

11. The military uses of outer space

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I. Introduction

Since the dawn of the space age, outer space has been regarded as the ultimate high ground from which the earth below could be controlled. Reflecting this view, the cold war space race between the superpowers was a natural corollary of the arms race. At the end of 2001, the one dominant power, the United States, had nearly 110 operational military spacecraft—well over two-thirds of all the military spacecraft orbiting the earth. Russia was a distant second, with about 40. The rest of the world had only about 20 satellites in orbit.

This chapter presents the current space programmes and provides an inventory of military spacecraft that were operational at the end of 2001. While there are various approaches to research on military space activities, an inventory provides a foundation for research on nuclear and conventional weapons. In the case of military space systems, however, an inventory is more difficult to construct and thus all the more important.

In the path-breaking chapters on military satellites published in the SIPRI Yearbook in the 1970s, the tables listed the satellites that had been launched over the course of the year.¹ At that time, when satellite launches were frequent and operational lifetimes were brief, this focus on annual launches was appropriate. Over time, however, annual launch rates have declined and operating lifetimes have been extended, so today it is meaningful to report on the spacecraft in operation.

The counting of operational military spacecraft poses greater challenges than those encountered in compiling inventories of, for example, nuclear weapons or naval forces. There is an abundance of literature on weapons, but the literature on military space activities is sparse.² Part of the reason for this has to do with normal secrecy and part with the relative invisibility of satellites in orbit. Fortunately, many spacecraft (even some highly classified satellites) are visible to amateur observers, a rich source of data.

¹ See, e.g., [Jasani, B.], 'Military satellites', *World Armaments and Disarmament: SIPRI Yearbook 1977* (Almqvist & Wiksell International: Stockholm, 1977), pp. 103–79; and [Jasani, B.], 'Military satellites', *World Armaments and Disarmament: SIPRI Yearbook 1978* (Taylor & Francis: London, 1978), pp. 69–130. See also Pike, J., Lang, S. and Stambler, E., 'Military use of outer space', *SIPRI Yearbook 1992: World Armaments and Disarmament* (Oxford University Press: Oxford, 1992), pp. 121–46.

² See Mehuron, T. A., '2001 Space Almanac', *Air Force Magazine*, Aug. 2001, pp. 29ff. This source provides the most readily accessible information, although it is apparently focused on nominal design constellation rather than actual operable spacecraft. One of the databases provided by Analytical Graphics for use with the Satellite Toolkit software, available at URL <<http://www.stk.com>>, is represented as consisting of 'operational' spacecraft, although close examination suggests that many spacecraft that are no longer operable are included in this database.

The most difficult task is to determine the lifetime of satellites. In the 1960s, the end of the operational life of a spacecraft was generally known since the satellite would burn up upon re-entering the earth's atmosphere. Today, a sizeable fraction of the 'operable' military spacecraft in orbit are not currently 'operational' but could be put into service at short notice. Thus it is not sufficient to count only the nominal constellation; it is also necessary to include in the inventory all the back-up, spare, residual, reserve and other operable spacecraft that form the total space order of battle.

Even this inventory of operable military spacecraft fails to capture the essence of military space power, which ultimately resides not in the spacecraft in orbit but in the user equipment on the ground and the integration of this equipment with terrestrial military forces. The increase in the number of US military spacecraft in orbit since the 1991 Persian Gulf War is modest compared to the revolutionary increase in the number, diversity and capabilities of terrestrial user equipment sets. Somewhat less tangible but equally important changes in doctrine, procedures and organization also contribute to translating satellites in space into military power on earth.

Sections II–IV of this chapter review the satellite programmes and military applications of the United States, Russia and all other countries. Section V discusses the companies that operate commercial satellites and their military uses. Section VI reports on the efforts to control the arms race in outer space in the Geneva-based Conference on Disarmament (CD) and section VII on the space-based systems for ballistic missile defence (BMD). Section VIII presents the main findings of this chapter, and section IX contains tables of the operational military satellites in orbit as of 31 December 2001.

II. The United States

Space operations are one of the distinctive attributes of the United States. While a few other countries conduct military space programmes of some significance, at present no other country can rival or contest US space dominance or the advantages this provides to US terrestrial military operations. Modern precision warfare is largely an artefact of the system of systems that combines intelligence, communications, navigation and other military space systems. While other countries may deploy tanks, ships and aircraft that are not individually inferior to their US counterparts, no other country can tie all these various platforms together, using military space systems, into a single, integrated precision-warfare system of systems.

US security managers are acutely aware of the fact that the advantages that accrue from this military space prowess are simultaneously a potential source of vulnerability. This awareness was reflected in a report issued at the outset of the George W. Bush Administration, produced by a commission headed by the incoming Secretary of Defense, Donald Rumsfeld:

we know from history that every medium—air, land and sea—has seen conflict. Reality indicates that space will be no different. Given this virtual certainty, the U.S. must develop the means both to deter and to defend against hostile acts in and from space. This will require superior space capabilities. . . . the U.S. has not yet taken the steps necessary to develop the needed capabilities and to maintain and ensure continuing superiority. . . . The relative dependence of the U.S. on space makes its space systems potentially attractive targets. . . . If the U.S. is to avoid a ‘Space Pearl Harbor’ it needs to take seriously the possibility of an attack on U.S. space systems.³

At the risk of over-simplification, it can be said that both proponents and critics of US space power would probably agree on a few core propositions. The USA enjoys a global preponderance of conventional military power that is unrivalled in human history. Its power-projection capabilities are uniquely enabled by military space systems. The Bush Administration is committed to ensuring this dominance for the USA and denying it to other countries. Ballistic missile defence, much of it based in space or dependent on space systems, is a critical element of ‘full-spectrum dominance’ to the extent that it denies adversaries the opportunity to offset US conventional supremacy through the resort to weapons of mass destruction. Of course, proponents and critics may differ as to the possibility and desirability of the realization of this vision.

Communications satellites

The USA maintains several geostationary communications satellite networks, which have been used extensively to support US military operations in the Balkans, Afghanistan and other areas.⁴ With the US military increasingly focused on power projection in relatively undeveloped theatres of operation, the ability to rapidly implement a dense communications network using satellite systems has become essential.

US satellite systems, as those of other countries, operate on several different bands, each with distinct advantages. Ultra-high frequency (UHF) satellites operate on 225–400 megahertz (MHz) and provide simple, low-cost communications, although on a relatively low bandwidth. Super-high frequency (SHF) satellites, operating on the X-band at 7.25–8.4 gigahertz (GHz), are the backbone high-bandwidth fixed and transportable networks. Extremely-high-frequency (EHF) satellites, which uplink in the V-band on 43–45 GHz and downlink on the K-band at 20.2–21.2 GHz, can support both high bandwidth and highly mobile users. Although authorized for commercial rather than governmental services, some military applications have been found for C-band satellites, which downlink at 3.6–4.2 GHz.

³ *Report of the Commission to Assess United States National Security, Space Management and Organization*, 11 Jan. 2001, Executive Summary, available at URL <<http://www.defenselink.mil/pubs/space20010111.html>>. To avoid the appearance that this report represented official policy, however, Rumsfeld resigned as chairman of the commission a few days before the report was issued.

⁴ Friend, T., ‘Search for bin Laden extends to earth orbit’, *USA Today*, 5 Oct. 2001, p. 9A.

EHF capabilities consist primarily of the Milstar advanced communications satellites, designed during the 1980s to provide anti-jam, low probability of intercept/detection communications for mobile ground terminals on vehicles, ships, submarines and aircraft. Two Block 1 spacecraft were launched in 1994 and 1995. They carried the Low Data Rate (LDR) payload, which supported 192 channels with data rates of 75–2400 bits per second (bps).

The Milstar programme was significantly restructured after the end of the cold war to improve support to tactical users, who had greater bandwidth requirements than those originally established for strategic nuclear users. The modified Block 2 spacecraft added the Medium Data Rate (MDR) payload, which supports data rates of 4800 bps to 1.544 megabits per second (Mbps) per channel, representing a sixfold increase in aggregate data throughput capacity. The first Block 2 Milstar satellite was launched on 30 April 1999 atop a Titan IVB booster. Because of a malfunction in the Centaur upper stage of the booster, the spacecraft was placed into a very low, useless orbit (740 km by 5000 km) and the Milstar satellite was declared a complete loss on 4 May 1999. On 27 February 2001 another Milstar Block 2 was successfully launched by a Titan 4/Centaur booster from Cape Canaveral.⁵ The third Block 2 Milstar spacecraft was planned for launch in January 2002. The final Milstar is planned for launch in November 2002 to replace Milstar 1.

When the Milstar programme was restructured in 1992, the requirement for Milstar to provide polar EHF coverage was dropped. In July 1995 an interim Polar Adjunct programme was initiated to fly a modified EHF payload from the Navy's UHF Follow-On (UFO) system on a classified host satellite. The first Hosted Polar Package was launched in November 1997, apparently on USA 136 (believed to be a TRUMPET signals intelligence satellite). The last two will be available in fiscal year (FY) 2003 and FY 2006.⁶ EHF packages were also carried on-board FLTSAT-7 and FLTSAT-8, launched in the late 1980s and apparently still in service.

The Global Broadcast Service (GBS) is a US Air Force-led joint programme to implement a high-capacity broadcast system providing continuous, one-way, high-speed, high-volume transmission of classified and unclassified data and imagery to US forces. The GBS programme is intended to reduce the dependence of the US Department of Defense (DOD) on expensive leased commercial satellite communications. The GBS transponders are hosted on the US Navy's UFO satellites, replacing the SHF payload beginning with UFO F8, launched in 1998. The GBS package includes four 24-Mbps military Ka-band (30/20 GHz) transponders.

⁵ Chuter, A., 'Milstar gets new capability to boost military comms', *Flight International*, 6 Mar. 2001.

⁶ US Department of Defense, Defense Technical Information Center (DTIC), 0603432F, Polar MILSATCOM (Space), RDT&E Budget Item Justification Sheet (R-2 Exhibit), June 2001. The 'R-2 Exhibit' documents are the highly detailed descriptions of DOD programmes submitted to the Congress in support of the annual budget request and as such represent the most authoritative source of information on current programmes. They are available on the DTIC Internet site at URL <<http://www.dtic.mil>>.

Advanced EHF (AEHF) is the follow-on satellite communications system to replenish the existing Milstar 1/2 (LDR/MDR) satellite constellations.⁷ The AEHF system will be compatible with existing EHF terminals and will provide a tenfold increase in communications capacity relative to Milstar 2. It will provide an increase in single-service capability from 1.5 Mbps to 8 Mbps, increase the number of coverage areas, and retain anti-jam and low-probability-of-intercept features.⁸ In November 2001 a team of Lockheed Martin and TRW was awarded the contract for the AEHF programme, with an initial launch planned for early 2006.⁹ This launch date represented a two-year delay from the originally projected date of 2004, and the programme's cost had risen from \$2.7 billion to \$3.7 billion.¹⁰ The full four-satellite AEHF constellation is planned to be operational by 2010.

SHF satellite communications programmes include the Defense Satellite Communications System (DSCS), the DSCS Service Life Extension Program (SLEP), the Wideband Gapfiller Satellite (WGS) System and the Advanced Wideband System (AWS) satellites. The SHF satellite systems are undergoing a transition from old-technology DSCS III satellites to the more advanced DSCS SLEP and WGS satellites; this began in 1999 and will continue until 2005. The population of SHF users is growing at a rapid pace.¹¹

The DSCS is the backbone of the US national security satellite communications system, providing secure voice and high data rates in the SHF band. The DSCS supports communications for global command and control, crisis management, intelligence and early-warning data relay, and diplomatic traffic for the ground mobile forces of all the military services. The constellation consists of five primary satellites (normally the most recent launches) dispersed along the equator for global coverage, as well an equal number of older 'residual' spacecraft that provide back-up coverage. When an older residual satellite is replaced at its location by a newer satellite, it is muted and sent into a super-synchronous orbit.

