]	[22.4]	23.7	25.5	28.3
Pakistan	*mn rupees*	718	771	878	978	984	938	1 029	1 208	2 059
Sri Lanka	*mn rupees*	46	66	72	71	73	68	60	60	62

Table 6A.16. South Asia: military expenditure as a percentage of gross domestic product

	1957	1958	1959	1960	1961	1962	1963	1964
Bangladesh	..	..	..	..	..	..	..	..
India	[*2.1*]	[*2.0*]	[*1.9*]	[*1.9*]	*1.9*	*2.6*	*3.8*	*3.6*
Nepal	..	..	..	..	..	..	..	..
Pakistan	[*2.5*]	[*2.6*]	[*2.8*]	*2.8*	*2.6*	*2.4*	*2.4*	*2.6*
Sri Lanka	*0.8*	*1.1*	*1.1*	*1.1*	*1.1*	*1.0*	*0.8*	*0.8*

Per cent

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1.8	1.8	1.5	1.2	1.3	1.3	1.1	1.0	2.2	3.2	..
8.2	10.8	10.4	11.5	15.8	20.1	19.2	35.3	40.2	..	..
5.9	6.8	6.8	5.6	6.3	7.1	10.8	14.7	12.5	13.9	(14.6)
8.5	8.4	9.2	11.4	11.2	10.3	10.4	12.0	19.5	13.9	..
9.6	14.7	21.8	26.7	27.5	24.2	40.8	38.0	34.0	29.8	..
15.2	14.1	20.5	20.6	17.8	16.6	13.8	15.8	12.9	15.5	..
1.5	2.2	2.4	4.3 ‖	5.0	4.3	4.0	3.6	5.7	8.0	..
2.7	3.2	3.2	3.0	2.8	2.6	3.3	..	..	..	..
..	..	..	..	11.8	12.8	17.8	24.8	20.8	..	..
8.4	11.4 ‖	8.0	8.4	8.2	7.5	7.7	5.7	5.1	..	..
6.7	5.8	10.6	10.0	11.9	9.3	10.8	16.0	13.9	14.0	14.9
..	..	..	2.6	3.1	3.2	3.6	4.4	4.5	(4.2)	..
..	..	..	11.8	11.8	14.2	14.8	19.3	14.6	..	..

US $ mn, at 1973 prices and 1973 exchange rates (Final column, X, at current prices and exchange rates)

1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1976X
37	32	34	30	24	29	39	38	45	60	..	74
..	..	..	..	..†	44	40	48	73	117	(114)	103
1 718	1 788	1 892	1 949	2 320	2 449	2 165	2 014	2 221	2 644	2 562	2 861
6	6	6	7	7	7	8	8	9	..	..	11[a]
324	333	363	396	474	525	470	459	462	463	449	780
16	17	17	21	31	28	23	24	25	23	45	21
2 101	**2 176**	**2 312**	**2 403**	**2 856**	**3 082**	**2 745**	**2 591**	**2 835**	[3 315]	[3 240]	3 850

Local currency, current prices

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1 088	1 177	1 273	1 322	1 361	1 360	1 467	1 774	1 925	2 479	3 331	..
..	..	..	..	..	..	233	313	568	1 080	1 575	1 663
9 027	9 535	10 170	10 840	11 747	14 438	16 206	16 737	20 044	23 356	25 638	27 178
35.2	41.9	45.9	51	58	66	72	82	99	126	..	..
2 575	2 240	2 307	2 588	2 975	3 730	4 350	4 695	5 932	7 212	7 751	8 373
65	69	78	85	113	172	162	145	170	192	176	352

Per cent

1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
..	..	..	..	..	..	..	..	0.6	0.6	1.0
3.6	3.4	3.1	3.1	3.0	3.0	3.4	3.5	3.0	3.0	(3.3)
[0.4]	[0.5]	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	..
4.0	4.5	3.5	3.4	3.5 ‖	(3.8)	[4.5] ‖	7.2	6.2	6.1	(6.0)
0.8	0.8	0.8	0.7	0.7	0.9	1.3	1.1	0.8	0.8	0.8

Table 6A.17. Far East: constant price figures

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Brunei[a]	..	..	..	..	..	..	..	4	12	13
Burma	(121)	(135)	(153)	(142)	(131)	(141)	(161)	(154)	168	131
Hong Kong	..	..	..	..	..	11	11	10	18	20
Indonesia	268	336	341	401	445	313	216	169	151	104
Japan	1 266	1 283	1 307	1 298	1 345	1 471	1 565	1 721	1 782	1 905
Kampuchea, Democratic (Cambodia)	..	..	[66]	[55]	56	58	56	59	55	56
Korea, North[a]	..	..	..	..	275	305	341	366	429	429
Korea, South	146	172	180	178	185	213	177	167	175	214
Laos	..	..	..	..	..	43	27	21	27	27
Malaysia	81†	85	75	69	58	59	79	110	155	191
Mongolia[a]	..	..	..	..	18	18	18	18	18	18
Philippines	55	57	63	61	60	61	63	60	60	65
Singapore	..	..	..	..	..	..	..	..	..†	..
Taiwan	206	257	291	270	251	268	324	394	442	523
Thailand	109	92	98	96	101	106	109	116	124	134
Viet Nam, North[a]	..	..	..	..	[340]	[390]	[485]	[585]	[620]	[640]
Viet Nam, South[d]	..	181	179	226	233	326	345	350	602	459
Total Far East	**[2 900]**	**[3 100]**	**[3 300]**	**[3 400]**	**[3 550]**	**3 783**	**3 977**	**4 304**	**4 838**	**4 929**

[a] At current prices and 1973 exchange rates.
[b] 1974.
[c] 1975.
[d] In 1975 the Republic of Viet Nam ceased to exist as a separate political entity. No military expenditure figures are available for Viet Nam since this date.

Table 6A.18. Far East: current price figures

	Currency	1957	1958	1959	1960	1961	1962	1963	1964	1965
Brunei	*mn dollars*	..	..	..	..	..	..	..	8.7	29.3
Burma	*mn kyats*	378	406	411	426	408	432	478	466	511
Hong Kong	*mn dollars*	..	..	..	..	..	33	34	34	57
Indonesia	*mn new rupiahs*	6.1	11.1	14.1	21.7	31.7	59.8	92.4	145	522
Japan	*thous mn yen*	152	154	159	163	178	208	238	272	300
Kampuchea, Democratic (Cambodia)	*mn riels*	..	..	[1 655]	[1 495]	1 610	1 736	1 764	1 899	1 846
Korea, North	*mn won*	..	..	..	..	[565]	[625]	[700]	[750]	[880]
Korea, South	*thous mn won*	11.3	12.8	14.0	14.8	16.7	20.5	20.5	24.9	29.9
Laos	*mn kips*	..	..	..	..	..	2 712	3 312	4 935	7 391
Malaysia	*mn ringgits*	160.6	166.2	142.3	131.3	110.9	112.0	154.9	216.5	303.1
Mongolia	*mn tugriks*	..	..	..	..	[60]	[60]	[60]	[60]	[60]
Philippines	*mn pesos*	169	182	187	193	201	208	219	227	237
Singapore	*mn dollars*	..	..	..	..	..	..	..	..	..
Taiwan	*thous mn dollars*	3.8	4.8	6.0	6.6	6.6	7.2	8.9	10.8	12.1
Thailand	*mn baht*	1 567	1 390	1 420	1 378	1 473	1 580	1 643	1 778	1 921
Viet Nam, South	*thous mn piastres*	..	6.0	6.1	[7.6]	8.3	12.0	13.6	14.3	28.5

US $ mn, at 1973 prices and 1973 exchange rates (Final column, X, at current prices and exchange rates)

1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1976X
11	11	8	21	16	[15]	15	25	45	69	124	*68*
129	125	145	161	162	148	151	108	92	86	..	*130*
24	24	24	25	27	29	22	24	20	30	..	*40*
226	292	339	359	405	456	430	401	586	521	494	*1 046*
2 039	2 177	2 369	2 597	2 875	3 216	3 395	3 447	3 546	3 598	3 707	*5 018*
61	62	67	143	143	189	113	[54]	..	..	..	*64*[b]
576	824	877	878	922	612	625	765	922	1 007	939	*1 007*
238	281	324	334	394	443	456	601	747	988	1 258	*1 459*
26	24	24	25	26	22	21	17	[7]	..	..	*[16]*[c]
177	184	179	243	273	269	280	262	342	335	419	*404*
24	30	38	44	50	57	63	110	111	121	120	*122*
72	82	92	104	104	120	207	268	290	279	275	*390*
42	64	128	163	206	218	206	209	240	287	..	*349*
534	579	575	577	697	764	819	653	642	708	855	*1 137*
154	185	217	252	298	309	300	289	332	401	441	*549*
[630]	[630]	[585]	[585]	[585]	[635]	[565]	[585]	[605]	..	..	*605*[c]
479	512	540	550	563	661	513	446	[244]	..	..	*465*[c]
5 442	**6 086**	**6 531**	**7 061**	**7 746**	**8 163**	**8 181**	**8 264**	**[8 825]**	**[9 000]**	**[9 600]**	*12 869*

Local currency, current prices

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
32.3	27.9	27.5	19.4	51.0	38.0	[37.5]	37.0	60	110	169	303
502	486	498	545	582	599	589	741	675	754	883	..
67	84	88	89	100	112	(128)	(112)	(143)	(123)	(191)	..
3 700	21 600	63 100	86 000	102 200	120 475	144 450	178 525	234 000	407 000	434 000	526 000
337	375	422	483	570	669	783	924	1 166	1 342	1 488	1 650
1 851	2 025	2 154	2 478	5 966	10 206	16 956	26 073	48 320	..	..	..
[880]	1 180	(1 690)	1 798	(1 800)	1 890	1 254	1 282	1 568	1 890	2 065	1 925
40.7	50.0	65.4	84.9	101.6	136.1	170.7	181.4	297	463	706	983
8 463	8 531	8 511	8 672	9 131	9 375	10 330	12 732	15 070	[11 400]	..	..
379.5	366.6	379.3	367.3	510	581	591	681	747	1 019	1 026	1 350
[60]	[80]	[100]	[130]	[150]	169	(191)	213	372	375	407	405
270	318	365	421	500	572	728	1 398	2 435	2 841	2 901	3 065
..	79	123	244	311	402	434	503	624	736	863	..
14.6	15.4	17.8	[18.5]	19.3	24.0	27.1	31.4	36.9	38.2	43.2	55.7
2 151	2 575	3 152	3 769	4 420	5 319	5 738	6 238	7 400	8 859	11 203	13 800
35.2	52.8	72.0	92.0	128.3	155.2	228.3	255.8	345	293	..	..

Table 6A.19. Far East: military expenditure as a percentage of gross domestic product

	1957	1958	1959	1960	1961	1962	1963	1964	1965
Burma	6.0	6.4	6.1	6.0	5.6	6.3	6.4	6.5	6.6
Hong Kong	..	..	..	..	..	0.5	0.4	0.4	0.5
Indonesia	..	..	..	5.4	6.3	4.6	2.9	2.0	2.2
Japan	1.4	1.3	1.2	1.1	0.9	1.0	1.0	0.9	0.9
Kampuchea, Democratic (Cambodia)	..	..	..	..	..	7.5	6.9	7.1	6.1
Korea, South	5.8	6.2	6.4	6.1	5.7	5.9	4.2	3.6	3.7
Malaysia	3.1	3.4	2.6	2.2	1.9	1.8	1.7	2.2	2.9
Philippines	1.6	1.6	1.5	1.5	1.4	1.3	1.2	1.1	1.1
Singapore	..	..	..	..	..	..	..	..	..
Taiwan	9.4	10.7	11.6	10.5	9.4	9.4	10.2	10.6	10.6
Thailand	3.4	2.9	2.8	2.6	2.5	2.5	2.4	2.4	2.3
Viet Nam, South	..	..	..	9.2	9.7	12.7	13.4	12.3	19.9

Table 6A.20. Oceania: constant price figures

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Australia	840	845	887	877	875	912	1 034	1 201	1 387	1 597
Fiji	..	..	..	..	..	..	..	..	..	..
New Zealand	134	131	137	141	131	127	132	155	172	182
Total Oceania	**974.0**	**976.0**	**1 024.0**	**1 018.0**	**1 006.0**	**1 039.0**	**1 166.0**	**1 356.0**	**1 559.0**	**1 779.0**

[a] 1975.

Table 6A.21. Oceania: current price figures

	Currency	1957	1958	1959	1960	1961	1962	1963	1964	1965
Australia	*mn dollars*	351	357	383	392	401	417	475	565	678
Fiji	*mn dollars*	..	..	..	..	..	..	..	..	..
New Zealand	*mn dollars*	49	50	54	56	53	53	56	68	78

Table 6A.22. Oceania: military expenditure as a percentage of gross domestic product

	1957	1958	1959	1960	1961	1962	1963	1964	1965
Australia	3.0	3.0	2.9	2.8	2.7	2.7	2.8	3.0	3.4
Fiji	..	..	..	..	..	..	..	..	..
New Zealand	2.2	2.2	2.2	2.1	1.9	1.8	1.7	1.9	2.0

Per cent

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
6.5	*5.7*	*5.3*	*5.4*	*5.7*	*5.7*	*5.3*	*5.9*	..	..
0.6	*0.7*	*0.7*	*0.6*	*0.5*	*0.5*	*0.5*	*0.4*	*0.4*	*0.3*
1.2	*2.5*	*3.0*	*3.2*	*3.1*	*3.3*	*3.2*	*2.6*	*2.2*	*3.3*
0.9	*0.9*	*0.8*	*0.8*	*0.8*	*0.8*	*0.9*	*0.8*	*0.9*	*0.9*
5.9	..	..	*5.6*	..	..	..	..	..	..
4.0	*4.1*	*4.2*	*4.1*	*3.9*	*4.3*	*4.4*	*3.7*	*4.4*	*5.0*
3.9	*3.7*	*3.7*	*3.2*	*4.1*	*4.5*	*4.2*	*3.8*	*3.4*	*4.6*
1.1	*1.2*	*1.2*	*1.2*	*1.2*	*1.1*	*1.3*	*2.0*	*2.4*	*2.5*
..	*2.1*	*2.9*	*4.9*	*5.4*	*5.9*	*5.3*	*4.9*	*5.0*	*5.5*
11.5	*10.5*	*10.4*	*9.4*	*8.5*	*9.2*	*8.8*	*8.1*	*7.0*	*6.8*
2.1	*2.4*	*2.7*	*2.9*	*3.2*	*3.7*	*3.5*	*2.9*	*2.8*	*3.0*
16.0	*15.8*	*20.1*	*17.2*	*16.5*	*16.2*	*20.9*	*16.4*	..	..

US $ mn, at 1973 prices and 1973 exchange rates (Final column, X, at current prices and exchange rates)

1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1976X
1 767	1 920	1 941	1 919	1 932	1 936	1 912	1 982	1 975	1 962	1 929	*2 535*
..	(0.5)	0.5	0.7†	0.6	0.7	0.9	1.0	0.9	..	..	*1*[a]
170	180	187	205	192	194	189	194	198	195	195	*213*
1 937.0	**2 100.5**	**2 128.5**	**2 124.7**	**2 124.6**	**2 130.7**	**2 101.9**	**2 177.0**	**2 173.9**	**(2 158)**	**(2 124)**	*2 749*

Local currency, current prices

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
804	918	1 025	1 065	1 094	1 169	1 240	1 340	1 599	1 833	2 069	2 301
..	..	0.3	0.3	0.4	0.4	0.5	0.7	0.9	0.9	..	..
85	84	93	101	118	122	132	139	159	186	214	245

Per cent

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
3.7	*3.9*	*4.0*	*3.7*	*3.5*	*3.4*	*3.2*	*2.9*	*2.9*	*2.8*
..	..	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*
2.1	*2.0*	*2.1*	*2.1*	*2.2*	*1.9*	*1.8*	*1.6*	*1.7*	*1.7*

Table 6A.23. Africa: constant price figures

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Algeria	..	..	..	..	..	(108)†	129	137	155	152
Benin (Dahomey)[a]	..	..	..	..†	2.2	(2.9)	(3.4)	(4.1)	4.5	4.0
Burundi	..	..	..	..	..	(1.6)†	(1.8)	(2.0)	3.0	3.1
Cameroon	..	..	..	17†	21	27	23	22	24	26
Central African Empire	..	..	..	..†	2.1	2.0	1.9	4.0	3.5	3.6
Chad	..	..	..	..†	0.1	2.5	2.7	3.0	5.2	8.6
Congo	..	..	..	..†	3.7	6.4	(6.5)	7.7	7.3	10.8
Equatorial Guinea	..	..	..	..	..	..	..	..	..	..
Ethiopia	..	..	(25)	30	(33)	36	48	62	66	60
Gabon	..	..	..	..†	1.7	2.5	3.8	3.0	4.3	4.2
Ghana	20†	20	21	34	47	46	42	38	33	32
Guinea[a]	..	..†	..	..	5	7	7	8	13	16
Ivory Coast	..	..	..	..†	6	14	13	17	20	19
Kenya	8.4	7.5	6.6	3.7	1.2	0.8	2.7†	8.1	13	17
Liberia	..	..	..	..	..	..	(4.2)	4.1	4.3	4.2
Libya	..	..	(8)	(7)	(9)	(21)	(23)	25	32	60
Madagascar	..	..	..	3†	14	15	14	14	15	16
Malawi	..	..	..	..	..	..	..	(1.1)†	1.2	1.5
Mali	..	..	..	..†	[8.2]	[8.6]	9.2	9.9	8.6	9.1
Mauritania	..	..	..	..†	[4.0]	[5.9]	7.0	3.3	3.4	3.2
Mauritius	0.5	0.5	0.5	0.4	0.3	0.4	0.4	0.4	0.4	0.4
Morocco	60	70	69	70	80	85	112	100	88	92
Mozambique	..	..	..	..	..	..	..	..	..	..
Niger	..	..	..	..†	2.4	3.9	6.4	7.2	10.1	4.4
Nigeria	13	25	30	34†	35	41	52	58	68	58
Rhodesia, S.	..	..	..	..	..	..	..	21	25	24
Rwanda	..	..	..	..	..	..†	(2.7)	2.9	3.4	6.6
Senegal	..	..	..	..†	5	10	13	23	24	22
Sierra Leone	..	..	..	3.0	2.5†	2.7	2.9	3.0	3.0	2.7
Somalia	..	..	..	..†	5.3	6.0	7.1	7.7	6.5	8.3
South Africa	130	96	91	103	163	263	267	374	384	416
Sudan	23	26	29	33	33	38	42	54	66	72
Tanzania	..	..	..	..	..†	18	21	27	30	33
Togo	..	..	..	..†	(0.4)	(0.9)	1.4	(4.0)	(4.3)	3.3
Tunisia	8	14	22	25	28	22	23	27	22	25
Uganda	4	4	4	2	0.3	2†	6	11	19	25
Upper Volta	..	..	..	(2.0)†	(2.4)	6.7	6.8	6.8	4.5	5.0
Zaire	..	..	..	..†	..	..	39	52	134	121
Zambia	..	10	..	13	20	21	22	11†	29	28
Total Africa	[300.0]	[275.0]	[325.0]	[390.0]	[575.0]	[855.0]	966.9	1 163.3	1 337.5	1 397.0

[a] At current prices and 1973 exchange rates.
[b] 1975.

US $ mn, at 1973 prices and 1973 exchange rates (Final column, X at current prices and exchange rates)

1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1976X
152	150	149	139	136	134	138	262	229	263	(300)	*309*
4.5	4.5	4.9	5.4	5.8	6.0	6.4	6.5	5.8	7.9	..	*7*
3.4	3.5	3.4	3.9	4.2	3.8	6.2	6.9	6.3	7.0	..	*9*
27	28	29	30	30	30	33	35	35	35	..	*49*
5.0	6.4	8.2	7.3	7.5	6.2	7.3	6.8	6.1	..	..	*8*[b]
11.4	11.5	15.0	19.7	19.0	18.5	19.0	19.3	17.0	15.4	..	*19*
12.1	11.2	12.4	16.7	17.7	16.7	17.7	24.2	19.9	29.6	..	*37*
..	..†	4.3	4.3	4.3	4.6	4.9	5.0	[5.3]	..	..	*5*[b]
51	48	47	43	45	50	48	64	125	..	..	*146*[b]
4.1	4.0	5.9	6.5	7.4	7.8	9.3	10.1	11.1	..	..	*17*[b]
51	57	53	47	45	38	41	50	46	34	..	*94*
17	17	17	[22]	[20]	[21]	20	20	21	..	..	*21*[b]
21	22	22	24	26	27	27	37	33	31	..	*44*
20	20	19	21	26	33	37	41	37	54	(61)	*69*
4.7	3.9	4.1	4.7	5.3	4.5	3.7	3.1	3.3	3.6	..	*5*
171	270	413	455	648	668	888	1 789	[1 650]	1 594	..	*1 993*
17	18	18	18	19	17	21	19	19	[23]	..	*31*
1.8	1.8	1.6	1.8	1.9	2.0	3.0	3.8	4.5	..	..	*6*[b]
9.3	8.9	10.3	11.8	9.1	11.2	10.0	10.7	11.4	(16.8)	..	*20*
3.3	3.5	3.6	3.6	3.5	[3.8]	5.7	[7.7]	20.4	29.3	[36.7]	*44*
0.4	0.3†	2.1	4.0	4.5	4.8	5.4	5.6	6.5	..	..	*9*[b]
99	116	125	118	126	158	193	172	174	583	(301)	*769*
..	..	..	..	..	..	..	..	19†	54	(50)	*58*
5.2	5.8	5.5	5.8	6.1	5.0	3.9	3.1	4.8	..	..	*6*[b]
201	346	564	550	468	553	564	671	1 090	1 187	..	*2 335*
27	28	28	62	62	67	88	110	122	151	(206)	*193*
6.4	5.8	5.1	5.4	5.8	6.7	9.0	6.6	6.1	..	..	*9*[b]
24	25	22	25	25	25	20	20	20	25	(30)	*37*
2.6	3.1	3.7	4.2	4.1	4.1	4.0	4.6	4.6	..	..	*6*[b]
9.8	10.5	10.5	13.1	13.3	15.6	16.1	17.8	16.9	16.3	..	*26*
469	467	481	460	511	518	633	830	1 020	1 298	1 625	*1 452*
72	88	96	124	143	128	111	90	79	..	..	*123*[b]
37	38	45	55	65	56	56	60	59	..	..	*84*[b]
3.7	3.9	4.0	4.4	4.6	4.9	5.6	6.3	6.5	9.4	..	*13*
23	28	27	30	31	35	36	45	56	74	193	*91*
28	35	36	38	65	82	60	46	49	32	..	*83*
4.9	4.9	5.1	5.6	5.6	5.9	6.3	6.0	11.9	..	..	*16*[b]
102	83	96	136	129	116	130	131	97	41	..	*77*
31	34	25	42	93	108	74	82	75	233	222	*301*
1 732.6	**2 011.5**	**2 421.7**	**2 567.2**	**2 842.7**	**2 996.1**	**3 361.5**	**4 728.1**	**5 223.4**	**[6 210]**	**[6 500]**	*8 621*

Table 6A.24. Africa: current price figures

	Currency	1957	1958	1959	1960	1961	1962	1963	1964	1965
Algeria	*mn dinars*	..	..	..	..	..	320	390	425	490
Benin (Dahomey)	*mn francs*	..	..	..	..	(480)	(655)	(765)	(905)	995
Burundi	*mn francs*	..	..	..	..	..	86	100	119	182
Cameroon	*mn francs*	..	..	..	2 185	2 840	3 780	3 575	3 585	3 975
Central African Empire	*mn francs*	..	..	..	..	250	250	250	580	547
Chad	*mn francs*	..	..	..	..	7	319	367	441	820
Congo	*mn francs*	..	..	..	..	500	915	990	1 235	1 235
Equatorial Guinea	*mn ekueles*	..	..	..	..	..	..	..	..	..
Ethiopia	*mn birr*	..	..	33	41	46	50	68	90	107
Gabon	*mn francs*	..	..	..	..	245	370	620	500	740
Ghana	*mn cedis*	8.3	8.5	9.1	14.9	21.9	23.4	21.9	22.2	25.4
Guinea	*mn syli*	..	..	..	..	100	150	150	157	275
Ivory Coast	*mn francs*	..	..	..	..	990	2 148	1 976	2 742	3 162
Kenya	*mn pounds*	2.0	1.8	1.6	0.9	0.3	0.2	0.7	2.1	3.5
Liberia	*mn dollars*	..	..	..	..	..	..	2.6	2.6	2.8
Libya	*mn dinars*	..	..	1.4	1.4	1.8	4.2	4.7	5.4	7.3
Madagascar	*mn francs*	..	..	..	396	2 094	2 266	2 211	2 334	2 644
Malawi	*mn kwachas*	..	..	..	..	..	..	..	0.7	0.8
Mali	*mn francs*	..	..	..	..	[2 020]	[2 130]	[2 330]	[2 400]	2 260
Mauritania	*mn ouguiyas*	..	..	..	..	[100]	[150]	197	99	104
Mauritius	*mn rupees*	2.0	2.0	2.0	1.6	1.3	1.4	1.5	1.5	1.5
Morocco	*mn dirhams*	165	198	198	210	244	272	379	354	320
Mozambique	*mn escudos*	..	..	..	..	..	..	..	..	..
Niger	*mn francs*	..	..	..	..	315	488	(855)	(1 010)	1 480
Nigeria	*mn nairas*	4	8	10	12	13	16	20	23	28
Rhodesia, S.	*mn dollars*	..	..	..	..	..	..	..	10.2	12.6
Rwanda	*mn francs*	..	..	..	..	..	..	132	(180)	220
Senegal	*mn francs*	..	..	..	..	740	1 480	1 975	3 700	3 900
Sierra Leone	*mn leones*	..	..	..	1.5	1.3	1.4	1.5	1.7	1.8
Somalia	*mn shillings*	..	..	..	..	23	26	32	39	37
South Africa	*mn rands*	52	40	38	44	71	116	119	171	182
Sudan	*mn pounds*	4.1	5.0	5.4	6.1	6.8	7.9	9.2	12.2	14.6
Tanzania	*mn shillings*	..	..	..	..	..	84	95	124	148
Togo	*mn francs*	..	..	..	..	66	144	229	682	678
Tunisia	*mn dinars*	2.5	4.4	6.6	7.4	8.6	6.6	7.1	8.6	7.4
Uganda	*mn shillings*	15	14	14	8	1	5	20	39	77
Upper Volta	*mn francs*	..	..	..	311	403	1 201	1 294	1 313	860
Zaire	*mn zaires*	..	..	..	..	..	..	3.3	6.1	15.3
Zambia	*mn kwachas*	..	3.4	..	4.8	7.2	7.8	8.0	4.2	12.0

Local currency, current prices

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
490	490	490	490	488	491	500	545	1 085	1 030	1 288	1 600
900	1 000	1 000	1 100	1 200	1 300	1 330	1 415	1 445	1 285	1 759	..
200	212	237	235	273	300	285	492	638	670	800	..
4 365	4 775	4 990	5 250	5 622	5 920	6 274	7 390	9 080	10 425	11 600	..
588	827	1 109	1 451	1 351	1 468	1 312	1 616	1 667	[1 715]	..	..
1 426	(1 950)	(2 000)	2 700	3 850	3 925	(3 950)	4 300	4 810	(4 930)	4 600	..
1 910	2 218	2 130	2 336	(3 200)	(3 530)	(3 655)	4 010	5 770	5 570	8 890	..
..	..	..†	247	243	246	260	280	282	[300]	..	..
109	93	88	88	88	92	96	102	146	305	..	..
740	740	740	1 130	1 285	1 514	1 682	2 107	2 556	3 612	..	..
25.5	39.0	47.2	46.8	43.1	42.7	40.0	47.9	73.7	96.2	108.5	..
325	345	350	360	[445]	[415]	[425]	416	413	(440)	..	..
3 260	3 600	4 000	4 185	4 900	5 335	5 425	6 025	9 860	9 834	10 458	..
4.7	5.7	5.8	5.6	6.1	7.9	10.6	13.1	16.6	17.9	28.7	34.9
2.8	3.3	2.8	3.3	3.8	4.3	3.8	3.7	3.7	4.5	(5.2)	..
14.7	43	71	118	(130)	(180)	(185)	(265)	(575)	[580]	(590)	..
2 800	2 990	3 220	3 380	3 370	3 840	3 625	4 660	5 290	(5 550)	[7 300]	..
1.0	1.1	1.1	1.0	1.2	1.4	1.5	2.4	3.5	4.8	..	..
2 365	2 540	2 565	2 950	3 400	3 175	4 200	4 455	5 290	[6 000]	9 700	..
100	108	117	125	135	142	[165]	265	[400]	1 200	(1 975)	(2 830)
1.5	1.5	1.5†	9.4	18.1	20.4	23.2	29.4	39.5	52.6	..	..
332	356	419	464	444	493	642	817	856	(935)	(3 400)	2 000
..	..	..	..	..	..	..	..	..	600†	(1 760)	1 900
710	855	915	960	1 025	1 120	1 010	890	725	1 225	..	..
26	87	151	271	299	289	351	371	516	1 104	1 463	..
12.6	14.1	15.3	15.4	[34]	[35]	[39]	[53]	71	86	119	184
480	391	357	329	401	430	511	757	731	873	..	..
3 800	4 050	4 300	3 960	4 461	4 678	4 969	4 461	5 225	6 907	8 823	10 998
1.7	1.7	2.1	2.6	3.1	3.0	3.2	3.3	4.3	(5.1)	..	..
46	54	60	64	80	81	92	101	132	[150]	165	..
204	238	241	256	257	303	327	438	641	894	1 263	1 760
16.1	17.9	19.6	24.1	32.5	38.0	38.0	38.6	39.7	43.0	..	..
168	194	207	244	312	385	357	391	507	625	..	..
584	629	670	735	830	948	1 063	1 261	1 604	1 960	3 153	..
8.8	8.4	10.5	10.5	11.8	12.6	14.6	15.8	20.5	(28)	39	(110)
102	120	142	163	190	376	462	418	535	690	692	..
975	910	930	1 045	1 160	1 205	1 230	1 400	1 445	[3 425]	..	..
15.9	18.3	23	30	48	48	50	65	84	(79)	62	..
12.6	14.6	17.9	13.3	23	54	66	48	58	(58)	(215)	246

Table 6A.25. Africa: military expenditure as a percentage of gross domestic product

	1957	1958	1959	1960	1961	1962	1963	1964	1965
Algeria	. .	. .	. .	. .	. .	[2.7]	(3.1)	3.2	3.5
Benin (Dahomey)	. .	. .	. .	. .	1.3	1.7	1.9 ▌	2.1	2.2
Burundi	. .	. .	. .	. .	. .	. .	(1.4)	. .	1.4
Cameroon	. .	. .	. .	. .	. .	[2.7]	2.4	2.2	2.3
Central African Empire	. .	. .	. .	. .	0.7	0.7	0.7	1.5	(1.3)
Chad	. .	. .	. .	. .	. .	0.6	0.7	. .	1.4
Congo	. .	. .	. .	. .	[1.5]	[2.6]	(2.7)	[3.2]	[2.9]
Ethiopia	. .	. .	. .	1.7	1.9	1.9	2.4	2.9	3.2
Gabon	. .	. .	. .	. .	0.7	0.9	1.4	1.0	1.5
Ghana	1.1	1.1	1.0	1.6	2.1	2.1	1.8	1.6	1.6 ▌
Guinea	. .	. .	. .	. .	[2.0]	[2.7]	(2.7)	. .	. .
Ivory Coast	. .	. .	. .	. .	0.6	1.3	1.0	1.1	1.3
Kenya	1.0	0.8	0.7	0.4	0.1	0.1	0.3 ▌	0.6	1.0
Liberia	. .	. .	. .	. .	. .	. .	(0.9)	0.9	1.0
Libya	. .	. .	. .	. .	. .	2.4	1.9	1.4	1.4
Madagascar	. .	. .	. .	0.3	[1.5]	1.5	(1.5)	1.5	1.6
Malawi	. .	. .	. .	. .	. .	. .	. .	0.5	0.4
Mali	. .	. .	. .	. .	. .	. .	. .	2.8	. .
Mauritania	. .	. .	. .	. .	[2.3]	[3.1]	3.6 ▌	1.4	(1.4)
Mauritius	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.2	0.2
Morocco	2.3	2.4	2.4	2.3	2.7	2.6	3.2	2.8	2.4
Niger	. .	. .	. .	. .	0.6	0.8	1.3	1.5	2.0 ▌
Nigeria	0.2 ▌	0.4	0.5	0.5	0.5	0.6	0.7	0.7	0.8
Rhodesia, S.	. .	. .	. .	. .	. .	. .	. .	1.5	1.7
Rwanda	. .	. .	. .	. .	. .	. .	. .	. .	. .
Senegal	. .	. .	. .	. .	0.5	0.9	1.1	2.0	2.0
Sierra Leone	. .	. .	. .	. .	. .	. .	. .	0.7	0.7
South Africa	1.1	0.8	0.8 ▌	0.8	1.3	2.0	1.8	2.4	2.3
Sudan	1.2	1.5	1.5	1.6	1.7	1.8	2.0	2.6	3.0 ▌
Tanzania	. .	. .	. .	. .	. .	1.6	1.9 ▌	2.1	2.4
Togo	. .	. .	. .	. .	[0.2]	[0.5]	0.7	1.8	1.6
Tunisia	. .	. .	. .	2.2	2.3	1.7	1.6	1.8	1.4
Uganda	0.5	0.5	0.5	0.3	0.03	0.2	0.4	0.8	1.3
Upper Volta	. .	. .	. .	(0.7)	[0.8]	[2.3]	(2.4)	[2.4]	1.5
Zaire	. .	. .	. .	. .	. .	. .	1.7	3.1	5.6
Zambia	. .	1.2	. .	1.1 ▌	1.8	1.9	1.9	0.9 ▌	1.8

[a] GDP figure used excludes the three Eastern states.

Per cent

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
3.2	3.0	2.6	2.4	2.1	2.1	1.8	1.8	2.3	[2.0]	..
1.9	2.1	2.0	2.1	2.1	2.1	2.0	2.0	1.9	1.5	..
..	..	(1.5)	(1.4)	(1.5)	(1.6)	(1.4)	(2.2)	2.4	(2.1)	..
2.3	2.3	2.1	2.0	1.9	1.9	1.8	1.9	(2.0)	[2.3]	..
(1.3)	1.8	2.2	[2.7]	2.4	2.6	(2.1)	2.6	(2.3)	(2.2)	..
..	3.3	3.4	(3.9) ▮	5.1	4.9	(5.3)	5.6	(5.5)	5.3	..
[4.2]	[4.6]	(4.0)	(4.0)	(5.0)	[5.1]	(4.3)	4.0	(4.5)	[4.5]	..
3.1	2.5	2.2	2.1	1.9	1.9	2.0	1.9	2.7	(5.2)	..
1.3	1.3	1.0	1.3	1.4 ▮	1.4 ▮	1.6	1.3	0.7	[0.9]	..
1.7	2.6	2.8	2.3	1.9	1.7	1.4	2.3	3.4	(3.9)	..
..	..	(4.9)	(4.6)	..	..	..	..	..	..	..
1.3	1.3	1.2	1.2 ▮	1.2	1.2	1.1	1.1	1.3	1.2	..
1.1	1.3	1.2	1.1	1.1	1.2 ▮	1.5	1.6	1.6	1.5	2.0
0.9	1.0	0.8	0.9	0.9	1.0	0.8	0.7	0.5	0.5	(0.5)
2.2	5.5	6.4	9.3	9.8 ▮	11.1	10.3	11.8	14.1	[14.7]	..
1.5	1.6	1.5	1.5	1.4	1.4	1.3	1.8	(1.5)	[2.0]	..
0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.6	0.7	0.7	..
..	..	..	2.2	..	1.9	(2.4)	(2.5)	(2.6)	..	..
[1.2]	[1.2]	1.2	(1.3) ▮	(1.4)	..	1.3	2.0	..	..	..
0.2	0.2	0.2	0.9	1.7	1.8	1.6	1.6	1.2	1.5	..
2.6	2.6	2.7	2.9	2.6	2.7	3.2	3.8	3.2	3.1	(9.5)
0.7	0.9	1.0	1.0	0.9	..	..	..	..	..	..
0.7 ▮	2.8[a]	5.2[a]	7.5[a]	5.7	4.2	4.2	4.2	(4.7)	(9.1)	..
1.7	1.7	1.8	1.5	3.2	2.8	2.8	3.4	3.9	4.3	..
..	2.6	2.1	1.7	1.8	1.9	2.3	3.1	2.5	2.8	..
1.8	2.0	2.0	1.8	1.9	1.9	1.7	1.9	1.9	2.1	2.5
0.6	0.6	0.7	0.8	0.9	0.8	0.9	0.8	0.8	0.8	..
2.4	2.5 ▮	2.4	2.2	2.0	2.2	2.1	2.3	2.8	3.5	(4.4)
3.2	3.3	3.4 ▮	3.8	4.4	4.8	4.4	3.6	2.9	(2.4)	..
2.4	2.6	2.6	3.0	3.4 ▮	3.9	3.2	3.0	3.2	3.4	..
1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.4	1.3	1.6	..
1.6	1.4	1.7	1.5	1.6	1.4	1.3	1.3	1.3	1.6	2.0
1.7	1.9 ▮	1.9	1.9	2.0	3.6	..	..	..	..	..
1.7	.. ▮	1.1	..	1.3	..	1.3	..	1.3	..	..
5.2	5.9 ▮	3.2	3.3 ▮	5.0	4.7	4.6	4.4	4.8	..	..
1.6	1.6 ▮	1.7	1.0 ▮	1.8	4.5	4.9	3.0	3.0	3.7	..

Table 6A.26: Central America: constant price figures

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Costa Rica	8.1	7.7	7.7	7.8	7.5	7.7	7.6	7.2	7.9	8.8
Cuba[a]	..	..	..	..	207	237	252	262	252	252
Dominican Republic	..	51	63	51	50	48	46	49	47	44
El Salvador	9.4	8.7	7.2	7.1	7.4	10.3	10.8	10.6	10.8	11.1
Guatemala	11	12	12	12	11	11	12	16	18	18
Haiti	10	12	12	12	13	13	12	12	11	10
Honduras	6.5	6.5	6.5	5.9	10.1	10.1	10.4	7.8	7.5	8.7
Jamaica	..	..	..	..	..	1.4†	5.9	6.1	6.3	6.4
Mexico	122	120	120	132	141	158	173	194	195	238
Nicaragua	..	..	..	..	11	12	12	11	11	13
Panama	..	..	..	..	..	3.5	3.5	3.4	4.0	3.4
Trinidad and Tobago	..	..	..	..	..	..†	2.7	4.0	3.4	3.3
Total Central America	**[350.0]**	**[375.0]**	**[400.0]**	**[435.0]**	**458.0**	**512.0**	**547.9**	**583.1**	**573.9**	**616.7**

[a] At current prices and 1973 exchange rate.
[b] 1975.

Table 6A.27. Central America: current price figures

	Currency	1957	1958	1959	1960	1961	1962	1963	1964	1965
Costa Rica	*mn colones*	(32.7)	(31.8)	32.0	32.9	32.6	34.3	35.0	34.2	37.2
Cuba	*mn pesos*	..	..	..	..	175	200	213	221	213
Dominican Republic	*mn pesos*	..	34.5	42.6	33.4	31.6	33.1	34.0	37.0	35.0
El Salvador	*mn colones*	19.2	19.0	15.6	15.3	15.5	21.7	23.0	23.0	23.6
Guatemala	*mn quetzales*	9.3	9.8	9.8	9.4	9.2	9.3	10.2	12.7	14.3
Haiti	*mn gourdes*	29.7	35.0	34.4	33.3	35.5	37.7	36.2	38.8	36.6
Honduras	*mn lempiras*	8.9	[9.1]	9.3	8.2	14.4	14.5	15.4	12.0	12.0
Jamaica	*mn dollars*	..	..	..	..	..	0.7	3.0	3.2	3.4
Mexico	*mn pesos*	792	862	883	1 021	1 111	1 258	1 388	1 589	1 651
Nicaragua	*mn córdobas*	..	..	..	..	49.2	53.2	54.3	53.2	57.2
Panama	*mn balboas*	..	..	..	..	..	[2.7]	[2.7]	[2.7]	[3.2]
Trinidad and Tobago	*mn dollars*	..	..	..	..	..	..	3.3	4.9	4.3

Table 6A.28. Central America: military expenditure as a percentage of gross domestic product

	1957	1958	1959	1960	1961	1962	1963	1964	1965
Costa Rica	*1.4*	*1.3*	*1.2* ǀ	*1.2*	*1.1*	*1.1*	*1.0*	*0.9*	*0.9*
Cuba[a]	..	..	..	..	..	*6.6*	*6.2*	*5.3*	*5.1*
Dominican Republic	..	*4.8*	*6.1*	*4.6*	*4.5*	*3.7*	*3.4*	*3.4*	*3.7*
El Salvador	..	*1.4*	*1.2*	*1.1*	*1.1*	*1.4*	*1.4*	*1.2*	*1.2*
Guatemala	*1.0*	*0.9*	*0.9*	*0.9*	*0.9*	*0.8*	*0.8*	*1.0*	*1.1*
Haiti	..	..	..	*2.4*	*2.6*	*2.6*	*2.4*	*2.3*	*2.1*
Honduras	*1.3*	[*1.3*]	*1.2* ǀ	*1.2*	*2.0*	*1.9*	*1.9*	*1.3*	*1.2*
Jamaica	..	..	..	..	..	*0.1* ǀ	*0.5*	*0.5*	*0.5*
Mexico	*0.7*	*0.7*	*0.6* ǀ	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*
Nicaragua	..	..	..	..	*1.9*	*1.9*	*1.8*	*1.5*	*1.4*
Panama	..	..	..	..	..	*0.5*	*0.5*	*0.4*	*0.5*
Trinidad and Tobago	..	..	..	..	..	..	*0.3*	*0.4*	*0.3*

[a] Percentage of gross material product.

US $ mn, at 1973 prices and 1973 exchange rates (Final column, X, at current prices and exchange rates)

1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1976X
9.0	11.7	12.7	5.6	7.3	7.3	8.1	8.2	10.1	..	*12*[b]
296	355	296	343	343	316	320	334	386	..	*393*[b]
42	43	42	40	40	40	37	42	45	68	*95*
11.1	13.1	32.0	10.8	12.9	13.3	14.8	22.3	20.8	..	*29*[b]
20	19	18	33	21	22	21	22	30	..	*40*[b]
10	10	10	10	9	10	8	7	8	6	*9*
9.4	8.1	16.8	9.7	12.5	16.2	15.9	14.8	14.3	[16.8]	*21*
6.7	6.9	6.0	6.6	7.8	8.1	12.9	11.8	11.8	..	*18*[b]
236	254	267	273	294	332	353	342	408	544	*726*
14	13	13	15	15	19	15	20	23	26	*32*
5.0	4.9	7.3	9.1	15.6	9.9	10.7	11.0	11.9	..	*15*[b]
3.4	3.2	3.3	5.0	5.0	4.7	3.7	4.0	5.0	..	*6*[b]
662.6	**741.9**	**724.1**	**760.8**	**783.1**	**798.5**	**820.1**	**839.1**	**973.9**	**[1 150.0]**	*1 396*

Local currency, current prices

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
41.6	42.8	58.0	64.5	30.1	39.9	42.0	53.3	70.6	102.5	..
213	250	300	250	290	290	267	270	282	(326)	..
32.4	31.2	32.5	31.0	31.3	31.9	34.4	36.6	47.6	57.7	95.3
23.9	24.3	29.5	71.8	24.9	29.9	31.3	37.0	65.2	72.5	..
14.7	16.3	15.7	15.6	28.7	18.5	19.5	20.7	26.0	39.7	..
35.4	35.8	35.6	35.2	35.8	36.6	39.1	39.9	42.3	50.9	44.2
14.1	15.4	13.6	28.9	17.2	22.8	31.1	31.7	33.3	(34.1)	[42.3]
3.5	3.8	4.1	3.8	4.6	5.7	6.3	11.7	13.6	[16.0]	..
2 100	2 148	2 355	2 560	2 750	3 125	3 700	4 409	5 292	7 262	(11 200)
65.9	72.4	70.9	72.2	85.8	86.8	112.9	107.4	154.4	190.9	226.4
(2.7)	4.1	4.1	6.2	7.9	13.9	9.3	10.7	13.0	14.7	..
4.3	4.5	4.6	4.9	7.5	7.8	8.0	7.3	9.5	13.9	..

Per cent

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1.0	*0.9*	*1.1*	*1.1*	*0.5*	*0.6*	*0.5*	*0.5*	*0.5*	*0.6*
5.3	*6.1*	*6.9*	*6.0*	*6.9*	*6.0*	*4.4*	*4.0*	*3.8*	..
3.1	*2.8*	*2.8*	*2.3*	*2.1*	*1.9*	*1.7*	*1.6*	*1.6*	*1.6*
1.1	*1.1*	*1.3*	*3.0*	*1.0*	*1.1*	*1.1*	*1.1*	*1.7*	*1.6*
1.1	*1.1*	*1.0*	*0.9*	*1.5*	*0.9*	*0.9*	*0.8*	*0.8*	*1.1*
1.9	*1.9*	*1.9*	*1.8*	*1.7*	*1.6*	*1.6*	*1.2*	*1.1*	*(1.2)*
1.3	*1.3*	*1.0*	*2.2*	*1.2*	*1.5*	*1.9*	*1.7*	*1.7*	*1.6*
0.5	*0.5*	*0.5*	*0.4*	*0.4*	*0.4*	*0.4*	*0.7*	*0.6*	*0.6*
0.7	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*
1.6	*1.6*	*1.5*	*1.4*	*1.6*	*1.5*	*1.8*	*1.4*	*1.5*	*1.8*
0.4	*0.5*	*0.5*	*0.7*	*0.8*	*1.2*	*0.7*	*0.7*	*0.7*	*0.8*
0.3	*0.3*	*0.3*	*0.3*	*0.4*	*0.4*	*0.4*	*0.3*	*0.2*	*(0.3)*

Table 6A.29. South America: constant price figures

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Argentina	658	682	540	596	580	558	559	515	573	646
Bolivia	4	[4]	[5]	[6]	7	7	15	15	17	16
Brazil	755	770	620	574	519	554	544	583	863	736
Chile	191	178	143	154	157	158	144	135	153	189
Colombia	69	63	52	59	70	111	122	115	126	127
Ecuador	24	23	20	27	26	25	22	25	28	26
Guyana	. .	. .	. .	. .	. .	. .	. .	. .	. .	1.2†
Paraguay	. .	. .	. .	. .	9	9	10	10	11	12
Peru	110	125	111	108	128	127	175	171	170	169
Uruguay	. .	. .	. .	. .	29	30	42	41	46	44
Venezuela	160	184	178	161	155	148	177	183	206	213
Total South America	**[2 000]**	**[2 060]**	**[1 700]**	**[1 725]**	**1 680**	**1 727**	**1 810**	**1 793**	**2 193**	**2 179.2**

[a] 1975.

Table 6A.30. South America: current price figures

	Currency	1957	1958	1959	1960	1961	1962	1963	1964	1965
Argentina	*mn new pesos*	71	98	171	236	263	325	402	452	647
Bolivia	*mn pesos*	24	[26]	[35]	[49]	58	61	137	147	178
Brazil	*mn cruzeiros*	35	41	44	55	70	114	194	388	924
Chile	*mn pesos*	0.073	0.082	0.091	0.109	0.119	0.135	0.179	0.245	0.358
Colombia	*mn pesos*	289	306	272	317	410	664	965	1 072	1 218
Ecuador	*mn sucres*	289	282	247	336	336	329	307	370	428
Guyana	*mn dollars*	. .	. .	. .	. .	. .	. .	. .	. .	. .
Paraguay	*mn guaranies*	. .	. .	. .	. .	[750]	[750]	[860]	[840]	[975]
Peru	*mn soles*	1 039	1 265	1 259	1 340	[1 687]	[1 785]	2 614	2 824	3 286
Uruguay	*mn new pesos*	. .	. .	. .	. .	0.187	0.221	0.365	0.509	0.9
Venezuela	*mn bolivares*	496	601	607	540	533	509	613	650	742

Table 6A.31. South America: military expenditure as a percentage of gross domestic product

	1957	1958	1959	1960	1961	1962	1963	1964	1965
Argentina	*2.6*	*2.5*	*2.3*	*2.3*	*2.2*	*2.2*	*2.1*	*1.7*	*1.8*
Bolivia	*0.8*	[*0.8*]	[*0.9*]	[*1.1*]	*1.2*	*1.1*	*2.4*	*2.3*	*2.5*
Brazil	*2.9*	*2.8*	*2.2*	*2.0*	*1.7*	*1.7*	*1.6*	*1.7*	*2.5*
Chile	*3.2*	*2.7*	*2.2* ▍	*2.6*	*2.5*	*2.4*	*2.1*	*1.9*	*1.9*
Colombia	*1.6*	*1.5*	*1.2*	*1.2*	*1.3*	*1.9*	*2.2*	*2.0*	*2.0*
Ecuador	*2.4*	*2.3*	*1.9* ▍	*2.4*	*2.2*	*2.0*	*1.8*	*1.9* ▍	*1.9*
Guyana	. .	. .	. .	. .	. .	. .	. .	. .	. .
Paraguay	. .	. .	. .	. .	[*1.8*]	[*1.7*]	[*1.8*]	[*1.6*]	[*1.7*]
Peru	*2.9*	*3.1*	*2.7*	*2.4*	[*2.6*]	[*2.4*]	*3.2*	*2.9*	*2.9*
Uruguay	. .	. .	. .	. .	*1.1*	*1.2*	*1.6*	*1.6*	*1.7*
Venezuela	*2.1*	*2.4*	*2.4* ▍	*2.1*	*2.0*	*1.7*	*1.9*	*1.8*	*2.0*

US $ mn, at 1973 prices and 1973 exchange rates (Final column, X, at current prices and exchange rates)

1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1976X
704	595	633	659	590	596	511	689	1 135	1 010	1 145	*1 205*
15	13	11	14	13	18	21	24	30	37	(39)	*68*
1 013	1 017	1 119	1 056	1 444	1 514	1 767	1 072	1 076	1 216	1 407	*1 521*
199	212	236	323	330	398	628	590	409	[912]	(882)	*[440]*
130	171	99	121	223	116	104	100	108	107	(85)	*134*
28	31	40	41	36	42	50	58	71	66	63	*104*
2.8	2.3	2.5	3.7	3.3	3.8	4.0	6.4	9.1	. .	. .	*10[a]*
13	13	14	16	11	19	17	16	19	22	23	*31*
215	215	226	285	297	276	337	345	469	378	(278)	*491*
52	39	53	59	77	69	65	56	78	48	46	*60*
242	241	228	229	277	312	304	422	475	353	(530)	*456*
2 613.8	**2 549.3**	**2 661.5**	**2 806.7**	**3 301.3**	**3 363.8**	**3 808.0**	**3 378.4**	**3 879.1**	**[4 160.0]**	**[4 510.0]**	*4 520*

Local currency, current prices

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
962	1 354	1 329	1 521	1 800	2 170	3 474	4 780	8 000	37 268	180 379	460 240
175	179	168	144	197	187	272	418	787	1 041	1 360	1 500
1 157	2 066	2 574	3 492	3 926	6 498	8 033	10 831	8 202	10 722	16 406	26 950
0.542	0.681	0.917	1.319	2.405	2.951	6.314	45.230	256.8	845.0	[5 875]	10 930
1 467	1 627	2 263	1 437	1 885	3 789	2 255	2 479	2 950	4 023	4 687	5 120
413	456	527	714	767	742	933	1 250	1 790	2 522	2 592	2 850
2.0	4.8	4.0	4.5	6.7	6.1	7.5	8.5	15.6	(24.0)	. .	. .
1 132	1 226	1 292	1 414	1 514	1 075	2 131	2 165	2 513	3 173	3 845	4 550
3 575	4 994	5 957	6 650	8 800	9 800	9 765	13 040	15 600	(26 250)	[28 200]	30 030
1.5	3.3	5.6	9.3	11.9	19.4	30.6	56.9	86.3	219	205	316
782	885	894	867	891	1 113	1 290	1 309	1 969	2 440	1 956	(3 154)

Per cent

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2.1	*2.3*	*1.9*	*1.9*	*1.9*	*1.6*	*1.6*	*1.3*	*1.6*	*2.8*	. .
2.2	*2.0*	*1.6*	*1.3*	*1.6*	*1.4*	*1.8*	*1.9*	*2.1*	*2.4*	. .
2.2	*2.9*	*2.6*	*2.6* ❙	*1.9*	*2.4*	*2.2*	*2.3*	*1.2*	*1.2*	. .
2.1	*2.0*	*2.0*	*2.0*	*2.5*	*2.3*	*2.6*	*3.7*	*2.7*	*2.2*	. .
2.0	*2.0*	*2.3*	*1.3*	*1.4*	*2.5*	*1.2*	*1.0*	*0.9*	*1.0*	. .
1.7	*1.7*	*1.8*	*2.2* ❙	*2.3*	*1.8*	*2.0*	*2.0*	*2.0*	*2.3*	*(2.1)*
0.5	*1.1*	*0.9*	*0.9*	*1.3*	*1.1*	*1.3*	*1.3*	*1.7*	*2.0*	. .
1.9	*2.0*	*2.0*	*2.0*	*2.0*	*1.3*	*2.2*	*1.7*	*1.5* ❙	*1.7*	*(1.8)*
2.6	*3.2*	*3.2*	*3.2*	*3.7*	*3.7*	*3.3*	*3.6*	*3.5*	*4.7*	*[3.7]*
1.5	*1.9*	*1.5*	*1.8*	*1.9*	*2.6*	*2.5*	*2.2*	*1.9*	*2.7*	. .
2.0	*2.1* ❙	*2.0*	*1.9*	*1.7*	*1.9*	*2.0*	*1.7*	*1.5*	*2.0*	. .

7. World arms production

A considerable proportion of the enormous financial resources devoted to military activities is spent by the four major weapon suppliers—the United States, the Soviet Union, the United Kingdom and France—in developing and producing weapons.

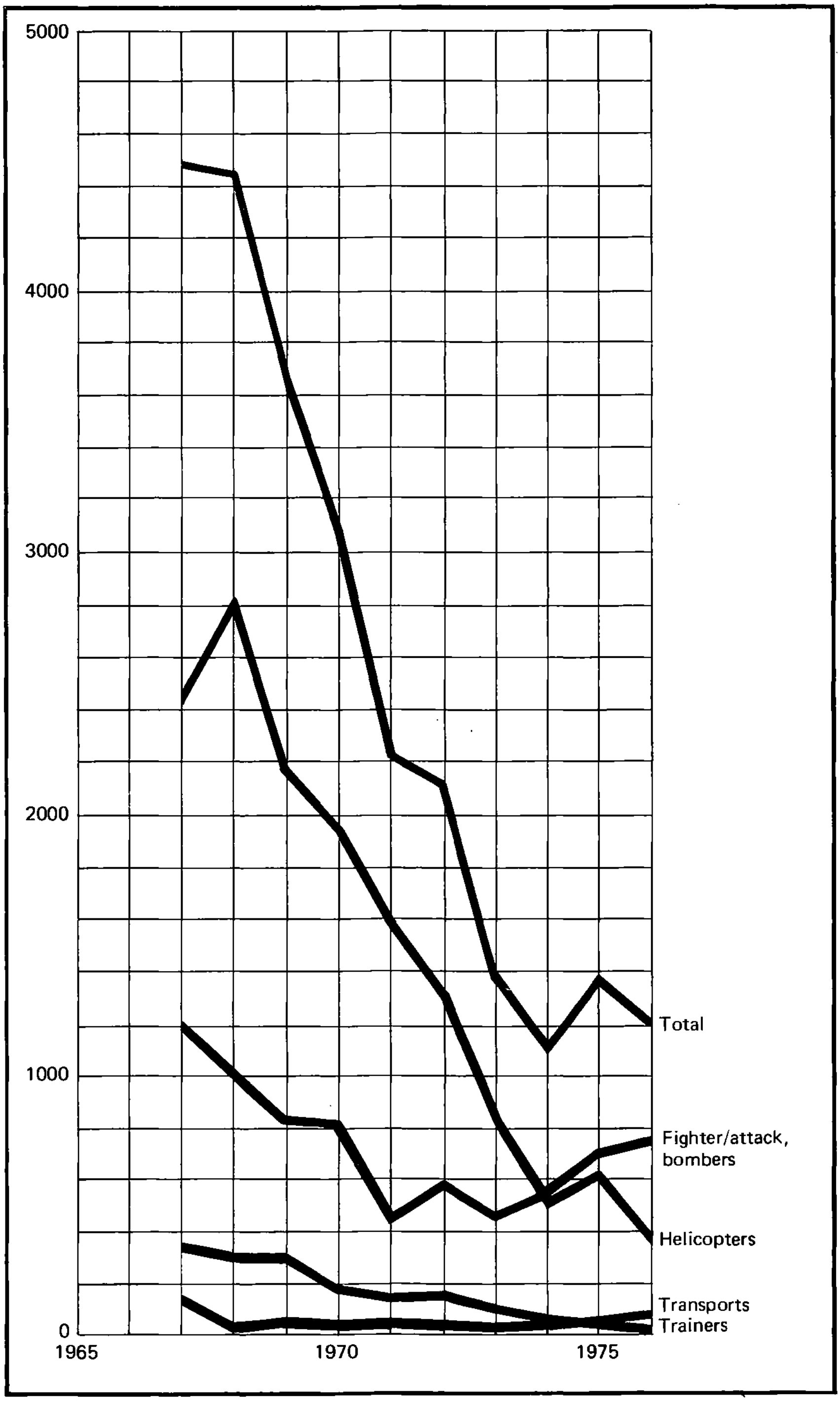
It is ironic that these four countries—all of them nuclear weapon states —have been involved in efforts to curb the spread of nuclear weapons, but until now have made no attempt to tackle the problem of the development and spread of conventional weapons. However, a start has been made in the establishment in 1977 by the USA and the USSR of a joint working group on the control of conventional arms transfers, although no substantial negotiations have yet taken place.

The registers in appendices 7A and 7B amply illustrate the continuing growth in arms production throughout the world. This is not an even growth, however. Certain types of weapon production periodically decline in favour of other types of weapon, as is illustrated in figure 7.1. From this figure it can be seen that the total rate of production of various types of aircraft in the USA has declined considerably since 1967, when the production rate was about 4 500 aircraft a year. By 1976, this figure had sunk to about 1 200 aircraft. It should be emphasized, however, that the unit cost of aircraft has escalated since 1967, which, among other reasons, almost certainly accounts for the decline in production.

Moreover, this decline in production has not been an absolute one. From the statistics, it can be observed that certain types of aircraft—fighters and bombers—have been produced at an increasing rate since 1971. This trend is likely to continue as the F-15, F-16 and F-18 build up to higher production rates to satisfy the US and other countries' requirements. The production of missiles is also likely to increase. In the coming year, for example, it is predicted that the number of Sparrow missiles to be procured by the US Air Force alone will increase from 880 to 1 300, and that of Sidewinder missiles will increase from 1 000 to 2 300. Although such figures for the production rates for aircraft and missiles for the Soviet Union are not published, similar trends are likely to exist.

A review of the Third World arms production registers, for both licensed and indigenous production (see appendix 7B), also shows a steady increase in the capacity of underdeveloped countries to produce their own major weapons. In fact, some Third World countries are now themselves

Figure 7.1. The rate of US military aircraft production



Source: US Aerospace Industries Association.

beginning to produce and export major weapons to other countries (see appendix 8A).

The countries in the Third World which are producing or have produced major weapons are listed in table 7.1. This list would, of course, be longer if the production of small arms were included.

Table 7.1. Production of major weapons in Third World countries, 1950–77[a]

Country	Military aircraft	Guided missiles	Armoured fighting vehicles	Warships
Argentina	×	×	×	×
Bangladesh				×
Brazil	×	×	×	×
Burma				×
Chile				×
Colombia	×			×
Dominican Republic				×
Egypt	×	×		
Gabon				×
India	×	×	×	×
Indonesia	×			×
Iran	×	×		
Israel	×	×	×	×
Korea, North	×			×
Korea, South	×			×
Libya	×			
Mexico	×			×
Pakistan	×	×	×	×
Papua New Guinea	×			
Peru	×			×
Philippines	×	×	×	×
Singapore				×
South Africa	×	×	×	×
Syria				×
Taiwan	×	×		×
Thailand	×			×
Venezuela				×
Viet Nam	×			

[a] Aircraft, missiles, armoured vehicles and ships are considered as major weapons. Most of the countries listed manufacture weapons of foreign design under licence. Initially these countries assemble imported parts, some of them later going on to produce them.

Source: SIPRI data.

Appendix 7A

Registers of indigenous and licensed production of major weapons in industrialized countries, 1977

I. Register of indigenously designed major weapons in development or production in industrialized countries, 1977

For sources and methods, see chapter 9. For conventions, see page 293.

Part 1. *Aircraft*

Country	Designation, description	Power plant	Weight *max takeoff wt, kg*	Speed *km/h* or *Mach no.*	Year design begun	Year of proto-type flight	Year in pro-duction	Number: domestic/ export or total	R&D cost *$ mn*	Unit price *$ mn*	Foreign-designed Power plant, Electronics or Armaments
NATO											
Canada	*DHC-5*										
	DHC-5D Buffalo STOL transp[a]	TP	22 316	420	..	1974	1975	../28	..	5	PP (USA)
	DHC-6 Twin Otter STOL transp	TP	5 670	338	1964	1965	(1965)	../560[b]	..	0.6[c]	–
	DHC-7R Ranger STOL transp/recce	TP	19 504	452	(1971)	(1978)	..	..[d]	..	~3.5	–
France	*Mirage F1* fighter	TJ	14 900	M 2.2	1964	1966	1972	185[e]/357[f]	..	~0.6	E-r (UK) Ar (USA)
	Mirage III interceptor, ground attack or recce	TJ	13 500	M 2.2	Mid-1950s	1956	1958	526[g]/470[h]	..	..	E-r (UK)
	Mirage 5 ground attack vers	TJ	13 500	M 2.2	..	1967	1969	73[i]/419[j]	..	..	..
	Mirage 50[k] multi-mission fighter	TJ	13 500	> M 2	..	(1975)	..	–/14	..	..	..
	Mirage 2000 fighter, interceptor	TJ	15 000	M 2.4	1975	(1978)	(1981)	..[l]	..	..	..
	Super Mirage Delta[m] fighter, long range interdiction	..	..	..	1976	(1978)	..	..	..	..	..
	Super Etendard multi-role carr-b	TJ	11 500	M 1	..	1974	1977	36[n]/..	..	10.5[o]	E-n (USA)
	Atlantic Mk IV[p] maritime patrol	TP	43 500	658	1977	1979–80	1982–83	..	..	..	PP (UK)
	Falcon 20G[q] maritime patrol	TS	..	..	..	1975	..	../41	..	5	PP (USA)
	AS 350 Ecureuil light multi-role hel	TS	1 900	267	..	1974	1978	../137	..	~0.22	–[r]
	SA 315B Lama light utility hel	TS	1 950	120	1968	1969	..	../> 200	..	0.22	–
	SA 319B/316B Alouette III light utility hel	TS	2 250	220	..	1967	1967	..[s]	..	..	–
	SA 321 G/H Super Frelon anti-sub vers	TS	13 000	275	..	1962	..	23[t]/74	..	..	–

Country	Designation, description	Power plant	Weight *max takeoff wt, kg*	Speed *km/h* or *Mach no.*	Year design begun	Year of proto-type flight	Year in pro-duction	Number: domestic/ export or total	R&D cost *$ mn*	Unit price *$ mn*	Foreign-designed Power plant, Electronics or Armaments
	SA 332 Puma[u] tactical transp hel	..	..	..	..	..	..	..	..	..	–
	SA 360 Dauphin utility hel	TS	2 800	315	1970	1972	1976	../..[v]	..	..	–
	SA 365 Dauphin twin-engine vers	TS	3 200	315	..	1975	1977	..	..	..	–
FR Germany	*Do 24/27* rescue flying boat	TP	18 600	416	1973	..	..[w]	..	..	..	PP (USA)
	AM-C 111 STOL transp	TP	6 800	415	..	(1978)	..[x]	..	..	..	PP (Can)
	Do 28 D-2 STOL transp	P	3 842	325	..	1966	1968	128[y]/52	..	..	PP (USA)
	AWI 2 Fantrainer trainer	..[z]	1 350	320	1970	1977	..	..	..	..	–
	Bo 105M utility hel	TS	2 300	270	1962	1966	1971	100[aa]/38	..	~0.74	PP (USA)
	PAH-1 anti-tank vers hel	TC	2 300	270	..	..	..	212/..	..	~0.92	PP (USA)
International:											
FRG (40%) UK (47.5%) It. (12.5%)	*Panavia MRCA* multi-purpose aircr	TF	17 240–18 145	M 2.2	1969	1974	1976[ab]	150[ac]/..	3 200[ad]	10.6[ae]	E-r (USA)
Fr. (50%) UK (50%)	*Jaguar, Sepecat* strike fighter/ trainer	TF	15 500	M 1.5	1964	1968	1971	~350[af]/–	..	..	..
	Jaguar International export vers	TF	15 500	M 1.5	..	..	1975	–/24	..	..	..
Fr. (50%) FRG (50%)	*Alpha-Jet* multi-purpose aircr	TF	7 000	991	1969	1973	1977	408[ag]/29[ah]	..	~4[ai]	..
Fr. (50%) FRG (50%)[aj]	*C-160 Transall* transp	TP	51 000	592	Early-1960s	1963	..	4[ak]/–	..	..	PP (UK)
Fr., UK[al]	*SA 330 Puma* medium tactical transp hel	TS	7 400	273	..	1965	1968	209/413[am]	..	..	..
	Lynx WG.13 multi-purpose hel	TS	4 763	273	1968	1971	1974	186/37	..	..	..
	SA 341/342 Gazelle light utility hel	TS	1 900	310	..	1967	1977	368/>70[an]	..	..	..
FRG, UK[ao]	*P277* anti-tank hel	TS	4 763	287	1977	..	..	..	..	..	PP (UK)
Italy	*MB.326 K, L* trainer/light strike	TJ	5 897	871	..	1957	..	../19[ap]	..	~1.3	PP (UK)
	MB.339 trainer/light strike	TJ	5 895	898	(1974)	1976	..	7[aq]/..	.	~1.6	PP (UK)
	G222 transp	TP	26 500	540	..	1970	1974[ar]	44/4	.	..	PP (USA)
	SF 260 MX/W/SW trainer/light strike/surveillance/COIN	P	1 200	340	..	1970	..	20/179	.	..	PP (USA)
	SM 1019E STOL light utility	TP	1 450	313	1969	1969	1974	80/..	..	..	PP (USA)
	A 109 multi-purpose hel	TS	2 450	311	..	1971	(1975)	5[as]/..	..	..	PP (USA)
	P166-DL3 multi-purpose utility	TP	4 300	417	..	1976	..	4/..	..	..	PP (USA)
Netherlands	*F.27 400M/500M/600M* recce/transp	TP	20 410	480	..	1965	..	../66	..	..	PP (UK)
	maritime patrol vers	TP	20 410	427	1975	1976	1977	../2	..	..	PP (UK) E (USA, Can.)

UK	*Buccaneer S Mk 2* strike/recce	TF	28 123	M 0.85	..	1963	1964	48[at]/..	..	..	Ar (Fr.)
	Harrier V/STOL strike/recce	TF	11 340	~M 1.3	..	1966	1968	139/118[au]	..	..	–
	Sea Harrier V/STOL strike/recce	TF	11 340	M 0.9	1975	1977	(1979)	25/..	..	..	–
	Strikemaster light strike/trainer	TJ	5 215	760	..	1967	..	../145	..	..	–
	Nimrod maritime recce	TF	87 090	926	1964	1967	1968	49[av]/	..	..	–
	AEW vers	TF	87 090	926	1973	1977	(1980)	11/..	~213	~36	–
	HS 748 Andover transp	TP	23 133	452	1957	1960	1961	31/26	..	..	–
	Coastguarder maritime patrol	TP	23 133	452	(1973)	1977	..	..	..	..	..
	SD3-30M STOL transp	TP	10 886	367	..	1974	..	..	..	..	PP (Can.)
	SD3-MR Seeker maritime patrol	TP	10 886	367	..	..	..	..	..	..	PP (Can.)
	SC.7 Skyvan Srs 3M STOL light transp	TP	6 577	327	..	1970	1970	–/48	..	..	PP (USA)
	HS.1182 Hawk trainer/strike	TF	7 375	M 1.16	(1971)	–[aw]	1976	175/50	..	5.8[ax]	PP (UK+Fr.)
	Defender ground support/recce/transp	P	2 993	283	..	1971	1972	../79	..	..	PP (USA)
	Trislander M transp/maritime patrol	P	4 536	290	1970	1970	1971	..[ay]/..	..	..	PP (USA)
	Jetstream 200 trainer	TP	5 700	454	..	1973[az]	1972	26/–	..	..	PP (Fr.)
	NDN-1 Firecracker trainer/COIN	P	1 202	441	(1977)	1977	..	..	..	..	PP (USA)
	Bulldog 120 primary trainer	P	1 066	241	1968	1969	(1971)	130/90	..	..	PP (USA)
	200 light strike vers	P	1 179	278	1974	1976	..	..	..	..	PP (USA)
USA	*B-1* strategic bomber	TF	176 810	~M 2	1970	1974	..[a]	..	24 800	101.7	–
	F-111F fighter-bomber	TF	41 500	M 2.2	..	..	..	106[b]/–	..	..	–
	FB-111H bomber[c]	..	..	..	(1977)	..	..	../–	~7 000	42.1	–
	F-15A Eagle fighter	TF	25 401	1 482	1965	1972	1974	296[d]/210	..	16.8	–
	F-14A Tomcat fighter/strike carr-b	TF	33 724	M 2.4	..	1970	..	..[e]/80	..	19.6	–
	F-18 light fighter/strike carr-b	TJ	19 960	M 1.8	1974	1978	(1982)	11[f]/–	12 800[g]	15.8[h]	–
	F-16 light fighter/strike	TF	14 968	> M 2.0	1974	1974	(1977)	650/508[i]	..	~11	E-f (UK)
	XFV-12A V/STOL light fighter carr-b	TF	8 845	> M 2.0	1973	1976	–	2/..	..	..	–
	AV-8B[j]/V/STOL strike carr-b	TF	13 154–13 608	M 1.3	1975	1978	1981	360/–	..	~6.25	PP (UK)
	F-4 Phantom strike/recce	TJ	24 765	> M 2.2	..	1958	..	–/657[k]	..	~8.94	–
	F-5E/F Tiger II light fighter										
	F-5E Tiger II light fighter	TJ	11 192	M 1.63	1970	1972	1973	77/679[l]	..	~6.25	–
	F-5F Tiger II two-seat vers	TJ	11 192	M 1.55	1970	1972	1973	3/69	..	..	–
	F-5B Freedom Fighter light fighter	TJ	9 298	M 1.34	..	1964	..	../84	..	..	–
	A-10A strike	TF	21 500	722	1970	1972	1975	339[m]/–	..	6.1	–
	A-7E Corsair II[n] stroke carr-b vers	TF	19 050	1 123	..	1968	1968	24[o]/–	..	7.16	–
	A-6 Intruder strike carr/land-b										
	A-6E Intruder strike carr/land-b	TJ	26 580	1 035	..	1970	..	238[p]/..	..	15	–
	EA-6B Prowler ECM vers	TJ	29 483	1 055	1966	1968	1969	90/..	..	..	–
	A-4M Skyhawk II strike carr/land-b	TJ	11 113	1 040	..	1970	1970	24/36[q]	..	..	–
	A-37B Dragonfly light strike COIN	TJ	6 350	816	1967	1967	(1968)	250/82[r]	..	..	–
	OV-10 E/F Bronco light strike	TP	6 563	452	..	1973	(1974)	–/30	..	~2.43	–
	P-3 Orion ASW patrol										
	P-3C Orion ASW patrol	TP	61 235	761	..	1968	1968	41/76[s]	..	29	–

Country	Designation, description	Power plant	Weight *max takeoff wt, kg*	Speed *km/h* or *Mach no.*	Year design begun	Year of proto-type flight	Year in pro-duction	Number: domestic/ export or total	R&D cost *$ mn*	Unit price *$ mn*	Foreign-designed Power plant, Electronics or Armaments
	P-3F Orion export 3C vers, simpler electronics	TP	61 235	761	..	..	1973	–/6	..	..	–
	S-3A Viking ASW carr-b	TF	23 831	834	1969	1972	1972	187[t]/–	..	..	–
	US-3A Viking carr-b transp vers	TT	21 592	834	(1975)	1976	..	30/..	..	..	–
	E-4 AABNCP Advanced Airborne National Command Post com. & con.										
	E-4B with advanced equipment	TF	351 530	958	..	1976	..	1/–	~353[u]	..	–
	E-3A AWACS-Airborne Warning and Control System AEW/com. & con.	TF	147 421	926	..	1972	1975	19/23[v]	..	~102.8	–
	E-2C Hawkeye AEW carr-b	TP	23 391	602	..	1971	1971	83/29[w]	994.4	20	–
	AMST-Advanced Medium STOL Transp YC-14 prototype	TF	107 500	811	1972	1976	..	2/–	11 000[x]	..	–
	C-130 Hercules medium transp										
	C-130H current standard vers	TP	79 380	620	..	1964	1965	12[y]/115	..	..	–
	EC-130Q airborne comm. relay	TP	79 380	620	..	..	..	10/–	..	..	–
	KC-130R/H tanker	TP	..	..	..	..	1973	14/2	..	~7.93	–
	T-37C basic jet trainer	TJ	3 402	612	..	..	..	– 19[z]	..	..	–
	T-2D/E Buckeye jet trainer carr/ land-b	TJ	5 977	840	..	1968	1968	–/32[aa]	..	4.345	–
	T-34C Mentor basic trainer	TP	1 938	414	1973	1973	1976	116[ab]/50	..	~0.458	PP (Can.)
	T-41D primary trainer	P	1 156	246	1963	..	..	238/5	..	..	–
	T-44A advanced trainer	TP	4 377	412	..	..	..	38/–	..	1.35	PP (Can.)
	F33A/C trainer	P	1 542	322	..	1959	(1960)	–/55	..	..	–
	C-12/Huron light transp	TP	5 670	530	1970	1972	1973	90/–	..	~0.8	PP (Can.)
	AAH-Advanced Attack Hel										
	AH-64	TS	7 892	307	1973	1975	1980	536[ac]/–	3 758	1.7	–
	AH-1 attack hel										
	AH-1S Cobra/TOW	TS	4 309	352	..	1973	1974	148[ad]/19	..	3.22	–
	AH-1J Sea Cobra	TS	4 535	333	..	..	..	7/202[ae]	..	~1.8	PP (Can.)
	AH-1T Sea Cobra attack hel	TS	6 350	..	..	..	..	49/–	..	~0.79	PP (Can.)
	UTTAS-Utility Tactical Transp Aircr System										
	YUH-60A medium transp hel prototype	TS	9 707	318	1972	1974	1979	15[af]/–	~3 700	1.56	–
	H-53 multi-purpose hel										
	CH-53E shipborne heavy lift	TS	31 638	315	1971	1974	1976	72/–	..	..	–
	RH-53D mine countermeasure	TS	22 680	315	1970	1972	1972	–/8	..	..	–
	CH-47C Chinook transp hel	TS	20 865	–	..	1967	1968	–[ag]/10	..	..	–
	Bell Model 214 Huey Plus utility hel	TS	6 803	241	1970	1974	1974	–/332[ah]	..	~0.6	–
	UH-1 Iroquois utility hel										
	UH-1N current production vers	TS	5 080	203	1968	..	1969	270/20	..	~0.79	PP (Can.)

	UH-1H current production vers	TS	3 660	204	..	..	1967	54/65	..	~0.79	–
	Lamps Mk III Light Airborne Multi-Purpose System hel	TS	5 805	265	1972	1978	1979	209/–	..	14.5	–
	Hughes 500 M light recce and ASW hel	TS	1 360	240	..	..	..	../110[at]	..	..	–
	Bell Model 206 JetRanger multi-purpose light hel	TS	1 451	225	..	..	..	–/53	..	..	–
	S-76 multi-purpose hel	TS	4 399	286	1975	1977	1978	..	..	..	–
	S-72 RSRA Rotor Systems Research Aircraft high speed multi-purpose research hel	TS	11 884	555	..	1976	..	..	..	..	–
Warsaw Treaty Organization											
Czechoslovakia	*L-39 Albatross* combat trainer	TF	4 600	750	..	1968	1972	400–500/ 600–500	..	..	PP (USSR)
	L-39Z light strike vers	TF	4 535	750	..	..	..	..	..	..	PP (USSR)
Poland	*TS-111 Iskra* trainer	TJ	3 800	722	..	1960	1962	> 300/..	..	..	–
	Iskra 100 ground attack	TJ	..	..	..	1972	..	../50	..	..	–
	Iskra 200 current production vers	TJ	3 840	720	..	..	..	..	..	..	–
	Mi-2M utility hel	TS	3 700	210	1968	1974	1975	> 5/..	..	..	PP (USSR)
USSR	(*Tu-26*) "*Backfire-B*" bomber	TF	127 000	> M 2	1969	(1971)	(1973)	~130/..	..	..	–
	MiG-25 "*Foxbat A*" fighter	TJ	36 200	M 2.8	..	1965	(1970)	..[a]/–	..	~11	–
	"*Foxbat B*" recce vers	TJ	33 400	M 3.2	..	..	(1969)	../–	..	..	–
	MiG-23 "*Flogger*" fighter										
	"*Flogger A*" initial vers	TJ	14 500	M 2	..	1967	(1970)	> 600[b]/ ~40[c]	..	..	–
	"*Flogger B*" fighter/strike vers	TJ	20 400	M 2.3	..	..	..	..	..	..	–
	"*Flogger C*" two-seat vers	TJ	20 400	M 2.3	..	..	..	..	..	..	–
	MiG-27 "*Flogger D*" multi-role fighter	TJ	20 400	M 1.5	..	..	..	../99	..	..	–
	Tu-22 "*Blinder*" interceptor vers	TJ	83 900	M 1.4	..	..	(1973)	225/12	..	..	–
	Su-19 "*Fencer*" multi-role combat	TJ	30 850	> M 2	..	(1970)	(1973)	../–	..	..	–
	Su-15 "*Flagon*"[d] fighter	TJ	16 000	M 2.5	..	1967	(1968)	> 700/..	..	..	–
	Su-17 "*Fitter C*" STOL strike	TJ	19 000	M 2.17	..	1967	(1970)	../–	..	..	–
	Su-20 export vers	TJ	..	..	..	..	..	../75	..	..	–
	MiG-21 "*Fishbed*" interceptor/ strike/recce	TJ	10 400	M 2.0	..	(1955)	(1958)	> 1 300/86	..	..	–
	Tu-95 "*Bear*" strategic bomber/ maritime recce	TP	154 220	805	..	1954	..	> 105/–	..	..	–
	Yak-36 "*Forger*" VTOL strike										
	"*Forger A*" ASW strike vers	TS	13 000	M 1.05	(1974)	..	..	~12[e]/–	..	..	–
	"*Forger B*" training vers	TJ	..	..	..	..	..	../–	..	..	–
	Il-38 "*May*" ASW	TP	(60 000)	645	..	1967	(1970)	55/6	..	..	–
	Il-76 "*Candid*" medium transp	TF	157 000	850	..	1971	1973	../–	..	..	–
	Mi-24 "*Hind A, B*" attack hel	TS	8 400	310	..	(1971)	(1973)	(100)/..	..	..	–

Country	Designation, description	Power plant	Weight *max takeoff wt, kg*	Speed *km/h* or *Mach no.*	Year design begun	Year of proto-type flight	Year in pro-duction	Number: domestic/ export or total	R&D cost *$ mn*	Unit price *$ mn*	Foreign-designed Power plant, Electronics or Armaments
	(*A-10*) attack hel	TS	..	341	..	(1975)	..	~40/..	..	..	–
	Mi-12 "*Homer*" heavy lift hel	TS	105 000	260	..	1969	(1972)	../–	..	..	–
	Mi-6 "*Hook*" heavy lift hel	TS	42 500	300	..	1957	..	> 500/4	..	..	–
	Mi-8 "*Hip*" transp	TS	12 000	260	..	(1960)	..	> 1 000/7[f]	..	..	–
	Ka-25 "*Hormone*" ASW/trans hel	T	7 300	220	..	1961	(1964)	(300)/(14)	..	..	–
Other Europe											
Finland	*Leko-70* primary trainer	P	1 200	240	1973	1975	..	30/..	..	~0.4	PP (USA)
International:											
Yug., Rom.	*Orao* (*Eagle*) light strike	TJ	9 000	1 100	1971	1974	1977	40[g]/..	..	..	PP (UK)
Spain	*C-101* trainer/light strike	TF	4 700	M 0.8	1975[h]	1977	..	60/..	..	27	PP (USA)
	T12 Aviocar STOL light transp	TP	6 300	445	1968	1971	1973	61/46	..	1.4	PP (USA)
Sweden	*System 37 Viggen* fighter/strike										
	JA 37 single seat interceptor	TF	17 000	M 2	1968	1974	1974	30[i]/–	..	..	PP (USA, Swe.) E-d, E-n (USA)
	AJ 37 strike	TF	15 000/ 20 500	M 2	1962	1971	1971	150/–	..	..	PP (USA, Swe.)
	SF 37 armed recce	TF	15 000/ 20 500	M 2	..	1973	(1973)	30[j]/–	..	..	PP (USA, Swe.)
	SH 37 all weather maritime recce	TF	15 000/ 20 500	M 2	..	1973	1975	../–	..	..	PP (USA, Swe.)
	SK 37 trainer/attack	TF	15 000/ 20 500	M 2	..	1970	1972	10/–	..	..	PP (USA, Swe.)
	SAAB 35X Draken fighter/strike/ recce	TJ	16 000	M 2	..	1955	1960[k]	560/63	..	..	PP (UK)
	SAAB Supporter light utility	P	1 200	260	..	1972	..	../77	..	..	PP (USA)
Switzerland	*PC-6/B2-H2 Turbo-Porter* STOL light utility	TP	2 770	260	1957	1959	..	~300[l]	..	..	PP (Can.)
	PC-7/7T Turbo-Trainer trainer/armed trainer	TP	2 700	460	..	1975	..	../16[m]	..	..	PP (Can.)
Yugoslavia	*J-1 Jastreb* light strike	TP	5 100	820	..	..	..	> 100/..	..	..	PP (UK)
	J-1-E export attack vers	TP	5 100	820	..	..	..	..	..	..	PP (UK)
	RJ-1 recce vers	TP	5 100	820	..	1976	..	..	..	..	PP (UK)
	TJ-1 trainer vers	TP	5 100	820	..	1974	..	..	..	..	PP (UK)
	G2-A Galeb jet trainer	TJ	4 300	756	1957	1961	1963	> 150/–	..	..	PP (UK)
	G2-A-E export vers	TJ	4 300	756	..	1974	1975	–/> 50	..	..	PP (UK)

Other Developed											
Australia	*N22 Nomad* STOL utility	TP	3 855	311	1965	1971	1974	11/6	..	0.85[n]	PP (USA)
	N24 stretched vers	TP	3 855	311	..	1976	..	../3	..	..	PP (USA)
China[o]	*F-9* fighter	TJ	10 700	..	..	..	..	..[p]	..	..	PP (USSR)
	F-8 (*MiG-21*) multi-role fighter	TJ	9 400	M 2.1	..	1964	1965	..[q]	..	..	..
	F-6 (*Improved Mig-19*) light fighter	TJ	8 780	1 452	..	1961	1961	..[r]/36	..	..	..
	F-12[s] fighter	..	..	M 2– M 2.3	(1977)	(1980)	..	..	..	..	PP (UK)
	..hel[t]	..	..	..	..	..	..	..	..	..	..
Japan	*T-2* advanced trainer	TF	9 675	M 1.6	1967	1971	1977	59/..	..	~8.45	PP (Fr., UK)
	F-1 Kai light strike vers	TF	13 674	M 1.6	1972	1975	1977	26[u]/..	..	~9.48	PP (Fr., UK)
	PS-1 ASW flying boat	TP	43 000	547	1959	1967	..	22/..	..	17.67	PP (USA)
	US-1 rescue vers	TP	45 000	481	1970	1974	..	26[v]/..	..	17.96	PP (USA)
	C-1 transp	TF	38 700	806	1966	1970	1973	32/..	..	13.92	PP (USA)
	MU-25[w] transp stretched vers	TP	4 900	462	..	1970	..	1/..	..	1.99	PP (USA)
	MU-2K utility	TP	4 500	462	..	1971	..	2/..	..	1.43	PP (USA)
	KM-2B trainer	P	1 510	413	..	1974	..	18[x]/..	..	0.49	PP (USA)
	P-2J ASW maritime patrol	TP	34 019	402	1961	1966	..	83/..	..	..	PP (USA)
	KH-7 utility hel	TS	2 700	..	1974	..	..	..	..	..	PP (USA)
	LTH[y] utility hel	TS	2 800	250	(1976)	1979	..	..	~33–35	..	..
New Zealand	*CT-4* trainer	P	1 088	286	..	1972	..	19[z]/75	..	..	PP (USA)

NATO, excluding the USA

[a] The DHC-5D can also be used for assault missions. After the production of 59 DHC-5s, the production line was closed down in 1972, but was re-opened in 1974 to produce the improved D model. India is negotiating for licensed production of the DHC-5C.

[b] By October 1977, 557 had been delivered; some 68 had been sold to the military including eight to the Canadian armed forces.

[c] Two were ordered by the US Air Force for $1.6 mn.

[d] Two prototypes of the DHC-7 have been built, one of which is planned to be converted into a prototype of the DHC-7R version.

[e] This includes six prototypes and pre-production aircraft. Most of these are F1-C interceptors and some F1-B trainers. The unit cost is in 1976 prices.

[f] The export figure of 357 aircraft includes F1-B, -C, -E and -G models. The F1-E is a multi-mission aircraft. South Africa ordered 32 A models and 16 C models, with some of the F1-As being assembled locally. France has agreed to supply Egypt with 15 aircraft and the remaining 185 will be licence-produced in Egypt. Four countries have options on 145 aircraft.

[g] Some 407 of these have been delivered.

[h] Some 300 of these have been delivered. Australia and Switzerland have built 98 and 54 aircraft, respectively, under licence.

[i] Fifty of these aircraft were ordered by Israel in 1965 but were not delivered and 18 are prototype and pre-production models.

[j] Options for 28 are held by Zaire. Of 419 aircraft 106 have been assembled under licence by Belgium.

[k] The Mirage 50 is basically the Mirage III with a more powerful SNECMA Altar 9k 50 engine.

[l] Three prototypes are under construction. The French Air Force plans to buy 200 with an initial order for 20–30 aircraft.

[m] This delta-wing derivative of the cancelled Super Mirage is planned to perform all the roles of the Mirage 2000 plus that of long-range interdiction. One prototype is under construction.

[n] Two prototypes have been built. The French Navy plans to order a total of 75.

[o] Unit price for the batch of 14 ordered for procurement in 1977.

[p] The development of Atlantic Mk II was cancelled because of its cost and complexity. Unlike the original Mk I, which was developed jointly by France, FR Germany and Belgium, Mk IV is a French aircraft which will use the same power plant and air frame as those of Mk I but have different avionics and weapon system. The French Navy has a requirement for 42 aircraft.

[q] The aircraft was entered for the US Coast Guard Medium-Range Surveillance Aircraft competition and won.

[r] Two models exist: *AS 350B Squirrel*, a European version which uses a French power plant and *AS 350C* Astar which uses a US power plant.
[s] Both SA 316B and 319B remain in production. Over 1 400 aircraft have been ordered and the current production rate is about 3–4 per month.
[t] This includes two prototype and three pre-production models. Of the total order of 97, 89 have been delivered.
[u] SA 332 is an interim version in the development of the SA 331 Super Puma.
[v] Of a total order of 53, 30 have been delivered.
[w] Originally the development of the aircraft began for the Spanish Air Force but France also has a requirement for new rescue aircraft. However, construction of the prototype and production will not start until sufficient demand has been demonstrated.
[x] Two prototypes are being built.
[y] About 250 military and civilian aircraft have been sold of which about 230 have been delivered.
[z] Two Wankel four-disc rotary engines.
[aa] The West German Army plans to buy a total of 227 aircraft. The unit cost is in 1976 prices.
[ab] Two pre-production and nine prototypes have been built and four more pre-production aircraft are being constructed.
[ac] A total of 809 aircraft are planned for: 100 for Italy, 324 for FR Germany and 385 for the UK. Of the 150 approved, 15 are for Italy, 57 for FR Germany and 75 for the UK.
[ad] The figure for the total development cost was presented to the West German Parliament in April 1976. The development cost for the British Air Defence Variant (ADV) is estimated to be $160 mn.
[ae] Unit fly-away cost for the West German aircraft in 1976 values. The unit cost of the British ADV is estimated to be $10.4 mn.
[af] This includes eight prototypes. The British order for 202 has been completed and of the French order for 200, some 140 have been delivered.
[ag] Of the total requirement of 200, FR Germany has ordered 175. France and Belgium have ordered 200 and 33 aircraft, respectively, which were their requirements. Belgium is also taking part in the production of the aircraft.
[ah] Egypt and Turkey have shown an interest in buying up to 120 and 60 aircraft, respectively.
[ai] The fly-away cost of the trainer aircraft.
[aj] The initial programme was completed with the production of 178 aircraft. Programme B was re-launched but the details have not been finally settled. The two countries would collaborate on a 50–50 basis with a single final assembly line in France.
[ak] France has ordered four but intends to procure a total of 25 aircraft.
[al] Puma and Gazelle are predominantly of French design. The production of the Gazelle is divided between Aérospatiale and Westland at a ratio of about 60:40; Lynx is predominantly of British design. All three aircraft are co-produced by the two countries.
[am] The total order stands at 622 aircraft of which 209 were ordered by France and the UK and at least 72 were civilian orders.
[an] Of the total order of 907, more than 710 have been delivered. Some of these are also civilian aircraft.
[ao] FR Germany and the UK are making a collaborative design and development study of the aircraft in order to meet the West German requirement for PAH-2s. A similar plan is under way between FR Germany and France.
[ap] Over 750 aircraft have been sold, of which at least 620 were for export. These include aircraft produced by Brazil and South Africa under licence. The unit cost is in 1976 prices.
[aq] These are pre-series aircraft under construction. Two prototypes have been built and the Italian Air Force plans to buy some 100 aircraft. The unit cost is in 1976 prices.
[ar] A total of 64 aircraft have been authorized for production.
[as] These are being delivered armed with TOW anti-tank missiles. The Italian Army is expected to order 50 after the five pre-production models.
[at] Two of those for the Royal Navy and some of the remaining for the RAF have been delivered. Production ended in early 1977 with the delivery of the final batch of 23 (of a total of 46) aircraft to the RAF.
[au] Eight of the 118 for the US Marine Corps are for the Spanish Navy and all have been delivered.
[av] Three of these are Nimrod R.1 specialized electronic intelligence (ELINT) versions. The remaining 46 will be modified to Mk 2 with updated ASW sensors and offensive systems by the end of 1978.
[aw] There are no separate prototypes but one pre-production Hawk flew in 1974 and the first five production aircraft are allocated to the development programme.
[ax] The Finnish government has ordered 50 aircraft for $240 mn which, among other things, covers the cost of aircraft, initial spares and training of personnel.
[ay] Some 40 are planned.
[az] There is no prototype for series 200. The first of these flew in 1973. The RAF received 9, 16 were delivered to the Royal Navy and one was lost in an accident.

USA

[a] Three prototype aircraft continued to fly research and development missions despite the decision to cancel their production. 244 aircraft were planned for procurement.
[b] A total of 562 aircraft in the F-111 and FB-111 series were built. The production has been completed with the delivery of the 100th and final aircraft in November 1976.
[c] $20 mn have been approved to begin development of a prototype. 167 including two prototype and 65 stretched versions of the FB-111A have been planned for.
[d] Of these, more than 136 have been delivered. The US Air Force plans to buy a total of 729. Of the export order, four of the 50 to Israel have been delivered. A letter of offer has been sent to Saudi Arabia for 60 aircraft. Japan has ordered 100 aircraft of which six would be bought direct from the USA followed by eight assembled in Japan from knocked-down parts. The remainder would be built under licence in Japan.

[e] Of these, 315 have been delivered to the US Navy which has a programme to procure a total of 521 aircraft. Of the 80 ordered by Iran, 21 have been delivered.
[f] These are development aircraft which have been ordered. The US Navy plans to buy a total of 800 aircraft.
[g] The total programme cost includes inflation costs through 1987.
[h] The fly-away cost for an export model is $6.5 mn.
[i] This includes an order for 348 by the four European consortium nations: Belgium (116), Denmark (58), Netherlands (102) and Norway (72). Iran has ordered 160 aircraft.
[j] The aircraft will be built under licence in the USA with some production work in the UK.
[k] Variants of the F-4 are ordered by or are in the process of being delivered to FR Germany (190), Greece (18), Iran (221), Japan (128), South Korea (18), Spain (42) and Turkey (40).
[l] Sixty of the 180 ordered by Taiwan will be supplied by the USA and the remainder will be assembled in Taiwan under licence. Nineteen of the 72 F-5E/F ordered by Switzerland will be supplied by the USA and the remaining 53 will be assembled in Switzerland.
[m] Against a planned procurement for 733 aircraft, 339 have been ordered. Sixty-two aircraft have been delivered.
[n] Pakistan had requested 110 A-7Ds but this has been turned down. Delivery of 60 A-7Hs (export version) to Greece is nearly completed. Orders for 31 of the two-seat version TA-7C have been received; a total of 65 have been planned.
[o] The production line for A-7E is kept open with the procurement of 12 in FY 1978 and 12 more in FY 1979. 536 have been built or are on order for the US Navy.
[p] Further conversion of 240 of the 508 A-6As built to A-6E versions is being carried out and these will be ready in 1979.
[q] These consist of 30 A-4Ms and six TA-4K models for Kuwait. The production of A-4s will terminate in October 1978 when a total of 2 966 aircraft will have been produced.
[r] This consists of 12 aircraft which were ordered by Ethiopia but whose delivery is under embargo.
[s] This includes a Canadian order for 18 CP-140s and one from Japan for 45. Initially three aircraft will be delivered to Japan from the USA, followed by six to be assembled in Japan from knocked-down parts and the remainder to be built under licence in Japan. A total of 456 aircraft of all versions was delivered by May 1977.
[t] 161 had been delivered by July 1977. The production line is scheduled to close down when the last of the remaining aircraft is delivered in March 1978.
[u] These are the estimated R&D costs, including test and evaluation to the end of 1981. Three E-4As have been built and two more E-4Bs are planned for.
[v] Seven of these are for Iran and 16 are for NATO procurement.
[w] Of these, Israel has ordered four with two on option and 23 are possible NATO procurement.
[x] Estimated cost of development and production of 275 aircraft.
[y] Over 1 500 aircraft of various versions have been produced.
[z] More than 1 000 of all versions have been sold. With the completion of the last order of 19, the production line is to shut down.
[aa] With the delivery of the last 32 aircraft, the production line was shut down in mid-1977.
[ab] The US Navy plans to acquire 278 aircraft.
[ac] The US Army requirement is for 536; two prototypes have been built and three more are being built.
[ad] The US Army plans to acquire a total of 305 aircraft.
[ae] The last 65 of a total of 202 Iranian aircraft will be armed with anti-armour TOW missiles. Production should end in 1977. Bell has a facility in Iran to assemble AH-1s now being delivered.
[af] Fifteen aircraft have been ordered with a further contract containing fixed price options on 353 more aircraft—56 to be delivered in FY 1978, 129 in FY 1979 and 168 in FY 1980. The US Army's total requirement is for 1 107 aircraft.
[ag] Some 361 CH-47A/B/Cs will be modernized, of which one of each are taken as prototypes. The YCH-47A/D was scheduled to fly in May 1977.
[ah] Bell has a facility at Shiraz in Iran to assemble the aircraft now being delivered. However, Iran's decision to acquire 400 more aircraft has led to a co-production agreement. It is planned to produce these aircraft in Iran during 1977–84.
[ai] Thirty-four of the 100 ordered by South Korea will be made in the USA and the rest will be assembled in South Korea. 500 Ms are also built under licence in Argentina and in Italy.