The DSCS SLEP will upgrade payloads on the last four DSCS satellites and provide up to five times the data throughput compared to the original DSCS III satellites. DSCS III B-8, the first SLEP satellite, was launched in January 2000. B-11, the second of four SLEP satellites, was successfully launched in October 2000 and was operating at 12° West by January 2001. DSCS III B-4 was retired in 2000, and A-2 and B-5 were scheduled for final retirement in mid-2002. DSCS III B-6 (SLEP) was planned for launch in May 2002, with A-3, the final SLEP spacecraft, scheduled for launch in May

⁷ Satellite Communications (Space) Program Element: 0303109N Exhibit R-2, FY 2002 RDT&E, Navy Budget Item Justification, June 2001.

⁸ Satellite Communications (Space) Program Element: 0303109N (note 7).

⁹ Merle, R., 'Lockheed, TRW win US satellite contract', *Washington Post*, 20 Nov. 2001, p. E05; and Gildea, K., 'Boeing pulls out of advanced extremely high frequency satellite program', *C4I News*, 29 Nov. 2001.

¹⁰ Schneider, G., 'New satellite system hit with delays', *Washington Post*, 15 Aug. 2001, p. E01.

¹¹ Satellite Communications (Space) Program Element: 0303109N (note 7).

2003.¹² The SLEP will extend the life of DSCS satellites until the Advanced Wideband System can be orbited.

The new WGS satellites will provide high-data-rate military satellite communications in accordance with the Joint Space Management Board's Military Satellite Communications (MILSATCOM) Architecture of August 1996. This programme was conceived to fill a short-term 'bandwidth gap' in military communications needs. The first WGS launch is scheduled for early 2004, with the remaining two launches scheduled for 2005. These dual-frequency WGS satellites will provide two-way X-band service (now provided by the DSCS), one-way Ka-band capabilities (now provided by the GBS) and a new high-capacity two-way Ka-band service.¹³

UHF communications are hosted on a wide variety of spacecraft, ranging from dedicated satellites to classified packages on objects that are supposedly 'space junk'.¹⁴

The US Navy, Air Force, Army and DOD share the Fleet Satellite Communication (FLTSATCOM) system, which provides reliable and secure communications for ships and submarines at sea, aircraft and military ground units throughout the world. Primarily intended to support communications between naval aircraft, ships and submarines, FLTSATCOM also supports the Strategic Command and the national command authority network. Fully operational since January 1981, the FLTSATCOM system has three satellites in geosynchronous orbit, all in reserve status.¹⁵

The UHF Follow-On communications satellite constellation fulfils DOD worldwide UHF communications requirements. The FLTSATCOM constellation has been largely replaced by the UFO spacecraft. The current constellation will be approaching the end of its design lifetime in 2003. One additional UFO spacecraft (F11) is planned to be launched in 2003. Even with this launch, the UFO constellation is expected to require phased replacement starting in 2007.

The Mobile User Objective System (MUOS) programme is the next-generation DOD advanced narrow-band UHF communications satellite constellation. It is intended to address the exponential growth of narrow-band communications demands.¹⁶

In addition to these overt military communications systems, the National Reconnaissance Office (NRO) operates a parallel network of less visible satellite communications systems to support the global collection and dissemination of intelligence data.

¹² Defense Satellite Communications System (DSCS), Missile Procurement, Air Force, Budget Activity 05, Other Support, Item no. 26 (June 2001).

¹³ Wideband Gapfiller Satellites (Space), Missile Procurement, Air Force, Budget Activity 05, Other Support, Item no. 18 (June 2001).

¹⁴ US Army, *The Army Satellite Communications Architecture Book* (US Army Signal Center: Fort Gordon, Ga., Apr. 2000), p. 4-2.

¹⁵ US Army (note 14), p. 4-5.

¹⁶ Satellite Communications (Space) Program Element: 0303109N (note 7).

The satellites of the Satellite Data System (SDS) support near-real-time communications between low-altitude imagery intelligence satellites and ground control stations, using highly elliptical semi-synchronous Molniya-type orbits, optimized for coverage of the North Pole region. The most recent launch of this programme, USA 162, was placed in orbit on 10 October 2001 on an Atlas booster launched from Cape Canaveral Air Force Station, Florida. This was apparently the second launch of a new generation of spacecraft, with the first (USA 137) having been launched in January 1998. These two launches probably replaced the second-generation spacecraft launched in 1989 and 1992 (USA 40 and USA 89). The current SDS constellation may also consist of another second-generation spacecraft, USA 125, launched in 1996, although both the mission and the status of USA 125 are somewhat unclear.

The US National Aeronautics and Space Administration (NASA) operates a constellation of six Tracking and Data Relay Satellite (TDRS) spacecraft, with TDRS-A having been withdrawn from service. The first six TDRS satellites were launched by the Space Shuttle in 1983–95. The next generation, TDRS-H, was launched on an Atlas 2A on 30 June 2000, featuring twice the capacity of previous spacecraft, with the inclusion of a Ka-band payload. TDRS supports near-real-time data transmission from the Lacrosse/Onyx low-altitude imaging intelligence satellites.¹⁷

In 1998 the NRO disclosed that it was ‘developing a Future Communications Architecture (FCA) that will be critical to the success of these future imagery and signals intelligence systems. The FCA will consist of a network of satellites and ground communications systems that will allow us to move and process large volumes of information from operational collection systems’.¹⁸ Little has been revealed about the FCA beyond the fact of the existence of the programme. A contract for the FCA is expected to be awarded before the end of 2003.¹⁹

The NRO successfully launched the Geosynchronous Lightweight Technology Experiment (GeoLITE) advanced demonstration satellite on a Boeing Delta II rocket on 18 May 2001. Built by TRW, the GeoLITE satellite has both a laser communications experiment and an operational UHF communications mission. The relationship between the GeoLITE and the FCA is unclear, although the FCA might use high-data-rate laser communications links if they are successfully demonstrated on the GeoLITE.

The Lincoln Experimental Satellites (LES 8 and LES 9) were experimental communications satellites, powered by radioisotope generators and built by the Lincoln Laboratory at the Massachusetts Institute of Technology. The Air Force Space Command continues to manage programme funding and retains

¹⁷ Charles, D., ‘Spy satellites: entering a new era’, *Science*, 24 Mar. 1989, pp. 1541–43; and Covault, C., ‘NASA, Boeing dispute major TDRS problem’, *Aviation Week & Space Technology*, 8 July 2001.

¹⁸ National Reconnaissance Office, Presentation by Keith R. Hall, Director, Assistant Secretary of the Air Force (Space), Senate Armed Services Committee, Strategic Forces Subcommittee, 11 Mar. 1998.

¹⁹ Taylor, C., ‘It’s not Hughes’ satellites, exactly, that Boeing was after’, *Seattle Times*, 23 Jan. 2000, p. E1.

control over the LES-9 satellite. In 2000 LES-9 was still active, relaying communications with the South Pole.²⁰

The civilian Iridium constellation of 66 low-earth-orbit communications satellites was fully deployed by the end of 1998, providing commercial mobile telephone, data and messaging services worldwide. However, the network attracted few customers; the Iridium owners declared bankruptcy and by March 2000 planned an immediate end to Iridium services. In November 2000 a new company, Iridium Satellite LLC, completed acquisition of the bankrupt company's satellites and control network. Iridium Satellite LLC contracted with Boeing to operate and maintain the satellite constellation. At the same time, the DOD awarded Iridium Satellite LLC a 24-month contract (with extension options until 2007) for unlimited Iridium satellite airtime for 20 000 government users.

Navigation satellites

The Navstar navigation system has fundamentally altered US military operations. Reaching full operational capability in the mid-1990s, the Navstar Global Positioning System (GPS) has profoundly improved the effectiveness of reconnaissance, weapon delivery and rapid deployment by US military forces. The most recent demonstration of this capability was in Operation Enduring Freedom in Afghanistan, where for the first time a significant fraction of all the munitions expended used GPS guidance.

The Navy Navigation Satellite System, also known as TRANSIT, was the world's first operational satellite navigation system, using satellites also known as Oscar. The last Oscar satellite was launched in August 1988, and the TRANSIT Program terminated navigation service on 31 December 1996, after Navstar reached full operational capability. Several Oscar satellites remain active in orbit, as part of the Navy Ionospheric Monitoring System (NIMS).

The Navstar GPS provides position, velocity and precise-time data for military aircraft, ships and ground personnel. The satellites broadcast high-accuracy, precisely synchronized signals that are received and processed by user equipment that computes position and velocity. This provides steering directions to target locations or navigation waypoints. The system provides location in three dimensions to a Spherical Error Probable (SEP) probability of 16 metres worldwide. GPS provides users with this worldwide three-dimensional positioning based on a constellation of 24 satellites. By the end of 2001, a total of 28 operational Navstar spacecraft were in orbit.²¹

²⁰ URL <http://www.phys.unsw.edu.au/~map/aasto/satellite_schedule_2000.pdf>.

²¹ All sources agree that as of the end of 2001 there were a total of 28 operational Navstar spacecraft in orbit, although they diverge on precisely which spacecraft remained in service. All of the Block I satellites, as well as GPS 2-1, 2-3, 2-6 and 2-7, have been retired. GPS 2R-1 was destroyed in a Delta launch failure on 17 Jan. 1997. Keeping track of the Navstar constellation is complicated by the remarkable diversity of designations attached to each spacecraft. Thus, the spacecraft launched on 10 Apr. 1992 is variously known as GPS 2A-13, GPS 2A-4 and Navstar 26, each of which refers to the type of spacecraft and the sequence in which it was launched. This satellite is also known by a Space Vehicle Number (SVN), assigned to spacecraft prior to launch and independent of subsequent launch sequence, which in this case is SVN 25. There are several public sources for the current status of the Navstar constellation,

The initial purchase of 28 Block IIA satellites was awarded as a multi-year contract in September 1982. A follow-on multi-year procurement of 20 Block IIR replenishment satellites plus one optional satellite began in FY 1991, with final delivery in FY 2000. The acquisition strategy for the Block IIF satellites was a competitive multi-year contract for six satellites, with advance procurement in FY 1996, and annual purchases of three modernized satellites in FY 2005 and FY 2006. Up to 12 Block IIR satellites will be modernized to include a second civil signal and a new military signal. The first six Block IIF satellites will be modernized to include a second and third civil signal and a new military signal. GPS III satellites will incorporate full modernization with a higher-power military signal, and there will be a competitive annual purchase of three satellites in FY 2007 and three satellites from FY 2008, with advance purchase beginning in FY 2006.²²

The Navstar spacecraft also host the Nuclear Detonation Detection System.

Weather satellites

The Defense Meteorological Satellite Program (DMSP) provides worldwide visible and infrared cloud imagery and other specialized meteorological, oceanographic, land surface and space environmental data to support US military strategic and tactical missions. It also provides real-time direct read-out of local weather to ground- and ship-based tactical terminals supporting DOD forces worldwide.²³ The primary Operational Linescan System (OLS) instrument monitors the global distribution of clouds and cloud-top temperatures, while other instruments provide more specialized data. The programme consists of two satellites in sun-synchronous polar orbits, with one satellite passing overhead in early morning and the other at noon local time. Additional spacecraft on which the primary OLS sensor has failed continue to provide data from other sensors.

As of mid-2001, four DMSP satellites were operational.²⁴ DMSP F10, which suffered an OLS failure on 8 February 1995, was finally retired on 14 November 1997. DMSP F11, which suffered an OLS failure on 22 April 1995, remained in service until early 1999, when it was retired. DMSP 5D-2 F12, launched on an Atlas E in 1994, remains in service. DMSP 5D-2 F13, launched on 24 March 1995, was the last flight of the Atlas E booster. As of late 2001 this spacecraft was reportedly in back-up

of which the SEM Almanac is the only one that includes SVN designators. Recent editions are available at URL <<http://www.navcen.uscg.gov/ftp/GPS/almanacs/sem>>. Other sources of Navstar constellation status reference the Pseudo Random Number (PRN) designator of the spacecraft transmitter, which is not permanently associated with a specific spacecraft. While some sources suggest that GPS 2A-04 and GPS 2A-13 are no longer in service, the SEM Almanac suggests that GPS 2-04 and GPS 2A-03 have been retired from service.

²² Global Positioning System (GPS), Missile Procurement, Air Force, Budget Activity 05, Other Support, Item no. 22 (June 2001).

²³ Defense Meteorological Satellite Program (DMSP), Missile Procurement, Air Force, Budget Activity 05, Other Support, Item no. 24 (June 2001).

²⁴ Testimony of Lieutenant General Edward G. Anderson, Deputy Commander in Chief, US Space Command, House Armed Services Committee, 20 June 2001.

status.²⁵ DMSP 5D-2 F14 was launched from Vandenberg Air Force Base (VAFB) by a Titan 2 rocket. On 12 December 1999, DMSP 5D-3 F15, the first Block 5D-2 spacecraft, was launched from VAFB on a Titan 2 rocket. Both of the Block 5D-3s remain in service.

The new DMSP-16 (5D-3-F16) is intended to replace DMSP 5D-3 F14, launched in March 1995. Following the first launch attempt, on 18 January 2001, which was delayed by weather, the launch was delayed numerous times throughout the year because of ground equipment, fuel valve, guidance system and fuel pump problems. At the end of the year the spacecraft was scheduled to be launched in early 2002.²⁶

In May 1994 the president directed the departments of defense and commerce to converge their separate polar-orbiting weather satellite programmes. The convergence into a single national resource will be completed once existing spacecraft are launched, with the first National Polar-orbiting Operational Environmental Satellite System (NPOESS) ready for launch in 2007.

The US Navy's GeoSat Follow-On (GFO) satellite was launched in February 1998 and remained in service at the end of 2001. Although initially thought of as a geodetic satellite, the system is used for real-time monitoring of the oceans. Satellite altimetry is a highly efficient method for precisely measuring the shape of the sea surface over large areas, which is directly related to the large-scale movements of water that influence the propagation of sound in the sea. GFO supports the environmental predictions that enhance US naval undersea war-fighting capabilities. All GFO data have been authorized for unconditional release and use by the civilian community.²⁷

Although no longer used for navigation purposes, the Oscar navigation satellites remain in service as part of the NIMS, sponsored by the Naval Security Group (NSG). This provides three-dimensional ionospheric models to obtain high geo-location accuracies to support signals intelligence collection. The system uses computer models, similar to those used in medical resonance imaging, to process signals transmitted from Oscar navigation satellites. Also known as the Tactical Regional Area Ionospheric Tomography System (TRAITS) under NRO sponsorship, this capability was validated in the Radiant White demonstration in 1996.²⁸

Early-warning satellites

The Defense Support Program (DSP) is a system of satellites in geostationary orbits, fixed and mobile ground processing stations, and a ground communica-

²⁵ URL <<http://www.isciences.com/NewSite/sensors/current.html>>.

²⁶ 'DMSP delayed again, rescheduled Dec. 20', *Space & Missile*, 8 Nov. 2001.

²⁷ 'GeoSat Follow-On METOC satellite—Factsheet', Space & Naval Warfare Systems Command, 11 Jan. 2001, available at URL <http://enterprise.spawar.navy.mil/spawarpublicsite/pao/fs/index.cfm?news_year=2002>.

²⁸ Navy Ionospheric Monitoring System (NIMS), URL <<http://sgdwww.arlut.utexas.edu/projects/nims>>.

tions network.²⁹ The DSP's primary mission is to provide strategic and tactical warning of ballistic missile attack. During the Gulf War, these satellites provided warning of Iraqi launches of Scud missiles.

During the cold war, the operational constellation consisted of three active spacecraft, but by the mid-1990s the constellation typically consisted of five operational spacecraft. DSP 20 was successfully launched on 8 May 2000, apparently replacing DSP 15, launched in 1990. Although the launch of DSP 21 was scheduled for 2001, it had not been launched by the end of the year. The programme includes subsequent launches of two additional satellites (DSP 22 and 23).³⁰

The Space-Based Infrared System (SBIRS) is designed to greatly improve warning of ballistic missile launches. SBIRS incorporates new technologies to enhance launch detection and improve reporting capabilities. The SBIRS will consist of satellites in Geosynchronous Orbits (GEO), Highly Elliptical Orbits (HEO), Low Earth Orbits (LEO), and an integrated centralized ground station serving all SBIRS space elements and DSP satellites.³¹

The US Nuclear Detonation (NUDET) Detection System (USNDS) provides a highly survivable capability to detect, locate and report nuclear detonations in the earth's atmosphere or in near space. The space segment consists of NUDET detection sensors on both the GPS/Nuclear Detonation System (NDS) satellites and the DSP/NDS satellites.³² The USNDS payload contains optical, X-ray, electromagnetic pulse (EMP/W-sensor) and dosimeter sensors.³³

Ocean-surveillance satellites

During the cold war the White Cloud Naval Ocean Surveillance System (NOSS) was the primary ocean-surveillance satellite system.³⁴ Each NOSS launch placed a cluster of one primary satellite and three smaller sub-satellites (that trail along at distances of several hundred kilometres) into low polar orbit. This satellite array could determine the location of radio and radar transmitters, using triangulation, and the identity of naval units, by analysis of their operating frequencies and transmission patterns. In 1990 the White Cloud constellation apparently consisted of at least three clusters of primary and secondary satellites, launched in 1987, 1988 and 1989. There have been no subsequent launches, and the system probably ended service in the mid-1990s.

The first launch of the second-generation NOSS system took place in June 1990, with a Titan 4 booster orbiting a trio of much larger satellites. As with

²⁹ Richelson provides an authoritative, comprehensive treatment of the DSP in Richelson, J. T., *America's Space Sentinels: DSP Satellites and National Security* (University Press of Kansas: Lawrence, Kans., Apr. 2001).

³⁰ Defense Support Program (DSP), Missile Procurement, Air Force, Budget Activity 05, Other Support, Item no. 25 (June 2001).

³¹ Space-Based Infra-Red System (SBIRS) High Advance Procurement, Missile Procurement, Air Force, Budget Activity 05, Other Support, Item no. 30 (June 2001).

³² Nudet Detection System (NDS), Space Budget Item Justification (Exhibit P-40), June 2001.

³³ NUDET Detection System (NDS), Missile Procurement, Air Force, Budget Activity 05, Other Support, Item no. 23 (June 2001).

³⁴ Richelson, J. T., *The US Intelligence Community* (Ballinger: Cambridge, Mass., 1985), pp. 140–43.

the earlier system, these flew in close formation, apparently to facilitate the tracking of ships at sea through triangulation. By 1996 three of these triplets (a total of nine spacecraft) were in orbit, despite a launch failure on 2 August 1993 that destroyed the payload.

On 8 September 2001 an Atlas booster launched USA 160, probably the first of a third-generation ocean-surveillance satellite system. The use of the Atlas booster implies that it was a somewhat smaller spacecraft than that launched by the Titan booster. By the end of 2001 the characteristics of this new, third-generation system remained rather obscure. Observers believed that one object which had not received an official USA designation was in fact a second spacecraft, with a third spacecraft expected to be deployed from the primary USA 160 payload in early 2002.³⁵

Signals intelligence satellites

The USA operates several constellations of signals intelligence (SIGINT) satellites in geostationary and highly elliptical orbits.

The geostationary SIGINT constellation probably consists of about half a dozen satellites. Although the precise number and status of these satellites are speculative, a fair approximation may be obtained by assuming that these spacecraft have an operational lifetime of about a decade, as is the case with commercial communications satellites. During the cold war a progressively larger and more capable series of spacecraft were placed into orbit, with programme names reportedly including Rhyolite, Chalet and Vortex. By the early 1990s all these spacecraft had almost certainly been withdrawn from service or relegated to back-up reserve status.

There were no new launches of signals intelligence satellites in 2001. By the end of the year, the active constellation probably consisted of a pair of MERCURY spacecraft, launched in 1994 and 1996, as well as a trio of ORION spacecraft, launched between 1990 and 1998. The nomenclature associated with these spacecraft is uncertain; the ORION spacecraft have also been referred to as MENTOR and MAGNUM.

In addition to these geostationary signals intelligence satellites, during the cold war a pair of Jumpseat satellites operated in highly elliptical Molniya-type orbits.³⁶ These satellites provided focused coverage of the far northern regions of the Soviet Union. Beginning in 1994 they were replaced with the much larger TRUMPET spacecraft, as many as three of which were apparently operational at the end of 2001.

In 1998 the NRO disclosed that it was 'introducing an Integrated Overhead SIGINT Architecture (IOSA) that will improve SIGINT performance and avoid costs by consolidating systems, utilizing medium lift launch vehicles wherever possible, and using new satellite and data processing technologies.

³⁵ Molczan, T., 'RE: Centaur and NOSS payload observed', 9 Sep. 2001, URL <<http://www.satobs.org/seesat/Sep-2001/0121.html>>.

³⁶ Richelson (note 34), p. 122.

At the urging of Congress, [it had] initiated the study phase for the follow-on architecture, IOSA-2'.³⁷

Imagery intelligence satellites

Imagery intelligence satellites provide US military planners and political decision makers with unrivaled global situation awareness.³⁸ Coupled with collateral intelligence from other sources, these systems have become an integral part of US war-fighting, as demonstrated most recently in Operation Enduring Freedom in Afghanistan.³⁹

The USA continued operation of three Improved Crystal (advanced KH-11) electro-optical real-time digital imagery intelligence satellites throughout the year. USA 161 was launched on 1 October 2001, apparently replacing USA 86, launched in 1992. During the cold war the KH-11 KENNAN constellation normally consisted of two spacecraft, but by the mid-1990s the constellation was expanded to as many as three spacecraft. These satellites can provide high-resolution imagery—generally reported to have a resolution of about 10 cm—which can be rapidly disseminated to users around the world.

The ONYX spacecraft (formerly known as LACROSSE) provide cloud-piercing coverage of targets using synthetic aperture imaging radar. Three spacecraft of this class, launched between 1991 and 2000, remained in service at the end of 2001.

In 1994 it was reported that Congress had funded 'Satellite 8X, an over \$1 billion spacecraft that trades off the extremely high resolution of Keyhole surveillance satellites for a wider field of view that would make it easier to map theatre operations'.⁴⁰ By 1998 the NRO stated that it was 'completing the development of the Enhanced Imaging System in response to growing customer demands and large area imagery collection shortfalls'.⁴¹ On 22 May 1999, USA 144 was launched into an orbit with a perigee of about 2600 km and an apogee of over 3100 km. The Improved Crystal spacecraft are in orbits of 300 km by 975 km, while the ONYX radar satellites are in roughly circular orbits at an altitude of about 650 km.

The NRO proposed the Future Imagery Architecture (FIA) Program in its FY 1998 budget submission to Congress in March 1997.⁴² Under FIA, the NRO would specify performance requirements such as resolution and revisit rates, while the means by which the requirements are met would be specified by the contractor. Reportedly, FIA is intended to collect 8–20 times the vol-

³⁷ National Reconnaissance Office, Presentation by Keith R. Hall (note 18).

³⁸ The indispensable guide to this subject is Richelson, J. T., *America's Secret Eyes in Space: The US Keyhole Satellite Program* (Ballinger: Cambridge, Mass., Feb. 1990).