WTO/Other Europe/Other Developed

[a] By 1976 more than 400 MiG-25A/B/C aircraft have been built.
[b] These include all versions to the Soviet Air Force.
[c] These include MiG-23 B/E versions.
[d] "Flagon-A" was the initial production model and "Flagon-B", a STOL aircraft, is at the development stage. "Flagon-E" is the improved version with new engines and avionics.
[e] About 10–12 appear to be deployed by the Soviet Navy on *Kiev*.
[f] 250 aircraft are currently stationed in Europe. Seven were recently ordered, two by Finland and five by Algeria.
[g] Two or three prototypes and up to nine pre-series aircraft have been built. The first production batch is believed to be nearly 40. Romania's and Yugoslavia's requirements are for 200 and 80 aircraft, respectively.
[h] The USA and FR Germany are assisting in the development of the aircraft. Four prototypes are being built. An initial order for 60 aircraft is planned.
[i] Thirty of the planned total procurement of about 150 aircraft were ordered in 1974.
[j] This includes some SH 37s.
[k] Various versions of Draken have been built for Sweden, Denmark and Finland. Some of the models have been partly assembled in Finland. Production has been completed with the delivery of all the Swedish and export aircraft.
[l] About 300 aircraft of all types had been built by mid-1977. The USA has built 120 under licence but production has been halted pending new orders.

[m] Production of 30 PC-7s has begun. Two versions, the PC-7 (basic trainer) and PC-7T (armed trainer), are announced.
[n] The unit cost of Search Master—a coastal surveillance version. Six of these have been ordered by Indonesia. By mid-1977, 62 aircraft (N-22 and N-24) had been sold.
[o] Aircraft of Soviet origin are shown with the Soviet designation in brackets. They are listed as indigenous weapons, because China has been almost totally isolated from Soviet technology since 1960.
[p] Production has been suspended. There is a suggestion that only a few dozen aircraft are operational.
[q] About 50 aircraft have been built. Unconfirmed reports suggest that China has agreed to supply Bangladesh with four squadrons of F-8 aircraft.
[r] A total of about 4 100 F-4 and F-6 aircraft have been produced.
[s] China is developing a new twin-engine aircraft powered by two Rolls-Royce Spey engines. It is reported that the design of the aircraft is based on technical manuals and construction of a MiG-23 supplied to China by Egypt.
[t] It has been confirmed that at least one type of helicopter is being produced at present in China. However, it is not clear whether this is completely of Chinese design or whether it is based on the Soviet Mi-4.
[u] The original planned procurement of 63 aircraft has been increased to 80 aircraft.
[v] Some 23 aircraft had been delivered by the end of 1976. Four search and rescue versions were ordered, three of which have been built.
[w] A total of 470 aircraft of all types has been sold.
[x] The first 18 of the planned 62 aircraft have been ordered.
[y] An agreement with FR Germany was signed in 1977 for joint production of the helicopter. Japan will pay 60 per cent of the development costs and will design and produce the fuselage, transmission system, landing system and other, minor components. FR Germany will be responsible for main and tail rotors, tail unit and hydraulic systems. Both countries will establish the final assembly lines.
[z] When the New Zealand order of 19 is completed, the production line will stop.

Part 2. *Missiles*

Country	Designation, description	Power plant	Warhead weight *kg* (if nuclear, *kt* or *Mt*)	Max range *km*	Year design begun	Year of proto-type flight	Year in pro-duction	Number: domestic/ export or total	R&D cost *$ mn*	Unit price *$ mn*	Foreign-designed Power plant, Electronics or Armaments
NATO											
France	*S-3* fixed-to-fixed	S	1.2 Mt	3 000	1973	..	(1980)	18/–	>456	..	..
	Pluton[a] mobile-to-fixed	S	15 kt or 25 kt	120	..	1969	1973	30/–	..	..	–
	Harpon mobile/aircr-to-fixed/tank	S	2.6	3	..	..	..	4 100	..	..	–
	SS/AS-11 mobile/aircr-to-fixed/tank	S	2.6	3	..	..	(1958)	167 000	..	..	–
	SS/AS-12 mobile/aircr-to-fixed/tank	S	28.6	8	..	..	(1962)	7 500	..	..	–
	R.440 Crotale mobile/ship-to-aircr	S	15	8.5	1964	1965	1968	16/..	..	..	–
	AS-15 mobile/aircr-to-ship	..	..	15	..	..	..	..	..	..	–
	AS-20 aircr-to-fixed/ship	S	30	7.4	..	..	..	5 700	..	..	–
	AS-30 aircr-to-fixed/ship	S	230	12	..	..	..	3 900	..	..	–
	AS-30L[b] lighter vers	S	115	..	..	..	..	..	..	..	–
	R.530 aircr-to-aircr	S	27	18	1958	..	(1963)	4 500[c]	..	..	–
	Super 530 aircr-to-aircr	S	HE	35	1971	1973	(1977)	1 000/–	..	..	–
	R.550 Magic aircr-to-aircr	S	12.5	7	1968	1972	1974	~6 000[d]	..	..	–
	Hirondelle system ship-to-aircr miss	S	HE	(40)	1971	..	(1977)	..	..	..	–
	Exocet anti-shipping										
	MM-38 ship-to-ship	S	165	45	(1967)	..	1972	..[e]	..	..	E-d (UK)
	AM-39 aircr/hel-to-ship	S	165	70	..	1973	1975	..[e]	..	..	..
	MM-39 ship-to-ship development	S	165	50	..	..	..	..	..	..	..
	MM-40 long-range vers	S	165	70	..	..	..	(1977)	..	..	..
	SM-39[f] submarine launched vers	S	..	50	..	..	..	..	..	..	..
	MQ1 Malafon ship-to-ship anti-sub	S	525	13	1956	1962	..	..	..	..	..
	M-2 sub-to-fixed	S	500 kt	3 000	..	..	1973	(48)/–	..	..	..
	M-20 sub-to-fixed	S	1 Mt	3 000	..	1976	1976	(96)/–	..	..	..
	M-4 (MIRV) sub-to-fixed	S	(6 or 7) × 150 kt	~4 000	..	1978	1985	(96)/–	..	..	..
	Matra AM 15[g] anti-ship	S	..	15	..	..	..	..	..	..	..
	AS-15[g] anti-ship	S	..	15	..	..	..	..	..	..	..
FR Germany	*BO810 Cobra 2000* portable-to-tank	S	2.7	2	1957	..	1960	> 150 000	..	..	PP (Switz.)
	Mamba portable-to-tank	S	2.7	2	..	1972	1974	..	..	..	..
	AS-34 Kormoran aircr-to-ship	S	160	~37	1964	1970	(1974)	350/–	..	..	E-g (Fr.)

Country	Designation, description	Power plant	Warhead weight kg (if nuclear, kt or Mt)	Max range km	Year design begun	Year of proto-type flight	Year in pro-duction	Number: domestic/ export or total	R&D cost $ mn	Unit price $ mn	Foreign-designed Power plant, Electronics or Armaments
International:											
FRG, Fr.	*HOT* mobile/hel-to-tank	S	6	4	1964	1971	1975	440[h]/ (168)	. .	. .	. .
	Milan portable-to-tank	S	3	2	1963	. .	1972	. .[i]/8 520	. .	. .	. .
	Roland mobile-to-aircr										
	I clear weather vers	S	6.5	6.2	1964	(1968)	(1974)	. .[j]	. .	. .	. .
	II all weather vers	S	6.5	6.5	1968	(1975)	(1976)	. .[j]	. .	~0.11	. .
Fr., UK	*Martel* aircr-to-fixed										
	AS.37 anti-radar vers	S	150	~60	(1960)	(1966)	1973	. .[k]	. .	. .	. .
	AJ.168 TV-guided vers	S	150	~60	(1960)	(1966)	1973	. .[l]	. .	. .	. .
Bel., Den., FRG, It., Neth., Nor., USA	*Sea Sparrow System*[m] ship-to-aircr miss	S	30	22.2	1969	1972	1973	100/102[n]	. .	. .	. .
Fr., It.	*OTOMAT* ship/aircr-to-ship										
	I initial vers	TJ	65	80	1969	1971	. .	470[o]	. .	. .	. .
	II longer-range vers	TJ	65	>100	1969	1974	(1975)	. .	. .	. .	. .
	III Téséo[p] extended-range vers	TJ	. .	20	. .	. .	. .	. .	. .	. .	. .
Italy	*Spuda System*[q] fixed-to-aircr	S	HE	31.5	. .	1974	–	. .	. .	. .	. .
	Indigo mobile-to-aircr	S	22	10	1962	1963	. .	. .	. .	. .	E-f (Switz.)
	Sparviero[r] portable-to-tank	S	4	3	1966	. .	. .	. .	. .	. .	. .
	Aspide-1A aircr/fixed-to-aircr	S	35	100	1969	1974	1977	. .	. .	. .	. .
	Airtos aircr-to-ship	S	35	11	(1969)	(1974)	. .	. .	. .	. .	. .
	Marte system[s] hel-to-ship	S	70	20	1969	1975	–	. .	. .	. .	. .
	Albatros system[t] ship-to-aircr miss	S	HE	. .	1966	(1970)	1973	~10/–	. .	. .	. .
	Sea Killer ship/hel-to-ship										
	II current vers	S	70	25	1965	1969	. .	. ./~90	. .	. .	E-f (Switz.)
	III under development	S	150	>45	(1972)	. .	–	. .	. .	. .	. .
Norway	*Penguin* ship-to-ship										
	Mk 1 initial vers	S	125	>20	1961	. .	1969	. .	. .	. .	. .
	Mk 2 longer vers	S	125	30	. .	. .	–	. .	. .	. .	. .
UK	*Swingfire* mobile-to-tank	S	6.8	4	1958	. .	(1968)	. .	. .	. .	. .
	Beeswing infantry vers	S	6.8	4	1958	. .	(1968)	. .	. .	. .	. .
	Golfswing Mk 2 infantry vers	S	6.8	4	1958	. .	. .	. .	. .	. .	. .
	Vigilant portable-to-tank	S	>5	1.4	1956	(1957)	1960	>15 000	. .	. .	. .
	Rapier mobile-to-aircr	S	0.5	7	1963	. .	1967	. .	. .	. .	. .
	Tracked Rapier[u] tracked vers	S	0.5	7	. .	. .	. .	. .	. .	. .	. .

	Tigercat towed/fixed-to-aircr	S	HE	> 5	..	..	(1969)	..	..	..	..
	Blowpipe portable-to-aircr	S	2.2	3	1966	..	(1973)	..	..	..	..
	XJ521 Sky Flash[v] aircr-to-aircr	S	HE	..	1973	1975	1977	..	..	..	Ar (USA)
	SRAAM (QC 434)[w] aircr-to-aircr	S	10	..	1972	..	–	..	..	..	..
	Red Top aircr-to-aircr	S	31	12	1957	..	(1962)	..[x]	..	..	..
	Sea Skua CL834 aircr-to-ship	S	~35	14	(1970)	..	–	..	..	..	..
	Sea Dart ship-to-ship	S/LP	HE	> 80	(1962)	(1965)	1970	..	..	..	..
	Seacat ship-to-ship	S	HE	4.75	1958	1962	(1962)	..	..	..	..
	Sea Wolf ship-to-miss/aircr/ship	S	~150	5	1967	1975	..	..	..	..	..
USA	*LGM-30G Minuteman 3* MIRV fixed-to-fixed	S	3× 200[a] kt	> 13 000	1966	1968	1970	560[b]/–	..	..	..
	BGM-71A TOW fixed/hel-to-tank	S	3.6	3.75	1962	1968	1969	31 700[c]	56	..	–
	Site Defense fixed-to-miss	S	N	~50	1971	..	..	../–	1 310	..	–
	Safeguard system fixed-to-miss										
	XLIM-49A Spartan high altitude[d]	S	N-Mt	> 185	1965	1968	1970	../–	..	..	–
	Sprint low altitude[d]	S	N-kt	~40	1963	1965	1970	../–	..	..	–
	MGM-52C Lance SP/towed-to-fixed	SL	10 kt or 454	120	1963	1965	1971	360[e]/275	447.5	~0.33	–
	SAM-D mobile-to-aircr	S	N/HE	..	1965	1970	(1981)	..	~6 000[f]	(26)	–
	MIM-23B Improved Hawk mobile-to-aircr	S	> 54	40	1964	1971	1972	../> 100	155	0.22	–
	MIM-72A/C Chaparral mobile-to-aircr	S	5	> 3	1964	1965	1966	..	143	0.75	–
	FGM-77A Dragon portable-to-tank	S	2.44	1	1968	1971	1973	../ > 2 300[g]	119	..	–
	FIM-92A Stinger portable-to-aircr	S	3	1	1972	1974	1977	445[h]/..	(120)	0.11	–
	AGM-69A/B SRAM aircr-to-fixed	S	200 kt	160	1966	1969	1971	1 500[i]/–	..	(0.35)	–
	AGM-86A/B ALCM aircr-to-fixed	TF	N-kt	1 200/ 2 400	1974	1976	(1979)	..	299.76[j]	(0.5)	–
	AGM-62B Walleye II aircr-to-fixed	–[k]	907	..	1968	(1973)	(1974)	150[l]/–	..	(0.29)	–
	AGM-88 HARM aircr-to-(fixed) radar	S	HE	18.5	1972	1975	(1980)	2 935/40	126.8[m]	0.08	–
	AGM-78 Standard ARM[n] aircr-to-(fixed) radar	S	100	25	1966	1967	1968	..	..	0.12	–
	AGM-45A Shrike aircr-to-(fixed) radar	S	HE	16	1962	..	1963	1 160[o]/..	..	0.37	–
	AGM-65 Maverick aircr-to-fixed/tank										
	AGM-65A standard vers	S	59	20	1966	1969	1972	1 500/ > 4 500[p]	..	~0.05	–
	AGM-65B scene-magnification	S	59	22.5	..	1977	..	4 000/..	..	..	–
	AGM-65C laser guided	S	59	..	(1972)	1973	1978	4 700/..	56.2	..	–
	AGM-65D imaging IR	S	59	..	1976	..	1981	8 940/..	117.4	..	–
	Hellfire aircr-to-fixed/tank	S	HE	5.6	1974	1976	1979	~200/..	122.6	~0.01	–
	AIM-54A Phoenix aircr-to-aircr/miss	S	HE	> 200	1962	1969	1973	2 495[q]/694	416	0.52[r]	–
	AIM-9 Sidewinder IR/IC aircr-to-aircr										
	9L new IR vers	S	10–15	18	1972	1975	1976	2 360[s]/ 3 782[s]	52	0.05	–
	9H current production vers	S	10–15	18	1968	..	1971	..	..	(0.03)	–

Country	Designation, description	Power plant	Warhead weight *kg* (if nuclear, *kt* or *Mt*)	Max range *km*	Year design begun	Year of proto-type flight	Year in pro-duction	Number: domestic/ export or total	R&D cost *$ mn*	Unit price *$ mn*	Foreign-designed Power plant, Electronics or Armaments
	AIM-7 Sparrow III aircr-to-aircr										
	AIM-7F latest vers	S	40	100	1968	1972	1975	1 790/654[t]	128.5	~0.072	–
	AGM-53 Condor aircr-to-ship/fixed	S	286	111	1963	1970	..	983[u]/..	282	(0.44)	–
	Standard I ship-to-aircr/miss/ship										
	RIM-67A ER—extended range	S	HE	55	1964	1965	1966	2 160[v]/..	..	(0.1)	–
	RIM-66A MR—medium range	S	HE	20	1964	1965	1966	3 892[v]/..	..	(0.1)	–
	Standard II ship-to-aircr/miss/ship	S	HE	(100)	1970	1972	1976	22[w]/..	115	0.12	–
	Harpoon anti-shipping										
	AGM-84A aircr-to-ship	TJ-S	227	110	1968	1972	1975	730/937[x]	320	~0.67	–
	RGM-84A-1 ship-to-ship	TJ-S	HE	110	1968	1970	1975	..	..	..	–
	UUM-84 Capoon sub-to-ship	TS-S	HE	..	1970	1974	..	..	..	..	–
	RUR-5A Asroc ship-to-ship	S	N/HE	8	1955	..	1959	..	..	..	–
	UGM-93 Trident MIRV sub-to-fixed										
	UGM-93A (I–4) initial vers	S	8× 100 kt	7 800	(1971)	1977	1979	48[y]/–	2 926	~13.96	–
	Trident II (D-5) longer-range	S	N	11 000	(1972)	..	..	../–	1 380	..	–
	UGM-73A Poseidon MIRV sub-to-fixed	S	(10× 50 kt) or (14× 50 kt)	4 600	1965	1968	1969	496[z]/–	..	5.6	–
	SLCM[aa] sub/ship-to-fixed										
	YBGM-110 competitive prototype	TF	450/N[ab]	> 3 600[ac]	1972	1977	(1980)	12[ad]/–	585	0.8	–
	YBGM-109 competitive prototype	TF	450/N[ab]	> 3 600[ac]	1972	1976	(1980)	..	..	~0.91	–
	UUM-44A Subroc sub-to-sub	S	N	~55	1958	1964	1965	../–	..	..	–
	MGM-31A Pershing IA fixed-to-fixed	S	60–400 kt	640	1966	..	1967	..[ae]/..	..	..	–
Warsaw Treaty Organization											
USSR	"*SS-18*" MIRV fixed-to-fixed	SL	50 Mt or 8× ~1 Mt	12 000	..	1972	(1974)	> 50[a]/–	..	..	–
	"*SS-19*" MIRV fixed-to-fixed	LP	6× 1 Mt	10 000	..	1973	(1974)	~140/–	..	..	–
	"*SS-17*" MIRV fixed-to-fixed	SL	4× 1 Mt	> 10 000	..	1972	(1975)	40/–	..	..	–
	"*SS-X16*" fixed/(mobile)-to-fixed	S	> 1 Mt	> 8 000	..	1972	..	../–	..	..	–
	"*SS-X20*" MIRV fixed/(mobile)-to-fixed	S	N 3 MIRV	7 500	..	1974	..	../–	..	..	–
	"*SS-12 Scaleboard*" mobile-to-fixed	..	500 kt	800	..	..	(1968)	../..	..	..	–
	"*SS-1C Scud B*" mobile-to-fixed	LP	850 or 40–100 kt	300	..	..	(1962)	../..	..	..	–
	"*Sagger AT-3*" mobile-to-tank	S	2.7	3	..	(1965)	..	../..	..	..	–
	"*SA-5 Gammon*" fixed-to-fixed	S	HE/N	250	..	(1963)	(1966)	../–	..	..	–
	"*SA-8 Gecko*" mobile-to-aircr	..	40–50	8	..	(1973)	(1975)	..	..	..	–
	"*SA-9 Gaskin*" mobile-to-aircr	S	HE	~5	..	..	(1974)	../..	..	..	–
	"*SA-6 Gainful*" mobile-to-aircr	S	80	80[b]	..	1967	(1970)	../..	..	..	–

	"*SA-2 Guideline*" mobile-to-aircr	SL	130[c]	50	..	1967	..	../..	..	..	–
	"*SA-3 Goa*" mobile-to-aircr	S	HE	35	..	..	(1960)	../..	..	..	–
	"*SA-7 Grail*" portable/mobile-to-aircr	S	2.5	3.6[d]	..	..	(1966)	../..	..	..	–
	"*AS-7 Kerry*" aircr-to-fixed/tank	(S)	HE	10	..	..	(1975)	..	..	..	–
	"*AS-6*" aircr-to-ship/fixed	S	200 kt	740[e]	..	..	(1970)	..	..	..	–
	"*AS-5 Kelt*" aircr-to-ship/fixed	LP	HE	320	..	..	(1968)	../..	..	..	–
	"*AA.6 Acrid*" aircr-to-aircr	S	60–100	~45	..	..	(1973)	..	..	..	–
	"*SS-NX-13*"[f] sub-to-ship/fixed	..	(N)	750	..	1973	..	..	..	..	–
	"*SS-N-12*"[g] ship-to-ship/fixed	..	..	555	..	..	..	..	..	..	–
	"*SS-N-11*"[h] ship-to-ship	S	~400	~50	..	..	(1968)	..	..	..	–
	"*SS-N-10*"[i] ship-to-ship	..	..	(54)	..	..	(1968)	..	..	..	–
	"*SS-N-9*"[j] ship-to-ship	S	HE	~275	..	..	..	..	..	..	–
	"*SS-NX-17*"[k] ship-to-ship	S	..	..	..	1975	..	..	..	..	–
	"*SS-NX-18*"[l] ship-to-ship	LP	..	8 000	..	1975	..	..	..	..	–
	"*SA-N-4*"[m] ship-to-hel	..	..	(37)	..	(1969)	..	..	..	..	–
	"*SA-N-3 Goblet*"[n] ship-to-aircr	S	HE	(30)	..	(1967)	..	..	..	..	–
	"*SS-N-8*"[o] sub-to-fixed	SL	1–2 Mt	~7 800	..	..	(1973)	../–	..	..	–
	"*SS-N-6 Mod 3*"[p] MRV sub-to-fixed	SL	3×1–2 Mt	3 000	..	..	(1967)	~1 000/–	..	..	–
	"*SS-N-7*"[q] sub-to-ship	S	HE	~55	..	1967	(1968)	>96/–	..	..	–
Other Europe											
Sweden	*RBS 70* mobile-to-aircr	S	1	5	1969	(1973)	1976	..	20[a]	..	..
	RB 53 Bantam anti-tank	S	1.9	2	1956	..	1963	..	..	..	..
	RB 05A[b] aircr-to-ship/fixed	LP	HE	..	1960	(1968)	1971	..	..	..	..
	RB 04E aircr-to-ship	S	200–250	..	1968	..	1973	..	..	..	E-g (Fr.)
	RB 08A[c] fixed-to-fixed	TJ	225	150	1959	..	(1966)	98/–	..	..	..
Other Developed											
Australia	*Ikara* ship-to-ship	S	HE	(20)[d]	..	..	1961	>1 000/..	..	..	..
Japan	*Kam-9* mobile/ship-to-tank/ship	S	1.9	>2	1964	..	..	..	..	..	..
	ASM-1 aircr-to-fixed/ship	S	140	45	1973	(1977)	(1980)	20[e]/..	36.5	..	..
	AAM-2[f] aircr-to-aircr	S	HE	5	..	1968	..	../–	..	..	..
China	"*CSS-3*"[g] fixed-to-fixed	LP	(3 Mt)	~6 500	..	1976	..	../–	..	..	..
	"*CSS-2*"[h] fixed-to-fixed	SL	1 Mt	4 000	..	..	1971	~20/–	..	..	..
	"*CSA-1*" (*SA-2*)[i] mobile-to-aircr	S/LP	(130)	(40)	..	..	..	../–	..	..	..
	"*CSS-N-1*" (*SSN-2*) ship-to-ship	S	HE	42	..	..	..	../–	..	..	..
	"*CSS-X-4*"[j] fixed-to-fixed	LP	3 Mt	11 000	..	1976	..	../–	..	..	..

NATO, excluding the USA

[a] A Super Pluton with a 180-km range is being developed for deployment in 1990.

[b] Completion of the West German order for AS-30s virtually brings the programme to an end. The AS-30L is now being developed with a semi-active laser-homing seeker.

[c] The production of the R.530 is expected to end in 1978. It will be superseded by the Super 530.

[d] Some 2 100 of the 5 000 ordered by France and 12 other countries have been delivered.

[e] More than 1 100 of these missiles have been ordered.

[f] The development of this submarine-launched version is being delayed by lack of funds.

[g] New radio-controlled missiles.
[h] A total of 4 800 missiles have been ordered by eight countries.
[i] Some 76 000 missiles have been ordered by 15 countries; of these more than 30 000 have been delivered. After an initial delivery of some vehicles to the UK in late 1977, the bulk of the British requirement—50 000 units—will be produced in the UK. This will make the UK the third partner.
[j] FR Germany has ordered 5 240 missiles. French and West German requirements are 10 800 and 12 200 missiles respectively. Norway has ordered 900. In January 1974 the US Army selected the Roland missile and awarded a $108 mn contract to Hughes Aircraft Co. for development of the US system. The Roland system will be adopted and produced under licence with the Boeing Aerospace Co. which is responsible for constructing the firing control. The US trials began in November 1975 and the first firing of the missile was due to take place in 1977.
[k] The AS.37 is a French passive radar seeker. Deliveries to the Armée de l'Air are almost complete and the production line could close.
[l] The AJ.168 is the British TV- and radio-guided missile. Deliveries to the RAF are almost complete and the production line could close.
[m] In the USA the system is referred to as the "improved point defense surface missile system" and uses the RIM-7H Sparrow missile. FR Germany became the seventh nation to participate in the NATO Sea Sparrow programme; the original four being Denmark, Italy, Norway and the USA, and Belgium and Netherlands joining two years later in 1970.
[n] This includes 82 ordered by Spain but awaiting US Congressional approval and a batch of 16 to be ordered by Japan to arm two improved "Haruna"-class destroyers.
[o] These include both the type I and type II. Nearly 100 missiles have been delivered.
[p] This is an extended-range version which is under development for coastal defence purposes.
[q] The system is designed to employ semi-active homing missiles, particularly the Aspide-1A missile now in advanced development.
[r] The missile is being developed for service in the 1980s. It can also be used from high helicopters.
[s] The system uses Sea Killer Mk 2 missiles.
[t] The system uses either Sparrow RIM-7H or Aspide-1A missiles.
[u] Iranian ground forces are to be supplied with a tracked version of the Rapier system. The UK will supply the complete Tracked Rapier System and a joint company, Irano-British Dynamics, has been established in Iran to manufacture missiles there.
[v] Sky Flash is a developed version of the US Sparrow AIM-7E missile.
[w] A naval version, Shield, has been proposed.
[x] Production has now ceased.

USA

[a] The development of improved-yield Mk 12A MIRVs is continuing. The Mk 12A is similar in size to the existing Mk 12 but has miniaturized arming and firing systems making enough space for three 350-kt W-78 warheads.
[b] 550 missiles are deployed. The US Air Force has 108 more available for training and test launches, 25 in long-term storage and 17 held as spares for Strategic Air Command use. Ten more missiles are being produced and production of 30 more has been funded for.
[c] Production of TOW (Tube-launched Optically tracked Wire-guided) missiles continues at about 30 000/year. An extended-range version is being developed. The R&D cost is in 1976 prices.
[d] The missile can engage targets at heights of between 0.5 km and 1.5 km.
[e] All these are missiles with non-nuclear warheads. There are six US battalions armed with Lance with 1-kt warheads in Europe. The R&D cost is in 1976 prices.
[f] The US Army estimate of the total cost of the SAM programme and the unit price are in 1976 prices.
[g] Between 30 000 and 40 000 have been sold. The R&D cost is in unit prices.
[h] The missile is competing for a replacement for the US Army and Marine Corps FIM 43A Redeye missile. A low rate of production is expected to start by the end of 1977. The R&D and unit costs are in 1976 prices.
[i] All 1 500 AGM-69A missiles have been delivered. AGM-69B missiles were to be produced to arm the B-1 but since the cancellation of B-1 procurement the future of the missile is unclear. The unit cost is in 1976 prices.
[j] The amount was awarded to cover the production of seven AGM-86As, 12 AGM-86B R&D missiles, 22 engines and 26 test flights. US Air Force planned procurement is for 1 800 missiles. The unit cost is in 1976 prices.
[k] Unpowered, guided (smart) bomb.
[l] Walleye I missiles are being converted to the new type. The estimated unit cost is in 1976 prices.
[m] R&D and unit costs are in 1976 prices.
[n] The AGM-78D-2 is the current version. The unit cost is in 1976 prices.
[o] Between 1965 and 1977, total production was 24 030 missiles. Current production versions are the AGM-45-7A and AGM-45-9 and version AGM-45-10 is under development. The unit cost is in 1976 prices.
[p] This includes 2 850 missiles delivered to Iran and 1 000 missiles ordered by Saudi Arabia. R&D costs for AGM-65C/D versions are in 1976 prices.
[q] Since production began in 1973, some 1 000 missiles have been built.
[r] This includes R&D costs. R&D and unit costs are in 1976 prices.
[s] These include all versions of the AIM-9 missiles ordered during 1977. The R&D and unit costs are in 1976 prices. The USA will co-operate with FR Germany in the production of AIM-9Ls. The latter has also asked other NATO nations to participate in this programme, but so far only Norway has agreed. The UK intends to join and to procure from the European consortium planned by FR Germany, the Netherlands and Norway.
[t] The order for 654 missiles includes 34 for South Korea subject to US Congressional approval. The R&D cost is in 1976 prices.
[u] There has been no change since funds for the Condor missile programme were denied in 1976. R&D and unit costs are in 1976 prices.
[v] Numbers of missiles of the two types on US ships by mid-1976. A total of 1 400 were deployed on foreign ships. The unit costs is in 1976 prices.
[w] Pilot production of 22 missiles began in 1976. The unit cost is in 1976 prices.

[x] Of the 937, 600 are for the UK where some 30 per cent of the work for these missiles will be done. The R&D cost is in 1976 prices. In the USA, studies have begun on a nuclear warhead for Harpoon missiles.
[y] The missiles will eventually be deployed in up to 30 Trident submarines, each carrying 24 missiles. The R&D costs for both versions are in 1976 prices.
[z] Of the US Navy's 41 SLBM submarines, 26 have been converted to operate Poseidon missiles instead of Polaris A3s. Five more are under conversion. The 31 submarines carry 16 launch tubes each. The remaining 10 submarines will continue to operate Polaris missiles. The unit cost is in 1976 prices.
[aa] SLCM=Sea-Launched Cruise Missile. The programme is a counterpart to the ALCM (Air-Launched Cruise Missile). The tactical model will have a range of 575 km or more and is likely to be armed with a conventional warhead for anti-shipping.
[ab] For land attack. The weapon would be armed with a nuclear warhead in the 250-kt yield range.
[ac] A US Navy variant has a reduced range of about 1 850 km; about half that of the submarine-launched version. When launched from B-52, the missile will have a range of about 2 960 km.
[ad] The US Navy hopes to acquire 1 200 missiles. The R&D and unit costs for both types are in 1976 prices.
[ae] A contract worth $7 mn was awarded for the production of the Pershing IA. The production line, which has been closed since 1975, will re-open in mid-1978.

WTO

[a] More than 50 are probably already deployed. About 200 may be deployed by the end of the programme.
[b] Maximum range at high altitude; at low altitude it is 35 km.
[c] A nuclear warhead can be fitted.
[d] The missile can engage targets at heights of 0.5–1.5 km.
[e] Maximum range at high altitude; at sea level it is 250 km.
[f] It is reported that the missile uses satellite-supplied targeting information.
[g] It is reported that the Soviet aircraft carrier "Kiev" is equipped with SS-N-12 missiles.
[h] Deployed on 55 "Osa II"-class missile boats and also on at least two "Kashin"-class and on four "Kildin"-class destroyers.
[i] Deployed on "Kresta 2" missile boats and "Kirvak"-class destroyers.
[j] Deployed on at least 14 "Nanuchka"-class missile gunboats and "Juliet"-class submarines.
[k] The missile can be fitted with MIRVs but tests observed so far have involved a single warhead. The new class of submarines reported to be under construction —a submarine larger than "Delta"-class—may carry SS-NX-17s. The submarine is equipped with 20 launch tubes.
[l] The missile is expected to be operational soon in some "Delta"-class submarines. Two MIRVs have been carried during trials.
[m] Deployed on "Kara"-, "Krivak"-, "Nanuchka"- and "Grisha"-class vessels.
[n] Deployed on two "Moskva" helicopter carriers, six "Kresta II" cruisers, and on a "Kara"-class ship.
[o] There are three models: model 1 is the only version in service at present; model 2 will enter service in the near future with three MIRVs; and model 3 has been tested with three MIRVs. The missile is carried by 10 "Delta I"- and four or five "Delta II"-class submarines. The former carried 12 rounds and later 16.
[p] Deployed on 34 "Yankee"-class submarines since 1967. About 1 000 missiles have been produced since that year. There are three models: model 1 is the original with a short range (2 400 km); model 2 is a longer range one (3 000 km); and model 3 has a range of 3 000 km and carries three MRVs.
[q] Deployed on at least 12 "Charlie I"-class submarines with eight launchers and also on "Charlie II"- and possibly "Papa"-class submarines.

Other Europe/Other Developed

[a] R&D cost in 1976 prices.
[b] Development of the RB 05B has been halted following a decision to buy the AGM-65 A/B Maverick missile.
[c] Developed from the Aérospatiale CT20 target drone.
[d] The range is determined more by the effective range of the sonar than by the Ikara missile itself.
[e] Twenty prototypes are being bought.
[f] The development of the missile continues although the weapon was rejected in favour of the US AIM-9J Sidewinder missile to replace AAM-1 missiles.
[g] The missiles are now operational and are deployed in silos in North West Sinkiang region.
[h] The missiles have been operational since 1971 and are deployed in western China. The missile probably formed the first stage of the China-1 satellite booster.
[i] CAS-1, a Chinese version of the Soviet SA-2 missile, is the basic operational SAM system. Production of the missile is being reduced.
[j] The missile, China's only full-range ICBM, is in the same class as the US Titan and Soviet SS-9.

Country	Class, description, armaments	Power plant	Displacement *tons*[a]	Speed *knots*	Laid down	Launched	Commissioned or completed	Number: domestic/export or total	Aircraft capacity	Unit price *$ mn*	Foreign-designed Power plant, Electronics or Armaments
NATO											
Belgium	*E71* frigate ShShM, SAM, A/S TT 100 mm	GT	2 283	28	1974	1976	1977	4/–	–	..	PP (UK) Ar. (NATO+Fr.) E-r (Neth.+USA)
Denmark	"*KV 72*" corvette ShShM, 76 mm 40 mm	D	1 000	> 30	..	..	..	3/–	–	..	PP (USA)
	Willemoes missile boat ShShM, 76 mm or 57 mm, TT	GT	220	40	(1974)	..	1975	10[b]/–	–	..	PP (UK)
France	(*Le Redoutable*) strategic sub 16 SLBM, TT	N	9 000	25	1964	1967	1971	6[c]/–	–	(230)	–
	Agosta patrol sub 4A/S TT	D	1 740	20	1972	1974	1976	4/4	–	..	–
	Type C70 destroyer A/S vers ShShM, SAM, 100 mm, 10TT A/A vers SAM, 2× 20 mm	GT	4 100	30	1974	1975	1978	24[d]/–	2A/S hel	..	PP (UK) Ar-hel
	Type A69 "*Avisos*" frigate 100 mm, 2× 20 mm, A/S TT	D	1 170	24	1972	1973	1975	12/2[e]	–	..	–
	PR 72S missile boat ShShM, 76 mm, 2× 20 mm	D	536	28	(1975)	..	..	–/12	–	..	Ar (It.+ Fr.)
	PR 72 patrol boat 76 mm, 40 mm	D	445	28	(1974)	1975	1976	–/4	–	..	Ar (It., Swe.)
	La Combattante II missile boat ShShM	D	255	40	..	1971	1972	–/18	–	..	–
	La Combattante III missile boat ShShM, 2× 76 mm, 2A/S TT	D	418	32	1975	..	1976	–/4	–	..	–
	Trident missile boat ShShM, 40 mm	D	130	25	1973	(1975)	1977	30/–	–	..	–
	"*P48*" patrol boat ShShM, 2× 40 mm	D	250	18.5	..	..	1971	../4	–	..	–
	P92 patrol boat 2× 20 mm	D	90	29	..	..	1975	–/20	–	..	–
	..patrol boat, ShShM, 2× 30 mm, 40 mm	D	165	40	..	..	..	–/14	–	~22	–
FR Germany	*Type 209* patrol sub 8TT	D	1 290	22	1971	1973	1974	–/28[f]	–	..	E-f (Neth.)
	Type 143 missile boat ShShM, 76 mm, 2TT	D	378	38	1972	1974	1975	10/–	–	(27)[g]	E-f (Neth.)
	Lürssen type missile boat ShShM, 76 mm, 2× 35 mm	D	410	38	..	..	1976	–/4[h]	–	..	Ar (It.)
	SAR-33 missile boat ShShM, 76 mm	D	190	40	..	..	..	–/14[i]	–	..	Ar (It., Fr.)
	.. missile boat, ShShM, 76 mm, 40 mm	D	230	40	..	..	..	–/6	–	..	Ar (Israel)

International:											
FRG, It., USA	*PHM-Patrol Hydrofoil Missile* ShShM, 76 mm	GT	221	> 40	1973	1974	1976	16[j]/–	–	54.68	E-r (Neth.)
FRG, Nor.	*Type 210* coastal sub	D	750	. .	. .	. .	. .	21[k]	–	. .	. .
Italy	*Sauro* patrol sub 6TT	D	1 631	20	1974	1977	1977	2/–	–	. .	. .
	Lupo frigate ShShM, 127 mm, 4× 40 mm, 6TT	GT	2 800	32.5	1974	1976	1977	6[l]/10	2 hel	. .	PP (USA), Ar (NATO)
	"*Sparviero*" fast hydrofoil ShShM, 76 mm	GT	62.5	50	. .	. .	1974	7/–	–	. .	. .
	. . corvette ShShM, 2× 76/62 mm	D	550	. .	. .	. .	(1978)	–/4	–	. .	–
Netherlands	"*Kortenaer*" frigate ShShM, SA, 76 mm, 4A/S TT	GT	3 500	30	1975	1976	1978	13/–	1A/S hel	. .	PP (UK) Ar (USA, NATO)
Norway	"*Hawk*" missile boat AS, 40 mm, 4TT	D	120	34	. .	. .	. .	14/16	–	. .	PP (FRG)
	"*Jägaren*" missile boat ShShM, 57 mm, 4TT	D	140	35	. .	. .	1972	–/17	–	(5)[m]	PP (FRG)
UK	*Swiftsure* attack sub 5A/S TT	N	4 500	30	1969	1971	1973	6/–	–	(75)[n]	. .
	Type 206 sub TT	D	600	17	1975	. .	. .	–/3	–	. .	. .
	Oberon patrol sub	D	2 410	17	1957	1959	1961	–/5[o]	–	(12)	. .
	Invincible A/S cruiser SA/ShShM	GT	19 500	28	1973	1977	(1980)	2/–	10 hel, 5 V/ STOL	269[p]	. .
	Sheffield destroyer SA/ShShM, 115 mm	GT	3 500	30	1970	1971	1976	10/–	1A/S hel	41.3[q]	. .
	Vosper Mk 10 frigate ShShM, 2× 115 mm, AS, 2A/S TT	GT	3 800	30	1972	1974	1976	–/6[r]	1A/S hel	(45)	E-r (Neth., It.)
	Weapon frigate ShShM, SA, 2× 40 mm, 6A/S TT	GT	4 000	> 30	1975	1977	(1978)	4/–	2A/S hel	30.5[s]	Ar (Fr.)
	Amazon frigate ShShM, SA, 115 mm, 6TT	GT	2 500	32	1969	1971	1974	8/–	1A/S hel	21.5[t]	Ar (Fr.)
	Brecon minesweeper/mine-hunter	D	725	17	. .	. .	1978	2/–	–	7.9[u]	–
	Island patrol boat 40 mm	D	1 250	16	. .	. .	1976	7/–	. .	. .	–
	Logistic Landing Craft	D	1 413	. .	1975	. .	1977	3/–	. .	. .	–
	VT-2 missile hovercraft ShShM	GT	(100)	(60)	(1974)	. .	. .	. .	–	. .	. .
	Vosper Mk 9 corvette ShShM 76 mm	D	850	27	. .	1977	(1979)	–/2	–	. .	. .
USA	*Trident* strategic sub SLBM[v]	N	18 700	30	1976	1977	1978	13[w]/–	–	~ 1 024	–
	Los Angeles attack sub SuSuM, 4A/S TT	N	6 900	40	1972	1974	1977	54[x]/–	–	264	–
	Nimitz aircraft carrier SA	N	93 400	> 30	1968	1972	1975	3/–	~ 100	2 000	–
	Virginia cruiser SA, ShSuM, 2× 127 mm, 6A/S TT	N	11 000	> 30	1972	1974	1976	4/–	2 hel	(368)[y]	–

Country	Class, description, armaments	Power plant	Displacement *tons*[a]	Speed *knots*	Laid down	Launched	Commissioned or completed	Number: domestic/ export or total	Aircraft capacity	Unit price *$ mn*	Foreign-designed Power plant, Electronics or Armaments
	Spruance destroyer SA, ShSuM, 2× 127 mm, 6A/S TT	GT	7 800	> 30	1972	1973	1975	30/4	4 hel 4 V/ STOL	(100)[z]	–
	Perry frigate ShShM, SA, 76 mm, 6A/S TT	GT	3 605	> 28	1975	1976	1977	50/3	2 hel	198	E-f (Neth.) Ar (It.)
	3K-SES-Surface Effect Ship air cushion frigate ShShM, SA	GT	3 000	> 80	(1978)[aa]	..	..	..	2 hel	159.9	–
	Tarawa amphibious assault SA, 3× 127 mm	T	39 300	24	1971	1973	1976	5/–	30 hel	230[ab]	–
	AALC-Amphibious Assault Landing Craft	GT	160	59	1971	1975	..	..	–	82[ac]	–
	Flagstaff hydrofoil gun boat[ad]	GT	56.8	> 40	1968	1968	1968	–/2	–	~ 20	..
	Pegasus hydrofoil missile boat ShShM, 76 mm	GT	221	> 40	..	1974	1977	5/–	–	35.6	–
Warsaw Treaty Organization											
German DR	*Kondor II* coastal mine-sweeper 6× 25 mm	D	280	21	..	..	(1971)	30/–	–	..	..
Poland	*Wisla* patrol boat 2× 30 mm, 4TT	D	70	30	..	..	..	12/–	–	..	..
USSR	"*Delta II*"[ae] strategic sub (16) SLBM	N	..	..	(1973)	1976	..	~ 4/–	–	..	–
	"*Delta*" strategic sub (12) SLBM	N	10 000	25	..	1972	1973	10/–	–	..	–
	"*Typhoo*"[af] ballistic missile sub	..	..	..	..	..	..	..	..	..	–
	"*Papa*"[ag] patrol sub SuShM, TT	N	..	..	..	(1971)	(1974)	1/–	–	..	–
	"*Charlie*" patrol sub 8 SuShM, 8TT	N	5 100	~ 30	..	1967	1968	12/–	–	..	–
	"*Charlie II*"[ah] patrol sub	N	..	..	..	..	..	2/–	–	..	–
	"*Victor*" patrol sub 8TT	N	5 100	> 30	..	(1966)	(1968)	18/–	–	..	–
	"*Victor II*"[ai] patrol sub	N	6 000	..	..	..	..	1/–	–	..	–
	"*Tango*" patrol sub	D	2 500	..	..	..	(1974)	3/–	–	..	–
	"*Kara*" cruiser SA, ShShM, 4× 76 mm, 4× 30 mm, 10TT	GT	10 000	~ 34	..	..	(1973)	5/–	1 hel	..	–
	"*Kresta II*" cruiser SA, ShShM, 4× 57 mm, 8× 30 mm, 10TT	ST	8 000	33	1968	..	..	10[aj]/–	1 hel	..	–
	"*Kiev*" A/S aircraft carrier ShShM, A/S TT, 4× 76 mm	..	40 000	30	1970	1972	1975	~ 5[ak]/–	25 V/ STOL, 25 hel	..	–
	.. aircraft carrier[al]	..	~ 50 000	..	..	..	..	..	..	..	–
	"*Krivak*" destroyer SA, ShShM, 4× 76 mm, 8TT	GT	3 900	38	..	..	1971	11/–	–	..	–

	"*Kashin*" destroyer SA, ShShM, 4× 76 mm, 4× 30 mm, 5TT	GT	4 500	35	..	..	1962	19/2	–	..	–
	"*Grisha*" corvette SA, 2× 57 mm, 4A/S TT	GT	900	30	..	1970	1972	18/–	–	..	–
	"*Nanuchka*" corvette SA, ShShM, 2× 57 mm	D	850	30	..	1971	..	14/8	–	..	–
	"*Turya*" hydrofoil patrol boat 2× 57 mm, 4TT	D	230	40	..	..	1973	17/–	–	..	–
	ACAC-Air Cushion Assault Craft[am] 30 mm	..	200	70	..	..	..	..	..	..	–
Other Europe											
Spain	*F.80* frigate SA, 76 mm, 6A/S TT	D	1 400	25	1974	1975	1976	10/–	–	..	PP (FRG) E-R (Neth.) E-s (USA) Ar (NATO, It.)
Sweden	*Näcken* patrol sub 8TT	D	1 125	20	..	..	1977	3/–	–	(20)[an]	..
	Spica II patrol boat 57 mm, 6TT	GT	230	~40	..	1972	1973	12[ao]/–	–	(8)	PP (UK)
Yugoslavia	.. missile boat ShShM, 57 mm	GT	240	40	(1973)	..	..	10/–	–	..	PP (UK), Ar (Fr.)
Other Developed											
China	*Han* patrol sub	(N)	3 000–5 000	..	(1971)	(1974)	..	(2)/–	–	..	..
	Ming patrol sub 6TT	D	(1 500)	..	(1971)	..	(1975)	2/–	–	..	..
	"*Romeo*" patrol sub 6TT	D	1 600	14	..	..	(1971)	36/–	–	..	..
	Luta destroyer ShShM, 4× 130 mm, 8× 57 mm, 8× 25 mm	T	3 750	> 32	..	..	1971	7/–	–	..	..
	Kiangtung frigate SA, 4× 100 mm, 8× 37 mm	D	180	(28)	1971	1973	1974	2[ap]/–	–	..	..
	Hainan corvette 2× 50 mm, 4× 57 mm, 4× 25 mm	D	500	~25	1963	..	..	15/–	–	..	..
	Hola missile boat ShShM, 4× 30 mm	D	200	32	(1972)	..	(1974)	(53)[aq]/–	–	..	..
	Hoku missile boat ShShM, 2× 25 mm	D	80	40	(1973)	..	(1974)	(50)[ar]/–	–	..	..
	Shanghai patrol boat guns, TT	D	155	30	1960	..	..	255/65	–	..	..
	Hai Dan[as] missile boat SuShM, 57 mm	GT	260–300	40	..	..	..	..	–	..	..
Japan	*Uzushio* patrol sub 6TT	D	1 850	20	1968	1970	1971	8/–	–	..	..
	Haruna destroyer ShSuM, 2× 127 mm, 2× 35 mm, 6A/S TT	T	5 200	32	1976	..	1980	2/–	3A/S hel	..	Ar (USA)
	Tachikaze destroyer SA ShSuM, 2× 127 mm, 3A/S TT	T	3 850	33	1973	1974	1976	2/–	–	..	Ar (USA)

Country	Class, description, armaments	Power plant	Displace-ment *tons*[a]	Speed *knots*	Laid down	Launched	Commis-sioned or com-pleted	Number: domestic/ export or total	Aircraft capacity	Unit price *$ mn*	Foreign-designed Power plant, Electronics or Armaments
	Yamagumo destroyer ShSuM, 4× 76 mm, 6A/S TT	D	2 100	27	1972	1973	1974	6/–	–	..	Ar (USA)
	Chikugo escort ShSuM, 2× 76 mm, 2× 40 mm, 8A/S TT	D	1 500	25	1968	1970	1970	12/–	–	..	..
	Miura amphibious craft 2× 76 mm, 2× 40 mm	D	2 000	14	1973	1974	1975	3/–	–	..	–
	Atsumi amphibious 4× 40 mm	D	1 550	13	1971	1972	1972	3/–	–	..	–

[a] For submarines, the displacement and speed are given when the ship is submerged.
[b] At least four of the 10 boats ordered have now been delivered.
[c] The fifth nuclear-powered submarine, *Le Tonnant*, was launched in 1977. Work on the sixth boat, *l'Inflexible*, has been delayed by lack of funds. The former and *l'Indoutable* will carry MSBS M4 and M20 missiles, respectively, with one-megaton thermonuclear warheads. The remaining three boats are equipped with MSBS M2 missiles.
[d] At least 24 are planned for completion by 1985, 18 being of an A/S version and six of an A/A version. Three are laid down and one has been launched.
[e] Seven boats have been commissioned. The South African Navy is to buy two ships which will be taken from the French Navy's own 14-ship building programme.
[f] Twelve were ordered by Greece and Turkey, 14 by South American navies and two by Indonesia. Some 14 ships have been delivered.
[g] The unit cost is in 1976 prices and includes development costs and the subsystem.
[h] The first of four ordered by Turkey in 1973 has been completed and the remaining three are being built or will be built in Turkey.
[i] The Turkish Navy is planning to introduce 14 boats by 1981–82. An order was placed in November 1976 for the construction of a new generation of missile boats.
[j] The US Navy's order for 30 has been reduced to six ships. FR Germany has a requirement for 10 and Italy, the third partner, will not place an order.
[k] A development project is in hand by the Norwegian and West German Navies to replace the Type 205 (FR Germany) and Type 207 (Norway) in the 1980s.
[l] Six improved "Lupo"-class frigates have been ordered by Italy. Of the 10 export boats, four vessels have been ordered by Peru, two of which will be built in Peru.
[m] The unit cost is in 1976 prices.
[n] The unit cost is in 1976 prices.
[o] Two for Australia are under construction and the third of a series of three built for Brazil has now been handed over. The unit cost is in 1976 prices.
[p] The unit cost is in 1976 prices.
[q] The unit cost is in 1976 prices.
[r] Six have been ordered by Brazil of which four are being built in the UK and two in Brazil. The first of the four from the UK have been delivered. The unit cost is in 1976 prices.
[s] The unit cost is in 1976 prices.
[t] The unit cost is in 1976 prices.
[u] The unit cost is in 1976 prices.
[v] This is one of the three elements in the US strategic triad concept, the other two being the new land-based mobile Missile-X being developed at present and the manned bomber capable of delivering either high-explosive or nuclear bombs or of launching cruise missiles. Each Trident submarine can carry 24 MIRV Trident missiles. The missile launch tubes have been designed to accommodate the larger Trident II missiles.
[w] A total of 13 submarines are planned for. Four are now under construction, a fifth is funded for FY 1977 and funding of the sixth and the seventh was requested in 1977.
[x] A total of 31 have been funded for and construction of 23 others has begun. Three have been delivered.
[y] Estimated cost in FY 1976 of the proposed fifth ship. This ship has, however, not be funded.
[z] The unit cost is in 1976 prices.
[aa] One prototype is being built.
[ab] The unit cost is in 1976 prices.
[ac] The R&D costs which include the two prototypes are being evaluated at present.
[ad] An order for two ships by Israel has been confirmed. Under a recent aid deal, six ships are covered. These will probably be armed with Gabriel ship-to-ship missiles.

[ae] It has been reported that the Soviet Navy has one or possibly two "Delta III"-class submarines. These have 20 launch tubes; the original "Delta I"-class had 12. A further batch of at least six "Delta II"-class are reported to be under construction.
[af] Construction of a new class of submarine has been reported. It will probably be equipped with the new SS-NX-18 MIRV SLBM with three warheads.
[ag] This cruise missile-class submarine is one of several.
[ah] An enlarged version of the "Charlie"-class.
[ai] This is an enlarged version of the "Victor"-class and it may now have superseded the "Victor" programme.
[aj] One is being built.
[ak] A second "Kiev"-class is being constructed.
[al] The first of a new class of aircraft carriers is being built.
[am] The first of a new class of ships under test was seen in July 1977.
[an] The unit cost is in 1976 prices.
[ao] The last in a series of 12 improved "Spica"-class has been launched and should be delivered in early-1977. Work has recently started on four modified "Spica" for Malaysia. The unit cost is in 1976 prices.
[ap] Further construction has apparently been delayed or suspended.
[aq] "Hola" is a modified version of the Soviet "Osa", seven of which were transferred directly from the Soviet Union.
[ar] "Hoku" is a modified version of the Soviet "Kamar", 10 of which were ordered from the Soviet Union.
[as] It has been reported that China has commissioned the first of a totally new and indigenously designed class of missile boat.

Country	Designation, description	Main armament *mm*	Combat weight *tons*	Road speed *km/h*	Year design begun	Year of prototype test	Year in production	Number: domestic/ export or total	R&D cost *$ mn*	Unit price *$ mn*	Foreign-designed Power plant, Electronics or Armaments
NATO											
France	*AMX-30* main battle tank	105	38	65	1957	1962	1966	320[a]/~300	..	..	–
	A/A vers, guns	30	..	..	..	..	..	..	..	..	–
	A/A vers, missiles	–	..	..	(1974)	..	1978	–/..	..	..	–
	AMX-13 light tank	105	15	60	..	..	1956	~7 000[b]	..	..	–
	VXB-170A Berliet amphibious armoured personnel carrier	20	15.5	85	1965	1969	1973	600/..	..	..	–
	AMX-10P amphibious armoured personnel carrier	20	13.8	65	(1965)	1969	1973	762/84	..	..	–
	AMX-10 HOT anti-tank	105	..	..	..	..	..	..	..	..	–
	AMX-10RC recce vers	105	15	85	..	(1973)	(1977)	350/..	..	..	–
	ECM 81 amphibious armoured personnel carrier	81	..	..	..	..	..	../250	..	..	–
	VAB Saviem forward armoured vehicle	90	12.9	92	(1969)	1973	..	2 175/..	..	..	–
	M-3 Panhard armoured personnel carrier	20	5.8	90	..	1969	1971	>800/ 3 300	..	..	–
	M-3 VDA A/A vers	22	..	..	..	(1973)	(1976)	..	..	..	–
	M-3 anti-tank, missile	..	..	..	..	..	(1976)	–/..	..	..	–
	AML-245 armoured recce and multi-purpose vehicle	..[c]	4.5–5.5	100	..	1960	(1960)	700/3 300	..	..	–
	H-90 current vers	90	5.5	90	..	..	..	..	..	..	–
	HS-30 current vers	30	..	..	..	..	..	..	..	..	–
	AMX-155 GCT field artillery tank	155	41	60	..	..	..	190/..	..	..	–
FR Germany	*Leopard II*[d] main battle tank	105 or 120	54.4	68	(1966)	1973	(1979)	1 800/..	..	..	E-f (USA)
	Leopard I main battle tank	105	42.2	65	1957	..	1965	2 077/ 1 390[e]	(25)	0.72	Ar (UK)
	Gepard anti-aircraft tank system	35	45.6	65	1966	1969	1976	420/210[f]	..	1.7	Ar, E-f, Er (Switz.)
	Marder armoured personnel carrier	20	28.2	75	1959	..	1970	2 476[g]/..	..	0.39	..
	Spähpanzer-2 Luchs armoured car	20	19.5	90	1965	1968	1975	408/..	..	..	..
	UR 416 armoured personnel carrier	..[h]	6.4	82	..	1973	..	../>450	..	..	..
	TPz-1 armoured personnel carrier and multi-purpose vehicle	7.62	16	90	1964	..	..	..[i]	..	..	..
International:											
It., FRG	*Lion*[j] main battle tank	105	43	65	..	..	1978	..	..	..	..
	FMBT-80 main battle tank	(120)[k]	..	..	1972	..	..	..	..	..	..

Italy	*Type 6616* armoured recce car	20	7.4	95	..	1973	..	50/..	..	..	Ar (Fr.)
UK	*Chieftain* main battle tank	120	54.9	48	(1958)	1959	1965	800/2 410[l]	..	~1.3	..
	ARV-Advanced Reconnaissance Vehicle	..	..	..	..	..	..	../246	..	..	..
	MBT-Main Battle Tank Mk 3 main battle tank	105	38.6	56	1958–63	..	..	../40	..	..	..
	Scorpion light tank	76	7.71–8.221	87	1964	..	1974	>2 000[m]	..	(0.2)	–
	FV721 Fox armoured car	30	6.386	104	1965/66	1967	1973	../(300)	..	..	–
USA	*XM-1* main battle tank	(105)	58	70	1972	1978	1980	461[n]/–	35.6	1.3	–
	M-60 main battle tank	105	53	48	1956	1959	..	1 600[o]/–	..	0.52[p]	–
	M-60A1 current vers	105	48	48	..	..	1962	~6 000/ ~1 040	..	0.59[p]	–
	M-60A2	152	51.5	48	1964	1965	1966	~540/..	..	..	–
	M-60A3 improved vehicle	..	..	..	..	..	1977	800/..	..	..	–
	M-48 main battle tank	90	52	48.3	1950	1951	(1951)	..[q]/421[r]	..	..	–
	XM-723 MICV-Mechanized Infantry Combat Vehicle	25	19.5	72	(1972)	1974	..	1 187[s]/..	67	0.22	–
	M113A1[t] armoured personnel carrier	12.7	10.93	68.4	1956	1964	(1965)	1 200[u]/ ~1 000	..	0.087	–
	AIFV-Armoured Infantry Fighting Vehicle	25	13.47	61.2	..	1970/71	..	../850[v]	..	..	–
	MICV-70 mechanized infantry combat vehicle	..	20.5	..	..	..	1978	250[w]/..	..	0.338	–
	V-150 commando armoured car	..[x]	9	96	early 1960	1971	..	–/..[y]	..	..	–
Warsaw Treaty Organization											
Czechoslovakia	*SKOT-2A* (*OT-64*) amphibious armoured personnel carrier	14.5	12.8	95	1959	..	(1963)	..	..	..	–
	OT-62 (*Topas*) armoured personnel carrier	14.5	15	62	..	..	..	..	..	..	–
Hungary	*FUG-70* amphibious scout car	14.5	7	100	..	1966	(1970)	..	..	..	–
USSR	*T-64/T-72*[z] main battle tank	125	~40	~80	..	..	1976	>2 000/..	..	..	–
	T-62 main battle tank	115	38	55	..	..	1962	../>1 000	..	..	–
	T-54/55 main battle tank	100	36.5	55	..	1947	1949	>30 000	..	..	–
	BMD amphibious light tank	73	~8	55	..	..	(1973)	../–	..	..	–
	BMP-1 infantry combat vehicle	73	12.6	~60	..	(1967)	(1967)	..	..	..	–
	M-1970 armoured personnel carrier	7.62	10	55	..	..	..	..	..	..	–
	BTR-50PK armoured personnel carrier	..[aa]	14.5	45	..	..	1957	../..	..	..	–
	BRDM-2 (*BTR-40PB*) recce car	14.5	7	100	..	(1966)	..	../..	..	..	–
	PT-76 light amphibious recce tank	76	14	45	..	..	(1952)	../..	..	..	–
	ZSU-23-4 anti-aircraft vehicle	23	15	~44	..	(1965)	1965	../..	..	..	–

Country	Designation, description	Main armament *mm*	Combat weight *tons*	Road speed *km/h*	Year design begun	Year of prototype test	Year in production	Number: domestic/ export or total	R&D cost *$ mn*	Unit price *$ mn*	Foreign-designed Power plant, Electronics or Armaments
Other Europe											
Austria	*Panzerjäger* anti-tank vehicle	105	17.5	65	1965	1967	1971	120/–	..	..	–
Sweden	*Ikv 91* light tank	90	15.5	64	1967	1970	1974	../–	..	..	..
	Pbv 302 (improved) armoured personnel carrier	20	13.5	66	1961	..	1965	../–	..	..	..
Switzerland	*Pz 68* main battle tank	105	39	60	(1968)	..	(1970)	110/..	..	(0.4)[a,b]	PP (FRG) Ar (UK)
	Piranha infantry combat vehicle	..[a,c]	7, 9.6 or 12.5	10	..	..	..	../350	..	~0.49	..
	Tornado 2 infantry combat vehicle	20 or 25	21	70	1967	1968	–[a,d]	–/..	..	..	..
Yugoslavia	*M60* armoured personnel carrier	12.7	9.5	45	..	(1965)	..	../..	..	..	..
	M-1975 armoured personnel carrier	20	..	..	..	(1975)	..	../–	..	..	..
Other Developed											
China	*T-59* (*T-54*)[a,e] main battle tank	100	36.5	48	..	..	(1963)	../..	..	..	–
	T-63 (light) tank	85	..	..	..	..	..	..	..	..	–
	T-60 (*PT-76*) light amphibious tank	85	15	40	..	..	..	../..	..	..	–
	M-1967 armoured personnel carrier	12.2	10	..	..	..	(1967)	..	..	..	–
Japan	*STB-6* main battle tank	105	38	53	1962	1969	1974	340/–	..	(0.7)[a,f]	Ar (UK)
	Type 73 amphibious infantry combat vehicle	12.7	14	60	..	..	(1974)	../–	..	..	..

[a] By end 1977, the French Army should have received 960 AMX-30s and 320 more have been ordered. Saudi Arabia has bought 200–300 tanks.

[b] About 7 000 AMX-13s of all versions have been built.

[c] Various types of armament are used. The latest in the series is a version with the new 60-mm mortar.

[d] It has been reported that the competition between Leopard II and the US XM-1 tank for US Army procurement was officially cancelled, although standardization will be implemented as far as possible. The request for the production of 1 800 tanks between 1979 and 1986 was approved.

[e] Of the West German order for 2 437 tanks, 360 have been delivered. The order for 1 390 tanks includes 200 ordered by Italy. The Italian requirement is for a total of 800 tanks; the remaining 600 will be built under licence in Italy. Turkey is currently negotiating for licensed production of the tank. The R&D and unit costs are in 1976 prices.

[f] The USA may procure 188 for some of its Army units in FR Germany. The unit cost is in 1976 prices.

[g] Some 2 136 have been built for FR Germany; the last batch was delivered in 1975. Further production includes some 340 units. A new version, known as TAM, has recently been built which consists of a turret armed with a 105-mm gun. Argentina has ordered some and intends eventually to produce indigenously. The unit cost is in 1976 prices.

[h] The missile vehicle is armed with TOW or Cobra anti-tank missiles and a reconnaissance vehicle is mounted with 20-mm cannon and 90-mm recoilless rifles.

[i] Production has only started recently.

[j] This is a version of the Leopard I and is designed for export particularly to countries with a hot climate and desert regions. The final assembly will be carried out in Italy.

[k] The question of a common gun for the FMBJ-80 and other tanks has not been resolved by the USA, FR Germany and the UK.
[l] Of the initial Iranian order, 760 tanks have been delivered. Further orders are: phase 1, 150 tanks; phase 2, 150 Shir Iran tanks, and phase 3, 1 200 Shir Iran 2 tanks. Thus the bulk (2 260 tanks) of the export orders is from Iran which is also providing the funding. Some 150 tanks will be ordered by Kuwait.
[m] Iran has ordered 250 tanks and a further order of 110, which is not finalized yet, seems likely only on a barter basis.
[n] A contract was made in November 1976 for the production of 11 development models including a two-year production option for 462. The US Army plans to procure 3 325 tanks. The value for R&D is the final appropriation figure and the unit cost is in 1976 prices.
[o] Proposed US inventory of M-60s between 1975 and 1989.
[p] The unit cost is in 1976 prices.
[q] Proposed inventories of various models are as follows: M-48A1/A2C—2 800 units in 1975 to be reduced to zero by 1980; and M-48A5—increasing the inventory to 1 200 by 1989.
[r] The M-48A1 has been sold to the Republic of Korea. The US Congress was notified of a proposed letter of offer to Taiwan for an unspecified number of M-48A1s at an estimated value of $8.1 mn.
[s] Initial production of 55 was to start in late 1977. The army should receive 1 187 MICVs of its total requirement for 2 410 by 1982. The R&D and unit costs are in 1976 prices.
[t] There are two versions available, one upon which the six-barrel Vulcan gun can be mounted and the other which can carry a TOW missile. The production of 10 pre-production prototype tanks with the TOW missile has been approved.
[u] The House Appropriations Committee has approved $89.4 mn for 1 200 of the US Army's M-113s. The unit cost is in 1976 prices.
[v] Developed from the M-113 armoured personnel carrier, it is in service with the Netherlands which will acquire 850, and is being tested in Belgium.
[w] 250 of a total of 3 162 have been bought.
[x] Various types of up to 81-mm mortars and a TOW anti-tank missile system can be fitted.
[y] Three models, the V-100, V-150 and V-200 have been exported to more than 20 countries.
[z] The T-62 tank was preceded by a temporary experimental model known as the T-70.
[aa] The vehicle can carry up to four machine-guns of 14.5-mm, 12.7-mm or 7.62-mm calibre.
[ab] The unit cost is in 1976 prices.
[ac] A wide range of armament can be fitted including 7.62-mm machine-guns, various turrets mounting 7-, 20-, 25- or 30-mm cannons or a 90-mm anti-tank gun.
[ad] Development is continuing. An enlarged version (24 tons) is called "Taifun"; a version with a 90-mm anti-tank gun is called "Gepard". They are intended for export and/or licensed production.
[ae] Vehicles of Soviet origin are shown with Soviet designations in brackets. They are listed as indigenous because China has been almost totally isolated from Soviet technology since 1960.
[af] The unit cost is in 1976 prices.

II. Register of licensed production of major weapons in industrialized countries, 1977

For sources and methods, see chapter 9. For conventions, see page 293.

Part 1. *Aircraft*

Licensee	Licenser	Year of licence	Designation, description	Power plant	Weight *max takeoff wt, kg*	Speed *km/h or Mach no.*	Nature of licence, technical changes by licensee	Year in pro- duction	Number: domestic/ export or total	Unit price *$ mn*
NATO										
Italy	USA	(1966)	*F-104S* fighter/strike	TJ	14 060	M 2.2	Mainly indigenous manufacture	1968	205/82[a]	. .
		1968	*CH-47C* transp hel	TS	17 463	286	Partial indigenous manufacture	1970	26/64[b]	8.5[c]
		1965	*SH-3D* A/S hel	TS	9 525	269	Indigenous manufacture except radar	1967	14/32	. .
		. .	*AB 214B* utility hel	TS	7 257	241	. .	. .	. .	. .
		(1971)	*AB 212A* A/S hel	TS	5 079	196	Indigenously developed A/S version of US aircraft	1975	28/24	. .
			AB 212 AWW-Above Water Warfare	TS	. .	. .	Under development	. .	. .	. .
		. .	*AB 204AS* A/S hel	TS	4 310	167	Indigenously developed A/S version of US aircraft	. .	. .	. .
		. .	*AB 205A-1* utility hel	TS	4 310	222	Indigenous manufacture	1969	. .	. .
		1961	*AB 206B-1* utility hel	TS	1 519	222	Indigenous manufacture	1971	. .	. .
		(1973)	*NH-500M* light hel	TS	1 360	244	Initially 40 aircraft assembled from imported components; assembly of wholly indigenously produced NH-500 was expected to start in 1977	1973	. .	. .
		1972	*HH-3F* search and rescue hel	TS	10 000	261	. .	. .	30/. .	. .
UK	USA	1966	*SH-3 Sea King* A/S hel	TS	9 525	208	Indigenous manufacture, British engines and avionics	1969	92/66[d]	. .
			Commando transp vers	TS	9 525	208	. .	1972	. ./30	. .
USA	Switzerland	(1965)	*AU-23A Peacemaker* COIN aircraft	TP	2 767	280	Military version of Porter developed in the USA	(1970)	. ./20	. .
Warsaw Treaty Organization										
Romania	UK	1968	*Islander* light transp	P	2 993	273	Indigenous manufacture	1969	315[e]	. .
	France	1971	*SA 319 Alouette III* utility hel	TS	2 250	220	Assembly, some indigenous manufacture	1971	130/–	. .

Other Europe										
Spain	FR Germany	..	*CASA 223K1* trainer	P	821	249	Indigenous manufacture	1972	–/50	..
Switzerland	USA	..	*F-5E Tiger II* light fighter	TJ	11 192	M 1.63	Initially assembled from knocked-down parts	..	18/–	..
Yugoslavia	UK, France	1971	*SA 341/342 Gazelle* light utility hel	TS	1 800	264	Assembly; 8 pattern aircraft were supplied	1973	132	..
Other developed										
Australia	USA	1971	*B206B-1* utility hel	TS	1 451	225	Some indigenous manufacture	1973	56[f]/–	..
Japan	USA	1969	*F-4EJ* fighter/bomber	TJ	24 765	> M 2	Mainly indigenous manufacture	1972	128/–	12.77
		1959	*P-2J* maritime patrol	TP	34 019	402	Indigenous manufacture, substantial modification of US design	1969	83[g]/–	10.31
		Early-1950	*KM-2B* trainer	TP	1 510	413	Indigenous, modified KM-2 which was developed from US *T-34A Mentor*	(1976)	6[h]/–	..
		(1962)	*SH-3A* A/S hel	TS	18 044	166	Mainly indigenous manufacture	..	~90/–	5.08
		(1961)	*KV-107II/IIIA* transp hel	TS	19 000	270	Indigenous manufacture	(1962)	2[i]/6	3.39
		(1967)	*OH-6J* light hel	TS	1 225	216	Assembly	1969	~100[j]/–	~0.58
		..	*TH-55J* light hel	P	1 670	138	..	1974	48/–	..
		(1976)	*AH-1* attack hel	TS	9 500	352	Initially locally assembled	..	32/–	..
			UH-1H utility hel	TS	4 309	204	..	..	58/–	1.45

Licensee	Licenser	Year of licence	Designation, description	Power plant	Warhead weight *kg* (if nuclear, *kt* or *Mt*)	Range *km*	Nature of licence, technical changes by licensee	Year in production	Number: domestic/ export or total	Unit price $ *mn*
NATO										
International:										
European NATO Consortium (leader, FRG)	USA	..[k]	*AIM-9 Sidewinder* aircr-to-aircr	S	..	..	FRG secured the right to produce AIM-9L	..	..	..
European NATO Consortium (leader, Nor.)	USA	..	*AGM-12B Bullpup* aircr-to-ship/fixed	LP	113	~11	..	..	..	..
Italy	USA	..	*AIM-7 Sparrow III* aircr/ ship-to-aircr/miss	S	30	(25)	Indigenous manufacture	..[l]	..	..
	FR Germany	..	*Bo 810 Cobra 2000* portable-to-tank	S	2.7	2	..	..	..	..
Turkey	FR Germany	..	*Bo 810 Cobra 2000* portable-to-tank	S	2.7	2	..	..	..	..
UK	FRG/France	1976	"*Milan*" anti-tank	S	3	2	Initially subsystems purchased from FRG and France will be assembled in UK; by mid-1979 all-British Milan will be built	..	50 000[m]	..
	USA	..	*XJ-521 Sky Flash* aircr-to-aircr	S	30	50	Indigenous, developed from the US AIM-7E Sparrow missile	(1978)	..	~0.16
	USA	..	*TOW* anti-tank	S	2.4	3.75	Substantial part of the system will be produced in UK	..	..	..
USA	FRG/France	(1975)	*Roland* SAM	S	6.5	6.2	..	..	..[n]	..
Other Europe										
Sweden	USA	..	*Rb 28* aircr-to-aircr	S	HE	10	..	..	..	..
		..	*Rb 27* aircr-to-aircr	S	HE	10	..	..	..	..
Yugoslavia	USSR	..	"*Sagger*" portable/mobile-to-tank	S	11.5	3	..	..	..	..

Japan	USA	1972	*MIM-14C Nike Hercules* fixed-to-aircr	S	HE	150	Non-nuclear version	(1973)	(36/–)	(3.0)[o]
		1972	*MIM-23 Hawk* mobile-to-aircr	S	HE	30	..	(1973)	(30/–)	(2.5)[o]
		1977	*MIM-23B Improved Hawk* mobile-to-aircr	S	> 54	40	..	..	..	..
		..	*AIM-7 Sparrow III* aircr-to-aircr	S	30–40	50–100	..	(1973)	600/–	..
		1977	*RIM-7H Sea Sparrow* fixed-to-aircr	S	30	18	..	..	..	..

Licensee	Licenser	Year of licence	Class, description	Displace-ment *tons*	Speed *knots*	Nature of licence technical changes by licensee	Year of first ship: Laid down	Year of first ship: Launched	Year of first ship: Commis-sioned or com-pleted	Number: domestic/ export or total	Unit price *$ mn*
NATO											
Turkey	FR Germany	..	*Jaguar III* missile boat ShShM	(400)	(38)	–	..	..	(1974)	3/–	..
Other Europe											
Spain	France	..	*Agosta* patrol sub 4A/S TT	1 725	20	Some French assistance	1975	..	1979	2/–	..

Part 4. *Armoured vehicles*

Licensee	Licenser	Year of licence	Designation, description	Main arma-ment *mm*	Combat weight *tons*	Road speed *km/h*	Nature of licence, technical changes by licensee	Year in pro-duction	Number: domestic/ export or total	Unit price *$ mn*
NATO										
Belgium	UK	..	*Scorpion* light tank	76	7.8	87	Substantial indigenous manu-facture	(1973)	(700)[p]/–	..
	FR Germany	1972	*Kanone JPZ4-5* anti-tank	90	26	70	Assembly	(1974)	80/–	0.37[o]
	Eire	..	*BDX* armoured personnel carrier	7.26	~8.2	100	..	123/..	..	..
Italy	FR Germany	..	*Leopard* main battle tank	105	42.2	65	Indigenous manufacture	(1973)	600/–	..
	USA	1963	*M113* armoured personnel carrier	–	10.7	64	Indigenous manufacture	..	~3 600/ 1 620	..
Warsaw Treaty Organization										
Czechoslovakia	USSR	..	*T-62* main battle tank	115	15	62	Probably indigenous manufacture	..	..	..
Hungary	Czechoslovakia	..	*OT-64* armoured personnel carrier	14.5	12.8	95	..	..	..[q]/–	..
Poland	USSR	..	*T-62* main battle tank	115	15	55	..	..	..	..
	Czechoslovakia	..	*OT-64* armoured personnel carrier	14.5	12.5	95	..	..	..[q]/–	..
Other Europe										
Spain	France	1972	*AMX-30* main battle tank	105	36	65	Assembly	(1974)	180/–	..
Other Developed										
Canada	Switzerland	1977	*AVGP-Armoured Vehicle General Purpose*	76	..	100	Design is based on Swiss Piranha model	..	350[r]/–	..

[a] Turkey has ordered 40 and holds an option on 18 more.
[b] Iran has ordered 50, Syria six, and Libya eight with an option on 18.
[c] The unit cost includes spares and technical support.
[d] The total order is for 158 plus some additional unspecified items.
[e] Over 200 aircraft have been produced to date.
[f] Production was completed in early 1977.
[g] The total requirement is for 89 aircraft. The last of the 83 should be delivered by late 1977. The unit cost is in 1976 prices.

[h] Production of only six aircraft has been approved so far although the Japanese Air Self Defense Force plans to buy 60 aircraft.
[i] Some 100 aircraft had been delivered by late 1975.
[j] Some 90 have been delivered.
[k] A memorandum of understanding between the USA and FR Germany for licensed production of the AIM-9 was signed in October 1977. Allocation of licensed production of the missile among Belgium, FR Germany, Norway and the UK was to have been decided by the end of 1977.
[l] The AIM-7E will enventually be replaced by the Aspide-1A missile. Manufacturing licences have been granted to Italy by FR Germany.
[m] The UK will initially purchase 5 000 missiles from France.
[n] The current five-year plan calls for 5 000 to 7 000 missiles at a cost, including 300 firing units, of about $2 000 mn.
[o] The unit cost is in 1976 prices.
[p] This includes both the Scorpion and a version armed with an anti-tank missile known as Striker.
[q] Production may be completed.
[r] Three versions have been ordered: 152 *Couger*, a wheeled fire-support vehicle armed with 76-mm guns; 179 *Grizzly*, a wheeled armoured personnel carrier; and 19 *Husky*, a wheeled maintenance and recovery vehicle.

Appendix 7B

Registers of indigenous and licensed production of major weapons in Third World countries, 1977

I. Register of indigenously designed major weapons in development or production in Third World countries, 1977[a]

For sources and methods, see chapter 9. For conventions, see page 293.

Country	Designation, description	Power plant	Arma-ment	Year design begun	Year in pro-duction	Produc-tion rate	Status of programme, other information	Number planned/ produced	Unit price $ mn
Argentina	*IA-58 Pucará* COIN combat	TP (Fr.)	MG (Belg.); cannon (Switz.)	1966	1972	1/month	Req: 100; ordered: 30 for AF; a contract for 15 more has been signed	../8	..
	IA-60 Pucará jet attack vers	J	..	..	..	..	Developing	..	..
	IA-62 trainer	TF (Fr.)	..	(1977)	(1981)	..	Req: ~100; design based on Pucará airframe has been proposed; speed: Mach 0.73; developing	..	..
	Cicaré CH-111 Colibré hel	P (USA)	–	1973	..	..	For AF training; first flight early 1976	..	..
	Survey ship	..	..	..	1974	..	Displ: 1 960 t	1/..	..
Brazil	*T-23 Uirapuru* primary trainer	P (USA)	–	1965	1968	..	Production continues; total number sold exceeds 130 (excluding civilian aircraft)	140/10	0.02[b]
	T-25 Universal primary trainer	P (USA)	–	1963	1971	..	Production continuing; 140 on order for Brazil	..	..

Country	Designation, description	Power plant	Armament	Year design begun	Year in pro-duction	Produc-tion rate	Status of programme, other information	Number planned/ produced	Unit price *$ mn*
	EMB-110 Bandeirante basic light transp	P (Can.)	–	..	1972	~3/month	10 versions for military and civilian use are produced; a total of more than 150 of all types has been ordered; including 9 to Chile and 5 to Uruguay	..	..
	EMB-110A navaid checking and calibration	P (Can.)	–	..	..	..	2 ordered by AF	..	..
	EMB-110B aerial photographic vers	P (Can.)	–	..	..	..	6 ordered by AF	..	..
	EMB-110K military transp	TP (Can.)	..	..	..	..	20 aircraft will be supplied to AF; EMB-110K1, a stretched version, has been proposed	..	..
	EMB-111 maritime surveillance	TP (Can.)	ASM	1973	(1974)	..	12 ordered by AF and 6 for export	../..	..
	N-621A Universal II trainer/COIN	P (USA)	Light bombs, rockets	1972	(1975)	..	The aircraft is improved version of T-25 Universal; 2 prototypes ordered; export order consists of 60[c] aircraft	../..	..
	Type X-40 missile	..	..	..	(1975)	..	Seen during military parade; range: 60 km[d]	..	..
	EE-9 Cascavel COIN APC/armed recce	D (FRG)	MG, 90-mm cannon	1970	1975	..	In production for Brazilian Army; 20 ordered by Qatar	..	..
	EE-11 Urutu APC	D (FRG)	MG, cannons various calibres	1970	(1972)	..	In production for Brazilian Army and Marines	..	..
	EE-17 Sucuri wheeled combat vehicle	..	105-mm gun	..	..	..	Recently developed vehicle	..	..
	Submarine	..	..	..	..	..	Planning	..	..
	Fast patrol boat	..	..	..	..	..	10 boats ordered by Chile but no details published	..	..
	Electronics	–	–	..	(1970)	..	..	..	..
	Turbojet engines	–	–	1970	..	..	Developing	..	..

Egypt	Defence industry	–	–	..	..	..	Four-country agreement signed on joint Arab arms industry 29 Apr 1975; initial funds: $1 000 mn	..	..
India	*HAL HJT-16 Mk I Kiran* jet trainer/ground attack	TJ (L: UK)	7.62-mm MG rockets	1961	1968	2/month	Req: 180 for AF and Navy; production gradually being phased out	180/~150	Export 1972: 0.4
	HAL HJT-16 Mk II Kiran jet trainer/ground attack	TJ (L: UK)	Nose-mounted integral MG, avionics	1974	..	–	Prototype is in flight test; production expected to start 1978	..	..
	HAL HF-24 Marut Mk I light fighter-bomber	TJ (L: UK)	Aden guns (UK), rockets, bombs	1956	1963	..	Production continues; further 45 aircraft now under construction	../125	..
	HAL HF-24 Marut Mk IT tandem trainer vers	TJ (L: UK)	Aden guns (UK), rockets, bombs	1967	1974	..	Req: 20; 10 being delivered; production may terminate	../10	..
	HAL HF-73 Marut Mk III strike/fighter	TJ (L: UK)	..	1969	–	–	Development progressing; prototype flight 1980	–	–
	HAL HAC-33 light STOL	TP (L: UK)	..	Design completed 1974	–	–	Req: "large number" for AF and Navy	–	Est. cost: 0.3[b]
	HAL HPT-32 basic trainer	P (USA)	..	Design completed 1974	–	–	Scheduled to replace AF HT-2 from 1981–82; 2 prototypes ordered; one to fly in mid-1977; aircraft also considered suitable for aerial observation, search and rescue and weapons' training	–	Est. cost[b]: 0.08 on production run of 50
	Armed light helicopter	..	..	1973	..	..	2 versions under development for Army/AF and Navy	..	Est. cost of development including production of 10: ~65
	Ship-to-ship miss	..	..	..	..	..	Successfully tested in Dec 1975	..	..
	Main battle tank	..	..	(1970)	..	..	Design: Avadi R&D Dept	–	–
	APC	..	..	..	..	..	Large-scale production planned; prototype trials 1973	..	..

Country	Designation, description	Power plant	Armament	Year design begun	Year in pro- duction	Produc- tion rate	Status of programme, other information	Number planned/ produced	Unit price *$ mn*
	Seaward Defence Boat Mk II patrol boat	..	..	1974	..	..	First of series of 8; SDB Mk II launched in 1977	..	..
	Nuclear-powered submarine	N	..	1974	–	–	Planning: design to be completed 1980	..	..
	Aero-engines	J	–	1965	(1976)	..	In production for HJT-16 Kiran at HAL, Bangalore, R&D	..	..
	Electronics	..	..	1965	..	..	Bharat Electronics; HAL Lucknow: avionics	..	..
	Target drones	..	..	(1970)	..	..	Testing: Jul 1974; speed: Mach 1.4	..	..
	Unguided rockets	..	..	..	..	..	..	..	..
Indonesia	*Lipnur LT-200* 2-seat light trainer (Pazmany PL-2 derivative)	TP (USA)	–	..	..	..	First 2 prototypes Sep 1973; production in hand; being evaluated by Taiwan, S. Korea, Japan, USA	–/50	..
	"*Mawar*"-class large patrol craft	D	A/A guns	..	(1973)	..	Displ: 147 t; speed: 21 knots; more to be built	5/3	..
Israel	*IAI-201 Arava* STOL military transp	TP (Can.)	MG	1966	1972	~2/month	In production; 55 of total order of 69 have been sold to L. American countries	77/39	..
	IAI "*Kfir*" combat aircr Mach 2.2 (Mirage III/5 development)	TJ (USA)	DEFA cannon, Rafael Shafrir AAM	1968	1974	3–4/month	Req: about 160; Ecuador had ordered 24 aircraft but this vetoed by the USA and order was cancelled; Israel has offered 24 "Barak" aircraft instead	~160/ ~100	~5.8
	IAI "*Kfir C-2*" fighter/ ground attack Mach 2.3	TJ (USA)	DEFA cannon, Rafael Shafrir AAM	..	..	~4/month	Over 30 aircraft in various stages of production	150/..	5 (including spares)
	IAI "*Kfir 5*" fighter-bomber	..	..	Design comple- ted 1957	..	..	IAI working on a considerably more advanced version on the lines of Mirage 2000	..	..

IAI-1124 Westwind naval patrol/SAR	TJ (USA)	..	..	..	..	This aircraft supersedes IAI-1123, the production of which ended in mid-1976; 3 were ordered by navy	..	3[b]
Anti-tank helicopter	..	..	1977	..	..	It is reported that preliminary design has started on an anti-tank helicopter	..	Est. cost: >1
Jericho fixed-to-fixed miss	S	Warhead HE/N	1966	..	..	Tested at range of 500 km in 1975	..	..
Rafael Shafrir air-to-air miss, IR-homing	S	11 kg	1965	1969	..	Range: 5 km; sales made to several overseas customers including Taiwan	..	0.02[b]
Gabriel ship-to-ship miss, vers I and II	S	150 kg	1966	I: 1970; II: 1974	..	Mk I range: >20 km; Mk II range: 40 km; sold to Singapore, S. Africa, Argentina, Malaysia, Thailand, Taiwan; third version with a range of 65 km being developed	..	..
Ship-to-ship miss	..	..	(1975)	..	..	Engine currently being produced with almost double the range of Gabriel	..	..
Luz air-to-surface miss	..	..	(1970)	..	..	Developing; TV-guided; to be installed on Kfir-C2	..	..
"*Katyusha*" artillery rocket	..	..	–	1971	..	Israeli version of captured Soviet rocket	..	..
Ze'ev short-range unguided artillery rocket, 2 vers	..	170 kg, 70 kg	..	(1973)	..	Ranges: 1 km, 4.5 km	..	..
RBY-Mk 1 armoured recce/COIN "*Rabix*" AC vehicle	G (USA)	Light MG	..	..	..	3.6 t; first displayed in 1975; trials successfully completed; being built now	..	..
Sabra main battle tank	D (USA)	Gun (UK)	(1969)	1971	..	40 t; prototype only; not yet in production	..	..
Merkava main battle tank	D (USA)	105-mm gun	..	..	..	56 t; 2 prototypes built; production of 40 pre-series has started	40/(7)	..
L33 field artillery tank	..	155-mm gun (Finnish)	..	1973	..	41.5 t; speed: 37 km/h	..	..

Country	Designation, description	Power plant	Armament	Year design begun	Year in production	Production rate	Status of programme, other information	Number planned/ produced	Unit price $ mn
	"*Reshef*"-class fast miss boat	D	Gabriel SSM	..	1973	2/year	First series of 7 completed; a second series of 6 started; an additional 6 to be built for S. Africa, 3 of which may be built in S. Africa	../7	..
	Qu-9-35 type patrol boat	..	Gabriel SSM	..	..	..	850 t; speed: 42 km/h; ASW hel; 9 being built	..	..
	Dvora missile boat	D	Gabriel SSM	..	..	..	Max 47 t; speed: 35 km/h; a prototype being completed	..	~3
	Avionics and electronics	–	–	..	1960	..	Tadiran largest electronics producer	..	..
	Engines	–	–	..	1969	..	Bet-Shemesh plant; IAI Bedek Aviation	..	..
	Napalm	–	–	..	(1951)	..	First used in 1956 war; also used in 1967 war	..	..
Korea, North	"*Najin*"-class frigate	D	..	..	1971	..	Larger version of "Sariwan"-class built in 1960s; first laid down 1971–72, completed 1973, second completed 1975, third probably launched in 1977	3/..	..
Korea, South	Medium-range ballistic miss	..	..	..	..	..	S. Korea has purchased all the plant and equipment of Lockheed Propulsion division indicating desire to eventually acquire missile technology for indigenous production	..	..
	Pack Ku multi-mission patrol ship	D (USA)	76-mm gun SSM	..	..	..	280 t; speed: 40 knots; 4 ships ordered by Indonesia	../3	..
	PSK fast patrol boat	D	..	..	..	..	Speed: 40 knots; new class of patrol boat being built for Indonesia; boat due to enter service in 1979	..	..

Kuwait	Rockets	..	–	..	1974	..	Operated with special guiding device; further development planned	..	..
Pakistan	Shipbuilding	–	–	(1974)	..	..	Karachi shipyard constructing 8 ships for Saudi Arabia and Abu Dhabi	8/..	..
Peru	Aircraft industry	–	–	1975	..	..	Construction of helicopters to be given priority; no details published	..	..
	Large patrol craft	..	..	..	1974	..	150 t; speed: 25 knots; 6 boats being built; first due for completion in 1976; launched in 1974	6/..	..
	"*Parinas*"-class tanker	D	..	..	1975	..	Displ: 13 600 t full load; laid down in 1975	../2	..
	Fleet tanker	D	..	..	..	..	Displ: 25 000 t; to be completed in 1977	..	..
Philippines	*PADC* light utility aircr	P (USA)	–	1975	..	..	During phase 2 in 1976 construction and testing of prototype to have taken place; first flight planned for mid-1978	..	..
	Bong-Bong II unguided artillery rocket	..	..	1972	..	..	R&D rocket test-fired 1972; no further details appeared	..	..
	Shipbuilding	–	–	..	..	..	Philippines plans to build 44- to 50-m gunboats; equipment will be foreign	..	..
Singapore	Shipbuilding	–	–	..	..	..	Vosper Thornycroft, Singapore, and other companies produce ships of various types; some 25 000 people employed in this industry	..	..
	Electronics	–	–	1974	..	..	Singapore Electronics and Eng. Pte. Ltd: precision equipment for military aircraft	..	..

Country	Designation, description	Power plant	Armament	Year design begun	Year in production	Production rate	Status of programme, other information	Number planned/ produced	Unit price *$ mn*
South Africa	Tank	..	..	..	1976	..	Government announced it was ready to start series production of indigenous tanks but no further details published	..	..
	Mine-clearing vehicle	–	–	..	1973	..	No further information since 1973	..	..
	"*Whiplash*" air-to-air miss, IR-homing	S	Warhead: HE	1966	1972	..	Range: 550 km	..	..
	Electronics	–	–	..	..	..	..	..	..
	Engines	–	–	(1969)	..	..	Local engine on Eland II AC	..	..
	Napalm	–	–	..	1968	..	Manufactured entirely from local material	..	..
	Chemical weapons: nerve gas, tear gas	–	–	1960	..	..	Self sufficiency achieved since large investments in arms industries	..	..
Taiwan	*T-CH-IB Chunghsing* medium trainer	TP (USA)	..	1970	..	..	Prototype first flew in 1973; 2 built; production begun against an order of 30 for AF	../2	..
	Jet trainer	..	..	..	–	–	Plans for jet trainer but no further details published	..	..
	XC-2 tactical transp	TP (USA)	..	1973	..	..	Construction of prototype began 1976; max speed: 546 km/h; max take-off weight: 11 340 kg	..	..
	Medium-range surface-to-surface miss	..	Warhead: HE	(1973)	..	..	Range: 960 km; developing	..	..
	Patrol boat	..	..	..	..	..	Displ: ~30 t	14/1	..
	Electronics	–	–	..	1960	..	R&D at 4 major institutes	..	..

Venezuela	Aircraft industry	–	–	–	–	–	To be established probably with foreign aid and with licensed production	..	..
	Shipbuilding industry	–	–	–	–	–	3 major shipyards to be built	..	..

[a] The following countries have shipbuilding industries, but there is no specific information on current projects: Burma, Cameroon, Chile, Colombia, Congo, Cuba, Dominican Republic, Egypt, Gabon, Guyana, Ivory Coast, S. Korea, Mexico, Syria, Thailand and Viet Nam.
[b] The unit cost is in 1976 prices.
[c] This includes a possible order for 40 aircraft from Bolivia.
[d] It is reported that Brazil has produced prototypes of two long-range surface-to-air missiles but no details are published.

II. Register of licensed production of major weapons in Third World countries, 1977

Licensee	Licenser	Designation, description	Power plant	Armament	Year of licence	Year in production	Production rate	Status of programme, other information	Number planned/ produced	Unit price[a] $ mn
Argentina	USA	*FMA Cessna A182* monoplane	P (Imp: USA)	..	1965	..	..	..	../150	..
		FMA Cessna A150 trainer	P (Imp: USA)	–	1971	..	..	..	../40	..
		Chincul Piper Cherokee light plane	P (Imp: USA)	–	1971	1973	20–30/ year	Single-engined assembly from knocked-down parts	1 000/..	..
		Chincul Piper Seneca light plane	P (Imp: USA)	–	1971	1973	..	Twin-engined; assembly from knocked-down parts	340/..	..
		Raca Hughes Model 500 hel	T (Imp: USA)	–	1972	..	..	Assembly from knocked-down parts; other models in the 500 series are 500C and 500M	120/20 (by Apr 1977)	..
	FR Germany	*Type 148* fast miss boat	D (Imp: FRG)	Triple launcher for Gabriel SSM; 76-mm and 40-mm guns; 2 21-in torpedo tubes (or 8 mines)	1970	1971	..	Displ: 265 t full load; speed: 38 knots; two ordered	..	..
	UK	*Type 42* destroyer	GT (Imp: UK)	Sea Dart SSM (Imp: UK); 1 hel (Imp: UK); 1 4.5-in automatic gun; 2 20-mm Oerlikon guns (Imp: Switz.)	1970	1971	..	Displ: 3 500 t full load; speed 30 knots; 1 built in UK and commissioned Nov 1975; 1 being built in Argentina, laid down 1971, launched 1974	../1	~45[b]

Licensee	Licenser	Designation, description	Power plant	Armament	Year of licence	Year in production	Production rate	Status of programme, other information	Number planned/ produced	Unit price[a] *$ mn*
		Type 21 "Amazon"-class frigate	GT (Imp: UK)	Exocet SSM; Seawolf SSM; A/S hel (Imp: UK); 1 4.5-in Mk 8 and 2 20-mm Oerlikon guns	1975	..	..	Displ: 2 500 t full load; speed 32 knots; preliminary agreement reached in 1975 for building 6 boats at Argentinian shipbuiding yard	6/..	..
Brazil	Italy	*EMB AT 26 Xavante* armed trainer/COIN (MB.326GB)	TJ (Imp: UK)	AS.11/12 ASM (Imp: Fr.); MG (Imp: It., Switz., UK)	1970	Sep 1971	30/year	Brazilian content increasing; only basic elements still from Italy; licence extended to 1978 for more production; first order of 112 has been delivered, second for 45; orders by Bolivia (18) and Togo (3) have been delivered	157/133	Aug 1972: 0.6
		EMB MB.32GK light strike/COIN	TJ (Imp: UK)	..	(1975)	..	..	Eventually to replace Xavante production; no further information published	..	..
		EMB MB.340 light strike/COIN	TF (Imp: UK)	..	..			Under study jointly by EMBRAER and Aermacchi for single-seat ground attack aircraft to meet A-X requirement of Brazilian AF; production of 4 prototypes to begin in 1978		
	France	(*Lama*) light utility hel	TS	..	1977	(1978)	..	Preliminary agreement signed by France and Brazil to start manufacture of helicopters in Brazil towards end-1978; initially Brazil will begin by assembling French helicopters, probably Lama; production will initially involve the civilian versions AS-350 Ecureuil and SA-315B Lama, but military versions are expected	..	..

	France/FR Germany	*Roland* SAM	S	Warhead: HE	..	..	..	Brazil holds partial licence	..	..
	USA	*EMB-810 Seneca* light plane	P (Imp: USA)	–	1974	1975	4/month	Assembly started mid-1975; E: USA; no royalties paid on aircraft built in Brazil; 27 produced in 1975; total of 82 sold by April 1977	../..	..
		EMB-720 Minvano light plane	P (Imp: USA)	–	1974	1975	3/month	22 produced by 1976; total of 45 sold by April 1977	../22	..
		EMB-710 Carioca light plane	P (Imp: USA)	–	1974	1975	10/month	32 produced in 1975; total of 145 sold by April 1977	../..	..
		EMB-711 Corisco light plane	P (Imp: USA)	–	1974	1975	10/month	57 produced in 1975; total of 111 sold by April 1977	../..	..
		EMB-721 Sertanejo light plane	P (Imp: USA)	–	1974	1975	4/month	2 built in 1975; total of 50 sold by April 1977	../..	..
		EMB-820 Navajo light plane	P (Imp: USA)	–	1974	1975	4/month	Total of 38 produced by April 1977	../..	..
	FR Germany	*MB 2000 Cobra* anti-tank miss	S	Warhead: HE	1973	1975	..	..	..	..
	UK	"*Niteroi*"-class destroyer	GT (Imp: UK); D (Imp: FRG)	Exocet SSM (Imp: Fr.); Seacat SAM (Imp: UK); Ikara ASM (Imp: Australia); 1 Lynx hel (Imp: UK); Vickers gun (Imp: UK); Bofors RL/gun (Imp: Sweden)	1970	1972	..	Displ: 3 800 t; first launched in UK Feb 1974, in Brazil Sep 1974; completion 1976–80; 2 being built in Brazil, 4 in UK	6/2	..
Colombia[c]	USA	*Cessna* utility light plane, various types	P (Imp: USA)	–	(1971)	1972	200/year planned for 1976	Currently Cessna aircraft are being assembled and partly built; according to last information published in 1975, output in 1975 was planned at 130/year, and 200/year in 1976; planned to manufacture complete air-frame by end-1976	..	..

Licensee	Licenser	Designation, description	Power plant	Armament	Year of licence	Year in production	Production rate	Status of programme, other information	Number planned/ produced	Unit price[a] *$ mn*
Egypt	France	*F1 Mirage* fighter	TJ	..	(1977)	..	..	Initially 15 aircraft will be bought from France and then 185 will be built in an Egyptian F1 production plant set up in Egypt with the help of French technicians; agreement may be modified by an agreement to produce Alpha Jet	185/–	..
		Crotale SAM	S	Warhead: HE	..	..	..	Egypt plans to sell licence-produced Crotales to Saudi Arabia, Kuwait and Belgium; no further information published	..	..
	France/FR Germany	*Alpha Jet* trainer/light strike	TF	..	(1977)	..	..	It has been reported that Egypt will produce 200 aircraft under licence in Egypt	..	..
	UK/France	*WG-13 Lynx* hel	TS (Imp: UK)	..	(1975)	–	..	Plans to build WG-13 temporarily abandoned	..	0.65[b]
	UK	*HS Hawk* trainer/ attack	TF (Imp: UK)	..	(1975)	–	–	Production plans temporarily abandoned	..	..
		BAC Golfswing anti-tank miss	S	Warhead: HE (1975)	Late (1975)	..	..	Vehicle-mounted vers of Swingfire; also to be supplied to Saudi Arabia; first two or three years, Egypt will assemble missiles from UK-supplied components and begin to build parts locally	~10 000/ ..	..
India	France	*F1 Mirage* fighter	..	..	..	..	..	India has been offered licensed production; initially F1 would be assembled; manufacture of sophisticated components would later go up to 100%; no further information published	~250/–	..

	HAL SA-315 Cheetah high-altitude hel (Aérospatiale SA-315 *Lama*)	TS (L: Fr.)	SS.11 ATM (L: Fr.)	Sep 1970	1972	..	Delivery of aircraft with completely locally built materials started in 1976; E: USA	100/50	..
	HAL SA-316B Chetak general-purpose hel (Aérospatiale Alouette III)	TS (L: Fr.)	SS.11 ATM (L: Fr.)	1962	1965	..	Manufactured from local raw materials; ordered: 219; Chetak is an armed version	219/193	..
	SS.11 Bharat ATM	S	Warhead: HE	1970	1971	..	Complete production rights handed over 1974	..	..
UK	*HAL Ajeet* light-weight fighter/ground attack (Gnat Mk II)	TJ (L: UK)	Aden cannon (Imp: UK)	1973	1976	..	Req: 100 for AF; first prototype flew 1975	100/..	2.5[b]
	Ajeet trainer vers	TJ (L: UK)	..	1973	(1978)	..	Prototype under construction not expected to fly before 1979	..	..
	HAL HS-748 transp	TP (L: UK)	–	..	1959	..	69 ordered: 45 for AF and 24 for civilian use; last 7 of 24 civilian were not taken up by Indian Airlines and therefore transferred to AF; 10 HS-748MF (military freighters) were ordered from UK to be assembled in India from knocked-down parts	79/69	..
	"*Vijayanta*" medium battle tank	D (Imp: UK)	105-mm gun	1965	1967	~100/year	Indigenization has now progressed to 95%	..	..
	"*Leander*"-class ASW frigate	T (Imp: UK)	1 Wasp hel (Imp: UK); 2 Seacat SAM launchers (Imp: UK)	1965	1973	..	Displ: 2 450 t; speed: 30 knots; third commissioned in Feb 1976, fourth is in process of being fitted out; fifth was launched Oct 1976 and the keel of the sixth was laid in Nov 1976; seventh, eighth and ninth will be developed featuring larger displacement and more advanced armament	9/3	..

Licensee	Licenser	Designation, description	Power plant	Armament	Year of licence	Year in production	Production rate	Status of programme, other information	Number planned/ produced	Unit price[a] $ mn
	USSR	*MiG-21M* fighter/ ground attack, Mach 2.0	TJ (Imp: USSR)	Atoll AAM (L: USSR)	1970	1973	2–3/month	By spring 1974 about 15 were delivered; 50 Soviet-built MiG-21PFMAs were ordered to supplement Indian production; improved version MiG-21MF; current indigenization level is 60–70%	150/~15	
		Bharat K-13A Atoll air-to-air miss	S	Warhead: HE	1964	1969	..	IR missile for HAL MiG-21 fighter	../>600	..
	Switzer-land	Electronics	–	–	1975	..	..	Contraves fire-control radar for L-70 A/A gun	..	..
Indonesia	France	*Puma* medium tactical transp hel	TS	..	1977	..	..	Agreement recently signed for licence-production of Puma	..	..
	FR Germany	*MBB Bo 105* hel	TS (USA)	..	1976	1976	2–3/month	Manufacture of sub-assemblies has now commenced	>50/>6	..
	Italy	*MB.326* trainer/light strike	TJ	..	(1976)	..	..	Plans announced in 1976 to build MB.326 under licence	..	..
	Spain	*C-212 Casa* light STOL transp	TP (USA)	–	(1975)	..	..	6 assembled and last of the initial 12 to be completed entirely from local manufacture	~18/6	..
	USA	*LT-200 Lipnur* light trainer	P (USA)	–	..	(1976)		6 of the 36 are pre-production aircr; 2 prototypes flight-tested in 1974; construction of 2 modified and improved pre-production aircr began in Dec 1974 and in 1976 it was planned to complete pre-production batch of 6 aircr	36/..	..

Iran	USA	*Bell 214A* utility hel	TS (Imp: Can.)	..	..	(1977)	..	Iran's decision to acquire 400 more Bell 214s (287 ordered and are being delivered) has led to a co-production agreement; initially to be assembled but later also produced in Iran	400/..	..
		Bell 209 HA-1J armed hel	TS (Imp: Can.)	XM-197 gun	..	(1976)	..	Assembly has started at Shiraz	..	..
		Hughes TOW anti-tank miss	S	Warhead: HE	..	..	..	TOW to be assembled at Shiraz	../–	..
		Electronics	–	–	1974	..	..	Iran has acquired licence to produce several types of electronic equipment	..	..
	UK	*BAC Rapier* SAM	S	Warhead: HE	1975	..	..	A joint company, Irano-British Dynamics was to start production of missile under licence in 1977; no further details published	../–	..
		Chieftain main battle tank	..	..	..	..	..	Ordered: 1 600; Iran negotiating for licence to produce part of total order	../–	..
Israel	USA	*General Dynamics F-16* fighter	..	..	..	..	..	Israel plans to acquire 160 F-16s, but no further details of negotiations for licence-production of F-16s in Israel published	160/..	6.1[b]
		"*Dabur*"-class coastal patrol boat (developed from US "Swift"-class boats)	D	Armament varies; MG, 20-mm cannon most common	..	..	..	Displ: 35 t; speed: 22 knots; production continuing	../25	..
	France	*Defa* 30-mm aircr cannon	–	–	..	..	..	Israel has modified Defa; for equipping Kfir combat aircr	..	..
Korea, North	China	Chinese "*Romeo*"-class sub	D	TT	..	..	..	Displ: 1 600 t; speed: 14 knots; production continuing	../2	..

Licensee	Licenser	Designation, description	Power plant	Armament	Year of licence	Year in production	Production rate	Status of programme, other information	Number planned/ produced	Unit price[a] $ mn
	USSR	Aircraft industry	–	–	. .	–	–	Established with Soviet assistance for licensed production of MiG-21 starting in 1978	. ./–	. .
		"*P-6*"-class fast attack torpedo boat	D	TT	. .	. .	. .	Displ: 66 t; speed: 43 knots; growing numbers being built locally	. .	. .
Korea, South	USA	*Hughes 500 MD* hel	T (USA)	. .	1976	. .	. .	34 currently being delivered by USA and 66 to be assembled in S. Korea	100/. .	. .
		Pazmany PL-2 light plane	P (USA)	–	. .	. .	. .	Korean AF built 1 prototype in 1971 for flight testing; later completed 3 more for evaluation as trainer aircr; no further details published	. .	. .
		PSMM multi-mission patrol and attack ship	GT (Imp: USA)	Standard ShShM; 1 76-mm 50-cal and 1 40-mm A/A gun; 2 0.50-cal MGs	. .	1975	. .	Displ: 250 t; speed: >40 knots; 3 were built in the USA and are commissioned; 4 to be built in S. Korea, first of which was reported under construction	7/(3)	. .
		CPIC-type coastal patrol boat	GT	(Harpoon) ShShM	(1974)	. .	. .	Displ: 70 t; speed: 45 knots; one built in the USA and commissioned in 1974; remaining 4 under construction in S. Korea		
Mexico	Israel	*Arava* STOL transp	TP (Imp: Can.)	MG	. .	–	–	No further information published regarding negotiations for establishment of a national aircr industry in which Israel will hold 10% share; Arava to be assembled in Mexico	. .	. .

		IAI "Kfir" fighter/ ground attack	TP (Imp: Can.)	DEFA cannon, Rafael Shafrir AAM	..	–	..	No further information published regarding ongoing negotiations for licensed production; order of ~100 needed to make project viable	–	..
	UK	"*Azteca*"-class large patrol boat	..	..	1976	(1977)	..	Displ: 130 t; speed: 24 knots; in addition to 21 purchased between 1974–76, 10 being built; plans to acquire total of 80	10/..	..
Pakistan	China	.. SAM system	–	–	(1975)	–	–	..	../–	..
	France	*Dhamial Alouette III* hel	TS (Imp: Fr.)	..	1968	1972	~1/month	Substantial proportion of locally-made parts; all 3 services receiving	../60	..
		Dassault-Breguet Mirage F1 fighter	TJ (Imp: Fr.)	..	..	–	–	Negotiations inconclusive	../–	..
	FR Germany	*MBB Bo 810 Cobra 2000* anti-tank miss	S	Warhead: 2.7 kg	1963	(1964)	..	Indig: 100%; production continues	..	..
	USA	*Cessna T-41D* primary trainer	P (Imp: USA)	–	1976	(1977)	~50–70/ year	Initially planned to assemble imported components	../–	..
		Breda Nardi Hughes 500 LOH hel	..	..	1975	(1976)	50/year planned	Agreement signed with Italy for production in Pakistan; E: Middle East	../–	..
		Cessna O-1 Bird Dog light plane	..	..	..	1970	~1/ month	Substantial proportion of locally made parts	..	..
Papua New Guinea	Australia	*Nomad* light transp	TP	–	(1977)	..	..	Initially work will consist of installation of on-board equipment and finishing	..	..
Peru	Italy	"*Modified Lupo*"-class guided-miss frigate	GT & D (Imp: It.)	2 OTOMAT SSM (Imp: It.) 1 ASW hel	1974	1974	..	Displ: 2 500 t; speed: 35 knots; 2 to be built in Italy, 2 in Peru; first one laid down Aug 1974	4/..	..

Licensee	Licenser	Designation, description	Power plant	Armament	Year of licence	Year in production	Production rate	Status of programme, other information	Number planned/ produced	Unit price[a] $ mn
Philippines	FR Germany	*PADC MBB Bo 105* hel	TS (Imp: USA)	..	1974	1974	..	Assembly of 38 helicopters approaching completion	38/>19	..
	Italy	*XT-001* primary trainer	P (Imp: USA)	–	(1975)	..	..	Prototype flew in 1975, virtually duplicate of Italian SF.260MP; no data on production published	..	..
	UK	*BN Islander* light transp	P (Imp: USA)	–	1974	1974	..	Phases 1 and 2 completed end-1975 with 20 aircr; phase 3 consists of assembly of 20 aircr from knocked-down components—one aircr due for flight testing in 1976 and 7 were on the assembly line; phase 4 will include production of sub-assemblies and aircr components for 60 units	100/<28	..
Singapore	FR Germany	*Lürssen Vegesack "TNC 48"*-class fast attack missile boat	D (Imp: FRG)	Gabriel SSM (Imp: Isr.); 1 57-mm and 1 40-mm gun	..	1973	2/year	Displ: 230 t; speed: 34 knots; 4 built and commissioned in Singapore; 3 ordered by Thailand in 1973, 2 of which commissioned in Aug and Nov 1976; no further information published regarding a reported order of a fourth one; displ for last 4: 260 t	../8	..
	UK	Coastal patrol craft	D	20-mm guns, MG	..	..	..	Displ: 25–82 t; 33 patrol craft delivered during past 5 years to customers including Brunei, Hong Kong, Kuwait, Malaysia and Sabah	../33	..
South Africa	France	*Atlas Mirage F1-CZ/AZ* fighter	TJ (Imp: Fr.)	AAM, ASM	1971	1971–78	..	Ordered: 48 consisting of 32 F1-AZs and 16 F1-CZs	100/..	..

		Eland armoured car (Panhard AML 60/90)	D	60-mm, 90-mm cannon	1965	1967	100/year	Indig: ~100%; second generation developed locally	../~1 000	..
	France/FR Germany	"*João-Coutinho*"-class frigate	..	Gabriel ShShM	Feb 1975	..	..	Announced as indigenous construction but perhaps originally to have been built in Portugal	6/–	..
	Israel	"*Reshef*"-class fast miss craft	D	Gabriel SSM (Imp: Isr.)	Late 1974	(1975)	..	Displ: 430 t; speed: 30 knots; 3 under construction in Haifa, 1 in S. Africa	6/–	18[b] with missiles
	Italy	*Atlas Impala II* light strike (MB.326K)	TJ (Imp: UK)	MG, rockets	1973	1975	..	Production of Impala Mk I ended with 151 built; 50 Mk IIs ordered	100/..	0.6[b]
		AFIC RSA-200 Falcon civil/military light plane	P (Imp: USA)	–	1965	1967	..	Production temporarily suspended	..	..
		Atlas AM-3C "*Bosbok*" monoplane	P (Imp: It.)	MG, rockets	1971	1975	..	Most, if not all, assembled by Atlas	40/~40	..
	Italy/USA	*C4M Kudu* (AL-60/ AM-3C derivative) STOL, light observation transp	P (Imp: It.)	–	(1974)	1975	..	Ordered: 37; deliveries now thought to have started	..	..
Taiwan	USA	*Northrop F-5E Tiger II* fighter	TJ	AIM-9 Sidewinder AAM	1973	1974	~3/month by mid-1977	Production started with assembly of knocked-down parts from USA but now proportion of locally manufactured components is progressively increasing; 120 of an order of 180 being assembled; 60 supplied by USA	300/~90	..
		Bell 205 UH-1H utility hel	TJ (Imp: USA)	..	1969	(1972)	..	Assembly of 118 completed, the last being delivered in Dec 1977	118/118	..
		Sidewinder AIM-9 AAM	S	..	..	..	..	Construction and production	..	..

Licensee	Licenser	Designation, description	Power plant	Armament	Year of licence	Year in production	Production rate	Status of programme, other information	Number planned/ produced	Unit price[a] *$ mn*
Venezuela	Italy	Coastal patrol craft	D	..	Mar 1973	1974	..	Displ: 65 t; speed: 25 knots; ordered: 21; 11 to be built in Venezuela	21/10	..

[a] The values of the licence-produced weapons are included in the tables of values of the arms trade, pages 256–57, estimated at 100 per cent of the import value.
[b] The unit cost is in 1976 prices.
[c] Four *Midget* experimental assault submarines were assembled under licence from Italy, the last one being commissioned in 1974. There have been no reports on the construction of further ships.

8. The trends in the arms trade with the Third World

Square-bracketed numbers, thus [1], *refer to the list of references on page* 253.

I. Introduction

The spread of conventional weapons from the industrialized world to the Third World represents only one of the many complex factors related to the wider issue of arms control and disarmament.[1] While disarmament negotiations since 1945 have concentrated technically on the issue of nuclear weapons and politically on the issue of preventing the outbreak of war between the United States and the Soviet Union, it remains a fact that practically all wars during this period have been fought in the Third World and with conventional weapons. About 75 per cent of the current world arms trade is now with the Third World. Between 1970 and 1976 alone, the value of major weapons—that is, aircraft, missiles, armoured fighting vehicles and warships—supplied to the Third World was equal to that for the two decades 1950–70.[2]

The traffic in arms expanded practically unnoticed, undescribed and undebated until 1965, with supplier and buyer interests overshadowed by the overwhelming prospect of a nuclear holocaust. The expansion was both quantitative and qualitative. Quantitatively, the volume of military transfers to the Third World has increased more than 15-fold over the past 25 years, or at an average annual increase of some 12 per cent. However, the volume of the arms trade to the Third World started to show a particularly sharp increase in both absolute and relative terms after 1965. The average yearly increase from 1970 to 1976 was 15 per cent, compared with the 1960s, when the corresponding average annual rate of increase was 5 per cent from 1960 to 1966. The boom in the arms trade which characterizes the present decade cannot be explained merely by the increase in the number of new nations, which obviously influenced the statistics during the 1950s and early 1960s—when, as a rule, the former Asian and African colonies of the UK and France set up armed forces upon gaining independence.

Qualitatively also, there has been a distinct change in arms transfers to the Third World. During the 1950s, the main arms-producing industrialized nations, in particular the United States, concentrated mainly

[1] A forthcoming SIPRI publication will analyse the role of all countries and all types of weapons involved in the global arms trade, as well as present a review of the arms control proposals made in various forums since 1970.
[2] See chapter 9 on the sources and methods of the study for a description of the SIPRI valuation of arms transactions.

on modernizing their own armed forces and those of their allies. Large numbers of the weapons used in World War II were disposed of by transferring them to the newly independent states outside Europe and North America. As the European economies recovered, however, the build-up of the defence industries in France, FR Germany, Italy, the UK, and so on constituted a competitive element on the arms market to the dominant position of the United States. A similar pattern—although on a much smaller scale—is discernible for the socialist bloc as well. This development resulted in what can be expressed as a change from a seller's market to a buyer's market, where today any nation possessing sufficient funds is likely to find a seller of any weapon system required.

In this connection it can also be said that the distinction between conventional and nuclear weapons may be difficult to justify in the future. Already, some types of nuclear *delivery* systems have been transferred to Third World countries (for example, the US Lance surface-to-surface missile to Israel and the Soviet Scud to Egypt, Iraq and Syria), and if the spread of production capacity for nuclear weapons in the wake of the spread of nuclear energy production is not safeguarded in time, the arms traffic may eventually come to include traffic also in nuclear weapons.

The underlying theory behind SIPRI's decision to examine the arms trade with the Third World was that this trade is unique in comparison to the trade in any other commodity, because of its political and military consequences, both for the buyers and for the sellers. This has been expressed in many ways by many sources. The following statement by Julius Nyerere, for example, may serve as well as any other to define the political aspect of arms supplies:

> For the selling of arms is something which a country does only when it wants to support and strengthen the regime or the group to whom the sale is made. Whatever restrictions or limits are placed on that sale, the sale of any arms is a declaration of support—an implied alliance of a kind. You can trade with people you dislike; you can have diplomatic relations with governments you disapprove of; you can sit in conference with those nations whose policies you abhor. But you do not sell arms without saying, in effect: "In the light of the receiving country's known policies, friends, and enemies, we anticipate that, in the last resort, we will be on their side in the case of any conflict. We shall want them to defeat their enemies." [1]

In other words, the provision of the means for warfare has an intrinsic political and military significance even where the supplying country states only a commercial interest.

II. The flow of arms

The producer–suppliers

The list of main weapon suppliers is identical to that of the leading weapon producers. More specifically, the *governments* of the producing countries control the exports of arms. The non-governmental, so-called illegal, traffic in arms comprises only a small proportion of the total international arms trade, particularly because even a private transaction requires an export licence from the government of the exporting country. According to the 1971 SIPRI study [2a], arms sales by private dealers represent no more than 4 per cent of the total arms transfers, and only a minute proportion of these dealers operate without government approval.

The United States occupies the leading position in the field of military technology and is consequently the leading single exporter of major conventional arms. The US share of total arms exports to the Third World from 1970 to 1976 was 38 per cent (see table 8.1 for the rank order of arms-exporting nations during this period). The Soviet Union is the second largest supplier, with a total share of 34 per cent. This dual domination of the arms market is not explained by technological capacity alone, but by a quantitative factor as well—both the United States and the Soviet Union possess large armaments industries as regards production capacity and turnover, and are thus able to produce long series of the various types of weapon.

These dominant positions were, however, not a reality during the immediate post-war years. It can be seen from table 8A.2 (Appendix 8A) that the United States and the Soviet Union had not firmly established their leading positions until the early 1960s. From 1945 until 1960, Britain remained ahead of the Soviet Union—mainly because of warship orders but also because of the export of large numbers of aircraft dating from the 1940s. The pattern of arms supplies thus illustrates the global change in political roles, especially of the big powers, after 1945.

The position of the secondary suppliers, too, did not stabilize until the 1960s. A period of some 10 years elapsed after World War II before the European countries could really enter the arms export market. First, their production capacity had to be resurrected after World War II, particularly in the case of France, FR Germany and Italy. Second, the European powers' own weapon requirements had to be satisfied first. Gradually, however, a pattern of arms exports emerged. From the rank order of suppliers of major weapons for the period 1970–76 in table 8.1, it is possible to classify the arms suppliers into four groups: first, the USA and the USSR as the dominant suppliers; second, the UK and France in a category of their own as major suppliers, each with a 9 per cent share of the market; third, a group of medium suppliers, including Canada, China, FR Germany, Italy and the Netherlands; and fourth, a group of small suppliers. (The countries listed in table 8.2, below, as Third World arms exporters all belong to the fourth category.) And for all exporters except the two single cases of Japan and Czechoslovakia, the trend is a rising one.

Table 8.1. Rank order of arms suppliers to the Third World, 1970–76

Supplier	Total value of arms supplies *US $ mn*[a]	Per cent of world total	Largest recipient regions	Region's per cent of supplier's total	Largest recipient country in each region	Country's per cent of supplier's total
USA	12 303	*38*	Middle East	*62*	Iran	*31*
			Far East	*27*	S. Viet Nam	*12*
			South America	*7*	Brazil	*2*
USSR	11 057	*34*	Middle East	*57*	Syria	*23*
			North Africa	*13*	Libya	*13*
			Far East	*13*	N. Viet Nam	*7*
UK	3 076	*9*	Middle East	*49*	Iran	*26*
			South America	*22*	Chile	*8*
			South Asia	*14*	India	*12*
France	2 963	*9*	North Africa	*24*	Libya	*16*
			Middle East	*23*	Egypt	*5*
			South America	*18*	Venezuela	*6*
Italy	562	*2*	Middle East	*40*	Iran	*34*
			South Africa	*27*	South Africa	*27*
			South America	*18*	Brazil	*10*
China	537	*2*	South Asia	*46*	Pakistan	*46*
			Far East	*29*	N. Viet Nam	*11*
			Sub-Saharan Africa	*25*	Tanzania	*16*
FR Germany	451	*1*	South America	*74*	Argentina	*22*
			Far East	*10*	Singapore	*6*
			Sub-Saharan Africa	*6*	Nigeria	*2*
Netherlands	214	*0.7*	Middle East	*40*	Iran	*28*
			Sub-Saharan Africa	*25*	Nigeria	*10*
			South America	*9*	Argentina	*6*
Canada	178	*0.6*	South America	*60*	Peru	*23*
			Sub-Saharan Africa	*28*	Zambia	*9*
			Middle East	*4*	Lebanon	*3*
Czechoslovakia	87	*0.3*	South Asia	*59*	India	*59*
			Middle East	*30*	Egypt	*11*
			Sub-Saharan Africa	*7*	Sudan	*7*
Spain	70	*0.2*	South America	*82*	Uruguay	*51*
			Far East	*11*	Indonesia	*11*
			Middle East	*7*	Jordan	*7*
Australia[b]	60	*0.2*	Far East	*82*	Indonesia	*50*
			South America	*15*	Brazil	*14*
			Middle East	*2*	Oman	*2*
Sweden	54	*0.2*	South Asia	*87*	Pakistan	*87*
			South America	*9*	Chile	*9*
			Sub-Saharan Africa	*4*	Sierra Leone	*4*
Poland[c]	30	*0.1*	South Asia	*99*	India	*99*
			Far East	*0.7*	Indonesia	*0.7*
Yugoslavia[c]	24	*0.1*	Middle East	*78*	Egypt	*70*
			Sub-Saharan Africa	*22*	Tanzania	*13*
Switzerland	17	*0.1*	South America	*59*	Argentina	*41*
			Far East	*18*	Thailand	*18*
			Middle East	*12*	Oman	*12*
New Zealand[b]	12	*0.04*	South Asia	*77*	India	*77*
			Far East	*23*	Thailand	*17*
Japan	6	*0.02*	Far East	*50*	Philippines	*50*
			Sub-Saharan Africa	*50*	Zaire	*50*
Belgium[b]	5	*0.02*	South Africa	*50*	South Africa	*50*
			Sub-Saharan Africa	*50*	Ethiopia	*50*
Ireland[b]	2	*0.01*	Middle East	*100*	Oman	*100*
Third World countries[d]	724	*2*	South Africa	*24*	South Africa	*24*
			Sub-Saharan Africa	*19*	Uganda	*15*
			South Asia	*18*	Pakistan	*12*
World total	**32 427**	**100**				

[a] At constant 1975 prices.
[b] Included under Other indus. West, table 8A.2, page 256.
[c] Included under Other indus. East, table 8A.2, page 256.
[d] See table 8.2 for the rank order of Third World arms suppliers.

With the increase in the number of countries capable of exporting arms, a noticeable competition for the Third World market broke out, resulting in what might be called a general commercialization of the arms trade. For the recipient countries this meant that, in cases where the dominant suppliers refused for political reasons to supply certain types of weapon, the emergence of new producers provided the buyers with new sellers to turn to. The case of Latin America provides an illustration of this development: during the early post-war period the United States had a virtual monopoly on arms sales in the region, but when the US government refused to sell the supersonic fighters requested, the buyers turned to European producers. South America is now among the three largest recipient regions for weapons from Australia, Canada, France, FR Germany, Italy, the Netherlands, Sweden, Switzerland and the UK. When the Soviet Union, according to Egyptian sources, refused to comply with requests for more sophisticated armaments, Egypt turned to West European producers for the acquisition not only of the weapons but of production know-how.

The so-called "buyer's market" in arms is visible on every occasion before the conclusion of a contract. The buyer often negotiates with several sellers at the same time, and the sellers do their utmost to improve the favourable conditions offered. The financial arrangements are of course of importance, but in addition no effort is spared to convince the buyer of the weapons' lethal capacities.

In this connection it is important that the weapon has been tested in any of the post-1945 battlefields in Indo-China or in the Middle East; in other words, they sell better when they are "well-blooded", as one source describes it:

> But the only real test and challenge to helicopter capability was at war; and Vietnam had given a useful flip to the business. "It's been well blooded", an electronics salesman assured me, about his system which had been used in helicopters over Vietnam, and the words "combat proven in South East Asia" were important in any sales pitch. The antics, the sudden take-offs and spectacular liftings on the television screens were all very well, but it was the sudden bursts of fire-power, the rain of bombs and the swoosh of torpedoes, which provided the real climax for the customers [3].

In regard to the enormous escalation of arms imports in the Middle East, it often goes unnoticed that the USA and the USSR are not the only suppliers to the region—several other countries are involved in securing their share of an apparently unlimited market, for example France and the UK, as well as Italy, the Netherlands, Spain, Switzerland and Yugoslavia.

The rise of Italy and Israel in the rank order of arms suppliers has occurred during the 1970s and for both these new producers, South Africa has become an important market. In particular, Italy has sold the licence for production of counter-insurgency (COIN) aircraft, and Israel has delivered ship-to-ship missiles.

In the case of FR Germany, the restrictions on arms production imposed by the Western European Union (WEU) in 1949 have been gradually loosened over the years, but it is still common practice for West German designs to be produced elsewhere, for example in Spain or France, and for the weapons not to be exported directly from FR Germany.

Among the Third World countries, the major arms exporters are those countries which have concentrated most heavily on the acquisition of military know-how, that is, which have invested in military industries (see table 8.2). Of those Third World countries which have reached an advanced production capability—most notably Argentina, Brazil, India, Israel and South Africa—Israel stands out as the most technologically advanced.[3] Moreover, several other Third World countries—in particular North and South Korea, and Taiwan—have fairly advanced indigenous arms industries and therefore export capacity, although because they have not yet begun to export, they are not included in table 8.2.[4]

For the socialist countries, it is also possible to discern a certain spread of export capacity, although on a much smaller scale than in the West. The Soviet Union alone accounts for 94 per cent of the socialist countries' arms exports (and furthermore, Czechoslovakia has on occasion acted as intermediary for Soviet suppliers, for example, to Egypt in 1955). But the past few years have seen an expansion of sales, particularly by Yugoslavia, Poland and Romania, of light trainers and other aircraft. This will in future make some impression on the large Soviet share of supplies from socialist countries.

Iran will probably invest heavily in local arms production, as will Egypt and Saudi Arabia. So far, Iran has re-exported US F-5A fighters, and Jordan's position as third in order of suppliers is likewise explained by the re-export of old equipment to South Africa and Oman.

The inclusion of the Ivory Coast and Gabon in the table is merely due to the export of French-designed patrol boats from French-built shipyards.

The transfer of know-how

The transfer of arms includes also the transfer of production know-how. The trend for Third World countries to import not only the weapons but

[3] If the production and export of *small arms* were taken into account, both Argentina and India would occupy a higher place in the rank order.

[4] In regard to the small suppliers listed in table 8.1 above, one aspect should be kept in mind —if *small arms* were included in the data, this would mean a change upwards in the position of such leading small arms producers as Sweden, Switzerland and Belgium (see the forthcoming SIPRI publication on the global arms trade).

Table 8.2. Rank order of Third World arms suppliers, 1970–76

Supplier	Total value of arms supplies *US $ mn*[a]	Per cent of Third World total	Largest recipient regions	Region's per cent of supplier's total	Largest recipient country/ countries in each region	Country's per cent of supplier's total
Israel[b]	174	*24*	Central America	*35*	El Salvador	*15*
			Far East	*30*	Singapore	*19*
			South Africa	*20*	South Africa	*20*
Iran	160	*22*	South Asia	*75*	Pakistan	*75*
			Middle East	*22*	Jordan	*21*
			Sub-Saharan Africa	*2*	Ethiopia	*2*
Jordan	159	*22*	South Africa	*90*	South Africa	*90*
			Middle East	*10*	Oman	*10*
			South Asia	*0.2*	Pakistan	*0.2*
Libya	77	*11*	Sub-Saharan Africa	*97*	Uganda	*97*
			South Asia	*3*	Pakistan	*3*
Brazil[b]	47	*6*	South America	*98*	Paraguay	*42*
			Sub-Saharan Africa	*2*	Togo	*2*
South Africa[b]	30	*4*	Sub-Saharan Africa	*100*	Rhodesia	*98*
					Malawi	*2*
Singapore	17	*2*	Far East	*81*	Brunei	*51*
			Middle East	*19*	Kuwait	*19*
Cuba	13	*2*	South America	*100*	Peru	*100*
Ivory Coast	10	*1*	Sub-Saharan Africa	*100*	Cameroon	*100*
India[b]	7	*1*	South Asia	*100*	Bangladesh	*70*
					Nepal	*30*
Iraq	6	*1*	Sub-Saharan Africa	*100*	Uganda	*100*
Gabon	6	*1*	Sub-Saharan Africa	*100*	Cameroon	*100*
Malaysia	5	*1*	Far East	*100*	Indonesia	*100*
Egypt	4	*0.5*	Sub-Saharan Africa	*67*	Nigeria	*67*
			North Africa	*33*	Libya	*33*
Abu Dhabi	4	*0.5*	Middle East	*100*	Oman	*56*
					Yemen	*44*
Argentina[b]	3.5	*0.4*	South America	*100*	Bolivia	*55*
					Peru	*43*
					Paraguay	*2*
Saudi Arabia	1	*0.1*	Middle East	*58*	Oman	*50*
			South Asia	*42*	Pakistan	*42*
Chile	0.5	*0.1*	South America	*100*	Ecuador	*100*
Third World total	724	100				

[a] At constant 1975 prices.
[b] Most weapons exported are of local production.

also entire arms industries is rising, although for technical reasons more slowly than the rise shown in the figures for imports of weapons.

The build-up of domestic arms production capacities generally follows a pattern: first, a licence is acquired from one of the leading industrialized nations and production facilities are built, often involving huge technical and personnel assistance from the seller. Production then starts with the local assembly of imported sub-assemblies, for example an aircraft. The next step is to complete the sub-assemblies locally from imported components, then to manufacture the components locally from imported raw materials, and finally to produce also the raw materials. This last stage is not possible for the majority of new producers until after a considerable period of time since it involves both the availability of natural resources and the existence of related industries and infrastructure. In general, new producers must always import some components, such as advanced electronics, engines and certain types of armament.

It would be a mistake, however, to conclude that, for example, the Third World exporting countries (see table 8.2, above) have benefitted economically from the build-up of their local arms industries. The enormous financial difficulties encountered by any arms producer are exemplified by the arms industries of Western Europe. These difficulties are multiplied in an underdeveloped country with an insufficient technological base and infrastructure. Many projects in the Third World have stagnated at the blueprint stage, and even when a "success" is noted, one final obstacle remains for a new arms producer to overcome—namely, to market the weapon in competition with the well established producers. Israel, which is by far the most experienced new arms producer outside Europe, is a case in point. The Kfir-2, a fighter-bomber indigenously developed on the basis of the Mirage-3 and -5, has so far been impossible to export because it has a US engine whose export can be vetoed by the US government for either political or commercial reasons. Moreover, in some countries, such as India, South Africa and Brazil, the build-up of a local arms production and export capacity simply represents the international division of labour between the industrialized and the underdeveloped worlds: large producers—national or multinational, US or European—set up some parts of their production in countries where labour is cheap. Thus, French Alouette helicopters are manufactured in India under a licence agreement which includes offset contracts for the re-export from India of components also for the French helicopters.

The pattern of exports

Arms trade statistics indicate that this traffic is essentially a Western affair and responsibility—together, the Western countries account for 77.5 per cent of the total trade in major weapons during the period 1970–76. Of the total value for exports from the socialist countries, the USSR still stands out as virtually the sole supplier, with a 94 per cent share, while China accounts for 4 per cent and Czechoslovakia, Poland, Romania and Yugoslavia account for the remainder. However, statistics provide no basis for conclusions of a normative nature, not least the arms trade statistics. Although the claim by some representatives of socialist countries that they only supply arms to "progressive forces" in the world cannot be backed up by data, it is true that both the USA and the USSR do supply to régimes or other groups considered friendly or at least not hostile. These supplier guidelines are described in the 1971 SIPRI study [2b] as the "hegemonic supply policy".

However, a number of the recipients of Soviet supplies cannot be said to meet the criterion of progressivity, just as a large number of US clients do not measure up to such criteria as "democracies" or "representatives of the free world". And many clients of the smaller, non-aligned arms producers hardly comply with the criterion of being tension-free areas. In summary, the arms producers' own perceptions of their respective countries' policies do not correspond to true situations. It is true that the Soviet Union and some East European states were the main arms suppliers—and often the sole suppliers—to several liberation movements of socialist ideology, for example to the FNL in Viet Nam, to FRELIMO in Mozambique, and so on, but it is also evident that the Sino-Soviet conflict, for example, has influenced both these countries' decisions to support one or the other of the liberation movements. This is particularly visible in Africa, where China pursued an anti-Soviet policy until it found itself arming the same forces in Angola that were receiving South African and tacit Western military support.

The group of arms suppliers which act mainly as strictly commercial agents, that is, which trade for financial reasons, in turn experience an insoluble moral–commercial conflict. This has occurred in France, FR Germany, Italy and the UK, for example, in the case of arms supplied to South Africa.

The importer–recipients

Data on the import of major arms by Third World regions and countries (see table 8.3) illustrate the impact of the two big conflicts after World War II, the Arab–Israeli conflict and the war in Viet Nam. The Middle East region accounts for a total of 51 per cent of all major arms imports by the Third World during the 1970s. But within the region, the pattern of weapon imports has changed since around 1970. Up to then, those countries which were directly involved in the Arab–Israeli conflict were the leading importers, but by the latter half of the decade Israel and Egypt were overtaken by Iran. Iran is the single country with the largest arms imports in the region, as well as in the Third World, reaching 30 per cent of the total value for the Middle East during 1970–76.

During 1976 alone, Iran's imports of major weapons made up 23 per cent of the total Third World value. Supplies to the Middle East are still clearly dominated by the two great powers, but there are indications of a future change in this pattern. Other European suppliers are taking more Iranian orders, for example, the UK, France and Italy; and only Israel

Table 8.3. Rank order of Third World arms importers, 1970–76

Importing region	Total value of arms imports *US $ mn*[a]	Percentage of Third World total	Six largest recipient countries	Total value of country's arms imports *US $ mn*[a]	Percentage of region's total	Largest supplier to each country	Percentage of country's total	Four largest suppliers per region	Percentage of region's total
Middle East	16 484	*51*	Iran	4 900	*30*	USA	*45*	USA	*46*
			Egypt	2 864	*17*	USSR	*89*	USSR	*38*
			Israel	2 785	*17*	USA	*97*	UK	*9*
			Syria	2 595	*16*	USSR	*99*	France	*4*
			Iraq	1 122	*7*	USSR	*97*		
			Saudi Arabia	962	*6*	USA	*70*		
Far East, incl Viet Nam	5 434	*17*	S. Viet Nam	1 475	*27*	USA	*100*	USA	*62*
			N. Viet Nam	881	*16*	USSR	*93*	USSR	*27*
			S. Korea	662	*12*	USA	*99*	UK	*3*
			N. Korea	621	*11*	USSR	*91*	China	*3*
			Taiwan	424	*8*	USA	*95*		
			Thailand	262	*5*	USA	*78*		
South America	2 818	*9*	Brazil	612	*22*	USA	*33*	USA	*29*
			Argentina	510	*18*	UK	*28*	UK	*24*
			Venezuela	487	*17*	France	*35*	France	*19*
			Chile	455	*16*	UK	*47*	FR Germany	*12*
			Peru	355	*13*	USA	*25*		
			Ecuador	157	*6*	FR Germany	*29*		
North Africa	2 474	*8*	Libya	2 091	*85*	USSR	*69*	USSR	*59*
			Morocco	280	*11*	France	*55*	France	*28*
			Tunisia	54	*2*	France	*94*	USA	*8*
			Algeria	49	*2*	France	*45*	UK	*2*
South Asia	2 461	*8*	India	1 648	*67*	USSR	*66*	USSR	*49*
			Pakistan	675	*27*	China	*36*	UK	*17*
			Afghanistan	60	*2*	USSR	*100*	France	*11*
			Bangladesh	49	*2*	USSR	*90*	China	*10*
			Sri Lanka	17	*1*	UK	*41*		
			Nepal	13	*1*	UK	*38*		

Sub-Saharan Africa	1 536	*5*	Zaire	233	*15*	France	*76*	USSR	*32*
			Uganda	210	*14*	USSR	*48*	France	*21*
			Nigeria	157	*10*	USA	*40*	USA	*11*
			Mozambique	132	*9*	USSR	*100*	China	*9*
			Tanzania	107	*7*	China	*79*		
			Zambia	96	*6*	USSR	*31*		
South Africa	779	*2*	–	779	–	–	–	France	*51*
								Italy	*19*
								Jordan	*18*
								Israel	*4*
Central America	426	*1*	Cuba	168	*39*	USSR	*100*	USSR	*39*
			Mexico	138	*32*	UK	*81*	UK	*29*
			El Salvador	32	*8*	Israel	*81*	USA	*16*
			Guatemala	23	*5*	USA	*61*	Israel	*14*
			Panama	18	*4*	USA	*22*		
			Nicaragua	18	*4*	Israel	*98*		
Oceania	3	*0.01*	Fiji	3	*100*	USA	*100*	USA	*100*
Third World total	**32 427**	**100**							

[a] At constant 1975 prices.

will for the foreseeable future continue to rely almost exclusively on the USA for its import requirements. The alternative for Israel, rather than trying to diversify its sources of major arms, would be to invest in domestic arms industries. Saudi Arabia has placed large orders with US companies, but France will in future become a more prominent arms supplier to that country.

In general, the present long-term plans by Saudi Arabia, Kuwait and some of the other so-called "oil states" include heavy investment in the joint Arab arms industry in Egypt,[5] where the first big projects at present being discussed and negotiated are for French- and British-licensed weapons (for example, the Mirage F-1 fighter, the Hawk fighter, the Swingfire anti-tank missile and the Lynx helicopter).

The countries relying exclusively on arms supplies from the Soviet Union for the period 1970–76 are Egypt, Syria and Iraq. This pattern is also changing, however, a trend which will show up in future statistics.[6] Egypt has turned from the Soviet Union to France and Britain, and also imported military transport aircraft from the United States after 1974. Iraq, a country to which the Soviet Union has supplied 97 per cent of all its major arms imports since 1970 (see table 8.3), has placed large new orders in France.

The second largest arms-importing Third World region is the Far East, where the impact of the Indo-China War is clearly visible in the arms trade data. Viet Nam has therefore consistently been shown separately in SIPRI arms trade data (see table 8.4).[7] It should be emphasized that these statistics cannot be taken as a direct measure of military *intervention*, since the total cost of the US involvement in Indo-China—and also of the preceding French involvement—by far exceeded the value of military aid and arms supplies to the South Vietnamese forces. The higher value of US arms supplies to South Viet Nam as compared to Soviet supplies to North Viet Nam is rather an illustration of the difference in strategy between a technologically advanced nation and a technologically underdeveloped nation—the North Vietnamese relied on the principles of guerrilla warfare and concentrated essentially on manpower and light arms, which are not included in the SIPRI statistics. The major share of North Viet Nam's arms imports is accounted for by the SAM-2 and SAM-3 air defence systems deployed around Hanoi and Haiphong, which accounted for 66 per cent of all the major arms imports to this country

[5] The Arab Organization for Industrialization (AOI), a pan-Arab arms industry with headquarters in Cairo, was set up in April 1975 with a starting capital of $1 040 mn. The original members include Egypt, Qatar, Saudi Arabia and the United Arab Emirates; Kuwait has also made financial contributions and is reportedly interested in joining.

[6] The arms trade statistics cover only weapons delivered and not those on order; see chapter 9.

[7] No SIPRI data are at present available for the unified country of Viet Nam from 1975 onwards.

Table 8.4. Imports of major weapons by North and South Viet Nam, 1954–75

Recipient	Total value of country's imports *US $ mn*	Supplier	Total value of supplies *US $ mn*	Percentage of recipient's total imports	Weapon category	Percentage of recipient's total
North Viet Nam	2 174	USSR	1 986	*91*	Aircraft	*19*
					Missiles	*66*
					Armoured vehicles	*4*
					Warships	*2*
		China	188	*9*	Aircraft	*3*
					Armoured vehicles	*1*
					Warships	*5*
South Viet Nam	2 207	USA	2 176	*98.5*	Aircraft	*62*
					Missiles	*0.3*
					Armoured vehicles	*17*
					Warships	*20*
		France	22	*1*	Aircraft	*0.4*
					Armoured vehicles	*0.4*
					Warships	*0.07*
		Canada	9	*0.4*	Aircraft	*0.4*
		Japan	0.5	*0.02*	Aircraft	*0.02*

during the 1970s. Considerably less effort was devoted to acquiring supplies for the air force, and only a minor share went to the typically conventional army's inventory of tanks, armoured cars and other armoured vehicles. North Viet Nam had no navy to speak of, and was equipped only with river gunboats and other light craft.

The US-supported military forces of South Viet Nam illustrate another military strategy—heavy investment in the air force (in addition to the US-piloted fleet), in a conventional army equipped with tanks, and in a navy.

The political dimension of arms supplies is also well illustrated by the two Korean nations: South Korea relies on the USA for 99 per cent of its major arms imports—a trend which is not likely to be reversed easily, as South Korea is investing more heavily in a local arms production capacity with US aid—and North Korea relies on the Soviet Union for 91 per cent of its major arms imports, the remainder being covered by China. North Korea is also putting much effort into achieving a local production capacity exclusively under Soviet licences.

Taiwan is one of the relatively few nations that have so far been given access to US military know-how (the sale of production licences being most common for the UK and France), most significantly with the local production of Northrop's F-5E Tiger-2 fighter, which started in 1974.

In Latin America, the US position as the dominant arms supplier has been eroded in favour of the UK and France, and several large orders, particularly for submarines, have been placed with FR Germany.

Venezuela, the region's "oil state", has shown a sharp increase in arms imports during the past decade. Both Brazil and Argentina, the two largest importers in the region, also invest heavily in domestic arms industries. Particular interest is shown in achieving a naval production capacity—Argentina is producing six "Amazon"-class frigates and one Type 42 destroyer under partial British licence. Brazil is producing two "Niteroi"-class destroyers, also under British licence and with technical assistance from the UK.

The position of North Africa as the fourth region according to volume of arms imports is due to the military build-up by Libya alone. Libya has turned to the Soviet Union for arms, while the other three countries remain customers of their former colonial power, France.

In South Asia, India stands out as the largest buyer, depending heavily on the Soviet Union. Most of the arms acquired by India have been on licence from the USSR—notably the MiG-21, including its Atoll missiles. India also produces British and French aircraft and missiles, and is actively engaged in the development of local designs, so far not too successfully. The fighter-bomber HF-24 Marut, begun in 1956, has still not achieved the planned capacity due to design and cost problems with the engine.

In the South Asian region, Bangladesh and Afghanistan also number among the customers of the USSR. Pakistan has purchased most of its heavy equipment from China, but in future other suppliers will take a bigger share of the market—in particular France, with negotiations under way for the local production of the Mirage F-1.

In sub-Saharan Africa, the two former colonial powers—the UK and France—dominated the arms trade market until the early 1970s. During the period 1970–76, the Soviet Union supplied 32 per cent of the region's arms imports, but this share is due mainly to large imports of fighter aircraft and tanks by Uganda, and to large supplies to Mozambique during 1976 alone.

For South Africa, the pattern of arms imports illustrates the effects of the 1963 embargo imposed by the United Nations. This meant that the UK, the former dominant supplier, fell back in favour of France and Italy, which have sold production licences for Mirage fighters and counter-insurgency aircraft. In reality the third largest supplier to South Africa is Israel, which has sold missile-armed patrol boats. (The inclusion of Jordan among the arms suppliers to South Africa is due to only one transaction, which took place in 1974 when Jordan secretly sold its used Tigercat missile system and Centurion tanks via a private company in Liechtenstein. Some of these arms have later appeared in Rhodesia.)

Finally, in Central America, Cuba has since 1960 dominated in arms imports, relying exclusively on the Soviet Union for its major arms. During the past three years Cuba has also begun to export arms: to

Angola in connection with its military and manpower aid during the civil war, and to Peru in 1977 with the delivery of 12 ex-Cuban Air Force MiG-21s.

The pattern of imports

Like the Third World exporters, the importers in this region can be grouped by pattern of arms purchases. The first and most obvious group consists of those countries directly involved in war or in civil war, or visibly close to or threatened by armed conflict at a given time. Examples of such countries are Cuba, Egypt, Ethiopia, India, Iraq, Israel, North and South Korea, Nigeria, Somalia, South Africa, Syria and Viet Nam.

A second prominent group today consists of what might be called the most developed nations in the underdeveloped regions—countries with régimes that strive for regional dominance, such as Brazil, India, Iran and South Africa.

A third category is a more loosely defined group of countries where the decision to build up or to modernize their armed forces is part of a general drive towards industrialization or an expression of every nation's *per se* legitimate demand for "national security". This is, of course, a broad generalization, and in reality there is a certain degree of interaction between the various factors leading to a decision to import a certain type of weapon.

Within the three groups outlined above, two additional factors determining the type and the volume of arms imports are at work—namely, the size of foreign exchange earnings and the interests of the two great powers. Trends in the flow of weapons tend to support the contention that the interests of the leading arms suppliers are the most important single determinant. In addition to the fact that there was no great increase in the number of conflicts, this would explain, for instance, the big rise in arms supplies to the Third World at the end of the 1950s. Several African countries did achieve independence in this period, but the volume of their arms imports was too low to explain the increase. The rise occurred because of the US policy of arming what were known as the "forward defense areas" around the socialist bloc, and because competition between the two great powers intensified as the Soviet Union entered the market in 1955. Until then, the Soviet Union had adhered to a policy of giving military support to socialist régimes alone. But following the general change in foreign policy away from the "two-camp theory" to the "theory of peaceful co-existence", the Soviet Union notably changed its approach towards underdeveloped countries. With the ideological acceptance of a third force, or the non-aligned countries, Soviet arms supplies to the Third World drastically increased.

The impact of industrialized countries' supplier interests is similarly illustrated by the even higher relative and absolute increase in arms deliveries beginning in 1970. With the 1973 oil crisis, the position of the industrialized world *vis-à-vis* the oil-producing countries changed: the big arms-producing nations found that by meeting the oil producers' demands for the most sophisticated armaments, they could somewhat compensate for the negative balance of payments resulting from the increase in oil prices. The difference in supplier policy from the 1950s and early 1960s is simply that *economic* rather than political interests determine the efforts of the supplying countries to export arms.

III. The weapons

The qualitative aspect of the general trend in the spread of arms supplies to the Third World can be expressed thus: during the 1950s the arms exported to underdeveloped nations were in general surplus or obsolete types, or second-hand—that is, the type was sold after having been replaced in some branch of the military in the industrialized country. Moreover, these arms were single weapons, which required little more in the way of spares, support equipment and service than did a civilian product. The sophisticated arms now being developed, produced and traded are not single weapons but rather *weapon systems*, often requiring large additional investments for the buyer in training and education both of operators and technical staff, outside aid in the form of technical and military advisers, a special infrastructure, and perhaps even a reorganization of the structure of the armed forces.

For example, in 1952 South Africa purchased 50 DeHavilland Vampire bombers, all from British surplus stocks, and most of these aircraft had been in service during World War II. At that time this acquisition represented a first step towards equipping a modern air force, although the delivery consisted of only 50 aircraft. The next generation, the French Dassault Mirage-3 that began to arrive from 1963, represented a transition to a weapon system, its capacity being multiplied by the air-to-air and air-to-surface missiles on board. With the advances in the producing countries in the field of missile technology and military electronics, the complexity or sophistication of modern major armaments became a reality.

Aircraft

One indicator of the spread of sophisticated armaments to the Third World is the acquisition of modern combat aircraft, with new capabilities ranging from all-weather types to versions carrying infra-red guided missiles, electronic countermeasures equipment, such miscellaneous equipment as bombs and napalm tanks, and so on. Table 8.5 shows the spread of supersonic fighter aircraft to the Third World since 1960: the criterion of supersonic speed is used to indicate the level of technological sophistication also found in the inventories of the major industrialized arms-producing nations and because nearly all these aircraft produced after 1960 were armed with missiles and such other armaments as cannons, machine-guns, bomb loads and napalm tanks. By the 1970s developments in these aircraft had reached the stage mentioned above—away from a single weapon to a weapon system with an enhanced destructive capacity.

The first two generations of fighter aircraft designed and produced after 1945 were still described by their specific single roles, for example, fighter, fighter-bomber, and so on. In comparison, the most recent ones are described by such dual- and multi-roles as multi-mission fighter and attack, air combat, air superiority fighter and so on. For example, the French Mirage F-1, described as a single-seat, multi-mission fighter and attack aircraft, with a maximum level speed at high altitude of Mach 2.2, carries the following standard weapon system: two 30-mm cannons and one air-to-air missile under each wingtip. For the interception role, the externally mounted weapons include Matra R-530 radar homing, or infra-red homing, air-to-air missiles on underfuselage and inboard wing pylons, and a Sidewinder or Matra 550 air-to-air missile at each wingtip station. For ground attack duties, typical loads may include one AS-37 Martel anti-radar missile or AS-30 air-to-surface missile, eight 450-kg bombs, four rocket launchers with 18 air-to-ground rockets each, or six 600-litre napalm tanks. Externally, the F-1 can also carry auxiliary fuel tanks, photoflash containers and a reconnaissance pod with a SAT Cyclope infra-red system and EMI side-looking radar. The plane also carries advanced electronic equipment for various roles such as a Doppler radar and bombing computer, navigation computer, position indicator, laser rangefinder and terrain-avoidance radar.

However, technological sophistication alone does not signify the complete military capacity of a nation, or the political and military intentions of a particular régime. A breakdown of the types of fighter aircraft delivered to Third World countries does, however, reveal some interesting aspects.[8]

Those régimes which have invested in achieving a conventional air force with a modern strike capacity have largely pursued the same path—varying, of course, according to political orientation towards East or West. The customers of the West first received more or less obsolete fighters and bombers left over after 1945, such as the British Spitfire and Vampire and

[8] A computerized breakdown by type of major weapons delivered—categorized by both seller and buyer—will in future be available on request from SIPRI.

Table 8.5. The spread of new combat aircraft to Third World countries, 1960–77[a]

Country	1960/1961	1962	1963	1964	1965	1966	1967	1968	1969
Taiwan	F-104				F-5A				
Pakistan		F-104						Mirage-3E	
Cuba		MiG-21F							
Egypt		MiG-21F					Su-7		
Israel		Mirage-3						A-4H	F-4A
Iraq			MiG-21F						
India			MiG-21F						
S. Africa			Mirage-3C		Mirage-3E				
Indonesia				MiG-21					
N. Korea					MiG-21FL				
S. Korea					F-5A				F-4E
Iran					F-5A			F-4A	
Philippines					F-5A				
Algeria					MiG-21				
Afghanistan						MiG-21			
Saudi Arabia						Lightning			
Thailand						F-5A			
Ethiopia						F-5A			
Morocco						F-5B	F-5A		
N. Viet Nam						MiG-21			
S. Viet Nam							F-5A		
Syria							MiG-21		
Jordan							F-104		
Peru								Mirage-5	
Lebanon								Mirage-30	
Kuwait								Lightning	
Libya								F-5A	
Sudan									
Venezuela									
Brazil									
Colombia									
Argentina									
Abu Dhabi									
Bangladesh									
Somalia									
Rhodesia									
Zaire									
Nigeria									
Uganda									
Malaysia									
Chile									
Oman									
Ecuador									
Tunisia									
Singapore									
Kenya									
Gabon									

[a] Excluding second-hand or refurbished aircraft. The new types acquired since 1960, with the year of production start in brackets, include:

Lockheed F-104 Starfighter, USA	(1956)
Mikoyan MiG-21F Fishbed-C, USSR	(1956)
Mikoyan MiG-21FL Fishbed-D, USSR	(1962)
Mikoyan MiG-21MF Fishbed-J, USSR	(1970)
Mikoyan MiG-23B Flogger-C, USSR	(1971)
Dassault Mirage-3C, France	(1960)
Dassault Mirage-3E, France	(1964)
Dassault Mirage-5A, France	(1967)
Dassault Mirage F-1C, France	(1973)
Northrop F-5A Freedom Fighter, USA	(1963)
Northrop F-5B Freedom Fighter, USA	(1964)
Northrop F-5E Tiger-2, USA	(1972)
BAC Lightning, UK	(1959)
Sukhoi Su-7B Fitter-A, USSR	(1956)
Sukhoi Su-11 Fishpot-C, USSR	(1965)
McDonnell Douglas A-4M Skyhawk-2, USA	(1970)
McDonnell Douglas A-4H Skyhawk-2, USA	(..)
McDonnell Douglas A-4N Skyhawk-2, USA	(..)
McDonnell Douglas F-4A/B Phantom, USA	(1958)
McDonnell Douglas F-4D Phantom, USA	(1965)
McDonnell Douglas F-4E Phantom, USA	(1967)
McDonnell Douglas F-15 Eagle, USA	(1973)
LTV A-7A Corsair-2, USA	(1965)
LTV A-7D Corsair-2, USA	(1968)
Lockheed P-3C Orion, USA	(1968)
Grumman E-2C Hawkeye, USA	(1971)
General Dynamics F-16, USA	(1976)
Ilyushin Il-38 May, USSR	(..)
Tupolev Tu-22, USSR	(1961)

1970	1971	1972	1973	1974	1975	1976	1977	On order
				F-5E			E-2C	
		Mirage-5						
	MiG-21MF							
		MiG-21MF		Mirage-3				
		A-4N				F-15	E-2C	F-16
				MiG-23				
	Su-7	MiG-21MF					Il-38	
					Mirage F-1C			
					A-7			
						MiG-23		
				F-5E				
				F-4E	P-3C	F-14A		F-16
		Su-7						
			F-5B	F-5E			Mirage F-1	
								F-5E
							MiG-21	MiG-23
		MiG-21MF	Su-7	MiG-23	Su-11			
		F-5B			F-5E			
						Mirage F-1C		
	Mirage-3				MiG-23B	Tu-22	Mirage F-1C	
MiG-21								Mirage 50
		F-5A	Mirage-3E					
		Mirage-3E			F-5E			
		Mirage-5						
		Mirage-3						
			Mirage-5	Mirage-3E				
			MiG-21MF					
				MiG-21				
					Mirage-3B			
					Mirage-5			
					MiG-21MF			
					MiG-21			
					F-5E			
						F-5E		
						Jaguar		
							Jaguar	Mirage F-1
							F-5E	
							F-5E	
								F-5E
							Mirage-5	

the French Ouragon. From 1953, Rockwell International's F-86 Sabre fighter was found in the Third World inventories and was eventually sold to as many as 13 nations. Taiwan's acquisition may serve to illustrate a typical import curve, starting with F-86Fs armed with Sidewinder missiles in 1954, then the F-104 Starfighter in 1960, followed by Northrop's F-5A Freedom Fighter in 1965, and the F-5E Tiger-2 in 1974, the latter being assembled under licence.

The Israeli inventory includes other of the types most often sold to Third World countries in this period. During the 1950s Israel received old French Ouragons and Mystère 4s, replaced in 1962 by the then considered highly advanced Mirage-3 fighter-bomber. From 1968, large deliveries began of several hundred McDonnell Douglas A-4 Skyhawks and F-4 Phantoms, to be replaced in turn by the new fighters for the 1980s—the McDonnell Douglas F-15 Eagle from 1976 and the General Dynamics F-16 from 1980. The F-16, which eventually won the NATO order in the competition for the "aircraft deal of the century", will also be found in Iran from 1980. In competition with these latest US models, the French Mirage F-1 has won several orders, for example from Kuwait, Libya, Saudi Arabia and South Africa.

The typical sequence for importers turning to the USSR may be illustrated by the case of Syria, which received MiG-15s and -17s during the late 1950s, followed by MiG-21s armed with Atoll air-to-air missiles in 1967 and the more advanced-version MiG-21 MF in 1972, and then the MiG-23 from 1974.

While these aircraft represent the result of a technological arms race among the producers (see table 8.5, above), the Third World customers have also concentrated on acquiring light aircraft, after the Viet Nam War generally referred to as counter-insurgency types.

Large numbers of armed helicopters and armed jet trainers have spread all over the region—among the largest customers are Iran, with over 500 Bell helicopters, and South Africa, where the Italian Aermacchi MB-326 GB/K is produced under licence as the COIN types Impala-1 and Impala-2. The MB-326 GB has also been licence-produced in Brazil since 1971 as the COIN type AT-26 Xavante, and has been purchased by Argentina, Bolivia, Zaire and several other nations. Another Italian plane with a COIN role is Siai-Marchetti's SF-260W Warrior, purchased by Ecuador, Morocco, Thailand, Zaire and Zambia. Among the most popular US COIN aircraft are the Rockwell OV-10 Bronco, and the Cessna A-37, sold during the past five years to Chile, South Korea and Venezuela, among others. Finally the Italian AM-3C and Italian–US AL-60 light planes are used for the COIN role in South Africa. The widespread need for and import of this type of aircraft in Third World countries is of interest when considering their protests in the United Nations against even discussing the registration of the arms trade, arguing that the poor nations in the world need these armaments for self-defence.

Missiles

The second indicator of the advance of military technology is the spread of missile weapon systems to the Third World (see table 8.6). The most widely acquired types during the 1950s and 1960s were the standard systems arming US, French and Soviet fighters, that is, the Sidewinder air-to-air missile, the Sparrow air-to-air missile, the French AS-12 and AS-11 missiles on helicopters and the Matra R-530 on Mirage aircraft, and the Atoll air-to-air missile on the many versions of the MiG-21. The later version of the Phantom fighter, the F-4E, carries, in addition to Sidewinder and Sparrow, the Hughes Maverick air-to-surface missile.

The new generation of air combat missiles for the 1980s so far includes the Hughes Phoenix air-to-air missile for Iran's and Israel's F-16 fighters, and the Rockwell Condor air-to-surface missile. The British BAC Sea Skua air-to-ship missile, arming Lynx helicopters and sold to Brazil among other customers, is another of the new products on the missile market.

The first armoured vehicles equipped with anti-tank missiles began to appear on a large scale in Third World countries from 1962. In particular, many of the Soviet customers have received large numbers of the AT-1, AT-2 and AT-3 systems. The British BAC Vigilant was also widely acquired.

More recent anti-tank missiles incorporate more complex technology, such as the popular Hughes TOW system[9] which can also be used as an air-to-ground system. Iran has purchased a large number, both for infantry use and to arm its Bell AH-1J attack helicopters. TOW was amply demonstrated as a helicopter weapon in Viet Nam—the missile can be fired even at high speeds and still hit the target. It is operated automatically, the gunner's task being only to keep his target in sight by telescope during missile flight. The light source in the missile is tracked by a sensor which measures the angle between the gunner's sight line and the flight direction of the missile. These displacements are transformed by the computer into guidance commands for the missile.

During the 1973 Middle East War, the small portable Soviet SA-7 anti-tank weapon made an impression as a highly lethal and easily handled weapon. It was subsequently used by the guerrilla forces in Angola, Guinea-Bissau, and Mozambique. The new West German–French anti-tank weapons, Euromissiles HOT and Milan, were developed according to the same principles as the SA-7 and have since been delivered to a

[9] TOW = Tube-launched, Optically-tracked, Wire-guided.

Table 8.6. The spread of missile systems to Third World countries, 1954–77[a]

Country	1954	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77
Israel	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Taiwan	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Pakistan			×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
South Africa			×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Philippines				×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
South Korea						×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Cuba								×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Indonesia								×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Thailand								×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Afghanistan									×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Egypt									×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Iraq									×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Kuwait									×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
India										×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Syria										×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Iran											×	×	×	×	×	×	×	×	×	×	×	×	×	×
Saudi Arabia											×	×	×	×	×	×	×	×	×	×	×	×	×	×
North Korea												×	×	×	×	×	×	×	×	×	×	×	×	×
Algeria												×	×	×	×	×	×	×	×	×	×	×	×	×
North Viet Nam													×	×	×	×	×	×	×	×	×	×	×	×
Libya														×	×	×	×	×	×	×	×	×	×	×
Peru														×	×	×	×	×	×	×	×	×	×	×
Argentina																×	×	×	×	×	×	×	×	×
Jordan																×	×	×	×	×	×	×	×	×

Qatar	×	×	×	×	×	×	×	×
Malaysia		×	×	×	×	×	×	×
Singapore		×	×	×	×	×	×	×
Sudan		×	×	×	×	×	×	×
Zambia		×	×	×	×	×	×	×
Brazil			×	×	×	×	×	×
Colombia			×	×	×	×	×	×
Brunei			×	×	×	×	×	×
Venezuela			×	×	×	×	×	×
South Viet Nam			×	×	×	×	×	×
Uganda				×	×	×	×	×
Chile					×	×	×	×
Rhodesia						×	×	×
Zaire						×	×	×
Ethiopia						×	×	×
Yemen								×
Ecuador								×
Tunisia								×

[a] Included are land-based fixed and mobile surface-to-ground and surface-to-air systems, air-to-air and air-to-surface missiles on fighter aircraft and on helicopters, and anti-tank, ship-to-ship and ship-to-air missiles.

Source: SIPRI country registers 1950–77.

Table 8.7. The spread of armoured fighting vehicles of post-1945 design to Third World countries, 1950–77[a]

Country	1950	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77
North Korea	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
South Korea		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Iraq				×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Burma					×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Egypt					×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Israel					×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Jordan					×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Peru					×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Venezuela					×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Indonesia						×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
South Africa						×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Pakistan						×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Taiwan						×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
India							×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Kuwait							×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Morocco							×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Syria							×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Cuba								×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Lebanon								×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Libya								×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Tunisia								×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Yemen								×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Iran									×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Nicaragua									×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Sudan									×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
South Viet Nam									×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Afghanistan										×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Ghana										×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Guinea										×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×

Liberia	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Nigeria		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Rhodesia		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Saudi Arabia		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Somalia		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Sri Lanka		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Togo		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Upper Volta		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
North Viet Nam		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Gabon			×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Mali			×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Algeria				×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Rwanda				×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Cameroon					×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Malaysia					×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Mexico					×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Zaire					×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Kampuchea (Cambodia)						×	×	×	×	×	×	×	×	×	×	×	×	×	×
Oman						×	×	×	×	×	×	×	×	×	×	×	×	×	×
Kenya						×	×	×	×	×	×	×	×	×	×	×	×	×	×
Singapore						×	×	×	×	×	×	×	×	×	×	×	×	×	×
Tanzania						×	×	×	×	×	×	×	×	×	×	×	×	×	×
Zambia						×	×	×	×	×	×	×	×	×	×	×	×	×	×
Brazil							×	×	×	×	×	×	×	×	×	×	×	×	×
Brunei							×	×	×	×	×	×	×	×	×	×	×	×	×
Jamaica							×	×	×	×	×	×	×	×	×	×	×	×	×
Uganda							×	×	×	×	×	×	×	×	×	×	×	×	×
Uruguay							×	×	×	×	×	×	×	×	×	×	×	×	×
Chile								×	×	×	×	×	×	×	×	×	×	×	×
Ecuador								×	×	×	×	×	×	×	×	×	×	×	×
Ivory Coast								×	×	×	×	×	×	×	×	×	×	×	×
Argentina									×	×	×	×	×	×	×	×	×	×	×
Bolivia									×	×	×	×	×	×	×	×	×	×	×

Country	1950	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77
Thailand																		×	×	×	×	×	×	×	×	×	×	×
Democratic Yemen																		×	×	×	×	×	×	×	×	×	×	×
Abu Dhabi																			×	×	×	×	×	×	×	×	×	×
Congo																			×	×	×	×	×	×	×	×	×	×
Mauritania																			×	×	×	×	×	×	×	×	×	×
Qatar																			×	×	×	×	×	×	×	×	×	×
Nepal																				×	×	×	×	×	×	×	×	×
Senegal																				×	×	×	×	×	×	×	×	×
Guyana																					×	×	×	×	×	×	×	×
Laos																					×	×	×	×	×	×	×	×
Bahrain																						×	×	×	×	×	×	×
Haiti																						×	×	×	×	×	×	×
Mauritius																						×	×	×	×	×	×	×
Sharya																						×	×	×	×	×	×	×
Dominican Rep.																							×	×	×	×	×	×
Ethiopia																							×	×	×	×	×	×
Malawi																							×	×	×	×	×	×
Philippines																								×	×	×	×	×
El Salvador																									×	×	×	×
Guatemala																									×	×	×	×
Mozambique																											×	×

[a] Including the following types: armoured car, tank, main battle tank.

Source: see source to table 8.6.

number of countries. The ship-to-ship or ship-to-air missile systems appeared in the Third World inventories from 1961, one widely sold type being the Soviet Styx missile, arming "Komar"- and "Osa"-class patrol boats. On missile boats sold during the 1970s, the most common armaments are the US Harpoon and the French Exocet. A new product so far sold to Singapore, South Africa and Taiwan is the Israeli-designed Gabriel ship-to-ship missile.

The fixed or mobile land-based anti-aircraft missile systems in a way represent a weapon category of their own. The first such systems introduced in the Third World were the US Honest John and Nike Hercules, delivered to South Korea and Taiwan in 1959. From 1961, the Soviet SA-2 entered the market, beginning in Cuba and Indonesia. Since then practically all Soviet customers have received one or several of the SA-2, SA-3, SA-4 and SA-6 systems. During the 1970s, the Raytheon Advanced Hawk has been sold, particularly in the Middle East, in competition with the South African-financed, French-developed Crotale. The most recent systems introduced in the Middle East also represent the most advanced technology: the US Lance surface-to-surface missile to Israel, and the Soviet Scud to Egypt, Iraq, Libya and Syria, both capable of carrying nuclear warheads and both being long-range systems.

Armoured vehicles

The import of armoured vehicles of post-1945 design is shown in table 8.7. In the breakdown by the categories of main battle tank, light tank and armoured car or armoured personnel carrier, the latter type dominates the army inventories of the Third World customers. Armoured cars are among those weapons which have proved highly useful for internal security roles. The US Ford M-113, the French Panhard car and the Soviet BTR-40/50 are the most common types, along with the British Saracen, Saladin, Ferret, Scorpion and Fox. Comparatively few of those countries listed in table 8.7 have acquired main battle tanks for the conventional warfare role; among these countries are of course the nations which have been or are involved in major conflicts, such as for example Israel and Egypt. The armed clashes between Ethiopia and Somalia in 1977 involved Soviet tanks and armoured cars on both sides, as well as MiG fighters from both air forces.

Some armoured vehicles are produced under licence, for example a development of the British Vickers 37-ton in India, known as Vijayanta, and the French Panhard cars in South Africa. Brazil is one of the very few Third World countries to have put indigenous designs into production —the EE-9 and EE-11 armoured cars, now being sold to Saudi Arabia. The latest models of the M-113 are usually equipped with the TOW anti-tank

Table 8.8. The spread of modern warships to Third World countries, 1950–77[a]

Country	1950	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77
Indonesia	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
India	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Israel	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
South Africa	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Brazil		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Chile		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Peru		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Venezuela				×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Ecuador					×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Thailand					×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Philippines						×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Burma							×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Egypt							×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Iran							×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
North Korea							×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Pakistan							×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Syria								×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Taiwan								×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
North Viet Nam								×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Argentina									×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Colombia									×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Iraq										×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Uruguay										×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Ethiopia											×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Togo											×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
South Viet Nam											×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Morocco												×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Tunisia												×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Congo													×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Cuba													×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Kuwait													×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Ivory Coast														×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
South Korea														×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Madagascar														×	×	×	×	×	×	×	×	×	×	×	×	×	×	×

Malaysia	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Senegal	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Algeria		×	×	×	×	×	×	×	×	×	×	×	×	×	×
Cameroon		×	×	×	×	×	×	×	×	×	×	×	×	×	×
Ghana		×	×	×	×	×	×	×	×	×	×	×	×	×	×
Mexico		×	×	×	×	×	×	×	×	×	×	×	×	×	×
Tanzania		×	×	×	×	×	×	×	×	×	×	×	×	×	×
Nigeria			×	×	×	×	×	×	×	×	×	×	×	×	×
Trinidad & Tobago			×	×	×	×	×	×	×	×	×	×	×	×	×
Jamaica				×	×	×	×	×	×	×	×	×	×	×	×
Kenya				×	×	×	×	×	×	×	×	×	×	×	×
Libya				×	×	×	×	×	×	×	×	×	×	×	×
Mauritania				×	×	×	×	×	×	×	×	×	×	×	×
Somalia				×	×	×	×	×	×	×	×	×	×	×	×
Sri Lanka				×	×	×	×	×	×	×	×	×	×	×	×
Brunei					×	×	×	×	×	×	×	×	×	×	×
Liberia					×	×	×	×	×	×	×	×	×	×	×
Niger					×	×	×	×	×	×	×	×	×	×	×
Guinea						×	×	×	×	×	×	×	×	×	×
Abu Dhabi							×	×	×	×	×	×	×	×	×
Saudi Arabia							×	×	×	×	×	×	×	×	×
Singapore								×	×	×	×	×	×	×	×
Oman									×	×	×	×	×	×	×
Panama									×	×	×	×	×	×	×
Qatar									×	×	×	×	×	×	×
Bangladesh									×	×	×	×	×	×	×
Yemen										×	×	×	×	×	×
Kampuchea (Cambodia)										×	×	×	×	×	×
Dubai												×	×	×	×
Bahrain													×	×	×
Laos													×	×	×
Equatorial Guinea													×	×	×
Lebanon															×

[a] Included are only post-1945 designs, confined to the following combat types: corvettes, aircraft carriers, cruisers, destroyers, fast patrol boats, frigates, gunboats and torpedo boats.

Source: see source to table 8.6.

missile, and generally it can be said that through the developments of new types of ammunition and small arms (high-speed bullets, and so on) the destructive capacity of these types of weapon is by 1977 much superior to that of weapons from the 1950s.

Warships

In general, the navy is the last of the military branches of Third World countries to receive modern equipment of the same type as that of the main naval powers of the industrialized world, for both technical and strategic reasons. In fact, few Third World nations possess a navy at all, that is, with submarines, destroyers and other heavy warships. Those nations which do possess a navy are found primarily in Latin America and the Far East, for example, Argentina, Brazil, Chile, India, Indonesia, Pakistan and Peru, and among the future big naval powers, Iran and South Africa are rapidly investing in such a capacity for the Indian Ocean (see table 8.8). The most common type of warship in the Third World is the fast patrol boat, after 1970 normally equipped with ship-to-ship missiles. Another new type of navy warship is represented by armed hovercraft. Iran now has the world's first, and largest, military hovercraft fleet.

Thus, table 8.8 includes relatively few heavy warships, and most of those destroyers and frigates imported were built before 1945 and then refurbished and modernized. France and FR Germany are the leading exporters of modern submarines, the "Daphne"-class and Type 209. The Soviet Union mostly exports types that were produced during the 1950s and have served some time in the Soviet navies. The first nation to receive a modern missile-armed frigate was Iran, which in 1971 received delivery of the British SAAM-class equipped with two types of naval warfare missile, and Argentina, Brazil and India are the only nations so far capable of producing modern frigates equipped for anti-submarine warfare, all under British licence and with a heavy input of British technical assistance.

IV. Conclusions

The conclusions to be drawn concerning this evermore unlimited, uncontrolled and increasingly commercialized dispersal of weapon systems from the industrialized world around the globe, are as follows:

1. There is no evidence that arms transfers *per se* contribute to national security for the buyer. The reverse may be equally possible.

2. There is no causal relationship between supplies of arms and the creation of political goodwill at the receiving end. Rather the opposite is

true—goodwill between the respective governments may result in arms deals, among other relationships.

3. For poor countries, the investment in major weapons and weapon industries depends mostly on the success of sales campaigns from the producing companies and governmental sales agencies, and results in a drain of the scarce resources needed for civilian economic development.

4. For the producing nations, arms exports are of most importance at the industry level, for the profit and existence of the single enterprise and its work force.

5. If, in future, nuclear weapons also begin to be widely traded, along with their carriers, the uncontrolled transfer of arms may become an even greater danger to world security.

References

1. Nyerere, J., "The Devil's Flunkey", *Far Eastern Economic Review*, 30 January 1971.
2. *The Arms Trade with the Third World* (Almqvist & Wiksell, 1971, Stockholm International Peace Research Institute).
   (a) —, p. 4.
   (b) —, p. 19.
3. Sampson, A., *The Arms Bazaar* (Hodder and Stoughton, London, 1977), p. 14.

Appendix 8A

Register of the arms trade with Third World countries, 1977

For sources and methods, see chapter 9. For conventions, see page 293.

In the register, the Third World countries in the Recipient column are listed in alphabetical order.

Tables 8A.1 and 8A.2 give the values of imports and exports of these weapons for the period 1957–77.

Table 8A.1. Values of imports of major weapons by Third World countries: by region, 1957–77[a]

Region[b]		1957	1958	1959	1960	1961	1962	1963	1964	1965
Middle East	A	392	325	311	161	196	574	393	388	441
	B[c]	346	329	277	314	327	342	398	447	545
Far East (excl Viet Nam)	A	276	661	518	762	200	356	310	392	340
	B	408	503	483	499	429	404	320	379	348
South America	A	147	176	59	181	205	109	72	51	110
	B	158	143	154	146	125	124	109	96	100
North Africa	A	7	5	8	12	15	39	34	40	81
	B	6	8	9	16	22	28	42	63	82
South Asia	A	332	639	194	268	289	189	221	79	213
	B	307	333	344	316	232	209	198	219	235
Sub-Saharan Africa	A	2	4	60	36	56	47	47	68	95
	B	16	21	32	41	49	51	63	70	77
South Africa	A	28	24	22	5	4	16	155	51	186
	B	33	30	17	14	40	46	82	100	112
Central America	A	8	15	19	58	211	298	96	34	18
	B	17	24	62	120	136	139	131	93	37
Oceania	A	–	–	–	–	–	–	–	–	–
	B	–	–	–	–	–	–	–	–	–
Total (excl Viet Nam)	A	**1 192**	**1 848**	**1 191**	**1 484**	**1 177**	**1 628**	**1 328**	**1 104**	**1 485**
	B	**1 291**	**1 391**	**1 378**	**1 466**	**1 362**	**1 344**	**1 344**	**1 468**	**1 536**
Viet Nam	A	10	63	12	31	74	75	56	91	74
	B	22	26	38	51	50	65	74	107	190
Total[d]	A	**1 202**	**1 911**	**1 203**	**1 515**	**1 251**	**1 703**	**1 384**	**1 195**	**1 559**
	B	**1 314**	**1 417**	**1 416**	**1 516**	**1 411**	**1 409**	**1 418**	**1 574**	**1 726**

[a] The values include licensed production of major weapons in Third World countries. For the values for the period 1950–56, see *SIPRI Yearbook 1976*, pp. 250–51.
[b] The regions are listed in rank order according to their average values for 1970–76.
[c] Five-year moving averages are calculated from the year arms imports began, as a more stable measure of the trend in arms imports than the often erratic year-to-year figures.
[d] Items may not add up to totals due to rounding. Figures are rounded to nearest 10.

Source: SIPRI worksheets. Information on individual countries and arms transactions is available on request.

SIPRI estimates as expressed in US $ mn, at constant (1975) prices
A = yearly figures, B = five-year moving averages

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
440	1 063	1 258	1 212	1 462	1 758	1 076	2 211	2 836	3 527	3 164	4 667
718	883	1 087	1 351	1 353	1 544	1 869	2 282	2 653	3 371	–	–
497	199	266	586	271	419	162	302	249	640	1 035	482
339	378	364	348	341	348	281	354	478	542	–	–
138	128	208	158	148	222	310	352	446	630	710	804
127	148	156	173	209	238	296	392	490	588	–	–
122	135	83	87	121	123	167	145	228	761	929	658
92	102	110	110	116	129	157	285	444	544	–	–
391	271	297	312	300	499	409	289	373	177	414	571
250	297	314	336	363	362	374	349	332	365	–	–
93	81	55	71	121	134	89	152	386	232	432	574
78	79	84	92	94	113	176	199	258	355	–	–
92	78	45	46	77	69	25	37	274	179	118	290
90	89	68	63	52	51	96	117	127	180	–	–
21	16	8	10	6	47	35	56	87	137	58	114
19	15	12	17	21	31	46	72	75	90	–	–
–	–	–	–	–	–	–	–	–	–	3	2
–	–	–	–	–	–	–	–	–	–	–	–
1 794	**1 971**	**2 220**	**2 482**	**2 506**	**3 272**	**2 273**	**3 545**	**4 878**	**6 284**	**7 312**	**8 163**
1 715	**1 990**	**2 195**	**2 490**	**2 551**	**2 816**	**3 295**	**4 050**	**4 858**	**6 036**	–	–
237	494	473	298	433	435	1 200	82	816	20	–	–
274	315	387	427	568	490	467	385	298	–	–	–
2 031	**2 465**	**2 693**	**2 780**	**2 939**	**3 707**	**3 473**	**3 627**	**5 064**	**6 304**	**7 312**	**8 163**
1 989	**2 305**	**2 582**	**2 917**	**3 118**	**3 305**	**3 762**	**4 435**	**5 156**	**6 094**	–	–

Table 8A.2. Values of exports of major weapons to regions listed in table 8A.1: by supplier, 1957–77[a]

Country[b]		1957	1958	1959	1960	1961	1962	1963	1964	1965
USA (incl	A	453	497	326	713	393	368	514	372	540
Viet Nam)	B	421	484	476	459	463	472	437	462	484
USSR (incl	A	335	257	146	215	511	1 029	429	375	544
Viet Nam)	B	203	229	293	432	466	512	578	669	773
UK	A	236	468	239	256	241	124	177	179	265
	B	286	292	288	266	207	195	197	188	203
France (incl	A	91	172	65	49	50	121	194	137	96
Viet Nam)	B	116	107	85	91	96	110	120	138	127
China (incl	A	7	302	174	163	–	–	–	51	9
Viet Nam)	B	97	129	128	128	67	43	12	21	25
Italy	A	38	37	*	9	–	1	20	20	7
	B	24	25	17	9	6	10	10	10	14
FR Germany	A	6	10	34	30	6	2	13	26	13
	B	14	18	17	16	17	15	12	27	28
Netherlands	A	2	1	6	1	3	3	*	11	22
	B	24	2	3	3	3	4	8	7	7
Canada (incl	A	5	7	88	14	22	3	13	11	18
Viet Nam)	B	30	33	27	27	28	13	13	11	13
Czechoslovakia	A	8	30	76	59	6	6	16	9	4
	B	49	50	36	35	33	19	8	9	10
Sweden	A	–	49	*	1	1	*	–	–	–
	B	13	11	10	10	–	–	–	–	–
Switzerland	A	–	–	–	–	–	–	2	–	1
	B	–	–	–	–	–	–	1	1	1
Japan (incl	A	15	29	15	–	14	24	1	1	6
Viet Nam)	B	14	14	15	16	11	8	9	9	10
Third World	A	7	14	2	4	2	10	4	3	4
	B	6	6	6	6	4	5	5	9	10
Other indus. West	A	–	–	–	2	3	2	1	*	30
	B	1	–	1	1	2	2	7	11	22
Other indus. East	A	1	38	32	*	–	11	*	–	*
	B	15	15	14	15	9	2	2	2	–
Total[c]	A	**1 202**	**1 911**	**1 203**	**1 515**	**1 251**	**1 703**	**1 384**	**1 195**	**1 559**
	B	**1 313**	**1 416**	**1 416**	**1 516**	**1 411**	**1 410**	**1 418**	**1 574**	**1 727**

[a] The values include licences sold to Third World countries for production of major weapons. For the values for the period 1950–56, see *SIPRI Yearbook 1976*, pp. 252–53.
[b] The countries are listed in rank order according to their average values for 1970–76.
[c] Items may not add up to totals due to rounding.
* < $0.5 mn.

Source: SIPRI worksheets. Information on individual countries and arms transactions is available on request.

SIPRI estimates as expressed in US $ mn, at constant (1975) prices
A=yearly figures, B=five-year moving averages

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
514	481	754	1 244	1 258	1 179	1 166	1 061	1 404	2 343	3 892	3 425
533	707	850	983	1 120	1 182	1 214	1 431	1 973	2 425	–	–
970	1 545	1 116	834	1 136	1 515	1 225	1 537	1 930	2 160	1 554	2 173
910	1 002	1 120	1 229	1 615	1 249	1 469	1 673	1 681	1 871	–	–
193	203	294	348	185	393	369	316	579	647	587	680
227	261	245	285	318	322	368	461	500	562	–	–
140	68	288	172	203	276	351	538	449	593	553	1 245
146	153	174	201	258	308	363	441	497	676	–	–
47	17	5	10	22	106	158	27	104	63	57	86
26	18	20	32	60	65	83	92	82	67	–	–
1	20	67	53	43	41	52	56	139	72	159	152
23	30	37	49	51	49	66	72	96	116	–	–
83	4	11	17	1	25	37	3	116	138	131	101
27	26	23	12	18	17	36	64	85	98	–	–
1	–	5	25	10	34	27	39	33	42	29	26
8	11	8	15	20	27	29	35	34	34	–	–
12	11	48	19	37	55	39	6	1	6	34	28
20	22	25	34	40	31	28	21	17	15	–	–
8	11	39	22	31	14	14	1	15	6	6	15
14	17	22	23	24	16	15	10	8	9	–	–
2	–	–	*	–	–	5	1	6	21	21	6
–	–	–	1	1	2	7	6	11	11	–	–
1	1	1	–	2	2	2	2	*	1	8	2
1	1	1	1	1	2	2	1	3	3	–	–
11	30	49	2	*	*	–	–	3	–	3	–
19	20	18	16	10	–	1	1	1	1	–	–
25	15	9	20	8	15	18	20	276	185	202	60
11	15	15	13	14	16	67	103	140	149	–	–
23	58	7	11	3	46	11	19	11	13	46	141
24	26	20	25	16	18	18	20	20	46	–	–
–	2	–	2	–	5	–	–	–	2	30	22
–	1	1	2	1	1	1	1	6	11	–	–
2 301	**2 465**	**2 693**	**2 780**	**2 939**	**3 707**	**3 473**	**3 627**	**5 064**	**6 304**	**7 312**	**8 163**
1 989	**2 305**	**2 581**	**2 917**	**3 118**	**3 305**	**3 762**	**4 435**	**5 156**	**6 094**	–	–

s

Register of the arms trade with Third World countries, 1977

Recipient	Supplier	No. of items	Item	Firm	Description	Date of order	Date of delivery[c]	No. delivered[c]
Abu Dhabi[a]	Brazil	200	EE-9 Cascavel	Engesa	Armed recce car	1977	..	..
	Canada	4	DHC-5D Buffalo	DeHavilland Canada	Transport	1977	..	..
	France	..	Crotale	Thomson-CSF	SAM	1976	..	..
		18	Mirage-5	Dassault-Breguet	Fighter	1976	1977	10
	UK	2	..	Cheverton Cowes	Patrol boat	1975	1977	2
		..	Rapier	BAC	SAM	1976	..	..
Algeria	USSR	6	MiG-21	Mikoyan	Fighter	1976	1977	6
Angola	Romania	16	BN-2A Islander	Britten-Norman	STOL transport	1976	..	..
	USSR	5	An-26	Antonov	Short-haul transport	1977	1977	5
Argentina	France	7	Mirage-3E	Dassault-Breguet	Fighter-bomber/intruder	1977	..	..
		72	MM-38 Exocet	Aérospatiale	ShShM	1975	..	..
	FR Germany	..	TAM[b]	..	Medium tank	1974	..	..
		2	Type 148[b]	Rio Santiago	Fast patrol boat	1975	..	..
		..	..[b]	..	Infantry combat vehicle	1974	..	..
	Israel	18	Gabriel-2	IAI	ShShM	1975	..	..
	Italy	1	G-222	Aeritalia	Military transport	1975	..	..
		2	G-222	Aeritalia	Military transport	1974	1977	1
	Sweden	10	Bantam	Bofors	ATM	1976	1977	10
	UK	12	Sea Dart	Hawker-Siddeley	ShAM	1970	1975 1977	6 6
		72	Seawolf	BAC	ShShM/ShAM	1975	..	..
		8	Type 21[b]	AFNE Shipyard	Frigate	1975	..	..
		2	WG-13 Lynx	Westland/Aérospatiale	ASW helicopter	1977	..	..
	USA	16	A-4P Skyhawk	McDonnell-Douglas	Fighter	1975	1976 1977	10 6
		25	A-4P Skyhawk	McDonnell-Douglas	Fighter	1976	1977	5
		21	Beech T-34 C-1 Turbo-Mentor	Beechcraft Corp	Armed trainer	1977	..	..
		4	Merlin-3A	Swearingen-Merlin	Transport	1977	1977	4
		2	Merlin-4A	Swearingen-Merlin	Transport	1977	1977	2
		6	S-2E Tracker	Grumman	Shipborne ASW fighter	1977	1978	6
		2	SP-2H Neptune	Lockheed	Marine recce/bomber	1976	1977	2

Bangladesh	China	50	F-9	Shenyang	Fighter	1976	1977	10
	New Zealand	2	CT-4 Airtrainer	NZAI	Trainer	1977	..	..
	UK	1	Salisbury	..	Frigate	1976	..	..
	USA	6	Bell-212	Bell	Helicopter	1976	1977	6
Bolivia	Argentina	18	IA-58 Pucara	FMA	Armed trainer/COIN	1975	1976	2
							1977	2
	Brazil	40	Neiva T-25 Universal	Neiva	Trainer	1977	..	..
	Canada	5	T-33A	Canadair	Trainer	1977	1977	5
	Switzerland	16	PC-7 Turbo-Trainer	Pilatus	Trainer	1977	1978	..
	USA	1	C-130H Hercules	Lockheed	Military transport	1977	1978	1
		1	C-130H Hercules	Lockheed	Military transport	1976	1977	1
Botswana	UK	3	BN-2A Defender	Britten-Norman	Transport	1977	..	..
Brazil	Australia	96	Ikara-3	Industry Dept	Anti-submarine missile	1972	1976	24
							1977	24
	France	600	AS-11[b]	Aérospatiale	ASM	1972	1974	144
							1975	144
							1976	144
							1977	144
		600	AS-12[b]	Aérospatiale	ASM	1972	1974	144
							1975	144
							1976	144
							1977	144
		4	Mirage-3E	Dassault-Breguet	Fighter-bomber/intruder	1977	..	..
		24	MM-38 Exocet	Aérospatiale	ShShM	1972	1977	12
		80	Roland-2	Aérospatiale-MBB	SAM	1972	1977	20
	FR Germany	..	Cobra-2000[b]	..	ATM	1973	1975	10
							1976	100
							1977	200
	Italy	40	AT-26 Xavante[b]	EMBRAER	Armed trainer/COIN	1975	1976	12
							1977	24
	UK	6	"Niteroi"[b]	Vosper	ASW frigate	1970	1976	2
							1977	1
		1	"Oberon"	Vickers	Submarine	1972	1977	1
		104	Seacat	Short	ShAM	1970	1976	18
							1977	36
		9	WG-13 Lynx	Westland/Aérospatiale	ASW helicopter	1975	1977	2
	USA	2	KC-130H Hercules	Lockheed	Tanker/transport	1977	..	..
Cameroon	China	2	"Shanghai-2"	..	Fast gunboat	1975	1977	2
	UK	2	HS-748	Hawker-Siddeley	Military transport	1976	1978	2
	USA	2	C-130H Hercules	Lockheed	Military transport	1976	1977	2

Recipient	Supplier	No. of items	Item	Firm	Description	Date of order	Date of delivery[c]	No. delivered[c]
Chad	France	6	A-1 Skyraider	Douglas	Fighter naval attack	1976	1977	6
Chile	Argentina	15	A-4P Skyhawk	McDonnell-Douglas	Fighter	1976	1977	15
	Brazil	6	EMB-111N Bandeirante	EMBRAER	Marine patrol	1977	1977	3
		10	..	Maclaren Yard	Fast patrol boat	1977	..	..
	France	47	AMX-13-105	Creusot-Loire	Tank	1976	1977	47
		50	AMX-30	Giat	MBT	1976	1977	50
		150	AS-11	Aérospatiale	ASM	1976	1977	300
		150	AS-12	Aérospatiale	ASM	1976	1977	150
		30	SA-330 Puma	Aérospatiale-Westland	Helicopter	1976	1977	30
	Israel	150	Shafrir	Raphael	AAM	1976	1977	150
	USA	2	C-130H Hercules	Lockheed	Military transport	1976	1977	2
		4	Merlin-3A	Swearingen-Merlin	Transport	1976	1977	2
Colombia	USA	10	Hughes-500C	Hughes	LOH	1976	1977	10
Comoros	Italy	3	SF-260W Warrior	SIAI-Marchetti	Light attack/COIN	1977	1977	3
Congo	France	1	Frégate	Aérospatiale	Light transport	1976	..	..
Cuba	USSR	..	SA-2	..	SAM fixed	1976	1977	..
		6	Yak-40	Yakovlev	Transport	1976	1977	6
Dubai	Italy	1	G-222	Aeritalia	Military transport	1977	..	..
		9	MB-326K	Aermacchi	Light attack/COIN	1975	1976	3
							1977	..
		3	MB-326L	Aermacchi	Trainer	1975	1976	1
							1977	..
Ecuador	France	18	Mirage F-1C	Dassault-Breguet	Fighter	1977	..	..
	FR Germany	72	R-550 Magic	Matra	AAM	1974	1977	12
		2	Type 209	Howaldtswerke	Submarine	1974	1977	1
	UK	12	Jaguar International	Breguet-BAC	Tactical support aircraft	1974	1977	2
	USA	14	Beech T-34 C-1 Turbo-Trainer	Beechcraft Corp	Armed trainer	1975	1978	..
Egypt	France	..	Arab Crotale	Thomson-CSF	SAM	1976	..	..
		24	AS-12	Aérospatiale	ASM	1975	1978	24
		504	HOT	Euromissile	ATM	1975	1976	120
							1977	504

		14	Mirage-5SD	Dassault-Breguet	Fighter	1976	1977	14
		42	SA-342 Gazelle	Aérospatiale-Westland	LOH	1975	1976	10
							1977	24
		20	Transall	Aérospatiale	Military transport	1976	..	..
		14	Mirage-5R	Aérospatiale	Fighter/recce	1977	..	..
	Italy	30	OTOMAT	Oto Melara/Matra	ShShM	1977	1978	..
	UK	4	Commando Mk 2	Westland	Assault helicopter	1975	1978	2
		12	HS-748-2A	Hawker-Siddeley	Cargo/troop transport	1977	..	..
		..	Swingfire	BAC	ATM	1975	1976	500
							1977	1 000
	USA	2	C-130E Hercules	Lockheed	Military transport	1976	1977	2
		14	C-130H Hercules	Lockheed	Military transport	1977	..	..
		4	C-130H Hercules	Lockheed	Military transport	1976	1976	2
							1977	2
		12	PQM-34 Mod. 124R	Teledyne-Ryan	Photo-recce drone	1977	..	..
Ethiopia	USSR	4	An-26	Antonov	Short-haul transport	1976	1977	4
		2 000	AT-3 Sagger	..	ATM	1977	1977	1 000
							1978	1 000
		40	BMP-40	..	APC	1976	1977	40
		5	Mi-8	Mil	Helicopter	1976	1977	5
		48	MiG-21	Mikoyan	Fighter	1977	1977	24
							1978	24
		..	MiG-23	Mikoyan	Fighter	1977	1977	6
		500	SA-3	..	SAM mobile	1977	1977	250
		..	SA-7	..	SAM portable infantry	1977	1977	..
							1978	1 500
		31	T-34	..	Light tank	1976	1977	31
		100	T-54	..	Tank	1977	1977	50
							1978	50
		150	T-55	..	Tank	1977	1977	100
	Yugoslavia	50	M-47	..	Tank	1977	1977	50
Gabon	France	1	Esterel 42M	Esterel	Patrol boat	1976	1978	1
		3	Mirage-5	Dassault-Breguet	Fighter	1975	1977	3
		2	Mirage-5R	Dassault-Breguet	Tactical recce/fighter	1975	1977	2
		12	SS-12	Aérospatiale	ShShM	1976	1978	12
	Italy	2	Sarzana	Intermar	Patrol boat	1975	1977	1
	USA	1	C-130H Hercules	Lockheed	Military transport	1977	1977	1
Gambia	UK	1	Fairey Lance	Fairey Marine	Gunboat	1975	1977	1

Recipient	Supplier	No. of items	Item	Firm	Description	Date of order	Date of delivery[c]	No. delivered[c]
Ghana	FR Germany	2	Lürssen 45M	Lürssen Werft	Patrol boat	1977	..	..
		2	Lürssen 58M	Lürssen Werft	Patrol boat	1977	..	..
	Italy	8	MB-326K	Aermacchi	Light attack/COIN	1976	1977	4
							1978	4
Guatemala	Israel	10	IAI-202 Arava	IAI	STOL transport	1977	..	..
	USA	6	Broadsword-P105	Halter Marine	Patrol boat	1975	1977	1
Guinea	China	2	"Shanghai-2"	..	Fast gunboat	1976	1977	2
Honduras	Israel	6	Mystère-4A	Dassault-Breguet	Bomber	1976	1977	6
		6	Mystère-4A	Dassault-Breguet	Bomber	1977	..	..
India	France	12	Alize	Dassault-Breguet	ASW fighter	1977	..	..
		..	R-550 Magic[b]	HAL	AAM	1977	..	..
		140	SA-315B Cheetah[b]	HAL Bangalore	Light helicopter	1971	1973	6
							1974	14
							1975	18
							1976	12
							1977	20
		99	SA-316B Alouette-3[b]	HAL Bangalore	Helicopter	1974	1975	30
							1976	30
							1977	39
		3 000	SS-11[b]	Bharat	ATM	1970	1972	250
							1973	250
							1974	400
							1975	400
							1976	400
							1977	400
	Poland	50	TS-11 Iskra	WSK-Mielec	2-seat jet trainer	1975	1976	20
							1977	30
	UK	100	Gnat Mk 2	HAL Bangalore	Fighter/bomber	1973	1976	5
							1977	5
		10	HS-748M	HAL	Military transport	1972	1976	5
							1977	5
		6	"Leander"	Mazagon Dock	Frigate	1964	1972	1
							1974	1
							1976	1
							1977	1
		5	Sea King	Westland	ASW helicopter	1977	..	..