³⁹ Petrie, G., 'Imagery for surveillance and intelligence over Afghanistan', *GI News*, Oct./Nov. 2001, URL <<http://www.ginews.co.uk>>.

⁴⁰ 'Intelligence conferees fund Satellite 8X, transfer U-2 to DARO', *Aerospace Daily*, vol. 171, no. 60 (26 Sep. 1994), p. 477.

⁴¹ National Reconnaissance Office, Presentation by Keith R. Hall (note 18).

⁴² National Reconnaissance Office, Presentation by Keith R. Hall (note 18).

ume of imagery compared to existing systems. On 27 April 1999 Raytheon was awarded a contract by the NRO to develop the Mission Integration and Development (MIND) ground infrastructure portion of FIA. On 3 September 1999 the NRO awarded a contract to Boeing to develop, provide launch integration and operate the FIA imagery intelligence satellites.⁴³

The Discoverer II imaging radar satellite system was originally planned to provide high-resolution (better than 1 metre) continuous coverage using a constellation of 24 medium-size satellites. This US Air Force programme represented something of a rival to the NRO's Future Imagery Architecture and failed to receive congressional approval. By the end of 2001 it had been recast as the Space-Based Radar, a 10-satellite surveillance and targeting constellation planned for deployment by 2008.⁴⁴

Anti-satellite systems

During the 1960s the United States had two different nuclear-tipped anti-satellite (ASAT) systems, although both were withdrawn from operational service by the early 1970s. In the late 1970s the USA began development of an air-launched ASAT system that would destroy target satellites by the direct impact of a miniature homing warhead. This programme was cancelled after limited testing in the 1980s, although it is believed that components of this system remain in storage for potential reactivation.

The Mid-Infrared Advanced Chemical Laser (MIRACL) at White Sands, New Mexico, is believed to have a limited ASAT capability against some satellites in low earth orbit. The Miniature Sensor Technology Integration (MSTI-3) satellite was launched in 1996 by the Air Force experimental satellite. Among the experimental technologies on board were special sensors designed to detect a laser weapon attack. On 19 October 1997 the Army's MIRACL laser was tested against MSTI-3. Two shots were fired, the first of 1-second duration to trigger the sensors on the MSTI-3 satellite designed to detect the attack, followed by a 10-second laser burst that attempted to overload the sensors. The results of the test remain classified, although it is known that the satellite was not destroyed in the test.⁴⁵

Technology development

The Space Test Program (STP) conducts space flight experiments for the military research and development community. These range from basic research to advanced development and from large free-flying spacecraft to small packages

⁴³ Dornheim, M. A., 'FIA outline takes shape', *Aviation Week & Space Technology*, 10 Dec. 2001, p. 73.

⁴⁴ Caceres, M., 'Military satellites: the next generation', *Aerospace America*, Jan. 2002, p. 20.

⁴⁵ Broad, W. J., 'Military is hoping to test-fire laser against satellite', *New York Times*, 1 Sep. 1997.

flown on other spacecraft, the Space Shuttle or the International Space Station.⁴⁶

III. Russia

During the cold war the Soviet space programme was characterized by a high annual rate of launch of spacecraft with relatively short operating lifetimes by Western standards.⁴⁷ At the end of 1990 the USSR had a total of 75 launches, one more than its total for 1989 but in marked contrast to the 90 launches of 1988 or the peak of 101 in 1982.⁴⁸ The Russian space programme has managed to achieve only a fraction of the Soviet launch rate. However, the elimination of obsolete short-lived systems and the extension of the operating lives of the remaining systems have significantly offset the declining launch rate.

The high launch rate and short operating lives of Soviet satellites during the cold war meant that accounting for the launches and re-entry of spacecraft provided the primary indicator of Soviet military space activity. The rather different operating pattern of Russian space forces means that accounting for operational spacecraft in orbit is a more meaningful indicator. It is also a decidedly difficult analytical challenge.

By one estimate, as of late 2001 Russia had 93 operational spacecraft in orbit, compared to a peak of nearly 200 satellites during the Soviet era. These spacecraft reportedly included 43 military satellites and about 20 dual-use satellites, with the remaining 30 spacecraft performing civilian and commercial functions. Of the 93 operational spacecraft, over 80 per cent of them had exceeded their design lifetimes.⁴⁹ Other sources suggest that over 70 per cent of the operational spacecraft had exceeded their design lifetimes.⁵⁰

In Russia, as in other countries, there is no hard and fast dividing line between military and dual-use space systems. A system-by-system survey suggests that by the end of 2001 Russia had over 40 operational military spacecraft in orbit, along with another 15 dual-use communications and navigation satellites, a finding remarkably consistent with official Russian statements.

Navigation satellites

Russia has continued operation of both Soviet-era navigation satellite networks. The Tsikada constellation consists of small satellites of modest capabilities in low earth orbits, similar to the US TRANSIT system that was

⁴⁶ US Department of Defense, *Space Test Program Status Report*, vol. 6, issue 2 (16 Apr. 2001), available on the STP Internet site at URL <<http://www.te.plk.af.mil/stp/stp.html>>.

⁴⁷ *Soviet Space History at a Glance* is a very useful resource for information on the Soviet and Russian space programmes; see URL <<http://www.astronautix.com/articles/sovance.htm>>.

⁴⁸ 'Soviets finish year with 75 launches', *Defense Daily—Special Supplement*, 9 Jan. 1991, p. S-1.

⁴⁹ Feller, G. and Stein, K., 'Russian space assets not getting any better', *Space & Missile*, vol. 2, no. 23 (8 Nov. 2001).

⁵⁰ Saradzhyan, S., 'Russia's space forces work to restore fire-ravaged facility', *Space.com*, 10 May 2001.

phased out in 1995. The GLONASS (Global'naya Navigatsionnaya Sputnikovaya Sistema, Global Navigation Satellite System) network of semi-synchronous satellites provides higher accuracy fixes and is similar to the US Navstar system.

In contrast to the US TRANSIT system, which was used by both civilian and military operators, the Russian low-earth-orbit network uses similar satellites in separate military (Cosmos designation) and civilian (Tsikada) networks. The Parus system is sometimes referred to as 'military Tsikada' or 'Tsikada-M'. Orbital planes 1–6 of the military system are spaced 30 degrees apart, while planes 11–14, used by the civilian system, are spaced 45 degrees apart. There was one launch of the Parus system in 2001, Cosmos 2378, on 28 May 2001. Normally, only a single satellite is operational in each orbital plane at any given time, and this launch apparently replaced Cosmos 2279, launched in 1994 to sustain an operational constellation of six spacecraft. However, these satellite constellations are subject to frequent changes as older spacecraft are reactivated and newer spacecraft are temporarily inactivated. The total number of potentially operable spacecraft may be over a dozen.⁵¹

The GLONASS network has experienced major developmental problems since its introduction in 1982. The fully deployed GLONASS constellation is intended to be composed of 24 operational satellites in three orbital planes. The deployment of GLONASS peaked in 1995 with a total of 22 operating satellites. Owing to financial difficulties in Russia, only three satellites were launched over the following five years, and by June 2000 only 10 satellites of the constellation were operational. Another trio was launched in 2000, and three more were launched on 1 December 2001. Of these, at least one was an improved GLONASS-M, which has a seven- to eight-year design life versus the three-year life of the previous satellites. By the end of the year, the active constellation remained at 10 spacecraft, with four of the spacecraft launched in 1995 having been withdrawn from service.⁵²

Communications satellites

The Soviet military communications network included three classes of satellites that operate in low-altitude orbits, only one of which remained in service at the end of 2001.

⁵¹ The status of Parus and other spacecraft with continuous radio beacons was detailed in *SPACEWARN Bulletin*, no. 520 (25 Feb. 1997) and updated in *SPACEWARN Bulletin*, no. 545 (1 Apr. 1999), URL <<http://nssdc.gsfc.nasa.gov/spacwarn/spx545-catiradiobeacon.html>>. A more current appreciation of the status of these satellites is available on the HearSat Internet site (URL <<http://hearsat.org>>) and at Russian Navigation Satellites, URL <<http://www.asahi-net.or.jp/~VQ3H-NKMR/satellite/freq-Nav.html>> (apparently updated in late 1997). This is an instance in which the fidelity of the Analytical Graphics Inc (AGI) database can be independently validated, and several discrepancies are noted. AGI reports a total of 12 of these spacecraft as 'active' although the nominal active constellation consists of only 6 spacecraft. AGI reports Cosmos 2327 as active, while other sources report that it failed in orbit.

⁵² Ministry of Defence of the Russian Federation, Coordination Scientific Information Center (KNITs), URL <<http://www.rssi.ru/SFCSIC/english.html>>.

The first-generation Strela-1M spacecraft were launched eight at a time on the SL-8 booster into a single orbital plane. Although the number of satellites active in this constellation was difficult to determine, the three most recently launched octuplets were usually thought to constitute the bulk of the nominal constellation of 24 satellites. The final launch under this programme (Cosmos 2187–2194) was conducted in 1992, and by the late 1990s this network was almost certainly inactive. The second-generation Strela-2M low-altitude communications satellites were launched one at a time on the SL-8 booster, with a constellation consisting of three satellites, each in a unique orbital plane separated by 120 degrees. Cosmos 2298, launched on 20 December 1994, was the final launch in this programme, which had almost certainly been terminated by the end of the decade.

The third-generation Strela-3 low-altitude satellites are launched in groups of six on a single SL-14 booster. The first launch under this programme was on 15 January 1985. Of the three classes of Soviet low-earth-orbit communications satellites, this is the only one to continue in Russian service. These store-dump communications satellites are generally believed to have been initially developed for the military by the Main Intelligence Administration (Glavnoye Razvedyvatelnoye Upravlenie, GRU). A commercial version was marketed as the Gonets-D1 in the 1990s. At the end of 2001, the constellation included Cosmos 2337–2339, which were launched in 1997, along with Gonets-D1 4–6. The next launch consisted entirely of Strela-3 military satellites, but all six were left in an elliptical orbit instead of the usual 1400-km circular orbit because of a booster malfunction.⁵³ The most recent launch, on 27 December 2001, again consisted of three Strela-3 military satellites and three Gonets D commercial spacecraft.

The Molniya satellites operate in highly inclined, highly elliptical orbits that are optimized for coverage of the northern hemisphere. The primary user of the Molniya-1 system's X-band transponders is the Russian Government and military, while the Molniya-3 system is used by both military and civilian agencies for *inter alia* television transmission.

The complete Molniya-1 constellation initially consisted of eight satellites in eight orbital planes separated by 45 degrees. This was subsequently modified to two constellations of four vehicles, with each consisting of four orbital planes spaced 90 degrees apart and with the ascending node of one constellation shifted 90 degrees from the other.⁵⁴ However, at the end of 2001 there appeared to be no more than six Molniya-1 spacecraft in operational service, with only the most recently launched pair—Molniya 1-90 and 1-91—displaying the prescribed regularity of orbital separation.⁵⁵

⁵³ Covault, C., 'Promise and peril mark Russian launch surge', *Aviation Week & Space Technology*, 13 July 1998, p. 78.

⁵⁴ Johnson, N. and Rodvold, D., *Europe and Asia in Space 1993–1994* (Kaman Sciences Corp./US Air Force Phillips Laboratory: Kirtland AFB, N. Mex., 1995).

⁵⁵ The puzzling irregularities of the Molniya constellation may be due to either an ongoing intentional reconfiguration of the constellation or the inability of Russia to sustain a symmetrical configuration, but the open literature is silent on this issue.