		144	Seacat	Short	ShAM	1972	1972	24
							1974	24
							1976	24
							1977	24
		1 000	Vijayanta-2[b]	Avadi	Tank	1974	1975	100
							1976	100
							1977	100
	USA	2	Boeing-737-100	Boeing	Transport	1977	..	..
	USSR	4	Il-38	Ilyushin	ASW aircraft	1975	1977	4
		600	K-13A Atoll	Bharat	AAM	1972	1973	30
						1972	1974	60
							1975	120
							1976	120
							1977	120
							1978	90
							1979	60
		5	Ka-25 Hormone	Kamov	ASW helicopter	1976	1978	5
		2	"Kashin"	..	ASW destroyer	1976	1978	2
		150	MiG-21-Bis[b]	HAL	Fighter	1976	1977	12
							1978	12
		100	MiG-21M[b]	HAL Nasik	Fighter	1972	1973	5
							1974	10
							1975	20
							1976	20
							1977	20
							1978	15
							1979	10
		8	"Nanuchka"	..	Missile patrol boat	1975	1977	3
		8	"Osa 65"	..	Missile patrol boat	1975	1977	2
		92	SSN-11	..	ShShM	1976	1978	..
		84	SSN-2	..	ShShM	1976	1976	24
							1977	24
		144	SSN-9	..	ShShM	1974	1977	54
Indonesia	Australia	6	N-22B Nomad	GAF	Cargo/transport	1977	..	..
		6	Type 16H	..	Patrol boat	1976	1977	6
	France	..	MM-38 Exocet	Aérospatiale	ShShM	1976	1979	..
							1980	..
		6	SA-330 Puma	Aérospatiale-Westland	Helicopter	1977	..	..
	FR Germany	50	Bo-105C[b]	Nurtanio	Helicopter	1975	1976	16
							1977	34
		8	F-27 Mk 400M	VFW/Fokker	Military transport	1975	1976	4
							1977	4
		4	F-27 Mk 400M	VFW/Fokker	Military transport	1977	1978	4
		2	Type 209	Howaldtswerke	Submarine	1977	..	..
	South Korea	4	..	Korea Tacoma	Fast attack patrol boat	1976	1979	..

Recipient	Supplier	No. of items	Item	Firm	Description	Date of order	Date of delivery[c]	No. delivered[c]
	Netherlands	3	Wilton	Fijenoord	Fast patrol boat	1975	1979	1
	Spain	28	C-212	Nurtanio	Utility transport	1975	1976 1977	3 3
	USA	16	Beech T-34 C-1 Turbo-Trainer	Beechcraft Corp	Armed trainer	1977	1978	16
		16	Bell 205	Bell	Helicopter	1977	..	..
		12	F-5E Tiger-2	Northrop	Fighter	1977	..	..
		30	LT-200[b]	Nurtanio	Trainer	1977	1976 1977 1978	6 10 20
		16	OV-10F Bronco	Rockwell	Light strike	1975	1976 1977	5 11
Iran	France	36	AS-12	Aérospatiale	ASM	1974	1976 1977	18 18
		12	Kaman 79	CMN	Missile patrol boat	1974	1979	..
	Italy	6	AB-212	Agusta	Helicopter twin-engine utility	1974	1976 1977	3 3
		50	CH-47C Chinook	Agusta	Helicopter	1977	1978	..
		2	S-61A-4	Agusta	Helicopter	1976	1977	2
	Netherlands	1	F-27 Mk 400M	VFW/Fokker	Military transport	1976	1977	1
		1	F-27 Mk 600	VFW/Fokker	Transport	1976	1977	1
	UK	1500	Chieftain Mk 5	Vickers/Royal Ordnance	MBT	1976	1977 1978	150 150
		..	Fox	Royal Ordnance	Armoured car	1975	..	..
		71	FV-4204	Vickers/Royal Ordnance	Armoured recovery vehicle	1975	1976 1977	50 21
		175	FV-4204	Vickers/Royal Ordnance	Armoured recovery vehicle	1977	..	..
		..	FV-4205	Vickers/Royal Ordnance	AVLB	1977	..	..
		..	Rapier M-548	BAC	SAM, tracked	1976	..	..
		110	Scorpion	Alvis-British Leyland	Light tank	1976	1977	110
		1	..	Swan Hunter	Fleet replenishment ship	1974	1978	1
		4	Supply ship	Yarrow	Logistics support/supply	1977	1981	..
	USA	216	AGM-65A Maverick	Hughes	ASM	1974	1976 1977	108 108
		222	AGM-84-A Harpoon	McDonnell-Douglas	ShShM	1974	1979	..
		424	AIM-54A	Hughes	AAM	1974	1976 1977 1978	100 200 124
		516	AIM-7E Sparrow	Raytheon	AAM	1976	..	..
		432	AIM-7F Sparrow	Raytheon	AAM	1974	1976 1977	216 216
		..	AIM-9L Sidewinder	Raytheon	AAM	1977	1980	..

432	AIM-9L Sidewinder	Raytheon	AAM	1974	1976 1977	216 216
164	AIM-9L Sidewinder	Raytheon	AAM	1975	1977	164
1 070	AIM-9L Sidewinder	Raytheon	AAM	1974	1976 1977 1978	350 432 288
202	Bell AH-1J	Bell	Gunship helicopter	1972	1974 1975 1976 1977	25 50 50 77
287	Bell-214A	Bell	Helicopter	1972	1975 1976 1977 1978	45 105 120 17
6	Bell-214A	Bell	Helicopter	1977	1978	6
39	Bell-214C	Bell	SAR helicopter	1976	1976 1977 1978	3 30 6
2 880	BGM-71A	Hughes	ATM	1972	1974 1975 1976 1977	400 700 700 1 080
1	Boeing 707-320C	Boeing	Tanker/freighter	1977	1978	1
12	Boeing 747-131	Boeing	Tanker/transport	1975	1976 1977	6 6
4	Boeing 747-200F	Boeing	Freighter	1977	1977 1978	1 3
7	E-3A AWACS	Boeing	Airborne warning/control	1977	. .	. .
80	F-14A	Grumman	Fighter/strike carr.-B	1974	1976 1977 1978	20 36 24
160	F-16A	General Dynamics	Light fighter/strike	1977	1980	. .
36	F-4E Phantom	McDonnell-Douglas	Fighter	1973	1976 1977	18 18
28	F-5F Tiger-2	Northrop	2-seat fighter	1975	1977	28
. .	FGM-77A Dragon	McDonnell-Douglas/ Raytheon	ATM shoulder-launched	1977	. .	. .
. .	M-113 A1	Ford	Armoured car	1976	. .	. .
. .	MIM-23B Hawk	Raytheon	SAM	1977	. .	. .
3	P-3C Orion	Lockheed	ASW/patrol	1976	1977	3
5	RF-4E Phantom	McDonnell-Douglas	Recce/fighter	1977	1979	5
6	RH-53D	Sikorsky	Mine countermeasures helicopter	1975	1976 1977	3 3
. .	RIM-67A Standard	General Dynamics	ShShM/ShAM	1974	. .	. .
4	"Spruance"	Litton	Destroyer	1974	1980	1
3	"Tang"	Portsmouth Electric	Submarine	1975	. .	. .

Recipient	Supplier	No. of items	Item	Firm	Description	Date of order	Date of delivery[c]	No. delivered[c]
	USSR	200	ASU-85	..	SP A/T-gun	1976	1977 1978	100 100
		500	BMP-76	..	Armoured car	1976	1977 1978	125 125
		6 000	SA-7	..	SAM portable infantry	1976	1977 1978	3 000 3 000
		6 000	SA-9	..	SAM land-mobile low-altitude	1976	1977 1978	3 000 3 000
		200	ZSU-23-4	..	SP A/A-gun	1976	1977 1978	100 100
Iraq	Czechoslovakia	30	L-39 Albatross	Aero	Jet trainer	1973	1977	10
		30	L-39Z Albatross	Aero	Trainer/ground attack	1973	..	..
	France	60	AM-39 Exocet	Aérospatiale	ASM	1976	1976 1977	18 42
		..	AMX-10P	Giat	Armoured car	1977	..	..
		..	AMX-30	Giat	MBT	1977	..	..
		72	Mirage F1-C	Dassault-Breguet	Fighter	1977	..	..
		360	HOT	Euromissile	ATM	1976	1977	120
		..	R-550 Magic	Matra	AAM	1976	..	..
		10	SA-321G Super Frelon	Aérospatiale	Medium lift helicopter	1976	1976 1977	2 8
		40	SA-330 Puma	Aérospatiale-Westland	Helicopter	1977	..	..
		60	SA-342 Gazelle	Aérospatiale-Westland	LOH	1976	1977	10
	Switzerland	16	MBB-223K Flamingo	Farner-Pilatus	Trainer	1977	..	..
	USA	8	C-130H Hercules	Lockheed	Military transport	1976	..	..
	USSR	..	AA-2 Atoll	..	AAM	1976	1977	210
		5	An-12	Antonov	Transport	..	1977	5
		5	An-24	Antonov	Transport	..	1977	5
		138	MiG-23	Mikoyan	Fighter	1976	1977	35
		10	"Osa"	..	Missile patrol boat	1976	..	..
		675	SA-6	..	SAM land-mobile	1977	1977	135
		..	SSN-2 Styx	..	ShShM	1976	..	..
		600	T-62	..	MBT	1976	1977	150
Israel	UK	36	Blowpipe	Short	SLAM	1972	1977 1978	24 12
		3	Type 206	Vickers	Submarine	1972	1977 1978	2 1
	USA	18	AH-1S Huey Cobra	Bell	Gunship helicopter	1977	1977 1978	6 12

		300	AIM-7F Sparrow	Raytheon	AAM	1975	1976	48
							1977	204
							1978	48
		300	AIM-9L Sidewinder	Raytheon	AAM	1975	1976	48
							1977	204
							1978	48
		200	BGM-71A TOW	Hughes	ATM	1977	1977	72
							1978	128
		8	CH-47C Chinook	Boeing-Vertol	Helicopter	1973	1976	4
							1977	4
		45	"Dabur-77"[b]	. .	Coastal patrol boat	1973	1975	10
							1976	20
							1977	15
		4	E-2C	Grumman	AEW	1976	1977	2
							1978	2
		23	F-15A Eagle	McDonnell-Douglas	Fighter/interceptor	1975	1976	4
							1977	15
							1978	4
		150	F-16A	General Dynamics	Light freighter/strike	1977	1980	. .
		. .	FGM-77A Dragon	McDonnell-Douglas/ Raytheon	ATM shoulder-launched	1975	. .	. .
		20	Flagstaff Mk 2[b]	Grumman	Hydrofoil patrol boat	1977	. .	. .
		5	HH-53C ELINT	Sikorsky	Helicopter	1976	1977	1
		2	KC-130H	Lockheed	Tanker/transport	1975	1976	1
							1977	1
		100	M-109	Ford	155-mm howitzer	1976	1977	50
							1978	50
		700	M-113 A1	Ford	Armoured car	1976	1977	100
		15	M-728	. .	Combat engineer vehicle tracked	1977	1977	5
							1978	10
		100	RGM-84A Harpoon	McDonnell-Douglas	ShShM	1975	1978	. .
		12	S-61R	Sikorsky	Helicopter amphibious transport	1975	1976	4
							1977	8
		2	TF-15A Eagle	McDonnell-Douglas	Combat trainer	1975	1977	2
Ivory Coast	France	6	Alpha Jet	Dassault/Dornier	Jet trainer	1977	1980	. .
		1	"Batral"	CMN	Transport ship	1977	. .	. .
		2	. .	Darcachon	Fast patrol boat	1977	1978	. .
		1	P-48	SFCN	Fast patrol boat missile	1975	1977	1
		24	SS-12	Aérospatiale	ShShM	1975	1977	24
	Netherlands	2	F-28	Fokker/VFW	Transport	1975	1977	2
Jamaica	UK	1	BN-2A Defender	Britten-Norman	Transport	1977	. .	. .
Jordan	USA	10	AH-1S	Bell	Gunship helicopter	1977	. .	. .

Recipient	Supplier	No. of items	Item	Firm	Description	Date of order	Date of delivery[c]	No. delivered[c]
		288	AIM-9J Sidewinder	Raytheon	AAM	1974	1975	108
							1976	144
							1977	36
		60	BGM-71A TOW	Hughes	ATM	1977	..	..
		2	C-130B Hercules	Lockheed	Military transport	1976	1976	1
							1977	1
		44	F-5E Tiger-2	Northrop	Fighter	1974	1975	18
							1976	24
							1977	2
		4	F-5F Tiger-2	Northrop	2-seat fighter	1974	1977	4
		..	M-110 A1	..	SP howitzer	1977	..	..
		700	M-113 A1	Ford	Armoured car	1976	1977	100
		100	M-48	..	MBT	1976	1977	50
							1978	50
		100	M-60-A1	Chrysler Corp	MBT	1976	1977	50
							1978	50
		532	MIM-23B Hawk	Raytheon	SAM	1974	1977	532
		4	S-76	Sikorsky	Helicopter troop-carrier	1976	1978	4
		100	M-61-A-1 Vulcan	General Electric	Air defence system	1974	1977	100
Kenya	Canada	4	DHC-5D Buffalo	DeHavilland Canada	Transport	1976	1977	2
							1978	2
	UK	6	BAC-167 Strikemaster	BAC	Armed trainer/COIN	1977	..	..
		2	BN-2A Defender	Britten-Norman	Transport	1977	..	..
		..	Fox	Royal Ordnance	Armoured car	1975	..	..
		40	Mk 3	Vickers	MBT	1977	..	..
	USA	10	F-5E Tiger-2	Northrop	Fighter	1976	1977	4
							1978	6
		2	F-5F Tiger-2	Northrop	2-seat combat trainer	1976	..	..
North Korea	USSR	..	MiG-21MF[b]	Mikoyan	Fighter	1974	1978	..
South Korea	Italy	..	Fiat-6614 CM[b]	Fiat	APC	1976	1977	20
	USA	12	A-37A	Cessna	COIN/trainer	1976	1977	12
		200	AGM-65A Maverick	Hughes	ASM	1976	..	..
		10	AH-1J	Bell	Gunship helicopter	1976	1977	10
		341	AIM-7E Sparrow	Raytheon	AAM	1977	1979	341
		733	AIM-9J Sidewinder	Raytheon	AAM	1972	1974	220
							1975	240
							1976	210
							1977	63

		600	AIM-9L Super Sidewinder	Raytheon	AAM	1975	1977	60
		45	Bell 205	Bell	Helicopter	1977	..	..
		1 152	BGM-71A TOW	Hughes	ATM	1976	1977	360
		10	C-123	Fairchild	Transport	1976	1977	10
		6	C-130H Hercules	Lockheed	Military transport	1977	..	..
		4	CPIC[b]	Korea Tacoma	Coastal patrol boat	1974	1977	2
		18	F-4E Phantom	McDonnell-Douglas	Fighter	1977	1979	..
		54	F-5E Tiger-2	Northrop	Fighter	1975	..	..
		72	F-5E	Northrop	Fighter	1975	1974 1975 1976 1977	22 24 21 5
		6	F-5F Tiger-2	Northrop	2-seat fighter	1975	1977	6
		2	"Gearing"	..	Destroyer	1976	1977	1
		24	Honest John	..	SSM battlefield support	1977	..	..
		100	Hughes-500M Defender	Hanjin	Helicopter missile	1976	1976 1977	4 30
		15	M-88 A1	Bowen-McLaugh	Tank recovery vehicle	1977	..	..
		45	MIM-14B Nike Hercules	Western Electric	SAM	1976	1977	45
		..	MIM-23B Hawk	Raytheon	SAM	1977	..	..
		24	OV-10G Bronco	Rockwell	COIN/trainer	1976	1977	24
		7	PSMM[b]	Korea Tacoma	Missile armed fast patrol boat	1974	1977	2
		120	RGM-84A Harpoon	McDonnell-Douglas	ShShM	1975	1978	..
		22	T-33A	Lockheed	Trainer	1972	1972 1973 1974 1975 1976 1977	4 4 4 4 4 2
Kuwait	France	..	Crotale	Thomson-CSF	SAM	..	1977	..
		2	Mirage F-1B	Dassault-Breguet	2-seat trainer	1973	1977	2
		18	Mirage F-1C	Dassault-Breguet	Fighter	1973	1976 1977	8 10
		120	MM-38 Exocet	Aérospatiale	ShShM	1977	..	..
		120	R-550 Magic	Matra	AAM	1973	1976 1977	48 72
		120	Super R-530	Matra	AAM intercept	1973	..	..
	UK	165	Chieftain Mk 5	Vickers/Royal Ordnance	MBT	1977	..	..
		18	Jaguar International	Breguet-BAC	Tactical support aircraft	1977	..	..
		10	..	Vosper	Missile armed fast patrol boat	1977	..	..
	USA	30	A-4M Skyhawk	McDonnell-Douglas	Bomber	1975	1977 1978	15 15

Recipient	Supplier	No. of items	Item	Firm	Description	Date of order	Date of delivery[c]	No. delivered[c]
		300	AIM-9H Sidewinder	Raytheon	AAM	1975	1977 1978	150 150
		2	C-9B Skytrain II	McDonnell-Douglas	Transport	1976	1977	2
		50	MIM-23B Hawk	Raytheon	SAM	1974	1977	50
		6	TA-4K Skyhawk	McDonnell-Douglas	Combat trainer	1975	1977 1978	4 2
	USSR	..	SA-7	..	SAM portable infantry	1977	..	..
Laos	USSR	6	An-24	Antonov	Transport	1976	1976 1977	2 4
		6	Mi-8	Mil	Helicopter	1976	1976 1977	2 4
		8	MiG-21MF	Mikoyan	Multirole fighter	1976	1977	10
		2	MiG-21UTI	Mikoyan	Tandem trainer	1976	1977	..
		1	Yak-40	Yakovlev	Transport	1976	1977	1
Libya	Brazil	200	EE-9	Engesa	Armed recce car	1977	1978	..
	France	40	MM-38 Exocet	Aérospatiale	ShShM	1976	1977	20
		2	..	CNIM	Tank landing ship	1975	1977 1978	1 1
		16	Mirage F-1A	Dassault-Breguet	Fighter	1975	1977	8
		6	Mirage F-1B	Dassault-Breguet	2-seat trainer	1975	1977	6
		16	Mirage F-1C	Dassault-Breguet	Fighter	1975	1977	8
		60	OTOMAT	Oto Melara/Matra	ShShM	1974	..	..
		10	"Combattante II"	CMN	Fast attack/missile patrol boat	1976	1977	5
		228	R-550 Magic	Matra	AAM	1975	1977	132
	Italy	8	CH-47C Chinook	Agusta	Helicopter	1976	1977	8
		4	..	CNR	Missile corvette	1975	1977	1
		1	S-61A-4	Agusta	Helicopter	1976	1977	1
		200	SF-260W Warrior	SIAI-Marchetti	Light attack/COIN	1977	..	..
	Spain	4	"Agosta"	..	Submarine	1976	..	..
	USSR	36	AS-4	..	ASM	1975	1977	12
		24	"Osa"	..	Fast patrol boat	1975	1976 1977	12 12
		288	SSN-2 Styx	..	ShShM	1975	1976 1977	144 144
		200	T-72	..	MBT	1976	1976 1977	50 150

		12	Tu-22	Tupolev	Bomber, long-range	1975	1977	4
	Yugoslavia	50	G-2AE Galeb	Soko	Armed trainer	1975	1977	10
Malaysia	France	96	MM-38 Exocet	Aérospatiale	ShShM	1976	..	..
		20	SA-341K	Aérospatiale	Helicopter	1976	1977	10
	FR Germany	6	Jaguar-2[b]	Lürssen	Fast patrol boat	1975	1977	2
		1	Lürssen[b]	Leong-Lürssen	Survey ship	1975	1977	1
		3	Lürssen PX	Lürssen	Fast patrol boat	1975	1978	..
	Israel	..	Gabriel-2	IAI	ShShM	1976	..	..
	Italy	5	AB-212	Agusta	Helicopter twin-engine utility	1974	..	..
	Sweden	4	"Spica-M"	Karlskrona	Fast patrol boat, attack	1976	1978	..
	UK	..	AT-105	GKN Sankey	APC wheeled	1977	..	..
	USA	16	S-61A-4	Sikorsky	Helicopter	1977	1978	..
Mauritius	Canada	2	DHC-5D Buffalo	DeHavilland Canada	Transport	1977	..	..
	UK	4	BN-2A Defender	Britten-Norman	Transport	1977	..	..
Mexico	Israel	10	IAI-201 Arava	IAI	STOL transport	1977	..	..
	UK	10	"Azteka"	..	Patrol boat	1975	1977	1
Morocco	France	3	"Batral"	CMN	Cargo ship	1975	1977	2
		25	Mirage F-1C	Dassault-Breguet	Fighter	1976	1978	..
		25	Mirage F-1C	Dassault-Breguet	Fighter	1977	1979	..
		48	MM-38 Exocet	Aérospatiale	ShShM	1977	..	..
		6	P-32	CMN	Coastal patrol boat	1976	..	..
		2	PR-72	..	Coastal patrol boat	1973	1977	1
		2	PR-72	..	Coastal patrol boat	1976	..	..
		300	R-550 Magic	Matra	AAM	1977	1978	..
	Switzerland	10	AS-202-18 Bravo	FFA	Trainer	1977	1978	..
	USA	1 000	BGM-71A TOW	Hughes	ATM	1975	1977	500
							1978	500
		6	C-130H Hercules	Lockheed	Military transport	1976	1977	6
		1	Gulfstream-2	Grumman	Transport	1976	1977	1
		334	M-113 A1	Ford	Armoured car	1975	1977	100
		10	MIM-72A Chaparral	Ford	Mobile-to-aircraft	1976	1977	10
		20	T-2D Buckeye	Rockwell	Trainer	1976	..	..
		12	T-34C-1 Turbo-Mentor	Beech	Trainer	1975	1977	12
Mozambique	USSR	20	BTR-40P-2	..	Armoured car	1976	1977	20
		12	MiG-21MF	Mikoyan	Multirole fighter	1976	1977	12

Recipient	Supplier	No. of items	Item	Firm	Description	Date of order	Date of delivery[c]	No. delivered[c]
		300	SA-7	. .	SAM portable infantry	1976	1977	300
		40	T-34	. .	Light tank	1976	1977	40
Nicaragua	Spain	5	C-212 Aviocar	CASA	Utility transport	1977	1977	5
Nigeria	France	3	"Combattante-3"	. .	Fast patrol boat	1977	1980	. .
		36	MM-38 Exocet	Aérospatiale	ShShM	1977	1980	. .
		11	SA-330 Puma	Aérospatiale-Westland	Helicopter	1977	. .	. .
	FR Germany	1	Blohm	Blohm/Voss	Frigate	1977	. .	. .
		3	Lürssen	Lürssen	Fast patrol boat	1977	. .	. .
	Italy	18	OTOMAT	Oto Melara/Matra	ShShM	1977	. .	. .
	UK	2	Brooke	Brooke Marine	Large patrol boat	1974	1977	2
		12	Bulldog-120	Scottish Aviation	Primary trainer	1977	1978	. .
		20	Fox	Royal Ordnance	Armoured car	1975	1977	20
		20	Scorpion	Alvis-British Leyland	Light tank	1975	1977	20
		18	Seacat	Short	ShAM	1975	1978	. .
		2	Vosper Mk 9	Vosper	Missile corvette	1975	1978 1979	1 1
	USA	7	CH-47C Chinook	Boeing-Vertol	Helicopter	1977	. .	. .
Oman	France	42	MM-38 Exocet	Aérospatiale	ShShM	1976	1977	42
		72	R-550 Magic	Matra	AAM	1975	1977	72
	UK	4	. .	Brooke Marine	Fast patrol boat	1974	1977	4
		1	. .	Brooke Marine	Special purpose logistics ship	1977	1979	1
		12	Jaguar International	Breguet-BAC	Tactical support aircraft	1974	1977	12
		28	Rapier	BAC	SAM, land/vehicle-based	1974	1977	28
Pakistan	China	60	F-6	Shenyang	Fighter	1976	1976 1977	30 30
	France	24	AM-39 Exocet	Aérospatiale	ASM	1976	. .	. .
		2	Breguet 1150	Dassault-Breguet	Marine patrol aircraft	1976	1977	2
		9	Crotale AMX-30	Matra Thomson	SAM	1975	1977	9
		10	Mirage-3R	Dassault-Breguet	Fighter-bomber/intruder	1975	1977	10
		10	Mirage-5	Dassault-Breguet	Fighter	1975	1977	10
		120	R-550 Magic	Matra	AAM	1975	1977	120
		35	SA-330	Aérospatiale-Westland	Helicopter	1977	. .	. .

	Portugal	1	Daphne	..	Submarine	1975	1977	1
	USA	840	AIM-9J Sidewinder	Raytheon	AAM	1976	1977 1978	420 420
		200	BGM-71A TOW	Hughes	ATM	1976	..	..
		2	"Gearing"	..	Destroyer	1976	1977	2
Panama	USA	7	Bell 205	Bell	Helicopter	1976	1977	7
Papua New Guinea	Australia	3	N-22B Mission Master	GAF	Cargo/transport	1977	1977	3
Paraguay	Brazil	10	AT-26 Xavante	EMBRAER	Armed trainer/COIN	1977	..	..
		10	EMB-110 Bandeirante	EMBRAER	Military transport	1977	..	..
Peru	Cuba	12	MiG-21	Mikoyan	Fighter	1976	1976 1977	6 6
	France	33	AS-30	Aérospatiale	ASM	1973	1976 1977	24 9
		3	"Combattante-2"	CMN	Fast patrol boat	1977	..	..
		14	Mirage-5	Dassault-Breguet	Fighter	1975	1976 1977	10 4
		12	MM-38 Exocet	Aérospatiale	ShShM	1977	..	..
	FR Germany	2	Type 209	..	Submarine	1975	..	..
	Italy	6	AB-212	Agusta	Helicopter, twin-engine utility	1976	1977	2
		4	Aspide-1A Albatros	Selenia	ShAM	1975	..	..
		4	"Lupo"[b]	Contieri Navali	Helicopter carrier/ASW	1974	..	..
		2	"Maestrale"	Contieri Navali	Improved "Lupo"-class ASW ship	1974	1978	1
		40	OTOMAT	Oto Melara/Matra	ShShM		1979	2
	Netherlands	1	..	..	Missile cruiser	1977	..	..
		2	F-27MPA Friendship	Fokker	Marine patrol	1976	1977	2
	UK	11	B-1-58	BAC	Bomber	1974	1976 1977	8 3
	USA	3	L-100-20 Hercules	Lockheed	Transport	1976	1977	3
		6	T-34C-1 Turbo-Mentor	Beech	Trainer	1977	1977 1978	3 3
	USSR	4	An-26	Antonov	Short-haul transport	1976	1977	4
		31	Mi-8	Mil	Helicopter	1976	1976 1977	6 25

Recipient	Supplier	No. of items	Item	Firm	Description	Date of order	Date of delivery[c]	No. delivered[c]
		10	SA-3	..	SAM, mobile	1976	1977	10
		100	SA-7	..	SAM, portable infantry	1976	1977	50
							1978	50
		36	Su-22	Sukhoi	Fighter-bomber	1976	..	..
		150	T-55	..	Tank	1976	1976	75
							1977	75
Philippines	Australia	74	DH Type 77	DeHavilland	Fast patrol boat	1975	1976	24
							1977	24
	FR Germany	38	Bo-105[b]	PADC	Helicopter	1974	1974	8
							1975	10
							1976	10
							1977	10
	UK	35	BN-2A Defender[b]	PADC	Transport	1974	..	..
		10	Scorpion	Alvis-British Leyland	Light tank	1976	1977	10
	USA	4	C-130H Hercules	Lockheed	Military transport	1976	1977	2
		2	HU-16B Albatross	Grumman	ASW fighter	1976	1977	2
		35	Vought F-8H Crusader	LTV	Fighter/attack	1977	1978	..
Qatar	Brazil	20	EE-9 Cascavel	Engesa	Armed recce car	1974	1976	10
							1977	10
	France	12	AMX-10P	Giat	Armoured car	1975	1977	12
		12	AMX-30	Giat	MBT	1975	1977	12
	UK	10	Spear 77 QAT	Fairey Marine	Fast patrol boat	1976	1977	10
		3	WG-13 Lynx	Westland/Aérospatiale	ASW helicopter	1976	1977	3
Rhodesia	France	20	Cessna F-337	Reims	Trainer	1976	1977	20
	UK	14	BN-2A Islander	Britten-Norman	Transport	..	1977	14
	USA	4	OV-10F Bronco	Rockwell	Light strike	1976	1977	4
South Africa	Canada	3	CL-215	Canadair	Multi purpose amphibious transp aircr	1975	1977	3
	France	360	AS-12	Aérospatiale	ASM	1974	1976	180
							1977	180
		30	AM-39	Aérospatiale	ASM	1974	..	..
		100	Eland-2[b]	Panhard	Armoured car	1976	1977	100
		36	MM-38	Aérospatiale	ShShM	1976	..	..

		32	Mirage-F1A[b]	Atlas	Fighter	1971	1977	..
	Israel	24	Gabriel-2	IAI	ShShM	1974	1978	..
		6	"Reshef"	ISR Yard, Haifa	Fast attack missile patrol boat	1974	1978	..
	Italy	100	Impala Mk 2	Atlas	Armed trainer/COIN	1974	1975	4
							1976	30
							1977	30
	Spain	6	..	Sandhoek, Austria	Corvette	1975	..	..
Saudi Arabia	France	250	AMX-10	Giat	Armoured car	1974	1975	50
							1976	50
							1977	50
		250	AMX-10	Giat	Armoured car	1975	1975	50
							1976	50
							1977	50
		22	SA-316B Alouette-3	Aérospatiale	Helicopter		1976	12
							1977	10
		..	Shahine	Thomson-CSF-Matra	SAM	1974	1980	..
	Italy	2	S-61A-4	Agusta	Helicopter	1977	..	..
	Japan	6	KV-107-2A	Kawasaki	SAR helicopter	1977	1978	..
	UK	21	BAC-167 Strikemaster	BAC	Armed trainer/COIN	1976	1977	21
		100	Fox	Royal Ordnance	Armoured car	1974	1977	50
		250	Scorpion	Alvis-British Leyland	Light tank	1974	1977	50
	USA	4	"322"-Class	Peterson	Coastal minesweeper	1975	1978	4
		650	AGM-65A Maverick	Hughes	ASM	1975	1976	325
							1977	325
		117	AGM-84-A Harpoon	McDonnell-Douglas	ShShM	1975	1979	..
		850	AIM-9J Sidewinder	Raytheon	AAM	1975	1976	425
							1977	425
		1 000	BGM-71A TOW	Hughes	ATM	1976	..	..
		8	C-130H Hercules	Lockheed	Military transport	1975	1977	8
		6	..	..	Missile corvette	1976	..	..
		20	F-5F Tiger-2	Northrop	Combat trainer	1976	1977	6
		400	FGM-77A Dragon	McDonnell-Douglas/ Raytheon	ATM	1976	1978	..
		12	..	Halter Marine	Coastal patrol boat	1976	..	..
		3	KC-130H Hercules	Lockheed	Tanker/transport	1975	1977	3
		..	MIM-23B Hawk	Raytheon	SAM	1976	..	..
		9	..	Tacoma	Missile patrol boat	1974	..	..
		6	..	..	Fast patrol boat	1976	..	..
Senegal	France	1	P-48	SFCN	Large patrol boat	1975	1977	1
		24	SS-12	Aérospatiale	ShShM	1975	1977	24
	UK	1	Lance	Fairey Marine	Fast patrol boat	1974	1977	1

Recipient	Supplier	No. of items	Item	Firm	Description	Date of order	Date of delivery[c]	No. delivered[c]
Singapore	UK	10	Tracked Rapier	BAC	SAM	1976	1977	10
	USA	200	AIM-9L Super Sidewinder	Raytheon	AAM	1976	..	..
		17	Bell 205A-1	Bell	Helicopter	1976	1977	17
		3	Bell-212	Bell	Helicopter	1977	1977	3
		18	F-5E Tiger-2	Northrop	Fighter	1976	..	..
		3	F-5F Tiger-2	Northrop	2-seat fighter	1976	..	..
		7	TA-4S Skyhawk	McDonnell-Douglas	Fighter	1972	1977	4
Sri Lanka	UK	5	..	Cheverton	Fast patrol boat	1977	..	..
Sudan	Brazil	6	EMB-110 Bandeirante	EMBRAER	Military transport	1976	1977	3
	Canada	4	DHC-5D Buffalo	DeHavilland Canada	Transport	1976	1977	2
		1	DHC-6 Twin Otter	DeHavilland Canada	Transport	1976	1977	1
	France	50	AMX-10	Giat	Armoured car	1977	..	..
		14	Mirage-50	Dassault-Breguet	Fighter	1977	1978	..
		10	SA-330 Puma	Aérospatiale-Westland	Helicopter	1977	1978	..
	FR Germany	20	Bo-105	MBB	Helicopter	1977	1977	10
	USA	6	C-130H Hercules	Lockheed	Military transport	1977	..	..
Surinam	Netherlands	3	..	.	Patrol boat	1975	..	..
Syria	Austria	2 000	Pinzgauer	Steyr-Daimler	All-terrain armoured vehicle	1977	..	..
	France	2 000	Milan	Euromissile	ATM	1975	..	..
		15	SA-321G Super Frelon	Aérospatiale	Medium lift helicopter	1975	1977	15
		15	SA-342 Gazelle	Aérospatiale-Westland	LOH	1976	1977	15
	Italy	18	AB-212	Agusta	Helicopter	1976	..	..
		6	CH-47C Chinook	Agusta	Helicopter	1976	1977	6
		12	SH-3D	Agusta	Helicopter ASW	1976	..	..
	Switzerland	16	MBB-223K Flamingo	Farner-Pilatus	Trainer	1977	..	..
	USA	2	L-100-20	Lockheed	Transport	1976	..	..
	USSR	180	AA-2 Atoll	..	AAM	1975	1977	180
		30	MiG-21MF	Mikoyan	Multirole fighter	1975	1977	30
		500	T-55	..	Tank	1976	1976 1977	250 250
		60	T-72	..	MBT	1977	..	..

Taiwan	USA	1 046	AIM-9J Sidewinder[b]	AIDC	AAM	1973	1974	6
							1975	30
							1976	180
							1977	288
		2	ASROC	..	Ballistic anti-submarine missile	1976	1977	2
		2	"Gearing"	..	Destroyer	1976	1977	2
		24	MIM-23B Hawk	Raytheon	SAM	1976	..	..
		20	MIM-72A Chaparral	Ford	SAM	1976	1977	20
		2	Scimitar	Halter Marine	Fast patrol boat	1976	..	..
		15	..	Tacoma	Fast patrol boat	1976	..	..
		180	F-5E Tiger-2	AIDC	Fighter	1973	1974	1
							1975	2
							1976	30
							1977	48
	USSR	..	Gabriel-2	IAI	ShShM	1977	..	..
Thailand	France	12	MM-38 Exocet	Aérospatiale	ShShM	1976	1979	..
	Indonesia	4	C-212 Aviocar	Nurtanio	Transport	1976	..	..
	Israel	15	Gabriel-2	IAI	ShShM	1973	1976	10
							1977	5
	Italy	3	..	Breda	Fast patrol boat	1976	..	..
	Singapore	3	Lürssen 45M	Lürssen Werft	Fast patrol boat	1973	1976	2
							1977	1
	Switzerland	5	PC-6 Turbo-Porter	Pilatus	Transport	1976	1977	5
	USA	96	AIM-9J Sidewinder	Raytheon	AAM	1976	..	..
		13	Bell 205 Iroquois	Bell	Helicopter	1977	..	..
		2	Bell-212	Bell	Helicopter	1977	1977	2
		13	F-5E Tiger-2	Northrop	Fighter	1976	..	..
		3	F-5F Tiger-2	Northrop	Combat trainer	1976	..	..
		2	Merlin-4A	Swearingen-Merlin	Transport	1977	1977	1
							1978	1
		6	OV-10C Bronco	Rockwell	Armed trainer/COIN	1977	..	..
Togo	France	5	Alpha Jet	Dassault/Dornier	Jet trainer	1977	1980	..
Tunisia	Austria	45	Kurassiers	Steyr-Daimler	Light tank	1976	..	..
	China	2	Yu Lin	Shanghai	Coastal patrol boat	1976	1977	2
	France	1	A-69 Aviso	..	Corvette	1972	..	..
	Italy	3	G-222	Aeritalia	Military transport	1975	..	..
		8	MB-326K	Aermacchi	Light attack/COIN	1976	1977	4
							1978	4

Recipient	Supplier	No. of items	Item	Firm	Description	Date of order	Date of delivery[c]	No. delivered[c]
		4	MB-326L	Aermacchi	Trainer	1976	1977	4
	UK	2	Vosper 103-ft	Vosper	Fast patrol boat	1974	1977	2
	USA	..	AGM-65A Maverick	Hughes	ASM	1976	..	..
		..	AIM-9J Sidewinder	Raytheon	AAM	1976	..	..
		10	F-5E Tiger-2	Northrop	Fighter	1976	..	..
		2	F-5E Tiger-2	Northrop	Combat trainer	1976	..	..
		..	MIM-72A	Ford	Mobile-to-aircraft	1977	..	..
Uganda	Switzerland	6	AS-202 Bravo	FFA	Trainer	1977	1977	6
Uruguay	Argentina	12	F-86F Sabre	North American	Fighter	1976	1977	12
Venezuela	France	1	Mirage-3E	Dassault-Breguet	Fighter-bomber/intruder	1977	1977	1
		6	Type 32M	Esterel Cannes	Coastal patrol boat	1975	1976 1977	4 2
	FR Germany	2	Type 209	Howaldtswerke	Submarine	1971	1976 1977	1 1
	Italy	2	AB-212	Agusta	Helicopter	1977	1977	..
		48	Aspide Albatros	Selenia	ShAM	1976	1978	..
		21	..	INMA, La Spezia	Coastal patrol boat	1973	..	..
		6	"Lupo Super Alpino"	CNR	Frigate	1975	1978	..
		48	OTOMAT	Oto Melara/Matra	ShShM	1975	1978	..
	UK	20	B-1-8 Canberra	BAC	Bomber	1976	1977	2
	USA	6	Bell-206B JetRanger	Bell	Helicopter	1976	1976 1977	3 3
		1	Bell-206L	Bell	Helciopter	1976	1977	1
		12	T-2D Buckeye	Rockwell	Trainer	1975	1976 1977	2 10
Upper Volta	UK	1	HS-748M	Hawker-Siddeley	Military freighter	1976	1977	1
Yemen	Saudi Arabia	4	F-5B Freedom Fighter	Northrop	Combat trainer	1977	1977	4
		20	Vigilant	BAC	ATM	1977	1977	20

Zaire	China	20	T-62	..	Tank	1977	1977	20
	France	20	Cessna-337 Milirole	Reims	Light strike	1977	1977	3
		12	..	..	Coastal patrol boat	1974	..	..
	USA	1	C-130H	Lockheed	Military transport	1977	1977	1
Zambia	Italy	10	AB-47G	Agusta	Light helicopter	1977	1977	10
	Sweden	20	MFI-17 Supporter	Saab-Scania	Armed trainer/COIN	1975	1976	15
							1977	5

[a] Member of the United Arab Emirates, which created a joint Union Defence Force in May 1975.
[b] Items produced in the recipient country under licence from the supplier country.
[c] Dates of delivery and numbers of weapons delivered from 1978 onwards are those planned for the particular items.

AA anti-aircraft
AIDC Aero Industry Development Center
ARV armoured recovery vehicle
AT anti-tank
ATM anti-tank missile
AV armoured vehicle
AVLB armoured vehicle, bridge layer
BAC British Aircraft Corporation
CMN Constructions Mechaniques de Normandie
DEF defence
FFA Flug- und Fahrzeugwerke AG Altenrhein
GAF Government Aircraft Factories
HOW howitzer
IAI Israel Aircraft Industries
LTV Ling-Temco-Vought Inc.
MBB Messerschmitt-Bölkow-Blohm
NZAI New Zealand Aircraft Industry
PADC Philippine Aerospace Development Corp.
SFCN Société Française de Construction Navale
VFW Vereinigte Flügtechnische Werke-Fokker
WSK Wytwórnia Sprzetu Komunikacyjnego

9. Sources and methods for the world armaments data

Square-bracketed numbers, thus [1], *refer to the list of references on page* 297.

This chapter describes the sources and methods used in the preparation of the appendices on military expenditure, arms production and arms trade (appendices 6A, 7A, 7B and 8A). Only the main points are noted here. Further details on the arms production registers are given in the SIPRI Yearbook 1974 and on the arms trade registers in the SIPRI Yearbook 1973. The four appendices are updated versions of those which appeared in the SIPRI Yearbook 1977. The register of the arms trade with industrialized countries, which has previously appeared in the SIPRI Yearbooks, is not presented in this Yearbook but will appear in the SIPRI Yearbook 1979. This is due to the fact that the arms trade with the Third World was this year given special attention (see also the analysis in chapter 8), since this topic is of particular interest for the United Nations special session devoted to disarmament to be convened in May 1978.

I. Purpose of the data

Together, the military expenditure tables and the arms production and trade registers form the nucleus of a comprehensive, quantitative and qualitative survey of world armaments. The purpose of the military expenditure estimates is to provide an indication of the overall volume of military activity in different countries, and of the resources absorbed by this activity. The arms production and trade registers show the origin, flow, costs and main characteristics with regard to the technical sophistication of the major weapons now being acquired in all countries. The main purpose of including military electronics and aero-engines in the arms production registers for the Third World is to illustrate the level of technology acquired. An analysis of the trade in arms and in arms production technology will be presented in the forthcoming SIPRI publication *The Global Arms Trade*, which will also include a complete set of country registers of arms imports for the period 1945–77, as well as some coverage of the transfer of small arms. Our data on the arms trade and arms production are currently being computerized, which means that requests for particular information such as the SIPRI worksheets will be more easily met in the future. It is also planned to computerize the military expenditure data. Background information of academic interest, such as the sources, and the SIPRI values used for individual weapons, will also be available.

Countries and time period covered

The appendices cover all the countries in the world.

The tables of military expenditure data, appendix 6A, are presented by region in the following order: NATO (North Atlantic Treaty Organization), WTO (Warsaw Treaty Organization), Other Europe, Middle East, South Asia, Far East, Oceania, Africa, Central America and South America. The individual countries are listed alphabetically within each of these regions.

Appendix 7A, arms production in the industrialized countries, includes register I, the indigenous arms production, and register II, the licensed production. Both registers in appendix 7A list the industrialized countries by region (NATO, WTO, Other Europe and Other Developed, the latter comprising Australia, China, Japan and New Zealand).

Appendix 7B, arms production in Third World countries, includes register I, the indigenous production of major arms, and register II, the licensed production of major arms. Both registers list the Third World countries in alphabetical order.

Appendix 8A, the arms trade with Third World countries, lists the recipient countries in alphabetical order. Tables 8A.1 and 8A.2—aggregate tables of the values of arms imports by the Third World and of exports by supplier countries—are presented by region corresponding to the regions employed in the military expenditure tables. (Aggregate tables of the values of arms imports by the industrialized countries will be presented in the forthcoming SIPRI publication on the global arms trade.)

The absence of a country or an entire region from one or another of the arms production or trade registers means that no activity of the type indicated has been found for that area.

The arms production registers include only the items believed to have been actually in production or under development during the calendar year 1977. The arms trade register covers items on order or delivered in 1977.

In the case of the military expenditure series it should be noted that in this edition of the *Yearbook* the figure for the most recent year is generally a budget estimate; deflation used for the constant dollar values for 1977 is estimated, and the figures for all the preceding years are, in general, final figures for actual outlays in that year. The degree of uncertainty relating to figures derives from the fact that contingencies may result in actual expenditures which differ—occasionally very widely—from the budgeted amounts; and government accounting procedures can require a considerable time after the closing of the fiscal year to arrive at a final figure for the total amount paid out during that period.

The military expenditure estimates refer to the calendar year in all cases. For countries where the government fiscal year differs from the calendar year, conversion to a calendar-year basis is made on the assumption of an even rate of expenditure throughout the fiscal year.

II. Sources

The sources of the data presented in the appendices are of five general types: official national documents; journals and periodicals; newspapers; books, monographs and annual reference works; and documents issued by international and intergovernmental organizations. The common criterion for all these sources is that they are open sources, available to the general public.

The official national documents include budgets; parliamentary or congressional proceedings, reports and hearings; statistics, White Papers, annual reports and other documents issued by governments and agencies; and statements by government officials and spokesmen. These and the journals, periodicals and newspapers contain information relating to both military expenditure and weapon production and trade. Comparatively few books or monographs are used, since the information in such works is generally too dated. An exception is annual reference works, which contain up-to-date information. The main official international documents used are those containing information relating to military expenditures. There are no surveys published by international or intergovernmental organizations on weapon production or trade.

The fact that different sources may give conflicting information on the same item necessitates an evaluation of the reliability of all the sources prior to entering the item in the arms *trade* registers in particular. In future, a reliability index of the most frequently used sources will be made by mathematically weighting the sources to facilitate their use in compiling the SIPRI data.

The following list shows a selection of the periodical publications which are regularly perused for relevant data:

Journals and periodicals

Aerospace International (Bonn-Duisdorf)
Africa Research Bulletin (Exeter, UK)
Air Actualités (Paris)
Air et Cosmos (Paris)
Air Force Magazine (Washington)
Air International (Bromley, UK)
Antimilitarismus Information (Frankfurt)
Arab Report and Record (London)
Armament Data Sheets (London, Aviation Studies Atlantic)
Armed Forces Journal (Washington)
Armies and Weapons (Genoa)
Asian Recorder (New Delhi)
Aviation and Marine International (Zurich)
Aviation Week and Space Technology (New York)

Campaign against Arms Trade, Newsletter (London)
Congressional Quarterly Weekly Report (Washington)
Defense and Foreign Affairs Digest (Washington)
Defense Business (Washington)
Défense Conjoncture (Neuilly, France)
Défense Interarmées (Neuilly, France)
Defense Monitor (Washington)
Défense Nationale (Paris)
Economist (London)
Facts and Reports (Amsterdam)
Far Eastern Economic Review (Hong Kong)
Flight International (London)
Forces Armées Françaises (Paris)
IDSA News Review on China, Mongolia and the Koreas (New Delhi, Institute for Defence Studies & Analyses)
IDSA News Review on Japan, South East Asia and Australasia (New Delhi, Institute for Defence Studies & Analyses)
IDSA News Review on South Asia (New Delhi, Institute for Defence Studies & Analyses)
IDSA News Review on West Asia (New Delhi, Institute for Defence Studies & Analyses)
IMF Survey (Washington, International Monetary Fund)
Interavia (Geneva)
Interavia Airletter (Geneva)
Interavia Data (Geneva)
International Affairs (London)
International Air Forces and Military Aircraft Directory (Stapleford, UK, Aviation Advisory Services)
International Defense Review (Geneva)
International Financial Statistics (Washington, International Monetary Fund)
Keesing's Contemporary Archives (Bristol)
Latin America (London)
Latin America Economic Report (London)
Milavnews (Stapleford, UK, Aviation Advisory Services)
Military Review (US Army Command and General Staff College)
Missiles and Rockets (Washington)
Monthly Bulletin of Statistics (New York, United Nations)
Monthly Bulletin of Statistics, The Republic of China (Taipei)
NACLA's Latin America & Empire Report (New York)
National Defense (Washington)
Nato Review (Brussels)
New Times (Moscow)
Österreichische Militärische Zeitschrift (Vienna)
Official Price List (London, Aviation Studies Atlantic)
Quarterly National Accounts Bulletin (Paris, OECD)
Soldat und Technik (Frankfurt)
US Naval Institute Proceedings (Annapolis, Md.)
Wehrtechnik (Bonn-Duisdorf)
3. Welt Magazin (Bonn)

Newspapers

Anti-Apartheid News (London)
Dagens Nyheter (Stockholm)
Daily Telegraph (London)
Financial Times (London)

Hindustan Times (New Delhi)
International Herald Tribune (Paris)
Japan Times (Tokyo)
Krasnaja Zvezda (Moscow)
Le Monde (Paris)
Neue Zürcher Zeitung (Zurich)
New York Times (New York)
Pravda (Moscow)
Rand Daily Mail (Johannesburg)
Standard Tanzania (Dar-es-Salaam)
Sunday Times (London)
Svenska Dagbladet (Stockholm)
Times (London)

Annual reference publications

For data on military expenditure, gross domestic product or net material product:

Africa (Africa Journal Ltd., London)
Africa Contemporary Record (Rex Collings, London)
Africa Guide (Africa Guide Company, Saffron Walden, UK)
Africa South of the Sahara (Europa Publications, London)
AID Economic Data Book: Africa . . . Far East, . . . Latin America, . . . Near East and South Asia (Washington, United States Agency for International Development)
Asia Yearbook (Far Eastern Economic Review Ltd., Hong Kong)
Europa Year Book—A World Survey (Europa Publications, London)
"Defence Expenditures of NATO Countries", NATO press release (Brussels, NATO)
Far East and Australasia (Europa Publications, London)
Far Eastern Economic Review Yearbook (Far Eastern Economic Review Ltd., Hong Kong)
Middle East and North Africa (Europa Publications, London)
Military Balance (London, International Institute for Strategic Studies)
Sivard, R. L., *World Military and Social Expenditures* (WMSE Publications, Leesburg, Virginia)
Statesman's Year-Book (Macmillan, London)
Statistical Yearbook (New York, United Nations)
World Military Expenditures and Arms Transfers (Washington, United States Arms Control and Disarmament Agency)[1]
Yearbook of National Accounts Statistics (New York, United Nations)

For data on weapon production or trade:

"Aerospace Forecast and Inventory", annually in *Aviation Week and Space Technology* (McGraw-Hill, New York)
Defense and Foreign Affairs Handbook (Copley & Associates, Washington)

[1] This source was previously called *World Military Expenditures and Arms Trade*, and before that, *World Military Expenditures*.

International Air Forces and Military Aircraft Directory (Stapleford, UK, Aviation Advisory Services)
Jane's All the World's Aircraft (Macdonald & Co., London)
Jane's Fighting Ships (Macdonald & Co., London)
Jane's Infantry Weapons (Macdonald & Co., London)
Jane's Weapon Systems (Macdonald & Co., London)
Jane's World Armoured Fighting Vehicles, C. F. Foss (Macdonald & Co., London)
"Military Aircraft of the World", annually in *Flight International* (IPC Transport Press, London)

III. Definitions and restrictions

The military expenditure estimates are intended to show the amount of money actually spent (outlays) for military purposes. It should be noted that in many countries there are alternative series for funds budgeted, appropriated (set aside) or obligated (committed to be spent). Since our objective is to show the volume of activity, series for actual expenditures have been chosen in preference to these alternatives. Even with this series, there may be some misrepresentation of the volume of activity—particularly for the United States and to a lesser extent for other major arms-producing countries—since payment for arms procurement may lag behind the actual production work. The expenditure series has the advantage, however, of being the only final measure of the actual amount of resources consumed.

Military expenditures are defined to include weapon research and development, to include military aid in the budget of the donor country and to exclude it from the budget of the recipient country, and to exclude war pensions and payments on war debts.

For calculating the ratio of military expenditure to national product, either gross domestic product (GDP) at purchasers' values or net material product (NMP) has been used, following the practice of the individual countries in identifying national product. GDP is defined as "the final expenditure on goods and services, in purchasers' values, *less* the c.i.f. [cost, insurance, freight] value of imports of goods and services" [1]. NMP is defined as "the net (of depreciation) total amount of goods and productive series produced in a year expressed at realized prices" [2]. The ratio of military expenditure to national product will generally be higher when NMP is used, since this measure excludes a variety of services which are included in GDP.

The arms production and trade registers cover primarily the four categories of "major weapons"—that is, aircraft, missiles, ships and armoured vehicles. Strictly speaking, all of these except missiles are potential "weapon platforms", while missiles are part of "weapon systems". However, our use of the term "weapon" or "major weapon" by and large conforms with general practice. The great majority of the aircraft, ships and armoured vehicles entered in the registers are armed: as such they constitute either the central component of a weapon system which is generally identified by reference to that platform or a major unitary fighting system. For the production of indigenously designed weapons and for licensed production in developed countries (appendix 7A), only the *armed* ships and armoured vehicles are included. However, all aircraft—even unarmed transport and utility planes—are covered. The reason for the different treatment of aircraft is twofold. First, most aircraft can easily be converted to carry armaments and to form effective fighting platforms. This is not equally true of unarmed armoured vehicles and support ships. Second, the technology required to produce aircraft of any kind is generally more advanced than that required for armoured vehicles and ships which may not differ significantly from their widely produced civilian counterparts. Coverage of the arms imports by the Third World countries (appendix 8A) and licensed production in Third World countries (appendix 7B) is extended to include unarmed ships and armoured vehicles as well as unarmed aircraft, the criterion for inclusion simply being delivery to the armed forces of the country concerned. This results in the listing of a very small number of items of the type not included in the indigenous production register.

As a result of the exclusion of small arms, ammunition and artillery, the coverage of arms imports by Third World countries is estimated to reflect only about one-half of the total procurement of military equipment in these regions. In the case of the developed countries, which are generally equipped with more sophisticated weaponry, the proportion would probably be considerably higher. One main aspect of the procurement activity in all countries, which is not reflected in the register, is that associated with infrastructure and support equipment, such as land-based radar systems, communications networks, data-processing facilities, and so on. The satellite systems produced by the United States and the Soviet Union for the purposes of reconnaissance, navigation and communications constitute the most advanced and expensive type of support equipment not covered by the register: funds for the development and production of space systems are estimated to account for about 6 per cent of the annual US budget for procurement of weapons and equipment.

IV. Military expenditure tables (appendix 6A)

The estimates of the military expenditures of NATO countries are taken from official NATO data, the figures for Warsaw Treaty Organization countries other than the USSR are from national budgets, and the estimates for the remaining countries in the world are in general taken from the United Nations *Statistical Yearbook*. The figures for the Soviet Union are SIPRI estimates, the methodology of which was explained in the *SIPRI Yearbook 1974* [3]. For many countries, the estimates for the most recent years are based on budget figures derived from newspapers and journals and other sources described above.

In order to provide time series estimates of total world military expenditure at constant prices, two operations must be performed. First, all national expenditure must be converted into a common currency: the most widely used unit for such a purpose is the US dollar, which SIPRI has also adopted. For this purpose it is necessary to use constant exchange rates, preferably those prevailing in a recent year. Second, it is necessary to adjust for the effect of changes in the level of prices.

For most countries we have used the official exchange rate in 1973 or, if this fluctuated during the year, the weighted average rate. For the Warsaw Treaty Organization countries, special purchasing power parities were used because these yielded more reasonable expenditure relationships both within the WTO and between these countries and the rest of the world. For WTO countries other than the USSR, purchasing power parities calculated by Benoit and Lubell were used [4]. For the USSR, SIPRI estimates of the rouble : dollar purchasing power parity have been calculated [3]. Since the 1974 SIPRI study, there has been a significant change of opinion in the US intelligence community concerning the volume of resources devoted to defence in the USSR. Throughout the 1950s and 1960s the open literature on this subject, both official and unofficial, had two general characteristics. First, it was assumed that the official Soviet defence budget was not comprehensive and that additional military expenditure was included in the allocation to "Science" and in the general residuals (unallocated expenditures) to be found in the State budget. Second, there was a widely held view that, because the military sector was a high-priority recipient of resources, its efficiency was relatively great. This meant that the rouble : dollar conversion ratios for military activities were relatively low, or that a relatively small number of roubles would translate into a relatively large number of dollars. This body of literature was reviewed and forms the basis of the SIPRI estimate of the dollar-equivalent of Soviet military expenditure [3].

The prevailing opinion in official US agencies[2] is new in at least two respects [5]. First, the "residuals" approach to estimating Soviet military expenditure appears to have been abandoned. Second, it is now felt that the relative efficiency of the military sector in the Soviet Union has been greatly overestimated in the past. The latter reassessment does not affect calcula-

[2] The Central Intelligence Agency (CIA), the Defense Intelligence Agency (DIA) and the Office of Net Assessment, Department of Defense.

tions of the dollar-equivalent of Soviet military expenditure. These estimates are now prepared, primarily by the US Central Intelligence Agency, by directly costing the Soviet military apparatus—manpower, procurement, operations, and so on—at US prices. However, the new assessment has a major impact on estimates of Soviet military expenditure in rouble terms. Estimates of expenditure in roubles have increased by a factor of about 2. Similarly, current estimates of the percentage of Soviet GNP devoted to military purposes (around 11–13 per cent) are nearly double those advanced in the latter half of the 1960s (6–8 per cent).

So far no detailed explanation of this change of opinion has been made public. Nor, as far as is known, have any unofficial studies appeared that confirm the official view. If such confirmation becomes available, SIPRI would review its present method of estimating the dollar-equivalent of Soviet military expenditure.

The adjustment for changes in prices was made by applying the consumer price index in each country. In many countries this is the only price index available: as an index of the general movement of prices, it is a reasonable one for showing the trend in the resources absorbed by the military, in constant prices. For further detail on this point, the reader is referred to the *SIPRI Yearbook 1972* [6].

V. Registers of indigenously designed and licence-produced weapons in development or production (appendices 7A and 7B)

Arrangement and classification of entries

Within the four broad categories of major weapons (aircraft, missiles, ships and armoured vehicles), the systems produced by each country are arranged by function. Thus aircraft are presented as follows: bombers, fighters, strike aircraft, other combat aircraft (for example, maritime patrol), reconnaissance aircraft and other electronic equipment platforms, transports, trainers, utility planes, armed helicopters, transport helicopters and utility helicopters. For all these categories, except bombers, other combat aircraft, reconnaissance aircraft and armed helicopters, there is a further subdivision between heavier and lighter types.[3] In the case of missile systems, a set of abbreviated descriptions of the launching platform and target is employed, and entries are listed first by launching platform (fixed land-based, towed,

[3] In the case of transport aircraft, the following apply: heavy (over 200 000 kg), medium (50 000–200 000 kg), ordinary (10 000–50 000 kg). For fighter and strike aircraft, light types are defined as those weighing less than 11 000 kg. Most unarmed helicopters fall into one of the following categories: heavy lift (over 50 000 kg), medium transport (c. 20 000 kg), transport (c. 6 000–7 000 kg), utility (2 000–5 000 kg) or light utility (under 2 000 kg).

mobile, portable, fixed-wing aircraft, helicopter, ship, submarine) and, within these groups, by target (fixed land-based, tank, missile, fixed-wing aircraft, helicopter, ship, submarine). For ships, the following descriptive categories were evolved on the basis of the nomenclature employed by the majority of countries: strategic submarines (equipped with long-range strategic missiles), hunter-killer (counter-submarine) submarines (fast, nuclear-powered submarines without anti-ship missiles), anti-shipping submarines (equipped with anti-ship missiles), ordinary submarines, coastal submarines, aircraft carriers (over 30 000 tons displacement), cruisers (7 000–25 000 tons), destroyers (3 500–6 999 tons), frigates or escorts (1 300–3 499 tons), corvettes (500–1 299 tons) and patrol boats or missile boats (below 500 tons). In the few cases where national descriptive designations radically depart from the scheme—for example, the French use of "corvette" for a 3 000-ton ship—these standardized descriptions have been inserted in square brackets in place of the official one.

An attempt has been made to place newer systems first and older ones second, within the various functional groupings.

Aircraft, ship and armoured vehicle armaments

No attempt has been made to describe the armaments carried on the combat aircraft since, in general, these are not only too numerous for the space available but also variable (that is, most combat aircraft can carry a variety of alternative weapon loads). For armoured vehicles, the main armament is indicated in the first of the columns of standardized data. In the case of ships, symbols indicating the nature and number of all armaments except the limited-capability anti-submarine mortars and rocket launchers are shown directly after the description. The order in which ship armaments are listed is as follows: missiles (ship-to-ship, ship-to-air, ship-to-submarine, submarine-to-submarine, submarine-to-surface), guns, anti-submarine torpedo tubes or torpedo launchers and ordinary torpedo tubes.

System specifications

The data on speed, weight and range are maximum values in all cases. In some cases these values are dependent on a number of variables. For example, in the case of aircraft the figure given for speed is the maximum speed under optimal conditions, which generally means that the aircraft carries no external payload and is flying at or near its maximum altitude.

Programme history

The dates given for design, prototype test and production are initial dates only, except for data pertaining to the Soviet Union, where little official data relating to weapon system developments are published. In the case of the USSR, the dates shown in the prototype test column generally refer to the time when a system was first reported to have been observed. In most cases these dates probably postdate initial prototype tests by one or two years.

Numbers to be produced

For the industrialized countries, an attempt has been made to divide the total planned production number of each system, or the number on order, between units to be manufactured for domestic military acquisition and units manufactured for export. When such data were available, the numbers to be procured for domestic acquisition are shown first, followed by a stroke and then the numbers for export. When a figure for total production was available but it was not known whether any of this production was intended for export, or what proportion was intended for export, a single figure appears.

For the Third World countries, an attempt has been made to show the number planned for production, followed by a stroke and then the number produced to date.

Financial data

Data on research and development (R&D) costs refer to the total amount of money spent—or planned to be spent—on the development of the system over a period of years. Data on unit prices are average figures for the cost of an equipped item, excluding prorated R&D costs, spares and associated ground equipment.

The financial data should be used with great caution: they are intended to indicate general orders of magnitude only. It has not been possible to obtain standardized information, and in some cases the R&D costs and average unit prices have been calculated on a constant-price basis, with reference to some year in the early 1970s, while in the other cases the figures represent actual funds expended over a period of years, with no allowance made for inflation. Projected costs for systems to be produced later in the 1970s have an even greater element of uncertainty added to the non-comparability arising from the fact that some figures are based on price levels in the early 1970s while others are computed on the basis of projected price levels.

Foreign-designed components

The final column of the register of indigenously designed weapons produced in the industrialized countries shows the use of foreign-designed power plants (engines), armaments or electronic components, with the exporting country indicated in brackets. Occasionally a foreign-designed component can be the result of a collaborative effort by the two or more countries. Such cases are entered as follows: PP (Fr. + UK). Similarly, a weapon system may incorporate electronic components or armaments designed and/or produced in more than one foreign country. Such cases are entered as follows: Ar (USA, It.) or E (UK, Switz.).

Weapon production in the Third World

The registers for the Third World (appendix 7B) are arranged differently from those for the industrialized countries. There are two reasons for this. First, the volume of weapon production activity in most Third World countries is comparatively small. Second, one of the main points which these registers attempt to illuminate is the degree of self-sufficiency in weapon design and production which individual Third World countries have achieved.

For these reasons the Third World arms production registers are arranged by country rather than by type of major weapon or small arm, and for each country all weapon development and/or production activity is listed. This necessitated some changes in the column headings. In addition, the column headings have been changed to permit the recording of more details on the degree of indigenization of a given weapon production programme. This information is also used to value the arms trade component of weapons produced under licence.

VI. Arms trade register (appendix 8A)

The descriptive terminology used in appendix 8A differs slightly from that employed in appendices 7A and 7B, and generally follows the practice used in previous SIPRI registers of the arms trade.

Value of the arms trade

The SIPRI values of the arms trade do not correspond to current prices paid for the weapons but are estimates constructed as a trend-measuring device, as follows.

Over the post-war period, an enormous variety of weapons has been supplied to the Third World. One way of providing a single measure of this heterogeneous flow is to put it into monetary terms which reflect both the quantity and also the quality of the weapons transferred. The "actual" prices paid are inadequate for this purpose, even if they were known in all instances, first because of the wide range of financial arrangements that have evolved for arms transactions. The United States, for example, has donated large quantities of armaments to many countries and, in most cases, has valued these grants for its own accounting purposes at one-third of the acquisition cost of the particular item of equipment. Depending on the condition of the equipment, this procedure may understate or overstate the true value of the transaction. For some arms transactions, mostly those involving the Soviet Union, payment has been made indirectly in the form of raw materials, or under credit terms not comparable with Western practice. Sales at discount prices are also difficult to evaluate. Weapons transferred free of charge or on lease as well as those produced under licence would not be included at all if an attempt were made to use actual prices to measure the trend in arms transfers.

From a financial point of view, the arms trade is complex and the available official or semi-official data is far from sufficiently detailed and comprehensive to form the basis for a reliable and consistent assessment of the value of the arms trade over time. In addition, of course, some important suppliers release no information whatsoever.

Because of these circumstances, SIPRI undertook to value the arms trade independently by constructing a price list (based on prices in 1968) of all the major weapons transferred to the Third World, and by using this to value every transaction recorded. (For a full description of the methodology, see *The Arms Trade with the Third World* [7].) The transactions recorded were confined to major weapons because this is the only component of the arms trade which can be documented comprehensively from open sources. This is a limitation, but statistically not so serious that the SIPRI data collection cannot be used as a reliable arms trade sample, since, for example, in fiscal year 1973, major weapons accounted for 56 per cent of the total value of goods and services provided under the US Foreign Military Sales and Military Assistance programmes. The remaining 44 per cent was composed of ammunition, communications equipment, other equipment, construction, repair and rehabilitation, supply operations, training and other services.

Meaning of the SIPRI values

The SIPRI arms trade values represent an attempt to measure the quantity of resources transferred to the Third World in the form of major weapon systems. To the extent that major weapons account for a fairly stable share of the total trade, the SIPRI values can be used also as an index of the trend in the total value of military goods and services transferred to the Third World. There is good reason to assume that major weapons have taken up a fairly stable share of the total trade in weapons and related equipment, at least in the past. The comprehensive nature of some of the larger arms deals concluded in recent years, particularly with Middle East countries, suggests that such items as technical assistance, electronic equipment and logistical facilities will account for a growing share of the financial value of the arms trade over the next few years.

Other considerations

Three other considerations must be taken into account in reconciling the SIPRI estimates of the value of arms trade with the Third World and the official figures published by, for example, the United States. First, the official figures refer to total arms exports, a large percentage of which are exports to other industrialized countries. Second, the official figures refer to the total value of contracts signed during the year; the weapons and equipment involved may not actually be delivered until several years after the contract has been signed. The SIPRI values are based only on major weapons that have been physically transferred in a given year. As an example, foreign military sales by the USA in fiscal year 1973 amounted to $3.6 thousand million but actual deliveries under this programme in that year amounted to less than half this sum, or about $1.4 thousand million. When the contract value of a particular deal is made public, this information is included in the register but the figures are not used in estimating the annual value of weapon transactions. Finally, the SIPRI values are expressed in constant prices. The original price list, based on 1968, has been inflated to reflect 1975 price levels.

VII. Conventions and abbreviations

The following conventions and abbreviations are used in the tables and registers of world armaments data in the appendices:

Conventions

..	Information not available
( )	Uncertain data or SIPRI estimate. For military expenditure: estimates based on budget figures or using an estimated consumer price index, or both. For GDP, NMP data: where sources other than *National Account Statistics* are used
[ ]	For military expenditure: rough estimate
<	Less than the number given
>	More than the number given
~	Approximate number

–	Nil
1969–	1969 and subsequent years
n.a.	Not applicable
†	For military expenditure: year of independence
I	For military expenditure: GDP figures used for years after this symbol are not *strictly* comparable with those for preceding years

Abbreviations

A	Attack
A/A	Anti-aircraft
AAM	Air-to-air missile
ABM	Anti-ballistic missile
AC	Armoured car
AD	Air defence
AEW	Airborne early warning
AF	Air Force
aircr	Fixed-wing aircraft
ALBM	Air-launched ballistic missile
ALCM	Air-launched cruise missile
APC	Armoured personnel carrier
approx	Approximately
Ar	Armament
ARM	Anti-radar missile
A/S	Anti-submarine
A/SM	Anti-submarine missile
ASM	Air-to-surface missile
A/S TT	Anti-submarine torpedo tubes
ASW	Anti-submarine warfare
A/T	Anti-tank
ATM	Anti-tank missile
AWACS	Airborne warning and control system
B	Bomber
batt	battery
carr-b or land-b	Aircraft carrier-based or land-based
COIN	Counter-insurgency
com.&con.	Command and control
Co-prod	Co-production
CVR(T)	Combat vehicle reconnaissance (tracked)
D	Diesel
Displ	Displacement of naval vessels, in tons

E	Electronic equipment
ECM	Electronic countermeasures
E-d	Computer/data processing equipment
E-f	Fire-control system (for armaments)
E-g	Guidance system (for missiles)
E-n	Navigation equipment
E-r	Radar
E-s	Sonar
ELINT	Electronic intelligence
Ex-Im	Export-Import Bank
F	Fighter
FAC	Fast attack craft
FB	Fighter-bomber
fixed	Fixed land-based
FROG	Free rocket over ground
GT	Gas turbine
HE	High explosive
hel	Helicopter
I	Interceptor
ICBM	Intercontinental ballistic missile (range > 5 500 km)
Imp	Imported
Indig	Indigenization
IR	Infra-red
IRBM	Intermediate-range ballistic missile (range 2 750–5 500 km)
J	Jet
kt	Kiloton (1 000 tons of TNT equivalent)
L	Licence
LOH	Light observation helicopter
LP	Liquid propellant
LRCM	Long-range cruise missile
MAP	(US) Military Assistance Program
MBT	Main battle tank (heavy, medium)
MG	Machine-gun
MIRV	Multiple independently targetable re-entry vehicle
miss	Missile

Mk	Mark
mobile	Mobile ground-based
Mod	Model
MRBM	Medium-range ballistic missile (range 1 100–2 750 km)
MRV	Multiple re-entry vehicle
MSBS	Mer-sol balistique stratégique
Mt	Megaton (1 000 000 tons of TNT equivalent)
N	Nuclear
P	Piston
PBV	Post boost vehicle
portable	Portable (man-carried)
PP	Power plant
recce	Reconnaissance
Req	Requirement
RL	Rocket launcher
RV	Re-entry vehicle
S	Solid propellant
SAM	Surface- or Ship-to-air missile
SAR	Search and rescue/sea-air rescue
ShAM	Ship-to-air missile
ShShM	Ship-to-ship missile
ShSuM	Ship-to-submarine missile
SL	Storable liquid
SLAM	Submarine-launched air missile
SLBM	Submarine-launched ballistic missile
SLCM	Ship- or Submarine-launched cruise missile
SP	Self-propelled ground-based
Sqds	Squadrons
Srs	Series
SSM	Surface-to-surface missile
ST	Steam turbine
STOL	Short take-off and landing
sub	Submarine
SuShM	Submarine-to-ship-missile
SuSuM	Submarine-to-submarine missile
t	Ton
TF	Turbofan
TOW	Tube-launched, optically-tracked, wire-guided

towed	Towed ground-based
TP	Turboprop
transp	Transport
TS	Turboshaft
TT	Torpedo tube
USAF	United States Air Force
USN	United States Navy
vers	Version
VG	Variable geometry
V/STOL	Vertical or short take-off and landing
VTOL	Vertical take-off and landing

References

1. *Statistical Yearbook* (United Nations, New York, 1974), p. XVII.
2. Wilczynski, J., "The Economics of Socialism", in C. Charter (Ed.), *Studies in Economics*, Number 2 (George Allen and Unwin, London, 1967).
3. *World Armaments and Disarmament, SIPRI Yearbook 1974* (Almqvist & Wiksell, Stockholm, 1974, Stockholm International Peace Research Institute), appendix 8B, pp. 172–204.
4. Benoit, E. and Lubell, H., "The World Burden of National Defense", in E. Benoit (Ed.), *Disarmament and World Economic Interdependence* (Universitetsförlaget, Oslo, 1967).
5. *Allocation of Resources in the Soviet Union and China—1976*, Hearings before the Subcommittee on Priorities and Economy in Government of the Joint Economic Committee of the Congress of the United States (US Government Printing Office, Washington, 24 May and 15 June 1976), esp. pp. 4, 17–24, 41–43.
6. *World Armaments and Disarmament, SIPRI Yearbook 1972* (Almqvist & Wiksell, Stockholm, 1972, Stockholm International Peace Research Institute), pp. 78–79.
7. *The Arms Trade with the Third World* (Almqvist & Wiksell, Stockholm, 1971, Stockholm International Peace Research Institute), pp. 785–92.

Part III. Developments in arms control and disarmament

10. Disarmament and development

Square-bracketed numbers, thus [1], *refer to the list of references on page 316.*

I. Introduction

If one were to gather opinions on the issues that have most preoccupied the attention of the international community since World War II, it is likely that the majority of respondents would put disarmament and development at the top of the list. It may not seem, however, that the two issues have any more than this in common. After all, they do address very different problems.

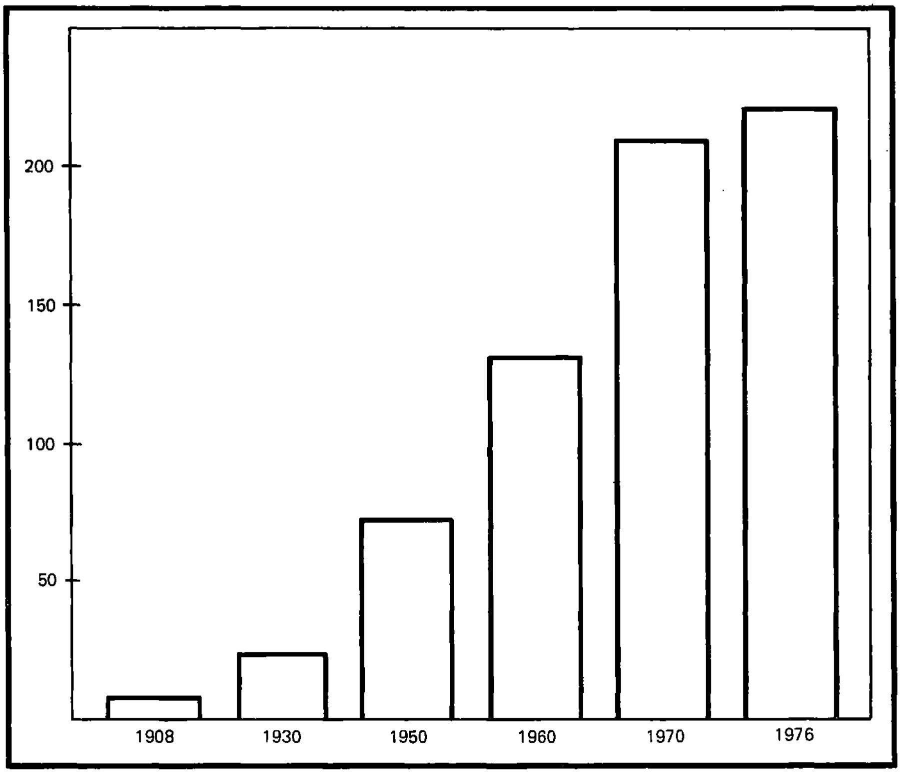
Development concerns the dichotomy between rich and poor countries. The rich countries, concentrated in the Northern Hemisphere, have productive capacities far in excess of that necessary to provide all the material requirements for their inhabitants, and have economies that, to a reasonable approximation, expand and diversify in a self-sustained fashion.

The so-called underdeveloped countries have economic systems that are typically weak and narrow in terms of the range of economic activities undertaken. Moreover, their economies do not grow and diversify in a self-sustaining fashion. Economic expansion must be planned and forcibly made to occur. While a degree of success has been achieved, it has been frustratingly inadequate. With very few exceptions, sustained rates of economic growth well in excess of the growth of population have not been achieved. For an enormous number of people, standards of living have been essentially static at an abysmal level for a long time and the "gap" between rich and poor countries has grown wider.

Disarmament is a very different issue. As a goal of the international community, it has a considerably longer history than development, which really only emerged after World War II. However, disarmament has also acquired a particular urgency since 1945. For the first time in history, man has devised and stockpiled the means for his own destruction. The two world wars already fought in this century brought destruction and loss of life on a scale unprecedented in history. But they did not in any way threaten the survival of mankind. A third world war, on the other hand, would present such a threat, at least to civilization as we know it. The central issue here, of course, is nuclear weapons; but in addition to the unbelievable destructive capacity embodied in the nuclear weapon stockpiles, the nations of the world also support very large conventional armed forces—far larger than in any other peacetime period (see figure 10.1).

Figure 10.1. World military expenditure, selected years, 1908–76

US $ thousand million, at constant 1970 prices



Source: Reference [13].

II. The link between disarmament and development

The rationale

Although disarmament and development may seem to be very different issues, active consideration is being given to linking them. The primary basis for such a link is money or, more accurately, the resources that money can buy. When they are juxtaposed, it is evident that there is a spectacular gap between the volume of resources devoted to armaments and the flow of official assistance to underdeveloped countries. In 1976, the resources devoted to armaments world-wide were valued at about $325 thousand million, while official development assistance (ODA) amounted to about $20 thousand million.[1] Put in another way, this

[1] This is a rough estimate. The latest official figure for ODA is $17.1 thousand million in 1975 [1a]. ODA is defined as grants and loans with a grant element of at least 25 per cent.

means that world armaments now absorb each year a quantity of resources far in excess of all the ODA provided over the past 20 years. The sheer size of the gap between these two aggregates accounts for much of the appeal of forging a link between them. A reduction in world military expenditure that would seem modest, even insignificant, from a disarmament standpoint could have a marked effect on the volume of development assistance.

Even if the comparison is broadened to include *all* financial flows to the underdeveloped countries, the gap between this total and world military expenditure is very large (figure 10.2). In 1975, total financial flows to underdeveloped countries were less than 15 per cent of world military expenditures, and even this figure would be reduced if account were taken of the factor income payments, primarily interest payments and profits, made by underdeveloped countries.

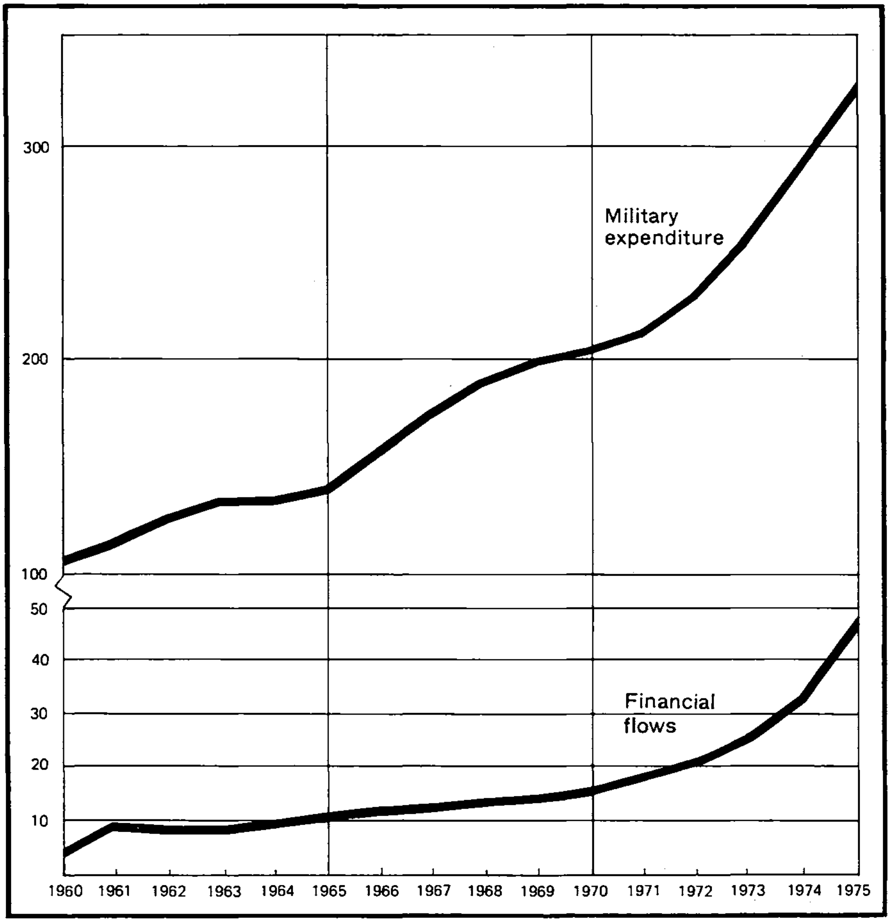
There is a judgement in this juxtaposition which it is just as well to make explicit, namely that expenditure on armaments is more dispensable than, say, expenditure on holidays and entertainment. Few would dispute this judgement. There is a surprisingly wide consensus that 30 years of arms racing and limited war have yielded levels of armament that, far from enhancing the security of states, have in fact diminished security. The paradox is more apparent than real. In a climate of secrecy, suspicion and misunderstanding, of rapidly changing military technology and powerful vested institutional and economic interests, the majority of countries have consistently reached the conclusion that it is on balance safer and much easier to continue the "race" than it is to withdraw. Nevertheless, it is significant that, if ways can be found to overcome or avoid these obstacles and to reduce arsenals and military expenditure, most people would regard this as a pure benefit.

The experience of the post-war period has demonstrated the immense complexity of the problem of underdevelopment. Increasing the volume of resources at the disposal of underdeveloped countries is by no means a sufficient condition for accelerated economic development, but it is a necessary one. It is also clear that the problem of securing additional resources for development will have to be tackled from many directions simultaneously. Governments will have to adopt measures to encourage private saving and to minimize their own consumption expenditures, while a significant improvement over the longer run of the terms of trade for underdeveloped countries must take place. But even if these and other measures are introduced, financial and technical assistance from the developed countries remains vital.

The picture here is not encouraging. The financial flows from members of the Development Assistance Committee (DAC) of the Organization for Economic Cooperation and Development (OECD), who provide more

Figure 10.2. Financial flows to underdeveloped countries and world military expenditure, 1960–75[a]

US $ thousand million, at current prices



[a] Financial flows to underdeveloped countries include, in addition to ODA, other official flows to underdeveloped countries, both bilateral and multilateral, and private direct investment. Financial flows from OPEC members are included for the years 1972–75.

Sources: The basic source was the *UN Statistical Yearbook*, several editions during 1961–75. Data for OPEC members were taken from reference [1]. World military expenditures in current prices were taken from reference [7].

than three-quarters of the estimated total of grant and concessionary assistance to underdeveloped countries, have not even matched inflation in recent years, as table 10.1 shows. Moreover, as a percentage of gross national product (GNP), the results achieved are well below the 0.7 per cent envisaged in the International Developmental Strategy for the decade

1971–80. It is true, of course, that the first half of the 1970s were difficult years from an economic standpoint, with sluggish growth, high unemployment and high inflation in most developed countries. It is noteworthy, however, that 14 of the 17 members of the DAC increased their military spending in real terms over the years 1971–75.

Table 10.1. DAC official development assistance, 1971–75

US $ mn

	1971	1972	1973	1974	1975
Net official development assistance					
Current prices	7 173	7 963	8 680	10 593	12 770
Constant (1970) prices	6 844	6 967	6 281	6 294	6 724
Per cent of GNP	*0.32*	*0.31*	*0.28*	*0.31*	*0.36*

Source: Reference [1b].

The resource link between disarmament and development is not confined, or should not be confined, to the possibility of significantly increasing the volume of resources transferred from developed to underdeveloped countries. Underdeveloped countries also divert significant quantities of resources to armaments and, on the whole, their military expenditures have been increasing rapidly. This aspect of the issue has not received the attention it deserves, so it is discussed more fully below.

Similarly, there is every reason to believe that the developed countries pay a high economic price for supporting large military establishments. This goes beyond the trite observation that resources devoted to armaments could be used in other, more useful, ways. A broad indication of this is provided by the fact that the economic performance of countries with relatively small military outlays, notably Japan and FR Germany, has been generally superior to that of those diverting a relatively large fraction of their resources to armaments.

It is likely, for example, that sustained high levels of military expenditure have a significant inflationary impact. Military expenditures are, of course, inherently inflationary, since they generate purchasing power but do not yield any offsetting increase in either consumable output or productive capacity. For those countries that support comprehensive defence industries and an associated research and development (R&D) capacity, the concentration of available funds and scientific and engineering talent in the military sector gives rise to inflationary pressures in another way. While the rate of technological advance and productivity growth is relatively high in sectors closely related to the military, essentially electronics and aerospace, it is correspondingly low in most other sectors, making the economy as a whole less capable of absorbing increases in the costs of production. Low productivity growth, in turn, discourages new investment, with the result that the capacity of many sectors in the economy to generate new employment is undermined. There is also evidence, at least for the United States, that a given sum of military expenditure generates less employment than the expenditure of an equivalent sum in many civil areas.[2]

It is important that the resource link between disarmament and development be considered as wider than the possibility of increasing the volume of resources transferred from rich to poor countries. Since all countries pay an economic price to maintain armed forces, an exclusive focus on the volume of international resource transfers that disarmament would make possible is likely to inhibit the emergence of widespread public support for disarmament. Similarly, the wider perspective admits the possibility of regional and even unilateral action to secure the economic benefits of disarmament or arms restraint.

Apart from the question of resources, it can also be argued that disarmament and development are linked in a more systemic way. Events in recent years—above all, of course, the oil crisis of 1973–74—have dramatized just how interdependent the nations of the world have become and how inevitable it is that this interdependence will grow. It follows that it will become progressively more difficult to insulate a nation or group of nations from the effects of economic and social upheavals, tensions and armed conflicts elsewhere in the world. From this standpoint, many observers see great danger in the prevailing dichotomy between rich and poor at both the national and international levels. It is difficult to pinpoint the form that these dangers may take, but it is easy to sense the fundamental incompatibility between the present enormous disparities in standards of living and the measure of stability that is required within nations to permit the most effective mobilization of energies and resources for development, and between nations to minimize the risk of confrontation, conflict and, above all, a nuclear holocaust. It is apparent that some general perception of this kind is part of the move to work towards a New International Economic Order.

[2] For a more extensive discussion of these and other relevant issues, including the general civilian utility of military R&D and the impact of military activities on the balance of payments and international trade patterns, the reader is referred to reference [3].

Past attempts to make the link

The proposition that disarmament and development should be linked is not in itself a new idea although, as the following chronological survey will make clear, the effort to forge a link has intensified considerably in recent years.

The reduction of military budgets has been a recurring disarmament proposal over the post-war period and on several occasions these proposals have been linked with the question of assistance to the underdeveloped countries. As early as 1953, the UN General Assembly, in Resolution 724A(VIII), urged its members that, when effective disarmament measures were implemented, a portion of the savings should be devoted to assisting the underdeveloped countries.

At the Geneva Summit Conference of July 1955, a French memorandum proposed that the resources made available by reductions in military budgets should be used in whole or in part to assist underdeveloped countries. Later in the same year, in Resolution 914(X), the General Assembly called upon the states concerned, especially those on the Subcommittee of the Disarmament Commission, to study the French proposal. The General Assembly repeated this request in subsequent years.

In March 1956, the Soviet Union proposed that a special fund for assistance to underdeveloped countries be established within the United Nations, to be financed by reductions in military budgets. Two years later the Soviet Union elaborated on this proposal in a draft resolution to the General Assembly recommending that France, the Soviet Union, the United Kingdom and the United States reduce their military budgets by 10–15 per cent and allocate part of the savings to a fund for development assistance.

In 1962 the UN published a report entitled *The Economic and Social Consequences of Disarmament*. The experts who prepared this report pointed out the following:

> A much larger volume of resources could be allocated to investment for productive development in [underdeveloped] countries even if only a fraction of the resources currently devoted to military purposes were used in this way. Disarmament could thus bring about a marked increase in the rate of growth of real income in the poorer parts of the world [4].

During 1964 Brazil submitted a working paper at the United Nations calling for the allocation of savings from the reduction of military budgets to development assistance. The Brazilian paper suggested that at least 20 per cent of the savings should go into an international fund for economic development, and for the conversion of economic activity from military to civil ends.

Following this, there appears to have been something of a hiatus until 1969. In that year, the General Assembly, in Resolution 2526(XXIV), requested member states to consider the possibility of using resources to further the objectives of the Second United Nations Development Decade. During the First Development Decade, the volume of official development assistance fell steadily, not only in relation to the gross national products of the donor countries but also to that of the underdeveloped countries, and was consistently well below UN objectives.

From about this time, efforts to link disarmament and development intensified. In a report published in 1972, a group of experts appointed by the UN Secretary-General pointed out that "a more substantial curtailment of the arms race would permit *for the first time* the kind of massive transfer of resources which could make a fundamental change in the prospects for economic and social development" [5].

In a subsequent UN report addressed specifically to the issues of disarmament and development, the authors introduced a note of caution on the question of a linkage. While this report emphasized the enormous potential in effective disarmament, the authors stressed that "fundamentally [disarmament and development] stand separately from one another" and "that national and international efforts to promote development should neither be postponed nor allowed to lag merely because progress in disarmament is slow" [6].

The issue of a link came to the forefront again in 1973, when the Soviet Union proposed that the five permanent members of the Security Council reduce their military budgets by 10 per cent and use part of the funds thus saved to provide assistance to the underdeveloped countries. This proposal was adopted by the General Assembly in Resolution 3093B(XXVIII) and led to a series of reports on how the international comparability of military budgets might be improved and on how reductions could be verified.

In 1976 the General Assembly, in Resolution 31/68(XXXI), called upon

> Member States and the Secretary-General to intensify their efforts in support of the link between disarmament and development . . . so as to promote disarmament negotiations and to ensure that the human and material resources freed by disarmament are used to promote economic and social development, particularly in the developing countries.

A second UN report on the economic and social consequences of the arms race, released in August 1977, strongly endorsed the need to link disarmament and development. Specifically, "the arms race with its economic costs and social and political effects, nationally and internationally, constitutes an important obstacle to effective progress . . .[on] the problem of development and the associated task of establishing a new international economic order" [3a]. "Development at an acceptable rate would be hard if not impossible to reconcile with a continuation of the arms race" and "disarmament should be so designed that [the] close connexion between disarmament and development gets full recognition" [3b]. The report points out that the transfer to development assistance of just 5 per cent of the current military expenditures of the developed market economies would be sufficient to fill the gap between realized and target volumes of development assistance [3c].

Finally, the United Nations commitment to the link between disarmament and development was very explicitly expressed by the Secretary-General in his *Report on the Work of the Organization* for 1977: "Disarmament must . . . be a vital part not only of our efforts to establish a better system of international peace and security, but also of our attempts to restructure the economic and social order of the world" [7].

Objections to the link

Before proceeding to discuss possible future action on linking disarmament with development, it is worthwhile briefly to consider several objections that have been raised to such a link. One broad objection to too strong a link has already been noted, namely that it would be unwise to create a situation in which accelerated development is dependent upon the achievement of disarmament. This is a valid point. Disarmament is clearly going to take a long time, although once the political will to achieve it exists, very substantial reductions in levels of armaments and military expenditure could be achieved in a comparatively short period, say, 10 years.

This is not the case with development. The achievement of significantly more equitable standards of living around the world is going to take many decades of consistently high rates of economic growth in the underdeveloped countries. In a recent study on the future of the world economy, Professor Leontief and others showed that in order to reduce the per capita income gap between rich and poor countries from the prevailing ratio of 12 : 1 to around 7 : 1 by the year 2000, the average rate of growth of per capita income in the underdeveloped countries will have to be even higher than the already ambitious targets set in the International Development Strategy for the Second Development Decade [8].

The message is clear. Development is going to require maximum effort over the very long term and countries should not allow the lure of a major "disarmament dividend" to undermine their resolve to mount such an effort or to delay it.

A second objection that can be raised is that if states are committed to military budget reductions, they may be tempted to concentrate their declining resources on forms of military power that offer the most "bang for the buck". The best example, of course, would be the temptation to abandon conventional forces in favour of a nuclear deterrent. More generally, agreements that focus exclusively on quantitative limitations, whether of military budgets or force levels, may lead to a more vigorous pursuit of the qualitative arms race. The force of this objection is much reduced by the fact that unless states were convinced that their security would be enhanced or at least not diminished by military budget reductions, they would not agree to such reductions in the first place. Nevertheless, interrelationships of this kind indicate "the importance of co-ordinating partial [arms control and disarmament] measures adopted in different fields" [3d].

A third line of objection stems from the fact that we seem to be a long way from negotiating agreements that involve any measure of real disarmament. The overwhelming concern at the present time is with "arms control" and in the priority list of criteria used to assess effective arms control agreements, the saving of resources is at the bottom. The foremost criteria are reducing the risk of the outbreak of war and reducing the devastation of war should it occur. There is no assurance that agreements directed at these two aims will result in lower total military expenditure. Indeed, it is perfectly conceivable that an agreement judged to be useful on these grounds would involve higher levels of expenditure.

This chapter will not assess the efficacy of the arms control approach in any detail but it seems pertinent to mention one consideration of particular relevance in the present context. The volume and trend of resources devoted to preparations for war always have and presumably always will communicate a strong message between potential adversaries. The value of an agreement that is judged to reduce the risk of war is likely to be short-lived if the magnitude and trend of military expenditure are unaffected.

III. Armaments and development

As mentioned above, a neglected aspect of the debate on the link between disarmament and development is the economic and social impact of the military in the underdeveloped countries themselves. This neglect may have been justified when military expenditures, arms imports and domestic arms production in underdeveloped countries were either very small or non-existent, but it is no longer justified today. Over the 20 years up to 1976, military expenditures in the underdeveloped countries increased, in real terms, by a factor of 6.5, and their share of the world total grew from 4.1 per cent in 1956 to 14.8 per cent in 1976. In current prices military expenditure in the underdeveloped countries taken as a group amounted to about $50 thousand million in 1976, scarcely an insignificant figure.

It is true that the members of OPEC (Organization of the Petroleum Exporting Countries) contribute disproportionately to these statistics but it should be remembered that, while these countries have comparatively lavish financial resources, they are in all other respects underdeveloped countries. If the OPEC countries are excluded, military expenditures in the remaining underdeveloped countries increased by a factor of 4.1 in real terms over the period 1956–76. Table 10.2 has been constructed to illustrate this point further.

Table 10.2. Military expenditure funds in underdeveloped countries grouped by per capita GNP, 1967–76[a]

Per capita GNP, 1971[a]	Number of countries	Per cent change in military expenditure 1967–76[b]	Average annual growth rate of military expenditure 1967–76[b]
I <$100	19	*+51*	*4.2*
II $100–199	18	*+168* (*+102*)	*10.4* (*7.3*)
III $200–399	23	*+236* (*+127*)	*12.9* (*8.6*)
IV $400–799	12	*+358* (*+36*)	*16.4* (*3.1*)
V >$800	9	*+170* (*+65*)	*10.4* (*5.2*)

[a] The figures in parentheses are the result of excluding from the sample (*a*) Israel, Egypt and Syria and (*b*) the members of OECD. Countries excluded, by group: II. Nigeria; III. Egypt, Syria; IV. Gabon, Iran, Iraq, Oman, Saudi Arabia; V. Israel, Kuwait, Libya, United Arab Emirates, Venezuela.
[b] Based on data at constant prices.

The same conclusion is inevitable if one examines the statistics on arms imports and the information on arms production in underdeveloped countries in appendices 8A and 7B respectively, bearing in mind that 20 years ago essentially no arms production was undertaken in these countries. The rate of growth of military expenditure has been sufficiently rapid to result in a rising fraction of gross domestic product devoted to the military in many underdeveloped countries (see table 10.3). Excluding the members of OPEC, military expenditures in the remaining underdeveloped countries represent about 4 per cent of their combined GNPs. Although this single figure conceals marked differences among underdeveloped countries, it does mean that, in the aggregate, military expenditures are significantly large in relation to such key variables in the development equation as domestic savings and investment.

Table 10.3. The distribution of military expenditure as a percentage of gross domestic product in underdeveloped countries: 1960 and 1974

Per cent

	c. 1960	c. 1974
< 1.0	*25.0*	*11.8*
1.0–1.9	*33.0*	*29.0*
2.0–2.9	*25.0*	*18.4*
3.0–4.9	*2.6*	*21.1*
5.0–9.9	*11.8*	*13.1*
> 10.0	*2.6*	*6.6*
Number of countries	76	76

Source: Reference [12].

Given these indicators of the scale and trend of resource consumption for military purposes in underdeveloped countries it seems entirely reasonable to assume that the military has a significant impact on the rate and direction of development. Accepting this to be the case, all countries should be anxious to know a great deal more about the economic and social impact of militarization than they do now.

Comparatively little empirical research has been done on the economic impact of the military in underdeveloped countries.[3] The most ambitious effort is a study by Emile Benoit [10]. Benoit found that the burden of the military, measured by military expenditure as a percentage of GNP, was positively correlated with the rate of growth of non-military GNP. This led him to argue that military expenditures were not directly competitive with resources for investment. On balance, Benoit argues, the direct and indirect growth stimulus provided by military spending more than offsets the indisputable fact that these resources might have been put to directly productive use. A key factor in this thesis is that,

> In reality . . . in most less developed countries only a small part of any income not spent on defense is put into highly productive investments. Most goes into consumption and much of the rest into social investment such as housing which may contribute more to consumer satisfaction than to increasing future production, or into "productive investments", which, however, are so badly conceived or managed that they operate at uneconomically high costs and contribute less to real growth than they may appear to do [10a].

Important questions remain, however. Benoit's proposition that the resources absorbed by the military are not likely to be used productively in any case is surely something that can be changed, and the low productivity of many civilian investments may be due, in part, to the fact that the military pre-empts the resources needed to secure higher pro-

[3] For a lucid and wide-ranging review of the literature on the role of the military in development, see reference [9].

ductivity. Further, there is no particular reason to suppose that a military-induced pattern of industrialization and growth is a desirable one; in fact there are grounds for presuming that it will not be.

The overwhelmingly predominant pattern of militarization in the Third World is the reproduction, on a miniature scale, of the armed forces supported by the highly industrialized states. In Third World countries the armed forces are centred around the complex, technologically sophisticated "weapon system"—the main battle tank, the capital ship and the combat aircraft. Even if a country simply imports these weapons outright, it is committed to a great deal more. A squadron of modern combat aircraft can require the support of several hundred diversely skilled people and the availability of hundreds or even thousands of components if it is to be operated at anything like its potential effectiveness. And a state that opts to acquire "modern" armed forces cannot do so on a once-and-for-all basis. All weapon systems are continuously refined and modified, so that a combat aircraft manufactured in 1970 and not modernized is likely to be a very different and, in professional eyes, a very inferior machine to the 1977 version. In addition, every 10 years or so an entirely new generation of weapons will appear.

When a nation endeavours to go beyond maintenance and operation to establish a capacity to repair and overhaul modern weapon systems, to produce spare parts and to assemble and perhaps manufacture such weapons locally, the economic ramifications escalate dramatically. Moreover, there is very little evidence from the states that have taken this path that any significant degree of independence is achieved. The technology gap between underdeveloped and industrialized countries, in the military field above all others, is enormous and, for all practical purposes, unbridgeable.

This being the case, the long-term effects of being peripheral participants in the technological arms race is something that underdeveloped countries should examine closely. At present something like $10 thousand million of the annual "productive surplus" of the underdeveloped world is being transferred directly to the industrialized countries via the trade in arms. This is more than one-half of the official development assistance provided to underdeveloped countries in 1975, including the substantial aid flows now coming from the members of OPEC. Given the absolute and relative magnitude of the resources expended and transferred for military purposes, it would seem sensible for both sides, that is, developed and underdeveloped, to consider this issue in the context of the North–South dialogue and the New International Economic Order. One obvious link is that if the scale and pattern of militarization in the underdeveloped countries are a significant impediment to development, the industrialized countries should weigh the current benefits derived from the sale of arms and military technology against the requirement for greater development assistance in the longer run. Much the same can perhaps be said of the increasingly serious debt-servicing problems faced by many underdeveloped countries, although at the present one can make only ill-informed guesses on the amount of debt accumulated for military purposes.

None of the above is intended to suggest that militarization is mainly responsible for underdevelopment. That would be a ridiculous assertion. On the other hand the relationships between militarization and economic growth and development are not negligible and we ought to know a great deal more about them. Every nation should want to assess whether the size, structure and armament of its military forces are compatible with its broader social and economic objectives. Conversely, it is surely desirable to be aware of the nature and dimensions of any incompatibilities.

The fact that the present state of knowledge is so inadequate is due predominantly to two factors. First, the mainstream of the academic social sciences, particularly economics, has tended to ignore the military as an extraneous factor beyond the reach of their analytical tools. The second factor is that the military sector is everywhere shrouded in secrecy, so that even the measurement of basic quantities and values, let alone the determination of relationships between these and economic growth and development, is either impossible or can be done only in a shallow and usually unconvincing manner.

Another relevant consideration here is that many of the obstacles that have frustrated arms control and disarmament negotiations among the major powers, including military budget reductions, may prove easier to overcome in negotiations among underdeveloped countries. For example, the absence of a capacity to design and develop weapons locally would considerably reduce the degree of detailed knowledge of military expenditures required to provide an acceptable degree of confidence that no surprise developments detrimental to a state's security would occur as agreed expenditure reductions were carried out. The developed countries might subscribe to an incentive system whereby any reductions in military expenditure achieved would be matched by an increase in development assistance from an international fund. In any case, those underdeveloped countries that reduced their military expenditure could argue more forcefully for increases in development assistance and exert greater pressures on the industrialized countries to follow their example.

IV. Conclusions

Disarmament and development are both critical goals of the international community and each deserves to be pursued as a matter of the highest priority. It should also be possible and perhaps even necessary to link them in a systematic fashion so as to improve the prospects of achieving both. The blatant contrast between the extravagant waste of resources on armaments and the urgent need for development can be used to rouse public support in favour of disarmament. On sheer practical grounds it is becoming increasingly apparent that the world is not so lavishly endowed with resources that waste can be ignored, least of all on the scale that armaments now consume resources.

A first priority is more knowledge of the economic and social implications of armaments. So long as we have nothing more than a vague notion that world armaments consume a large quantity of resources that might have been put to alternative uses, it is unlikely that any widespread and effective pressures based on economic considerations will emerge to reduce armaments. Similarly, any concrete measures to reduce military expenditures or to link such reductions to development will require detailed and reliable information. At present, proposals on these subjects seem unrealistic because their serious consideration presupposes a good deal more knowledge than we have.

In August 1977, the Nordic countries submitted a working paper to the Preparatory Committee for the Special Session of the General Assembly devoted to disarmament proposing a major international study on armaments, disarmament and development [11]. The execution of such a project will require a vast amount of information, most of which is not now available. If this proposal is accepted by the UN special session and particularly if stress is placed on the provision of the necessary data, it will be a major step forward.

A second consideration to be stressed is that efforts to achieve disarmament and development and any system linking the two must be global for reasons given above. The developed countries, because they account for 85 per cent of world military expenditure, clearly have a special responsibility, but opportunities to reduce military expenditures and reallocate resources exist everywhere. A working international system linking disarmament and development may take a long time to accomplish. Since the problems that such a system seeks to address will only grow in size and complexity, it is imperative that a beginning be made.

As an immediate objective, the special session could move to accelerate work on the international comparability of military expenditures with a view to facilitating agreements at least to reduce the rate of growth of military expenditures. The savings resulting from a lower growth rate of military expenditure may seem less concrete than specified reductions in the absolute level of expenditure but they are hardly less certain. During the past 75 years, world military expenditure has increased at an average annual rate of 4.5 per cent in real terms. A conservative projection for the remainder of this century suggests a growth rate of 3.6 per cent.[4] This will mean that in the year 2000 world military expenditure will be something like $820 thousand million, in 1977 prices. Holding the rate of increase to, say, 1.5 per cent would reduce this figure by $320–500 thousand million. The cumulative "savings" between now and the year 2000 would, of course, be very much larger.

References

1. *Development Cooperation, 1976 Review* (OECD, Paris, 1976).
   (a) —, p. 59.
   (b) —, pp. 210–11.
2. Sivard, R. L., *World Military and Social Expenditures, 1977* (WMSE Publications, Leesburg, Va., 1977).
3. *Economic and Social Consequences of the Armaments Race and its Extremely Harmful Effects on World Peace and Security*, A/32/88 (United Nations, New York, 1977).
   (a) —, p. 26.
   (b) —, p. 73.
   (c) —, p. 65.
   (d) —, p. 75.
4. *The Economic and Social Consequences of Disarmament* (United Nations, Department of Economic and Social Affairs, New York, 1962), p. 51.
5. *Economic and Social Consequences of the Arms Race and of Military Expenditures*, A/8469/Rev. 1 (United Nations, New York, 1972), p. 34.
6. *Disarmament and Development*, ST/ECA/174 (United Nations, New York, 1972), p. 22.
7. *Report of the Secretary-General on the Work of the Organization*, A/32/1 (United Nations, New York, 1977).
8. Leontief, W. *et al.*, *The Future of the World Economy* (Oxford University Press, New York, 1977), pp. 2–4.
9. Kaldor, M., "The Military in Development", *World Development*, Vol. 4, No. 6, 1976, pp. 459–82.
10. Benoit, E., *Defense and Economic Growth in Developing Countries* (Lexington Books, Lexington, Mass., 1973).
    (a) —, p. xx.
11. *Disarmament and Development: Proposal for a United Nations Study. Finland, Denmark, Norway, Sweden: Working Paper*, UN document A/AC.187/80, 31 August 1977.
12. *World Armaments and Disarmament, SIPRI Yearbook 1977* (Almqvist & Wiksell, Stockholm, 1977, Stockholm International Peace Research Institute).
13. *Armaments and Disarmament in the Nuclear Age* (Almqvist & Wiksell, Stockholm, 1976, Stockholm International Peace Research Institute), p. 12.

[4] This projection is based on the trend of military expenditure over the period 1966–75 and the projected rate of economic growth in the 15 regions of the world identified in *The Future of the World Economy* [8]. The growth rates of GNP projected under Scenario A in that study were used since these come close to the minimum that must be achieved if the relative position of the underdeveloped countries is not to deteriorate further.

11. The comprehensive test ban

Square-bracketed numbers, thus [1], *refer to the list of references on page 355.*

I. The CCD in 1977

In pursuance of the UN General Assembly resolution of 10 December 1976 [1], urging the Conference of the Committee on Disarmament (CCD) to continue to give the highest priority to a comprehensive test ban (CTB) agreement, the Committee devoted a substantial proportion of its time to this issue. Although no concrete results have yet been achieved, the CCD sessions were marked with optimism. There were several reasons for this. Positive signals came from both the USSR and the USA, indicating that greater political importance is being attached by the leaders of these countries to the achievement of a CTB. In this respect, the most optimistic development was the statement of 2 November 1977 by Soviet President Brezhnev, concerning a moratorium on nuclear explosions for peaceful purposes along with a ban on all nuclear weapon tests for a definite period [2]. (See also chapters 1 and 16.) Two revised draft treaties were tabled, one by the USSR and the other by Sweden, containing a number of important positive changes and fresh ideas. Work by the *ad hoc* group of scientific experts on seismological questions continued. In addition, new hopes emerged when trilateral talks on a CTB began between the USA, the USSR and the UK.

The future too seems promising. The May–June 1978 UN General Assembly special session on disarmament has presented an opportunity to exert new pressures on the nuclear powers to fulfil their many pledges for disarmament. Here the complete cessation of nuclear weapon tests is believed to be one of the more important measures necessary.

The Soviet draft treaty

The draft, proposed on 22 February 1977 [3], is an expanded version of the previous document [4]. The new draft was conceived as an answer to the criticism expressed by the members of the Committee, concerning the inadequacies of the previously proposed verification system. In this text, a new paragraph 3 of Article II appears which reads:

In case a State Party to this Treaty has doubts regarding the nature of a seismic event that occurred in the territory of another State Party to this Treaty, it has the right to raise the question of carrying out an on-site inspection in order to ascertain the true nature of that event. The State Party to the Treaty that raised this question must cite appropriate grounds in support of the necessity of carrying out the inspection. The State Party to the Treaty which is the object of doubts regarding its compliance with the Treaty, recognizing the importance of this question, may take a favourable position regarding the carrying out of an inspection in its territory, provided it finds the ground convincing, or it may take another decision. Such an inspection shall be carried out according to rules established by the inviting State Party.

Thus, according to the new draft, the verification system for the comprehensive test ban treaty would consist of: (*a*) national technical means of control; (*b*) international exchange of seismological data; (*c*) consultation between the parties; (*d*) on-site inspection on a voluntary basis, carried out after the inspected side had accepted a challenge from a party suspecting a violation of the treaty, provided it found the evidence convincing; and (*e*) complaints to the UN Security Council, where evidence for the complaint should be given.

The Swedish draft treaty

The new Swedish draft submitted to the CCD [5] differs from the previous one [6] in a number of aspects. First, in Article I, paragraph 1, it does not specify the environments where nuclear explosions are to be forbidden, defining the scope of the prohibition as extending to "any environment". This change indicates the desire of Sweden to reach a treaty that is independent of the Partial Test Ban Treaty (PTBT) rather than complementary to it. Thus states that do not agree to a CTB could still subscribe to the PTBT. Second, in Article III, paragraph 4, it envisages the possibility of establishing a Consultative Committee, composed of all the state parties. This Committee is to be responsible for clarification of the doubts raised by the seismic event in question. According to paragraph 5 of this article, if these doubts persist after the consultations, a party may still bring the issue to the attention of the Security Council, as a last step in the verification procedure.

Third, it provides for an optional provision (Article I, paragraph 4 and Article VII, paragraph 4) for the two great nuclear weapon powers to undertake an obligation not to test nuclear weapons after a preliminary period during which they are allowed to test, despite signing the treaty. These arrangements would be necessary if the two major nuclear powers were not willing to refrain from nuclear testing immediately upon signature of the treaty. Two alternatives are then proposed: (*a*) Article VII, based on the acceptance by the two great powers of certain restraints in testing from the date of signature until the treaty enters into force; and (*b*) Article I, paragraph 4, based on such acceptance for a fixed period after their signature, which might hasten the entry into force of the treaty.

Finally, the Swedish draft adds a new article (Article IX), which permits a party, after due notice, to withdraw from the treaty if it has not been adhered to by all nuclear weapon states during the specified number of years after its entry into force. It was thought that this provision would deal with the difficulties in bringing all the nuclear weapon states to a simultaneous agreement on a nuclear test ban. The period elapsing between the signature of the treaty and the right to withdraw from it is meant as a time which would permit some nuclear weapon states to carry out part of their testing programmes. The right to withdraw would act as a political leverage on the other nuclear weapon states not to join the agreement too late. This new article is in agreement with the previous Swedish position according to which the participation of all states, especially nuclear ones, is a necessity. It should not at the same time be a precondition of the agreement since the two great nuclear powers are so overwhelmingly superior in nuclear arms that they can and must start the process of the elimination of nuclear tests.

In addition to these two drafts, which were analysed in great depth at the CCD, other topics linked to a CTB were discussed, such as verification, the question of participation in a future agreement, and peaceful nuclear explosions, and two working papers were presented by Japan [7–8]. Informal meetings were also held on 18–22 April 1977.

Alongside the work of the main body of the CCD, the *ad hoc* Group of Scientific Experts, established in 1976 to consider international measures to detect and identify seismic events, held three sessions during 1977, on 21–25 February, 25–29 April and 25 July–5 August 1977. The Group submitted its second, third and fourth reports on its work [9–11].

The trilateral discussions

At the first meeting of the summer session of the CCD on 5 July 1977, the delegates of the USA and the USSR informed the Committee of the "useful preliminary consultations" on a test ban treaty that the two states had held during June and early July of that year. They also stated they would shortly be joined by the UK to begin negotiations on an agreement on a test ban which, after preparation of a draft treaty, might further be elaborated into an international treaty by the members of the Committee. It was stated that the reasons for taking the talks out of the CCD forum was that the parties concerned believed that "broad agreement could be easier if the nuclear powers members of the Committee first found a way to bridge their differences on the subject". Other countries commented that while there was a need for bilateral or trilateral talks on the subject among the nuclear powers, such talks must be extended into multilateral negotiations. Concern was also voiced as to whether the results of the consultations would be duly made known to the members of the Committee. Some delegates expressed their regret that the CCD had to wait until the three powers finished their discussions. At the same time the delegates urged the Committee to reach an agreement on a draft treaty before the General Assembly special session on disarmament was convened. Following their announcement, the three nuclear powers discussed nuclear test ban issues during the summer of 1977 in three subsequent series of meetings: one, on 13–27 July, the second on 3–28 October, and the third during December.

The matters discussed trilaterally are surrounded by secrecy. What is known about them is that the main subjects of discussion are the questions of verification, participation, peaceful nuclear explosions, and entry into force.

II. The military significance of nuclear testing

Although perhaps not very rational, it is currently held that a CTB is a decisive criterion of the willingness of the nuclear powers to curb their arms competition and that it will mark the turning point in disarmament efforts in general. The CTB is also seen by non-nuclear weapon states as a chance to bring the nuclear weapon powers on to more equitable terms with them, making it easier for these non-nuclear weapon states to endure the unequal terms that they accepted in the Non-Proliferation Treaty (NPT). One may even go so far as to say that a CTB is regarded as a means of strengthening the NPT régime by creating a more favourable attitude on the part of the non-nuclear weapon states, and thus reversing the growing possibilities of nuclear proliferation.

The expectations of the international community in general are one side of the coin, however. The great nuclear weapon powers also have their stakes in a CTB. The current precarious period of "essential" strategic equality gives them a unique occasion to freeze the technological refinements of one of the main elements of their strategic weapon systems, that is, nuclear warheads and other nuclear explosive devices. In concluding a CTB they can help to create better conditions for political and technical bargaining at the Strategic Arms Limitation Talks (SALT), and can unload some of the pressures that they feel from the non-nuclear powers.

Up to the end of 1977, 1 117 nuclear explosions had been carried out. The frequency of tests increased after the 1963 Partial Test Ban Treaty with 629 underground and atmospheric tests up to 1976. The numbers of tests for the individual countries are as follows: USA, 626 tests (333 after the PTBT); USSR, 371 (207 after the PTBT); France, 70 (62 after the PTBT); UK, 27 (4 after the PTBT); and China and India, 22 and 1 respectively, both of these latter countries beginning to test after the PTBT [12a].

From the above figures one may conclude that the potential of the strategic arsenal is proportional to the number of tests carried out, since the two main nuclear powers which are responsible for the majority of tests enjoy greater strategic superiority than all the other nuclear states. Thus testing is obviously an important factor in the creation and maintenance of strategic nuclear arsenals.

Military arguments against a CTB

It can be assumed that nuclear tests are carried out for the following reasons:

(1) to study the physics of nuclear explosions and nuclear devices in order to contribute to the continuous advance of knowledge in nuclear technology;
(2) to develop nuclear weapons;
(3) to investigate the effects of nuclear weapons;
(4) to validate new designs of nuclear weapons;
(5) to identify new options to meet new military circumstances;
(6) to maintain viable nuclear weapon stockpiles;
(7) to maintain the level of experience and competence of personnel and laboratories;
(8) to check whether nuclear weapons meet safety requirements;
(9) to assist in the evaluation of a threat from other nuclear states;
(10) to give grounds for tactical and strategic doctrines on the use of nuclear weapons; and
(11) to save money in the process of developing nuclear weapon systems.

An understanding of nuclear physics is obviously indispensable for the production of nuclear weapons. However, it is claimed that this knowledge, even after over 30 years of testing, is still not complete. Thus it is said that a quarter of the tests counted as weapon development tests, which were carried out in the period 1963–71, were to increase knowledge of physics [13a]. This aspect of nuclear testing was the reason for the opposition of Teller and others to the PTBT in 1963. They hoped for the discovery of new, hitherto unknown phenomena, which would make it possible to develop "clean", as well as extremely "dirty" bombs, and assumed that the breakthrough would bring about changes comparable to the initial development of nuclear and thermonuclear weapons. One could arguably maintain that this goal has been achieved since the introduction of "neutron" devices and the development of weapons with very limited radioactive fall-out. Neither is, however, a purely "clean" or "dirty" weapon since each depends on the same physics and technology—however advanced—as "conventional" nuclear weapons. Thus, testing enabled progress to be made in known technologies, but did not revolutionize them. Research and development (R&D) tests permitted major advances in the yield-to-weight ratios of nuclear weapons, for example. However, it seems that the maximum in this area has already been achieved in the latest versions of nuclear weapons, especially the recent tactical ones. Thus it may be said that although progress in nuclear weapon technology still occurs, it is yielding increasingly smaller returns [14].

The majority of tests—about 65 per cent—were held in connection with the development of new nuclear weapons. Developments in weapon technology—such as new materials or new components—create in themselves demands for new and better weapons, new safety regulations, delivery systems and doctrines of their battlefield use. It may be said that the general advances in a nuclear state's arsenal, corresponding to the demands of the nuclear arms race, are continually creating new demands for other nuclear weapon designs. This observation is corroborated by an examination of the history of weapon development. The rise in the number of tests in the USA just after the PTBT was connected with the development of the anti-ballistic missile (ABM) system. When this field of activity was foreclosed by the SALT ABM Treaty, there were new demands to incorporate the then available multiple independently targetable re-entry vehicle (MIRV) technology into the US arsenal. MIRVs required special geometry of the weapons, different materials, and different protection for the missiles carrying them. All this necessitated new testing. At present, interest is directed towards completion of the Trident Mk 4 and Minuteman Mk 12A warheads, both of which require testing.[1] In addition, new plans for nuclear testing are connected with investigations on the different basing concepts for the MX missile.

Apart from the programmes devoted to strategic weapons, there is a visible growth of activity in the field of tactical nuclear weapons. The modernization guidelines in this respect call for: (*a*) enhanced survivability of nuclear weapons under nuclear attack; (*b*) enhanced responsiveness of tactical nuclear weapons in comparison with that of strategic forces; (*c*) increased employment flexibility; (*d*) greater control over collateral damage and reduced undesired damage to friendly territories; and (*e*) a significant advantage in weapon employment over conventional alternatives. Special categories of tactical nuclear weapons are demanded such as enhanced-radiation weapons ("neutron bombs"), suppressed-radiation weapons (converting the neutrons into blast effect, to be used against small hard targets) and induced-radiation weapons (to obtain short but intensive radioactivity in an attacked area, thus denying it to an enemy).

A number of new weapons fitting these requirements have already been produced, or tests on them are nearly complete. In addition, a variety of

[1] If the Threshold Test Ban Treaty is ratified, some of these tests would not be allowed.

new studies are being undertaken, such as that on a new 8-inch nuclear projectile for the US Army's 155-mm long-range artillery. In turn, the US Air Force is acquiring new versions of the tactical bomb type B-61, mods. 3 and 4, which will be compatible with the improved aircraft designs. Tests of the so-called Shallow Burst Munition or earth penetrator, which in its tactical form is a substitute for, or supplement to, Atomic Demolition Munitions, are near completion. The warhead for this weapon, called Walleye 2, would detonate with a force of about 50 tons of TNT, thus blurring all the imaginable thresholds between conventional and nuclear weapons. Design studies are also being undertaken on new warheads for the Navy Standard Missile SM-2 to augment its capability against anti-ship cruise missiles, for the Harpoon anti-ship missile, for the Subroc anti-submarine weapon as well as for the new variant of the Mk 46 torpedo. New delivery modes are also being considered for the tactical bombs called Modular Glide Weapons, as well as for Maverick and Condor missiles [15].

Throughout US atomic weapon history, about 50 models—some in several versions—have been developed. The current US stockpile consists of about 25 basic models of nuclear weapons. Their number is rated to be about 40 000 active and war-reserve warheads. Thus it may be assumed that the world aggregate number of nuclear weapons is close to a figure of 100 000.

It is difficult to judge whether similar developments are taking place in other nuclear arsenals, especially that of the USSR. It is clear, however, that the smaller number of tests on the Soviet side indicates a smaller theoretical capacity to diversify its warheads, an assertion which is supported by US experts. It is held that the USA carried out approximately four times as many tests because its arsenal is composed of smaller and more complex nuclear assemblies. It is apparent that the Soviet arsenal is less versatile, especially so far as tactical weapons are concerned.

The majority of tests are devoted to investigations on the effects of nuclear weapons. It seems natural that together with the increasing maturity of nuclear weapon technologies and the growth in their numbers, military planners are demanding more knowledge about the conditions of use of these weapons. Such knowledge comes from an awareness of the effects of nuclear explosions from one's own weapons against those of the enemy and vice versa, as well as from experience of the performance of military forces in a nuclear warfare environment.

In the USA the main body responsible for research on the effects of nuclear weapons is the Defense Nuclear Agency (DNA), which co-operates with several other institutions, both civilian—such as the Atomic Energy Commission (AEC) and the National Aeronautics & Space Administration (NASA)—and military—such as the Energy Research and Development

Administration (ERDA) and the scientific institutes of the armed services.

During 1976, tests on the effects of nuclear weapons concerned the vulnerability of selected NATO and WTO forces and arms, the effectiveness of nuclear weapons in interdiction operations, the operation of aircraft in nuclear engagements, and the determination of collateral damage from low-yield nuclear weapons. Tests were also carried out to determine the effects of nuclear-induced phenomena which may disturb the action of incoming re-entry vehicles.

In 1977 the objectives of the DNA changed in response to the new US strategic doctrine of flexible and limited response, which induced testing in three main areas: military control, communication and command (C^3), tactical nuclear weapons and the survivability of satellite communications systems [15a, 16]. Research on C^3 involves control of (*a*) all the hardware elements, from walkie-talkie to communications satellite, in a nuclear explosion environment; (*b*) software suitability, such as methods of rapidly transmitting large amounts of data; and (*c*) the effects of an explosion on radio wave propagation. All this research comes under the umbrella of the Integrated Nuclear Communications Assessment Program. Next year's programmes will include hardening of satellite-based communications systems, and an examination of the interference along propagation paths caused by nuclear bursts in the ionosphere.

A new impetus for research at the DNA is provided by the plans to develop the MX strategic missile, which will require an evaluation of the response of different MX-basing concepts to nuclear effects and tests on deeply buried missiles and communications systems to find system protection designs for a mobile system, whether in trenches, tunnels or lakes [17].

Another innovation of a strategic character is the idea of industrial hardening, which will require extensive analysis and experiments.

As may be seen, like weapon development tests, the testing of nuclear effects is closely linked to every new military concept and requirement dictated by new military doctrines and the continuing arms race. Furthermore, it is reasonable to say that the development of new weapon systems and nuclear testing are interdependent, that is, that testing originates from the military demand for new weapons and conversely that the new technologies discovered through testing give impetus to new designs. Thus testing widens the range of possibilities from which the military can choose.

Turning to the third rationale for testing considered here, reliability testing, it is held that maintenance of a reliable stockpile of nuclear weapons is even more important than the development of new designs, since without a reliable level of a nuclear arsenal's efficiency, the confidence of a nuclear power in its deterrence potential will be undermined. This gradual loss of confidence in US nuclear arsenals, it is claimed, would increase pressures within the non-nuclear states that rely on the US protective "nuclear umbrella" to create their own nuclear defence capabilities [18a]. Reliability testing is thus regarded as a condition for successful non-proliferation politics. (Such an assertion strongly contradicts the widespread belief that a CTB would contribute to strengthening the NPT régime.) The military argue that reliability tests are necessary (*a*) because weapon components change physically and chemically as they age; (*b*) because new knowledge is gained which may point to certain flaws; and (*c*) because the minor modifications and improvements made using new materials and mechanics must be checked in actual performance before such weapons can be accepted in war reserve.

The lifetimes of US strategic offensive warhead/missile systems have run 11 years or less, the average to date being six years [13b]. Should stocks of these weapons be kept for longer periods, their reliability would be unpredictable. It is often argued that deteriorated stockpiles cannot be rebuilt according to an identical design for the practical reasons that people building weapons dislike repeating old designs instead of working out new ones, that new materials may differ from the old and that the state of knowledge demands that minor changes be made in any case [19].

As one expert testified [13b], over a 10-year period (up to 1971) some 91 modifications were made on the stockpiled weapons, of which 60 were to rectify a deficiency recognized after a warhead had entered into the stockpile. Despite this high figure, there were only five cases in a period extending for nearly 15 years in which a nuclear test was carried out specifically in order to correct the discovered deficiency. The explanation for this is that these deficiencies are checked and corrected in time when nuclear weapon effects, military training, and seismic research tests are carried out. Though there are few correcting tests, they are considered vital for the entire weapon system.

What seems to be an extremely important claim is that maintenance and correction testing can be satisfactory even if carried out with low-yield devices. The reason for this is the construction of nuclear weapons, of which one of the most tricky components is an assembly of high explosives and a subcritical configuration of a fissile core. These two are required to act together in order to create the supercritical configuration leading to the nuclear chain-reaction, thus triggering a fusion or fusion–fission reaction. This "trigger" of thermonuclear weapons is usually in the low-yield range [18b]. Thus, what nuclear weapon experts demand is not all kinds of testing but primarily testing of low-yield devices. This alone would contribute a good deal to preserving the reliability and usability of nuclear weapon stockpiles.

Weapon designers and military experts in the field claim that to maintain nuclear stockpiles in a high state of readiness and reliability requires great expertise from people and laboratories [14]. In order to keep up this experience, an active R&D programme is indispensable, part of which is nuclear testing. As one of these experts puts it: "Confidence in reliability of a particular weapon is used with reference to the whole body of knowledge encompassed within the whole nuclear explosive technology" [13a].

The question of nuclear weapon laboratories may also be considered from another point of view. In the internal debate on the test ban the scientific and engineering community may exert powerful pressure on public opinion and decision-makers. It is significant that the two laboratories exclusively responsible for R&D on all the US nuclear warheads, the Lawrence Livermore Laboratory and the Los Alamos Scientific Laboratory, employ about 12 000 people, many of them directly connected with the highest political and military circles [20].

Safety tests are an integral part of the development of nuclear weapons, and their importance increases over time, even after the weapons enter the stockpiles. In addition, tests are required to ascertain whether an appropriate level of confidence has been reached. According to Westervelt:

> US nuclear weapons: they must be "one-point-safe" in any credible accident or attack (there must be no nuclear yield, for example, if they are struck by a bullet that detonates the high-explosive). The one-point-safety requirement, as noted above, places severe restrictions on weapons design, and it is the cause of significantly more tests during their development than would otherwise be needed [18c].

One-point-safety means that there are a number of other "points" which prevent the weapon from accidentally detonating, but at least one of them must function well. With this insurance nuclear weapons can be transported and stored all over the world. Thus safety requirements condition deployment of these weapons.

The final rationale for nuclear testing discussed here is that tests allow states to evaluate the threat posed by the nuclear weapons of other states and to assess the vulnerability or survivability of their nuclear forces. This in turn provides a basis for the strategies and tactics of their war planners. To construct plausible war doctrines, both strategic and tactical, considerable knowledge about the possible threats to one's own weapons as well as about one's own capabilities is needed. This knowledge, it is argued, is gained through nuclear tests.

The importance of low-yield testing

The most serious problem for the negotiators of a CTB is posed by the argument that low-yield nuclear tests are becoming increasingly vital to the development of nuclear weapons. The difficulty stems from the fact that it is the low-yield range of nuclear explosions which is the most difficult to distinguish from natural events and to monitor.

A summary of the arguments on the usefulness of low-yield tests is given in the official CCD document prepared by the United Kingdom in 1966 [21]. According to this source, all kinds of tests—stockpile confidence tests, nuclear effects tests, tests for developing new designs and R&D tests—can be carried out with yields of up to a few tens of kilotons and yet still serve the purpose. These arguments are upheld by Westervelt, who points to the importance of reliability tests of low-yield assemblies, which make up the trigger of bigger fusion and fission–fusion devices.

A further reason why small tests are considered important relates to the possibility of being able to produce a large nuclear device on the basis of knowledge gained from low-yield tests and small version weapons without any additional experiments. Theoretically it may be possible to create a militarily significant nuclear weapon arsenal using the experience gained from the construction of smaller weapons, even though reliability may be compromised in this way.

Nuclear weapon tests and strategic stability

There are two conflicting opinions about the possible influence of a CTB on the stability of strategic deterrence. One view holds that a CTB would gradually undermine the existing balance in strategic weapons. The credibility of strategic deterrence is said to depend on a continuous supply of new and more effective designs for nuclear weapons, especially since the flexible and limited response strategy was adopted as an official US doctrine. In this doctrine the ability of the arsenals to be maintained in a permanent state of readiness and improvement is crucial, both of which require the full range of testing.

A modification of this view holds that a smaller number of low-yield tests which are specifically directed at checking the reliability of nuclear stockpiles, is necessary. Mutual confidence in a high level of an arsenal's reliability is a precondition of the strategic balance.

The other view holds that a CTB would, on the contrary, dampen the strategic arms race, and that this effect would be a stabilizing one. A complete ban on testing would undoubtedly preclude the full exploitation of available technology but there is no evidence to suggest that it would fundamentally hinder the maintenance of a strategic deterrent by either side. An increasing lack of confidence in the correct functioning of nuclear warheads would make the actual use of these weapons in attack very hazardous. The fear of a first strike on both sides would thus be removed, especially since the emergence of unexpected new weapons is unlikely without testing. It is claimed that the deterrent value of nuclear weapons would not decline at the same rate as their physical deterioration, provided that extreme demands of efficiency and accuracy were not made on them.

The crux of the argument against the CTB as a destabilizing factor stems from the belief that the deterioration of nuclear arsenals would not be equal on both sides, due to possible failures of the verification system which would tempt the Soviet side to test clandestinely and in this way to maintain the reliability of its weapons, possibly even to develop new ones [15d, 22a]. According to one expert, "if the uncertainty in stockpiled weapons were not about equal for all . . . then [it] could be quite destabilizing" [13c]. This observation leads to a strong emphasis on verification requirements.

This discussion of the effects of a CTB on strategic stability seldom considers the question of what is more destabilizing—a diminution of confidence in weapons' reliability or a permanent increase in the degree of sophistication and numbers of nuclear weapon systems. Even if the two sides can keep pace with each other technologically, this permanent military competition cannot but create a politically unstable and conflict-bound situation. Moreover, the arms race and strategic stability are more decisively affected by non-nuclear developments in military technology (like advances in warhead accuracy) than by nuclear developments. Nuclear tests are therefore not vital to the strategic security of nuclear states.

Nuclear weapon tests and strategic doctrines

A complete ban on nuclear testing would have a different impact on strategic arsenals depending upon the kind of military doctrines prevalent at the time. Current testing programmes are directed at designing small and reliable weapons to fit into very accurate means of delivery. Such weapon systems are required for a strategic doctrine which envisages the use of nuclear weapons in a much wider range of options than any general doctrine of deterrence. Such weapons are aimed at a large number and wide variety of targets, which in effect enables the "threshold" for their use to be substantially lowered. For a state designing its arsenal according to this concept, a CTB would be rather disturbing, if not disastrous. On the other hand, having been deprived of the possibility of improving the quality of its weapons by testing them, the military may be inclined to rely more on large yields. Since the technology of constructing large-yield nuclear weapons is less demanding and since the nuclear states have already acquired a substantial amount of knowledge of such weapons, a ban on testing would have a much smaller impact on the arsenal intended to be used only as a general deterrent.

It seems rational to assume that the strategy of flexible and limited nuclear response based on small, reliable and accurate weapon systems stresses opportunities for a first-strike and surprise attack. In a time of crisis it may be tempting to pre-empt with these weapons against the nuclear weapons of the other side, without necessarily inviting a retaliatory counter-value strike. Testing helps to strengthen this destabilizing option, and is thus destabilizing in itself.

The danger of clandestine testing

A further argument against a CTB is that it cannot be completely verified by existing seismological means, which would allow the possibility of clandestine tests with small-yield devices. These, in turn, are considered sufficient to maintain the reliability of nuclear arsenals and perhaps even to improve them. A number of experts believe that the basic requirement of a CTB is that it should affect the arsenals of all the parties to the treaty equally. At the same time, opponents of a CTB claim that being a "closed" society, the USSR is more resistant to observation. Moreover, it is said that it treats lightly its obligations under international agreements. US society, on the other hand, is pictured as law-abiding and entirely open to external and internal scrutiny, with no chance of unlawful testing escaping punishment. There is thus, the opponents conclude, an inherent danger in a CTB for the United States and the West.

To deal with the above assertions is a difficult matter. Feelings of this kind are based on beliefs, not on hard fact. So far the record of both sides in implementing disarmament treaties is similar: both have adhered to the substance of the treaties in force, both have a record of some technical infringements of certain provisions (such as those on venting radioactive debris from underground nuclear tests [23–24a]), and both demanded that certain issues be clarified in connection with the fulfilment of the SALT I treaties. There are thus no grounds for suspecting that one of the sides will be more treacherous in the future.

There are also a number of more concrete arguments against the possibility of a violation of a CTB, based on considerations of the potential political and military costs and benefits of violations, given the current progress in monitoring technology [25]. Even the most ardent opponents of a CTB, concerned with the possibility of illegal testing, admit that for such testing to remain clandestine, tests must be few and far between, low-yield, or coincidental with natural seismic events. Any progress from such testing would thus be slow, technically difficult, expensive, and even then would be hard to conceal. Moreover, the consequences of such testing being discovered would be disastrous both politically and militarily. The whole structure of détente politics, disarmament discussions, trade and co-operation would be in jeopardy. The arms race would be speeded up and the confidence once lost would be difficult to regain.

It is generally assumed that the United States is more advanced in its variety of nuclear weapon test designs and in general knowledge of nuclear explosion technology. To overcome this lead would require an enormous effort, and even successful clandestine testing would do little to narrow the gap. As some writers have put it, "a complete nuclear test ban treaty would not be a threat to US security whether or not evaded by the Soviet Union to the limited extent feasible . . ." [26a].

Non-nuclear tests and the future of nuclear arsenals

It has been established that a CTB would make it more difficult to maintain nuclear arsenals at a high level of reliability. However, in the light of known methods of simulating physical conditions in laboratories and taking into account the potentials of non-nuclear techniques to test and validate nuclear weapons, the expected deterioration of nuclear arsenals need not be as rapid as opponents to the treaty often claim. One should remember that knowledge of nuclear weapon technology has been founded and can draw on the experience of over 30 years of testing, based on a great deal of theoretical research and engineering.

To a large extent the preparedness and reliability of nuclear stockpiles can be checked by non-nuclear methods, which can verify the action of all the components of a nuclear warhead short of its actual detonation. According to the US Department of Defense:

> the reliability of the stockpile will be affected by the willingness of the government to spend possibly large sums of money to work around recognized deficiencies without nuclear tests. With such funding available the loss in reliability could often be avoided or delayed, although in the absence of nuclear testing corrective measures might involve longer periods of system degradation and might involve settling for a warhead performance well off the optimum [22b].

In a statement presented during US Congress hearings, Walske admits that modifications of nuclear weapon designs for reliability and safety, as well as checking the weapons after modifications were made, did not require tests. Obviously, as Westervelt argues, without an actual test weapon designers are denied the final proof that new or modified weapons actually work as intended, and, for example, the action of the trigger mechanism for hydrogen warheads cannot be checked at all, but these problems constitute only a small—although admittedly important—part of the general issue of the credibility of the nuclear deterrent. According to Wiesner and York, even if nuclear testing were able to resolve some uncertainties concerning nuclear arsenals, removing these uncertainties would "contribute virtually nothing more to management of the real military and political problems, even though it would produce neater graphs" [27].

Initial tests of current nuclear weapons have always been non-nuclear.

The nuclear explosion has only been the final proof after a whole range of other tests have been carried out, such as controls in experimental physics, and engineering, laboratory and field tests. Ageing of weapons is checked first by disassembling and microscopically testing the weapon, and only in an anomalous situation are further checking, modification and finally a nuclear test required [13d].

The opponents of a CTB are afraid that the creativity and scientific vigour of nuclear laboratories would be seriously reduced by the treaty. However, this argument hardly holds water given the fact that extensive computations, laboratory simulations and a new emphasis on laboratory experimental programmes (connected, for example, with laser fusion and controlled thermonuclear reactions) seem to be a lasting trend.

During the past decade US defence agencies have made extensive studies on the development of sophisticated equipment that produces radiation types and levels equivalent to those generated by nuclear weapons. As a result of these efforts, several large laboratory facilities have been constructed which have eliminated the need for some types of underground nuclear test. Indeed some simulation programmes were developed, despite the availability of underground nuclear tests, because of their cheapness and because of existing PTBT restrictions on atmospheric tests. The information obtained from simulated programmes is said to be as good as that from actual nuclear tests.

During recent years several experiments to test the effects of small, close-to-the-surface nuclear explosions were performed on the basis of computer codes, developed over years, which actually used special kinds of conventional high explosive to simulate nuclear charge. These experiments were designed to check the utility of earth-penetrating nuclear weapons. A similar series of tests with high explosives is now being undertaken in connection with the development of the MX strategic missile. Under a project called Strategic Structures, different basing concepts for the MX are validated, each of them using different simulation methods. In 1975 a 100-t TNT charge was used for this purpose and extensive small-scale experiments verified the tunnel concept for the MX [17a]. In 1976 the DNA detonated a 600-t high-explosive charge to determine survival levels of some modern tactical equipment and to provide data for the MX [28a].

Among the new laboratories simulating nuclear tests, the newest is the CASINO installation at the Naval Surface Weapons Center at White Oak where X-ray effect tests are performed [15b]. The SGEMP (System Generated Electro-Magnetic Pulse) research is carried out to check the causes of large electrical currents and voltages. This is performed by the Laboratory Radiation Simulator Development and Effects Simulation Using Radiation Simulation programmes. It is now known how to build large SGEMP simulators and from 1978, intensive tests are planned [16].

In 1976 successful non-nuclear tests were performed to determine the effects of nuclear-induced ice and rain clouds on incoming re-entry vehicles. In 1977 tests in which barium is released at high altitudes in a direct path between satellites and airborne and ground receivers have been carried out by NASA under Satellite Transmission Effects Simulation (STRESS). Tests with barium provide a partial simulation of nuclear disturbances and data to check the accuracy of code predictions, enabling the application of these codes to nuclear detonations. NASA will also launch a special transmitter to evaluate the propagation of a number of data through the atmosphere when it is disturbed by natural phenomena related to the effects of nuclear blast. Thus "nuclear effects" tests on satellite communications will be made without actually carrying out nuclear tests [28b].

Another example of current simulation programmes is the industrial hardening concept being checked on different specimens of equipment and structures using high explosives to create different overpressures [29].

Even without an agreement on a CTB, all these examples of non-nuclear tests reduce nuclear tests to an increasingly redundant and costly alternative. With the application of further methods of simulation and non-nuclear testing, the degradation of existing nuclear stockpiles and even some work on their qualitative improvement could continue undisturbed under the conditions imposed by a CTB.

The CTB and the nuclear arms race

Any nuclear weapon system is composed of much more than a nuclear warhead. It requires a multitude of elements constituting its delivery system, propulsion and guidance, and communication and control during its action. The performance of a nuclear weapon system thus depends on many non-nuclear elements and on doctrines and tactics of its use in war.

When the question was raised during US Senate hearings in 1971 of whether there was "any known system now in any stage of development which you would not equip with a satisfactory warhead without further testing?", the answer was, "About half the systems in the development engineering phase could be so equipped, in some cases with a loss in a desired characteristic, such as maximum yield to weight ratio or minimum cost" [13e].

The arms race is much more decisively affected by non-nuclear developments both for tactical and strategic warfare, than it is by nuclear developments. Examples of this are readily available. It is improvements in accuracy which have made current nuclear weapons the lethal instruments that they are, not their new nuclear characteristics. Even the development of MIRVs, the most remarkable advance in the nuclear arsenals of the past decade, has been due to non-nuclear technological progress. The currently most advanced weapon system—the cruise missile—is considered such a wonder not because of the nuclear warhead it can carry, but for its enormous range, accuracy and manœuvrability made possible by its specific fuel, engine, computers, guidance system and materials, none of which is connected with nuclear technology or nuclear tests.

One may assume that similarly important innovations in the domains of missiles, aircraft, warships, submarines, ASW techniques, electronic battlefield, reconnaissance, and so on, driving the central arms race, may occur without any regard to the issue of nuclear testing. Thus, whilst a CTB would produce a certain slow-down in the process of nuclear weapon improvement, it is unlikely that it would seriously restrain the strategic arms race. The importance of this treaty would lie therefore more in its psychological and political consequences than in its purely military outcomes. As Panofsky has put it, "there are no purely technical arguments of great strength for or against a comprehensive test ban treaty" [26]. Its importance is of a political nature.

III. Verification of a CTB

Verifying compliance with a CTB would have to be carried out by both seismic and non-seismic methods, both of which give a very high degree of certainty that no atmospheric, underwater or surface explosion can be carried out undetected. The available instruments are capable of discovering any substantial "venting" of radioactivity from underground nuclear explosions. The whole range of possible non-seismic means of verification of international agreements concerning underground tests has been described in the *SIPRI Yearbook 1972*. Since then, no important technological advance has been reported, but the degree to which satellite observation techniques have been developed was well illustrated by the case of the South African activities in the Kalahari Desert (see page 70). If one adds up all the possible evidence which can be obtained by satellite observations—preparations at the test site, drilling, possible subsidence craters, and dust cloud generated by the test and by the earth's subsidence —the conclusion must be that the satellite-borne technical capability for verification of a CTB is quite substantial.

However, although all the non-seismic methods taken together represent a substantial verification capability and may be restrictive for the potential violator of a CTB, they are far from effective in every possible case. Because of this fact, verification of a CTB must largely rely on seismic detection and identification of underground nuclear explosions.

Explosions and earthquakes: general characteristics

The obvious difference between an earthquake and an underground nuclear explosion lies in the nature of the source and, in particular, in its geometry and size. An explosion is a point source whilst an earthquake occurs in a larger or smaller fault, where two bodies of rock slip past each other. Both events produce seismic waves but their excitation is different. An explosion radiates mainly compressional P waves simultaneously in all directions. This signal is simpler compared with that of an earthquake of comparable magnitude and there is an absence of large signals after the P signal. An explosion also generates substantially weaker Rayleigh and Love surface waves. An earthquake produces both compressional and dilatational P waves and also distortional (shear) S waves, both of which vary with direction, and are asymmetrical. The P wave shape shows wide variability, with large P signals of varying amplitude following immediately after the onset. These differences diminish with increasing earthquake depth. In theory, too, Rayleigh and Love waves should not be generated by an underground explosion. However, an explosion carried out in a seismically unstable area may release accumulated tectonic strain energy and thus both types of surface waves may be generated.

Natural difficulties in seismic detection

The above-mentioned differences in excitation of seismic waves of explosions and earthquakes are, however, not easily discernible from their recorded seismic signatures. The actual seismic records are dependent on several factors, such as geographical location of the event and of the station monitoring it, depth of focus, size of the event, distance between the event and the station, wave-propagation path, level of noise and kind of receiver. All these factors influence the clarity of the recording and the characteristics of the recorded waves, hence the distinction between explosions and earthquakes.

Geological properties of the Earth

The characteristics of seismic waves are dependent on the interior structures and character of the Earth's surface. Seismic waves are reflected and refracted on different rock layers and any other geological inhomogeneity. The influence of geological structures is similar for both explosions and earthquakes as far as both the kinematic characteristics (travel-time and travel-path properties) and the dynamic characteristics (amplitudes, period, particle motion, and wave-forms) are concerned [12b]. An enormous mosaic of regional geological differences and lateral inhomogeneities produces regional variations in wave velocity and certain shadow zones for a given amplitude of waves. The result is erroneous estimation of travel-times, location of the events and all other parameters used to discriminate waves from seismic sources. The records are dependent not only on the tectonic nature of the material surrounding the source and on the structures through which the waves pass but also on the formations beneath the station sites. Thus the records from many seismic stations vary. In the case of array stations operating sensors over large areas, the records may become distorted because of the subsurface geology. In this case amplitudes, times of arrival, and azimuthal variations may differ among the records from different seismometers operated by the same station.

The problem of identifying explosions is different, in practice, in each of three possible situations: explosions in seismic areas, in areas of minor or ill-defined seismic activity, and in virtually aseismic areas [30a].

In order to overcome this difficulty stemming from the complicated nature of the structure of the Earth, a sample of explosions, announced in advance, would be of great value for mapping and instrument calibration, especially if they occur in structurally varied and seismically unchecked areas.

Background and instrumental noise

The actual recording of a seismic signal is disturbed by both instrumental and natural background noise. The former influences mainly the long-period seismometers due to their long eigen-periods and is caused by variations in temperature, pressure, and local atmospheric convection currents. This noise may to a great extent be overcome by installing seismometers in well controlled environments.

Natural noise is of utmost importance for the detection and identification of seismic events since it sets a threshold of detectability for these events. It is generally assumed that if the noise and signal are in the same spectral band, then in order to detect the signal it must be two to three times stronger than the background noise. Thus an improvement in the signal-to-noise ratio is a basic condition of fine detectability.

One way of overcoming noise is to make a careful choice of site for the station. Another is to use seismometers located in boreholes, taking advantage of the attenuation of the surface-wave component of noise with depth.

The more advanced method of enhancing the signal-to-noise ratio is the use of arrays. Arrays permit the antenna theory to be applied to seismic recording, as well as different methods of signal processing and filtering. The application of the antenna theory is based on the fact that each element of the array receives signals that are identical in form but may be shifted in time. By means of appropriate time delays, the signals can be added in a process called "beam forming", theoretically giving a gain in the signal-to-noise ratio equal to the square root of the number of sensors used if the noise is incoherent [12c].

One of the specific signal-processing methods produces a so-called correlogram. Two records are produced by summing all the instruments on each arm of a cross array; the parts of these records that are similar are accentuated and those that are dissimilar are reduced. The records are electronically multiplied point by point and smoothed over time intervals of 1.5 or 2 seconds. With the aid of correlograms it has been possible to distinguish the signal of a small (400-pound) underground chemical explosion from seismic disturbance produced by a small earthquake, both recorded by an array 2 400 km distant [31–32.]

When the seismometers of an array station are spaced very close, the short-period noise may become coherent. P waves and coherent noise differ, however, in propagating velocities. This permits the velocity filtering to be applied in the array signal processing.

Magnitude distribution of earthquakes

A complicating factor in seismic detection is that if the detection sensitivity of the instruments is expanded, the number of recorded earthquakes, and thus the number of seismic events to be identified, rapidly increase. Since the numbers involved are large, the problem of identifying an explosion among them becomes a difficult technical problem. Moreover, with an increase in detection, the number of anomalous cases also increases, which adds to the confusion.

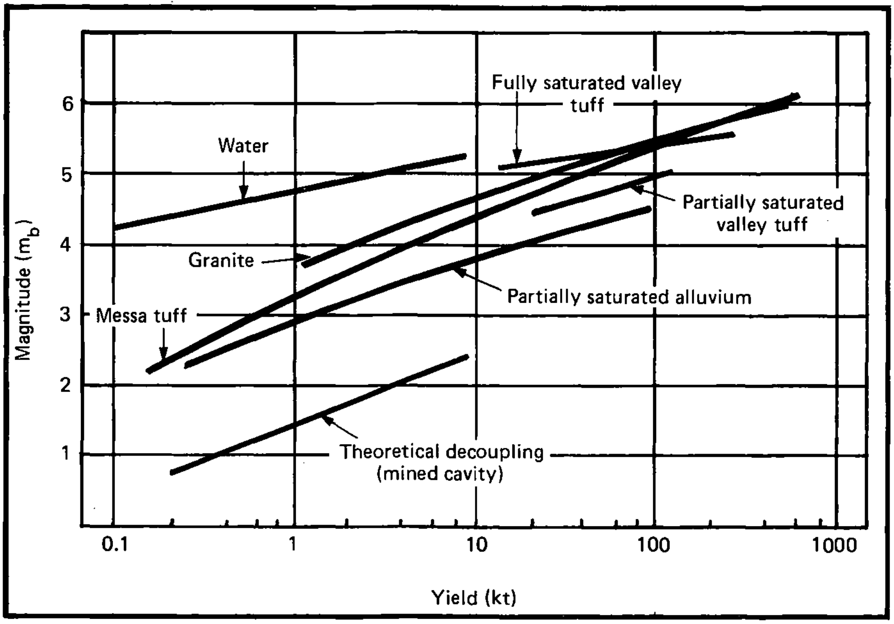
Given the large numbers of explosions requiring analysis, a new approach is needed in monitoring a CTB. Verification will have to be seen more in terms of deterrence of possible violations than in terms of actual identification of every single event. The deterrence would consist in confrontation of a prospective violator with a certain disclosure probability at a politically determined level. Thus statistical methods and decision theory may be applied to the statistical properties of known seismic discriminants, allowing the required compromise to be made between a sufficient probability of disclosing explosions and a not-too-high incidence of false alarms about natural events [12d, 33–34].

The magnitude-to-yield ratio in different media

In general, seismology operates with measurements of the seismic events expressed in the magnitude of body- or surface-waves. In connection with nuclear explosions, these terms must be converted into weapon yields, in kilotons or megatons. The problem is that the magnitude-to-yield relationship is material- or medium-dependent, which is illustrated in figure 11.1.

This physical reality is significant in that the properties of soft rocks cause a much weaker excitement of seismic waves from a given yield compared with that in hard rocks such as granite, and so create the theoretical possibility of hiding an explosion in such a medium and diminishing the chances of discovery.

Figure 11.1. The relation between seismic magnitude (m_b) and kiloton explosive yield in various media[a]



[a] The lines represent mean theoretical trends.

Source: See reference [36], based on data from the US Atomic Energy Commission.

The technology for seismic monitoring

Seismologists use a number of different instruments with which to detect, record, compute and analyse seismic signals. Seismometers can be used singly or in larger numbers, forming seismic array stations. Several stations may be connected in national and international networks.

Three types of seismological recording are currently used: short-period (maximum sensitivity at frequencies above 1 Hz), long-period (usually around 20 seconds, sometimes at even longer periods), and broad-band (frequency from 0.1 to 10 Hz). Short-period instruments mainly record P waves; long-period ones show most clearly the surface waves [12e]. The broad-band instruments are less capable of perceiving waves from weak events than narrow-band instruments (which have the best signal-to-noise ratio). However, they record more exactly the spectral differences between explosions and earthquakes [35].

Only a general description of a seismometer will be attempted here. It is basically composed of a magnet fixed to the ground and a spring-suspended mass with an electric coil. When seismic waves move the ground and the magnet attached to it, they leave the mass with the coil relatively unaffected. The relative motion of the magnet and coil generates a current in the coil which is proportional to their relative velocity.

Seismometers are characterized by a rather limited bandwidth (the frequency interval within which the instrument is designed to work) and a very high dynamic range (the ratio of the largest to the smallest signal a system can record). Modern short-period seismometers connected to high-quality amplifiers are capable of recording signals as weak as 0.1 nm (1 Ångström). The maximum ground motion that can be recorded by a short-period instrument is of the order of a few millimetres, and by the long-period instruments is 10 nm to 10 mm.

The seismometers available now can withstand severe environmental conditions, and because of this can be located both in deep boreholes and on the ocean floor. They should thus be capable of satisfying any requirement for monitoring a CTB.

Since the accuracy of seismic data depends to a large degree on its geographical distribution, allowing arrival times to be observed from a number of widely dispersed stations, the establishment of large national and international networks of stations has become imminent.

In 1974 as many as 1 116 seismological stations were in operation, most of them in Europe, Japan, the United States and the Soviet Union [12f]. They represent very different capabilities as regards their instruments and sensitivities. Most of them are for monitoring local earthquake activity and are of small but not entirely negligible usefulness for CTB monitoring.

The largest network of stations existing is that established in 1961, the World Wide Standard Stations Network (WWSSN). Of the 125 stations planned, 112 were operational by 1966. They are equipped with identical short- and long-period seismometers recording on photographic paper. Data from these stations, however, by and large lack the high sensitivity level required by a CTB. Moreover, the United States, which supported the operation of this network up to 1968, has reduced its financial support and by 1971 only 90 WWSSN stations were regularly recording. This useful basic seismological network is substantially cutting down its capabilities [36a].

The second largest network is located in the Soviet Union. It consists of 44 stations, using the three main types of seismometer mentioned above. The characteristic feature of this network is an extensive use of broad-band "Kiros" type seismometers [37].

As a successor to the WWSSN system might be considered the Seismological Research Observatories (SRO), of which 13 are to be established by the US Advanced Research Project Agency (ARPA) in different parts of the world. Each is equipped with a specially designed broad-band borehole seismometer whose signals are filtered into short- and long-period frequency bands. It is intended to link this sysem of stations with a co-ordinating centre, from which data will be generally available [38].

Table 11.1. List of reported array stations

Country	Location and/or abbreviation	Total aperture *km*	No. of seismometers	
			Short-period	Long-period
Australia	Warramuga/Tennant Creek/WRA	20	20	–
	Tasmania	..	..	..
	Snowy Mountains	..	..	..
Bolivia	La Paz LPBV	..	..	..
Brazil	Brasilia BAO	20	17	–
	SAA	..	19	–
Canada	Yellowknife YKA	20	19	3
Finland	Yyväskylä HEL	90	3	–
France	Paris CEA	500	20	–
FR Germany	Graffenberg GGGR	10	9	3
India	Gauribidanur GBA	10	10	3
Iran	Teheran ILPA	40	–	7
Japan	Tokyo DDR	..	Irregular	..
Norway	Oslo OONY	..	–	–
	NORSAR NAO	50[a]	49	7
South Korea	KSRS	40	19	7
Sweden	Hagfors HFS	40	15	3
United Kingdom	Eskdalemuir EKA	20	22	–
United States	LASA LAO	80[a]	180	13
	ALPA ALP	40[a]	–	7
	Wichita Mountains WMO	..	–	–
	Cumberland Plateau CPO	..	–	–
	Uinta Basin UBO	..	–	–
	Tonto Forest TFO	..	–	–
	Blue Mountain BMO	..	–	–

[a] Reduced after modification.

Sources: See references [12, 31, 36–37].

As mentioned above, array stations are being built in order to increase the detection capability of seismometers over background noise. They are established in different configurations, whose apertures extend from a few to as many as 200 km. The number of seismometers used ranges from three to several hundred (the original Large Aperture Seismic Array [LASA] had 525 seismometers). These array stations necessitated the application of solid-state amplifiers and analogue techniques as well as digital data-transmission equipment to transmit signals from remote seismometers to a data-recording centre and to analyse them despite their great volume.

Several array stations of different capabilities are in operation [12g, 36b, 37a, 39a]. These stations work with either short- or long-period seismometers or with both. A list of reported array stations is given in table 11.1.

The largest and most modern array station is LASA in Montana, currently consisting of 13 sub-arrays made up of 25 short-period instruments each, and each sub-array containing a three-component set of long-period seismometers. Another station of similar capabilities is the Alaska Long-Period Array (ALPA), originally with 19 long-period seismometers, now refitted with newly developed long-period borehole seismometers. After the conclusion of this upgrading programme the array will consist of seven three-component seismometers with an aperture of 40 km. The Norwegian Seismic Array (NORSAR) station is undergoing a similar modernization: 132 short-period seismometers and 22 three-component long-period seismometers are reduced to seven sub-arrays of 49 short- and seven long-period seismometers, extending over a distance of 50 km.

One of the most modern and technically advanced is the Swedish Hagfors Observatory array station, composed of three sub-arrays with 15 short- and three long-period seismometers, equipped with unidirectional velocity-filtering detectors using an analogue coincidence technique.

Yet another network of seismic stations, set up in the 1970s, is a system of 10 Very-Long-Period Experiment (VLPE) stations, located in different parts of the world. Their seismometers are installed in well sealed underground vaults. These stations are able to record clearly long-period signals useful in identifying earthquakes and are therefore of importance for CTB purposes, despite their low efficiency in detecting explosions. Five of these stations are to be upgraded by the addition of a vertical-component short-period seismometer and the recording system used by SRO stations. These stations will subsequently form the Auxiliary SRO stations system.

At present there are about 2 000 seismic stations operating world-wide. They may be classified into three categories: (*a*) large- and medium-aperture array stations, with independent high detection, location and identification capabilities; (*b*) broad-band single stations, capable of detecting and identifying independently but without an independent capacity to locate; and (*c*) other stations, primarily for local events and of sporadic usefulness for general identification purposes [40].

In view of future requirements for a CTB, the idea of ocean-floor seismographs and unattended seismological stations (so-called "black-boxes") has been put forward. Ocean-floor seismograph stations have proved feasible in several experiments. They could make it possible to monitor offshore from such seismologically active regions as the Kurile Islands. Both long- and short-period instruments may be deployed. Another project consists of a free-fall, unattended and untethered seismograph with a coded sonar recall capable of operating at depths of up to 8 350 metres and recording for a period of 30 days on magnetic tape [39b].

The Unattended Seismological Observatory (USO) as designed by

ARPA could be emplaced on foreign soil with the co-operation of the host country [39c]. A unit of such stations would consist of: (*a*) a borehole package of one 3-axis long-period, and three short-period seismometers. It also contains amplifiers, temperature sensors, level indicator and notating mechanisms (the latter used during the installation and check-out of the package); (*b*) an instrumentation shelter, with basic electronics, amplifiers, automatic gain control circuits, time code generator and a 14-track magnetic tape recorder; and (*c*) a power supply system with a thermo-electric generator and a tank which can work unattended for at least eight months. The USO is protected by the intrusion detection system against any possible tampering and falsification. It would cost $300 000 per unit and could be installed within from six days to a month depending on the depth of the borehole.

Identification of underground nuclear explosions

Several criteria for identifying nuclear explosions have been established, with varying discriminatory capacities. Only a few may be considered as able to distinguish positively between explosions and earthquakes. However, even those of a small auxiliary nature, when taken together, represent a valuable diagnostic aid in identification. With the advances in seismology as a science, the number of these criteria is bound to expand, as are their abilities to distinguish between natural and man-made events.

A very simplified and abridged overview of the most important criteria is presented below. For a more detailed description, the reader is referred to the sources indicated.

Location of an event

To locate an event requires estimating its latitude, longitude, origin time and depth. When an event is accurately located, this can give a positive indication as to its source. If this location is extremely improbable as a site of a man-made explosion, or is in an ocean-covered area, it is identified as an earthquake. Similarly, if an event is located in a known seismic area, it is more probably a natural phenomenon.

A standard method of finding the position of a distant event uses the measurements of travel-times of P waves at four or more stations. The observed arrival-times are compared with the arrival-times calculated from assumed earthquake origin-time and from its position. The azimuth of the event is estimated either from the direction of the incoming waves or from the amplitude ratio of the horizontal components of the waves. Bolt [36c] describes another method of locating an event by using the observed times of arrival from groups of earthquakes appearing in the same region. After pooling data from many sources and stations, the determination of the regional bias due to geological conditions is possible. Here a master event technique is useful, permitting the comparison of seismic wave arrival-times for a particular region.

Methods of accurately locating an event are becoming increasingly effective. Whereas the SIPRI report of 1969 [37b] mentioned the possibility of locating explosions of 20- to 60-kt yields in hard rock within 10 to 40 km, in 1970 Basham and Whitham [30b] established location accuracy as 20–45 km for events of body wave magnitude 4.5 (corresponding to 10 kt). Bolt [36c] assumes that currently operating standard stations can provide location accuracy of about 10–15 km in most cases for an event of the same magnitude. Finally, Dahlman and Israelson [12h] state that they "regard the achievable location accuracy of about 10 kilometres for seismic events, corresponding to fully contained explosions in hard rock of about 1 kt as adequate for monitoring a CTB without on-site inspection. The stations needed to achieve this are, with few exceptions, operating today."

Depth of focus

This term describes the depth of a seismic source beneath the Earth's surface. It is obvious that when it is possible to determine reliably that the focal depth of a suspicious event is significantly greater than that to which a hole can be practically drilled, this is positive evidence that the event was an earthquake. The depth of focus criterion is described as the most effective method of distinguishing between earthquakes and explosions. About 30 per cent of all earthquakes occur at depths exceeding 50 km, and an even larger percentage of events occur at greater depths than it is possible to install nuclear devices.

There are several methods for determining the depth of focus [12i, 36d, 41, 42a, 43a]. The most straightforward method is to use the time difference between the arrival of the first P wave and its reflection from the surface, called p^P. Moreover, when several stations show clear onsets of P and p^P waves, the time intervals between them give an average depth, with an uncertainty of perhaps 10 km or even less. However, P travel times differ according to region and clear identification of p^P reflection is sometimes obscured by their scatter or attenuation at the source. The shallower the earthquake the more difficult it is to use this method. A similar method uses sP reflection of S waves, originating as a conversion of S wave energy into P waves. The effects of attenuation in the mantle can be removed by so-called deconvolution of the record. Another way is cepstrum forming, that is, forming the spectrum of the spectrum of the P signals and scalloping the amplitude spectra of these signals. Yet other methods mentioned by different sources are analysis of the shape of signals using surface waves and their amplitude spectra, since the Rayleigh wave spectrum is sensitive to the depth of an event for periods between 10 to 50 seconds. For this latter method, however, the structure of the medium and the source parameters of the event must be known. A comparison of short-period P signals from different events also shows a range of depth since the waves from deep earthquakes frequently differ from those of shallow earthquakes. Measurement of travel-times of PKP waves (those passing through the Earth's core) may also be mentioned as a possible aid, since it is now possible to predict the travel-times of these waves. If data is used from the stations located near the source several other methods are applicable, such as measurement of S and P wave arrival-times, comparison between local phases of P waves, that is P_n and P_g waves (those going through Earth's upper mantle under Mohorovičić discontinuity and granite layer). As with the problem of location, the master event technique is very useful in establishing the depth of focus. It serves to determine accurate travel-times, and corrections for a possible area of tests to be designed.

The accuracy of the depth of focus estimation is still not satisfactory, though it is improving. It was established as about 50 km in the 1969 SIPRI report; Whitham and Basham indicate that it cannot be better than 10 km, and Evernden believes it to be about 30 km.

Relative excitation of P and surface waves

This method is based on the fact that shallow earthquakes generally radiate long-period surface waves more efficiently than do explosions of equivalent short-period energy-release (measured by excitation of P body waves). The actual excitation of these two types of wave is compared through their magnitudes: m_b, the magnitude of short-period P waves (about one second) and M_s, the magnitude of long-period surface waves (about 20 seconds) [12j]. The differences between the magnitudes for shallow earthquakes and explosions are so large that they have caused this method to be considered the most successful identification technique.

The applicability of this method is dependent on the ability to detect surface waves from events for which body waves are detected. In other words, the magnitude threshold at which surface waves can be detected is the threshold at which the criterion can be applied in a positive way. The difficulty stems from the fact that while some earthquakes are masked by other unrelated events of large magnitude, others do not generate surface waves at all, partly because they have abnormally high stress-drop, which makes their mechanism similar to explosions. However, as Evernden points out, so-called "anomalous" events which have M_s/m_b values similar to explosions, are not anomalous but are probably just inadequately analysed, since most of the variations in these values are explainable by source mechanisms and depth effects [43b].

The actual reading out of the surface waves may be enhanced by basing it on spectral analysis of the full 20- to 40-second interval of Rayleigh waves. Sometimes the maximum of both Love and Rayleigh wave magnitudes can be used to improve the M_s/m_b discrimination [44]. This possibility is based on the observation that patterns of Love and Rayleigh waves are complementary: at different azimuths either Love or Rayleigh waves are in maximum. Another improvement is to use the R_g phase of the surface waves at short distances.

The M_s/m_b ratio is, however, strongly dependent on regional attenuations of body-waves at source and station site, and on azimuthal and depth dependence of surface waves. For these reasons this criterion may be successfully used only in one and the same region, since the degree of distinction between natural and man-made events varies from region to region. One of the possible solutions would be to design the surveillance network so as to exploit whatever systematic features exist in the radiation patterns of surface waves from regions requiring surveillance.

The magnitude threshold of events to which the discussed discriminant may apply is already very low. The 1969 SIPRI report expressed the opinion that at m_b 4.75 and above it was possible to identify all explosions from the seismic events detected. Bolt holds that in some regions of western USA, the discriminant worked well down to m_b 3.75. This result may, however, be invalid for other regions [36e]. Dahlman and Israelson set the limit equally low: "it has also been shown that separation is attainable for weak events, that is, events equivalent to explosion yield in hard rock down to about 1 kt" [12k]. An explosion of one kiloton is equivalent to body wave magnitude m_b 4.0.

Complexity of P waves

This criterion utilizes the seismic signal's signature characteristics in time. It is one of several short-period discriminants which show great promise, although it was described in 1971 as not as useful as expected. The discriminant is usually expressed as the ratio of the P wave energy in the first five seconds to the P wave energy in the following 30 seconds [42b]. It appears generally that explosions produce less complex signals than do shallow-focus earthquakes. However, as the 1969 SIPRI report points out, the complexity of P waves is often a function of azimuth. Thus a simple earthquake at one station may become highly complex at another. Similarly, signals from explosions differ. The power of discrimination declines considerably with the magnitude of an event.

One way of strengthening this criterion is through regionalization of data on complexity. Assuming minimum complexity values for earthquakes as those to be expected from explosions in a given area, the border value of complexity for earthquakes in the area can be obtained, since earthquakes cannot be simpler than explosions at a given level of energy release.

Dahlman and Israelson describe a number of other ways of utilizing signal wave forms as discriminants. One of them is the multi-dimensional vector, describing relative amplitudes during the initial 10 seconds after the signal's onset; another possibility is to use autoregressive models in representing P signals; and yet another one mentioned in the same source is to use a discriminant called pulse width, that is, the ratio of the area to the maximum amplitude of signal corrected for the response of the seismometer [12l].

Other short-period discriminants

These discriminants are based on spectral differences between short-period signals from earthquakes and explosions, given the fact that even very small explosions are significantly richer in high frequencies than are small earthquakes. An early discriminant of this category was the dominant period of short-period signals. A more advanced one is the signal's spectral ratio, or SR, based on a comparison of amplitudes in one low-frequency (0.35–0.85 Hz) and one high-frequency band (1.45–1.95 Hz). When comparing several bands of different frequencies, combined spectral ratio is obtained. Another parameter used for discrimination is the third moment frequency or TMF, that is, the expression of the relative high-frequency content of signals. It was established that explosions usually yield large TMF values. Also tested were discriminants based on the whole spectrum of signals, divided into narrow bands of a given width. This permits a characterization of the spectrum by a spectral amplitude vector [12m].

The spectral discriminants are extremely efficient in distinguishing between earthquakes and explosions, despite the regional and source variations observed. Although they do not identify events as clearly as the M_s/m_b discriminant, they have wider application and, moreover, are less sensitive than the M_s/m_b discriminant to noise variations and signal interference.

Rayleigh and Love wave spectra

Explosions excite fewer or no long-period surface waves. If, however, records from long-period seismometers are available, then Rayleigh wave spectra can be analysed. Signals are analysed from the point of view of ratio of energy in Rayleigh waves at periods of 19–22 and 40–60 seconds. Another method is to use the Rayleigh waves' record envelope area (A_R), obtained from integrated spectra of all three orthogonal seismic records. This value may be compared with the magnitude of the event. Evernden plots individual station values of A_R versus distance and then defines a curve of A_R change with distance based on this data. Together with other discriminants, like depth of focus and long-period criteria, this discriminant seems to be very efficient.

As with A_R, the Love wave (A_L) energy can be measured with different instruments (horizontal). The horizontal component of Rayleigh wave motion has to be separated from the record [42c].

Polarity of first motion

This criterion uses the differences of radiation pattern between a totally compressive explosion and both compressive and rarefactional radiation of earthquakes. This criterion was deemed to be the most positive at the 1958 Geneva conference. However, the first motion orientation is difficult to observe in the presence of noise and is now considered of doubtful usefulness. Only broad-band seismometers may be of help in recording the early signals. Even then, however, the criterion cannot be used at low magnitudes [37c, 42d, 45].

Long-period S waves

These waves can be detected only by long-period instruments. The criterion works on the assumption that explosions generate less shear-wave energy than do earthquakes. The influence of disturbing noise can be overcome in monitoring these waves by using a station near-by and through long-period array processing. The method of analysing S waves is to check the amplitudes of the waves and to compare the P wave amplitude–period data [42e]. S wave excitation may provide a means of establishing negative evidence for event discrimination.

Long-period P waves

This criterion, similar to the long-period S waves criterion, works through a comparison of amplitude of a signal's period. As Evernden points out, data of long-period P waves suggest that amplitude-to-period values normalized to 20 degrees of distance for shallow-focus continental earthquakes are greater than 5.0, whereas comparable values for explosions are less than 5.0 [42e].

Corner frequency

This discriminant is mentioned by Dahlman and Israelson. Corner frequency is the frequency at the point when the amplitude of a seismic signal, having been constant at low-frequency range, suddenly drops. It can be estimated from the amplitude spectra of long-period and short-period P wave signals. Observed differences in corner frequency are as large as 3 to 10 for explosions and earthquakes [12n].

Several other discriminants are mentioned as being developed at present. These are S to P wave amplitude ratio; Love and Rayleigh spectral ratio; L_g to R_g local phase amplitude ratio; prevailing period of Love waves, foreshocks and aftershocks; and azimuthal magnitude scatter [39d]. All of them, as those mentioned above, have an auxiliary value in identifying seismic events, although they are less effective than the first three criteria discussed.

The threshold of identification of seismic events

The threshold of identification of seismic events can be defined as the smallest seismic event (earthquake or underground nuclear explosion) which can be clearly detected, located and identified at a specific distance. This threshold thus varies according to region, station and distance and is higher for identification than for detection. The data on threshold are usually given as the incremental 90 per cent level, which is the magnitude at which 90 per cent of events actually occurring at that magnitude are detected or identified. Since detection and location are based on P waves, the thresholds of detection and location are assumed to be equal to the P wave detection threshold. Since the most powerful discriminant, M_s/m_b, is based on the records of surface Rayleigh waves, the most generally accepted identification threshold is equal to the Rayleigh wave detection threshold.

There is a large variety of opinion about the actual level of capabilities for seismic discrimination. These opinions, however, clearly indicate that the threshold of detection and identification is steadily decreasing, and what was considered to be optimistic half a decade ago is now accepted as entirely rational even by the most pessimistic experts. When the 1969 SIPRI report was published, the identification threshold using the M_s/m_b discriminant was believed to be equal to magnitude m_b 4.75, or to a yield of about 20–60 kt. A year or two later, Basham and Whitham [30c] considered as the lowest P wave detection threshold m_b 4.5, corresponding to a 3- to 10-kt range anywhere in the Northern Hemisphere, and for the Rayleigh wave threshold (in body wave magnitude) m_b 5.0, that is, the 10- to 20-kt range. Partly based on the work of Basham and Whitham, the SIPRI report of 1971 [46], prepared by Davies, gives the identification threshold as a 20-kt explosion in hard rock, and points to the possibility of achieving the level of a 10-kt explosion in two years' time with the use of newly established instruments. In 1970 ARPA issued a summary report of the seismic discrimination meeting which established that "the method for discrimination which applies at m_b 5 extends below m_b 4.5" and that "the arrays, and the experimental very long period installations are expected to provide the body of surface wave data, at teleseismic distances, needed to determine the effectiveness of the $M_s:m_b$ discriminant at magnitudes less than m_b 4.5". Moreover another version of the same report, not approved for public release, put the same findings in a more optimistic way: "Adequate data were presented on $M_s:m_b$ values to establish that discrimination by M_s/m_b is on average as well done at m_b 4 as at m_b 5" and "Inspection of Ogdensburg long-period data as a function of source region suggests that a 10 db gain in a signal-to-noise ratio over that obtainable by visual inspection of the Ogdensburg records is adequate for distances of greater than 60 degrees" [39e]. Magnitude m_b 4 corresponds to the yield of a 1- to 2-kt explosion in hard rock.

In 1971 Canada presented a working paper to the CCD [47] which concluded that "in any case, this problem of event location is solved in principle down to m_b 4.2 or so" and added the possibility that if well sited medium-aperture arrays were established, the limit for m_b 4.0 (M_s 2.6, corresponding to 5–10 kt) will be obtainable. Similar conclusions were reached by Brune during 1971 Congressional hearings [13f]. The same source brings together several opinions of seismologists concerning the possible identification thresholds, which range from m_b 3.75 to m_b 4.75 with stress on the possibility of lowering this threshold positively to m_b 4.0. As indicated above, the requirements concerning new instruments such as very long-period and array stations are satisfied. Moreover, the statements discussed here mainly concern the M_s/m_b discriminant. When applying this criterion alone, the Hagfors observatory in Sweden can positively identify explosions of yields above some 10 kt. However, for identification of an explosion down to a yield of one kiloton, short-period identification methods, some of which are mentioned above, giving good identification of seismic events, can be successfully used [48].

Dahlman and Israelson concluded their monograph on seismic monitoring of nuclear explosions thus:

Summarizing this technical discussion, we conclude that it is possible to implement a monitoring system, consisting of (1) a global network of seismological stations, (2) access to photographic satellite data, and (3) an international data collection and evaluation center, by which magnitude-4 earthquakes and explosions, corresponding to hard-rock explosion yields of about 1 kt, can be detected, located, and identified with a high degree of confidence [12n].

Negative evidence as an identification criterion

Verification of seismic events by so-called negative evidence takes advantage of the fact that the absence of certain waves or the lack of certain characteristics of seismic signals typical for earthquakes are good proof that the event was an explosion. These negative criteria may be applied to several observations. Thus a lack of excitation of Rayleigh and Love waves would be evidence of an explosion, especially when the observed P waves indicate such a magnitude that, had an event been an earthquake, such waves would have been observable. To apply such negative evidence, as Basham and Whitham [30d] indicate, the regionalization of data is necessary, in order more easily to identify an unusual event which can distort the evidence. Dahlman and Israelson [12o] describe a method in which the noise amplitude at the expected arrival time of surface waves is used as an estimate of the upper limit to M_s (magnitude based on surface waves). Thus despite an absence of surface waves, the ratio M_s/m_b is calculated in their method and the applicability of this criterion is increased by a unit of about half of m_b.

By definition, negative evidence does not provide positive identification of a seismic event. However, it gives a higher certainty of discrimination between earthquake and explosion signals. Professor Brune, in testimony to the US Congress, stated on the problem of negative identification: "The present data, primarily from the Western United States, indicate that there will not be a serious false alarm problem above m_b 4 once optimum arrays are deployed but we cannot be sure for other regions of the earth" [13g]. Nevertheless, another witness to the Congress, Dr Lukasik, denied the concept of negative evidence: "There is tremendous variability in seismic observations... As a result there are lots of reasons why one might not in a given case receive a surface wave from an earthquake. This opens up the very disturbing possibility of generating false alarms . . ." [39f].

The problem of evasion

Evasion concerns the clandestine activity of a state carrying out underground explosions in such a manner that advantage is taken of natural phenomena or engineering capabilities, so that the seismic records of such explosions would be obscured or hidden from surveillance instruments. There exist several such possibilities, which can be grouped into three categories: decoupling, hiding in natural seismic disturbances, and multi-shot evasion (earthquake simulation).

Evasion by explosion decoupling

Since the explosion yield corresponding to a given magnitude read out from a seismogram depends on the medium, there are possibilities of evading the monitoring of a given explosion by siting it in a low-coupling medium, like dry alluvium, or in a cavity large enough to prevent its walls from being subjected to stress exceeding the elastic range of pressure.

A number of experiments have shown that the decoupling factor for dry alluvium is up to 10 for low-yield explosions. This means that a 10-kt explosion would generate a seismic signal whose amplitude would be reduced by a factor of 10 compared with that obtained from a hard-rock explosion.

However, there are several stringent requirements for the existence of deep dry alluvium: (*a*) the presence of accumulating sedimentary sequences (*b*) abnormally high porosity of the accumulating sediments; (*c*) abnormally low rainfall; and (*d*) the absence of through-flowing trunk streams [49a].

Places where all these highly restrictive conditions are satisfied are extremely rare. The only one definitely known is the Nevada Test Site (NTS), of which only 800 km^2 consists of highly porous rock which is dry to a depth of more than 300 metres. No other such area is known in the United States. In the USSR the three possible locations of somewhat similar materials are at the Caspian Sea, a region east of Tibet, and the latitude of Lake Aral near the southern border of the USSR. However, these deposits are virtually all at or within 100 metres of base-level. The place geologically most similar to the NTS is a basin near the Tien Shan, which seems, however, to have lower porosities and is drained by through-flowing trunk streams. Only a few points in the southern area of central Asia indicate the probable presence of 100 to 300 metres of dry alluvium, and there are a few other locations of equally deep deposits of poorly consolidated sediments. This latter material is more coupling than alluvium, and the effective use of such material is possible with devices of up to 1–2 kt.

Decoupling in a cavity can be full or partial. The explosion is fully decoupled when the shock-wave deformation of the cavity walls is elastic. Such decoupling requires large cavities. The decoupling factor in this case is said to be around 100. Full decoupling of a 1-kt explosion requires a hole 45 metres in diameter, and a 10-kt explosion requires a cavity 100 metres in diameter. Diameters of this size are theoretically obtainable only in salt formations or in hard rock.

Partial decoupling occurs in a smaller cavity than that required for full decoupling, greatly though incompletely reducing the seismic signal. In practice the decoupling factor in this case is about 10. There is also a possibility of decoupling in a so-called heat-sink by lining the cavity with a material absorbing (through volatilization) most of the energy of the explosion, and so reducing the seismic signal.

Salt domes of the size required do exist. However, no salt deposits in the USA or the USSR appear to have the necessary correlation of thickness (for a 90-metre cavity, a homogeneous salt mass should have a depth and thickness of 450 metres) and homogeneity required to preserve the stability of a large-diameter hole. So far as the cavity in hard rock is concerned, Evernden points out that it is almost impossible to find natural rock masses which meet the isotropy, homogeneity and elasticity requirements assumed for theoretical studies. There are always fractures in the rocks, and considerable *in situ* stresses. Evernden concludes his argument with the opinion that there seems to be little possibility of achieving fully decoupled explosions at yields of greater than 10 kt [49b].

Evasion by hiding in natural seismic disturbances

This evasion scheme is based on obscuring the seismic signals from an explosion in a strong coda of signals from natural events of the same or a higher magnitude. One way of doing this is to locate the device in a highly seismic area and to explode it when large earthquakes occur, followed by a sequence of aftershocks. Such a man-made event would not raise suspicion as to its location and even wave signals would be difficult to discern. This method of evasion is called partial hiding—it is aimed at concealing mainly long-period waves, since the short-period signals from the seismic region might not raise suspicion in any case. However, the short-period signals would not be affected and with the availability of short-period identification methods, such as new methods of determining the depth of focus, the chances of successfully hiding an explosion are rather small, depending on its yield. Despite the high seismicity of a region, the number of opportunities for hiding a 3- to 5-kt explosion (m_b in hard rock is 4.5) are rather small. Dahlman and Israelson calculated it to be from 0.3 per year in the western USA to 3 per year in the Kuril Islands [12p].

Another possibility exists in hiding an explosion in a very strong earthquake in a region far from the explosion site—say 500 km away. This very strong earthquake would saturate the seismic station for a protracted period, making it very difficult to identify an explosion's signal. However, this evasion scenario is weak in that such earthquakes occur very seldom. The evader would thus have to wait trigger-ready with the explosion, which is practically impossible. Moreover, as is pointed out by Dahlman and Israelson, stations in distance ranges of between 100–135° and 150–180° from the earthquake and within 90° from the explosion, would probably be able to detect even a weak explosion. An experiment with an m_b 7.3 earthquake and an m_b 4.7 explosion (a few kilotons) shows that the explosion could, with a high probability, be discerned at Hagfors station [12q].

Evasion by earthquake simulation

If a specific geometrical pattern and well chosen time sequence of several nuclear explosions is used, their seismic signals would be clearly detected but might be misinterpreted as having been generated by a natural earthquake. One such experiment with simulation of an earthquake's signal by superimposing eight seismograms of single explosions was carried out by Kolar and Pruvos [50], who designed the geometry, firing orders, yields and time delays for these explosions. They also studied the engineering, logistic, camouflage and diagnostic arrangements which would be crucial in undertaking and hiding such clandestine tests. The authors claim that presently available criteria are too weak or too little developed to be able to discern the real nature of such an explosion, and that if precautions are taken to conceal such tests from non-seismic observation means, such clandestine tests could be completely successful. However, entirely different opinions, pointing to the great capacity of seismic stations to discover such multi-shot evasions, are expressed by a number of other experts [12r, 51–52], and in a British working paper presented to the CCD in 1975 [53]. According to these sources, it would be impossible to avoid the identification of multi-shot events by such criteria as first motion, complexity and the M_s/m_b discriminant. Nevertheless, a multi-shot sequence cannot alter the relative excitation of Love and Rayleigh waves. Moreover, it would be nearly impossible to imitate a strong and systematic azimuthal pattern of surface waves, so that for a majority of monitoring stations at different places, the waves really look like those coming from an earthquake. The British paper points at the availability of broad-band seismometers as an efficient way of counteracting evasion by multi-shot techniques. Moreover, as Dahlman and Israelson argue, there is a great difference between a theoretical experiment and its practical applicability. The effects of real explosions are extremely difficult to judge with certainty, since it is almost impossible to predict the seismic signals received by a number of globally dispersed stations.

The feasibility of evasion—a general assessment

Several possibilities for seismic evasion exist. Each one presents, however, enormous technical problems in its practical application, and as some US experiments show, these undertakings are several times more costly than tests carried out openly. Currently available seismic discrimination techniques make it certain that only very small explosions—of at most a few kilotons—could possibly escape identification as man-made. A number of non-seismic methods of surveillance also exist which are difficult, if not impossible to circumvent. If stations were permitted close to the more seismically active areas, then, as shown in very interesting studies by Evernden, using 15 internal and 15 external close-by stations, the level of possible discovery would be very high indeed [51].

We may conclude this section on evasion with a statement made by Dr Panofsky:

> Any means of evasion, however successful technically, still involves a not negligible risk of detection; information leaks, either deliberate or inadvertent, can give clues of evasion attempts involving complex undertakings. Therefore, any attempt at evasion involves a balance of risks, costs, and incentives. Since military incentives for evasion are not large, it would be difficult to see why a nation would sign a comprehensive nuclear test ban with the deliberate intent of then proceeding with evasion [26b].

IV. Nuclear explosions for peaceful purposes and a CTB

Possible peaceful applications of nuclear explosions cover explosions carried out for scientific research, the excavation of canals, the creation of underground storage cavities and water reservoirs, the stimulation of "tight" gas formations, *in situ* retorting of oil shales, *in situ* leaching mineral ores (such as copper), electrical power generation by sequential fusion explosions in a cavity and extinguishing gas-well fires [12s, 24c, 36f].

Two states, the USA and the USSR, carried out all but one of the peaceful nuclear explosions (PNEs) thus far made—the exception being made by India. Thus only these two states have had a chance to examine the concept of PNEs in depth. It is claimed that none of the above-mentioned peaceful applications—while being technically possible—presents an economically attractive alternative. In addition, the radioactive decontamination of products obtained from PNEs and the radioactive pollution of the environment may cause insurmountable problems [54–57]. A further serious constraint is the legal commitment of over 100 countries party to the PTBT not to allow any radioactive debris from a PNE to stray beyond their own borders. Any amendment conceding the right to vent radioactive debris would require the action of all the parties concerned, and would undermine the value of the treaty.

Despite these arguments, some countries, especially India and Brazil, see a great potential in PNEs and argue that they may speed up their development. The cost effectiveness of PNEs, they claim, may be greater for the underdeveloped countries than it would be for the industrialized states [58]. It seems therefore that only a wide dissemination of the data on which judgements must be based will be able to alter the insistence of some states on the possible "benefits" of PNEs. Furthermore, their positions will probably not change until the nuclear weapon states carry out their obligations under Article V of the NPT, concerning PNEs [59–60].

Article V of the NPT states:

> Each Party to the Treaty undertakes to take appropriate measures to ensure that, in accordance with this Treaty, under appropriate international observation and through appropriate international procedures, potential benefits from any peaceful applications of nuclear explosions will be made available to non-nuclear-weapon States Party to the Treaty on a non-discriminatory basis and that the charge to such Parties for the explosive devices used will be as low as possible and exclude any charge for research and development. Non-nuclear-weapon States Party to the Treaty shall be able to obtain such benefits, pursuant to a special international agreement or agreements, through an appropriate international body with adequate representation of non-nuclear-weapon States. Negotiations on this subject shall commence as soon as possible after the Treaty enters into force. Non-nuclear-weapon-States Party to the Treaty so desiring may also obtain such benefits pursuant to bilateral agreements.

This legal obligation, which has not yet been fulfilled, may be contradictory to the purposes of a CTB. How this could and will be solved is not at present clear.

It is clear that a nuclear explosive device designed for a peaceful purpose cannot be distinguished from a purely military device. The same materials, technology and expertise are required for its construction, and if necessary, a peaceful device may be transported over military targets and exploded as a bomb. Thus peaceful nuclear explosion technology is tantamount to a nuclear weapon capability. Moreover, no verification procedure can ascertain that a PNE is not being used for a military purpose which makes it an easy cover for nuclear weapon tests. Under a comprehensive test ban, without a corresponding ban on PNEs, the temptation to use the latter for illegitimate purposes would be a real one, and the effectiveness of the provisions of a CTB could not be guaranteed [26c].

There seems to be no reason to trade the possible but doubtful economic value of PNEs for the danger of postponing the conclusion of a CTB, or weakening this agreement to the point of its having no practical significance. The net difference between the two choices is the danger of the world-wide proliferation of nuclear explosives technology, which would, in turn, be bound to lead to the proliferation of nuclear weapons. All the painstaking agreements in arms control that have hitherto been reached—primarily the NPT—would be considerably endangered. This would be particularly tragic in view of the fact that a ban on PNEs cannot be regarded as an especially great sacrifice. The enormous resources needed in utilizing PNE technology in terms of research, engineering and production of the hundreds of devices that would be necessary for a single large project, are simply not worth it.

Notwithstanding the present controversies, a decision must be taken soon to achieve a meaningful CTB which includes PNEs in its terms. Even an agreement to postpone PNEs until further studies on their applicability have been carried out and arrangements for their international control made, would be preferable to an agreement on a CTB which excluded PNEs from its scope—thus containing a dangerous loophole which would endanger this, and a number of other important disarmament agreements [61].

V. Conclusions

1. Negotiations on a nuclear test ban are, after two decades, approaching a decisive moment. Whether a CTB will be a truly effective and comprehensive instrument depends on all the parties to the negotiations, and particularly on the nuclear weapon powers. Its importance is measured

by its inextricable connection with the non-proliferation régime and the future of disarmament efforts.

2. Nuclear weapon tests are just a small fraction of the general nuclear arms race. Since they are not the main driving force of this arms race, their prohibition would be helpful, but not decisive, in restraining the qualitative advances of nuclear arsenals. To achieve more substantial progress in strategic arms control and disarmament, much more is required than to stop the tests. However, a CTB would be an important beginning.

3. The conclusion of a CTB would be of great importance in strengthening the NPT and PTBT agreements. Achievement of a CTB may indicate an intention of the great powers to end the arms race. It would give an impetus for wider disarmament efforts, and may assist détente.

References

1. UN document A/Res/31/66.
2. *Pravda*, 3 November 1977.
3. Disarmament Conference document CCD/523.
4. UN document A/10241.
5. Disarmament Conference documents CCD/526 and CCD/526/Rev. 1.
6. Disarmament Conference document CCD/348.
7. Disarmament Conference document CCD/524.
8. Disarmament Conference document CCD/540.
9. Disarmament Conference documents CCD/528 and Corr. 1.
10. Disarmament Conference document CCD/534.
11. Disarmament Conference document CCD/542.
12. Dahlman, O. and Israelson, H., *Monitoring Underground Nuclear Explosions* (Elsevier Scientific Publishing Company, Amsterdam, 1977).
    (a) —, p. 47.
    (b) —, p. 58.
    (c) —, pp. 149–54.
    (d) —, pp. 212–19.
    (e) —, pp. 109–13.
    (f) —, pp. 121–28.
    (g) —, pp. 128–30.
    (h) —, p. 189.
    (i) —, p. 190.
    (j) —, p. 219.
    (k) —, p. 235.
    (l) —, p. 239.
    (m) —, pp. 241–47.
    (n) —, p. 252.
    (o) —, p. 234.
    (p) —, p. 320.
    (q) —, p. 321.
    (r) —, p. 323.
    (s) —, pp. 291–303.
13. *Comprehensive Nuclear Test Ban Treaty*, Hearings before a subcommittee on

Arms Control, International Law and Organization of the Committee on Foreign Relations, US Senate, 92nd Congress, 1st Session (US Government Printing Office, Washington, 22–23 July 1971).
(a) —, p. 130.
(b) —, p. 106.
(c) —, p. 101.
(d) —, pp. 101 and 108.
(e) —, p. 134.
(f) —, pp. 144–45.
(g) —, p. 142.

14. Feld, B. T. *et al.* (Eds.), *Impact of New Technologies on the Arms Race*, Pugwash Monograph (MIT Press, Cambridge, Mass., 1971), p. 136.
15. *Military Record of CBR/Atomic Happenings*, Report WS 094/77 (Aviation Studies Atlantic, London, January 1977).
(a) —, p. 12.
(b) —, p. 14.
16. *Military Record of CBR/Atomic Happenings*, Report WS 096/77 (Aviation Studies Atlantic, London, July 1977).
17. *Military Record of CBR/Atomic Happenings*, Report WS 093/77 (Aviation Studies Atlantic, London, November 1976), p. 5.
18. Westervelt, D. R., "Candor, Compromise, and the CTB", *International Security*, 7 January 1977.
(a) —, p. 11.
(b) —, pp. 6–7.
(c) —, p. 8.
(d) —, p. 5.
19. Hopkins, J. C., "Why Not Stop Testing? A Weapons Designer's View", *Bulletin of the Atomic Scientists*, April 1977, pp. 30–31.
20. Day, S. H., Jr., "The Nuclear Weapons Labs", *Bulletin of the Atomic Scientists*, April 1977, pp. 21–32.
21. Disarmament Conference document CCD/492.
22. *Prospects for a Comprehensive Nuclear Test Ban Treaty*, A Staff Report for the Use of the Subcommittee on Arms Control, International Law and Organization of the Committee on Foreign Relations, US Senate (US Government Printing Office, Washington, 1 November 1971).
(a) —, p. 3.
(b) —, p. 4.
23. *SIPRI Yearbook of World Armaments and Disarmament 1968/69* (Almqvist & Wiksell, Stockholm, 1969, Stockholm International Peace Research Institute), pp. 249–54.
24. *World Armaments and Disarmament, SIPRI Yearbook 1972* (Almqvist & Wiksell, Stockholm, 1972, Stockholm International Peace Research Institute).
(a) —, p. 387.
(b) —, pp. 413–17, 437–60.
(c) —, pp. 424–25, 464–69.
25. Rathjens, G. W., "The Verification of Arms Control Agreements", *Arms Control Today*, Vol. 7, No. 7/8, July–August 1977.
26. *Hearings on S. Res. 67 Calling on the President to Promote Negotiations for a Comprehensive Test Ban Treaty*, before the Subcommittee on Arms

Control, International Law and Organization of the Committee on Foreign Relations, US Senate, 93rd Congress, 1st Session, 1 May 1973 (US Government Printing Office, Washington, 1973).
(a) —, p. 111.
(b) —, p. 115.
(c) —, pp. 116–17.