The first Soviet geostationary orbit satellites were the Raduga military and government communications satellites, first launched in 1975. By the early 1990s as many as 12 spacecraft of this series were operational in orbit, although by the end of 2001 only half this number remained operational. The oldest was Raduga 29, launched in 1993, with the most recent being Raduga 1-6, launched on 6 October 2001. The Geizer (Potok) Soviet military communications satellites operated in geostationary orbit to provide data relay support to imagery intelligence satellites, as well as fixed ground points. At the end of 2001 as many as five of these spacecraft were operational, ranging from Cosmos 2085, launched in 1990, to Cosmos 2371, launched on 4 July 2000.

Weather satellites

The Russian low-altitude weather satellite network supports both civilian and military users, in contrast to the separate systems operated by the USA. The Russian military presumably use data from the several Meteor 2 and Meteor 3 satellites, which are usually operational.

Early-warning satellites

During the cold war, the Soviet ballistic missile early-warning satellite network consisted of nine Oko satellites in Molniya-type orbits. These satellites were designed to detect launches of intercontinental ballistic missiles (ICBMs) from the continental United States but provided no coverage of sea-based missile launches. A total of six launches were conducted in 1990, indicative of the effort required to sustain this constellation.⁵⁶ By the mid-1990s Russia had evidently contented itself with maintaining only four or five operational Oko spacecraft in orbit, despite the fact that this left gaps of several hours in coverage of US land-based missile launch facilities. At the end of 2001 only four satellites—Cosmos 2340, 2342, 2351 and 2368—remained in service, with the most recent launch in December 1999. A fire damaged the Oko's Serpukhov-15 ground control facility near Moscow on 10 May 2001, although by the next day the Golitsyno-2 back-up facility had regained control of the spacecraft.⁵⁷

The second-generation Prognoz early-warning spacecraft, known as the SPRN (Spetsializirovannim apparatom dlya obnaruzhenniya yadernix vzrivov, Special Apparatus for Observation of Nuclear Forces) is a geostationary system similar in concept to the US Defense Support Program. Following an experimental flight in 1975 (Cosmos 775), launches resumed in 1984 (Cosmos 1546), and the USSR registered a total of seven orbital slots for the Prognoz system. In practice, only three locations (24° West, 12° East and 80° East) were actually used, and by the end of the cold war the operational constella-

⁵⁶ 'Congress splits on milspace budget', *Military Space*, 25 Sep. 1989, p. 2.

⁵⁷ Saradzhyan (note 50).

tion apparently consisted of two spacecraft positioned at 12° East and 24° West (which was apparently the primary location).

Cosmos 2224 was launched on 17 December 1992 and was on station at 12° East until May 1999. Subsequent flights were less successful.⁵⁸ Cosmos 2282 was launched in July 1994 but drifted off station after 15 months. Cosmos 2345 was launched on 14 August 1997 and was positioned at 24° West but reportedly failed at some time between late 1997 and early 1999. Another Prognoz class early-warning satellite, Cosmos 2350, was launched on 29 April 1998, replacing Cosmos 2244 at 12° East.⁵⁹ Several weeks after the launch, it was reported that contact had been lost with Cosmos 2350 on 6 July and that the spacecraft had been written off as lost.⁶⁰ It appears that by mid-1999 Russia was without an operational geostationary early-warning spacecraft, a situation that was not remedied until the launch of Cosmos 2369 on 24 August 2001. Initially stationed at 80° East, in early December 2001 Cosmos 2379 was drifting west and by the end of the year was stabilized at the 24–25° West primary location.

Electronic intelligence satellites

The USSR apparently never launched more advanced SIGINT systems into highly elliptical or geosynchronous orbits, although in the late 1980s several launches of communications and early-warning spacecraft were initially incorrectly attributed to the electronic intelligence (ELINT) mission. By the final years of the cold war the Soviet ELINT capability consisted of two complementary low-earth-orbit systems.⁶¹

One of these systems consisted of a constellation of six low-altitude satellites, comprising the so-called 'third-generation' Tselina-D ('Virgin Land') ELINT system. The final launch attempt under this programme, in May 1994, ended with a booster failure. Based on the demonstrated short lifetimes of these spacecraft, this system is certainly no longer operational.⁶²

The more advanced Tselina-2 ELINT satellites were initially launched in 1984 on the Proton booster, with operational flights using the Zenit-2 booster. This 6-ton spacecraft is placed into a 71° inclination orbit at an altitude of 840–860 km.⁶³ The absence of launches during 1989 had raised doubts about the future of this fourth-generation satellite,⁶⁴ although by the early 1990s it

⁵⁸ 'Missile warning system fails', *Jamestown Foundation Monitor*, 17 July 1998; and Lantratov, K., 'Cosmos-2379 in flight', *Novosti Kosmonavtiki*, no. 10 (2001), pp. 37–38.

⁵⁹ Golotyuk, Yu. and Golotyuk, S., 'Kosmos-2350—the president's new "eye"', *Defense and Security*, 5 May 1998.

⁶⁰ Bogatyrev, V., 'Russian missile defense is breaking down', *Kommersant Daily*, 15 July 1998, p. 2; and Bratersky, A., 'Russian defense satellite crippled', *Space News*, 20 July 1998, p. 7.

⁶¹ Clark, P., 'Soviet worldwide ELINT satellites', *Jane's Soviet Intelligence Review*, July 1990, pp. 330–32.

⁶² The Analytical Graphics Inc. database reports Cosmos 2221, 2228 and 2242 as being active as of the end of 2001, an assessment that is almost certainly in error.

⁶³ URL <<http://www.russianspaceweb.com/tselina.html>>.

⁶⁴ Clark, P., 'Economic changes in the Soviet space program', *Jane's Soviet Intelligence Review*, May 1990, p. 236.

appeared that this programme was intended to consist of a constellation of four spacecraft in orbital planes separated by 45 degrees.⁶⁵ In practice, these plans were marred by persistent launch vehicle failures.

The most recent flight under this programme was Cosmos 2369, launched on 3 February 2000 on a Zenit-2 from the Baikonur Cosmodrome, apparently replacing Cosmos 2263, which had been in orbit since 1993. The overall operational status of this constellation is difficult to assess in the absence of overt indicators as to the operational health of individual spacecraft and in the absence of apparent orbital alignments among recently launched spacecraft.⁶⁶ Cosmos 2369 replicated the rough alignment of Cosmos 2262 with Cosmos 2278 (launched in April 1994) and Cosmos 2297 (launched in November 1994), with at least two satellites of this trio providing simultaneous coverage of targets. There are no simple orbital relations among three more recent flights—Cosmos 2322 (launched in October 1995), Cosmos 2233 (launched in September 1996) and Cosmos 2360 (launched in July 1998). At the time of the launch of Cosmos 2360, two other spacecraft of the series were reportedly operational (presumably Cosmos 2322 and 2233).⁶⁷ By the end of 2001, probably at least three, but no more than six, of these spacecraft remained in operational service.

Ocean-surveillance satellites

During the cold war the USSR operated two classes of satellites for locating and identifying Western naval units. The nuclear-powered Radar Ocean Reconnaissance Satellites (RORSATs) used a radar with a power of several kilowatts to detect surface ships. Following the problems with the nuclear-powered Cosmos 1900 RORSAT, which malfunctioned on 12 April 1988,⁶⁸ there were no further RORSAT launches.

The Electronic Ocean Reconnaissance Satellites (EORSAT) intercept radio and radar transmissions. The first US-P (US-Upravleniye Sputnik) and the first improved US-PM spacecraft were launched in 1974. In an apparent response to the withdrawal of the RORSAT from peacetime service, the EORSAT constellation was significantly expanded. Until the end of 1988 the EORSAT network consisted of two spacecraft flying in a single orbital plane. However, additional launches in 1989 led to a brief period during which five EORSATs were operating simultaneously in two distinct orbital planes.⁶⁹ The first of the improved US-PM spacecraft was launched in 1993, with subse-

⁶⁵ Tarasenko, M., 'Launch of Cosmos-2360', *Novosti Kosmonavtiki*, no. 15/16 (1998), p. 25.

⁶⁶ The AGI database reports a total of 10 spacecraft in this series (ranging back to Cosmos 2219, launched in Nov. 1992) as being operational, an assessment that is almost certainly in error.

⁶⁷ Zak, A., 'Classified Russian spy satellite launch delayed', *Space.com*, 2 Feb. 2000.

⁶⁸ 'Soviets confirm Cosmos 1900 difficulties', *Aerospace Daily*, 16 May 1988, p. 252.

⁶⁹ Covault, C., 'Soviet military space operations developing longer life satellites', *Aviation Week & Space Technology*, 9 Apr. 1990, pp. 44-49.

quent launches establishing a constellation of three spacecraft in orbital planes separated by 120 degrees.⁷⁰

By 2001, only EORSAT was operating. Cosmos 2367 had been launched in December 1999 to replace Cosmos 2347, launched in December 1997. On 20 December 2001, Cosmos 2382 was launched, probably to replace Cosmos 2367 since the EORSAT spacecraft had typically operated for about two years before being replaced.⁷¹

Imagery intelligence satellites

During the cold war, launches of short-lived film-return imagery intelligence satellites constituted a significant fraction of annual Soviet launch activity. The USSR launched a total of 32 imagery intelligence satellites in 1988, 32 in 1989 and 21 in 1990. These third- and fourth-generation systems used film returned to earth in re-entry capsules and typically remained in orbit for only a few weeks.⁷²

With the end of the cold war, the pace of Russian launches of imagery intelligence satellites declined precipitously, and more detailed information concerning the remaining operational systems became publicly available.⁷³ The sixth-generation Orlets-1 film-return spacecraft was first launched in 1986, with the most recent launch, Cosmos 2290, in August 1994. However, the absence of subsequent launches indicates that this programme has been abandoned.

The fourth-generation Yantar-4K1 Oktant is a high-resolution film-return imagery intelligence satellite. The first satellite, Cosmos 1097, was launched on 27 April 1979. The most recent flight of the derivative Yantar-4K2 Kobalt class satellite, Cosmos 2377, was launched from Plesetsk on a Soyuz booster on 29 May 2001. Cosmos 2377 re-entered on 10 October 2001 after a four-month mission.

The fifth-generation Yantar-4KS1 Terilen digital-transmission imagery intelligence satellite first flew in late 1982, with the launch of Cosmos 1426. With a mission duration ranging from six months to a year, one of these spacecraft, also called Neman, was in orbit providing almost continuous coverage. Cosmos 2320, launched in September 1995, appeared to continue this effort, although when it was de-orbited in September 1996 Russia was, for several months, apparently left without an imagery intelligence satellite in orbit. Subsequently, Cosmos 2359 was launched in 1998, remaining in orbit

⁷⁰ URL <<http://www.astronautix.com/craft/uspm.htm>>.

⁷¹ Feller and Stein (note 49).

⁷² Detailed descriptions of the fourth-generation Yantar systems are provided in Sorokin, V., 'Yantar history', *Novosti Kosmonavтики* (Videokosmos) no. 17 (1997), p. 57, and no. 18/19 (1997), available at URL <<http://www.users.wineasy.se/svengrahn/histind/Recces/fourth.htm>>.

⁷³ Some confusion remains among various sources as to the nomenclature and classification associated with specific launches. Authoritative sources include URL <<http://www.astronautix.com/articles/sovnlance.htm>> and URL <<http://www.users.wineasy.se/svengrahn/histind/Recces/Recces.htm>>.

for a year. Cosmos 2370 was launched on 3 May 2000 and continued in operation in orbit until it re-entered on 4 May 2001.

On 6 June 1997 Russia launched Cosmos 2344, an advanced real-time digital imagery intelligence satellite, subsequently identified as Arkon-1.⁷⁴ This 20-ton spacecraft was launched into a much higher orbit (roughly 1500 km by 2800 km) than that of any previous Soviet or Russian imagery intelligence spacecraft (which typically orbited at altitudes of a few hundred kilometres). The system is reportedly capable of providing imagery with a resolution of up to 2 metres.⁷⁵

Although some reports suggested that the spacecraft had failed shortly after launch,⁷⁶ the continued commercial availability of 1- and 2-metre resolution digital imagery at the end of 2001 strongly suggests that the Arkon-1 spacecraft remains operational, since it was the only Russian imagery intelligence satellite in orbit at the end of the year.

In October 2001 Russian officials indicated that additional intelligence satellites would be launched in connection with the campaign against terrorism in Afghanistan.⁷⁷ By the end of the year, however, no additional launches had taken place.

Several Russian camera systems provide imagery that is commercially available. The KVR-3000 provides 2-metre imagery, while the DD-5 provides 1-metre imagery (it appears that this imagery is collected by the Arkon-1 spacecraft). The imagery archive dates back to 1992, and tasking is accepted for future imagery acquisition. However, 1-metre imagery of some areas may be denied, delayed or only available if re-sampled to 2-metre resolution.⁷⁸

Anti-satellite systems

The USSR conducted the final test of the co-orbital ASAT system in 1982. According to most sources the system was deactivated around the time of the end of the cold war. Some reports suggest that an improved version had been placed on alert status, although it was not flight tested. Other reports suggest that an untested air-launched system, similar to the US Miniature Homing Vehicle system tested in the 1980s, remained under development in the early 1990s. With the end of the cold war, various other untested Soviet ASAT projects came to light.⁷⁹

⁷⁴ 'Kosmos 2344 is Arkon-1', *News Bulletin of the Astronautical Society of Western Australia*, vol. 23, no 3 (Dec. 1997), pp. 27–29, URL <<http://www.users.wineasy.se/svengrahn/histind/Recces/Arkon.htm>>.

⁷⁵ Covault, C., 'New Russian recon keyed to area surveillance', *Aviation Week & Space Technology*, 23 Feb. 1998, p. 37. The continued commercial availability of Russian 1-metre digital imagery suggests that the best resolution of imagery from Arkon-1 is no worse than 1 metre and possibly better.

⁷⁶ Zak, A., 'Russian spy sats nearly extinct, offer little help in Afghanistan', *Space.com*, 4 Oct. 2001.

⁷⁷ United Press International, 'Russia to lift satellites over Afghanistan', 3 Oct. 2001, quoting the chief of Russia's Space Forces, Col. Gen. Anatoly Perminov.

⁷⁸ Satellite Imagery Systems, URL <http://www.cartographic.com/satellite_systems.asp>.

⁷⁹ Wade, M., 'ASAT', *Encyclopedia Astronautica*, available at URL <<http://www.astronautix.com/project/asat.htm>>.

IV. Other countries

Australia

The Royal Australian Navy has leased transmission capacity on PanAmSat Corporation's Leasat 5 satellite from Hughes Space and Communications Company. Leasat 5 was leased to the US Navy until early 1997. Under the terms of this unique contract, Hughes Global Services led the effort to relocate the satellite to an orbital station from which PanAmSat will monitor and control Leasat 5's payload on behalf of the Australian Defence Force. The satellite arrived on station at 156° East on 3 April 1998 to provide UHF satellite communications services to Australia.⁸⁰

China

China became the third country, after the USA and the USSR, to launch an imagery intelligence satellite when its first FSW (Fanhui Shi Weixing, or Return Type Satellite) spacecraft was launched in 1975. A total of 14 of these spacecraft had been launched by the end of 1994. The first launch of an improved version, the FSW-2, was conducted in 1992, with another launched in 1994. The third (and most recent) FSW-2 launch took place on 20 October 1996, with the spacecraft returning to earth on 4 November 1996. By the end of 2001 China, surprisingly, had not launched an imagery intelligence satellite for over five years. It is generally believed that China has met its limited imagery intelligence requirements through the commercial purchase of imagery from Russia. Published reports suggesting that the China–Brazil Earth Resources Satellite (CBERS) is 'Beijing's first high-resolution imaging satellite . . . disguised as a civilian earth monitoring system . . . being used to target U.S. forces in the region' would appear to be without foundation.⁸¹

China launched the Zhongxing-22 (Zhongxing means 'China Star'), also known as ChinaSat-22, communications satellite on 26 January 2000. Officially characterized by China as a civilian satellite with a life expectancy of eight years, Zhongxing-22 is reportedly operated by the China Telecommunications Broadcast Satellite Corporation.⁸² This launch was evidently the first of the previously announced Feng Huo network, which according to registration with the International Telecommunications Union would consist of up to five satellites (ChinaSat-21 to -25) providing mobile communications services.⁸³ The US Defense Intelligence Agency (DIA) was reported to have 'identified the satellite as Feng Huo-1, the first of several military communications satellites for the Qu Dian C4I system'. According to the classified DIA assessment, the FH-1 system 'will allow theater commanders to communicate

⁸⁰ Hughes Global Services, 'Hughes to lease defense satellite transponders to Australian defence force', News release, 11 May 1998.

⁸¹ Gertz, B., 'Chinese "civilian" satellite a spy tool', *Washington Times*, 1 Aug. 2001, p. A1.

⁸² Yee, A., 'China launches Telco Bird', *Space Daily*, 26 Jan. 2000, URL <<http://www.spacedaily.com/news/china-00b.html>>.

⁸³ Clark, P., 'Chinese communications satellites', *Via Satellite*, Feb. 2001.

with and share data with all forces under joint command' and will provide the Chinese military with 'a high-speed and real-time view of the battlefield which would allow them to direct units under joint command more effectively'. The satellite would reportedly provide the military with both C-band and UHF communications.⁸⁴

The Beidou (Big Dipper) Navigation Test Satellite 1 (BNTS-1) was launched by a Chinese Long March 3M booster on 31 October 2000 into a geostationary orbit⁸⁵ slot at 140° East, to the east of China. It was followed by Beidou 1B on 21 December 2000, which was placed in a geostationary orbit at 80° East. The launch of this second Beidou completed the two-satellite navigational system, which will provide positional information for highway, railway and marine transportation.⁸⁶

The precise nature of this system remains somewhat obscure, but it appears to be analogous to the Wide Area Augmentation System (WAAS) implemented in the USA to supplement the Global Positioning System. In the US WAAS, a network of precisely surveyed ground reference stations receive GPS signals and determine if errors exist and compute corrections. These corrections are then transmitted from a geostationary communications satellite on the same frequency as GPS.⁸⁷ This could enable China to continue to use the US GPS system, even in the face of US efforts to deny GPS to adversaries in wartime.

Europe

The NATO IV Satellite Communications (SATCOM) System provides strategic and tactical SHF and UHF communications for NATO maritime and land forces. The spacecraft are hardened against nuclear effects and resistant to signal jamming. Built by British Aerospace and Matra Marconi Space, the spacecraft have a design operational life of seven years. The NATO SATCOM system currently consists of the NATO IVA and NATO IVB satellites and a previous-generation NATO IIID satellite. The satellites are operated in inclined geosynchronous orbits, with the NATO IVA satellite carrying operational traffic at 17.8° West, the NATO IVB as the primary spare at 20.2° West and the NATO IIID as the final spare at 18° West. The NATO Communications and Information Systems (CIS) Operating and Support Agency (NACOSA) at the Supreme Headquarters Allied Powers Europe in Mons, Belgium, coordinates and authorizes access to NATO satellites. The NATO SATCOM post-2000 study is evaluating options for a replacement for the NATO IV satellites after 2004. The proposed NATO Satellite Broadcast Service (SBS) is intended to be a counterpart to the US Global Broadcast Service.

⁸⁴ Gertz, B., 'China's military links forces to boost power', *Washington Times*, 16 Mar. 2000, p. A1.

⁸⁵ Long, W., 'China launches first navigation satellite', *Space Daily*, 31 Oct. 2000, URL <<http://www.spacedaily.com/news/gps-00k.html>>.

⁸⁶ *SPACEWARN Bulletin*, no. 566 (1 Jan. 2001), URL <<http://nssdc.gsfc.nasa.gov/spacewarn/spx566.html>>.

⁸⁷ The WAAS is described at URL <<http://gps.faa.gov/Programs/WAAS/waas.htm>>.

The Skynet 4 constellation consists of three spacecraft. The initial trio was launched in 1988 and 1990, with an expected operational life of seven years. Replacement spacecraft were launched in 1998, 1999 and most recently in February 2001. Skynet 4B, the oldest of the initial trio, was reportedly retired in June 1998, a few months after the launch of Skynet 4D.⁸⁸ The three new Skynet 4 spacecraft provide worldwide UHF and SHF communications, and two of the older Skynet spacecraft may remain on back-up status. The proposed Skynet 5 system, eventually to replace Skynet 4, includes two geosynchronous satellites to provide coverage over Europe, the Middle East, Africa, parts of Asia, the Atlantic Ocean and the eastern United States.⁸⁹

Sicral (Satellite Italiano per Comunicazione Riservate), Italy's first military satellite, provides communications for the Italian Ministry of Defence. Launched with Skynet 4F on 7 February 2001, Sicral carries nine UHF, SHF and EHF transponders.

In November 2000 the French Ministry of Defence chose Alcatel Space as the prime contractor for the Syracuse III system, with the first launch to be carried out in late 2003. This new dedicated military spacecraft will augment the existing Telecom 2 hybrid civil/military communications satellites which host Syracuse II transponders. Syracuse III will provide significantly greater data throughput, operational flexibility and resistance to jamming.

The Spanish Hispasat is a dual-use system supporting civil, military and government communications requirements. It has provided X-band services to the Spanish Ministry of Defence since 1992. The Hispasat 1D spacecraft is scheduled for launch in late 2002, joining the Hispasat 1A, 1B and 1C satellites. On 13 July 2001 Loral Space & Communications was selected to build two new satellites. XTAR-EUR is scheduled to be launched in 2003, and SpainSat in 2004. The XTAR-EUR satellite will offer leased transponder services to government customers and provide a back-up to the Spanish Ministry of Defence. SpainSat, providing dedicated communications for the Spanish Ministry of Defence, will carry nine X-band transponders and a Ka-band payload.⁹⁰

In December 1997 France, Germany and the UK signed an agreement for the joint project-definition phase of a future military satellite communications system known as TRIMILSATCOM. This project envisioned the joint development, manufacture and launch of a constellation of at least four SHF/EHF satellites, with the ownership and use of the constellation to be shared among the partner nations.⁹¹ TRIMILSATCOM was initially the preferred approach for meeting the UK's SKYNET 5 requirement, although the UK withdrew

⁸⁸ URL <http://www.tbs-satellite.com/tse/online/sat_skynet_4b.html>.

⁸⁹ URL <<http://www.mod.uk/dpa/projects/skynet5.htm>>.

⁹⁰ 'Space Systems/Loral to build two new satellites to provide X-band satellite services to governments', Loral Space & Communications, 13 July 2001, URL <<http://www.loral.com/inthenews/010713.html>>.

⁹¹ British Ministry of Defence, 'UK, France and Germany join forces for new generation of satellites', document 217/97, 16 Dec. 1997, available at URL <<http://www.fas.org/news/uk/971216-uk.htm>>.

from the project in August 1998. The BIMILSATCOM followed, with French and German participation; the first launch is planned for 2005.⁹²

Helios is a military observation satellite programme developed by France, Italy and Spain. The Helios 1 programme was developed for a total investment of 10 billion francs (€1.52 billion) shared among France (78.9 per cent), Italy (14.1 per cent) and Spain (7 per cent). Helios 1A was launched on 7 July 1995, followed by Helios 1B on 3 December 1999. The 1-metre resolution images from these satellites are also made available to the Western European Union.