27. Wiesner, J. B. and York, H. F., "National Security and the Nuclear Test Ban", in *Arms Control. Readings from Scientific American* (W. H. Freeman & Co., San Francisco, 1973), pp. 129–32.
28. *Military Record of CBR/Atomic Happenings*, Report WS 095/77 (Aviation Studies Atlantic, London, March 1977).
(a) —, p. 6.
(b) —, p. 3.
29. *Military Record of CBR/Atomic Happenings*, Report WS 097/77 (Aviation Studies Atlantic, London, October 1977), p. 1.
30. Basham, P. W. and Whitham, K., *Seismological Detection and Identification of Underground Nuclear Explosions*, A Report Prepared for the Arms Control and Disarmament Division (Department of External Affairs, Canada, November 1970).
(a) —, p. 47.
(b) —, p. 33.
(c) —, pp. 62–63.
(d) —, p. 61.
31. *The Detection and Recognition of Underground Explosions*, A Special Report of the United Kingdom Atomic Energy Authority (London, December 1965).
32. Bullard, E., "The Detection of Underground Explosions. Arms Control", in *Arms Control. Readings from Scientific American* (W. H. Freeman & Co., San Francisco, 1973).
33. Ericsson, U. A., "Event Identification for Test Ban Control", *Bulletin of the Seismological Society of America*, Vol. 60, No. 5, October 1970, pp. 1521–46.
34. Ericsson, U. A., "Identification of Underground Nuclear Explosions and Earthquakes", *FOA Reports*, Vol. 5, No. 8, December 1971, pp. 1–8.
35. Marschall, P. D. *et al.*, "How and Why to Record Broad Band Seismic Signals", *Nature*, Vol. 239, No. 5368, 15 September 1972, pp. 154–55.
36. Bolt, B. A., *Nuclear Explosions and Earthquakes. Parted Veil* (W. H. Freeman & Co., San Francisco, 1976).
(a) —, pp. 114–19.
(b) —, pp. 141–47.
(c) —, p. 148.
(d) —, pp. 149–51.
(e) —, p. 154.
(f) —, pp. 181–99.
37. *Seismic Methods for Monitoring Underground Explosions*, Stockholm Paper No. 2 (Almqvist & Wiksell, Stockholm 1969, Stockholm International Peace Research Institute).
(a) —, pp. 32–37.
(b) —, p. 12.
(c) —, p. 46.
38. Disarmament Conference document CCD/491.

39. *Hearings on Extent of Present Capabilities for Detecting and Determining the Nature of Underground Events* before the Subcommittee on Research, Development, and Radiation of the Joint Committee on Atomic Energy, 92nd Congress, 1st Session, 27–28 October 1971 (US Government Printing Office, Washington, 1971).
(a) —, pp. 17–39.
(b) —, pp. 62–63, 138.
(c) —, p. 118.
(d) —, pp. 44–45.
(e) —, pp. 361–64.
(f) —, p. 46.
40. Disarmament Conference document CCD/493, p. 4.
41. Douglas, A. *et al.*, "Estimating the Firing Depth of Underground Explosions", *Nature*, Vol. 237, No. 5349, 5 May 1972, pp. 26–28.
42. Evernden, J. F., "Identification of Earthquakes and Explosions by Use of Teleseismic Data", *Journal of Geophysical Research*, Vol. 74, No. 15, 15 July 1969.
(a) —, pp. 3837–56.
(b) —, pp. 3831–33.
(c) —, pp. 3833–36.
(d) —, pp. 3828–31.
(e) —, p. 3837.
43. Evernden, J. F., "Further Studies on Seïsmic Discrimination", *Bulletin of the Seismological Society of America*, Vol. 65, No. 2, April 1975.
(a) —, pp. 360, 377–78.
(b) —, pp. 386–89.
44. Evernden, J. F. and Kohler, W. M., "Bias in Estimates of m_b at Small Magnitudes", *Bulletin of the Seismological Society of America*, Vol. 66, No. 6, December 1976, pp. 1887–1904.
45. Davies, D., "Monitoring Underground Explosions", *Nature*, Vol. 241, 5 January 1973, p. 21.
46. *Seismic Methods for Monitoring Underground Explosions*, 1971 Progress Report (Almqvist & Wiksell, Stockholm 1971, Stockholm International Peace Research Institute), p. 21.
47. Disarmament Conference document CCD/327.
48. *Nuclear Weapons and Nuclear Explosions. Hagfors Seismic Array Station* (FOA, Stockholm, 1977).
49. Evernden, J. F., "Study of Seismological Evasion. Part 1. General Discussion of Various Evasion Schemes", *Bulletin of the Seismological Society of America*, Vol. 66, No. 1, February 1976.
(a) —, pp. 245–80.
(b) —, p. 253.
50. Kolar, O. C. and Pruvost, N. L., "Earthquake Simulation by Nuclear Explosions", *Nature*, Vol. 253, No. 5489, 24 January 1975, pp. 242–45.
51. Evernden, J. F., "Study of Seismological Evasion. Part III. Evaluation of Evasion Possibilities Using Codas of Large Earthquakes", *Bulletin of the Seismological Society of America*, Vol. 66, No. 2, April 1976, p. 591.
52. Marschall, P. D. and Hurley, R. W., "Recognizing Simulated Earthquakes", *Nature*, Vol. 259, No. 5542, 5 February 1976, pp. 378–80.
53. Disarmament Conference document CCD/459.

54. Carter, L. J., "Peaceful Nuclear Explosions: Promises, Promises", *Science*, Vol. 188, No. 4192, 6 June 1975.
55. Poulose, T. T. and Raja Mohan, C., "Peaceful Nuclear Explosions", *IDSA Journal*, Vol. 9, No. 1, July/September 1976, pp. 14–36.
56. Nordyke, M. D., "A Review of Soviet Data on the Peaceful Uses of Nuclear Explosions", *Annals of Nuclear Energy*, Vol. 2, No. 9/10, 1975, pp. 657–73.
57. *An Analysis of the Economic Feasibility, Technical Significance, and Time Scale for Application of Peaceful Nuclear Explosions in the US, with Special Reference to the GURC Report Thereon*, Final Report to the US Arms Control and Disarmament Agency from the Program on Science, Technology and Society, Cornell University, Ithaca, AC5AD-23, April 1975.
58. Seshagiri, N., *The Bomb! Fallout of India's Nuclear Explosion* (Vikas Publishing House, PVT Ltd., Delhi, 1975), pp. 51–140.
59. *World Armaments and Disarmament, SIPRI Yearbook 1975* (Almqvist & Wiksell, Stockholm, 1975, Stockholm International Peace Research Institute), pp. 493–95.
60. *World Armaments and Disarmament, SIPRI Yearbook 1976* (Almqvist & Wiksell, Stockholm, 1976, Stockholm International Peace Research Institute), pp. 376–409.
61. Myrdal, A., *The Game of Disarmament* (Pantheon Books, New York, 1976), pp. 212–25.

12. The destruction of chemical warfare agents

Square-bracketed numbers, thus [1], *refer to the list of references on page 374.*

I. Introduction

After many years of negotiations at the Conference of the Committee on Disarmament (CCD) in Geneva, there is now some hope that an agreement on the prohibition of the production of chemical warfare (CW) agents and on their destruction will be reached.

The destruction of large quantities of CW agents raises the question of the verification of these disarmament measures and entails many technical and economic problems. It must be emphasized that in carrying out the destruction of CW agents, human safety and environmental protection must be given the highest priority.

Although suitable methods are known for detoxifying CW agents, there is still a lack of knowledge about dealing with very large stocks—amounting in certain cases to several thousand tonnes.

In recent decades, extensive technical knowledge has been gained on the production and storage of large quantities of CW agents. Knowledge of the best methods for detoxifying CW agents has—apart from purely scientific work on such compounds—mainly been derived from isolated cases of destruction after World Wars I and II and from the disposal of deteriorated stocks in routine replacement.

As regards detoxification, the situation is comparable to that prevailing in industry until a few years ago—the overriding aim was to develop and manufacture new ranges of products, without giving much thought to the technical means of destroying material that was no longer serviceable. However, there has been greater awareness over the past two decades in civilian industry of the necessity for human safety and environmental protection. This has led to fundamental changes. Part of the civilian experience can now be applied to the large-scale destruction of CW agents. However, much technical and scientific work remains to be done.

Detoxification data in the military literature relate mainly to wartime conditions and are, accordingly, of limited use [1–2]. The information concerns the detoxification or destruction of CW agents deposited on land, buildings and equipment, and on man. Under these conditions, the CW agents are present on a large surface or are scattered over a large area. The reaction conditions of the detoxification process are very different for concentrated CW agents stored in containers or loaded in chemical munitions.

Many proposals for the destruction of CW agents have been put forward in recent years at the CCD negotiations in Geneva [3–25].

The following sections give a brief survey of the information published on the destruction of CW agents and of the methods employed.

II. Present stocks of CW agents

There is a great deal of technical literature on the chemistry, mode of action and military significance of CW agents [26–27].

The number of potential CW agents has grown considerably in recent years. However, among the biologically active compounds of interest as CW agents, only a few can be produced on a large scale and stored for military use [28–29].

It is generally assumed that the most important CW agents are organophosphorus compounds, such as sarin, soman and VX and other V-agents. These are all nerve gases of extremely high toxicity and lethality. They inhibit especially enzymes of the cholinesterase type, which are necessary for nerve-transmission processes. The following compounds serve as examples of this group.

Trivial name(s)	Chemical name
VX	Ethyl *S*-2-diisopropylaminoethyl methyl phosphonothiolate
Tabun, GA	Ethyl phosphorodimethylamidocyanidate
Sarin, GB	Isopropyl methylphosphonofluoridate
Soman, GD	Pinacolyl methylphosphonofluoridate

In view of the large stocks dating from World War II and the post-war years, the following CW agents or groups of CW agents will have to be included among those to be destroyed.

Vesicants of the mustard gas type, especially:

Trivial names	Chemical name
Mustard gas, sulphur mustard, yperite, HD	Bis(2-chloroethyl) sulphide
Nitrogen mustard, HN-2	Bis(2-chloroethyl)methylamine
Nitrogen mustard, HN-3	Tris(2-chloroethyl)amine

Organo-arsenic vesicants of the lewisite type:

Trivial name(s)	Chemical name
Lewisite, L	Dichloro(2-chlorovinyl)arsine
ED	Ethyldichloroarsine

Sternutators and lachrymators, such as:

Trivial name(s)	Chemical name
Adamsite, DM	Phenarsazine chloride
CS	2-Chlorobenzylidene malononitrile
CN	Chloroacetophenone

Incapacitating chemical agents, such as:

Trivial name	Chemical name
BZ	3-Quinuclidinyl benzylate

In addition to these CW agents, stocks of binary-weapon components must likewise be destroyed, provided that no alternative civilian use can be found for them.

In addition to the CW agents proper, certain other poisons from civilian production—for example, hydrocyanic acid and phosgene—can also be used for loading in chemical weapons. Both these poisons were classed, along with similarly toxic compounds, among CW agents in World Wars I and II. A great deal of information on the methods for destroying such compounds can be found in the literature [30].

The above-mentioned CW agents are stored mainly in containers (drums, tanks, silos, and so on) and in munitions ready for use (rockets, shells, mines, and so on). The precursors are kept exclusively in storage containers and the binary-weapon components are partially loaded in munitions.

CW agents and their precursors are thus destroyed in two different ways: (*a*) destruction of the CW agent itself, and (*b*) destruction of the CW agent-loaded munitions (with or without explosive).

Varying approaches are required for the destruction of CW agents loaded in munitions, according to whether the munitions can readily be emptied of the CW agent or whether—owing to special technical features, such as fuze construction or the unfamiliar design of captured munitions—the CW agent cannot be removed. The latter case arises where munitions have become corroded as a result of unsatisfactory storage, making deactivation difficult or impossible.

III. Methods for destroying CW agents

Appropriate detoxification reactions for the large-scale destruction of CW agents are briefly described below. It is not possible here to enter into the details of the course of reaction, the special reaction conditions or the reaction kinetics. The discussion relates to stocks of CW agents that have not been loaded in munitions or that have been withdrawn from them. The destruction of CW agent-loaded munitions is dealt with in section VI.

There are two basic methods for destroying CW agents: (*a*) thermal cleavage, and (*b*) chemical cleavage. Thermal cleavage is carried out either in the absence of air as pyrolysis, or in the presence of air as incineration. Chemical cleavage is carried out via (*a*) hydrolysis, (*b*) oxidative chlorination, or (*c*) other less important ways.

The choice of method and of reaction conditions depends on the CW agent in question and on the given technical requirements. Chemical reactions that proceed to completion within minutes or seconds at normal or moderately high temperatures are preferable. Catalysable reactions are thus of great interest.

IV. Thermal cleavage

Cleavage by pyrolysis[1]

Despite the lack of knowledge about this method for destroying CW agents, pyrolytic cleavage is considered an attractive method since all the CW agents considered are relatively heat-sensitive, being rapidly converted to non-toxic products at temperatures of 200–500°C. However, apart from the liquid and viscous residues formed in these conversion

[1] Pyrolysis is generally defined as the thermal decomposition of a compound. With respect to waste carbonaceous materials, pyrolysis represents a means of converting the unwanted waste into a usable commodity with economic value. Most municipal and industrial wastes which are basically organic in nature can be pyrolysed to coke or activated charcoal and gaseous mixtures which may approach natural gas in heating values.

Pyrolysis has only recently been applied to the conversion of organic wastes. The process has traditionally been used to convert homogeneous materials of low economic value, such as wood chips and heavy hydrocarbon distillation residues, to compounds of higher overall economic value, such as fuel gas, pitch, creosote, acetic acid, crude methanol and charcoal (from wood chips), and coke, fuel gas and gas oil (in the distillation of residues).

In view of the increasing constraints on energy use and raw material availability, pyrolysis is receiving a new look as an ultimate disposal technique.

reactions, very dangerous or corrosive gases (such as hydrogen fluoride, hydrogen chloride, and sulphur dioxide) are evolved, making further precautionary measures necessary.

Autoclaves commonly used in the chemical industry can be used as reaction vessels for pyrolysis. The residues—with the exception of organo-arsenical CW agents—can, like their counterparts in the civilian chemical industry, be further treated or disposed of.

Cleavage by incineration[2]

CW agents are so energy-rich that they can be burned in the presence of air. The heat of combustion of any particular CW agent, as well as its heat or energy of formation, can be obtained from the literature or calculated from the theoretical oxygen demand [31].

In practice, CW agents are burned generally mixed with fuel oil or with cheap distillates from the petroleum industry. The low vapour pressure of most CW agents, together with their viscosity and solubility properties, can make furnace operations difficult; hence mixture with fuel oil is beneficial and also permits the combustion process to be made continuous. The mixture of CW agent and fuel oil is normally sprayed via a nozzle into the flame, the flame temperature being comparable to that of an oil burner.

Several thousand tonnes of mustard gas were destroyed by this method in Europe after World War II. Great quantities of mustard gas continue to be destroyed by this method in the USA [32]. Substantial amounts of corrosive waste gases (such as hydrogen fluoride, hydrogen chloride, and sulphur dioxide) are formed in the combustion process in this method and must be retained in absorbers and neutralized. The combustion gases leaving the incinerator are water-quenched before being passed through cross-flow packed scrubbers in series to remove pollutants. The scrubbing media employed are calcium hydroxide and sodium hydroxide for GB, and nitric acid, sodium hydroxide and calcium hydroxide for VX incineration products.

This method may also be used for the disposal of munitions or tanks containing lewisite in concentrated form. The combustion products are carbon dioxide, water, hydrogen chloride, and arsenic trioxide. The

[2] Incineration is a controlled process that uses combustion to convert a waste to a less bulky, less toxic or less noxious material. The principal products of incineration, from a volume standpoint, are carbon dioxide, water and ash, while the products of primary concern—by virtue of their environmental effects—are compounds containing sulphur, nitrogen and the halogens. When the combustion products from an incineration process contain undesirable compounds, a secondary treatment such as after-burning, scrubbing or filtration is required to lower concentrations to acceptable levels prior to atmospheric release. The solid and liquid effluents from the secondary treatment processes will occasionally require treatment prior to ultimate disposal.

arsenic trioxide, removed by alkaline scrubbing, should be converted to the insoluble magnesium salt and placed in controlled storage.

Nitrogen mustard may also be handled by means of this system. The combustion products of the nitrogen mustards are carbon dioxide, water, hydrogen chloride, and nitrogen oxides. The nitrogen oxides require scrubbing or reduction to nitrogen and oxygen before the combustion gases are released into the atmosphere.

This technique may also be applied to munitions or tanks containing sulphur mustard in concentrated form. The sulphur mustard is dissolved in petrol (gasoline) and the solution incinerated. The combustion products are carbon dioxide, water, sulphur dioxide and hydrogen chloride, which are removed by alkaline scrubbing.

A variant of this method is that the CW agent is first bound to an adsorption agent, such as activated charcoal, then partially detoxified with clay minerals (e.g., bentonite) and incinerated. Incineration in admixture with lime, charcoal or clay minerals has the advantage that the combustion residue is either in solid or powder form, thus being easier to remove from the combustion furnace than the highly viscous residues. However, with present-day incineration facilities, one drawback is that the feed of solid or pasty mixtures from CW agents can take place only discontinuously, which is time-consuming and requires extra equipment.

In those cases where very large stocks of CW agents (several hundreds or thousands of tonnes) have to be destroyed, a continuously operated process—that is, a liquid feed of fuel oil plus CW agent, or CW agent alone—is preferable.

V. Chemical cleavage

Cleavage by hydrolysis

Hydrolytic cleavage of CW agents is a fundamental detoxification reaction. It results in most cases in detoxification or, at any rate, in a sharp reduction of potency.

This method is important for organophosphorus CW agents of the sarin or soman type. For example, the hydrolytic half-life of sarin at pH 10 is 4.5 minutes; for tabun, under the same conditions, it is 15.5 minutes. Sarin undergoes its first reaction at the P–F bond and then at the P–O single bond. The normal reaction products are sodium fluoride and the sodium salt of methylisopropylphosphoric acid. The thio-choline type compounds are first attacked at the P–S bond. Quantitative conversion is possible only by the use of strong alkalis in moderately concentrated solutions. Heating of the hydrolysis mixture increases the rate at which the reactions occur. These techniques are adequate for dilute systems if agent concentration is monitored and if the salt products are dried and stored.

Under Project Eagle, the US Army has developed a chemical detoxification procedure for the demilitarization of weapon systems containing sarin: 5 per cent excess sodium hydroxide in an 18 per cent solution reacts with sarin to form sodium salts of low toxicity, which are then recovered by evaporation and stored in plastic-lined drums. VX may be detoxified with caustic alkali and spray-dried to give the sodium salts. These salts may also be stored or used as raw materials for other processes. This method is considered adequate for VX.

The conditions for hydrolysis should be suitably adjusted so as to reduce the reaction time substantially—to the order of seconds—when the reaction is performed using hydrogen peroxide. In the case of sarin, the perhydroxyl ion accelerates the reaction 50 times compared with alkaline hydrolysis.

Moreover, it is possible to catalyse the hydrolytic cleavage of organophosphorus compounds, such as sarin and soman, with anions (e.g., with the hypochlorite ion) and with cations (e.g., with aquohydroxo complexes of various metals, ammino and amino complexes of copper, as well as chelate complexes of uranium, lanthanum, vanadium, zirconium, and molybdenum, among others).

There is a lack of knowledge about performing these reactions on a large scale, particularly in the case of VX and other V-agents. Basic research in this field is still inadequate and investigational findings by military laboratories remain classified.

On the basis of published material and of the results of investigations carried out on structurally analogous civilian compounds (e.g., pesticides of the Amiton or Systox type), it may be said that, owing to the relatively sparing water-solubility of the V-agents, their hydrolysis must proceed relatively slowly (for VX the hydrolytic half-life at pH 10 is approximately 30 hours). Several other hydrolytic reactions occur simultaneously and about 10 per cent of the products formed are highly toxic. It may thus be preferable to subject V-agents to oxidative chlorination.

As regards the hydrolytic cleavage of vesicants of the mustard gas type, normal hydrolysis proceeds too slowly for practical purposes, and it does not appear possible to catalyse it by any simple means. Hence, oxidative chlorination is much to be preferred also in this case.

In dilute aqueous solution, chlorine converts lewisite into arsenic trioxide and dichloroethene. As a chlorinated organic compound, dichloroethene requires further treatment. Arsenic trioxide is slightly soluble and hence should not be placed in a landfill as such. If arsenic trioxide is treated with a suspension of magnesium hydroxide, insoluble magnesium arsenite is formed. The magnesium arsenite thus precipitated and the excess magnesium hydroxide can be stored under controlled conditions, or the slurry can be evaporated to dryness and stored in a permanent disposal area. Aqueous chlorine or sodium hypochlorite treatment, followed by reaction with magnesium hydroxide, is satisfactory for the decontamination or disposal of lewisite even though an arsenite is produced that must be kept in indefinite long-term storage. Both *cis* and *trans* isomers of lewisite are completely decomposed in sodium hydroxide solutions at temperatures above 40°C.

The sodium arsenite produced is soluble and requires treatment with magnesium hydroxide, as previously noted, to form insoluble magnesium arsenite before disposal in a controlled storage facility (lined lagoon, tank, abandoned quarry or mine, and so on).

The other CW agents discussed here are also decomposable, but the rate of hydrolysis, even in alkaline media, is too slow for it to be exploited in a large-scale detoxification process.

Cleavage by oxidative chlorination

Oxidative chlorination of CW agents is a "classic" detoxification procedure, having been successfully used as far back as World War I. Aqueous solutions or suspensions are used in this process.

The detoxification agents in this process are bleaching powder (chloride of lime) or preparations of Perchloron (calcium hypochlorite) or of sodium hypochlorite, which, according to their method of manufacture, contain different amounts of available chlorine (i.e., hypochlorite). These compounds bring about the cleavage of numerous CW agents, chlorination and oxidation occurring simultaneously. In the detoxification of organophosphorus CW agents, there is the further advantage that the hypochlorite ion simultaneously acts as a catalyst in accelerating hydrolytic cleavage. Sulphur mustard added to 10 per cent calcium hypochlorite solution is decomposed in a few minutes. Thus 7.0 kg of calcium hypochlorite, which contain 0.7 kg of calcium oxide equivalent to 0.93 kg of calcium hydroxide, are theoretically required to detoxify 1 kg of sulphur mustard.

The nitrogen mustards, when acidulated, react with calcium hypochlorite in solution to yield much less toxic compounds, including aldehydes, chloramines, and chlorates. The reactions are violent with dry or highly concentrated hypochlorite. Because of the phase-separation problem, sufficient agitation and time must be allowed for the reaction. Mustard sulphone produces severe burns if left on the skin. In practice, therefore, 1.2 times the required amount of calcium hypochlorite is used. The decontamination is conducted in a closed system where all the air leaving the system is scrubbed through calcium hypochlorite solution and filtered. The salts formed upon detoxification are placed in a landfill after evaporation of the water. This treatment process is used for destroying sulphur mustard that is excess, contaminated, or loaded in surplus munitions.

Owing to the extraordinarily high reactivity of hypochlorites, particularly bleaching powder and Perchloron, the reaction with the CW agents to be detoxified may take place explosively. These reactions must, therefore, be carried out only in aqueous solution or suspension. For large quantities of CW agents, this detoxification procedure with hypochlorite compounds is time-consuming and thus not very suitable.

Nevertheless, the reaction is useful when only small quantities of CW agents have to be destroyed and when transport to an incinerator would, perhaps, not be worthwhile. Other occasions may arise, for example, when buildings, soil, or other limited areas have been contaminated by accident or by carelessness in handling large quantities of CW agents in an incinerator. In all such cases, detoxification is carried out as prescribed in military instruction manuals.

Other detoxification reactions

Of the numerous other chemical methods for detoxifying CW agents, three examples are given below.

1. For large-scale detoxification processes, aqueous or water–alcohol solutions of sodium or potassium sulphide or hydrosulphide, or mixtures of such sulphides, with the addition of soap or other emulsifiers, are suitable. Such solutions or suspensions are especially effective for detoxifying many tear-gases, but the method may also be used for other CW agents [33].

Chloroacetophenone reacts with sodium sulphide in alcoholic or alcohol–water solutions to form bis(acetylphenyl) thioether (melting point 74°C), which displays no physiological effects. This process is attractive because it not only converts the chloroacetophenone into a compound showing no physiological effects, but also most nitro compounds, when present, are decomposed to non-explosive substances. This process results in the liberation of hydrogen sulphide, which must be collected by an alkaline scrubber. The alcoholic solution containing the decomposed compounds may be sprayed into an incinerator equipped with an alkaline scrubber to remove any hydrogen chloride, nitric oxide, and sulphur oxides formed. An additional method consists in boiling chloroacetophenone in an alcohol–water solution with sodium thiosulphate, the sodium salt of acetylphenyl thiosulphonic acid being obtained. The thiosulphonate solution must then be sprayed into an incinerator equipped with an alkaline scrubber. This process converts the chloroacetophenone into a compound having no physiological effects, but incineration of the thiosulphate is required. This option does not, in most cases, offer any advantages over incineration or sodium sulphide treatment.

However, the problem in these cases is that the workers handling these solutions may be poisoned by hydrogen sulphide, which is liberated if the pH is inadvertently allowed to drop into the acidic range.

2. Another fairly universal method for detoxifying CW agents was developed some years ago in FR Germany [34–38]. It consists in using tetracalcium aluminate hydrates as well as the structurally related sheet silicates—characterized by the ability to swell in water—belonging to the group of montmorillonites or bentonites [39].

Although large-scale technology for these reactions is still lacking, it appears likely that minerals of the kind mentioned—provided that they are readily and cheaply available in quantity in the countries concerned—will open a noteworthy possibility for universal detoxification.

3. Monoethylamine has been tested in the USA as a universal detoxification agent [40]. The results were satisfactory in those cases where the quantities of CW agents were not too large. However, monoethylamine is not readily and cheaply available in quantity everywhere.

Of the other chemical detoxification methods, brief mention may be made of reactions using oxidizing agents. Numerous oxidizing agents are available industrially, such as potassium permanganate, potassium chlorite, potassium chlorate, alkali peroxides, alkali chromates, and chromic acid. These and other compounds have been used for several cases of industrial detoxification and could, no doubt, also be adapted to the special purpose of detoxifying CW agents.

Finally, to conclude the discussion on oxidation, a few general remarks are given on wet air oxidation (WAO). According to recent publications, WAO provides some of the best practical technology available for destroying waste substances, recovering valuable inorganic materials from the waste stream, and conditioning sludge solids for easy disposal [41–42]. Since the oxidation is exothermic, substantial energy recovery is also feasible.

WAO is based on the discovery that organic materials in aqueous solution or suspension can be oxidized to any desired extent by air, under pressure, at temperatures in the approximate range 180–370°C. The degree of oxidation (from 0 to 100 per cent) depends on the temperature and the amount of air supplied. The wet air oxidation of some compounds can be effectively catalysed.

WAO will be used by the US Navy to destroy safely and without air pollution, off-specification and outdated propellants, explosives and munitions. Such materials have been disposed of in the past by open-pit burning. In WAO, however, a slurry of ground explosives is oxidized with air; the residue is a small volume of inert ash and salts. The Naval Ordnance Station at Indian Head, Maryland, USA, is the site of the first installation of this kind [41].

VI. Destruction of munitions loaded with CW agents

In April 1969, the US Army prepared a plan for the development of a transportable system capable of disposing of any of the chemical munitions stockpiled by the US Department of Defense [43–45]. Because of the presence of a large variety of chemical munitions and because of the availability of engineering personnel and shop facilities, the South Area of Tooele Army Depot, Utah, was selected for test and operation of the Transportable Disposal System (TDS). The system design is based on the removal of the chemical warfare agent from the various munitions, and the separate incineration of agent, casings, and explosives and propellants. This system consists of 12 major sub-systems [43, 47]:

1. Explosive Containment Cubicle (ECC) for the removal of explosives from explosive-loaded munitions.
2. Projectile Demilitarization Facility (PDF) for the removal of agents from projectiles and mortar ammunition and the decontamination of the empty hardware.
3. Bulk Item Facility (BIF) for the removal of agent from non-explosive containing bombs and ton cylinders and the decontamination of the empty hardware.
4. Deactivation Furnace (DF) for burning propellant, explosives, and empty rocket and mine bodies.
5. Deactivation Furnace Scrubbers System (DFSS) for pollution control of the effluent from the DF.
6. Metal Parts Furnace (MPF) for the thermal decontamination of empty metal parts that previously contained agents or might have been contaminated by agent.
7. Air Pollution Control System (APCS) for scrubbing the gaseous effluent of the MPF.
8. Agent Incinerator Scrubber System (AISS) which incinerates agent and reduces pollutant to acceptably low levels.
9. Dunnage Incinerator (DI) with scrubber used for non-toxic combustibles.
10. Sludge Removal and Treatment System (SRTS) used to remove explosive materials from spent decontaminating solutions and evaporate the water.
11. Controls Module (CM) which monitors and controls the above system.
12. Personnel Support Complex (PSC) providing changing rooms, locker rooms, toilets and showers, lunchroom and laundry.

In general, the destruction of munitions loaded with CW agents is hazardous. The components of the munition should first be cautiously separated from each other. Chemical munitions commonly contain a fuze plus a propelling charge or a burster for scattering the CW agent. In rockets, the explosive charge may be larger than that in a bomb or shell. Most chemical munitions have solid propellants. The propellant and the explosive charge can generally be separated without the use of force. The explosive removed is then destroyed in the usual way by incineration or detonation. The CW agent from such munitions can be handled by any of the methods already described.

A more difficult problem is presented by old munitions that have become corroded or in some way damaged. In such cases it is not always possible to separate the components. Once the details of the fuze construction and the bursting or propelling charge have been ascertained, it ought to be possible to bore holes in the casing holding the CW agent and thus to reduce the risk of explosion. The CW agent is then removed, after which the burster is deactivated.

Among the most difficult cases are those chemical munitions, where, owing to the risk of explosion, neither the removal of the explosive nor the withdrawal of CW agent through boreholes can be hazarded. The possibility remaining is to detonate the munition or to devise some other intervention, but there is always the risk of human poisoning by any CW agent released. If the fuze and the bursting charge are in order, it ought to be possible to detonate the munition in the normal way. However, the safety device may make it impossible to detonate the munition by self-ignition, and an external explosive charge may be necessary.

Sometimes it is possible, by using a small explosive charge, to blow a hole in the casing holding the CW agent without igniting the initiating explosive. Each munition must be individually assessed and the outcome depends on the skill and experience of the explosive-ordnance-disposal unit.

With rocket shells containing CW agent, where routine methods for the removal of propellant may not be feasible, there is the danger that the propellant may self-ignite. In such cases it is vital to prevent the rocket from developing its normal thrust. A large hole should quickly be drilled in the rocket and the fuze removed.

Liquid-propelled rockets can be drilled under or above water in a tank, and the oxidizer—normally an acid—can be neutralized chemically in the aqueous solution. The propellant is generally water-soluble, or it can be separated by density differences.

A method that has frequently been used since World War II consists in detonating the munition underground within a water-filled steel container. The water slows down the fragments as they fall to the bottom, from where the scraps of metal can be removed. The CW agent may partially dissolve in the water or sink to the bottom. The previously described chemical methods for detoxification or destruction can then be used.

Brief mention may be made of the possibility of destroying CW agents by means of an underground explosion, particularly a nuclear explosion. Such an alternative was proposed in the USA in connection with the dumping of chemical munitions in August 1970, but was rejected at that time by the US Atomic Energy Commission.

Other possibilities of munition disposal—used to different degrees after World Wars I and II—are ocean dumping, burying underground, and embedding together with detoxifying agents in deep disused mines. After World Wars I and II, considerable quantities of munitions, chemical and non-chemical, were disposed of by ocean dumping. The following section deals with these alternatives in greater detail.

VII. Personnel and environmental protection in destroying CW agents

The same or even greater precautions are required for workers engaged in destroying CW agents as for soldiers in CW military units—that is, protective clothing, protective equipment and medical protection must match that employed in chemical warfare. In addition, medical check-ups of those working with CW agents or related compounds must focus not only on the signs and symptoms of acute poisoning, but also on any incipient delayed lesions [46].

The problem of environmental protection in the destruction of CW agents is very far-reaching. Definite proposals have already been put forward for the destruction of CW agents in compliance with environmental protection requirements [47]. Owing to the extreme toxicity of CW agents, all the methods used for the removal of wastes in the civilian sector cannot be applied to CW agents.

Thus, ocean dumping appears to be unacceptable for highly toxic organophosphorous agents, such as sarin, soman or VX, or for sparingly soluble and slowly hydrolysing vesicants, such as sulphur and nitrogen mustards [48–49]. Therefore, for environmental protection reasons, a method such as ocean dumping may be considered allowable only in exceptional cases and only where very small amounts of CW agents are involved. Moreover, in the event of a comprehensive ban on CW agents, the disposal of large stocks by ocean dumping should be prohibited as being potentially too dangerous.

In 1968 the US Department of the Army determined that the disposal of certain chemical munitions was necessary to remove excess and unserviceable material from the national deterrent stockpile. The proposed disposal plan (Operation CHASE) was reviewed by the US National Academy of Sciences, which recommended that the particular disposal should proceed as planned, with certain modifications, and that ocean dumping should not be used for further disposals of chemical munitions [50–54].

The practice of deep-water dumping has been discontinued. This method of disposal accounted for some 100 000 tonnes of unserviceable ordnance over the period 1964–71 in the Maritime Administration Hulk Numbered Deep Water Dumps system alone. In this system, an obsolete vessel (a merchantman) was stripped free of all but fixed elements of the structure, and the fuel tanks were thoroughly cleaned. The ordnance was then stowed to give maximum density (more buoyant items being packed in 55-gallon [200-litre] drums filled with concrete), the hulk was towed at least 16 km from shore and scuttled at a depth of 900 m.

The dumping areas were selected to reduce the probability of fish kills in the event of detonations, some of which were intentional and others unintentional. In most cases, the hulk bottomed without detonations, and in no case did detonation occur prior to scuttling. A dump of this type might range up to 7 700 tonnes at a time, but was generally in the broad vicinity of 4 500 tonnes.

Small-scale deep-water dumping practices have commonly been conducted for many years in the USA as ordnance-disposal methods. Such operations involve dumping up to 230 tonnes of material at a time in sites meeting the previously mentioned 16-km, 900-m criteria. The actual dumping is performed over a short period of time, rather than all at once. No detonation has ever been experienced in operations of this type. Of 13 sites selected for such dumps in 1971, only one lay less than 32 km from shore (3 700 m deep). All liquid propellants, industrial chemicals and chemical agents were excluded from this type of disposal.

In cases of unavoidable dumping of CW agents in the ocean or in other waters, as well as in cases of accidental contamination of rivers and lakes, for example, steps must be taken to ensure proper analytical monitoring of the water for content of CW agents [55]. Likewise, where applicable, early-warning systems must be set up for any leaks or release of CW agents into the atmosphere [56–57]. Much work has already been done in this direction in civilian industry.

In the event of an international agreement on a partial or a comprehensive ban on CW agents and the destruction of all stockpiles, supplementary international agreements must be concluded which ensure that the destruction of stocks is carried out in compliance with environmental protection requirements. Where necessary, an international agency, analogous to the International Atomic Energy Agency (IAEA) in Vienna—perhaps the UN Environment Programme (UNEP)—should supervise compliance with environmental protection requirements in the destruction of CW agents.

VIII. Conclusions

The destruction of CW agents in the large amounts existing at present is technically feasible. Large-scale methods have already been tested and research is proceeding in this field. Many but not all of the methods used for waste disposal in civilian industry can be applied to the destruction of CW agents.

Special difficulties may arise in the destruction of CW agents loaded in munitions, particularly when the latter are in defective condition. Special procedures must be applied in each case.

The protection of workers and of people inhabiting the locality is a factor of prime importance in the destruction of CW agents. Special protective and medical surveillance measures are necessary for this purpose. Apart from the prevention and treatment of acute poisoning caused by CW agents, medical programmes should also focus on delayed lesions caused by these compounds.

All work in the destruction of CW agents must comply with stringent environmental protection requirements. The required analytical and surveillance measures need to be guaranteed and, if necessary, supervised by an international agency.

References

1. *Chemical, Biological, and Radiological (CBR) Decontamination*, Technical Manual No. 3-220 (US Department of the Army, Headquarters, Washington, 22 November 1967).
2. Blumenstein, W., *Entgiftungs- und Entaktivierungsgeräte* (Deutscher Militärverlag, E. Berlin, 1965).
3. Sweden, Disarmament Conference document CCD/324, 30 March 1971.
4. USA, Disarmament Conference document CCD/360, 20 March 1972, p. 6.
5. USA Disarmament Conference document CCD/366, 20 June 1972.
6. USA, Disarmament Conference document CCD/367, 20 June 1972.
7. Finland, Disarmament Conference document CCD/381, 27 July 1972.
8. Argentina, Brazil, Burma, Egypt, Ethiopia, Mexico, Morocco, Nigeria, Sweden and Yugoslavia, Disarmament Conference document CCD/400, 26 April 1973.
9. Bulgaria, Czechoslovakia, Hungary, Mongolia, Poland, Romania, USSR, Disarmament Conference document CCD/403, 28 June 1973.
10. Japan, Disarmament Conference document CCD/420, 30 April 1974.
11. Canada, Disarmament Conference document CCD/434, 16 July 1974.
12. USA, Disarmament Conference document CCD/436, 16 July 1974.
13. Sweden, Disarmament Conference document CCD/485, 9 April 1976.
14. USA, Disarmament Conference document CCD/497, 29 June 1976.
15. USA, Disarmament Conference document CCD/498, 29 June 1976.
16. German DR, Disarmament Conference document CCD/506, 6 July 1976.
17. Sweden, Disarmament Conference document CCD/PV.622, 16 August 1973.

18. Japan, Disarmament Conference document CCD/PV.631, 30 April 1974.
19. USSR, Disarmament Conference document CCD/PV.647, 30 July 1974.
20. Disarmament Conference document CCD/PV.652, 15 August 1974.
    (a) —, Sweden, p. 10.
    (b) —, USSR, p. 19.
21. USA, Disarmament Conference document CCD/PV.654, 22 August 1974.
22. USA, Disarmament Conference document CCD/PV.702, 13 April 1976.
23. Sweden, Disarmament Conference document CCD/PV.704, 22 April 1976.
24. Hungary, Disarmament Conference document CCD/PV.721, 17 August 1976.
25. Poland, Disarmament Conference document CCD/PV.722, 19 August 1976.
26. *The Problem of Chemical and Biological Warfare*, 6 volumes (Almqvist & Wiksell, Stockholm, 1971–75, Stockholm International Peace Research Institute).
27. Lohs, Kh., *Synthetische Gifte*, 4th ed. (Militärverlag der DDR, E. Berlin, 1974).
28. *Chemical Disarmament: New Weapons for Old* (Almqvist & Wiksell, Stockholm, 1975, Stockholm International Peace Research Institute).
29. Franke, S., *Lehrbuch der Militärchemie*, 2 volumes, 2nd ed. (Militärverlag der DDR, E. Berlin, 1977).
30. Booz-Allen Applied Research Inc., *A Study of Hazardous Waste Materials, Hazardous Effects and Disposal Methods*, Report No. PB 221 466 (National Technical Information Service, Springfield, Virginia, July 1973).
31. Blomqvist, G. *et al.*, *Destruktion av C-Stridsmedel*, Report FOA 1, A 1583-T3 (Försvarets Forskningsanstalt, Avdelning 1, Sundbyberg, Sweden, April 1974).
32. *The Disposal of Chemical Agent Mustard at Rocky Mountain Arsenal*, Final Environmental Impact Statement for Project Eagle, Report No. PB 200 540-F, Phase I (US Department of the Army, Headquarters, Edgewood Arsenal, Maryland, 1971).
33. Lohs, Kh. and Martinetz, D., *Entgiftung* (Akademie-Verlag, E. Berlin, 1978).
34. Dosch, W. and Keller, H., "Universelle Entgiftungsmittel für chemische Kampfstoffe", *Zivilverteidigung*, No. 2, 1972, pp. 68–74.
35. Dosch, W., "Entgiftung chemischer Kampfstoffe", *Zivilverteidigung*, No. 7/8, 1970, pp. 72–76.
36. Dosch, W., "Entgiftung chemischer Kampfstoffe", *Zivilverteidigung*, No. 10, 1970, pp. 35–38.
37. Dosch, W., "Entgiftung chemischer Kampfstoffe", *Zivilverteidigung*, No. 12, 1970, pp. 39–42.
38. Dosch, W., "Entgiftung chemischer Kampfstoffe", *Zivilverteidigung*, No. 1, 1971, pp. 39–42.
39. Deutsche Forschungsgemeinschaft, *Tonmineralogie* (Harald Boldt Verlag KG, Boppard, FR Germany, 1976).
40. Mirabella, P. D., *Pilot Plant Procedures Developed for Neutralization of Chemical Agents in the Toxic Gas and War Gas Identification Sets* (*Obsolete Identification Sets*), Technical Report No. EM-TR-76041 (US Department of the Army, Headquarters, Edgewood Arsenal, Aberdeen Proving Ground, Maryland, April 1976).
41. "Wet Air Oxidation Comes of Age", Practical, Available Technology Report, *Environmental Science and Technology*, Vol. 9, No. 4, April 1975, pp. 300–301.

42. Liptak, B. G. (Ed.), *Environmental Engineers' Handbook*, (Chilton Book Co., Radnor, Pennsylvania, 1974).
43. Powers, P. W., *How to Dispose of Toxic Substances and Industrial Wastes* (Noyes Dath Corp., Park Ridge, New Jersey, and London, 1976).
44. Battelle Memorial Institute, *Program for the Management of Hazardous Wastes for Environmental Protection Agency* (Office of Solid Waste Management Programs, Washington, July 1973).
45. *Demilitarization of Toxic Munitions at US Army Materiel Command Installations*, Draft Environment Impact Statement, Report No. PB-203 509-D (US Department of the Army, Headquarters, Edgewood Arsenal, Maryland, 14 October 1971).
46. *Delayed Toxic Effects of Chemical Warfare Agents* (Almqvist & Wiksell, Stockholm, 1975, Stockholm International Peace Research Institute).
47. Ottinger, R. S. *et al.*, "Recommended Methods of Reduction, Neutralization, Recovery or Disposal of Hazardous Waste" in Vol. VIII: *Propellants, Explosives and Chemical Warfare Materiel*, Report No. PB-224 586 (National Technical Information Service, Springfield, Virginia, August 1973).
48. *Ocean Disposal of Unserviceable Chemical Munitions*, Hearings before the Subcommittee on Merchant Marine and Fisheries, House of Representatives, 91st Congress, Serial No. 91-31 (US Government Printing Office, Washington, August 1970).
49. *Ocean Dumping, National Policy Report to the President* (US Council on Environmental Quality, Washington, October 1970).
50. Linnenbom, V. J., *Final Report on First Post-Dump Survey of the CHASE X Disposal Site*, Report No. NRL-MR-2273 (US Naval Research Laboratory, Washington, May 1971).
51. Czul, E. C., Carey, E. W. and Heemstra, F. W., *Second Post-Dump Survey of the CHASE X Disposal Site*, Report No. NRL-MR-2319 (US Naval Research Laboratory, Washington, August 1971).
52. Czul, E. C., *Third Post-Dump Survey of the CHASE X Disposal Site*, Report No. NRL-MR-2524 (US Naval Research Laboratory, Washington, November 1972).
53. Czul, E. C., *Fourth Post-Dump Survey of the CHASE X Disposal Site*, Report No. NRL-MR-2819 (US Naval Research Laboratory, Washington, June 1974).
54. Ferer, K. M., *Fifth Post-Dump Survey of the CHASE X Disposal Site*, Report No. NRL-MR-2996 (US Naval Research Laboratory, Washington, March 1975).
55. Lindsten, D. C. and Schmitt, R. P., *Decontamination of Water Containing Chemical Warfare Agents*, Report No. USAMERDC-2125 (US Army Mobility Equipment Research and Development Center, Fort Belvoir, Virginia, January 1975).
56. *Papers of a Seminar on Early Warning Systems for Toxic Substances*, Conference Report (Office of Toxic Substances, US Environmental Protection Agency, Washington, July 1975).
57. Sittig, M., *Pollution Control in the Organic Chemical Industry* (Noyes Data Corp., Park Ridge, New Jersey, 1974).

13. The prohibition of new weapons

Square-bracketed numbers, thus [1], *refer to the list of references on page 390.*

I. Environmental weapons

On 18 May 1977, the UN Secretary-General opened for signature the Convention on the prohibition of military or any other hostile use of environmental modification techniques, the so-called ENMOD Convention. On the same day the Convention was signed by Belgium, Bolivia, Bulgaria, Byelorussia, Canada, Czechoslovakia, Denmark, Ethiopia, Finland, the German Democratic Republic, the Federal Republic of Germany, Hungary, Iceland, Iran, Ireland, Italy, Lebanon, Liberia, Luxembourg, Mongolia, Morocco, the Netherlands, Norway, Poland, Portugal, Romania, Spain, Turkey, Uganda, Ukraine, the USSR, the UK, the USA and Yemen. By September 1977, nine more states had signed the Convention, and one had deposited its instrument of ratification.

The Convention, which is a product of bilateral talks between the USA and the USSR, and of multilateral negotiations conducted at the Conference of the Committee on Disarmament (CCD), consists of 10 articles and an annex. Four of the articles were clarified and amplified in "understandings" worked out at the CCD [1], but these were not written into the Convention. Nevertheless, as part of the *travaux préparatoires*, they may be useful for interpreting the provisions of the Convention. (For the text of the Convention and Understandings, see appendix 13A.)

The ENMOD Convention deals with man-made changes in the environment which affect the dynamics, composition or structure of the earth, including its biota, lithosphere, hydrosphere and atmosphere, or of outer space (Article II). The employment of techniques producing such modifications is prohibited if the user pursues "military or any other hostile" purposes with a view to causing destruction, damage or injury to another state party. In the opinion of the USA, the targets alluded to here include the enemy's military forces and civilian population, as well as its cities, industries, agriculture, transportation and communications systems, and natural resources and assets [2]. Neither is a party to the Convention allowed to assist, encourage or induce other nations to engage in these activities.

The ban under the Convention applies to the conduct of military operations during armed conflicts, as well as to hostile use when no other weapons are being employed or when there is no overt conflict. However, only those hostile uses of environmental modification techniques which have "widespread, long-lasting or severe effects" are prohibited (Article I). The meaning of these terms, according to the "understanding relating to Article I" worked out by the CCD, is as follows: (*a*) "widespread"—encompassing an area on the scale of several hundred square kilometres;[1] (*b*) "long-lasting"—lasting for a period of months, or approximately a season; and (*c*) "severe"—involving serious or significant disruption or harm to human life, natural and economic resources or other assets.

The presence of any one of the three criteria is sufficient for the environmental modification technique to be deemed outlawed for hostile purposes.

Thus, the use of the techniques in question is prohibited if two requirements are met simultaneously: (*a*) that the use is hostile; and (*b*) that it causes destruction, damage or injury at, or above, the set threshold. Non-hostile use of modification techniques is exempted from the prohibition, even if it produces destructive effects above the threshold. Hostile use which produces destructive effects below the threshold is also permissible.

However, according to the "understanding relating to Article II", also worked out by the CCD, earthquakes, tsunamis, an upset in the ecological balance of a region, changes in weather patterns (clouds, precipitation, cyclones of various types and tornadic storms), changes in climate patterns, changes in ocean currents, changes in the state of the ozone layer, and changes in the state of the ionosphere appear to be unconditionally prohibited when produced by hostile use of environmental modification techniques: it is assumed that all these phenomena would result, or could reasonably be expected to result, in widespread, long-lasting or severe destruction, damage or injury.[2] Furthermore, it has been recognized that the use of techniques producing other phenomena could appropriately be included, in so far as the criteria of hostility and destructiveness were met. It will be noted, however, that the events enumerated in the "understanding" are rather fanciful. They are unlikely to be caused through deliberate action for warlike purposes, that is, in such a way that the effects would be felt only, or primarily, by the enemy.[3]

Asked whether the use of herbicides as an instrument for upsetting the ecological balance of a region was prohibited under the ENMOD

[1] According to the interpretation provided by the USA, the entire area would have to experience destruction, damage or injury at approximately the same time to meet the "widespread" criterion. This could result from a single operation or could be the cumulative result of a series of operations conducted over a period of months or years. If, over the course of several years, a total area on the scale of several hundred square kilometres were affected, but the area actually suffering destruction, damage or injury at any one time were small, the "widespread" criterion would not be met [3a].

[2] This assumption was confirmed by the USA at the meeting of the First Committee of the UN General Assembly on 1 November 1976 [4].

[3] It is significant that long before the Convention had been negotiated, the USA renounced the use of climate modification techniques for hostile purposes even should such techniques be developed in the future [5]. For further discussion of these aspects of the Convention, see reference [6].

Convention, the US representative to the CCD stated that, in his view, such use of herbicides as a means of destruction, damage or injury was prohibited if the effects were widespread, long-lasting or severe. He stressed, at the same time, that the Convention did not affect the use of herbicides for control of vegetation within military bases and installations or around their immediate defensive perimeters [3b]. An analogous policy had been announced by the USA in connection with the ratification of the 1925 Geneva Protocol prohibiting chemical and biological warfare [7]. In the view of most nations, the Geneva Protocol has already banned, without qualification, the use in international armed conflicts of *all* chemical methods of warfare, including the use of substances having direct toxic effects on plants [8].

As a consequence of the threshold approach, the techniques producing effects which are considered not to be widespread, long-lasting or severe, such as precipitation modification (short of changing the weather pattern), or formation or dissipation of fog, have escaped proscription. And it is such techniques that are likely to be used on a limited scale to influence the environment with hostile intent, especially in tactical military operations to facilitate the effectiveness of other weapons.

No convincing reason has been given why any hostile modification of the environment or any amount of damage caused by such modification should be tolerated at all. Perhaps one exception might be legally (if not ecologically) justified: the use of modification techniques on a state's own territory to forestall or stop foreign invasion. This could be construed as concordant with the "inherent right" of self-defence under the UN Charter (Article 51).

The effectiveness of paragraph 1 of Article I of the ENMOD Convention (which restricts the ban to widespread, long-lasting or severe effects) for eliminating the dangers of military or any other hostile use of environmental modification techniques will be examined at review conferences, the first of which is to be convened five years after the entry into force of the Convention (Article VIII). The possibility of amending the Convention has been provided for (Article VI), and the 1976 UN resolution dealing with the Convention called upon the CCD to keep under review the problem of effectively averting the dangers of hostile environmental modification [9]. But there is no commitment to make the partial Convention comprehensive by removing the established threshold in a follow-up agreement.

The Convention stipulates that the use of environmental modification techniques for peaceful purposes shall not be hindered. The question therefore arises whether such use is subject to any restrictions.

The relevant clause (Article III, paragraph 1) contains a proviso to the effect that the use of modification techniques for peaceful purposes "shall be without prejudice to the generally recognized principles and applicable rules of international law concerning such use". But the "understanding relating to Article III", formulated by the CCD, makes it clear that the Convention does not deal with the question of whether or not a given use of environmental modification techniques for peaceful purposes is in accordance with generally recognized principles and applicable rules of international law. Thus, the legal grounds for making complaints about breaches of this clause have been left undetermined.

The parties undertake to facilitate and participate in the "fullest possible" exchange of scientific and technological information on the use of environmental modification techniques for peaceful purposes. They shall contribute, as far as they are in a position to do so, to international economic and scientific co-operation in the preservation, improvement and peaceful utilization of the environment, with due consideration for the needs of the developing areas of the world (Article III, paragraph 2). The practical value of these promises is difficult to measure. They may well turn out to be of little consequence, as has been the case with similar provisions in the Biological Weapons Convention.

To clarify problems relating to the objectives of the Convention and to its application, the parties may resort to consultations. These consultations could be carried out either on a bilateral basis, or through "appropriate" international procedures. The latter may include the services of international organizations (such as the World Meteorological Organization or the UN Environment Programme), as well as the consultative committee of experts to be convened upon request (Article V). The functions and rules of procedure of the consultative committee, to which any party may appoint an expert, are set out in an annex that constitutes an integral part of the Convention. The role of the consultative committee is to establish facts and to provide expert views with regard to problems raised by the party requesting its services. The experts will have the right, through the chairman, to request from states and from international organizations such information and assistance as is necessary for the accomplishment of the committee's work. No voting on matters of substance is allowed, but a summary of the findings, incorporating all views and information presented to the committee during its proceedings, would be distributed to the parties.

The consultative committee, as a body, is not entitled to pass judgement on whether a violation has occurred, or to formulate recommendations. The political decision that a party has been harmed or "is likely to be harmed" as a result of a violation of the Convention, including the determination of culpability, will be the prerogative of the UN Security Council. Each party may lodge a complaint with the Security Council, either directly or after first making use of the consultative machinery. In the latter event, the complainant could benefit from the evidence already collected to support the validity of the charge. However, the Security Council may initiate its own investigation of the allegations in co-operation with the parties.

Although the consultative committee is to be set up within the framework of the consultative procedure rather than the complaint procedure, and although its functions are strictly circumscribed, its role in the overall verification process should not be underestimated. Since the committee is to be convened whenever a party requests it, any questions can be taken up. For example, nothing in the Convention or its annex prevents a country from raising questions of interpretation. And the right to decide procedural matters related to the organization of its work, by a majority of those present and voting, enables the committee to order an inquiry. The fact that voting will be held only on procedural questions may be considered a shortcoming, although not an irreparable one since the findings could be drafted in such a way as to make the prevailing opinion on substantive questions discernible. The essential point is that experts will be given an opportunity to examine each case before a complaint reaches the level of political action, and to make their views widely known. It is difficult to see what else could be achieved at this stage of verification. Even if the Security Council were to undertake its own investigation, it would at first simply inform the parties of the results of the investigation. The complaining country would draw its own conclusions from the information received and decide upon further action: either to drop the charges or ask the Security Council formally to condemn the violator.

The Council would act "in accordance with the provisions of the Charter of the United Nations" (Article V, paragraph 2) as it is, in any case, bound to act in all instances regarding "threats to peace, breaches of the peace, and acts of aggression" (Chapter VII of the UN Charter), irrespective of whether or not a specific treaty has been violated. But the great-power veto in the Security Council has been used to block substantive decisions and even proposals for the establishment of organs for investigation or observation, especially when accusations were directed against the permanent members of the Council or their allies. A complainant may find it unacceptable that the inequality of states under the UN Charter, whatever its historical justification, should be carried over to relations under other international instruments. Moreover, it is not at all sure that all members (permanent or non-permanent) of the Security Council called upon to examine a charge of violation of the Convention, would themselves be party to that Convention.[4] It would therefore

[4] China refused to participate in the vote on the resolution dealing with the ENMOD Convention, stating that the Convention was designed to divert attention from "immediate concerns". France abstained, explaining that the text of the Convention may give rise to technical, legal and political difficulties [10].

be inconvenient to have recourse to such a body. Considering these uncertainties, an injured country may decide to forgo the complaint procedure and to pursue another course of action on the basis of the findings of the consultative committee, if it considers the findings to be sufficient proof of violation. Whatever action is then taken, it cannot be a withdrawal because, unlike some arms control treaties, the ENMOD Convention has no withdrawal clause.[5] Formally it is of unlimited duration (Article VII).

The ENMOD Convention will enter into force upon the deposit of instruments of ratification by 20 governments. Unlike some other treaties, there is no requirement that this number include the UK, the USA and the USSR. But it is obvious that, without the participation of the most technically advanced states, the Convention would be essentially meaningless.

The main drawback of the Convention consists in its limited scope. It prohibits techniques which could produce apocalyptic effects, but are still the subject of scientific speculation and which, if proved feasible, seem to be hardly usable as rational weapons of war. On the other hand, it condones hostile manipulation of the environment with relatively "benign" techniques which are already in existence.

On the positive side, the Convention has introduced a novel verification scheme under which it is possible for the complaining party to have all relevant facts examined by experts before it decides whether or not to turn to the UN Security Council for further action. The establishment of such a mechanism is an advance over previous practice and a precedent for future treaties of a similar nature.

And, finally, the ENMOD Convention is the first agreement in the field of arms control to designate the UN Secretary-General as depositary, and to give him a role in implementing compliance procedures.

II. Weapons of mass destruction

In 1975, at the initiative of the USSR, the UN General Assembly included in the agenda of its 30th regular session an item entitled "Prohibition of the development and manufacture of new types of weapons of mass destruction and of new systems of such weapons" [11]. Simultaneously, a Soviet draft agreement was submitted for consideration by the Assembly [12].

[5] Under such a clause, each party reserves the right to withdraw from the treaty if it decides that extraordinary events, related to the subject matter of the treaty, have jeopardized its supreme interests. (Denunciation or withdrawal are generally not permitted unless there is a special provision to this effect. See Article 56 of the Vienna Convention on the Law of Treaties, of 23 May 1969.)

The key article of the draft provided that each state party to the agreement should undertake not to develop or manufacture new types of weapons of mass destruction or new systems of such weapons, "including those utilizing the latest achievements of modern science and technology". Asked to identify the weapons or systems to be prohibited, the Soviet representative to the United Nations mentioned, among other things, binary chemical weapons, "gene engineering" as a biological weapon, as well as environmental modification techniques, but admitted that the items subject to prohibition would have to be specified in negotiations. The draft envisaged a possibility to extend the ban to cover additional types and systems of weapons after the entry into force of the agreement. Compliance with the obligations was to be checked by each party through measures undertaken "in accordance with its constitutional procedures". Other provisions were similar to those included in arms control treaties signed in recent years.

The idea of slowing down the qualitative arms race by barring new, potentially dangerous weapon developments aroused a positive response. It is generally considered easier to ban arms which are at the research and experimentation stage than to eliminate those already developed, manufactured and stockpiled in world arsenals. Accordingly, in December 1975 the UN General Assembly requested the CCD to work out the text of an agreement prohibiting new types of weapons and new systems of weapons of mass destruction, and to submit a report on the results.[6] The General Assembly took note of the Soviet draft but did not specifically recommend it as the basis of a treaty [13]. Since then, the item has been on the agenda of the disarmament negotiations, and several meetings of government experts have been held to discuss different aspects of the issue.

The first problem which was discussed concerned the definition of "weapons of mass destruction" and, in particular, "new" weapons. It was recalled that on 12 August 1948, the UN Commission for Conventional Armaments, seeking to distinguish its terms of reference from those of the UN Atomic Energy Commission, resolved that weapons of mass destruction outside its jurisdiction included "atomic explosive weapons, radioactive material weapons, lethal chemical and biological weapons". At the same time, the Commission decided that "any weapons developed in the future which have characteristics comparable in destructive effect to those of the atomic bomb or other weapons mentioned above" should also be considered as weapons of mass destruction. The

[6] The resolution containing this request was adopted with 112 states voting in favour, one voting against (Albania), and 15 abstaining (Belgium, Denmark, France, Federal Republic of Germany, Ireland, Israel, Italy, Luxembourg, Malawi, Mauritania, Morocco, the Netherlands, Uganda, the United Kingdom and the United States). A similar request was subsequently included in a UN General Assembly resolution adopted in 1976 and in one of the two resolutions on weapons of mass destruction adopted in 1977.

1948 resolution was not adopted unanimously—it was opposed by the USSR, which criticized the UN definition as being restrictive, and referred to conventional bombs and rockets used in World War II as weapons which also had mass destructive effects [14]. No further attempt had been made since then to evolve a generally acceptable formula. Nevertheless, the term "weapons of mass destruction" has remained in usage and has even been employed in certain arms control treaties, such as the Outer Space Treaty of 1967 and the Sea-Bed Treaty of 1971, without a clear definition of its meaning. It was understood by the parties to cover at least chemical and biological weapons, in addition to nuclear weapons, which were specifically mentioned. Subsequently, environmental modification techniques producing widespread, long-lasting or severe effects also came to be regarded as weapons of mass destruction if employed for hostile purposes (see section I of this chapter).

The means of transporting or propelling weapons are commonly considered as a separate category, if they are separable from the weapons and not an indivisible part thereof.[7] But the problem has been how to define a "system" of weapons of mass destruction. A weapon system is described in military literature as a system comprising the weapon, the means of locating and identifying the target, the means of delivering the weapon to the target, and the means of controlling both the engagement as a whole and at least a part of the sequence of operations that brings the weapon to the target. These components must be so ordered and interrelated as to form a distinct and substantially autonomous system. Furthermore, the application of the term is restricted to systems whose target-location or weapon-control functions are largely performed by inanimate apparatus [15].

Assuming that the above description were acceptable, one would still have to define the meaning of a "new system" and to stipulate whether a conventional weapon system would become a "new system of weapons of mass destruction" if it were adapted to the use of existing and known weapons of mass destruction, and which components of a system of existing weapons of mass destruction needed to be modified to make it new and, thereby, subject to prohibition. It would seem that a weapon not identified as a weapon of mass destruction could not become classified as a *new* weapon of mass destruction because of the development of a new system using it. On the other hand, if new weapons were to be outlawed, it would be redundant to prohibit systems specially developed for, and usable only with, the weapons banned.

The USSR announced its readiness to clear up the issues involved and to work out, together with other states, all the formulae necessary for an

[7] Compare the definition of a nuclear weapon contained in Article 5 of the Treaty prohibiting nuclear weapons in Latin America (Treaty of Tlatelolco).

international agreement. To facilitate the discussion, it presented on 10 August 1976 a working paper containing draft definitions [16]. According to this paper, new weapons of mass destruction would include types of weapons which were based on qualitatively new principles of action and whose effectiveness may be comparable with or surpass that of traditional types of weapons of mass destruction.

The term "based on qualitatively new principles of action" was to signify that either the means of producing the effect, or the target or the nature of the effect of the weapon was new. "Means of producing the effect" was to be understood as a specific type of physical, chemical or biological action. The term "target" was to encompass vitally important elements of the human organism, elements of man's ecological and geophysical environment, and also installations vitally important for human existence. The "nature of the effect" was to be understood to mean a new type of destruction leading either to immediate mass annihilation or to the gradual extinction of large groups of the population.

As examples of new types of weapons of mass destruction to be covered by the ban, the USSR listed infrasonic weapons emitting acoustic waves designed to injure internal human organs; weapons designed to damage the human reproductive system; and "ethnic" weapons using various agents for selective extermination of specific population groups. Each of these weapons was claimed to be "new" in so far as the target, and/or the means of producing the effect, and/or the nature of the effect were new.

As far as new systems of weapons of mass destruction are concerned, the USSR expressed the view that they should include systems of weapons which assume the quality of weapons of mass destruction as a result of the use of new technical elements in their "strike or logistic" components, and that the new "nature of the effect", as defined above, would determine the transition from a traditional to a new system of weapons of mass destruction. As an example, the Soviet working paper pointed out that missile, artillery, aircraft or other traditional weapon systems may assume the character of a new system of weapons of mass destruction if they embody a new technical element, such as "fuel–air ammunition" for producing powerful fuel–air explosions. (Fuel–air explosives were compared in certain respects to chemical weapons because, due to the rapid combustion of oxygen over wide areas, they could cause death by asphyxiation.) The modernization of existing systems not leading to "qualitatively new principles of action" was not covered by the definition of new systems.

A number of states found that the Soviet definitions were not adequate for inclusion in an internationally binding document since they referred to areas of scientific development whose military implications were extremely difficult to assess. The USA insisted that the definition agreed in 1948 by the UN Commission for Conventional Armaments should be accepted as a comparability standard for future discussions and as a basis for identifying new candidate weapon types as weapons of mass destruction. But the main criticism was related to the fact that some weapons, considered by the USSR as "new", appeared to belong to the existing and recognized categories of weapons of mass destruction, and were either the subject of current negotiations within the context of chemical or environmental means of warfare, or had been outlawed by international treaties, as in the case of biological warfare agents. In particular, concern was voiced that the comprehensive scope and the effectiveness of the Biological Weapons (BW) Convention were being called into question. The USSR was reminded that the purpose of the BW Convention was to exclude completely the possibility of biological agents and toxins being used as weapons, and that, consequently, the Convention prohibited not only existing means of biological and toxin warfare, but also any that might come into existence in the future, including infective agents that might be created by recombinant DNA (genetic engineering) techniques [17]. It was noted that new scientific and technological developments, relevant to the treaties in force, can be discussed at the review conferences provided for in arms control agreements concluded in recent years. As regards fuel–air explosives, the position of the Western countries was that these were to be considered conventional weapons.

In response to the critical remarks, the USSR acknowledged that an agreement on new types and systems of weapons of mass destruction should not cover means of warfare which had already been banned or were about to be banned. It denied, however, that the 1948 resolution (see above) had actually defined weapons of mass destruction. In its view, the UN Commission for Conventional Armaments merely submitted a list of types of weapons which might be included in that category [18]. Nevertheless, in a revised draft put forward on 8 August 1977, the USSR based its description of the object of the envisaged prohibition on the 1948 formula and expanded it [19]. It proposed that, for the purpose of the agreement, the expression "new types and new systems of weapons of mass destruction" should include weapons which may be developed in the future, either on the basis of scientific and technological principles that are known now but that have not yet been applied "severally or jointly" to the development of weapons of mass destruction or on the basis of such principles that may be discovered in the future, and which will have properties similar to or more powerful than those of known types of weapons of mass destruction in destructive and/or injurious effect.

The types and systems of weapons to be prohibited under the agreement proposed by the USSR were to be specified in an annex. An "approximate" list included the following items: (*a*) radiological means of a non-explosive type, acting with the aid of radioactive materials; (*b*) technical means of inflicting radiation injury based on the use of charged or neutral particles to affect biological targets; (*c*) infrasonic means using acoustic radiation to affect biological targets; and (*d*) means using electromagnetic radiation to affect biological targets.

In an apparent move to meet the position of states opposed to a prohibition of an entire, ill-defined class of weaponry, the USSR suggested that, parallel to a general agreement, parties may, in cases where they deem it necessary, conclude special agreements on the prohibition of particular new types and systems of weapons of mass destruction.

Reacting to the new version of the Soviet draft agreement, Canada stated that it saw no justification for the belief that new weapons of mass destruction based on new applications or new principles of science threatened to appear in the foreseeable future [20], and the USA stated that it was not aware of any scientific developments since 1948 which would warrant changing or transforming the 1948 UN definition of weapons of mass destruction into an operative clause of a multilateral treaty. The USA noted the Soviet preparedness also to conclude agreements dealing with specific weapons, but found that most examples enumerated in the Soviet list did not qualify as weapons of mass destruction [21]. A number of experts at the CCD shared this opinion. With regard to example (*b*) above, it was pointed out that the feasibility of generating charged or neutral particles by accelerator techniques did not allow conclusions to be drawn concerning the possibility of their use as a mass destruction weapon; moreover, restricted ranges and marginal energy outputs would be sufficient technical reasons to render improbable their use for any weapon purposes. Scepticism was also expressed regarding the potential for using infrasound waves as a mass destruction device, as indicated in example (*c*), because such a device could not be effective with respect to distant targets, and because it was difficult to see how the necessary high amount of acoustic energies could ever be generated. As far as example (*d*) is concerned, it was felt that the means for using electromagnetic radiation against living targets should not be designated as weapons of mass destruction. In general, there were doubts as to whether a mass destruction weapon could be identified in terms of its destructive impact merely by extrapolating from small-scale effects established under special laboratory conditions.

Only radiological means of warfare, appearing in the Soviet list as example (*a*), were found by the USA and certain of its allies to be appropriate candidates for the prohibition. In fact, there is nothing "new" in radiological weapons. They were included in the 1948 definition of weapons of mass destruction as "radioactive material weapons", and the desirability of outlawing them was examined several years ago. Thus, in 1969 the UN General Assembly invited the CCD to consider effective methods of control against the use of radiological methods of warfare conducted independently of nuclear explosions [22]. Subsequently, in a special working paper submitted to the CCD on 14 July 1970 [23], the Netherlands expressed the view that the use of radioactive agents independently of nuclear explosions was "not very plausible". This contention was substantiated as follows.

In order to kill or harm people within a few hours, a very high radiation dose would be required. But the radioactive isotopes one would need for that purpose have a short or very short half-life, which implies that they cannot be stored. The isotopes in question can be produced, for instance, by irradiating uranium in a high-flux reactor, and one would then obtain a considerable amount of highly radioactive material which would remain lethal for a few days. But transport of this material to the target area would be a difficult and cumbersome job, in the first place on account of the heavy protective shielding which would be needed, and large-scale use of such isotopes for so-called strategic purposes would be out of the question. Whereas the use of highly radioactive materials for causing short-term effects would seem to run into almost insurmountable practical difficulties, the same does not apply to the use of less radioactive materials which can harm life or health after months or years. For this purpose one might use materials having a long half-life, for instance strontium-90, which has a half-life of about 30 years. Such materials are not so difficult to handle and can be obtained relatively easily from the radioactive waste of reactors. But there would be little military rationale for achieving these long-term harmful effects.[8]

The conclusion arrived at by the Netherlands—that radiological warfare did not seem to have "any practical significance" and that it was difficult to see the "practical usefulness" of discussing arms control measures related to such warfare—was not contested in the CCD, and the matter was dropped.

Since 1970, the amount of radioactive materials accumulated in nuclear power production has increased, but nothing is known to have happened which would undermine the conclusion concerning their applicability as weapons of war, and no nation is known to be manufacturing radiological weapons today.[9] It is certainly necessary to guard against the seizure of radioactive material by sub-national, terrorist groups. However, this can be achieved by measures other than arms control. In any event,

[8] Similar views were expressed a few years earlier by the US Department of Defense [24].

[9] It was reported that the US military had considered the use of radiation to stop infiltration of North Vietnamese to South Viet Nam in the early 1960s but gave it up as impractical [25].

considering that the material is very dangerous to handle, a non-governmental diversion is unlikely. Nevertheless, in 1976 the USA proposed that an agreement be concluded to preclude the diversion and prohibit the use of radioactive material as radiological weapons, so as to complement the 1925 Geneva Protocol [26], and a few months later it became known that the USA and the USSR had entered into negotiations on such an agreement. If the resulting treaty is restricted to non-explosive radioactive materials, it will have very low arms control value.

It is worth mentioning that the 1969 UN resolution which dealt with radiological methods of warfare also drew attention to the danger of maximizing the radioactive effects of nuclear weapons. It recommended that, in the context of nuclear arms control negotiations, the need for effective methods of control in this field should be examined. In the discussion that followed, a view was expressed that maximizing radioactive effects of nuclear weapons by increasing the amount of fall-out "would hardly offer distinct military advantages" [23]. This view was not contested. Lately, however, there has been considerable interest in enhancing initial radiation effects of nuclear weapons. A newly developed small hydrogen warhead, commonly referred to as the neutron bomb, is destined to kill mainly by radiation, while blast and heat effects—the most immediately destructive effects of standard nuclear bombs—would be significantly minimized and restricted to an area much smaller than that subjected to fatal radiation. This weapon is meant to be used with short-range missiles and artillery in certain tactical military operations against troops and tank concentrations, without destroying nearby population or industrial centres.

The introduction of the neutron bomb into the arsenals of states would narrow the distinction between conventional and nuclear weapons and might thereby lower the threshold for the use of the latter. Moreover, the neutron bomb would not only kill people quickly in the immediate vicinity, but would also expose to radiation many others who would be ill for weeks or months before they died. The insidious nature of the neutron bomb has led some to argue that it should be included among the inhumane weapons subject to prohibition under the humanitarian laws of war.[10] In any event, if the aim of the envisaged agreement on radiological weapons is to reduce the danger from radioactivity, it would seem plausible to ban all weapons, explosive or otherwise, which rely for their effects *mainly* on nuclear radiation.

The following conclusion can be drawn from the debate on weapons of mass destruction. There is now widely shared recognition that new

[10] For example, Oleg Bogdanov, professor at the Moscow Institute of State and Law, considers the neutron bomb as a weapon causing "unnecessary suffering" and falling under 1907 Hague Convention IV [27].

weapons might be developed on the basis of scientific or technological principles other than those used in the weapons listed in the 1948 definition of weapons of mass destruction, and that the development of such new weapons should be prevented [28]. However, there are serious doubts as to whether this could be achieved in one legal instrument. A single treaty encompassing all imaginable new types of weapons could not be sufficiently clear as regards its object or sufficiently precise as regards its scope to become an effective arms control measure. Unclear and imprecise agreements may lead to misunderstandings and disagreements undermining the international confidence which arms control is supposed to build. In addition, verification of an omnibus treaty would encounter enormous, if not insurmountable, difficulties, as it would involve monitoring a wide gamut of scientific activities, the military implications of which are often not obvious. And since the nature of the threat posed by a given weapon and its characteristics determine the means for its control, a case-by-case study would be indispensable. Bearing in mind that existing weapons of mass destruction have been developed in total secrecy, self-verification, as suggested by the USSR, would certainly be unacceptable.

It would, therefore, seem more realistic to tackle each specific and clearly identified new weapon of mass destruction separately, with due account being taken of its peculiarities; the definition of what is to be prohibited would then present no special problem. But to detect signs of a new weapon being developed, pertinent scientific discoveries would have to be reviewed on a current basis and their possible military impact examined. This could be the task of an international body of experts, specially set up for the purpose. In the meantime, states could pledge themselves to refrain from developing weapons of mass destruction based on new principles.

However, in disarmament talks priority should logically be given to weapons already in existence, especially nuclear weapons, the mass destructive effect of which has already been demonstrated. A substantial reduction in the nuclear arsenals may also have an inhibitory effect on the development of new weapons.

References

1. Disarmament Conference document CCD/520, Annex A.
2. Disarmament Conference document CCD/PV.691.
3. Disarmament Conference document CCD/PV.703.
   (a) —, p. 8.
   (b) —, p. 10.
4. UN document A/C.1/31/PV.20.
5. Statement by the Director of the Bureau of International Scientific and

Technological Affairs, Department of State, before the US Senate Foreign Relations Subcommittee on Oceans and International Environment, on 26 July 1972.
6. *Ambio* (Royal Swedish Academy of Sciences), Vol. VI, No. 4, 1977, pp. 216–21.
7. US Executive Order 11850, Renunciation of Certain Uses in War of Chemical Herbicides and Riot Control Agents, 8 April 1975, 40 Federal Register 16187.
8. UN document A/RES/2603A/XXIV.
9. UN resolution 31/72.
10. UN document A/C.1/31/PV.51.
11. UN document A/10243.
12. UN document A/C.1/L.711, issued later as Disarmament Conference document CCD/511.
13. UN document A/RES/3479 (XXX).
14. UN document S/C.3/SR.13.
15. Pretty, R. T. and Archer, D. H. R. (Eds.), *Jane's Weapon Systems 1969–70* (Sampson Low, Marston and Co., London, 1969).
16. Disarmament Conference document CCD/514.
17. Disarmament Conference document CCD/PV.721.
18. Disarmament Conference document CCD/PV.736.
19. Disarmament Conference document CCD/511/Rev.1.
20. Disarmament Conference document CCD/PV.760.
21. Disarmament Conference document CCD/PV.761.
22. UN document A/RES/2602C (XXIV).
23. Disarmament Conference document CCD/291.
24. Glasstone, S. (Ed.), *The Effects of Nuclear Weapons*, prepared by the US Department of Defense (US Atomic Energy Commission, Washington, 1962), pp. 464–65.
25. *Washington Post*, 19 November 1976.
26. UN document A/C.1/31/PV.37.
27. Press Agency APN, Daily Review 4VPO/O 55522, Stockholm, 16 November 1977.
28. UN resolutions 32/84A and 32/84B.

Appendix 13A

Convention on the prohibition of military or any other hostile use of environmental modification techniques

The States Parties to this Convention,

Guided by the interest of consolidating peace, and wishing to contribute to the cause of halting the arms race, and of bringing about general and complete disarmament under strict and effective international control, and of saving mankind from the danger of using new means of warfare,

Determined to continue negotiations with a view to achieving effective progress towards further measures in the field of disarmament,

Recognizing that scientific and technical advances may open new possibilities with respect to modification of the environment,

Recalling the Declaration of the United Nations Conference on the Human Environment, adopted at Stockholm on 16 June 1972,

Realizing that the use of environmental modification techniques for peaceful purposes could improve the interrelationship of man and nature and contribute to the preservation and improvement of the environment for the benefit of present and future generations,

Recognizing, however, that military or any other hostile use of such techniques could have effects extremely harmful to human welfare,

Desiring to prohibit effectively military or any other hostile use of environmental modification techniques in order to eliminate the dangers to mankind from such use, and affirming their willingness to work towards the achievement of this objective,

Desiring also to contribute to the strengthening of trust among nations and to the further improvement of the international situation in accordance with the purposes and principles of the Charter of the United Nations,

Have agreed as follows:

ARTICLE I

1. Each State Party to this Convention undertakes not to engage in military or any other hostile use of environmental modification techniques having widespread, long-lasting or severe effects as the means of destruction, damage or injury to any other State Party.

2. Each State Party to this Convention undertakes not to assist, encourage or induce any State, group of States or international organization to engage in activities contrary to the provisions of paragraph 1 of this article.

ARTICLE II

As used in article I, the term "environmental modification techniques" refers to any technique for changing—through the deliberate manipulation of natural processes—the dynamics, composition or structure of the earth, including its biota, lithosphere, hydrosphere and atmosphere, or of outer space.

ARTICLE III

1. The provisions of this Convention shall not hinder the use of environmental modification techniques for peaceful purposes and shall be without prejudice to the generally recognized principles and applicable rules of international law concerning such use.

2. The States Parties to this Convention undertake to facilitate, and have the right to participate in, the fullest possible exchange of scientific and technological information on the use of environmental modification techniques for peaceful purposes. States Parties in a position to do so shall contribute, alone or together with other States or international organizations, to international economic and scientific co-operation in the preservation, improvement and peaceful utilization of the environment, with due consideration for the needs of the developing areas of the world.

ARTICLE IV

Each State Party to this Convention undertakes to take any measures it considers necessary in accordance with its constitutional processes to prohibit and prevent any activity in violation of the provisions of the Convention anywhere under its jurisdiction or control.

ARTICLE V

1. The States Parties to this Convention undertake to consult one another and to co-operate in solving any problems which may arise in relation to the objectives of, or in the application of the provisions of, the Convention. Consultation and co-operation pursuant to this article may also be undertaken through appropriate international procedures within the framework of the United Nations and in accordance with its Charter. These international procedures may include the services of appropriate international organizations, as well as of a Consultative Committee of Experts as provided for in paragraph 2 of this article.

2. For the purposes set forth in paragraph 1 of this article, the Depositary shall, within one month of the receipt of a request from any State Party to this Convention, convene a Consultative Committee of Experts. Any State Party may appoint an expert to the Committee whose functions and rules of procedure are set out in the annex, which constitutes an integral part of this Convention. The Committee shall transmit

to the Depositary a summary of its findings of fact, incorporating all views and information presented to the Committee during its proceedings. The Depositary shall distribute the summary to all States Parties.

3. Any State Party to this Convention which has reason to believe that any other State Party is acting in breach of obligations deriving from the provisions of the Convention may lodge a complaint with the Security Council of the United Nations. Such a complaint should include all relevant information as well as all possible evidence supporting its validity.

4. Each State Party to this Convention undertakes to co-operate in carrying out any investigation which the Security Council may initiate, in accordance with the provisions of the Charter of the United Nations, on the basis of the complaint received by the Council. The Security Council shall inform the States Parties of the results of the investigation.

5. Each State Party to this Convention undertakes to provide or support assistance, in accordance with the provisions of the Charter of the United Nations, to any State Party which so requests, if the Security Council decides that such Party has been harmed or is likely to be harmed as a result of violation of the Convention.

ARTICLE VI

1. Any State Party to this Convention may propose amendments to the Convention. The text of any proposed amendment shall be submitted to the Depositary, who shall promptly circulate it to all States Parties.

2. An amendment shall enter into force for all States Parties to this Convention which have accepted it, upon the deposit with the Depositary of instruments of acceptance by a majority of States Parties. Thereafter it shall enter into force for any remaining State Party on the date of deposit of its instrument of acceptance.

ARTICLE VII

This Convention shall be of unlimited duration.

ARTICLE VIII

1. Five years after the entry into force of this Convention, a conference of the States Parties to the Convention shall be convened by the Depositary at Geneva, Switzerland. The conference shall review the operation of the Convention with a view to ensuring that its purposes and provisions are being realized, and shall in particular examine the effectiveness of the provisions of paragraph 1 of article I in eliminating the dangers of military or any other hostile use of environmental modification techniques.

2. At intervals of not less than five years thereafter, a majority of the States Parties to this Convention may obtain, by submitting a proposal

to this effect to the Depositary, the convening of a conference with the same objectives.

3. If no conference has been convened pursuant to paragraph 2 of this article within ten years following the conclusion of a previous conference, the Depositary shall solicit the views of all States Parties to this Convention, concerning the convening of such a conference. If one third or ten of the States Parties, whichever number is less, respond affirmatively, the Depositary shall take immediate steps to convene the conference.

ARTICLE IX

1. This Convention shall be open to all States for signature. Any State which does not sign the Convention before its entry into force in accordance with paragraph 3 of this article may accede to it at any time.

2. This Convention shall be subject to ratification by signatory States. Instruments of ratification or accession shall be deposited with the Secretary-General of the United Nations.

3. This Convention shall enter into force upon the deposit of instruments of ratification by twenty Governments in accordance with paragraph 2 of this article.

4. For those States whose instruments of ratification or accession are deposited after the entry into force of this Convention, it shall enter into force on the date of the deposit of their instruments of ratification or accession.

5. The Depositary shall promptly inform all signatory and acceding States of the date of each signature, the date of deposit of each instrument of ratification or accession and the date of the entry into force of this Convention and of any amendment thereto, as well as of the receipt of other notices.

6. This Convention shall be registered by the Depositary in accordance with Article 102 of the Charter of the United Nations.

ARTICLE X

This Convention, of which the English, Arabic, Chinese, French, Russian and Spanish texts are equally authentic, shall be deposited with the Secretary-General of the United Nations, who shall send duly certified copies thereof to the Governments of the signatory and acceding States.

IN WITNESS WHEREOF, the undersigned, being duly authorized thereto by their respective Governments, have signed this Convention, opened for signature at Geneva on the eighteenth day of May, one thousand nine hundred and seventy-seven.

Annex to the convention

Consultative Committee of Experts

1. The Consultative Committee of Experts shall undertake to make appropriate findings of fact and provide expert views relevant to any problem raised pursuant to paragraph 1 of article V of this Convention by the State Party requesting the convening of the Committee.

2. The work of the Consultative Committee of Experts shall be organized in such a way as to permit it to perform the functions set forth in paragraph 1 of this annex. The Committee shall decide procedural questions relative to the organization of its work, where possible by consensus, but otherwise by a majority of those present and voting. There shall be no voting on matters of substance.

3. The Depositary or his representative shall serve as the Chairman of the Committee.

4. Each expert may be assisted at meetings by one or more advisers.

5. Each expert shall have the right, through the Chairman, to request from States, and from international organizations, such information and assistance as the expert considers desirable for the accomplishment of the Committee's work.

Understandings worked out at the Conference of the Committee on Disarmament[1]

Understanding relating to Article I

It is the understanding of the Committee that, for the purposes of this Convention, the terms "widespread", "long-lasting" and "severe" shall be interpreted as follows:

(a) "widespread": encompassing an area on the scale of several hundred square kilometres;
(b) "long-lasting": lasting for a period of months, or approximately a season;
(c) "severe": involving serious or significant disruption or harm to human life, natural and economic resources or other assets.

It is further understood that the interpretation set forth above is intended exclusively for this Convention and is not intended to prejudice the interpretation of the same or similar terms if used in connexion with any other international agreement.

[1] Disarmament Conference document CCD/520, Annex A.

Understanding relating to Article II

It is the understanding of the Committee that the following examples are illustrative of phenomena that could be caused by the use of environmental modification techniques as defined in Article II of the Convention: earthquakes; tsunamis; an upset in the ecological balance of a region; changes in weather patterns (clouds, precipitation, cyclones of various types and tornadic storms); changes in climate patterns; changes in ocean currents; changes in the state of the ozone layer; and changes in the state of the ionosphere.

It is further understood that all the phenomena listed above, when produced by military or any other hostile use of environmental modification techniques, would result, or could reasonably be expected to result, in widespread, long-lasting or severe destruction, damage or injury. Thus, military or any other hostile use of environmental modification techniques as defined in Article II, so as to cause those phenomena as a means of destruction, damage or injury to another State Party, would be prohibited.

It is recognized, moreover, that the list of examples set out above is not exhaustive. Other phenomena which could result from the use of environmental modification techniques as defined in Article II could also be appropriately included. The absence of such phenomena from the list does not in any way imply that the undertaking contained in Article I would not be applicable to those phenomena, provided the criteria set out in that Article were met.

Understanding relating to Article III

It is the understanding of the Committee that this Convention does not deal with the question whether or not a given use of environmental modification techniques for peaceful purposes is in accordance with generally recognized principles and applicable rules of international law.

Understanding relating to Article VIII

It is the understanding of the Committee that a proposal to amend the Convention may also be considered at any Conference of Parties held pursuant to Article VIII. It is further understood that any proposed amendment that is intended for such consideration should, if possible, be submitted to the Depositary no less than 90 days before the commencement of the Conference.

14. Mutual force reductions: status and prospects[1]

Square-bracketed numbers, thus [1], *refer to the list of references on page 416.*

I. Introduction

Almost 10 years have passed since the Foreign and Defence Ministers of the North Atlantic Treaty Organization (NATO), meeting at Reykjavik, voiced the opinion that "the ultimate goal of a lasting, peaceful order in Europe requires an atmosphere of trust and confidence" and expressed their belief that "measures in this field including balanced and mutual force reductions can contribute significantly to the lessening of tension and to further reducing the danger of war" [2a].

More than six years have passed since the leaders of the Soviet Union responded by proposing "reductions of forces and armaments in areas where military confrontation is especially dangerous, above all in Central Europe", a response endorsed by the Political Consultative Committee of the Warsaw Treaty Organization [3–4].

More than four years ago, representatives of 12 states belonging to NATO[2] met delegates from the member countries of the Warsaw Treaty Organization (WTO) in Vienna to begin negotiations on "Mutual Reductions of Forces and Armaments and Associated Measures in Central Europe"—to give these negotiations their full if cumbersome title.

During all this time there has been no progress towards reductions in armaments; in fact, both sides have continued to improve qualitatively the forces deployed in Central Europe, if not to increase them numerically. Europe remains an armed camp: one million NATO soldiers, seamen and airmen in the Federal Republic of Germany and the Low Countries confront one million WTO troops in the German Democratic Republic, Poland and Czechoslovakia, while hundreds of thousands more men are ranged against each other in Southern and Northern Europe (see table 14.1).

There are a number of reasons for this lack of progress, some of which derive from the magnitude and complexity of the military problems associated with mutual force reductions in Europe. Firstly, estimates of

[1] This chapter is derived from a longer paper written for a forthcoming SIPRI publication. Acknowledgement is made to Chatto & Windus Ltd, for permission to draw upon the book *Arms Control and European Security: A Guide to East–West Negotiations* [1] for parts of the chapter.

[2] Of the three remaining members of the Atlantic Alliance, Iceland has no armed forces, Portugal is an unofficial observer and France chose not to participate in the Vienna Conference.

Table 14.1. NATO and WTO ground and air forces immediately available for operations in Europe, mid-1976

Region		Divisions		Equivalents[a]		Troops		Tanks in formations[b]		Aircraft[c, d]	
Northern	NATO[e]	0		2		32 000		250		250	
	WTO	[2⅓]		[2⅓]		[30 000]		[510]		[65]	
Central	NATO	20⅔	(22⅔)	26	(28)	603 000	(645 400)	6 430	(6 755)	1 320	(1 320)
	WTO	58	[71]	54	[67]	727 000	[865 000]	15 700	[18 876]	3 000	[4 225]
Southern	NATO	33⅓		41⅓		540 000		4 050		850	
	WTO	28	[34]	27	[33]	302 000	[345 000]	5 815	[7 460]	865	[1 115]
Western	NATO[f]	1	(9)	1	(8)	21 000	(190 600)	250	(850)	510	(980)
Total	**NATO**	**56**	**(66)**	**70⅓**	**(79⅓)**	**1 196 000**	**(1 408 000)**	**10 980**	**(11 905)**	**2 930**	**(3 400)**
	WTO	**86**	**[107⅓]**	**81**	**[102⅓]**	**1 029 000**	**[1 240 000]**	**21 515**	**[26 846]**	**3 865**	**[5 405]**

All figures are approximate since unclassified sources do not agree.

Figures in square brackets, thus [ ], include those units inside the western military districts of the USSR which are combat-ready and which could be employed in operations outside the Soviet Union, such as Category I divisions, squadrons of the Tactical Air Force, and so on.

Figures in parentheses, thus ( ), include French forces.

[a] "Division equivalents" reflects the fact that some divisions have only two brigades, rather than the customary three, and that others are manned at considerably less than operational levels. (See, for example, the note concerning WTO formations in reference [29a].) It also reflects the fact that some armies have independent brigades, that is, units which are not organized into divisions.

[b] Including 550 tanks earmarked for US dual-based or NATO-committed divisions but exclusive of NATO and WTO tanks held in war reserve.

[c] Exclusive of squadron reserves or war reserves.

[d] Exclusive of US dual-based squadrons and of naval aircraft on both sides.

[e] Danish and Norwegian forces only; the West German division assigned to the Northern Command is included in the total for the Central Region.

[f] Forces deployed in the UK, Spain and France.

Source: Reference [1d].

the military balance must take into account not only conventional forces but also nuclear ones (see appendix 14B), not only units now ready for combat but also those of reserve status or manned largely by cadres, and not only those troops in Central Europe[3] but also those from the Soviet Union on the one hand and from Western Europe and North America on the other. Secondly, assessments of this balance, and of the factors affecting it, differ not only between East and West but also among members of the Western alliance.[4] Moreover, given both the difficulties of assessing the balance and the differing perceptions of that balance, it is hard to work out measures which would maintain that "undiminished security" which is the goal of both sides at the Vienna Conference. Finally, one must recognize that the military balance is not static, in that the introduction of new weapons, such as anti-tank guided missiles, or technological innovations, such as the development of "smart" bombs, can induce perturbations whose magnitude no one can assess with confidence. (For a brief discussion of one field where technology has recently affected military capabilities to a marked extent, see reference [7].)

Even if these were the only factors influencing proposals and outcomes at the Vienna Conference, the lack of progress would not be surprising. Unfortunately, however, they are not; political difficulties, as well as military–technical ones, have also slowed the pace of negotiations. One such difficulty arises from the fact that the procedures for developing and evaluating proposals are extraordinarily complex and subject to all kinds of bureaucratic influence; for example, one participant has identified 10 major elements of the United States government, making their inputs at three levels of decision-making, along with three different components of NATO: the North Atlantic Council; the Senior Political Committee; and the *ad hoc* group on Mutual and Balanced Force Reductions [8].[5] Another difficulty arises from the fact that the individuals

[3] In this context, "Central Europe" or the "Central Region" encompasses Poland, Czechoslovakia, the two Germanies, Belgium, the Netherlands and Luxembourg. The participants in the Vienna Conference are focusing on the forces in this region (sometimes called the NATO Guidelines Area, NGA, that is, the area to which NATO proposals for force reductions apply). The forces include (*a*) indigenous forces—those of the countries of the region, and (*b*) stationed forces—those elements of the armed forces of the USSR on the one hand, and of the USA, the UK, and Canada (and France) on the other, which are deployed within the region.

[4] For example, several knowledgeable US senators have questioned "whether the current posture of NATO's conventional forces in the Central Region is capable of dealing with a dramatically altered Soviet threat in Eastern Europe" [5], while the equally knowledgeable West German Minister of Defence, Georg Leber, stated almost simultaneously—in an interview with *Das Bild* on 26 December 1976—that NATO maintained an overall "balance" in regard to the military potential of the WTO, adding, "In this context it will not do to count man against man and tank against tank" [6].

[5] The differences over approaches to measures for the limitation of armaments are reflected in the titles used by each side, with NATO continuing to employ the word "balanced" in its own references to the negotiations under way at Vienna even after the delegates had agreed to drop it from the official title of the Conference.

involved in this complex process—and hence the positions espoused—have also changed over time; for example, Carter, Callaghan and Schmidt all assumed office after the initial talks on mutual force reductions had begun and some of the principal ministries in the USA, the UK and FR Germany have changed hands several times since January 1973. However, the greatest obstacle by far to progress in mutual force reductions arises out of the varying (and frequently opposed) interests and objectives of the two alliances, and of the individual members thereof —interests which affect both their perceptions of security and their judgements of the various measures proposed.

The purpose of this chapter is to review the factors which have influenced the approaches to mutual force reductions (MFR) of NATO and the WTO, to discuss the proposals that each side has advanced at Vienna (for a chronological table of the proposals, see appendix 14A), and to evaluate the prospects for the future. Obviously, this is a difficult task, whose satisfactory execution would require both more time and more space than are available. For this reason, the analysis will focus on those concerns, interests and attitudes which are seemingly common within each alliance. Although this is admittedly a failing, it need not be a serious one, if only because an assessment of the incentives and disincentives influencing decisions within alliance councils has merit in itself. Thus, to begin with, an examination will be made of relevant influences on NATO attitudes towards MFR.

II. NATO and MFR

General interests and concerns

When, at its meeting in Rome on 26–27 May 1970, the North Atlantic Council made the first specific proposal for negotiations on mutual and balanced force reductions [2b], it had a number of reasons for doing so. The first reason was the desire to improve détente. Even before former US Secretary of State Kissinger pointed out that "in the nuclear age, there is no alternative to détente", his predecessors in the Department of State and in other foreign and defence ministries throughout the Western world had come to the same conclusion, namely, that they must "pursue the search for progress towards a more stable relationship [between East and West] in which the underlying political issues can be solved" [2c], and that MFR could contribute to this. The second reason was to avoid, postpone or obtain offsetting compensations for any reductions in US forces in Europe, which at that time seemed as imminent as they promised to be unsettling. The third was to avoid further shifts in the military balance in Europe, which had been altered by a steady improvement in

WTO forces that NATO—for political reasons—found it difficult to match (for information supporting this statement, see reference [9]). (Despite the increased "threat" from the WTO, West European expenditures for defence in constant dollars remained static from 1965 to 1970 and increased only slightly in the early 1970s [10].) The fourth reason was the desire to obtain some compensation for Western participation in the Conference on Security and Co-operation in Europe (CSCE), which the WTO had proposed early in 1969; since NATO thought that the proposed CSCE presented more problems than opportunities, it felt that Western acquiescence to such a conference should be offset by Eastern participation in negotiations which offered a greater prospect of gains by the West, or which at least dealt with subjects of greater interest to the West.

Had these been the only factors operative, it is likely that agreement on mutual force reductions would have been reached long ago—and on terms closer to those offered by the WTO than to those favoured by NATO. However, neither internal political problems nor economic difficulties have meant that the Western allies are prepared to accept any or all measures for mutual force reductions in Europe.

For one thing, the continuing build-up of Soviet nuclear and conventional forces—whatever its justification in terms of Soviet security—has induced concern about Soviet intentions. Although few in the West fear a direct and unprovoked assault by the WTO, a larger number worry about WTO behaviour in time of crisis and wonder about the ultimate intentions of the Soviet Union in building up what is (as they see it) overwhelming power in and on the borders of Europe [11–14]. In these circumstances, the belief that the Soviet Union is seeking to extend its political influence by the adroit exercise of military pressures is fairly widespread and questions of whether the USSR is aiming at political hegemony over Western Europe are more numerous than they were three or four years ago. (For further details concerning perceptions of threats, see reference [1a].)