The first of the improved Helios 2 series is scheduled for an initial launch in early 2004. Helios 2 is intended to provide significantly enhanced resolution, reduced access delay and a day/night capability. The total cost of the programme is estimated at \$1.8 billion for the development and operation of two satellites over a 10-year period.⁹³ In contrast to Helios 1, initially only France committed substantial resources to Helios 2, although in early 2001 Belgium reportedly decided to contribute a 2.5 per cent share of the cost, the minimum contribution needed to gain access to imagery from the satellite.⁹⁴ Spain is expected to join the Helios 2 programme at a similar level.⁹⁵

By 2006–2008, additional European imagery intelligence capabilities might include four German SAR-Lupe radar satellites, four Italian Cosmo/Skymed radar satellites and two French Pléiades high-resolution optical platforms.⁹⁶ In early 2001 the French and Italian governments reportedly agreed to jointly develop the Cosmo Pléiades, with launches planned in 2003–2006.⁹⁷ However, as of the end of 2001 the status of all these programmes remained uncertain, with no flight hardware under construction.

India

India embarked on high-resolution satellite imaging with the launch of the Indian Remote Sensing Satellite (IRS) IRS-1C in 1995 and IRS-1D in 1997. These satellites provided imagery with a resolution of 5.8 metres, which was the highest-resolution imagery publicly available prior to the launch of the Ikonos satellite in late 1999. While useful for mapping, this imagery had only modest national security applications.

According to published plans, the IRS-P5 (Cartosat-1) was intended to be India's first high-resolution imagery intelligence satellite system, with a ground sample distance (GSD) of 2.5 metres, a significant improvement over the 5.8-metre resolution of the IRS-1C earth resources satellite. The Cartosat

⁹² McLean, A., 'European exploitation of space: when rather than if', *RUSI Journal*, Oct. 1999, pp. 47–50.

⁹³ Boucheron, J.-M., 'Rapport d'information sur le renseignement par l'image', Député, no. 3219, Assemblée Nationale, 4 July 2001.

⁹⁴ 'Belgium to join Helios-2 program', *Intelligence Newsletter*, no. 406 (23 May 2001).

⁹⁵ 'Belgium and Spain to join Helios 2', *Orbireport*, 12 July 2001.

⁹⁶ Western European Union (WEU), 'Space systems for Europe: observation, communications and navigation satellites', WEU Assembly document 1643, 18 May 1999.

⁹⁷ 'France and Italy to jointly develop Cosmo Pleiades remote sensing system', *SPACEandTECH Digest*, 5 Feb. 2001, available at URL <<http://www.spaceandtech.com>>.

programme was approved in 1997, with Cartosat-1 initially scheduled for launch in late 1999 and the follow-on Cartosat-2 planned for launch in 2002. Cartosat-2 was planned to offer imagery with a resolution of less than 1 metre.⁹⁸ By mid-2000 the Cartosat-1 remained under development, with a launch anticipated in 2001–2002.⁹⁹ By 2001 the Cartosat-1 was scheduled for 2002–2003, and the annual report of the Indian Space Research Organization simply indicated that ‘work on a more advanced cartographic satellite, Cartosat-2, has also been initiated’, with a launch target date in 2003–2004.¹⁰⁰

The Technology Experiment Satellite (TES), a remote sensing and photo-reconnaissance satellite, was launched by a Polar Satellite Launch Vehicle PSLV-C3 rocket from the Sriharikota High Altitude Range on 22 October 2001. The 1100-kg satellite carried a high-resolution panchromatic (black and white image) camera, with a GSD variously reported as either 2.5 metres or 1 metre.¹⁰¹

Israel

Israel began working on satellite reconnaissance technology in the late 1980s and launched the Ofeq 1 (Horizon) satellite in 1988.¹⁰² The Ofeq 2, launched in 1990,¹⁰³ also used the Shavit (Comet) booster based on the Jericho 2 ballistic missile. These small experimental spacecraft did not include intelligence collection capabilities, despite press reports to the contrary.¹⁰⁴ Israel launched the Ofeq 3 imagery intelligence satellite in 1995, although because it had an orbital inclination of 143.4° it could only cover the area of the earth between latitudes 36.6° North and South. Use of the Shavit booster required it to be launched across the Mediterranean Sea into a retrograde orbit in order to avoid overflight of Arab countries to the east. On 22 January 1998 Israel attempted to launch a new imagery intelligence satellite, but the Shavit booster failed after launch and was destroyed. Although sometimes described as ‘Ofeq 4’, it was the first commercial EROS launch. Ofeq 3 re-entered on 24 October 2000, having substantially exceeded its two-year life expectancy. The ImageSat International commercial satellite was launched soon afterwards. Future plans for the Ofeq programme are unclear, although some reports suggest that another launch may be planned for early 2002.

⁹⁸ ‘Cabinet nod for two satellite proposals’, *India World*, 25 June 1997.

⁹⁹ ‘Plan to launch INSAT series’, *The Tribune*, 7 June 2000.

¹⁰⁰ Indian Space Research Organization (ISRO), *Annual Report 2000–2001*, available at URL <<http://www.isro.org/rep2002/Annual%20.htm>>.

¹⁰¹ Gopal, S., ‘INDIA IN SPACE: launching of technology experiment satellite’, South Asia Analysis Group Paper no. 349 (28 Oct. 2001), claims 1-metre resolution, while Roy, P. S. and Agarwal, V., ‘Technology trends in remote sensing and data analysis’, URL <<http://www.gisdevelopment.net/technology/rs/techrs0018.htm>>, claim 2.5-metre resolution.

¹⁰² The authoritative transliteration appears to be ‘Ofeq’ although ‘Offeq’ and ‘Ofek’ are frequently encountered in the literature.

¹⁰³ Brinkley, J., ‘Israel puts a satellite into orbit a day after threat by Iraqis’, *New York Times*, 4 Apr. 1990.

¹⁰⁴ ‘A new spy in the sky’, *Time*, 2 Apr. 1990, p. 33.

Japan

While Japan has no dedicated military communications satellites, the Japan Self Defense Forces (JSDF) rely on the commercial Superbird spacecraft.¹⁰⁵ Space Communications Corporation (SCC), a Japanese satellite communications service company, was established in 1985 by Mitsubishi Corporation, Mitsubishi Electric Corporation and other Mitsubishi Group companies. SCC operates four Superbird communications satellites.¹⁰⁶

Japan began to consider redefining its long-standing policy precluding the use of space for military purposes as early as 1994. North Korea's August 1998 Taepo Dong missile test prompted a national consensus in Japan for development of the Information Gathering Satellite (IGS) intelligence programme. On 6 November 1998 the Japanese Cabinet decided to develop and launch four satellites by 2002, including a pair with optical sensors of 1-metre resolution and a pair with imaging radar capabilities of somewhat lower resolution. On 29 September 1999 the Japanese and US governments signed an agreement facilitating the acquisition by Japan of remote sensing parts and components and related information for indigenous development of the IGS system. The spacecraft are projected to weigh about 1.5 metric tons and orbit at an altitude of about 500 km.¹⁰⁷

By June 2001 the revised schedule called for the launch of two satellites in the winter of 2002 and a second pair in the summer of 2003, with a pair of second-generation spacecraft by the end of FY 2005 (the Japanese fiscal year begins on 1 April).¹⁰⁸ In August 2001 the Japanese Government requested funding of 70.7 billion yen in the FY 2002 state budget for the IGS project, a reduction of 8.5 per cent from the FY 2001 budget. At that time the launch of the four first-generation optical and radar satellites was projected for February and July 2002. The revised plan called for launching two identical replacement satellites in 2005–2006 and development of a pair of more advanced spacecraft that could be launched as early as 2008.¹⁰⁹ As of 20 November 2001 the National Space Development Agency (NASDA) of Japan launch schedule projected the launch of the first IGS satellite on an H-IIA (Standard) booster in FY 2002 and the launch of the second IGS satellite on the same type of booster in FY 2003, but gave no indication of the timing of subsequent launches. However, other reports suggested that the first launch had in fact slipped to 2003.¹¹⁰

¹⁰⁵ Hirayama, [no initial], (Capt.), Communications Division Operations & Plans Department Maritime Staff Office, 'The view from Japan—current C4I in JMSDF & its future', 2 Feb. 2000.

¹⁰⁶ URL <http://www.superbird.co.jp/english/super_33.htm>.

¹⁰⁷ 'Japan aims to launch 4 intelligence satellites by 2002', *Kyodo News/Japan Weekly*, 13 Nov. 1998.

¹⁰⁸ Jiji Press Ticker Service, 'Japan delays info-gathering satellite plan', 13 June 2001.

¹⁰⁹ 'Gov't seeks 70 bil. yen for spy satellites', *Kyodo News*, 3 Sep. 2001.

¹¹⁰ 'Australia to help Japan with spy satellite launch', *Kyodo News*, 22 Oct. 2001.

South Korea

The Korea Aerospace Research Institute (KARI) launched the Korea Multi-Purpose Satellite-1 (KOMPSAT-1) in December 1999 using the US commercial Orbital Sciences Corporation Taurus launch vehicle. This civilian remote sensing spacecraft, cooperatively developed by KARI and TRW, had several sensors, including one providing panchromatic imagery with a GSD of 6.6 metres—sufficient for mapping although not for military intelligence collection.¹¹¹

Work started in 1999 on the Korea Multi-Purpose Satellite-2 (KOMPSAT-2), intended to provide 1-metre resolution imagery. By early 2000 ELOP Israel had begun assembly of the payload, similar to the Israeli Ofeq intelligence satellite, with a launch planned for 2003.¹¹² In March 2001 it was announced that KOMPSAT-2 would be launched on China's LM-2C rocket from Xichang in April 2004.¹¹³

Taiwan

Taiwan's ROCSAT-2 remote sensing mission, offering 2-metre resolution, was approved in October 1997. Taiwan's National Space Program Office (NSPO) signed a contract with France's Matra Marconi Space on 29 November 1999, to build the ROCSAT-2 satellite. A contract awarded to DASA Dornier of Germany in early 1999 had been cancelled because of opposition from China.¹¹⁴ Initially scheduled to fly in 2002, in mid-2001 NSPO selected the Orbital Sciences Corporation Taurus rocket to launch ROCSAT-2 in mid-2003.¹¹⁵

Turkey

The Turkish Intelligence Satellite Supply Project called for a pair of high-resolution earth observation satellites.¹¹⁶ In July 2000 the Turkish Government awarded Israel Aircraft Industries (IAI) a \$270 million contract for an imagery intelligence satellite based on the Israeli Ofeq.¹¹⁷ The competing French company Alcatel Space protested the award and in August 2000 won the contract. In January 2001 the Turkish Defence Ministry cancelled the contract, in retaliation for the French Parliament's condemnation of the Ottoman Empire's killing of its Armenian minority in the early 20th century. Following this can-

¹¹¹ 'Korea multi-purpose satellite', URL <<http://kompsat.kari.re.kr>>.

¹¹² Kelly, M., 'S Korea satellite assembly begins', *Flight International*, 2 May 2000, p. 30.

¹¹³ Xinhua General News Service, 'China to launch S.Korean satellite', 21 Mar. 2001.

¹¹⁴ 'Chinese opposition may halt German contract to build spacecraft', *China News*, 18 Aug. 1999.

¹¹⁵ 'Taiwan drops India to launch ROCSAT 2 on Taurus', *SPACEandTECH Digest*, 15 June 2001.

¹¹⁶ Petrie, G. and Buyuksalih, G., 'Aiming high—Turkey's efforts to develop a capability in space remote sensing', *Geoinformatics*, Nov. 2001, pp. 34–39.

¹¹⁷ 'Intelligence satellite', *Military Procurement International*, vol. 10, no. 16 (5 Aug. 2000).

cellation, IAI was the presumptive candidate to build the spacecraft,¹¹⁸ although by the end of 2001 no contract award had been publicly announced.