These doubts about Soviet intentions derive from the belief that détente depends upon a continuing balance of strength between East and West—a belief which has been expressed in virtually every NATO communiqué [2d–2e, 15]. This belief not only makes (perceived) shifts in the military balance even less acceptable than might otherwise be the case but also has side-effects which impinge directly on mutual force reductions, such as the search for measures which could redress alleged imbalances in military capabilities between East and West, for example, by asymmetrical reductions in WTO and NATO ground forces. It also stiffens resistance to measures which could erode Western advantages, as, some feel, could cuts in tactical nuclear delivery vehicles (TNDVs). (See table 14.2.) Since, moreover, maintenance of NATO conventional and nuclear capabilities depends on the solidarity of the Western allies—especially on whole-hearted participation by the United States—NATO has tended to eschew measures which could divide that alliance, as could early and drastic reductions in indigenous troops or differential treatment of the forces of different allies. It has also opposed measures which would block the rationalization of missions and forces within the Atlantic alliance, or could hamper the ultimate creation of a European Defence Force (EDF), as could the imposition of national ceilings under MFR. Thus, NATO has positions to maintain, as well as objectives to achieve, at the Vienna Conference.

Given the largely negative incentives to MFR, it is understandable that NATO foresaw (and encountered) a number of problems in achieving "equal security at lower cost"—its initial objective in the negotiations. One problem is that any reductions will undoubtedly affect the number and capabilities of US troops in Europe and hence, in Western eyes, the credibility of the US deterrent. Another is that they may result in a shift of WTO forces from the Central Front to the flanks of NATO, thereby enhancing West German security at the expense of Greece and Norway. A third is that the MFR talks may require changes in NATO military doctrine and operational concepts, thereby resurrecting defunct problems.

Even if the military issues underlying various approaches to MFR can be resolved, the attempt to do so may divide the alliance. Furthermore, certain kinds of agreement may impose legal restrictions on some members of NATO, but not on all, and almost any agreement would give the Soviet Union and its allies some degree of influence over NATO force postures and defence programmes. More important, arms control might erode NATO's sense of purpose and sap its already low vitality. Hence, some NATO countries are inclined to give higher priority to maintaining alliance cohesion and freedom of action than to adopting armament control measures, however fruitful these might be.

Perhaps most important, many are worried lest mutual force reductions further tilt the military balance in favour of the WTO, either by depriving NATO of weapons which are deemed essential to its security or by so thinning Western defences that the armies of the WTO could penetrate them. Although they may consider war very unlikely, the members of NATO cannot rule it out entirely, and hence must prepare to wage war if necessary. Moreover, they may fear the effects of a further weakening of Western defences on the will of some states to resist political pressures. Given these concerns, it is understandable that some officials should oppose force reductions of any kind and that others should endorse only proposals favourable to the West.

Table 14.2. NATO and WTO forces in Central Europe, mid-1976

	United States	Other NATO: Stationed forces		Other NATO: Indigenous	Total NATO		Soviet Union	Other WTO	Total WTO
Ground forces									
Divisions	4	3	(5)	13⅔		(22⅔)[a]	27	31	58
Division equivalents[b]	5⅔	2⅓	(4⅓)	18	26	(28)	27	27	54
Manpower in divisions[c]	84 200	24 000	(54 000)	203 925	315 125	(347 125)	336 000	251 250	587 250
Combat and direct-support troops[d]	169 400	52 000	(94 000)	381 600	603 000	(645 400)	437 000	290 000	727 000
Personnel	189 000	58 000	(116 000)	487 000	734 000	(792 000)	455 000	444 000	899 000[e]
Tanks[f]	2 500	650	(975)	3 280	6 430	(6 755)	7 900	7 800	15 700
Air forces									
Personnel	41 000	–		149 800	190 900	(190 900)	45 000	142 000	187 000
Combat aircraft[g]	260	136		924	1 320	(1 320)	1 300[h]	1 700[i]	3 000
light bombers	–	25		–	25	(25)	100	30	130
fighter/ground attack	150	72		658	880	(880)	550	420	970
fighter/interceptors	70	24		151	245	(245)	500	1 100	1 600
reconnaissance	40	12		118	170	(170)	150	150	300
Naval forces[j]									
Personnel	–	–		61 500	61 500	(61 500)	–	41 000	41 000
Major surface combat ships	–	–		35	35	(35)	–	5	5
Attack submarines	–	–		30	30	(30)	–	6	6
Combat aircraft	–	–		135[k]	135	(135)	–	51[l]	51
Total men under arms	**230 000**	**58 000**	**(116 000)**	**698 300**	**986 400**	**(1 044 400)**	**500 000**	**627 000**	**1 127 000**
Tactical nuclear delivery vehicles[m]	879	130		1 332	2 336		1 054	351	1 405
Artillery	498	70		793	1 361		234	–	234
Rockets	–	8		86	94		108	109	217
VSRBM	36	–		20	56		96	71	167
SRBM	108	–		72	180		16?	–	16
Strike aircraft	232	52		361	645		600	171	771

All figures are approximate since unclassified sources do not agree.

Figures in parentheses, thus ( ), include French forces.

[a] Exclusive of British, French and US troops in Berlin (some 6 000 and equivalent in combat power to about two brigades).
[b] "Division equivalents" reflects the fact that some divisions have only two brigades rather than the customary three (as do those in the British Army of the Rhine) and that others are at cadre strength only—a factor which reduces the Polish Army from a nominal strength of 15 divisions to an actual one of 13 "division equivalents". It also reflects the fact that some brigades are independently organized, as are the three infantry brigades of the US Seventh Army. The figures for the USA include two Army cavalry regiments, which are included in reference [29b] but not in US figures.
[c] Calculated from reference [29c]. Soviet units are assumed to be at full strength and other WTO forces assumed to be at three-quarter strength [29a]. All NATO forces are assumed to be at full strength except the US armoured cavalry regiments, Canadian battle group, and NATO units in Berlin.
[d] Computed on the basis of 29 100 men per US division and 21 200 for other NATO divisions, and including 7 000 US and British personnel in Berlin which are not reflected in the division totals. The Soviet combat and direct support troops are computed from the information provided in reference [29d]. (Those Soviet figures seem somewhat high in that they allow for only 18 000 troops in all administrative and logistic support positions.)
[e] The strength of the WTO ground forces in Central Europe has reportedly been given at 805 000 in information passed to NATO at the Vienna Conference [30].
[f] Including approximately 550 stockpiled for US dual-based or immediate reinforcing formations, as indicated in reference [29e], but not reserve stocks held by either NATO or WTO forces.
[g] The breakdown by types is based on primary mission, as given in the country section of reference [29], rounded to the nearest five. Since many aircraft are dual-purpose, this breakdown is illustrative only; for example, 60 of the West German fighter-bombers double as interceptors and the 120 G-91s can be used as ground attack aircraft or for reconnaissance.
[h] The breakdown by types of Soviet aircraft was derived by assuming that the 1 300 aircraft in Central Eastern Europe were structured similarly to the overall total of 2 500 given in reference [29f].
[i] The breakdown by type of other WTO aircraft was derived from country data, rounded off to the nearest five.
[j] One difficulty in dealing with regional force reductions in general, and naval forces in particular, is that the areas covered do not necessarily correspond with those which make sense militarily. The Netherlands Navy should be considered as operating in the Atlantic, and the Danish, together with the Soviet Navy, as operating in the Baltic. If these shifts were made, the balance would be as follows:

	Major surface combat ships	Attack submarines	Combat aircraft
NATO	24	30	135[k]
Central WTO	52	19	141[l]

[k] About 85 are F-104G fighter-bombers of the West German Naval Air Arm; the remainder are maritime reconnaissance aircraft.
[l] Of these, about 50 are Polish MiG-15 and MiG-17 fighter-bombers, the remainder Polish light bomber/reconnaissance aircraft and similar aircraft of the Soviet Naval Air Force.
[m] For details about tactical nuclear vehicles, see reference [1e].

Source: Reference [29].

The NATO approach to MFR

NATO would thus like to see significant reductions of Soviet troops in Eastern Europe, wherever they are stationed, and is less concerned about cuts in the forces of other WTO countries. It would also like to see asymmetrical reductions in WTO ground and air forces, especially in units, such as tank divisions and amphibious brigades, which are particularly suited to offensive operations; this would reduce local WTO advantages (which could, some fear, enable the WTO to launch a surprise attack with some assurance of success) and compensate for geographic "asymmetries" arising from the fact that the USSR—where powerful reinforcements are stationed—is closer to the frontier between the two Germanies than is the USA, from whence must come the bulk of the NATO reinforcements. In addition, NATO would undoubtedly want assurances that Soviet units withdrawn from Eastern Europe would not be moved to other areas (such as the Kola Peninsula) from which they could threaten NATO's flanks; that they be either dissolved or stationed deep in the interior of the USSR; and that restrictions be placed on their redeployment to the European theatre.

NATO would prefer that there be only small cuts in US (and other) stationed forces and that they should not preclude the ability of these forces to return to the European theatre in fighting trim—which suggests cuts in manpower rather than in organized units and retention rather than removal of equipment now in Europe. The Western allies might accept somewhat larger reductions in indigenous forces but they would not want them to apply to reserve units, upon which they rely heavily to match the reinforcements available from within the USSR. Nor would they wish them to apply to air force units, upon which they rely to offset WTO advantages in tanks and armoured personnel carriers (see table 14.2) or to TNDVs in general, which serve both this purpose and that of deterring WTO "aggression" through fear of escalation into nuclear war. In addition, they would certainly wish to preserve the ability to alter the size and composition of national forces and their freedom of movement within NATO territory, both as a hedge against political pressures and as a contribution towards the creation of a joint European Defence Force.

III. The WTO and MFR

General interests and concerns

Despite the failure both of early post-war efforts at disarmament and of those of the mid-1950s aimed at establishing acceptable limits on the forces of the major states, the countries of the WTO did not abandon their interest in disarmament. Even before NATO issued its first call for MFR, the WTO had, in its statement of 9 July 1966, put forward a long list of suggestions for "partial measures aimed at military détente on European territory" [2f]. Throughout the long, difficult and frequently disheartening series of manœuvres which followed the Rome Declaration of NATO and preceded the convening of the Vienna Conference, the members of the WTO continually urged the Western powers, in the words of General Secretary Leonid Brezhnev, to "taste the wine" of negotiations on arms control.

First and foremost among the reasons for this was probably the hope that military détente would contribute to political détente and thus enhance security, both directly and indirectly. Second only to this was probably the desire to reduce the economic burden of defence, which is very large, reaching 6 per cent of gross national product in the German Democratic Republic and perhaps 11–13 per cent in the USSR [16a]. In addition, members of the WTO may also have seen in MFR an opportunity to reduce, if not to eliminate, several threats to their security, arising out of NATO's advantage in military technology and out of "the tendencies to military integration which have been gathering momentum in Western Europe" [17a]—tendencies which could only be strengthened by a continuing confrontation between East and West. And they must have hoped that MFR would prevent the Federal Republic of Germany—the strongest economic power in Western Europe and the one wielding the greatest political influence—from continuing to build up its military capabilities and in this way achieving a position from which it could conceivably exert pressures against the countries in Eastern Europe.

Moreover, the WTO had interests to secure, as well as future possibilities to obstruct. One of these interests lay in reducing Western tactical nuclear capabilities, because this would blunt a weapon on which NATO had long depended and also because it could, the WTO hoped, reduce the damage from any nuclear exchange in Europe—a motive which strongly influenced the East Europeans.[6] Another interest would be to advance long-term security objectives, which looked to the dissolution of NATO and the WTO and their replacement by a collective security system in Europe; to the withdrawal of all nuclear weapons to the territories of the powers possessing them; to the creation of nuclear-free zones (NFZs) and the signing of agreements not to be the first to use nuclear weapons; and to reductions in armed forces, especially in that part of Europe west of the Soviet frontier [19]. Whatever the prospect of achieving all of these objectives, some measures would obviously go further in this direction than others.

[6] In the words of one Polish writer, "Even the kind of 'Brest-to-Brest' engagements contemplated by some American strategists—a theatre, in other words, running from the River Bug to the Atlantic—would amount to an all-out war with the most appalling consequences" [18].

The WTO approach to MFR

As might be expected, the WTO approaches to MFR are very different from those of NATO. While the WTO may well seek sizeable withdrawals of US forces and significant cuts in those of FR Germany, it is not as interested in reductions in other NATO troops. It would be more interested in cutting NATO tactical nuclear forces than conventional ones and in constraining highly mobile elements (such as fighter-bombers) than comparatively static ones; and, given its own estimates of the global balance of power, it might insist that any units affected by MFR—especially US ones—should be dissolved rather than kept on the military roster.

The WTO might in return acquiesce in small to medium reductions of Soviet troops (perhaps 10–20 per cent over a protracted period) and even larger cuts in other East European armies and air forces. (Sizeable reductions in indigenous forces can probably be made without significantly weakening WTO defences, partly because only selected East European troops are earmarked for combined operations with Soviet units [20] and partly because the USSR would be able to reinforce those units from combat-ready forces inside its own territory.) Since, however, the WTO sees NATO as militarily ahead on a global basis and as having a balance of forces in Central Europe, it would be reluctant to accept asymmetrical reductions in the forces in that area. (As one Soviet writer has pointed out, asymmetries in the force structures of the two alliances do not necessarily generate advantages for one or the other but simply reflect differences in military doctrine, alliance relations and capacity to produce particular kinds of weapons [21].) Thus the USSR and its allies might hold out for more or less proportionate cuts in manpower, weapons and/or units (which would implement the principle of "undiminished security" as they interpret it) or might seek trade-offs reflecting their greater concern about tactical nuclear weapons—in either case putting forward measures opposed to those favoured by NATO.

IV. The negotiations on MFR

The above discussion indicates why those conferring in Vienna have had great difficulty in agreeing on arms control measures applicable to Central Europe. Indeed, the preliminary positions taken in the negotiations followed a predictable pattern, with NATO and WTO proposals almost diametrically opposed.

The WTO initially suggested measures which would affect both stationed and indigenous forces on a proportional basis, with reductions of 20 000 men each in NATO and WTO ground and air forces in 1975, to be followed in subsequent years by cuts of 5 and then 10 per cent.[7] These percentage reductions were to apply also to significant weapons, such as tanks, aircraft and rocket launchers, and cuts in both men and weapons would be effective "in the form of comparable military units". (So far, the WTO has given no public indication of whether these units would be small ones, such as battalions and air squadrons, or large ones, such as divisions and air wings.) "Foreign" units were to be withdrawn to their countries of origin (a measure which would presumably affect the Belgian and Netherlands troops now deployed in FR Germany, as well as those of US, British, Canadian and French[8] origin), while "national" units were to be disbanded, their personnel demobilized and their equipment decommissioned. Moreover, reductions in, and a subsequent freeze on, remaining ground and air forces were to be applied on a national basis, that is, West German forces would be cut by 15 per cent and frozen at their reduced levels of men and equipment.

Given the existing military balance in Central Europe (see table 14.3), the numbers of airmen and soldiers to be demobilized or withdrawn under the initial WTO proposal would be about 165 000 for NATO and about 185 000 for the WTO.[9] If tactical nuclear delivery vehicles were defined in a limited way, cut-backs by both sides would be about equal; if nuclear-capable artillery were included, however, NATO would have to dispose of a further 200 TNDVs. While the WTO would presumably scrap or retire more conventional weapons, it would still retain its present superiority of almost two to one in aircraft and tanks, upon which it relies to offset other NATO advantages, thereby observing the principle of "undiminished security".

[7] This proposal was subsequently modified to provide that only US and Soviet forces would initially be cut, that this be done in numbers proportional to the troop strength on each side, and that armed forces of other participating states be frozen in numbers, pending second-stage reductions on the basis of percentages to be subsequently agreed upon (see appendix 14A).
[8] The treatment to be accorded the French forces in FR Germany under any agreement on MFR may be something of a problem. As previously indicated, France is not participating in the Vienna Conference and the French government has announced that it will not be bound by any agreements reached there—a position which both sides seemingly respect. However, French troops are bound to be affected by measures for the redeployment of "foreign" forces and/or for the reduction of troops in the area, as proposed by the WTO, and will presumably be brought under the common "ceiling" of 700 000 ground force personnel proposed by NATO; if they are not, NATO would in consequence have a considerable advantage. Both the WTO and the NATO proposals, therefore, would require unilateral withdrawals by France in accordance with the agreement, bilateral negotiations to the same end between France and FR Germany, or the absorption by other Western countries of cuts which would otherwise have to be made in French forces. In any of these cases, there would probably have to be some understanding between France and its allies with respect to the kinds of change which would be made in French forces in FR Germany and to the ways in which these could be made to conform to the terms of any treaty on MFR.
[9] This would be the case if one used Western figures for the number of men on the Central Front. If, however, one based these calculations on the figure of 805 000 WTO ground force personnel which the members of the WTO have reportedly stated that they maintain in Central Europe [22], the reductions would be virtually identical.

This is not, of course, the Western view. As mentioned previously, NATO sees itself faced on the Central Front by WTO ground and air forces which are superior in numbers of tanks, aircraft and guns, if not in overall combat capabilities. NATO has therefore proffered a package to achieve balanced, that is, equal, ground forces in Central Europe (see appendix 14A). This would be done in two stages, the first involving the withdrawal of approximately 16 per cent of US and Soviet stationed forces, the latter including five divisions and some 1 500 to 1 700 tanks.[10] Since there are only half as many US soldiers in Central Europe as there are Soviet ones, this would result in asymmetrical cuts in manpower, the figures commonly cited being 28 500 US soldiers and 3 000 airmen compared with 67 500 Soviet airmen [23]. This first stage would partially achieve the NATO goal of cutting back Soviet troops and redressing existing "imbalances".

The second stage would go even further in those directions by establishing ceilings of 700 000 men on the ground forces of both sides, which would require NATO to eliminate another 50 000–60 000 men[11] and the WTO to eliminate over twice as many, with each alliance to decide which national forces would be cut, and by how much. Even if reductions in weaponry during the second stage were only proportionate to those in manpower, the WTO would again lose more tanks, guns and armoured personnel carriers, thus further diminishing its ability to conduct mobile operations. Since both cuts in manpower and reductions in weapons would affect the WTO disproportionately, NATO might not only eliminate the disparities in combat manpower and in the character of the ground forces of the two sides which it considers disadvantageous but might also partially offset the geographical asymmetries which allegedly favour the USSR. Moreover, since it would retain most, if not all, of the dual-capable delivery systems on which it relies so heavily,[12] NATO might indeed feel more secure.

Whether the WTO will be persuaded that this is true in its case is perhaps debatable; WTO spokesmen have charged that the Western

[10] The initial proposal called for the removal of a complete tank army; however, this has reportedly been modified to allow the USSR more flexibility in selecting the units to be withdrawn (see appendix 14A).

[11] The exact total would depend on whether French forces were counted under the ceiling, and, if they were, on the number of French troops still in FR Germany at the time agreement was reached; since the initial proposal was made, these have been reduced in strength from 58 000 to 48 000 (see table 14.3).

[12] In December 1975, NATO offered a modified proposal which featured reductions in the number of tactical nuclear warheads, nuclear-capable fighter-bombers and Pershing ballistic missiles in the first-stage withdrawal of US and Soviet forces. This proposal also called for ceilings for these weapons and for air forces in the Central European area—an idea subsequently adopted by the WTO. It was, however, contingent on WTO acceptance of common ceilings on ground forces. (See appendix 14A.)

Table 14.3. Land and air forces in the reduction zone, mid–1976

	Manpower *thousand*		Equipment			Manpower *thousand*		Equipment	
NATO	Ground	Air	Tanks	Aircraft	WTO	Ground	Air	Tanks	Aircraft
Stationed forces					*Stationed forces*				
USA	193[a]	35	2 000[b]	335	USSR	475	60	9 250	1 300
UK	58[a]	9	575	145					
Canada	3	2	30	50					
Subtotal	254	46	2 605	530					
France	(50)[a, c]	(–)	(325)	(–)					
Subtotal, incl. France	(304)	(46)	(2 930)	(530)	Subtotal	475	60	9 250	1 300
Indigenous forces					*Indigenous forces*				
Belgium	62	19	300	145	Czechoslovakia	135	46	2 500	550
FR Germany	345	110	3 000	509	German DR	105	36	1 550	375
Netherlands	75[d]	18	500	160	Poland	220	62	2 900	850
Subtotal	482	147	3 800	814	Subtotal	460	144	6 950	1 775
Total	**732**	**193**	**6 405**	**1 344**	**Total**	**935**[e]	**204**	**16 200**	**3 075**
Total, incl. France	**(782)**[c]	**(193)**	**(6 730)**	**(1 344)**					

Figures in parentheses, thus ( ), include French forces.

[a] Including troops in West Berlin.
[b] Including 600 tanks stockpiled for reinforcements from the USA.
[c] Reduced by 10 000 in April 1977.
[d] Including Marines.
[e] NATO estimate is reportedly 925 000; data furnished by the WTO sets figure at 805 000.

Source: Reference [16b].

proposals would alter the balance of power in Central Europe and contradict the principle of undiminished security for both sides [17b, 24]. In their turn, the negotiators for the WTO have borrowed a leaf out of NATO's book, by offering to withdraw missiles, strike aircraft and "nuclear munitions" equal in number to those withdrawn by the USA—*if* the USA and its allies accept the WTO proposals for proportionate reductions, by country, in all types of weapon and in men belonging to air and ground forces [17b, 24–25]. The Western powers would not accept this proposal, both sets of proposals were shelved, and the delegates turned to a discussion of the data concerning men under arms in Central Europe, on which there is also disagreement. By mid-1977, therefore, the negotiations on MFR were seemingly deadlocked on virtually every issue: the types of forces which should be reduced; whether these reductions should be asymmetrical or proportional; whether reductions should apply to all direct participants in proportion to their troop strength or be determined by the two alliances; whether the link between first-stage reductions, involving US and Soviet forces, and second-stage reductions, affecting all forces, should be tight or loose; and even what the size of the forces in the Central Region should be.

V. Prospects for agreement

It is clear that there are fundamental divergencies between the security interests of the members of NATO and those of the countries of the WTO, reflected both in their attitudes towards MFR and in the proposals for force reductions put forward. If all goes on as before, there is little prospect of agreement in the foreseeable future.

This is particularly true because the incentives for NATO to make mutual reductions in forces have diminished since the negotiations started. Firstly, détente is viewed less favourably and measures intended to promote it are advanced more cautiously than was true four or five years ago. Secondly, the pressures for unilateral US troop withdrawals from Europe have diminished, partly in consequence of this changed view of détente and partly because the USA has recovered somewhat from the immediate consequences of the Viet Nam War [26]. Thirdly, both the USA and the countries of Western Europe are seemingly concerned about the steady pace of Soviet force improvements, and are hence prepared—despite their worsened financial positions—to devote more resources to defence. Fourthly, the process of preparing for and conducting the negotiations in Vienna has resulted in the adoption of positions which are difficult to abandon, such as the concept of parity in ground forces; as Netherlands Foreign Minister van der Stoel put it, the countries of the West could in no circumstances agree to a form of wording "that would . . . mean setting a treaty-like seal on the unequal balance of numbers between Eastern and Western troops" [27]. In consequence, there is a general feeling that the members of the WTO can and should, accept the Western proposals described above, though this does not rule out minor modifications such as those reportedly under discussion in the autumn of 1977 (see appendix 14A).

The attitudes of the countries of the WTO are seemingly more mixed. For one thing, the economic incentives to force reductions are still strong, especially among the lesser powers, who could benefit immediately and directly from reductions in forces. Secondly, the commitment to "military détente" is still high, for the reasons already explained. Conversely, the first flush of Soviet enthusiasm for reductions (the Strategic Arms Limitation Talks as well as MFR) would seem to have faded, especially in the light of what Soviet leaders see as Western attempts in both forums to achieve "unilateral military advantages" [17c]. Moreover, US–Soviet relations are at a lower ebb now than when the negotiations at Vienna opened, partly because of changes in key US personnel—such as the ousting of President Nixon and the replacement of Kissinger by Vance as Secretary of State—and partly because the style and the policies of the Carter Administration have caused irritation in some Soviet circles. Hence, there is little prospect that the WTO will come round to accepting the NATO proposal.

This does not mean that the Vienna Conference is about to break up; not only is the process of negotiation itself regarded as important but both sides still hope for, plan for and desire to achieve satisfactory results. It does, however, mean that the attainment of those results depends on: (*a*) a re-examination of perceptions which seem to persist on both sides, such as the Western belief that the WTO is building up forces for a massive conventional attack and the Eastern one that NATO is planning nuclear aggression; (*b*) a re-evaluation of the interests of the participants; (*c*) a reassessment of proposals designed to advance self-interests at the expense of the interests of the other side—such as NATO's reluctance to programme cuts in the *Bundeswehr* by keeping tenuous the link between first-stage reductions of stationed forces and second-stage reductions of indigenous ones and such as the WTO insistence that the only way of achieving these cuts is to impose national force ceilings; and (*d*) some movement on other fronts, such as SALT, the implementation of agreements reached at the CSCE, and so on.

If these developments do take place, then the delegates to the Vienna Conference could find a middle way, possibly along the lines suggested below.

(1) They could attempt in various ways to clarify the data concerning

forces in Central Europe, which according to Eastern sources are approximately equal, but according to Western sources are still unbalanced (see table 14.3 and reference [22]). If the WTO figures turn out to be correct, there should be no problem.[13]

(2) If differences persisted, then the conferees would still have to face the issue of asymmetrical reductions or the almost equally difficult one of recategorizing and/or re-evaluating the forces brought under agreement in order to achieve parity,[14] not because this is of overriding importance militarily but because the concept of parity seems to have become an *idée fixe* in the West.

(3) From this vantage point, the delegates could engage in proportional reductions by some mutually agreeable percentage, such as 10 or 15 per cent, of all soldiers, seamen and airmen on active duty and of all major units, such as ground force divisions and air force elements of comparable size and importance.

(4) They could apply these reductions to nuclear-armed units as well as to conventionally equipped ones, albeit perhaps at smaller percentages or at a slower rate.

(5) They could freeze the size of the armed forces left in the reduction zone and the number of offensive weapons remaining therein, pending further reductions, but not freeze the numbers of defensive weapons, such as surface-to-air missiles and anti-tank guns.[15]

[13] Basically, there can be three reasons for the discrepancies: (*a*) the WTO has deliberately provided false data—which seems improbable; (*b*) the "counting rules" for determining equivalences in ground forces (which must be applied because of differences in the functions assigned to the various components of the armed forces in NATO and the WTO) turn out to be imprecise; in view of the extensive interchanges on this subject which have taken place between East and West, this would seem unlikely; (*c*) NATO intelligence is wrong—either because its basic assumptions (such as those about manning levels in WTO divisions) are inaccurate or because there is a time-lag in assessing changes which have taken place, as in the number of men under arms in the several countries of Eastern Europe; this is, of course, possible, although many in NATO uphold the validity of intelligence estimates.

Verification of either (*a*) or (*c*) could be extremely difficult, in that it might require the transmission of data on a scale not previously acceptable, the provision of reassuring information in ways not yet discussed [1b], or the re-evaluation of sources of intelligence.

[14] Among the possible ways of establishing "parity" as a starting-point for percentage reductions could be: (*a*) voluntary reductions by the WTO of troop levels to those which it has given out at the Vienna Conference (805 000 men in ground forces)—a move which would seem reasonable if the WTO had made an honest mistake in compiling the data; (*b*) counting naval personnel as well as men belonging to air and ground forces, which would reduce by 25 000 the "gap" between NATO and the WTO; and (*c*) counting a percentage of the civilian workers from Western countries in the NGA equal in number to WTO military personnel performing similar tasks.

To some extent, (*b*) and (*c*) are ingenuous but political solutions have in other instances been based on less valid compromises.

[15] As an exception, fighter-interceptor squadrons should be reduced by the same percentages as other air force units and the number of interceptors frozen at the resulting ceiling. If this is not done, the shift in the air balance may be so detrimental to NATO as to be unacceptable; in addition, difficulties of verification suggest simplicity in reductions and in force ceilings.

(6) They could allow each alliance to determine the nature and the magnitude of cuts in the armed forces of their member states, under circumstances which either ensured that the alliance paid a penalty for this in terms of greater reductions than would otherwise be necessary or that it accepted other constraints, such as limitations on the percentage of men under arms from any one country.

It should be noted that even these measures, far-reaching as they may seem to some at first glance, would have comparatively little effect on the military balance in Europe. One reason is that cuts of 10 or even 15 per cent in TNDVs would not really begin to scratch the surface of the nuclear capabilities of each side; furthermore, such cuts could be offset by changes in the allocation of weapons from non-nuclear to nuclear roles or by substituting weapons placed outside the reduction zone. Another reason is that although reductions of, say, 15 per cent in major units—and personnel—would probably require the withdrawal of one US division and perhaps four Soviet ones, as well as a cut-back of at least two divisions in the *Bundeswehr*, they would (*a*) have little or no effect on the mobilization capability of indigenous countries, since the units disbanded would presumably be added to the reserves, and (*b*) have only a marginal impact on reinforcement capabilities, the actual degree depending largely on whether the units withdrawn from the reduction zone left their equipment behind or had to take it with them.[16] On the other hand, the proposed measures should reduce to some extent the capacity for surprise attack, both by curtailing the size of active duty forces and by diminishing both absolutely and proportionally the number of offensive weapons in the hands of these forces. They should also have considerable psychological impact: on the West by reducing both the surprise-attack capabilities of the WTO and its advantages in armoured fighting vehicles, and on the East by cutting down to some extent on both tactical nuclear delivery vehicles and the *Bundeswehr*, which are its prime targets under MFR. Moreover, since the security of each side would, at least by some judgements, be "undiminished"[17] the proposals should be acceptable.

To some, the measures outlined may seem utterly unrealistic; to others, they may not appear to go far enough. To both sides it is necessary to say that only a firm resolve all round to pursue MFR and a willingness to

[16] One analyst, assessing the results of NATO's Stage One proposals, which would involve withdrawing about one US division and four Soviet divisions, estimated that there would be a slight improvement in the NATO position during the first three weeks following mobilization, but none thereafter [28]. Since the larger number of reserves resulting from cut-backs in indigenous forces could be mobilized in almost the same time as now, his results should stand for the overall ability to bring forces to bear in the event of mobilization.

[17] For a more complete discussion of the implications for security of reductions similar in magnitude, see reference [1c].

accept less than optimal solutions will allow attainment of even these measures. Whether or not this will happen is impossible to prophesy; if it should happen, all that can be said is that all the countries in Europe would have a greater degree of security than is now the case—and perhaps at less cost.

References

1. Coffey, J. I., *Arms Control and European Security: A Guide to East–West Negotiations* (Chatto & Windus, London, 1977).
   (a) —, pp. 40–44.
   (b) —, pp. 205–206.
   (c) —, pp. 168–72.
   (d) —, tables 6, 7, 8, pp. 256, 258, 260.
   (e) —, table 2, p. 248.
2. Klaiber, W. *et al.*, *Era of Negotiations: European Security and Force Reductions* (D. C. Heath & Co, Lexington, Massachusetts, 1973).
   (a) —, appendix C, p. 111.
   (b) —, appendix I, p. 133.
   (c) —, appendix B, paragraph 5, p. 108.
   (d) —, appendix B, paragraph 5, pp. 107–108.
   (e) —, appendix C, paragraph 4, p. 111.
   (f) —, appendix A, paragraph 3, p. 104.
3. Brezhnev, L. I., "Report of the Communist Party of the Soviet Union" [at the XXIVth Party Congress, 30 March 1971], *Current Digest of the Soviet Press*, No. 12, 20 April 1971, p. 13.
4. *New York Times*, 27 January 1972, p. 3.
5. Nunn, S. and Bartlett, D. F., "NATO and the New Soviet Threat", *The Atlantic Community Quarterly*, Vol. 15, No. 1, Spring 1977, p. 20.
6. *The Bulletin*, Press and Information Office of the Government of the Federal Republic of Germany, Vol. 25, No. 1, 5 January 1977, p. 3.
7. Digby, J. F., *Precision-Guided Weapons*, Adelphi Paper No. 118 (International Institute for Strategic Studies, London, Summer 1975), pp. 1–24.
8. Clark, D. L., "What's an MBFR?" *Air University Review*, Vol. 27, No. 5, July/August 1976, pp. 51–64, especially table on p. 57.
9. *World Armaments and Disarmament, SIPRI Yearbook 1976* (Almqvist & Wiksell, Stockholm, 1976, Stockholm International Peace Research Institute), pp. 128–33.
10. *World Armaments and Disarmament, SIPRI Yearbook 1977* (Almqvist & Wiksell, Stockholm, 1977, Stockholm International Peace Research Institute), pp. 222–25.
11. Schmuckle, G., "Possibility and Prospects of a Surprise Attack by Warsaw Pact Conventional Forces" (tape recording, NATO Information Service, July 1977).

12. Haig, A. M., Jr., "The Growth of Soviet Military Power" (tape recording, NATO Information Service, July 1977).

13. Luns, J. A. H., "Soviet Intentions" (tape recording, NATO Information Service, July 1977).

14. Callaghan, J., "The Alliance Between Détente and the Soviet Arms Buildup" (tape recording, NATO Information Service, July 1977).

15. "North Atlantic Council Final Communiqué", *NATO Review*, Vol. 25, No. 3, June 1977, paragraph 3, pp. 20–21.

16. *The Military Balance, 1977–1978* (International Institute for Strategic Studies, London, 1977).
    (a) —, table 2, p. 82.
    (b) —, p. 110.

17. Proektor, D., "Military Détente: A Soviet View", *Survival*, Vol. XVIII, No. 6, November/December 1976.
    (a) —, p. 265.
    (b) —, pp. 263–64.
    (c) —, p. 263.

18. Frelek, R., "Some Remarks on European Security and Co-operation", *Sprawy Miedzynarodowe* [International Affairs], special English-language edition dealing with problems of European security and cooperation, 1970, p. 7.

19. *Europe 1980: The Future of Intra-European Relations*, Reports Presented at the Conference of Directors and Representatives of European Institutes of International Relations, Varna, Bulgaria, 3–5 October 1972 (A. W. Sijthoff, Leiden, 1972), especially pp. 121–36.

20. Erickson, J., "MBFR: Force Levels and Security Requirements", *Strategic Review*, Vol. 1, No. 3, Summer 1973, pp. 29–31.

21. Kostko, Yu., "Mutual Force Reductions in Europe", *Survival*, Vol. XIV, No. 5, September/October 1972, pp. 236–38.

22. *Daily Telegraph*, 5 October 1976, p. 10.

23. *New York Times*, 16 September 1973, p. 4.

24. Khlestov, O., "Mutual Force Reductions in Europe", *Survival*, Vol. XVI, No. 6, November/December 1974, p. 294.

25. *Financial Times*, 27 February 1976, p. 6.

26. Williams, P., "Whatever Happened to the Mansfield Amendment?" *Survival*, Vol. XVIII, No. 4, July/August 1976, pp. 146–53, especially pp. 151–53.

27. Assembly of Western European Union, *Proceedings*, 22nd Ordinary Session, First Part, June 1976, Vol. II (WEU, Paris), p. 195.

28. Fischer, R. L., *Defending the Central Front: The Balance of Forces*, Adelphi Paper No. 126 (International Institute for Strategic Studies, London, Autumn 1976), p. 43, especially figure 4.

29. *The Military Balance, 1976–1977* (International Institute for Strategic Studies, London, 1976).
   (a) —, p. 12.
   (b) —, p. 6.
   (c) —, table, p. vii.
   (d) —, p. 99.
   (e) —, p. 101.
   (f) —, p. 102.

30. *New York Times*, 4 February 1977, p. 1.

Appendix 14A

Square-bracketed numbers, thus [1], *refer to the list of references on page 421.*

NATO and WTO proposals for mutual force reductions, 1973–77

NATO

22 November 1973 [1a, 2]

Type of force to be reduced	Conventional
Phases	Over several years (7 years)
Actual reductions	1. 15 per cent reduction each by USA and USSR 2. 15 per cent reduction by all direct participants
Other specific proposals	700 000 to be final ceiling for both NATO and WTO, representing 10 per cent cut by NATO and 20 per cent by WTO

16 December 1975 [6-7]

Type of forces to be reduced	Nuclear and conventional
Phases	Two: one consisting of specific reductions, and the other of general ceilings
Actual reductions	1. USA: 29 000 troops 1 000 tactical nuclear warheads 54 F-4 aircraft 36 Pershings 2. USSR: 68 000 troops 1 700 tanks
Other specific proposals	900 000 to be final ceiling for NATO and WTO ground and air forces in second phase; subceiling of 700 000 for ground forces; no subceilings for individual countries

WTO

8 November 1973 [1b, 3]

Type of force to be reduced	Nuclear and conventional (ground and air)
Phases	Over three years
Actual reductions	1. 1975: reduction of 20 000 armed forces each by NATO and WTO 2. 1976: 5 per cent reduction in armed forces and armaments by all direct participants 3. 1977: 10 per cent reduction in armed forces and armaments by all direct participants
Other specific proposals	Both foreign and indigenous forces reduced on each side

31 October 1974 [4-5]

Phases	USA and USSR to reduce first, followed by all direct participants
Actual reductions	1975: reduction of 20 000 troops by all direct participants

13 February 1975 [8-9]

Freeze on numbers of forces of direct participants throughout duration of negotiations

NATO		WTO	
28 October 1977[a]		**6 March 1975** [10]	
Type of forces to be reduced	Nuclear and conventional	Phases	1. 1975: first six months, USA and USSR; last six months, FR Germany and Poland; throughout year, UK, Benelux, Canada, German DR and Czechoslovakia 2. 1976: first six months, USA and USSR; last six months, other direct participants
Phases	Two: one consisting of specific reductions, one of general ceilings		
Actual reductions	USA: 29 000 troops 1 000 nuclear warheads USSR: 65 000–70 000 troops 1 500–1 700 tanks		
Other specific proposals	In second phase, forces of NATO and WTO placed under equal manpower ceilings	Actual reductions	1. 1975: 10 000 troops each reduced by USA and USSR; 5 000 troops each reduced by FR Germany and Poland; 5 000 troops reduced by UK, Benelux and Canada together; 5 000 troops reduced by German DR and Czechoslovakia together 2. 1976: 5 per cent each reduced by USA and USSR; 5 per cent each reduced by all direct participants 3. 1977: 10 per cent each reduced by all direct participants
		Other specific proposals	Both manpower and armaments to be reduced
		19 February 1976 [7, 12]	
		Phases	Two: USA and USSR to reduce first, followed by other direct participants
		Actual reductions	1. 2–3 per cent of both NATO and WTO troops reduced by USA and USSR

NATO	WTO	
		2. USA: 300 tanks 54 F-4 aircraft .. Pershings .. nuclear warheads 36 Nike Hercules and Hawks USSR: 300 tanks 54 Fitter aircraft .. Scud-5s .. nuclear warheads 36 SAM-2s 3. Equal percentage reduced by all direct participants in next phase
	Other specific proposals	1. Reductions carried out in complete units, together with corresponding weapons and equipment 2. Foreign troops withdrawn to be disbanded

[a] By late 1977 there had been no official confirmation that this proposal had been made to the WTO [11].

References

1. *World Armaments and Disarmament, SIPRI Yearbook 1974* (Almqvist & Wiksell, Stockholm, 1974, Stockholm International Peace Research Institute).
   (a) —, p. 30.
   (b) —, p. 29.
2. Middleton, D., "NATO Reported to Decide on Troop-cut Offer to Soviets", *New York Times*, 16 September 1973, p. 4.
3. Khlestov, O., "Mutual Force Reductions in Europe", *Survival*, Vol. XVI, No. 6, November/December 1974, p. 294.
4. Melnikov, L., "Vienna—A New Initiative", *Foreign Broadcasting Information Service*, USSR, 19 October 1974, Vol. iii, No. 224, p. BB-2.
5. *World Armaments and Disarmament, SIPRI Yearbook 1975* (Almqvist & Wiksell, Stockholm, 1975, Stockholm International Peace Research Institute), p. 608.
6. Lemaitre, P., "Les Propositions Mises au Point par l'OTAN sur la Réduction des Forces Accentuent les Reserves Françaises", *Le Monde*, 14 December 1975.

7. *World Armaments and Disarmament, SIPRI Yearbook 1977* (Almqvist & Wiksell, Stockholm, 1977, Stockholm International Peace Research Institute), p. 17.
8. Novikov, N., "A New Impetus", *Foreign Broadcasting Information Service*, USSR, 20 February 1975, Vol. iii, No. 35, p. BB-2.
9. *World Armaments and Disarmament, SIPRI Yearbook 1976* (Almqvist & Wiksell, Stockholm, 1976, Stockholm International Peace Research Institute), p. 478.
10. "An Initiative Which Demands An Answer", *Foreign Information Broadcasting Service*, USSR, 27 March 1975, Vol. iii, No. 56, p. BB-1.
11. Burt, R., "A New Western Plan Seeks to End Impasse in Troop-cut Parley", *New York Times*, 25 October 1977, p. 1.
12. Petrov, A., *Foreign Information Broadcasting Service*, USSR, 13 May 1976, Vol. iii, No. 94, pp. BB-1–BB-2.

Appendix 14B

NATO and WTO nuclear weapons and delivery vehicles deployed in Europe, 1977

Table 14B.1. Characteristics of NATO and WTO nuclear weapons and nuclear weapon delivery vehicles (NWDVs) deployed in Europe, 1977

Weapon category	Producing country	Type	Designation	Maximum range *km*	Warhead/bomb	Yield *kt*	Comments
Atomic Demolition Munition (ADM)	USA	Medium	SM 50	–	–	0.5–1	
		Phase 2	D-444	–	–	0.05–0.1	
Artillery	USA	155-mm SP how	M-109	15	W-74 and W-75	0.5–0.8	HE/N/C, soon ER of ~5–10 kt
		155-mm SP how	M-109 A1	18		0.8–2	
		203-mm SP how	M-110	17	..	1	–
		203-mm SP how	M-110 E-2	17	..		Replacing M-110 and several hundred M-107 guns (M-107 only HE)
		203-mm how tow	M-115	17	..	..	
	USSR	203-mm how tow	M-55	29	..	..	N capability uncertain
SSM	USA	Lance	MGM-52C	140	Warheads with three yields, for example:	1–50	HE/N
					M-234	0.85–2	
					ER	3	
		Pershing 1/2	MGM-31A	900	Warheads with three yields	60–400	HE/N
		Honest John	MGR-1B	50	Warheads with three yields	1–16, up to 100	HE/N
		Sergeant	MGM-29A	150	..	10–100	

Weapon category	Producing country	Type	Designation	Maximum range km	Warhead/bomb	Yield kt	Comments
	France	SSBS-S2	–	150	..	..	
		Pluton	–	~100	..	10–15	
	USSR	Scud A[a]	SS-1B	100	..	..	
		Scud B	SS-1C	300	..	..	HE/N
		FROG 3–7	–	90	..	..	
		Scaleboard	SS-12	900	..	..	
		Sandal	SS-4	2 400	..	(1 Mt)	
		Skean	SS-5	2 500	..	(1 Mt)	
		–	SS-20	4 500	..	(3 × .. kt)	MIRVed
SAM	USA	Nike Hercules	B-34	150	Warheads with three yields	2–5	Ceiling up to 45 km
Aircraft[c]	USA	–	F-111	5 000[b]	B-43	20	
		–	F-104	~2 500	B-53	300	
		–	F-4	~3 500	B-55	300	
		–	F-15	~4 500	B-61	100–300	
					ER	3	
					SR	20	
					IR	10	
	UK	–	Vulcan B2	7 000	..	..	
		–	Buccaneer S2	4 500	..	..	
		–	Jaguar	1 900	..	..	(Co-production with France)
	USSR	–	Il-28	3 500	..		
		–	Su-7 A/B	1 500	..		
		–	Su-17/20	~1 000	..		Sources indicate probable
		–	MiG-21 J/K/L	~1 000	..	..	yields of ~150 kt and
		–	MiG-23/27	1 200	..		1–20 Mt
		–	Tu-22	1 300	..		
		–	Tu-16	3 200	..		
	France	–	Mirage IVA	~3 000	..		Mirage III is also given by sources as having a nuclear capability

Key

..	Data not available	C	Chemical	IR	Induced radiation	SP	Self-propelled
–	Nil; not applicable	ER	Enhanced radiation	N	Nuclear	SSM	Surface-to-surface missile
( )	Number uncertain	HE	High explosive	SAM	Surface-to-air missile	tow	Towed
~	Approximately	how	Howitzer	SR	Suppressed radiation		

[a] All names and designations of Soviet weapon systems are those code-names used by NATO.

[b] The range for aircraft differs substantially according to load, speed and ceiling. The figures given are therefore approximations.

[c] All aircraft types are listed here, including all the relevant versions, whether or not the actual nuclear capability is confirmed (see note *f*, table 14B.2).

Sources: *The Military Balance 1977–78* (International Institute for Strategic Studies, London, 1977);
Record, J., *US Tactical Nuclear Weapons in Europe, Issues and Alternatives* (Brookings Institution, Washington, 1974);
Pretty, R. T. (Ed.), *Jane's Weapon Systems 1976* (Macdonald and Jane's, London, 1975);
Taylor, J. W. R. (Ed.), *Jane's All the World's Aircraft 1976–77* (Macdonald and Jane's, London, 1976);
Miettinen, J. K., "Mininukes and Neutron Bombs, Modernization of NATO's Tactical Nuclear Weapons, Introduction of Enhanced Radiation Warheads", *Instant Research on Peace and Violence*, Vol. VII, No. 2, 1977, pp. 49–58;
Military Record of CBR/Atomic Happenings, Report WS 98/78 (Aviation Studies Atlantic, London, January 1978), pp. 18–19;
Robinson, Jr., C. A., "Increasing Soviet Offensive Threat Spurs Stronger Europe Air Arm", *Aviation Week & Space Technology*, Vol. 107, No. 6, 1 August 1977, pp. 38–46;
Coffey, J. I., *Arms Control and European Security, A Guide to East–West Relations* (Chatto & Windus, London, 1977).

Table 14B.2. Numbers of NATO and WTO nuclear weapons and nuclear weapon delivery vehicles (NWDVs) deployed in Europe, 1977[a]

	NATO					WTO				
Weapon category	Deploying country/ region	Type	No. NWDVs	No. nuclear weapons	Comments	Deploying country/ region	Type	No. NWDVs	No. nuclear weapons	Comments
ADM†	USA	Various	–	~300		–	–	–	–	
Artillery	Belgium	155-mm how	41	–[b]		USSR	203-mm how	. .	. .	N capability doubtful
		203-mm how	11	–						
	FR Germany	155-mm how	80	–						
		203-mm how	80	–						
	Netherlands	155-mm how	. .	–						
		203-mm how	. .	–						
	Central Region, indigenous	–	~250	–						
	Canada	155-mm how	18	–						
	UK	. .	. .	. .						
	USA	155-mm how	300	~2 000						
		203-mm how	200	~1 000						
	Central Region, total		~800	~3 000						
	Denmark	155-mm how	72	–						
		203-mm how	12	–						
	Italy	155-mm how	. .	–						
	UK	155-mm how	50	. .						
		203-mm how	16	–						
	NATO (excl. USA)	–	~450	–						
	NATO, total	–	**~1 000**	**~ 3000**						
SSM[c]	Belgium	Lance	(12)	–	On order	Czechoslovakia	Scud A/B	27	–	
		Honest John	8	–			FROG 3/7	40	–	
	FR Germany	Lance	26	–	Altogether 175 ordered	German DR	Scud B	16	–	

		Sergeant	20	–			FROG 7	24	–	
		Honest John	70	–		Poland	Scud A/B	36	–	
		Pershing	72	–			FROG 3/7	46	–	
	Netherlands	Lance	. .	–	On order					
		Honest John	8	–						
	Central Region, indigenous	–	~220	–		*Central Region, indigenous*	–	~190	–	
	USA	Lance	~430	. .	Total number to reach 645	USSR	Scud A/B	(~60)	–	
							FROG 7	(~55)	–	
		Pershing	108	. .	216 in USA as reserve					
		Honest John	216	. .	Soon to be replaced by Lance					
	Central Region, total	–	~950	~1 000		*Central Region, total*	–	(~305)	–	
	Greece	Honest John	8	–		Bulgaria	Scud A/B	20	–	
							FROG 3/7	36	–	
	Italy	Lance	(8)	–		Hungary	Scud A/B	8	–	
	Turkey	Honest John	18	–			FROG 3/7	22	–	
	UK	Lance	. .	–	On order	Romania	Scud A/B	20	–	
							FROG 3/7	30	–	
						USSR	Scud A/B	(~55)	–	Based in western USSR; number for Scaleboard is hypothetical
							FROG 7	(~50)		
							Scaleboard	(~32)	–	
							SS-20	(~20)		
							SS-4[d]	(~500)		
							SS-5[d]	(~100)	–	
	NATO, excl. USA	–	~250	–		*WTO, excl. USSR*	–	~326	. .	
	NATO, total	–	~1 000	~1 000		**WTO, total**	–	(~1 000)	. .	
	France	SSBS-S2	18	. .						
		Pluton	24	. .						
SAM	Belgium	Nike Hercules	21	–						
	FR Germany	Nike Hercules	216	–						
	Netherlands	Nike Hercules	16	–						
	Central Region, indigenous	–	253	–						

Weapon category	NATO: Deploying country/ region	Type	No. NWDVs	No. nuclear weapons	Comments	WTO: Deploying country/ region	Type	No NWDVs	No nuclear weapons	Comments
	USA	Nike Hercules	144	–						
	Central Region, total	–	~400	~400						
	Denmark	Nike Hercules	36	–						
	Greece	Nike Hercules	6	–						
	Italy	Nike Hercules	(48)	–	(8 SAM groups)					
	Turkey	Nike Hercules	(48)	–	Some squadrons equipped with Nike Ajax					
	NATO, excl. USA	–	~400	–	–					
	NATO, total	–	~550	~550	–					
Aircraft[e]	Belgium	F-104[f]	72	–		Czechoslovakia	Su-7[f]	80	–	
	FR Germany	F-104	240	–	Including 96 land-based naval aircraft		MiG-21	292	–	
						German DR	Su-7	30	–	
		F-4	120	–			MiG-21	116	–	
	Netherlands	F-104	72	–						
						Poland	Il-28	16	–	
							Su-7	30	–	
							Su-20	28	–	
							MiG-21	340	–	
	Central Region, indigenous	–	504	–		*Central Region, indigenous*	–	934	–	
	Canada	F-104	48	–		USSR	..	..	..	
	UK	Buccaneer	28	–						
		Jaguar	60	–						
	USA	..	(~250)	–	17th Air Force in FR Germany and Netherlands					
	Central Region, total	–	(~900)	–		*Central Region, total*	–	..	..	

Denmark	F-104	40	–		Bulgaria	MiG-27	..	–	
Greece	F-4	37	–			MiG-21	48	–	
	F-104	15	–		Hungary	Su-7	30	–	
Italy	F-104	144	–			MiG-21	116	–	
Norway	F-104	38	–		Romania	MiG-21	210	–	
Turkey	F-104	74	–		USSR	Il-28 Su-7 Su-17/20 MiG-21 MiG-27 Tu-22	~1 000	..	
	F-4	70	–						
UK	Buccaneer	42	–	Including 14 land-based naval aircraft					
	Vulcan	50	–						
	Jaguar	12	–						
USA	F-111 F-4 F-15	156 400 72	2 500	All in service in Europe, including Central Region					
NATO, excl. USA	–	1 122	–		*WTO, excl. USSR*	–	~1 350		
NATO, total	–	**1 750**	**~2 500**		**WTO, total**	–	**~2 350**	–	
Total NATO nuclear warheads	–	–	**~7 350**	~5 000 in Central Region	**Total WTO nuclear warheads**	–	..	..	Figure of 3 500 is given as a hypothetical figure for Soviet stockpile in Europe, based on known number of NWDVs

† Atomic Demolition Munition (ADM)

[a] All numbers differ substantially from source to source and should therefore be taken only as rough estimations.

[b] A portion of the nuclear warheads possessed by NATO countries are under a dual-key system of control, that is, they are controlled both by the country where they are based and by US forces.

[c] Figures for SSMs cover both the short-range ballistic missiles (SRBMs) and the medium-range ones (MRBMs) for the WTO in Europe.

[d] It is known that a substantial number of these are based in far-eastern USSR.

[e] Figures for aircraft do not include naval aircraft based on aircraft carriers, nor do they include reconnaissance aircraft.

[f] Only the general designation of the aircraft is given. The figures, however, apply to several different models of varying capabilities; some models may perhaps not represent a nuclear capability and some others, with a probable but not certain nuclear capability, may not be listed.

Sources: See sources to table 14B.1.

15. The strategic arms limitation talks

Square-bracketed numbers, thus [1], *refer to the list of references on page 454.*

I. A SALT II agreement

On 3 October 1977, the five-year US–Soviet interim agreement limiting strategic offensive weapons, a component of the SALT I agreement, expired. Under this agreement the USA is limited, for example, to 1 000 intercontinental ballistic missiles (ICBMs) and 710 submarine-launched ballistic missiles (SLBMs), and the USSR to 1 408 ICBMs and 950 SLBMs (see table 15.1). It has been expected that a new agreement (SALT II) would be negotiated on the basis of the so-called Vladivostok accords, signed by President Nixon and General Secretary Brezhnev in December 1974, but such an agreement has yet to be achieved. Shortly after the interim agreement expired, however, the USA and the USSR made statements to the effect that they would, in the meantime, keep to the terms of the SALT I agreement.

A new treaty based on the Vladivostok accords would limit both the USA and the USSR to the deployment of 2 400 bombers, ICBMs and SLBMs. Of this total, no more than 1 320 ICBMs and SLBMs would be permitted to carry multiple independently targetable re-entry vehicles (MIRVs) (see table 15.2). According to the Soviet interpretation, the Vladivostok accords cover all strategic missiles, but the US interpretation is that only ballistic strategic missiles are included. Because the USA wants to deploy long-range cruise missiles, which are not ballistic, this dispute has become a major obstacle to a SALT II agreement.

A lesser problem has been whether or not to classify the Soviet Tupolev Backfire bomber—a supersonic swing-wing aircraft with a 2 500-nautical mile unrefuelled operational radius—as a strategic bomber. A third issue has been the verification of the number of deployed ICBMs equipped with MIRVs. Such verification, without on-site inspection, seems to be virtually impossible and therefore, if MIRVs are to be restricted, it is likely that any deployed ICBM of a type which has been tested with MIRVs will have to be assumed to be carrying them.

On 18 and 20 March 1977, US Secretary of State Cyrus Vance discussed with President Leonid Brezhnev a set of proposals, different from those in the Vladivostok accords, on which the new Carter Administration wished to base a SALT II treaty. Reportedly, the main proposal was that the total number of strategic bombers, ICBMs and SLBMs should be limited to between 1 800 and 2 000, rather than the Vladivostok limit of

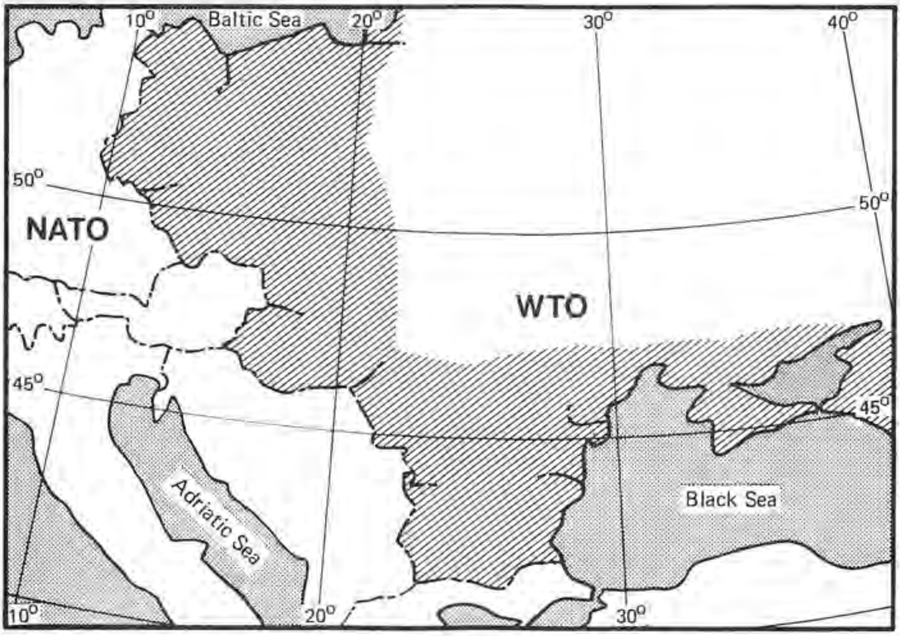
Table 15.1. SALT I ceilings on US and Soviet offensive strategic weapons

Weapon system	USA	USSR
ICBM launchers	1 000–1 054, depending on whether old ICBMs are replaced by SLBMs	1 408–1 618, depending on whether old ICBMs are replaced by SLBMs; a sub-limit of 308 was placed on modern "heavy ICBMs"
SLBM launchers	710, provided that 54 Titan II ICBMs are withdrawn	950, provided that 210 SS-7 and SS-8 ICBMs are withdrawn
Ballistic missile submarines	44, provided that 54 Titan II ICBMs are withdrawn	62, provided that 210 SS-7 and SS-8 ICBMs are withdrawn

Table 15.2. US and Soviet strategic delivery systems

	Mid-1977		Vladivostok limits	Carter March 1977 proposal		Tentative SALT II agreement, as of November 1977	
Weapon system	USA	USSR		USA	USSR	USA	USSR
Heavy ICBMs	54	288	308	54	150	308	308
Other ICBMs	1 000	1 189					
SLBMs	656	849					
Strategic bombers	301	(140)					
Total strategic nuclear delivery systems	*2 011*	*2 466*	*2 400*	*1 800–2 000*	*1 800–2 000*	*2 160–2 250*	*2 160–2 250*
MIRVed ICBMs	550	230		550	550	800–850	800–850
MIRVed SLBMs	496	0					
Total MIRVed missiles	*1 046*	*230*	*1 320*	*1 100–1 200*	*1 100–1 200*	*1 200–1 250*	*1 200–1 250*
MIRVed ICBMs+SLBMs+ strategic bombers with ALCMs						1 320	1 320

Figure 15.1. Diagrammatic coverage of land-based NATO cruise Nissles into WTO territory, with range 600 km

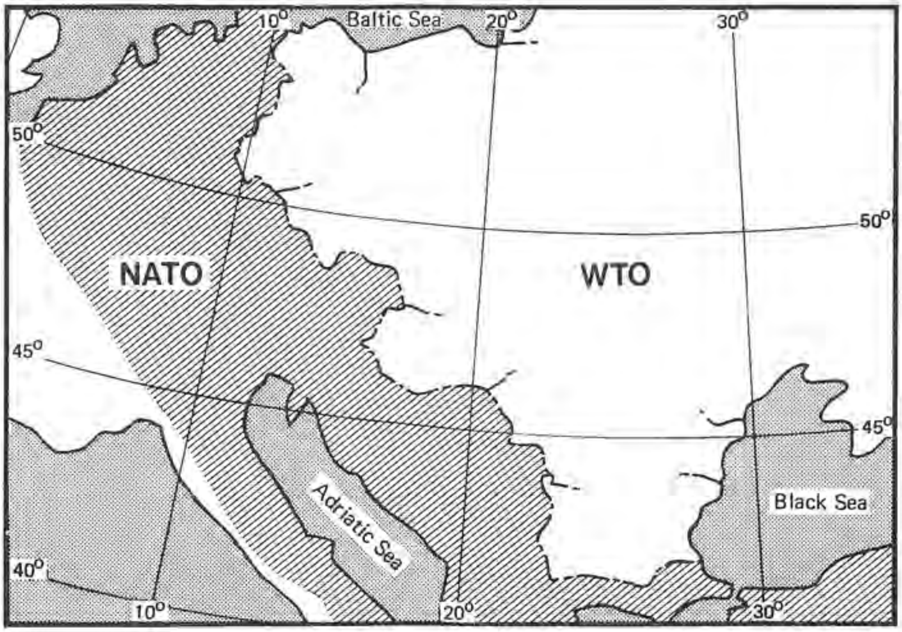


2 400 [1–2]. The total number of MIRVed ICBMs and SLBMs should be between 1 100 and 1 200 instead of 1 320. And the number of MIRVed ICBMs should be limited to 550. The number of so-called "heavy ICBMs" deployed should not exceed 54 Titan IIs for the USA and 150 SS-9s and/or SS-18s for the USSR.

It seems that it was also proposed that no cruise missiles with ranges over 2 500 km should be deployed and that cruise missiles launched from aircraft other than strategic bombers should have ranges limited to 600 km. The Backfire bomber seemingly was to be excluded from an agreement, subject to certain unspecified conditions. The modification of existing ICBMs and the deployment of new types, including mobile ICBMs, was apparently not to be allowed. The number of flight tests of existing ICBMs and SLBMs was to be limited to six per year.

The USSR rejected these US proposals, although it is not publicly known precisely why. Reportedly, the Soviet counter-proposal was to negotiate a SALT II treaty according to the Vladivostok accord, including cruise missiles. There were speculations on the effect of the human rights issue on the Soviet attitude, but there is little doubt that the US proposals were far-reaching enough to take the USSR by surprise. Moreover, they were probably seen as unacceptably favourable to the USA and unfavour-

Figure 15.2. Diagrammatic coverage of land-based WTO cruise missiles into NATO territory, with range 600 km



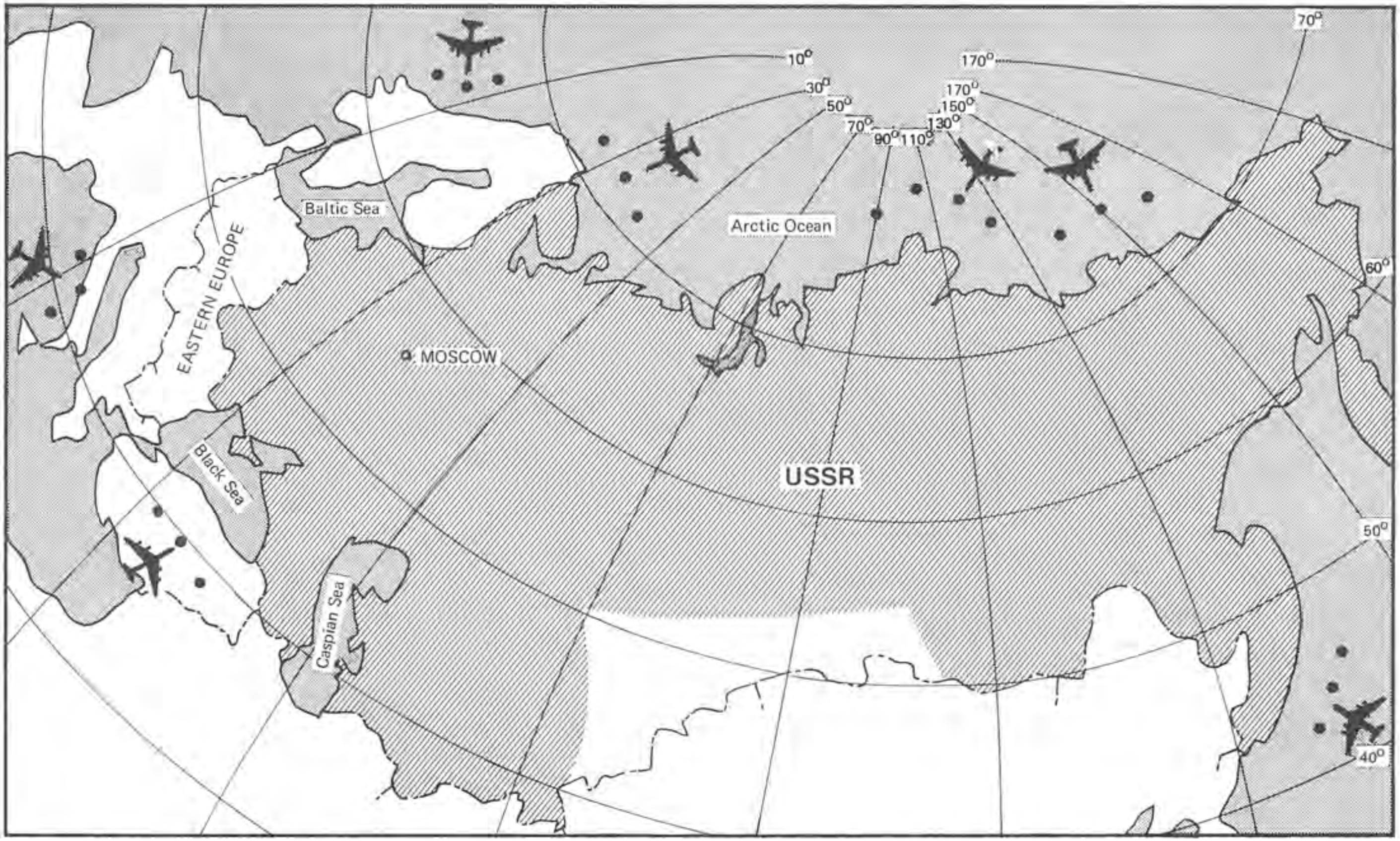
able to the USSR. In fact, there may have been considerable Soviet doubts as to the intentions of the new Carter Administration as regards foreign policy issues in general, and arms control in particular.

One probable specific objection to the Carter proposals was the low numerical limit set on Soviet heavy ICBMs. The USA is concerned that MIRVed warheads delivered by heavy ICBMs will eventually threaten the US ICBM forces. Another probable Soviet objection was the limit on the number of ballistic missile tests, which would have seriously restricted Soviet improvements in missile accuracy—an area in which the USSR is significantly behind the USA. The Soviet Union also probably wanted more restrictions than the Carter proposals offered on cruise missile deployment, because it lags behind the USA also in the development of the latest-generation cruise missile technology.

Renewed negotiations after the failure of the US initiative in March seem to have led to a tentative SALT II agreement, at least in outline (although it seems that many details have yet to be worked out). In fact, after President Carter had held meetings with Soviet Minister for Foreign Affairs Gromyko in September 1977, he implied that a new SALT treaty was in the offing.

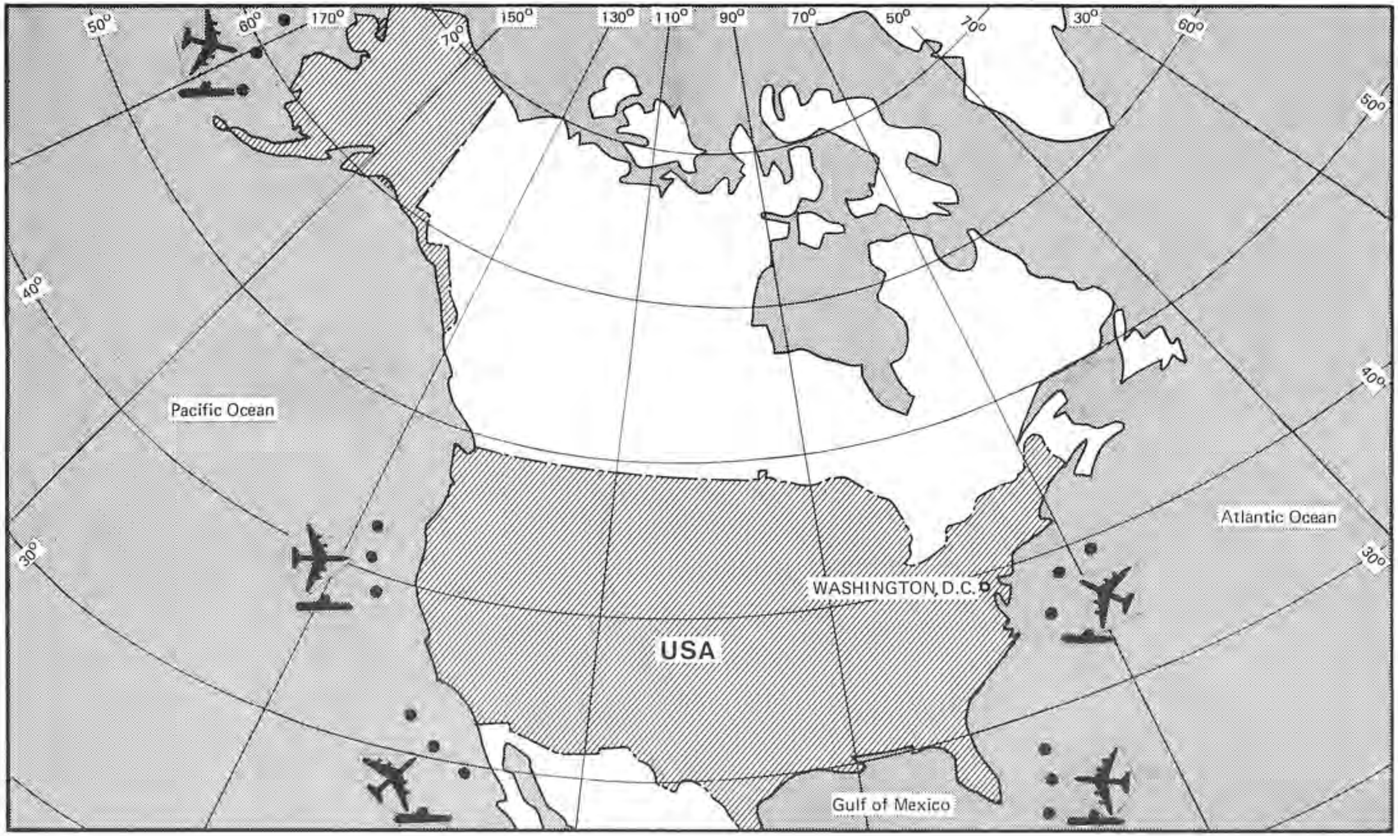
Apart from a basic treaty limiting the number of US and Soviet strategic

Figure 15.3. Coverage of Soviet targets by cruise missiles carried in aircraft which stay 300 km outside WTO territory, for a range of 2 500 km



2F2

Figure 15.4. Coverage of US targets by cruise missiles carried in aircraft which stay 300 km outside US territory, for a range of 2 500 km



nuclear weapons until 1985, the present intention is that there should be a three-year protocol dealing with certain contentious weapons[1] and a "statement of principles" governing further SALT negotiations (essentially an agenda for SALT III).

It is currently (in December 1977) predicted [4] that the new SALT II treaty will limit the total number of strategic bombers, ICBMs and SLBMs of each of the USA and the USSR to between 2 160 and 2 250. Within this total, there may be a limit of 1 320 on the total numbers of ballistic missiles equipped with MIRVs and bombers armed with cruise missiles. The new agreement may limit the number of MIRVed land-based ICBMs and SLBMs to between 1 200 and 1 250. A further limit of between 800 and 850 may be placed on land-based ICBMs. It seems that the USSR may be allowed 308 heavy ICBMs of the SS-18 type.

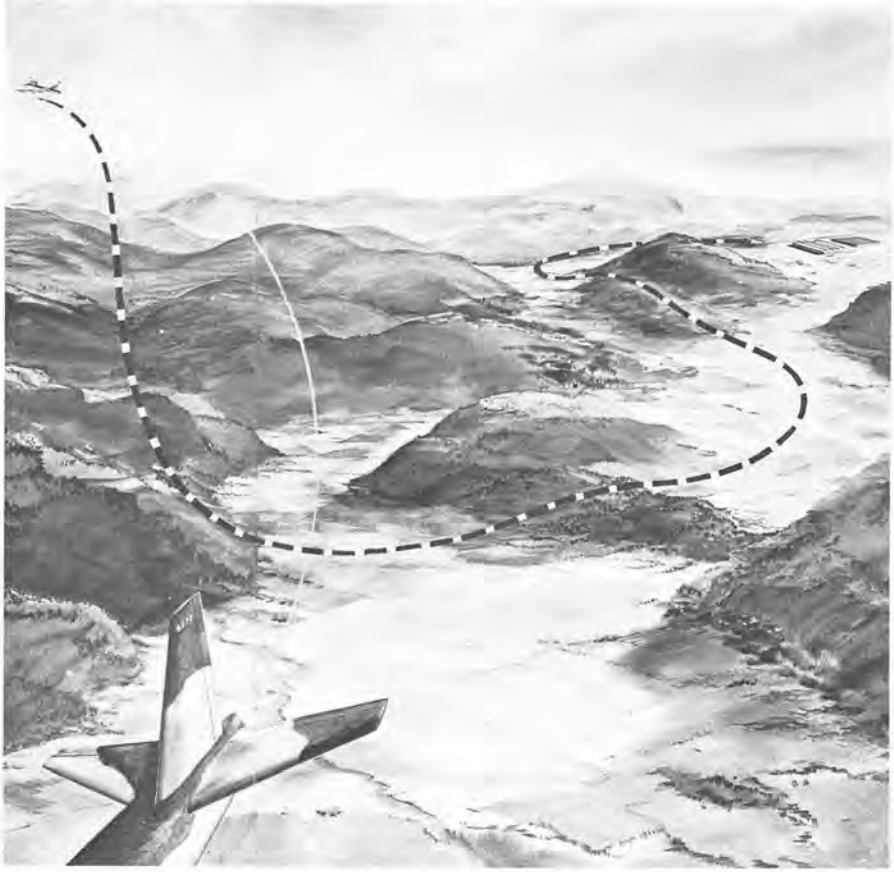
The three-year protocol may limit the range of air-launched cruise missiles (ALCMs) to 2 500 km and of ground- and sea-launched cruise missiles to 600 km. Apart from the SLBMs already tested, the deployment of new strategic weapons may be banned for the three-year period. The Soviet Backfire bomber will probably not be counted as a strategic bomber within the limit of total strategic delivery vehicles but the USSR may be prohibited from deploying the Backfire as a strategic bomber against the USA. Also, the rate at which the aircraft may be produced in future will probably be stipulated.

The cruise missile ranges presumably refer to operational ranges, that is, the great-circle distances between launch points and targets. Because a cruise missile may make many deviations in its course—to avoid obstacles and defended areas, for example—the actual distance flown may be much greater than the operational range. Verification of a cruise missile range limitation would be exceedingly difficult to achieve by "national technical means", as far as deployed missiles are concerned. About all that could be observed from satellites would be the ranges over which missiles are tested.

The USA admits to having 1 710 ballistic missiles (1 054 ICBMs and 656 SLBMs) of which 1 046 (550 ICBMs and 496 SLBMs) are MIRVed. About 300 B-52s are assigned strategic roles (although 478 B-52s exist) (see table 15.3). The USSR is thought to have 2 326 ballistic missiles (1 477 ICBMs and 849 SLBMs) of which up to 230 ICBMs are MIRVed (see table 15.4). Perhaps 140 Soviet long-range bombers are assigned

[1] In a speech before the Women's National Democratic Club in Washington, D.C. on 10 November 1977, Paul C. Warnke, Director of the Arms Control and Disarmament Agency, explained that the three-year protocol "would handle on a temporary basis some of the weapons systems which are being considered and as to which our thinking has not progressed to the point at which we know where our best interests would lie in a long-range solution. The protocol would leave us in a position to continue with all of the developments that we feel are essential to protect our security in the event that arms control turns out to be a failure" [3].

Figure 15.5. Flight path of a cruise missile[a]



[a] Many deviations from a straight flight path may be made, to avoid defences and so on, so that the operational range may be considerably longer than the shortest path between launch-point and target.

strategic roles. The USSR appears to be scrapping about 100 old ICBMs (SS-7s and SS-8s).

Although the USA is developing the MX ICBM, it has not officially announced plans to increase the number of its MIRVed ICBMs above the current level of 550. The first Trident strategic nuclear submarine is scheduled to be operational in 1981. Others may become operational at a rate of four every three years.

The deployment of air-launched cruise missiles is planned to begin in 1980, perhaps at the rate of about 35 per month. Therefore, 130 B-52Gs could be armed with 20 missiles each by 1985.

The USSR has deployed MIRVs over the past five years at an average rate of about 60 per year, although in a peak year double this number were deployed. The USSR may, therefore, find it difficult to increase its MIRVed ICBM force from 230 to 800 by 1985.

Table 15.3. The current US strategic delivery vehicle capability

Vehicle	Number of vehicles deployed	Number of warheads per delivery vehicle	Total delivery capability *No. warheads*	Total yield per delivery vehicle *Mt*	Total delivery capability *Mt*
MIRVed vehicles					
Minuteman III	550	3	1 650	0.51	280
Poseidon C-4	496	10 (average)	4 960	0.4	198
Sub-total	1 046		6 610		478
Non-MIRVed vehicles					
B-52	300	11[a]	4 300[b]	12[a]	3 800[b]
Titan	54	1	54	7.5	405
Minuteman II	450	1	450	1.5	675
Polaris C-3	160	3	480	0.6	96
Sub-total	964		5 284		4 976
Total	**2 010**		**11 894**		**5 454**

[a] Excluding SRAM.
[b] Including SRAM.

Table 15.4. The current Soviet strategic missile delivery capability

Vehicle	Number of vehicles deployed	Number of warheads per delivery vehicle	Total delivery capability *No. warheads*	Total yield per delivery vehicle *Mt*	Total delivery capability *Mt*
MIRVed vehicles					
SS-17	40	4	160	4	160
SS-18	50	8	400	10	500
SS-19	140	6	840	6	840
Sub-total	230		1 400		1 500
Non-MIRVed vehicles					
SS-7	109	1	109	5	545
SS-8		1		5	
SS-9	238	1 and 3	476[a]	20	4 760
SS-11	840	1 and 3	960	1 or 0.6	816
SS-13	60	1	60	1	60
SS-N-5	21	1	21	1	21
SS-N-6	544	1 and 3	1 088[a]	1 or 0.6	435[a]
SS-N-8	284	1	284	1	284
Sub-total	2 096		2 998		6 921
Total	**2 326**		**4 398**		**8 421**

[a] Estimates.

Figure 15.6. The current US strategic missile delivery capability

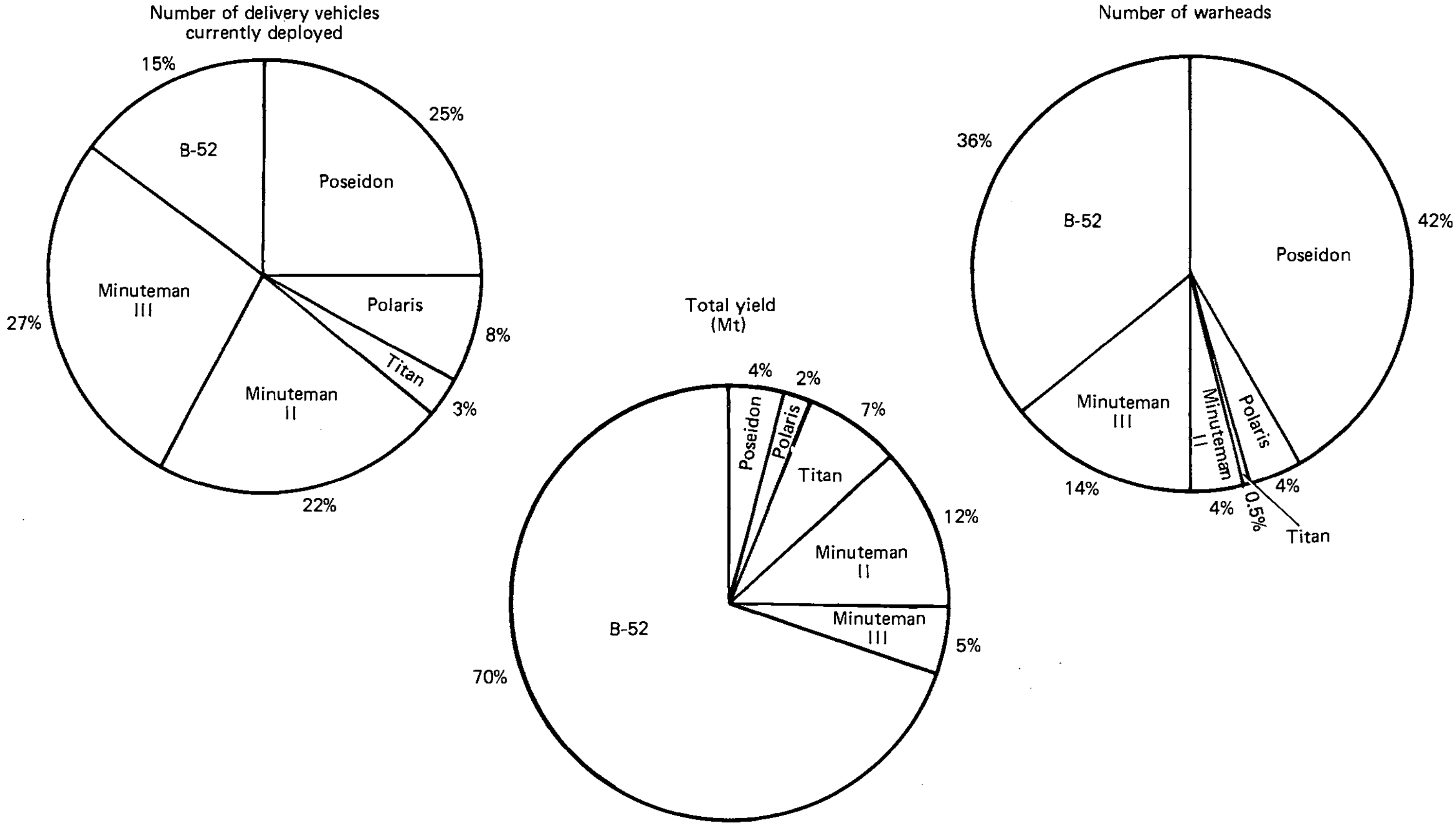


Figure 15.7. The current Soviet strategic missile delivery capability

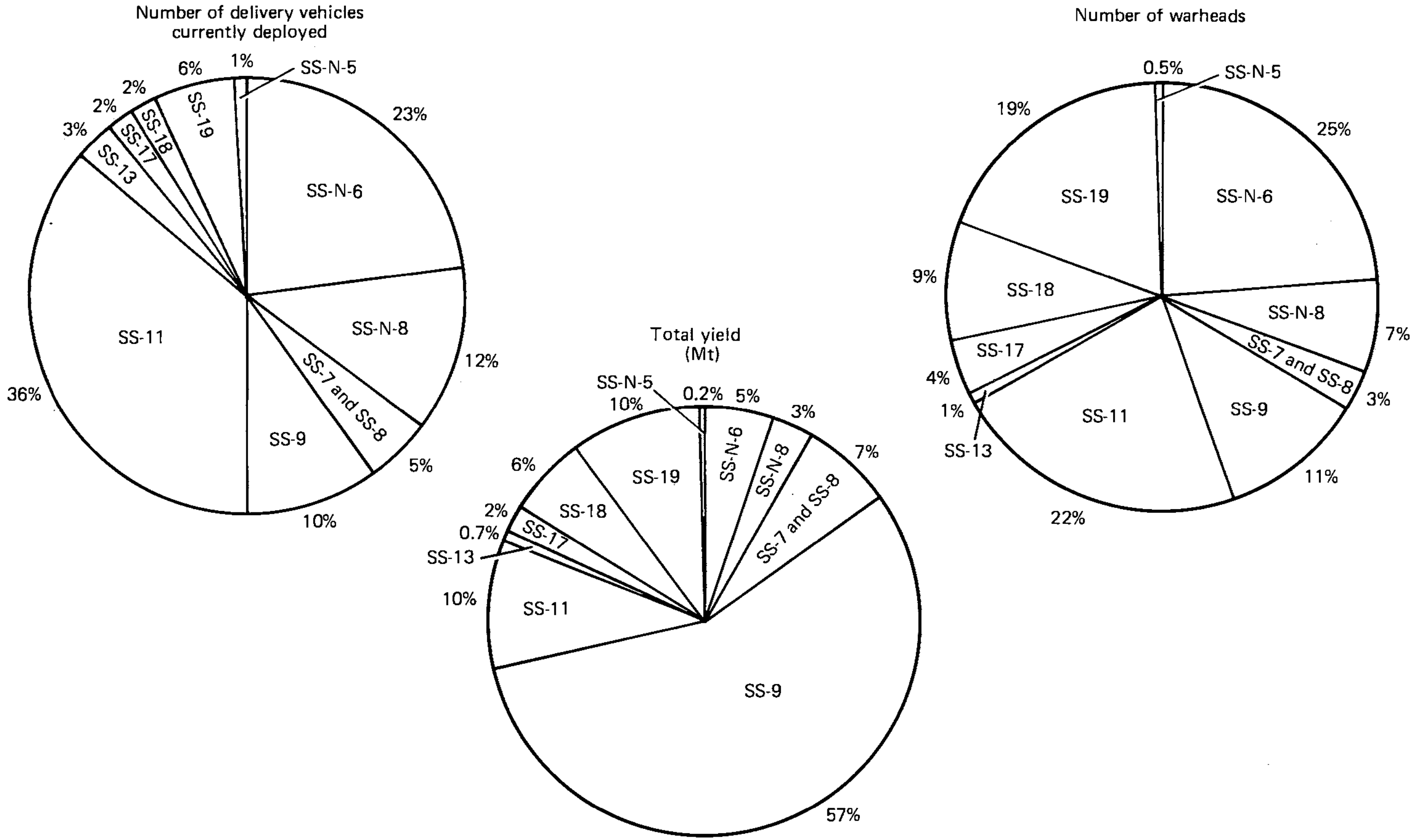
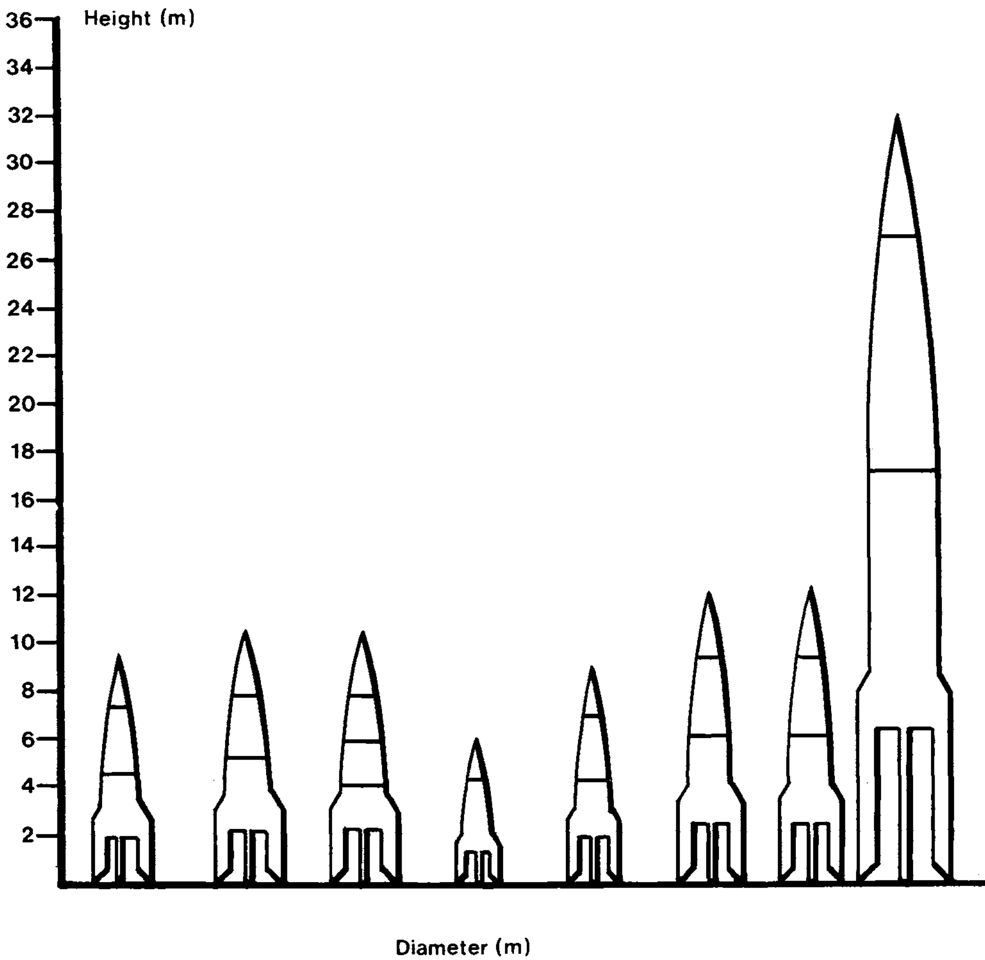


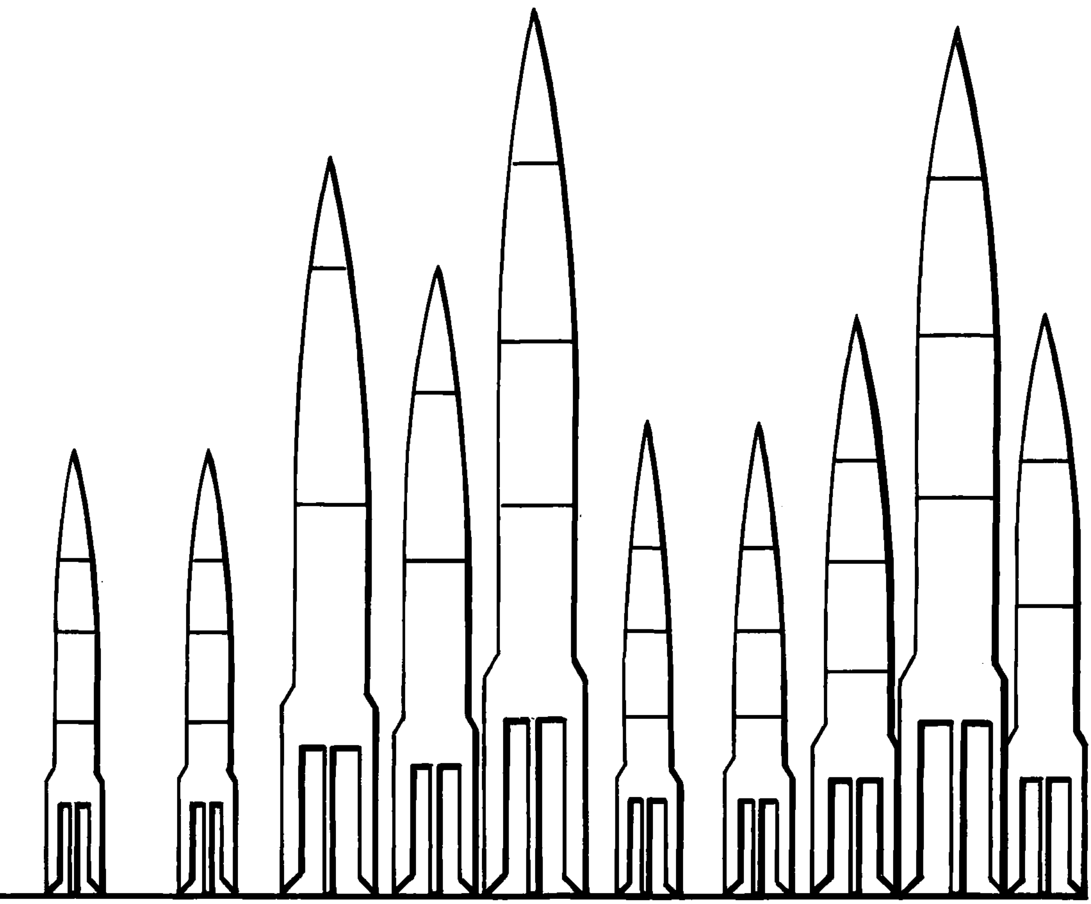
Figure 15.8. US and Soviet strategic ballistic missiles

	US SLBMs			Soviet SLBMs				US ICBMs
	Polaris A-3	Poseidon C-3	Trident D-5	SS-N-5	SS-N-6	SS-N-8	SS-N-18	Titan II
Date introduced	1964	1970	–	1963	1968	1973	–	1962
Number deployed	160	496	0	24	554	296	0	54
Number of MIRVs	3 (MRV)	10–14	10–14	1	1 (or 3 MRV)	1	2 or 3	1
Range (*km*)	2 500	2 500	4 000	700	1 300–1 600	4 200	4 200	6 300
Propellant	s	s	s	l-st	l-st	l-st	l-st	l
Throw-weight (*kg*)	500	1 000		. .	700	700		4 000
CEP (*m*)	900	550		3 700	1 800–2 800	1 500		900

Key: Propellant fuel: l = liquid, l-st = liquid-storable, s = solid, st = storable.



		Soviet ICBMs							
Minuteman II	Minuteman III	SS-7	SS-8	SS-9	SS-11	SS-13	SS-17	SSK18	SS-19
1966	1970	1962	1963	1965	1966	1968	1977	1976	1976
450	550	Being phased out	Being phased out	263	850	60	40	50	140
1	3	1	1	1	1 (or 3 MRV)	1	1–6	1–8	1–6
6 900	7 000	6 000	6 000	6 500	5 600	4 300	5 000	5 500	5 000
s	s	st	st	l	st	s	l-st	l-st	l-st
1 000	1 000	2 000	2 000	7 300	1 000	500	3 200	7 300	3 200
550	350	2 800	2 800	900–1 300	900–1 300	1 300	600	450–600	450



Diameter (m)

Table 15.5. Probable US strategic delivery vehicle capability in 1985, with or without SALT II

Vehicle	Number of vehicles deployed	Number of warheads per delivery vehicle	Total delivery capability *No. warheads*	Total yield per delivery vehicle *Mt*	Total delivery capability *Mt*
MIRVed vehicles					
Minuteman III	550	3	1 650	0.51	280
Poseidon C-4	496	10[a]	4 960	0.4	198
Trident D-5	144	10[a]	1 440	0.4	58
B-52G with ALCM	130	20	2 600	4	520
Sub-total	1 320		10 650		1 056
Non-MIRVed vehicles					
B-52 (penetrating)	170	11[b]	2 870[c]	12[b]	2 240
Titan	54	1	54	7.5	405
Minuteman II	450	1	450	1.5	675
Polaris	160	3	480	0.6	96
Sub-total	834		3 854		3 416
Total	**2 154**		**14 504**		**4 472**

[a] Average.
[b] Excluding SRAM.
[c] Including SRAM.

According to current deployment plans, the USA, for example, will in 1985 probably have 550 MIRVed ICBMs, 496 MIRVed SLBMs on 31 Poseidon nuclear submarines, 144 MIRVed SLBMs on six Trident submarines, and 130 B-52G bombers each equipped with 20 cruise missiles. (The present plan is eventually to arm all 173 B-52Gs with cruise missiles.) These strategic delivery systems could deliver about 10 600 nuclear warheads—2 600 by cruise missiles, about 1 600 by land-based ICBMs and about 6 400 by SLBMs. Single-warheaded ICBMs, the remaining SLBMs and the other strategic bombers could deliver an additional 4 000 warheads (see table 15.5).

US ICBMs, SLBMs and strategic bombers deployed in mid-1977 could deliver about 12 000 nuclear warheads (see table 15.3, above). The total of 14 600 US strategic nuclear warheads which may be deployed in the mid-1980s therefore still represents an increase in the size of the US nuclear arsenal.

A SALT II treaty similar to the one which the USA and the USSR are now reported to be considering would not significantly affect quantitative increases in the US nuclear arsenal as it is currently planned. Similarly, the size of the Soviet nuclear arsenal is likely to increase considerably.

Qualitative improvements in nuclear warheads are likely to be more destabilizing than quantitative increases in nuclear arsenals. The latter have for a long time been so huge as to make further increases meaningless, at least from the military and strategic points of view. The major test of SALT will, therefore, be its effect on qualitative aspects of the nuclear arms race. Specifically, it is to be hoped that the deployment of mobile ICBMs will be prevented.

II. Cruise missiles[2]

As described above, one major obstacle to the negotiation of a new SALT agreement has been the development of a new generation of cruise missiles. These missiles are small, pilotless aircraft powered by air-breathing jet engines. In contrast, ballistic missiles are powered by rocket engines.

Cruise missiles are old weapons, dating back to the German V-1 or "buzz-bomb" of World War II. Soon after the war, the USA and the USSR began developing these missiles. A variety of types were produced (surface-to-surface, surface-to-air and air-to-surface) for both short-range (tactical) and long-range (strategic) applications (see table 15.6).

In the early 1960s, US long-range surface-to-surface cruise missiles were replaced by ballistic missiles. However, other cruise missiles—for

[2] Cruise missile technology was described in detail by SIPRI in reference [5].

Figure 15.9. Air-launched cruise missile after release from its carrier aircraft

example, the 1 000-km range nuclear-armed Hound Dog air-to-surface missile, first deployed on B-52s in 1960—have remained in use.

In 1962, the USSR deployed the SS-N-3 Shaddock—a 450-km range cruise missile carrying a nuclear warhead—and some short-range types (mainly naval air-to-surface missiles). Current Soviet cruise missiles include the 60-km range SS-N-7, the 750-km range SS-N-12 surface-to-surface naval missile, and the 550-km range AS-6 air-to-surface missile.

In 1972, the US interest in cruise missiles revived, according to some as a "bargaining chip" for SALT. A number of technological advances favoured cruise missile development. The most important by far was the combination of the miniaturization of computers in terms of volume and weight for a given power output (that is, advances in large-scale integrated circuitry) with an accurate data base about the co-ordinates of potential targets. Very small but accurate missile guidance systems could thus be developed. For example, the McDonnell Douglas Terrain Contour Matching (TERCOM) system, which weighs only 37 kg, can guide a cruise missile to its target with a CEP of a few tens of metres.[3] TERCOM uses

[3] The Circular Error Probability (CEP) is the radius of the circle, centred on the target, within which 50 per cent of the warheads aimed at the target will fall.

an on-board computer to compare the terrain below the missile (scanned with a radar altimeter) with a pre-programmed flight path. From very accurate maps which have become available using satellite mapping techniques, the positions of targets and the contours of flight paths can be obtained with unprecedented accuracy. Targets could not be located accurately enough from earlier maps to make effective use of the new cruise missile guidance systems. Very small jet engines were also available. For example, the Williams Research Corporation produces a turbo-fan engine (the F107-WR-100), about 80 cm long, 31 cm wide, weighing only about 60 kg, and generating a thrust of about 275 kg.

Using these new technologies, cruise missiles are being developed in the USA to be launched from air, sea and ground platforms. Perhaps the most important characteristic of these cruise missiles is that the ratio of the payload carried to the physical weight of the missiles is relatively very high (typically about 15 per cent compared with a fraction of 1 per cent for a typical ballistic missile).

The Boeing ALCM

The AGM-86A, an air-launched cruise missile (ALCM) developed by Boeing, is derived from the Subsonic Cruise Armed Decoy (SCAD), a missile which was cancelled in 1974. SCAD was meant to replace the Hound Dog missile on strategic bombers.

The AGM-86A ALCM is 4.3 metres long, 1.16 metres high, and has a wing-span of 2.9 metres, a wing area of about 1 square metre, and a total launch weight of 864 kg. The AGM-86A was designed to be carried by B-1 and B-52 bombers. The plan was that each B-1 should carry up to 24 ALCMs and each B-52, 20 missiles—12 on wing-mounted pylons and 8 internally.

Before the missile is loaded into the aircraft which carries it, the wings are folded into the missile's fuselage, which has a width of about 0.6 metre. The tail and engine inlet also retract for carriage by the parent aircraft. After the missile is ejected from the aircraft, the engine inlet pops up, the elevons[4] are deployed and then the tail snaps into a vertical position. The turbo-fan engine is ignited and the wings are unfolded. Elevons, tail fins and inlet surface are activated by explosive charges. Power for the elevons is provided in flight by electric motors which are part of the flight control system. The deployment procedures take about two seconds after launch and thrust is applied in about 10 seconds. The ALCM is propelled by the Williams Research turbo-fan engine at a subsonic speed. The maximum speed probably exceeds Mach 0.8 (about 930 km per hour), with a cruising speed of Mach 0.5–0.6.

[4] The elevon is the movable part of the trailing edge of the wing.

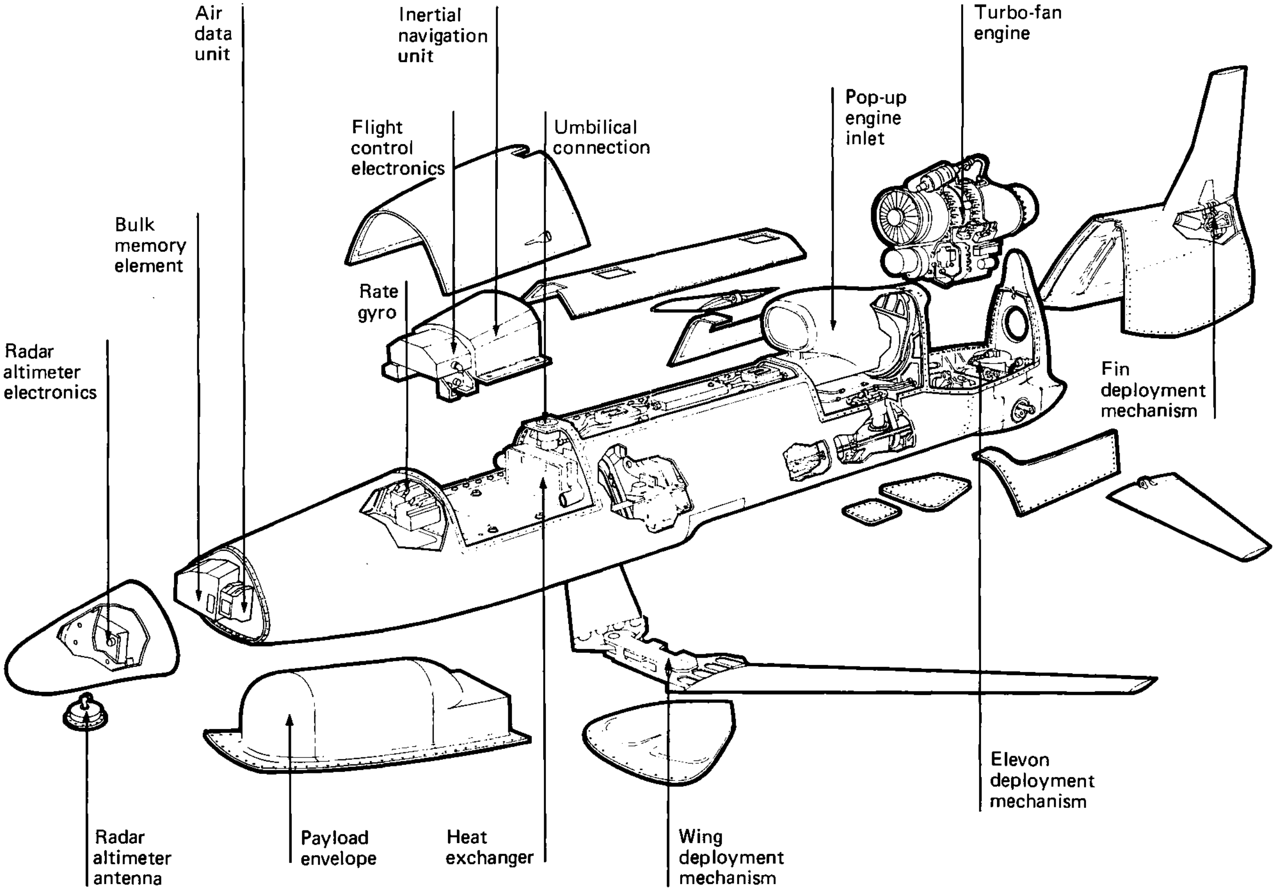
Table 15.6. Some US and Soviet cruise missiles

Country	Name	Type	Propulsion	Launch weight *kg*	Max range *km*	Warhead	Comment
USA	Matador	SSM	SPB/TJ	5 680	800	N/HE	Operational 1954
	Regulus I	SSM	SPB/TJ	6 587	925	N	Operational 1954; submarine- or ship-launched
	Regulus II	SSM	SPB/TJ	~13 600	~1 500	N	Cancelled 1958
	Navaho	SSM	LPB/RJ	..	8 000	N	Cancelled 1958
	Bull Goose	ASM	SPB/TJ	..	..	None	Cancelled 1958; decoy missile
	Crossbow	ASM	TJ	..	..	..	Cancelled 1958; radar-homing bomber defence missile
	Snark	SSM	SPB/TJ	~22 700	~10 140	N	Initially operational 1958, withdrawn 1961
	Mace	SSM	SPB/TJ	7 054	1 045	N/HE	Operational 1960
	Hound Dog	ASM	TJ	~4 500	~1 100	N	Operational 1960
	Bomarc	SAM	LPB/RJ	6 820	~460	N/HE	Operational 1960
	Quail	ASM	TJ	~500	..	None	Operational 1961; decoy missile
	SCAD	ASM	TF or TJ	..	~1 000	N	Cancelled 1973
	Harpoon	SSM/ASM	SPB/TJ	635	~100	~230 kg of HE	Operational 1976 ship-, submarine- or air-launched anti-ship
	SLCM (Tomahawk)	SSM	–/TF	1 360	3 700	N	Flight tested 1976; land-based and tactical anti-ship variant proposed (TJ); air-launched
	TALCM	ASM	TF	..	2 500	N	Under development; in fly-off competition with AGM-86B in late 1979
	AGM-86A	ASM	TF	860	1 250	N	Flight tested 1976
	ALCM-B	ASM	TF	1 200	2 500	N	Under development in fly-off competition with TALCM in late 1979
USSR	Kennel	ASM	TJ	..	100	HE	Operational 1956
	Scrubber	SSM	SPB/RJ	~6 500	240	HE	Operational 1958
	Kipper	ASM	TJ	~3 500	200	..	Operational 1960
	Kangaroo	ASM	TJ	~8 000	600	..	Operational 1961
	Shaddock	SSM	SPB/TJ	~4 500	~400	..	Operational 1962
	Genef	SAM	SPB/RJ	~1 000	~70	..	Operational 1964
	SS-N-7	SSM	..	..	~60	..	Operational 1969; can be launched from submerged submarine
	AS-6	ASM	TF or TJ	..	~750	..	Operational 1971
	SS-N-12	SSM	TF or TJ	..	~600	..	Under development

Code: Type: SSM (surface-to-surface missile); ASM (air-to-surface missile); SAM (surface-to-air missile). Propulsion: LPB (liquid-propellant booster); SPB(solid-propellant booster); RJ (ram-jet); TJ (turbo-jet); TF (turbo-fan). Warhead: HE (high explosive); N (nuclear).

2G

Figure 15.10. Cross-section of a US air-launched cruise missile (Boeing AGM-86A)



The missile is guided by the McDonnell Douglas system using a combination of inertial and terrain-comparison guidance. In terrain comparison, the missile is kept to its course by an on-board computer which compares pre-programmed geographical details of the flight path with the topography the missile sees during its actual flight. Deviations from the planned flight are then corrected automatically.

The ALCM is designed to have a very small radar image and to fly at very low altitudes (a couple of hundred metres over rough terrain and a few tens of metres over smooth ground). The missile is difficult to detect and destroy. Defence against the missiles would thus be both difficult and costly, particularly if they were launched in large numbers. Effective detection of ALCMs would probably involve look-down radars carried in Airborne Warning and Control System (AWACS) aircraft. To patrol a long frontier would require a fleet of such aircraft—a very costly undertaking. A large number of long-range interceptor aircraft would also be required to operate with AWACS to intercept and destroy the incoming missiles, which would also be extremely costly. The deployment of cruise missiles would, therefore, most probably escalate the arms race. And in addition, a defensive system against cruise missiles is generally more expensive than the cruise missiles themselves.

The AGM-86A ALCM was designed to use the same launch and support equipment as the Short Range Attack Missile (SRAM) now deployed on B-52s and intended for the B-1. The aircraft could, therefore, carry a mix of ALCMs and SRAMs, which are meant to be complementary weapon systems [6]. SRAM is 4.3 metres long, 46 cm in diameter, and has a launch weight of about 1 000 kg and a maximum range of 220 km. It is powered by a pulsed solid-propellant rocket at supersonic speeds and carries a nuclear warhead (200-kt yield W-69 warhead). SRAMs are intended for use against enemy defence systems—striking surface-to-air missiles, air-defence radars, and so on—to make it easier for bombers to penetrate the defences. The missile is also intended for use as a stand-off weapon, allowing bombers to attack targets near the enemy borders without crossing the air-defence perimeter. One thousand five hundred SRAMs have been deployed on B-52 G/H and FB-111 bombers: up to 20 on each of the former and six on each of the latter.

The AGM-86A ALCM probably has an operational range of about 1 200 km, but a B-model is in an early stage of development, with an operational range of about 2 500 km. This range will be achieved by adding a 1.3-metre long section to the fuselage to carry extra fuel for the turbo-fan engine. A 40-cm long tailpiece is added to streamline the tail and reduce drag. The wing-span of the B-version is 3.3 metres, that is, 47 cm longer than the A-version.

Jettison tests of full-scale AGM-86As were performed in 1975. Test flights of powered prototypes were made in 1976. Engineering development began in 1977.

In July 1977 President Carter cancelled production plans for (but not the development of) the B-1 and opted for a cruise missile force carried on B-52s and/or on wide-bodied aircraft such as Lockheed C-5As or Boeing 747s. The idea apparently is that the carrier aircraft should stay, say, 500–1 000 km away from the borders of the Soviet Union and Eastern Europe, thereby avoiding contact with air defence systems, including interceptor aircraft and their air-to-air missiles. The cruise missiles could then strike at targets on enemy territory. This requirement clearly puts a premium on the range of cruise missiles and it seems likely that the A-version of the AGM-86 will be dropped in favour of the long-range B-version. The Carter Administration is also anxious to accelerate the deployment of air-launched cruise missiles so that it can begin in early 1980.

The Tomahawk air-launched cruise missile (TALCM) is being developed by General Dynamics (see table 15.7). A fly-off competition between Boeing's ALCM and the TALCM is currently planned for late 1979. Production of the chosen missile is to begin soon thereafter. Work on the missiles is controlled by a joint project office, managed by a US naval officer.

The Tomahawk (YBGM-109)

The Tomahawk is actually designed in several versions. It can be launched from submarines and surface ships, from land-based platforms, and from aircraft.

The Tomahawk, basically designed to fit standard torpedo tubes, has a round fuselage of about 52 cm in diameter. For ship use it is stored until launch in a 0.22 gauge stainless steel canister filled with nitrogen (an inert gas) which just fits into a torpedo tube [7]. The capsule protects the missile from damage and is a safety measure in case the missile's fuel tanks should leak. The Tomahawk has a wing-span of 3.8 metres, is 5.6 metres long and is fitted with a 61-cm long solid booster. (The booster is not used for the air-launched version.) The booster drives the missile for about six seconds after launch while the wings and four tail fins are unfolded.

The missile weighs, when full of fuel, about 1 400 kg and the capsule 450 kg. In the strategic (long-range) version, the operational range of the Tomahawk for a given amount of fuel is probably about the same as that of the AGM-86B.

The Tomahawk uses the same guidance technique and the same engine and nuclear warhead (the 200-kt yield W-80 warhead) as the Boeing ALCM. The main difference is the airframe. More than 20 Tomahawks have so far been flight-tested.

Table 15.7. Comparison of Boeing ALCM, Tomahawk ALCM and SLCM, ASALM and SRAM

	Launch weight *kg*	Length *cm*	Body diameter *cm*	Wing-span *cm*	Probable maximum operational range *km*
Boeing AGM-86A ALCM	862	426	60	292	1 250
Boeing AGM-86B ALCM	1 200	594	60	364	2 500
General Dynamics Tomahawk ALCM	–	556	51.7	386	2 500
General Dynamics YBGM-109 SLCM (strategic)	1 360	617	51.7	386	3 700
Martin Marietta ASALM	1 200	426	53	–	–
Boeing AGM-69A SRAM	1 000	426	46	–	220

The tactical (short-range) version of the Tomahawk is armed with a conventional rather than a nuclear warhead. Instead of a turbo-fan engine, a turbo-jet engine is used (the Teledyne CAE J402 as in the Harpoon ship-to-ship missile). And the TERCOM guidance system is replaced by a radar-seeker guidance system.

Apart from their high accuracy and relative invulnerability, cruise missiles are quite cheap. In a production run of, say, 2 000 missiles, the unit cost (including development costs) is likely to be about $750 000 (much less than the cost of a modern main battle tank).

The cruise missiles described above fly at subsonic speeds. But the Martin-Marietta Advanced Strategic Air-Launched Missile (ASALM), now in the research stage, is a supersonic long-range follow-on to the ALCM. If deployed, these US Air Force missiles may be used as first-strike weapons.

The ASALM, planned to be about 4.3 metres long, 53 cm in diameter and 1 200 kg [8] in weight, is to be powered by an integrated rocket ram-jet engine and to carry a nuclear warhead. The solid-propellant rocket is to provide the initial thrust and then the ram-jet fuel burns in the empty rocket combustion chamber. ASALMs may be deployed in the mid-1980s.

Cruise missile proliferation

Cruise missiles have considerable potential as strategic nuclear delivery systems for smaller countries. Britain and France, for example, are showing great interest in these missiles as potential cheap replacements for their strategic nuclear weapons as these become obsolete in the 1980s. Most industrialized countries (and possibly some Third World ones) are technically capable of producing cruise missiles indigenously. But what is often lacking is a precise knowledge of the co-ordinates of potential targets and accurate information about the flight path to navigate to their co-ordinates with the full effectiveness of the missile's guidance system.

If cruise missiles should proliferate, particularly among NATO countries, this could have far-reaching effects. The USSR would likely react strongly against such proliferation, particularly to the Federal Republic of Germany. The USSR would also argue that this would make arms control and disarmament negotiations more difficult, particularly the MFR talks (see chapter 14) and the SALT negotiations.

If cruise missiles do proliferate widely, they may turn out to be the most far-reaching military technological development ever. And there is little doubt that improved versions of cruise missiles will, in future, be developed in rapid succession.

References

1. *Aviation Week and Space Technology*, 18 April 1977, p. 16.
2. *Aviation Week and Space Technology*, 11 July 1977, p. 18.
3. "SALT and the Test Ban: Cause for Optimism", text of a speech by P. C. Warnke, 10 November 1977, Arms Control and Disarmament Agency news release.
4. *Aviation Week and Space Technology*, 17 October 1977, p. 14.
5. *World Armaments and Disarmament, SIPRI Yearbook 1975* (Almqvist & Wiksell, Stockholm, 1975, Stockholm International Peace Research Institute).
6. *International Defense Review*, No. 3, 1976, p. 370.
7. *Interavia*, No. 3, 1976, p. 260.
8. *Aviation Week and Space Technology*, 21 March 1977, p. 84.

16. Developments in arms control and disarmament

I. The multilateral disarmament negotiating machinery

The United Nations

Since the creation of the United Nations in 1945, the UN General Assembly—the most widely representative of the UN organs—has been the principal forum for international policy debate. The subjects of these debates invariably include arms control and disarmament issues, which are dealt with primarily in the First (Political) Committee but also in other main General Assembly committees or directly in the plenary sessions without recourse to subsidiary bodies.

The UN General Assembly serves as a sounding-board for new ideas and proposals, which are usually incorporated in draft General Assembly resolutions requiring for their adoption a two-thirds majority of the members present and voting. The General Assembly also receives reports about on-going multilateral negotiations and attempts to influence the talks by making specific recommendations. These recommendations have no mandatory character, but do carry some political and moral weight, especially when made unanimously. Essentially, however, the UN General Assembly is a deliberative body which provides a forum for official statements as well as for informal discussions.

The UN Security Council has as one of its statutory responsibilities the formulation of plans for the establishment of a system for the regulation of armaments. It is to be assisted in this work by the Military Staff Committee, consisting of the chiefs of staff of the permanent members of the Council or their representatives (Articles 26 and 47 of the UN Charter). In the early post-war period the Security Council was actively engaged in arms control discussions, but since the 1950s its role in this field has diminished. It has never requested assistance from the Military Staff Committee. Nevertheless, in the context of its responsibility for the maintenance of international peace and security, the UN Security Council has been assigned a role in several arms control agreements, mainly in dealing with complaints about breaches of obligations contracted under these agreements.

During the past 30 years a number of other UN bodies have been established to deal with disarmament issues. Some of them ceased to function upon completion of their tasks, while others adjourned *sine die* or were simply dissolved. By the end of 1977, a few such bodies were still in existence.

The UN Disarmament Commission, set up by the General Assembly in 1952 with a limited membership, and expanded in 1959 to include all UN members, was originally entrusted with the task of preparing proposals for the regulation, limitation and reduction of armed forces and armaments, and for the elimination of weapons of mass destruction. Subsequently, however, the Commission became a multilateral forum for discussion rather than negotiation. It has not met since 1965.

For more than 22 years, the UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) has been dealing with a question closely related to the cessation of nuclear weapon tests. The specific task of this committee is to assemble, study and disseminate information on observed levels of ionizing radiation and radioactivity in the environment and on the effects of such radiation upon man and his environment.

A few UN bodies have been established *ad hoc* for specific issues related to arms control. One *ad hoc* committee is studying the implications of the 1971 General Assembly resolution which declared the Indian Ocean a zone of peace, and another is examining the views and suggestions expressed by governments on the convening of a World Disarmament Conference.

There are also disarmament forums outside the UN framework, both bilateral (US–Soviet) and multilateral. In the latter category, a conference to negotiate the "mutual reduction of forces and armaments and associated measures in Central Europe" has been meeting since 1973. A second forum devoted to European matters, the Conference on Security and Co-operation in Europe, deals with confidence-building measures and questions related to disarmament, in accordance with the Final Act of the Conference, of 1 August 1975.

Another regional body, the Agency for the Prohibition of Nuclear Weapons in Latin America, was created by the parties to the 1967 Treaty of Tlatelolco. It holds consultations among member states on matters relating to the purposes, measures and procedures set forth in the treaty and is responsible for the supervision of compliance with the obligations arising therefrom.

The CCD

The central institution dealing with multilateral arms control is at present the Conference of the Committee on Disarmament (CCD), which holds its sessions in Geneva. Set up as the Eighteen Nation Disarmament Committee (ENDC) in 1961, it was subsequently enlarged and re-named in 1969. Unlike their predecessor, the Ten-Nation Disarmament Committee (which had been established by a decision of the foreign ministers of France, the UK, the USA and the USSR in 1959, and met from March to

June 1960), the ENDC and later the CCD included not only NATO and WTO (Warsaw Treaty Organization) countries, but also non-aligned states. In 1977, the membership of the CCD included Argentina, Brazil, Bulgaria, Burma, Canada, Czechoslovakia, Egypt, Ethiopia, the German Democratic Republic, the Federal Republic of Germany, Hungary, India, Iran, Italy, Japan, Mexico, Mongolia, Morocco, the Netherlands, Nigeria, Pakistan, Peru, Poland, Romania, Sweden, the USSR, the UK, the USA, Yugoslavia and Zaire. France is also a member of the Committee, but has so far not participated in its work.

Technically, the CCD is not a UN body; the General Assembly has merely endorsed a US–Soviet agreement concerning its creation. Nevertheless, it is serviced by the UN Secretariat and submits reports to the General Assembly which, in turn, requests the negotiators to take up or devote special attention to certain issues.

The CCD was established to discuss primarily general and complete disarmament. Fairly soon, however, its interest shifted to partial, so-called collateral measures. Several multilateral arms control agreements have been negotiated there, namely: the Non-Proliferation Treaty, the Sea-Bed Treaty, the Biological Weapons Convention and the Environmental Modification Convention. The Partial Test Ban Treaty, which resulted from trilateral talks held in 1963 among the UK, the USA and the USSR, had been preceded by intensive multilateral negotiations in the CCD. The CCD agenda adopted in 1968 includes the following items: (*a*) further effective measures relating to the cessation of the nuclear arms race at an early date and nuclear disarmament; (*b*) non-nuclear measures; (*c*) other collateral measures; and (*d*) general and complete disarmament under strict and effective international control.

Under the first item, the CCD may discuss measures dealing with the cessation of testing, the non-use of nuclear weapons, the cessation of manufacture of weapons, the reduction and subsequent elimination of nuclear stockpiles, nuclear-free zones, and so on; under the second heading—chemical and biological warfare, regional arms limitations, and so on; under the third heading—prevention of an arms race on the sea-bed, and so on. The agenda of the CCD is open-ended, giving delegations the right to raise and discuss any disarmament subject.

Negotiations in the CCD take place at formal or informal plenary meetings, or in *ad hoc* working groups, all closed to the public and the press. To clarify technical problems, meetings of experts are arranged, sometimes with the participation of scientists from non-CCD member states. There is no voting in the CCD. While decisions, both procedural and substantive, are adopted by consensus, dissenting opinions may be written into the annual report. Once the text of a treaty has been worked out by the CCD, it is transmitted to the UN General Assembly, often with a request to have it recommended for signature and ratification by the UN member states.

The all-embracing character of its agenda and the flexibility of its procedures have contributed little to the efficacy of the CCD. Since the USA and the USSR bilaterally discuss strategic nuclear arms limitation and related issues, and even such non-nuclear matters as limitations of conventional arms transfers, the range of measures to be negotiated multilaterally has shrunk considerably. Moreover, as a body, the CCD does not initiate discussions of specific measures. Rather, the USA and the USSR usually decide which items should become the subject of regular multilateral talks. Only after these two powers have reached agreement on the basic provisions of a treaty to be concluded may the Conference negotiate the details. Proposals for substantive changes in the bilaterally agreed clauses are, as a rule, jointly resisted by the USA and the USSR.

In recent years, attempts have been made to improve the work of the existing deliberative bodies by making it less diffuse and more goal-oriented. These attempts are reflected in proposals for streamlining the proceedings of the regular General Assembly sessions and, particularly, in the decision to convene, in 1978, a UN General Assembly special session devoted to disarmament, with a prospect of having such sessions, or world disarmament conferences, convened also in the future. The envisaged function of these large meetings is to formulate principles governing disarmament negotiations, to establish a programme of action and to assess its implementation. Of primary importance, however, is the operation of the machinery for negotiating specific agreements. Since 1976, there have been a few positive developments in this respect. The CCD has introduced improvements of a procedural character, relating to the schedule of its sessions, preparation of reports, contents of its communiqués and distribution of documents. It has also established rules for *ad hoc* groups working out draft treaties or other texts. But the necessary structural modifications have not, as yet, taken place. The existent negotiating machinery still suffers from a number of shortcomings.

The link with the United Nations

The loose relationship of the CCD with the United Nations is considered by most countries as objectionable. Since one of the main purposes of the United Nations is to prevent and remove threats to the peace, there is no justification for restricting its functions to exhortations or recommendations where arms control and disarmament are concerned. The UN is expected to carry the responsibility for, and be directly involved in, all multilateral arms control negotiations which concern the community of nations as a whole. Neither should the UN be excluded from talks in more restricted forums, in so far as their outcome may affect other nations as well. In other words, there is good reason for strengthening the role of the United Nations in the field of disarmament.

Though desirable in many respects, a close link between a multilateral disarmament body and the UN should not necessarily mean that all UN rules of procedure, including voting, are automatically to be applied. In matters of security, attempts at imposing the will of the majority on a dissenting minority, through procedural devices, are usually fruitless, and may even be counter-productive. It would, therefore, seem preferable to maintain the requirement of consensus among negotiators.

Structure of the negotiating body

It is generally considered that, to function effectively, a body which works out treaty texts should not be too large. It is difficult, however, to determine where the borderline for the number of participants actually lies. Experience has shown that the present size of the CCD, that is, approximately 30 members, is adequate, although a slight expansion of the membership would appear to be tolerable. The problem with such a limitation is that non-members are prevented from making contributions or having a say on matters which may involve their national interests. In fact, treaties agreed to in the CCD have often been submitted to the remaining members of the UN for approval, practically on a take-it-or-leave-it basis. This shortcoming could perhaps be remedied by adopting certain procedures—either individually or jointly. Thus, for example, the membership of the negotiating committee could comprise permanent participants, which would include the militarily most significant states, as well as temporary participants, subject to rotation with other states, with the understanding that, in view of the amount of expertise necessary to negotiate arms control measures, the rotation would not take place too often. Another possibility would be to keep all UN members informed, currently and in detail, about the on-going talks, and invite them to present their views or proposals, either in writing or orally. But to avoid diluting the singular character of the negotiating body, the rights of non-members would have clearly to be circumscribed. Yet another possibility would be to revitalize the UN Disarmament Commission and entrust it with the task of examining, and possibly amending, the drafts agreed to in the negotiating body, before the final texts were submitted to the General Assembly for approval.

Chairmanship

The chairmanship of the CCD is now assumed jointly, and on a permanent basis, by the USA and the USSR. (At individual meetings, the chair is rotated in alphabetical order among all CCD members, but the role of the chairman of the day has been reduced to recognizing the speakers and reading out the communiqués.) The co-chairmanship was established in the early 1960s, in recognition of the special position of the two most powerful nations in the field of armaments, and as a realization of the fact that their consent was indispensable in reaching agreement on meaningful arms control measures.

At the initial stage, the institution of US–Soviet co-chairmanship was helpful in smoothing out the conduct of business and in facilitating informal work at the CCD, but its usefulness has diminished, and is no longer well suited to current political circumstances. Indeed, it is now deemed to be an obstacle in drawing China and France into the negotiating process. The question of chairmanship in the CCD can be solved by applying the pattern of existing UN organs, or another formula concordant with the democratic principle of the sovereign equality of nations. This relatively modest change would not, and could not, affect the role which the USA and the USSR are called upon to play in bringing about disarmament by virtue of their political and military standing in the world.

Additional structural innovations may be required to enable the negotiating machinery, be it the CCD or a new body,[1] to perform its functions properly. These could include permanent sub-committees to deal with several issues simultaneously. However, in addition to new working methods, it is essential to define in more precise terms than hitherto the tasks of the negotiators and to establish a concrete agenda for their work. This will become possible when a coherent programme of disarmament has been agreed upon at the highest possible level, specifying consecutive steps to be taken in a logical and politically realistic order.

II. Major post-World War II agreements related to arms control[2]

Antarctic Treaty

Signed: 1 December 1959.

Entered into force: 23 June 1961.

Treaty banning nuclear weapon tests in the atmosphere, in outer space and under water (Partial Test Ban Treaty—PTBT)

Signed: 5 August 1963.

Entered into force: 10 October 1963.

[1] In January 1978, the French government proposed that the CCD should be replaced by a new negotiating forum.

[2] For the texts of these and other arms control agreements and the status of their implementation, see *Arms Control: A Survey and Appraisal of Multilateral Agreements* (Taylor & Francis, London, 1978, Stockholm International Peace Research Institute).

Treaty on principles governing the activities of states in the exploration and use of outer space, including the moon and other celestial bodies (Outer Space Treaty)

Signed: 27 January 1967.

Entered into force: 10 October 1967.

Treaty for the prohibition of nuclear weapons in Latin America (Treaty of Tlatelolco)

Signed: 14 February 1967.

Entered into force: 22 April 1968.

Treaty on the non-proliferation of nuclear weapons (Non-Proliferation Treaty—NPT)

Signed: 1 July 1968.

Entered into force: 5 March 1970.

Treaty on the prohibition of the emplacement of nuclear weapons and other weapons of mass destruction on the sea-bed and the ocean floor and in the subsoil thereof (Sea-Bed Treaty)

Signed: 11 February 1971.

Entered into force: 18 May 1972.

Agreement on measures to reduce the risk of outbreak of nuclear war between the USA and the USSR (US–Soviet Nuclear Accidents Agreements)

Signed: 30 September 1971.

Entered into force: 30 September 1971.

Convention on the prohibition of the development, production and stockpiling of bacteriological (biological) and toxin weapons and on their destruction (BW Convention)

Signed: 10 April 1972.

Entered into force: 26 March 1975.

US–Soviet treaty on the limitation of anti-ballistic missile systems (SALT ABM Treaty)

Signed: 26 May 1972.

Entered into force: 3 October 1972.

US–Soviet interim agreement on certain measures with respect to the limitation of strategic offensive arms (SALT Interim Agreement)

Signed: 26 May 1972.

Entered into force: 3 October 1972.

US–Soviet agreement on the prevention of nuclear war

Signed: 22 June 1973.

Entered into force: 22 June 1973.

Protocol to the US–Soviet treaty on the limitation of anti-ballistic missile systems

Signed: 3 July 1974.

Entered into force: 25 May 1976.

US–Soviet treaty on the limitation of underground nuclear weapon tests (Threshold Test Ban Treaty—TTBT)

Signed: 3 July 1974.

Not in force by 31 December 1977.

Document on confidence-building measures and certain aspects of security and disarmament, included in the Final Act of the Conference on Security and Co-operation in Europe

Signed: 1 August 1975.

US–Soviet treaty on underground nuclear explosions for peaceful purposes (Peaceful Nuclear Explosions Treaty—PNET)

Signed: 28 May 1976.

Not in force by 31 December 1977.

French–Soviet agreement on the prevention of the accidental or unauthorized use of nuclear weapons (French–Soviet Nuclear Accidents Agreement)

Concluded through an exchange of letters on 16 July 1976 between the foreign ministers of France and the USSR.

Entered into force: 16 July 1976.

Convention on the prohibition of military or any other hostile use of environmental modification techniques (ENMOD Convention)

Signed: 18 May 1977.

Not in force by 31 December 1977.

British–Soviet agreement on the prevention of an accidental outbreak of nuclear war (British–Soviet Nuclear Accidents Agreement)

Signed: 10 October 1977.

Entered into force: 10 October 1977.

III. *UN General Assembly resolutions adopted in 1976 and 1977*

This list includes resolutions concerning exclusively disarmament matters, as well as other resolutions making reference to disarmament. In the latter case, the negative votes or abstentions do not necessarily reflect the positions of states towards the disarmament paragraphs of the relevant resolutions.

Only the essential parts of each resolution are given here. The text has been abridged, but the wording is close to that of the resolution.

The resolutions are grouped according to subject, irrespective of the agenda items under which they were discussed.

Resolution no. and date of adoption	Subject and contents of resolution	Voting results
	Strategic arms limitation	
31/189 A 21 December 1976	Regrets the absence of positive results during the past three years of bilateral negotiations between the governments of the USSR and the USA on the limitation of their strategic nuclear weapon systems; expresses concern for the very high ceilings on nuclear arms set for themselves by both states, for the total absence of qualitative limitations of such arms, for the protracted time-table contemplated for the negotiation of further limitations and possible reductions of the nuclear arsenals, and for the situation thus created; urges anew the USSR and the USA to broaden the scope and accelerate the pace of their strategic nuclear arms limitation talks, and stresses once again the necessity and urgency of reaching agreement on important qualitative limitations and substantial reductions of their strategic nuclear weapon systems as a positive step towards nuclear disarmament.	*In favour* 107 *Against* 10: Bulgaria, Byelorussia, Czechoslovakia, German Democratic Republic, Hungary, Mongolia, Poland, Ukraine, USSR, USA *Abstentions* 11: Belgium, France, Federal Republic of Germany, Greece, Israel, Italy, Lao People's Democratic Republic, Luxembourg, Malawi, Turkey, UK *Absent or not participating in the vote:* Albania, Angola, Benin, Cape Verde, China, Comoros, Congo, Cuba, Democratic Kampuchea, El Salvador, Gambia, Haiti, Honduras, Liberia, Mozambique, Samoa, Seychelles, Somalia, South Africa
32/87 G 12 December 1977	Regretting the absence of definitive results of US–Soviet negotiations on the limitation of strategic nuclear weapon systems, notes with satisfaction the statements made on 4 October 1977 by the President of the USA, and the statement made on 2 November 1977 by the President of the Supreme Soviet of the USSR. Stresses the necessity and urgency for the USSR and the USA to strive to implement as soon as possible these statements and reiterates with special emphasis the invitation to the governments of both countries to keep the General Assembly informed in good time of the results of their negotiations.	*In favour* 134 *Against* 2: Albania, China *Abstentions* 0 *Absent or not participating in the vote:* Angola, Comoros, Democratic Kampuchea, Djibouti, Equatorial Guinea, Grenada, Madagascar,[a] Malawi, Samoa, Saudi Arabia, Seychelles, South Africa, Viet Nam

2H

Non-proliferation of nuclear weapons

31/11 10 November 1976	Welcomes the steps taken by the International Atomic Energy Agency in concluding safeguards agreements with many states, and notes the efforts of the Agency in connection with its work regarding the physical protection of nuclear materials and its detailed study of the concept of regional fuel cycle centres.	Adopted without vote
31/75 10 December 1976	Referring to the Final Declaration of the first Review Conference of the parties to the NPT, urgently calls for determined efforts by all nuclear weapon states: (*a*) to bring about the cessation of the nuclear arms race; (*b*) to undertake effective measures in the direction of nuclear disarmament; (*c*) to find an early solution to the difficulties in reaching agreement to discontinue all test explosions of nuclear weapons for all time as a step towards the realization of these objectives; and emphasizes the particular responsibility of the two major nuclear weapon states in this regard. Stresses the urgency of international co-operative efforts in appropriate forums to prevent the further proliferation of nuclear weapons or other nuclear explosive devices; recognizes that states accepting effective non-proliferation restraints have a right to full access to the peaceful uses of nuclear energy and underlines the importance of all efforts to increase the availability of energy, particularly for the needs of the developing countries of the world; and requests the International Atomic Energy Agency to accord high priority to its programme of work in these areas.	*In favour* 115 *Against* 2: Albania, China *Abstentions* 19: Algeria, Argentina, Bhutan, Bolivia, Brazil, Burma, Chile, Comoros, Cuba, France, India, Mauritania, Mozambique, Nigeria,[c] Pakistan, Portugal, Spain, Uganda, United Republic of Tanzania *Absent or not participating in the vote:* Angola, Cape Verde, Democratic Kampuchea, Guinea, Haiti, Honduras, Sao Tome and Principe, Seychelles, South Africa, Zambia
31/189 D 21 December 1976	Requests the International Atomic Energy Agency to give special attention to its programme of work in the non-proliferation area, including its efforts in facilitating peaceful nuclear co-operation and increasing assistance to the developing areas of the world within an effective and comprehensive safeguards system; further requests the Agency to continue its studies on the questions of multinational fuel cycle centres and an international régime for plutonium storage as effective means to promote the interests of the non-proliferation régime; and calls upon the Agency to give careful consideration to all relevant suggestions presented to it which aim at strengthening the safeguards régime.	*In favour* 106 *Against* 2: Albania, China *Abstentions* 22: Algeria, Argentina, Bhutan, Bolivia, Brazil, Burma, Chile, Colombia, France, India, Lesotho, Mauritius, Mexico, Pakistan, Panama, Paraguay, Peru, Romania, Uganda, United Republic of Tanzania, Yugoslavia, Zambia *Absent or not participating in the vote:* Angola, Benin, Cape Verde, Comoros, Congo, Cuba, Democratic Kampuchea, El Salvador, Gambia, Haiti, Honduras, Liberia, Mozambique, Samoa, Seychelles, Somalia, South Africa

Resolution no. and date of adoption	Subject and contents of resolution	Voting results
32/49 8 December 1977	Notes with appreciation the contribution of the International Atomic Energy Agency in facilitating the elaboration of a convention on the physical protection of nuclear materials and urges prompt completion of the work on this convention. Also notes with appreciation the Agency study on regional nuclear fuel cycle centres, the intention of the Agency to continue its research in this field, especially with regard to economic and non-proliferation implications, and the decision of the Board of Governors to keep the matter of peaceful nuclear explosions under review, seeking the services of the *Ad Hoc* Advisory Group on nuclear explosions for peaceful purposes, as required.	Adopted by consensus
32/87 F 12 December 1977	Emphasizes the particular responsibility of those nuclear weapon states that have already accepted international obligations, namely, in Article VI of the NPT, with respect to the cessation of the nuclear arms race and the discontinuance of nuclear weapon tests and notes as encouraging the recent efforts under way towards these ends; urges states that as yet have not adhered to the NPT, to do so at an early date or, at a minimum, to accept other arrangements involving the application of safeguards to their complete nuclear fuel cycle that would provide satisfactory assurances to the international community against the dangers of proliferation while guaranteeing to the states concerned unhindered and non-discriminatory access to the peaceful benefits of nuclear energy. Emphasizes the importance of common efforts to study satisfactory arrangements for an adequate supply of nuclear fuels and other materials and facilities necessary for the efficient implementation and operation of national nuclear power programmes without jeopardizing the respective fuel cycle policies or international co-operation agreements and contracts for the peaceful uses of nuclear energy, provided that agreed safeguard measures are applied. Solemnly affirms the following principles: (*a*) states should not convert civil nuclear materials or facilities to the production of nuclear weapons; and (*b*) all states have the right, in accordance with the principle of sovereign equality, to develop their programmes for	*In favour* 111 *Against* 2: Albania, China *Abstentions* 16: Algeria, Benin, Bhutan, Burma, Colombia, France, Guyana, Israel, Kuwait, Mauritania, Pakistan, Peru, Spain, Uganda, United Republic of Tanzania, Zambia *Absent or not participating in the vote:* Angola, Argentina, Barbados, Botswana, Brazil, Chile, Comoros, Cuba, Democratic Kampuchea, Djibouti, Equatorial Guinea, Grenada, India, Madagascar,[a] Malawi, Samoa, Saudi Arabia, Seychelles, South Africa, Viet Nam

2 H 2

the peaceful use of nuclear technology for economic and social development in conformity with their priorities, interests and needs and should have, without discrimination, access to, and be free to acquire, technology and materials for the peaceful use of nuclear energy under effective and non-discriminatory safeguards against the proliferation of nuclear weapons.

Expresses its strong support for the efforts of the International Atomic Energy Agency to increase the effectiveness of its safeguards system in order to ensure that the peaceful uses of nuclear energy will not lead to the proliferation of nuclear weapons or other nuclear explosive devices. Recognizes the need adequately to ensure the physical protection of nuclear materials, facilities and transport, and requests the International Atomic Energy Agency to continue the consideration of reaching an international agreement for such protection. Expresses its support for the continuation of the studies by the International Atomic Energy Agency on the question of multinational fuel cycle centres and an international régime for plutonium management.

Security of non-nuclear weapon states

31/189 C
21 December 1976

Requests the nuclear weapon states, as a first step towards a complete ban on the use or threat of use of nuclear weapons, to consider undertaking, without prejudice to their obligations arising from treaties establishing nuclear weapon-free zones, not to use or threaten to use nuclear weapons against non-nuclear weapon states not parties to the nuclear security arrangements of some nuclear weapon powers.

In favour 95
Against 0
Abstentions 33: Algeria, Argentina, Australia, Austria, Belgium, Bhutan, Bulgaria, Byelorussia, Canada, Czechoslovakia, Denmark, France, German Democratic Republic, Federal Republic of Germany, Greece, Hungary, Iceland, India, Iraq, Ireland, Italy, Japan, Luxembourg, Mongolia, New Zealand, Norway, Poland, Sweden, Ukraine, USSR, UK, USA, Yugoslavia
Absent or not participating in the vote: Albania, Angola, Benin, Cape Verde, Comoros, Congo, Cuba, Democratic Kampuchea, Democratic Yemen, El Salvador, Gambia, Haiti, Honduras, Liberia, Mozambique, Samoa, Seychelles, Somalia, South Africa

32/87 B
12 December 1977

Recalling Resolution 31/189 C of 21 December 1976 (see above) urges the nuclear weapon powers to give serious consideration to extending the undertaking proposed by that resolution and to take expeditious action in all relevant forums to strengthen the security of non-nuclear weapon states; recommends that all possible efforts be made at the General Assembly special session

In favour 95[d]
Against 0
Abstentions 38: Algeria, Argentina, Australia, Austria, Belgium, Benin, Bhutan, Bulgaria, Byelorussia, Canada, Congo, Cuba, Cyprus, Czechoslovakia, Denmark, France, German Democratic Republic, Federal Republic of Germany, Greece, Hungary,

Resolution no. and date of adoption	Subject and contents of resolution	Voting results
	devoted to disarmament to evolve binding and credible security assurances to non-nuclear weapon states.	Iceland, India, Iraq, Ireland, Italy, Japan, Luxembourg, Mongolia, Norway, Oman, Poland, Sierra Leone, Sweden, Ukraine, USSR, UK, USA, Yugoslavia *Absent or not participating in the vote:* Albania, Angola, Comoros, Democratic Kampuchea, Djibouti, Equatorial Guinea, Grenada, Guinea, Madagascar,[a] Malawi, Samoa, Saudi Arabia, Senegal, Seychelles, South Africa, Viet Nam
	Nuclear weapon tests	
31/66 10 December 1976	Condemns all nuclear weapon tests, in whatever environment they may be conducted; calls once again upon all nuclear weapon states to suspend the testing of nuclear weapons by agreement, subject to review after a specified period, as an interim step towards the conclusion of a formal and comprehensive test ban agreement, and emphasizes in this regard the particular responsibility of the nuclear weapon states party to international agreements in which they have declared their intention to achieve at the earliest possible date the cessation of the nuclear arms race. Calls upon all states not yet parties to the Treaty banning nuclear weapon tests in the atmosphere, in outer space and under water to adhere to it forthwith; and urges the Conference of the Committee on Disarmament to continue to give the highest priority to the conclusion of a comprehensive test ban agreement.	*In favour* 105 *Against* 2: Albania, China *Abstentions* 27: Algeria, Belgium, Bulgaria, Byelorussia, Comoros, Congo, Cuba, Czechoslovakia, Equatorial Guinea, France, Gambia, German Democratic Republic, Federal Republic of Germany, Greece, Hungary, Italy, Luxembourg, Madagascar, Mauritania, Mongolia, Poland, Ukraine, USSR, UK, United Republic of Tanzania, USA, Zambia *Absent or not participating in the vote:* Angola, Benin, Cape Verde, Democratic Kampuchea, Guatemala,[a] Guinea, Haiti, Honduras, Lebanon, Sao Tome and Principe, Seychelles, South Africa
31/89 14 December 1976	Recalling Resolution 3478 (XXX) of 11 December 1975, which called upon all nuclear weapon states to enter into negotiations not later than 31 March 1976, with a view to reaching agreement on the complete and general prohibition of nuclear weapon tests, with 25 to 30 non-nuclear weapon states participating in such negotiations; deploring the fact that such negotiations have not begun; and believing that the conclusion between the USSR and the USA of treaties on the limitation of underground nuclear weapon tests and on underground nuclear explosions for peaceful	*In favour* 95 *Against* 2: Albania, China *Abstentions* 36: Australia, Austria, Belgium, Bhutan, Botswana, Brazil, Burma, Canada, Chile, Comoros, Denmark, France, Federal Republic of Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, Madagascar, Malawi, Mauritania, Netherlands, New Zealand, Norway, Paraguay, Portugal, Spain, Sweden, Turkey, Uganda, UK, United Republic of Tanzania, USA, Zambia

	purposes contributes to the creation of favourable conditions for the cessation of all nuclear weapon tests, again calls upon all nuclear weapon states to proceed as soon as possible with negotiations on the conclusion of a treaty on the complete and general prohibition of nuclear weapon tests, with the participation of non-nuclear weapon states.	*Absent or not participating in the vote:* Angola, Benin, Cape Verde, Congo, Democratic Kampuchea, Equatorial Guinea, Grenada, Guinea-Bissau, Haiti, Lebanon, Malta, Seychelles, South Africa
32/78 12 December 1977	Reiterates its grave concern that in spite of the repeated resolutions of the General Assembly related to nuclear weapon testing in all environments, adopted by very large majorities, such testing has continued unabated during the past year; notes with satisfaction that negotiations have begun among three nuclear weapon states with a view to drafting an agreement on the subject of this resolution; declares that the conclusion of such an agreement and its opening for signature would be the best possible augury for the success of the General Assembly special session devoted to disarmament; urges the three nuclear weapon states to expedite their negotiations with a view to bringing them to a positive conclusion as soon as possible, and to transmit the results for full consideration by the CCD. Requests the CCD to take up the agreed text resulting from the negotiations referred to above with the utmost urgency, with a view to the submission of a draft treaty to the General Assembly at its special session devoted to disarmament.	*In favour* 126 *Against* 2: Albania, China *Abstentions* 1: France *Absent or not participating in the vote:* Angola, Burma,[a] Central African Empire, Comoros, Democratic Kampuchea, Djibouti, Equatorial Guinea, Grenada, Guinea, Lao People's Democratic Republic, Madagascar,[a] Malawi, Mauritania, Mauritius,[a] Samoa, Saudi Arabia, Seychelles, Somalia, South Africa, Viet Nam
	Atomic radiation	
31/10 8 November 1976	Requests the UN Scientific Committee on the effects of atomic radiation to continue its work, and requests all member states and the United Nations agencies and non-governmental organizations concerned to supply to the Committee further data relevant to its work, with a view to facilitating the preparation of its comprehensive report to the General Assembly.	Adopted without vote
32/6 31 October 1977	Commends the UN Scientific Committee on the Effects of Atomic Radiation for the valuable contribution it has made since its inception to wider knowledge and understanding of the levels, effects and risks of atomic radiation; and requests the Committee to continue its work, including its important co-ordination activities, to increase knowledge of the levels and effects of atomic radiation from all sources.	Adopted without vote

Resolution no. and date of adoption	Subject and contents of resolution	Voting results
	Study of nuclear weapon-free zones	
31/70 10 December 1976	Reiterates the conviction that the establishment of nuclear weapon-free zones can contribute to the security of countries in such zones, to the prevention of proliferation of nuclear weapons and to the goals of general and complete disarmament. Draws the attention of governments to the comprehensive study of the *ad hoc* group of qualified experts on the question of nuclear weapon-free zones, and the views, observations and suggestions concerning that study contained in the report of the Secretary-General, and expresses the hope that they will enhance further efforts of the governments concerning nuclear weapon-free zones and will be of assistance to states interested in the establishment of such zones.	*In favour* 132 *Against* 0 *Abstentions* 0 *Absent or not participating in the vote:* Albania, Angola, Benin, Cape Verde, China, Democratic Kampuchea, Guatemala,[a] Guinea, Haiti, Honduras, Libya, Sao Tome and Principe, Seychelles, South Africa
	Latin American nuclear weapon-free zone	
31/67 10 December 1976	Again urges the USSR to sign and ratify Additional Protocol II of the Treaty for the prohibition of nuclear weapons in Latin America (Treaty of Tlatelolco).	*In favour* 119 *Against* 0 *Abstentions* 14: Bulgaria, Byelorussia, Cuba, Czechoslovakia, Democratic Yemen, German Democratic Republic, Guyana, Hungary, Maldives, Mongolia, Poland, Uganda, Ukraine, USSR *Absent or not participating in the vote:* Albania, Angola, Benin, Cape Verde, Democratic Kampuchea, Guatemala,[a] Guinea, Haiti, Honduras, Sao Tome and Principe, Seychelles, South Africa, Swaziland
32/76 12 December 1977	Recalling that the United Kingdom and the Netherlands became parties to Additional Protocol I of the Treaty of Tlatelolco in 1969 and 1971, respectively, notes that the Protocol was signed on 26 May 1977 by the President of the USA and that the government of that country has decided to take the necessary steps for its ratification, and again urges France to sign and ratify the Protocol.	*In favour* 113 *Against* 0 *Abstentions* 14: Argentina, Bulgaria, Byelorussia, Cuba, France, German Democratic Republic, Greece, Guyana, Hungary, Mongolia, Poland, Uganda, Ukraine, USSR *Absent or not participating in the vote:* Albania, Angola, Central African Empire, Comoros, Congo, Cyprus,[a] Czechoslovakia,

		Democratic Kampuchea, Djibouti, Equatorial Guinea, Grenada, Guinea, Lesotho, Madagascar,[a] Malawi, Mauritius,[a] Samoa, Saudi Arabia, Seychelles, Somalia, South Africa, Viet Nam
32/79 12 December 1977	Recalling that the UK, the USA, France and China are already parties to Additional Protocol II of the Treaty of Tlatelolco, again urges the USSR to sign and ratify the Protocol.	*In favour* 118 *Against* 0 *Abstentions* 13: Bulgaria, Byelorussia, Congo, Cuba, Czechoslovakia, German Democratic Republic, Guyana, Hungary, Mongolia, Poland, Uganda, Ukraine, USSR *Absent or not participating in the vote:* Albania, Angola, Central African Empire, Comoros, Democratic Kampuchea, Djibouti, Equatorial Guinea, Grenada, Guinea, Madagascar,[a] Malawi, Mauritius,[a] Samoa, Saudi Arabia, Seychelles, Somalia, South Africa, Viet Nam

African nuclear weapon-free zone

31/69 10 December 1976	Reaffirms the call upon all states to respect and abide by the Declaration on the denuclearization of Africa; reaffirms the call upon all states to consider and respect the continent of Africa, including the continental African states, Madagascar and other islands surrounding Africa, as a nuclear weapon-free zone; appeals to all states not to deliver to South Africa or place at its disposal any equipment or fissionable material or technology that will enable it to acquire a nuclear weapon capability; and requests the Secretary-General to render all necessary assistance to the Organization of African Unity towards the realization of its solemn Declaration on the denuclearization of Africa, in which the African heads of state and government announced their readiness to undertake, in an international treaty to be concluded under the auspices of the United Nations, not to manufacture or acquire control of nuclear weapons.	Adopted without vote
32/81 12 December 1977	Condemns any attempt by South Africa to introduce nuclear weapons into the continent of Africa; demands that South Africa refrain forthwith from conducting any nuclear explosion on the continent of Africa or elsewhere; urgently requests the Security Council to take appropriate effective steps to prevent	*In favour* 131 *Against* 0 *Abstentions* 0 *Absent or not participating in the vote:* Albania, Angola, Argentina, Central African Empire, Comoros, Democratic Kampu-

Resolution no. and date of adoption	Subject and contents of resolution	Voting results
	South Africa from developing and acquiring nuclear weapons, thereby endangering international peace and security; appeals to all states to refrain from such co-operation with South Africa in the nuclear field as will enable the racist régime to acquire nuclear weapons, and to dissuade corporations, institutions and individuals within their jurisdiction from any such co-operation.	chea, Djibouti, Equatorial Guinea, Grenada, Guinea, Madagascar,[a] Malawi, Mauritius,[a] Paraguay, Samoa, Saudi Arabia, Seychelles, South Africa
	South Asian nuclear weapon-free zone	
31/73 10 December 1976	Urges the states of South Asia and such other neighbouring non-nuclear weapon states as may be interested to continue to make all possible efforts to establish a nuclear weapon-free zone in South Asia and to refrain, in the meantime, from any action contrary to this objective.	*In favour* 91 *Against* 2: Bhutan, India *Abstentions* 43: Argentina, Australia, Austria, Belgium, Bulgaria, Burma, Byelorussia, Cuba, Cyprus, Czechoslovakia, Denmark, Fiji, France, German Democratic Republic, Federal Republic of Germany, Greece, Hungary, Indonesia, Ireland, Israel, Italy, Japan, Lao People's Democratic Republic, Lebanon, Luxembourg, Malawi, Malaysia, Maldives, Mauritius, Mongolia, Netherlands, New Zealand, Norway, Poland, Singapore, Sweden, Ukraine, USSR, UK, United Republic of Tanzania, USA, Yugoslavia, Zambia *Absent or not participating in the vote:* Albania, Angola, Cape Verde, Democratic Kampuchea, Guinea, Haiti, Honduras, Sao Tome and Principe, Seychelles, South Africa
32/83 12 December 1977	Reaffirms its endorsement, in principle, of the concept of a nuclear weapon-free zone in South Asia; urges once again the states of South Asia and such other neighbouring non-nuclear weapon states as may be interested to continue to make all possible efforts to establish a nuclear weapon-free zone in South Asia and to refrain, in the meantime, from any action contrary to this objective; and calls upon those nuclear weapon states which have not done so to respond positively to this proposal and to extend the necessary co-operation in the efforts to establish a nuclear weapon-free zone in South Asia.	*In favour* 105 *Against* 0 *Abstentions* 28: Argentina, Australia, Austria, Bhutan, Bulgaria, Burma, Byelorussia, Congo, Cuba, Cyprus, Czechoslovakia, Denmark, France, German Democratic Republic, Greece, Hungary, India, Indonesia, Israel, Lao People's Democratic Republic, Mongolia, Norway, Poland, Singapore, Sweden, Ukraine, USSR, Yugoslavia *Absent or not participating in the vote:* Albania, Angola, Comoros, Democratic Kampuchea, Djibouti, Equatorial Guinea, Grenada, Guinea, Madagascar,[a] Malawi, Samoa, Saudi Arabia, Senegal, Seychelles, South Africa, Viet Nam

Middle East nuclear weapon-free zone

31/71 10 December 1976	Expresses the need for further action to generate momentum towards realization of the establishment of a nuclear weapon-free zone in the Middle East, and urges all parties directly concerned to adhere to the NPT as a means of promoting this objective.	*In favour* 130 *Against* 0 *Abstentions* 1: Israel *Absent or not participating in the vote:* Albania, Angola, Benin, Burma, Cape Verde, Democratic Kampuchea, Guatemala, Guinea, Haiti, Honduras, Libya, Nicaragua, Sao Tome and Principe, Seychelles, South Africa
32/82 12 December 1977	Reiterates its recommendation that, pending the establishment of a nuclear weapon-free zone under an effective system of safeguards, the states concerned should: (*a*) proclaim solemnly and immediately their intention to refrain, on a reciprocal basis, from producing, acquiring or in any other way possessing nuclear weapons and nuclear explosive devices and from permitting the stationing of nuclear weapons in their territory or the territory under their control by any third party; (*b*) refrain, on a reciprocal basis, from any other action that would facilitate the acquisition, testing or use of such weapons or would in any other way be detrimental to the objective of the establishment of a nuclear weapon-free zone in the region under an effective system of safeguards; and (*c*) agree to place all their nuclear activities under International Atomic Energy Agency safeguards. Reaffirms its recommendation to the nuclear weapon states to refrain from any action contrary to the purpose of the present resolution and the objective of establishing, in the region of the Middle East, a nuclear weapon-free zone under an effective system of safeguards and to extend their co-operation to the states of the region in their efforts to promote this objective.	*In favour* 131 *Against* 0 *Abstentions* 1: Israel *Absent or not participating in the vote:* Albania, Angola, Central African Empire, Comoros, Democratic Kampuchea, Djibouti, Equatorial Guinea, Grenada, Guinea, Libya, Madagascar,[a] Malawi, Mauritius,[a] Samoa, Saudi Arabia, Seychelles, South Africa

Indian Ocean as a zone of peace

31/88 14 December 1976	Deeply concerned that there has been an escalation of the military presence of the great powers conceived in the context of great power rivalry in the Indian Ocean, and believing therefore that the implementation of the purposes and objectives of the Declaration of the Indian Ocean as a zone of peace, contained in Resolution 2832 (XXVI) of 16 December 1971, has acquired a new urgency, requests the *Ad Hoc* Committee on the Indian Ocean and the littoral and hinterland states of the Indian Ocean to	*In favour* 106 *Against* 0 *Abstentions* 27: Austria, Belgium, Bulgaria, Byelorussia, Canada, Cuba, Czechoslovakia, Denmark, France, German Democratic Republic, Federal Republic of Germany, Hungary, Ireland, Israel, Italy, Luxembourg, Mongolia, Netherlands, Norway, Pakistan, Poland, Sweden, Turkey, Ukraine, USSR, UK, USA

Resolution no. and date of adoption	Subject and contents of resolution	Voting results
	continue their consultations with a view to formulating a programme of action leading to the convening of a conference on the Indian Ocean.	*Absent or not participating in the vote:* Albania, Angola, Benin, Cape Verde, Congo, Democratic Kampuchea, Equatorial Guinea, Grenada, Guinea-Bissau, Haiti, Lebanon, Seychelles, South Africa
32/86 12 December 1977	Renews the invitation to the great powers and other major maritime users of the Indian Ocean that have not so far seen their way to co-operating effectively with the *Ad Hoc* Committee on the Indian Ocean and the littoral and hinterland states of the Indian Ocean to enter with the least possible delay into consultations with the littoral and hinterland states of the Indian Ocean in pursuance of General Assembly Resolution 3468 (XXX). Decides that, as the next step towards the convening of a conference on the Indian Ocean, a meeting of the littoral and hinterland states of the Indian Ocean be convened in New York at a suitable date. Other states not falling within this category, but which have participated or have expressed their willingness to participate in the work of the *Ad Hoc* Committee, could attend the meeting. Decides to enlarge the composition of the *Ad Hoc* Committee by the addition of Democratic Yemen, Ethiopia, Greece, Mozambique and Oman.	*In favour* 123 *Against* 0 *Abstentions* 13: Belgium, Canada, Denmark, France, Federal Republic of Germany, Ireland, Israel, Italy, Luxembourg, Netherlands, Norway, UK, USA *Absent or not participating in the vote:* Albania, Angola, Comoros, Democratic Kampuchea, Djibouti, Equatorial Guinea, Grenada, Madagascar,[a] Malawi, Samoa, Saudi Arabia, Seychelles, South Africa
	Chemical and biological weapons	
31/65 10 December 1976	Requests the Conference of the Committee on Disarmament to continue negotiations as a matter of high priority, taking into account the existing proposals, with a view to reaching early agreement on effective measures for the prohibition of the development, production and stockpiling of all chemical weapons and for their destruction.	Adopted without vote
32/77 12 December 1977	Requests the CCD to undertake the elaboration of an agreement on effective measures for the prohibition of the development, production and stockpiling of all chemical weapons and for their destruction, taking into account all existing proposals and future	Adopted without vote

	initiatives submitted for its consideration. Invites all states that have not yet done so to accede to the Convention on the prohibition of the development, production and stockpiling of bacteriological (biological) and toxin weapons and on their destruction, as well as to accede to the 1925 Protocol for the prohibition of the use in war of asphyxiating, poisonous or other gases, and of bacteriological methods of warfare, and calls again for strict observance by all states of the principles and objectives of those instruments.	
	Weapons of mass destruction	
31/74 10 December 1976	Requests the Conference of the Committee on Disarmament to continue the negotiations, with the assistance of qualified governmental experts, aimed at working out the text of an agreement on the prohibition of the development and manufacture of new types of weapons of mass destruction and new systems of such weapons.	*In favour* 120 *Against* 1: Albania *Abstentions* 15: Australia, Belgium, Denmark, France, Federal Republic of Germany, Ireland, Israel, Italy, Luxembourg, Netherlands, Spain, Sweden,[a] Uganda, UK, USA *Absent or not participating in the vote:* Angola, Cape Verde, China, Democratic Kampuchea, Guinea, Haiti, Honduras, Sao Tome and Principe, Seychelles, South Africa
32/84 A 12 December 1977	Requests the CCD to continue negotiations aimed at working out the text of an agreement on the prohibition of the development and manufacture of new types of weapons of mass destruction and new systems of such weapons, and, when necessary, specific agreements on this subject; and urges all states to refrain from any action which would impede international talks aimed at working out an agreement or agreements to prevent the use of scientific and technological progress for the development of new types of weapons of mass destruction and new systems of such weapons.	*In favour* 110 *Against* 1: Albania *Abstentions* 25: Australia, Austria, Belgium, Canada, Denmark, France, Federal Republic of Germany, Greece, Iceland, Ireland, Israel, Italy, Ivory Coast, Japan, Luxembourg, Mauritania, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Turkey, UK, USA *Absent or not participating in the vote:* Angola, China, Comoros, Democratic Kampuchea, Djibouti, Equatorial Guinea, Grenada, Madagascar,[a] Malawi, Samoa, Saudi Arabia, Seychelles, South Africa.
32/84 B 12 December 1977	Urges states to refrain from developing new weapons of mass destruction based on new scientific principles; calls upon states to apply scientific discoveries for the benefit of mankind; reaffirms the definition of weapons of mass destruction contained in the resolution of the Commission for Conventional Armaments of 12 August 1948, which defined weapons of mass destruction as	*In favour* 102 *Against* 1: Albania *Abstentions* 28: Austria, Barbados, Benin, Botswana, Bulgaria, Burundi, Byelorussia, Cuba, Czechoslovakia, Egypt, German Democratic Republic, Ghana, Guyana, Hungary, Jamaica, Kenya, Mali, Mauritania, Mongolia, Nigeria, Poland, Sierra

Resolution no. and date of adoption	Subject and contents of resolution	Voting results
	atomic explosive weapons, radioactive material weapons, lethal chemical and biological weapons and any weapons developed in the future which have characteristics comparable in destructive effect to those of the atomic bomb or other weapons mentioned above. Welcomes the active continuation of negotiations relating to the prohibition and limitation of identified weapons of mass destruction, and requests the CCD, while taking into account its existing priorities, to keep under review the question of the development of new weapons of mass destruction based on new scientific principles and to consider the desirability of formulating agreements on the prohibition of any specific new weapons which may be identified.	Leone, Tunisia, Uganda, Ukraine, USSR, United Republic of Tanzania, Upper Volta *Absent or not participating in the vote:* Angola, Brazil, China, Comoros, Democratic Kampuchea, Djibouti, Equatorial Guinea, Grenada, Lao People's Democratic Republic, Madagascar,[b] Malawi, Samoa, Saudi Arabia, Senegal, Seychelles, South Africa, Trinidad and Tobago, Viet Nam
	Environmental means of warfare	
31/72 10 December 1976	Refers the Convention on the prohibition of military or any other hostile use of environmental modification techniques (the text of which is annexed to this resolution) to all states for their consideration, signature and ratification; requests the Secretary-General, as depositary of the Convention, to open it for signature and ratification at the earliest possible date; and expresses the hope for the widest possible adherence to the Convention.	*In favour* 96 *Against* 8: Albania, Ecuador, Grenada, Kenya, Kuwait, Mexico, Panama, Zambia *Abstentions* 30: Argentina, Bahamas, Barbados, Burundi, Chile, Comoros, Congo, Costa Rica, Dominican Republic, Equatorial Guinea, France, Gabon, Gambia, Iraq, Ivory Coast, Jamaica, Malaysia, Mauritius, New Zealand, Pakistan, Paraguay, Peru, Rwanda, Togo, Trinidad and Tobago, Uganda, United Republic of Cameroon, United Republic of Tanzania, Venezuela, Yemen *Absent or not participating in the vote:* Angola, Benin, Cape Verde, China, Democratic Kampuchea, Guatemala, Guinea, Haiti, Honduras, Sao Tome and Principe, Seychelles, South Africa
	Outer space	
31/8 8 November 1976	Invites states which have not yet become parties to the Treaty on principles governing the activities of states in the exploration and use of outer space, including the moon and other celestial bodies; the Agreement on the rescue of astronauts, the return of astro-	Adopted unanimously

	nauts and the return of objects launched into outer space; the Convention on international liability for damage caused by space objects; and the Convention on registration of objects launched into outer space, to give early consideration to ratifying or acceding to those international agreements.	
32/195 20 December 1977	Requests the Secretary-General to undertake research analysing the experience gained in the application of the Treaty on principles governing the activities of states in the exploration and use of outer space, including the Moon and other celestial bodies over the past ten years and showing its importance for the development of international co-operation in the practical application of space technology. Recommends that the Committee on the peaceful uses of outer space should consider at its next session measures to encourage the largest possible number of states to participate in the Treaty.	Adopted by consensus
	Sea-Bed Treaty Review Conference	
32/87 A 12 December 1977	Welcomes the positive assessment by the Review Conference of the effectiveness of the Treaty on the prohibition of the emplacement of nuclear weapons and other weapons of mass destruction on the sea-bed and the ocean floor and in the subsoil thereof since its entry into force; invites all states that have not yet done so, particularly those possessing nuclear weapons or any other types of weapons of mass destruction, to ratify or accede to the Treaty as a significant contribution to international confidence. Affirms its strong interest in avoiding an arms race in nuclear weapons or any other types of weapons of mass destruction on the sea-bed, the ocean floor or the subsoil thereof; requests the CCD—in consultation with the states parties to the Treaty and taking into account the proposals made during the Review Conference and any relevant technological developments—to proceed promptly with the consideration of further measures in the field of disarmament for the prevention of an arms race in that environment; and calls upon all states to refrain from any action which might lead to the extension of the arms race to the sea-bed and the ocean floor.	Adopted without vote

Resolution no. and date of adoption	Subject and contents of resolution	Voting results
	Economic and social consequences of the arms race	
32/75 12 December 1977	Welcomes the up-dated report of the Secretary-General on the economic and social consequences of the arms race and of military expenditures and expresses the hope that it will help to focus future disarmament negotiations on nuclear disarmament and on the goal of general and complete disarmament under effective international control. Decides to submit the report to the General Assembly special session devoted to disarmament and recommends that the conclusions of the report should be taken into account in future disarmament negotiations.	Adopted without vote
	Disarmament and development	
32/88 A 12 December 1977	Endorses the recommendation by the Preparatory Committee for the General Assembly special session devoted to disarmament that the General Assembly should initiate a study on the relationship between disarmament and development, the terms of reference of the study to be determined by the Assembly itself at its special session.	Adopted without vote
	Strengthening of international security	
31/92 14 December 1976 (Resolution on the implementation of the Declaration on the strengthening of international security)	Reaffirms the opposition to any threats or use of force, intervention, aggression, foreign occupation and measures of political and economic coercion which attempt to violate the sovereignty, territorial integrity, independence and security of states. Recommends urgent measures to stop the arms race and to promote disarmament, the dismantling of foreign military bases, the creation of zones of peace and co-operation and the achievement of general and complete disarmament as well as the strengthening of the role of the United Nations, in accordance with the Charter, in order to eliminate the causes of international tensions and ensure international peace, security and co-operation. Invites the	*In favour* 95 *Against* 0 *Abstentions* 17: Australia, Belgium, Canada, France, Federal Republic of Germany, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, Netherlands, Norway, Portugal, Turkey, United Republic of Tanzania, USA *Absent or not participating in the vote:* Albania, Angola, Argentina, Bhutan, Brazil, Cape Verde, Central African Republic, Chad, China, Comoros, Cuba,[a] Democratic Kampuchea, Denmark, Dominican Republic, El Salvador, Equatorial Guinea, Ghana, Greece, Grenada, Guinea,[a] Haiti, Kenya, Kuwait,

	states parties to the Conference on Security and Co-operation in Europe to implement fully and urgently all the provisions of the Final Act.	Lebanon, Madagascar, Paraguay, Sao Tome and Principe, Seychelles, Singapore, Somalia, South Africa, Sweden,[a] UK, Zambia
32/154 19 December 1977 (Resolution on the implementation of the Declaration on the strengthening of international security)	Urges effective measures to put an end to the arms race and to promote disarmament, particularly nuclear disarmament, the creation of zones of peace and co-operation, the withdrawal of foreign military bases and the achievement of tangible progress towards general and complete disarmament under effective international control and the strengthening of the role of the United Nations in this regard. Expresses the hope that further positive results will be achieved at the meeting of representatives of states participating in the Conference on Security and Co-operation in Europe, concerning the full implementation of the Final Act of the Conference, which will be conducive also to the strengthening of world security, bearing in mind the close interrelation of the security of Europe to the security of the Mediterranean, the Middle East and all other regions of the world. Supports the conversion of the Mediterranean into a zone of peace and co-operation in the interests of peace and security.	*In favour* 118 *Against* 2: Israel, USA *Abstentions* 19: Australia, Austria, Belgium, Canada, Denmark, France, Federal Republic of Germany, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Sweden, Turkey, UK *Absent or not participating in the vote:* Albania, Cape Verde, China, Democratic Kampuchea, Djibouti, Gambia, Grenada, Paraguay, Seychelles, South Africa
	Disarmament and détente	
32/155 19 December 1977 (Declaration on the deepening and consolidation of international détente)	Convinced that progress in arms control and disarmament negotiations and the elimination of the threat of war are of great importance for the continued relaxation of tension and for further development of friendly relations among states, declares the determination to consider taking new and meaningful steps aimed at achieving the objective of a cessation of the arms race, in particular the nuclear arms race, and realization of disarmament measures, especially nuclear disarmament, with the ultimate objective of general and complete disarmament under strict and effective international control.	Adopted by consensus
	Disarmament and security	
32/87 C 12 December 1977	Requests the Secretary-General to initiate a study on the inter-relationship between disarmament and international security.	Adopted without vote

Resolution no. and date of adoption	Subject and contents of resolution	Voting results
	Non-use of force	
31/9 8 November 1976	Taking note of the draft world treaty on the non-use of force in international relations, submitted by the USSR, invites member states to examine this draft as well as other proposals and statements made during the consideration of the relevant item.	*In favour* 88 *Against* 2: Albania, China *Abstentions* 31: Australia, Austria, Bangladesh, Belgium, Benin, Canada, Chad, Chile, Denmark, Fiji, France, Federal Republic of Germany, Iceland, Ireland, Israel, Italy, Japan, Malawi, Malta, Mauritania, Netherlands, New Zealand, Norway, Pakistan, Paraguay, Portugal, Sweden, Turkey, UK, United Republic of Cameroon, USA *Absent or not participating in the vote:* Bahamas, Bolivia, Cape Verde, Comoros, Congo,[a] Costa Rica,[a] Democratic Kampuchea, Equatorial Guinea, Gabon, Ghana, Guatemala, Guinea-Bissau, Haiti, Kenya, Lesotho, Liberia, Luxembourg,[b] Oman, Qatar,[a] Sao Tome and Principe, Seychelles, Sierra Leone, South Africa, Uganda
32/150 19 December 1977	Decides to establish a Special Committee on enhancing the effectiveness of the principle of non-use of force in international relations, and instructs the Committee to consider proposals and suggestions submitted by any state, bearing in mind the views expressed during the debate on this item, with the goal of drafting a world treaty on the non-use of force in international relations as well as the peaceful settlement of disputes.	*In favour* 111 *Against* 4: Albania, China, UK, USA *Abstentions* 27: Australia, Austria, Belgium, Canada, Chad, Denmark, France, Federal Republic of Germany, Iceland, Ireland, Israel, Italy, Ivory Coast, Japan, Liberia, Luxembourg, Mauritania, Netherlands, New Zealand, Norway, Pakistan, Portugal, Saudi Arabia, Somalia, Spain, Sweden, Turkey. *Absent or not participating in the vote:* Cape Verde, Democratic Kampuchea, Equatorial Guinea, Gambia, Grenada, Seychelles, South Africa
	Reduction of military budgets	
31/87 14 December 1976	Recalling that in Resolution 3463 (XXX) of 11 December 1975, the General Assembly requested the Secretary-General to prepare, with the assistance of a group of qualified experts, a report containing an analysis and examination in concrete terms of issues regarding a system of international measurement, reporting and	*In favour* 120 *Against* 2: Albania, China *Abstentions* 11: Bulgaria, Byelorussia, Cuba, Czechoslovakia, German Democratic Republic, Hungary, Mongolia, Poland, Uganda, Ukraine, USSR

comparisons of military expenditures, and noting with appreciation the report submitted in response to the mentioned resolution, invites all states to communicate to the Secretary-General their comments with regard to matters covered in the report and in particular: (*a*) their views and suggestions on the proposed standardized reporting instrument contained in the report; (*b*) any information they may wish to convey on their military expenditure accounting practices, including a description of methods currently in use; and (*c*) suggestions and recommendations concerning possible practical approaches for the further development and operation of a standardized reporting system.

Absent or not participating in the vote: Angola, Benin, Cape Verde, Congo, Democratic Kampuchea, Equatorial Guinea, Grenada, Guinea-Bissau, Haiti, Lebanon, Oman, Seychelles, South Africa

32/85
12 December 1977

Recognizing the value of the availability of a satisfactory instrument for standardized reporting on the military expenditures of member states, particularly of the states permanent members of the Security Council, as well as any other state with comparable military expenditures, requests the Secretary-General to ascertain those states which would be prepared to participate in a pilot test of the proposed reporting instrument and to report on this to the General Assembly at its special session devoted to disarmament.

In favour 120
Against 2: Albania, China
Abstentions 13: Bulgaria, Byelorussia, Cuba, Czechoslovakia, German Democratic Republic, Hungary, Mauritania, Mongolia, Poland, Swaziland, Uganda, Ukraine, USSR
Absent or not participating in the vote: Angola, Comoros, Democratic Kampuchea, Djibouti, Equatorial Guinea, Grenada, Lao People's Democratic Republic, Madagascar,[a] Malawi, Samoa, Saudi Arabia, Seychelles, South Africa, Viet Nam

Regional disarmament

32/87 D
12 December 1977

Invites all states to inform the Secretary-General of their views and suggestions concerning the regional aspects of disarmament, including measures designed to increase confidence and stability as well as means of promoting disarmament on a regional basis. Decides to consider the desirability of requesting the Secretary-General to prepare, with the collaboration of a special group of qualified governmental experts, a comprehensive study of all the regional aspects of disarmament, bearing in mind, *inter alia*, the decisions and recommendations of the General Assembly special session devoted to disarmament.

In favour 91
Against 0
Abstentions 40: Algeria, Argentina, Bahamas, Bahrain, Benin, Bhutan, Brazil, Cape Verde, Congo, Cuba, Democratic Yemen, Egypt, India, Indonesia, Iraq, Jamaica, Jordan, Kuwait, Lebanon, Malaysia, Mauritania, Morocco, Mozambique, Nigeria, Oman, Peru, Philippines, Qatar, Sao Tome and Principe, Sri Lanka, Sudan, Syria, Thailand, Trinidad and Tobago, Tunisia,[a] United Arab Emirates, United Republic of Tanzania, Upper Volta, Yemen, Yugoslavia
Absent or not participating in the vote: Albania, Angola, China, Comoros, Democratic Kampuchea, Djibouti, Equatorial Guinea, Ethiopia, Grenada, Lao People's Democratic Republic, Libya, Madagascar,[b] Malawi, Samoa, Saudi Arabia, Seychelles, South Africa, Viet Nam

Resolution no. and date of adoption	Subject and contents of resolution	Voting results
	Human rights in armed conflicts	
31/19 24 November 1976	Calls upon all parties to armed conflicts to acknowledge and to comply with their obligations under the humanitarian instruments and to observe the international humanitarian rules which are applicable, in particular the Hague Conventions of 1899 and 1907, the Geneva Protocol of 1925 and the Geneva Conventions of 1949.	Adopted by consensus
31/64 10 December 1976	Noting that the discussions and proposals regarding the prohibition or restriction of the use for humanitarian reasons of certain weapons have focused on napalm and other incendiary weapons, on indiscriminate methods of using land mines, on perfidious weapons and weapons which rely for their effect upon fragments invisible on X-ray, on certain types of small-calibre projectile which may be especially injurious and on certain blast and fragmentation weapons, invites the Diplomatic Conference on the reaffirmation and development of international humanitarian law applicable in armed conflicts to accelerate its consideration of the use of specific conventional weapons, including any which may be deemed to be excessively injurious or to have indiscriminate effects, and to do its utmost to agree on possible rules prohibiting or restricting the use of such weapons.	Adopted without vote
32/44 8 December 1977	Welcomes the successful conclusion of the Diplomatic Conference on the reaffirmation and development of international humanitarian law applicable in armed conflicts which has resulted in two Protocols additional to the Geneva Conventions of 12 August 1949, adopted by the Diplomatic Conference on 8 June 1977, namely, Protocol I relating to the protection of victims of international armed conflicts and Protocol II relating to the protection of victims of non-international armed conflicts. Notes the recommendation, approved by the Diplomatic Conference, that a special conference be called on the issue of the prohibition or restriction of the use for humanitarian reasons of	Adopted by consensus

	specific conventional weapons. Urges states to consider without delay the matter of signing and ratifying or acceding to the two Protocols additional to the Geneva Conventions of 1949; and calls upon all states to take effective steps for the dissemination of humanitarian rules applicable in armed conflicts.	
32/152 19 December 1977	Decides to convene in 1979 a United Nations conference with a view to reaching agreements on prohibitions or restrictions on the use of specific conventional weapons, including those which may be deemed to be excessively injurious or have indiscriminate effects, taking into account humanitarian and military considerations, and on the question of a system of periodic review of this matter and for consideration of further proposals. Decides to convene a UN preparatory conference for the conference referred to above and requests the Secretary-General to transmit invitations to all states and parties invited to attend the Diplomatic Conference on the reaffirmation and development of international humanitarian law applicable in armed conflicts.	*In favour* 115 *Against* 0 *Abstentions* 21: Belgium, Bulgaria, Byelorussia, Canada, Cuba, Czechoslovakia, France, German Democratic Republic, Federal Republic of Germany, Hungary, Israel, Italy, Japan, Luxembourg, Mongolia, Poland, Turkey, Ukraine, USSR, UK, USA *Absent or not participating in the vote:* Albania, Burma,[a] Cape Verde, China, Democratic Kampuchea, Djibouti, Gambia, Grenada, Guinea, Lao People's Democratic Republic, Seychelles, South Africa, Viet Nam
	Disarmament Decade	
31/68 10 December 1976	Deplores the meagre achievements of the Disarmament Decade in terms of truly effective disarmament and arms limitation agreements, and the detrimental effects on world peace and economy of the continuing unproductive and wasteful arms race, particularly the nuclear arms race; calls again upon all states, as well as the organs concerned with disarmament issues, to place at the centre of their preoccupations the adoption of effective measures for the cessation of the arms race, especially in the nuclear field, and for the reduction of military expenditures; and to make sustained efforts with a view to achieving progress towards general and complete disarmament. Calls upon member states and the Secretary-General to intensify their efforts in support of the link between disarmament and development, so as to promote disarmament negotiations and to ensure that the human and material resources freed by disarmament are used to promote economic and social development, particularly in the developing countries. Urges the CCD to adopt a comprehensive programme dealing with all aspects of the problem of the cessation of the arms race and general and complete disarmament	Adopted without vote

Resolution no. and date of adoption	Subject and contents of resolution	Voting results
	under strict and effective international control, and calls upon non-governmental organizations and international institutions and organizations to further the goals of the Disarmament Decade.	
32/80 12 December 1977	Calls upon member states and the Secretary-General to intensify their efforts in support of the link between disarmament and development envisaged in General Assembly Resolution 2602 E (XXIV) on the Disarmament Decade, so as to promote disarmament negotiations and to ensure that the human and material resources freed by disarmament are used to promote economic and social development, particularly in the developing countries. Urges that the unparalleled technical possibilities now available to mankind should be exploited for the purposes of combating poverty, ignorance, disease and hunger throughout the world.	*In favour* 130 *Against* 0 *Abstentions* 1: Sierra Leone[a] *Absent or not participating in the vote:* Albania, Angola, Central African Empire, China, Comoros, Democratic Kampuchea, Djibouti, Equatorial Guinea, Grenada, Guinea, Madagascar,[a] Malawi, Mauritius,[a] Samoa, Saudi Arabia, Seychelles, Somalia, South Africa
	World Disarmament Conference	
31/190 21 December 1976	Requests the *Ad Hoc* Committee on the World Disarmament Conference to maintain close contact with the representatives of the states possessing nuclear weapons in order to remain currently informed of their respective attitudes, as well as to consider any relevant comments and observations which might be made to the Committee.	Adopted without vote
32/89 12 December 1977	Requests the *Ad Hoc* Committee on the World Disarmament Conference to submit to the General Assembly at its special session devoted to disarmament a special report on the state of its work and deliberations.	Adopted without vote
	United Nations role in disarmament	
31/90 14 December 1976	Having considered the report of the *Ad Hoc* Committee on the review of the role of the United Nations in the field of disarma-	Adopted without vote

ment, which contains agreed proposals with regard to the following subjects: (*a*) improved methods of work of the First Committee in disarmament matters; (*b*) relationship between the General Assembly and other United Nations bodies in the field of disarmament; (*c*) role of the United Nations Disarmament Commission; (*d*) role of the United Nations in providing assistance on request in multilateral and regional disarmament negotiations; (*e*) relationship between the General Assembly and the CCD; (*f*) increased use of in-depth studies of the arms race, disarmament and related matters; (*g*) improvement of existing United Nations facilities for the collection, compilation and dissemination of information on disarmament issues, in order to keep all governments, as well as world public opinion, properly informed on progress achieved in the field of disarmament; (*h*) assistance by the Secretariat, on request, to states parties to multilateral disarmament agreements in their duty to ensure the effective functioning of such agreements, including appropriate reviews; and (*i*) strengthening of the resources of the Secretariat, endorses the proposals and requests the Secretary-General to implement as soon as possible the measures recommended.

32/87 E 12 December 1977	Emphasizes the need for a disarmament periodical presenting in highly readable form current facts and developments in the field of disarmament, such as summaries of new proposals, of important relevant statements and communiqués and of in-depth studies undertaken by the United Nations or the CCD, annotated bibliographies and brief summaries of important books and articles on disarmament questions and related matters, and requests the Secretary-General to initiate the publication of a disarmament periodical in all working languages of the General Assembly.	Adopted without vote

UN General Assembly special session on disarmament

31/189 B 21 December 1976	Decides to convene a General Assembly special session devoted to disarmament, to be held in New York in May/June 1978, and to establish a preparatory committee, composed of 54 member states, with the mandate of examining all relevant questions relating to the special session, including its agenda.	Adopted without vote

Resolution no. and date of adoption	Subject and contents of resolution	Voting results
32/88 B 12 December 1977	Endorses the report of the Preparatory Committee for the General Assembly special session devoted to disarmament and the recommendations contained therein for the special session to be held between 23 May and 28 June 1978. Requests the Preparatory Committee to continue its work in order to prepare a draft final document or documents for consideration and adoption by the General Assembly at its special session and to submit to the Assembly its final report.	Adopted without vote

[a] Later advised the Secretariat it had intended to vote in favour.
[b] Later advised the Secretariat it had intended to abstain.
[c] The vote of the delegation of Nigeria should have been recorded as being in favour.
[d] New Zealand later advised the Secretariat it had intended to abstain.

IV. Chronology of major events concerning disarmament and related issues

January–December 1977

21 February The agreement between Belgium, Denmark, the Federal Republic of Germany, Ireland, Italy, Luxembourg, the Netherlands, the European Atomic Energy Community (Euratom) and the International Atomic Energy Agency (IAEA), in implementation of Article III of the NPT, enters into force.

21 March In a speech made at the Soviet Trade Union Congress, the General Secretary of the Central Committee of the Soviet Communist Party states that the USSR will not increase the numerical strength of its troops in Central Europe until an agreement is reached on the reduction of armed forces and armaments in that area, provided that NATO forces in the area are not increased either.

31 March A communiqué, issued upon the conclusion of US–Soviet talks in Moscow, states that questions related to the completion of preparations for a new agreement on the limitation of strategic offensive arms occupied a central place in the talks, and that the discussion of these issues will continue. The USA and the USSR also agree that bilateral contacts, including meetings of experts, will be held to discuss other questions concerning the limitation of armaments and disarmament.

31 March At a press conference in Moscow, the Soviet Foreign Minister rejects the US proposals for the reduction of nuclear delivery vehicles as one-sided, and accuses the USA of unilaterally revising the 1974 US–Soviet Vladivostok agreement. He states that the USSR is ready for constructive negotiations with the USA, provided that the US government takes into consideration the security interests of the Soviet Union and its allies, and does not try to obtain unilateral advantages.

7 April In a statement on nuclear power policy, the US President announces that the USA will continue to embargo the export of equipment or technology that would permit uranium enrichment and chemical reprocessing. It will explore the establishment of an international nuclear fuel cycle evaluation programme aimed at developing alternative fuel cycles and a variety of international and US measures to assure access to nuclear fuel supplies and spent fuel storage for nations sharing common non-proliferation objectives.

27 April In a message to Congress, the US President asks for an increase in the effectiveness of international safeguards and controls on peaceful nuclear activities to prevent further proliferation of nuclear explosive devices, the establishment of common international sanctions to prevent such proliferation, an effort to encourage nations which have not ratified the NPT to do so at the earliest possible date, and the adoption of programmes to enhance the reliability of the USA as a supplier of nuclear fuel. He also says that, as a continuing condition of US supply, the USA will require that recipients have all their nuclear activities under IAEA safeguards.

8 May At a meeting in London, heads of government of Canada, the Federal Republic of Germany, France, Italy, Japan, the UK and the USA, state that their objective is to meet the world's energy needs and to make peaceful use of nuclear energy widely available, while avoiding the danger of the spread of nuclear weapons. They are also agreed that, in order to be effective, non-proliferation policies should, so far as possible, be acceptable to both industrialized and developing countries alike.

11 May Participants in the North Atlantic Council meeting, held in London, welcome the efforts of the USA to negotiate with the USSR an agreement to limit and reduce strategic arms which takes into account allied interests. With respect to the talks on mutual force reductions in Europe, they call for a positive response to the additional offer they made to the Warsaw Treaty Organization (WTO) countries in December 1975, and reaffirm their overall objective of establishing approximate parity in ground forces in the form of a common collective ceiling for ground force manpower and the reduction of the disparity in tanks, which would ensure undiminished security at a lower level of forces.

18 May The NATO Defence Planning Committee, meeting in ministerial session in Brussels, reaffirms the Western position in the Vienna negotiations and the importance they attach to the principle that NATO forces be maintained and not reduced except in the context of a mutual and balanced force reduction agreement with the WTO, which must in no way diminish the collective security of the NATO Alliance.

18 May The UN Secretary-General opens for signature the Convention on the prohibition of military or any other hostile use of environmental modification techniques (ENMOD Convention).

26 May The US President signs Additional Protocol I of the Treaty of Tlatelolco, under which the extra-continental or continental states, which are internationally responsible for territories lying within the limits of the geographical zone established by the Treaty, undertake to apply the statute of military denuclearization to such territories.

26 May The foreign ministers of the states members of the WTO, meeting in Moscow, reiterate their proposal for an agreement among the participants in the Conference on Security and Co-operation in Europe on the non-first use of nuclear weapons against each other.

15 June The Commonwealth heads of government, meeting in London, express serious concern at the level of naval activities of the great powers and the establishment and expansion of the military installations in the Indian Ocean area. They call upon the great powers to pursue urgent contacts between themselves with a view to eliminating great-power rivalry and tension from the Indian Ocean. They express the hope that the great powers and the major maritime users of the Indian Ocean will actively co-operate with the littoral and hinterland states and with the *Ad Hoc* Committee of the United Nations in the context of on-going consultations for convening a conference on the Indian Ocean with a view to implementing the UN Declaration on the Indian Ocean as a zone of peace.

20 June–1 July The Review Conference of the parties to the Sea-Bed Treaty takes place in Geneva.

22 June In a French–Soviet declaration on non-proliferation of nuclear weapons, both states reaffirm their determination to exert efforts aimed at preventing the proliferation of such weapons, and express their readiness to contribute to the improvement of IAEA controls. They also support the working out of a convention for the physical protection of nuclear materials against unauthorized use or application.

30 June The South-East Asia Treaty Organization (SEATO) is dissolved, in implementation of a decision made by its Ministerial Council in September 1975.

19 September–7 October The Ninth Consultative Meeting of the signatories to the 1959 Antarctic Treaty is held in London.

21 September The 15-nation Nuclear Suppliers Group (the so-called London Club) agrees on guidelines for nuclear transfers.

27 September Addressing the UN General Assembly the Soviet Foreign Minister states that the USSR is ready, in agreement with the UK and the USA, not to conduct underground nuclear weapon tests during a certain period, even before the remaining nuclear powers join the future agreement.

4 October The follow-up Conference on Security and Co-operation in Europe opens in Belgrade.

10 October The British–Soviet Agreement on the prevention of an accidental outbreak of nuclear war is signed in Moscow.

11–12 October The NATO Nuclear Planning Group, meeting in ministerial session in Bari, Italy, discusses the current situation in SALT and other arms control negotiations. Views are also exchanged on reduced-blast/enhanced-radiation weapons in the context of the modernization of theatre nuclear forces.

21 October In a speech made in Moscow, the Chairman of the Presidium of the Supreme Soviet of the USSR suggests that, in the context of the Final Act of the Conference on Security and Co-operation in Europe, an agreement be reached not to hold military exercises above a certain level, say, 50 000–60 000 men.

26 October In a joint Indian–Soviet Declaration, both sides favour the rapid conclusion of a treaty on the complete and general prohibition of nuclear weapon tests as well as agreements banning the development and manufacture of new types and systems of weapons of mass destruction and on the prohibition and destruction of chemical weapons.

2 November In a speech made in Moscow, the Chairman of the Presidium of the Supreme Soviet of the USSR proposes that agreement be reached on a simultaneous halt in the production of nuclear weapons by all states, and expresses Soviet readiness to reach agreement on a moratorium covering nuclear explosions for peaceful purposes, together with a ban on all nuclear weapon tests for a definite period.

4 November The UN Security Council decides that all states shall cease forthwith any provision to South Africa of arms and related material of all types.

4–21 November A special session of the US–Soviet Standing Consultative Commission is held in Geneva to review the 1972 ABM Treaty. The parties agree that the Treaty is operating effectively and requires no amendment at this time.

8–9 December Ministers participating in the North Atlantic Council meeting in Brussels review the state of negotiations in Vienna and indicate the importance they attach to the inclusion of associated measures in an agreement on mutual and balanced force reductions in Central Europe. They stress the need for a genuine data discussion as a basis for further progress in these negotiations. They also affirm their intention to play a constructive role in the UN General Assembly special session devoted to disarmament.

12 December The UN General Assembly requests the Preparatory Committee to prepare a draft final document or documents for consideration and adoption by the 1978 UN General Assembly special session devoted to disarmament.

12 December Protocols I and II, additional to the Geneva Conventions of 12 August 1949, as adopted by the Diplomatic Conference on the reaffirmation and development of international humanitarian law applicable in armed conflicts, are opened for signature.

22 December The Indian Prime Minister states in Parliament that India is committed not to explode any nuclear device for peaceful purposes or make any nuclear weapons.

24 December In an interview with a *Pravda* correspondent, the Chairman of the Presidium of the Supreme Soviet of the USSR proposes a mutual renunciation of the production of the neutron bomb.

INDEX

B

C

G

J

K

L

M

N

Q

R

S

V

Y

Z

Errata

World Armaments and Disarmament, SIPRI Yearbook 1978

Page 80, lines 8–9.	Read "a West German firm, signed with the Zaire government" for " . . . signed with the West German government".
Page 438, Table 15.3.	Read "Poseidon C-3" for "Poseidon C-4". Read "Polaris A-3" for "Polaris C-3".
Pages 442–443, Figure 15.8.	Read "Poseidon C-4" for "Trident D-5". Read "Range *(nautical miles)*" for "Range *(km)*".
Page 444, Table 15.5.	Read "Poseidon C-3 and C-4" for "Poseidon C-4".

World Armaments and Disarmament
SIPRI Yearbook 1978

This is the ninth SIPRI Yearbook. The aim is to bring together information on world armaments and military expenditure and developments in efforts made to limit or reduce them. The first eight Yearbooks attracted world-wide attention and were used extensively in the United Nations, the Geneva disarmament negotiations and in national political circles as an authoritative source of information.

The *SIPRI Yearbook 1978* concentrates on new topics, in three areas:

1977, developments of the year

Developments in armaments and disarmament, the nuclear fuel cycle, the military impact on the human environment, and the arms race in space

Developments in world armaments

World military expenditure, arms production, and arms trade in 1977

Developments in arms control and disarmament

Disarmament and development, a comprehensive test ban, the destruction of chemical warfare agents, the prohibition of new weapons, mutual force reductions in Europe, the Strategic Arms Limitation Talks, and developments in arms control and disarmament

Press comments on the SIPRI Yearbook 1977

"... the main reference work on the arms race and disarmament efforts on a global scale."

Le Monde Diplomatique (France)

"... the most copious and reliable fund of facts and figures drawn from non-secret sources, relating to armaments and disarmament. It is hard to imagine anyone with an interest in this subject, politician, diplomat, political scientist, expert or journalist, being able to dispense with the yearbooks."

Polish Perspectives (Poland)

"The institute gives a synoptic view of world armaments and military expenditures as well as a description of the efforts made to control the arms build-up."

Afrique Nouvelle (Senegal)

"Of all the large international literature on armaments and disarmament, the SIPRI Yearbook—a product of independent research—is one of the most reliable sources of information and knowledge."

Journal of Peace Research (Norway)

"Most of what the public might want to know, and much that it would probably prefer to ignore, about the state of the world's armies is published in the latest edition of the SIPRI Yearbook."

Middle East Economic Digest (England)

ALERE FLAMMAM

Taylor & Francis Ltd
10-14 Macklin Street
London WC2B 5NF