V. Commercial operators

The precise division between imagery that is useful for national security planning and imagery that is useful for civil purposes is ambiguous and dependent on the specific applications. The French SPOT (Satellite pour l'observation de la terre) satellite, first launched in 1985, was the first to provide 10-metre resolution imagery, sufficient to depict airfields and other large installations. Within a decade, the Indian IRS-1C offered 5-metre imagery and a corresponding fourfold improvement in interpretability. Such imagery, however, was largely inadequate for most national security applications.

In 1992 the US Congress passed the Landsat Act, which authorized US companies to build and launch commercial imaging satellites. In 1994 President Clinton signed a Presidential Decision Directive (PDD-23) that further defined the government's remote sensing policies.¹¹⁹

By the late 1990s the impending introduction of commercial systems offering 1-metre resolution imagery marked the advent of commercial products with clear national security applications. These first-generation systems will soon be supplemented by commercial systems offering imagery of roughly 0.5-metre resolution.

Although not explicitly aimed at the national security market, other commercial systems are planning improved resolution capabilities. The French SPOT-5 spacecraft, to be launched in early 2002, will offer 2.5-metre panchromatic imagery.¹²⁰ The Canadian Radarsat-2 imaging radar satellite, with a launch planned in 2003, will offer all-weather imagery with a best resolution of 3 metres.¹²¹

Space Imaging

In April 1994 Space Imaging was granted a licence to offer 1-metre resolution satellite imagery. Lockheed Martin Commercial Space Systems built and launched the Ikonos satellite under contract to Space Imaging. On 27 April 1999 the first attempt to launch an Ikonos spacecraft failed because of a launch vehicle malfunction. On 24 September 1999 Space Imaging launched

¹¹⁸ Demir, M., 'Turkey scraps spy satellite contract with France, opens door to Israel', *Jerusalem Post*, 25 Jan. 2001; and 'Turkey cancels spy satellite order', *SPACEandTECH Digest*, 29 Jan. 2001.

¹¹⁹ Stout, M. and Quiggin, T., 'Exploiting the new high resolution satellite imagery: Darwinian imperatives?', *Commentary* (Canadian Security Intelligence Service), no. 75 (summer 1998); Dehqanzada, Y. A. and Florini, A. M., *Secrets for Sale: How Commercial Satellite Imagery Will Change the World* (Carnegie Endowment for International Peace: Washington, DC, 2000); and Baker, J. C., O'Connell, K. M. and Williamson, R. A. (eds), *Commercial Observation Satellites: At the Leading Edge of Global Transparency* (RAND and the American Society of Photogrammetry and Remote Sensing: Santa Monica, Calif., 2001).

¹²⁰ URL <<http://www.spot.com/home/system/future/spot5/spot5.htm>>.

¹²¹ URL <<http://radarsat.mda.ca/>>; and URL <<http://www.rsi.ca/rs2/home.htm>>.

Ikonos-1, the world's first successful 1-metre resolution, commercial earth imaging satellite. The system provides 1-metre resolution black-and-white and 4-metre resolution colour imagery.

On 19 January 2001 Space Imaging announced that it had been awarded a licence by the National Oceanic and Atmospheric Administration (NOAA) to operate a spacecraft capable of providing 0.5-metre resolution imagery, with a launch anticipated in 2004.

Space Imaging has several regional affiliates able to task the Ikonos satellite and downlink high-resolution imagery directly to ground receiving stations.¹²² Space Imaging Middle East, with its headquarters in Dubai, United Arab Emirates (UAE), was established as Dubai Space Imaging in November 1997 by a group of UAE investors. The company supplies imagery of Eastern Africa, Central Asia, the Middle East and the Persian Gulf. Japan Space Imaging Corporation was established in May 1988 by Mitsubishi Corporation for the East Asian region, including Japan. Space Imaging Europe S.A. (SIE) in Athens, Greece, has the exclusive right to a 12 million square kilometre territory that covers most of Europe, the Middle East and North Africa. On 21 November 2000 Space Imaging signed a contract with Turkey's Inta Space Systems Inc., a subsidiary of Cukurova Holdings, for the formation of a new commercial regional affiliate, Space Imaging Eurasia. In December 2000 Space Imaging Asia (e-HD.com) opened in Seoul, South Korea, with exclusive rights for coverage of Korea, and tasking rights over North-East Asia. On 31 August 2001 the Center for Remote Imaging, Sensing and Processing (CRISP) at the National University of Singapore began direct tasking and data collection of imagery from the Ikonos satellite.

DigitalGlobe

In 1993 the US Department of Commerce granted DigitalGlobe's predecessor, WorldView Imaging Corporation (WorldView), the first licence to operate an imagery satellite system. In January 1995 EarthWatch Incorporated (EarthWatch) was formed in a merger of WorldView and Ball Aerospace. The EarlyBird-1 satellite, designed to provide 3-metre resolution imagery, was launched on 24 December 1997 but failed in orbit four days later. On 21 November 2000 the QuickBird-1 satellite, designed to provide 1-metre imagery, was lost owing to a launch vehicle failure. In September 2001 EarthWatch became DigitalGlobe.¹²³

The QuickBird-2 spacecraft was successfully launched on 18 October 2001. The spacecraft provides the highest-resolution satellite imagery available to the commercial market—61-cm panchromatic resolution at nadir. Originally,

¹²² Space Imaging has affiliate companies in Greece—Space Imaging Europe S.A. (SIE); Japan—Japan Space Imaging Corporation; South Korea—Space Imaging Asia; Singapore—Center for Remote Imaging, Sensing and Processing (CRISP); Turkey—Space Imaging Eurasia; the UAE—Space Imaging Middle East (LLC) (SIME); and the USA, in Thornton, Colorado.

¹²³ URL <<http://www.digitalglobe.com>>.

the satellite was to collect and provide 1-metre imagery from a 600-km orbit, but the improved resolution was obtained by lowering the orbit to 450 km.

QuickBird satellite data are downlinked through two ground stations, in Norway and Alaska, which are linked to the control centre in Colorado. Eurimage is the exclusive distributor of DigitalGlobe products in Europe and North Africa, while Hitachi Software Engineering Co., Ltd is the exclusive distributor for customers in Asia. These two companies are also major investors in DigitalGlobe. Other international resellers include Sinclair Knight Merz in Australia, INTERSAT in Brazil, INCOM in Chile and BMP Geomatica in Peru.

Orbimage

Orbimage, an affiliate of Orbital Sciences Corporation, operates the OrbView-1 and OrbView-2 low-resolution satellites and plans to add a high-resolution satellite, OrbView-3. The attempted launch of the OrbView-4 imaging satellite on 21 September 2001 failed because of a malfunction in the Orbital Sciences Corporation's Taurus rocket. OrbView-4 carried sensors providing 1-metre resolution panchromatic and 4-metre resolution multi-spectral imagery. Following this loss, the company filed for bankruptcy, although plans apparently continued for future launches.¹²⁴

OrbView-3, planned for launch in 2002, will have the same resolution as OrbView-4. OrbView-3 imagery will be downlinked in real time to ground stations located around the world or stored on-board the spacecraft and downlinked to Orbimage's master US ground stations. Orbimage ground stations are operational in Australia, Canada, Chile, Italy, South Korea and South Africa.

ImageSat International¹²⁵

West Indian Space was incorporated in the Netherlands Antilles in 1997 as a joint venture of the Israeli companies IAI and Electro-Optics Industries (El-Op), and the US company Core Software Technologies. In August 2000 the company changed its name to ImageSat International, with ownership distributed between IAI (44 per cent), El-Op (12 per cent) and Core (44 per cent).¹²⁶ In late 2001 it was reported that the addition of other private investors

¹²⁴ Johnston, N., 'Va. satellite firm files plan to reorganize; Orbital Imaging's move follows satellite loss', *Washington Post*, 26 Sep. 2001.

¹²⁵ ImageSat has affiliate companies in Argentina—CONAE (National Commission on Space Activities); Israel—ImageSat Israel; Italy—IPT (Informatica per il Territorio); Japan—Hiroshima Earth Environment Information Center; South Korea—Satellite Technology Research Center; Russia—Sovinform-sputnik; Singapore—Centre for Remote Imaging, Sensing and Processing (CRISP); South Africa—Satellite Applications Centre (SAC); Sweden—Metria Satellus; Taiwan—Center for Space and Remote Sensing Research; and the USA—Core Software Technology (CST).

¹²⁶ 'West Indian Space changes name to ImageSat, announces product offerings', *SPACEandTECH Digest*, 14 Aug. 2000.

from Europe and the USA had brought the non-Israeli holdings to about 60 per cent of the company.¹²⁷

The EROS A1 satellite was launched by a Russian Start-1 booster on 5 December 2000. The EROS A1 provides either 1.8-metre resolution 'Standard' imagery or 1-metre 'Over-Sampled' imagery. In August 2001 ImageSat International initiated production of the follow-on EROS B1, designed to provide 0.5-metre resolution imagery, with a launch scheduled for late 2003.¹²⁸

The lightweight EROS A1 spacecraft does not have on-board data storage, and imagery acquisition is restricted to footprints within a 2000-km radius of a ground station. The primary archive facility is located in Limassol, Cyprus, and as of early 2000 the company had reportedly signed agreements with 15 ground stations worldwide.¹²⁹ Satellite Operating Partners (SOP) provide dedicated regional coverage for the exclusive use of regional customers. SOP customers have complete control of the satellite over their area of coverage and retain a local archive of collected imagery. Alternatively, Priority Acquisition Service (PAS) provides confidential tasking of the ImageSat spacecraft while it is in a customer's coverage area (which appears to restrict the availability of the imagery to other customers).¹³⁰

VI. Prevention of an arms race in outer space

The issue of the military uses of space has resurfaced on the arms control agenda. The USA's plans for an expansive BMD system architecture featuring space-based components, and the growing importance of 'space control' in US military strategy, have fuelled international concern about the militarization of outer space.¹³¹ China, France and Russia have called for the negotiation of a new multilateral treaty prohibiting the deployment of weapons in space and restricting its use for peaceful purposes. These calls have been supported by other states, including Canada and Sri Lanka.

China has taken a leading role in advocating the creation of a non-militarized 'space sanctuary'. In the Conference on Disarmament, China proposed in 1999 the re-establishment of an ad hoc negotiating committee under item three of the CD agenda, 'Prevention of an arms race in outer space' (PAROS).¹³² This proposal has been backed in principle by Russia.¹³³ In 2001

¹²⁷ Wagner, M. J., 'Evaluating the EROS-A1 satellite—an Israeli commercial high-resolution spy in the sky', *Geoinformatics*, Nov. 2001, pp. 6–9.

¹²⁸ Opall, B., 'ImageSat initiates production of new craft', *Space News*, 13 Aug. 2001.

¹²⁹ Moring, F., Jr., 'Internet sales drive marketing for Israeli-built satellite', *Aviation Week's Space Business*, 3 Apr. 2000.

¹³⁰ Wagner (note 127).

¹³¹ Referring to the USA's interest in the military uses of space, a senior Chinese representative warned at the United Nations that 'outer space is now faced with the danger of being weaponized, which manifests itself in two aspects, namely, the development of the missile defence programme and the "space control" plan'. Statement by Hu Xiaodi, Head of the Chinese delegation at the 2001 session of the United Nations Disarmament Commission, 10 Apr. 2001.

¹³² China proposed the establishment of an ad hoc committee 'to negotiate the conclusion of an international legal instrument banning the testing, deployment and use of any weapons, weapon systems or

China intensified its diplomatic efforts to open substantive negotiations on space weapons in the light of the US administration's proposal to replace the 1972 Treaty on the Limitation of Anti-Ballistic Missile Systems (ABM Treaty) with a new US–Russian strategic framework.¹³⁴ Although it is not a party to the ABM Treaty, China has derived considerable security benefits from the treaty's prohibition of national missile defences. This created a strategic environment that allowed the Chinese deterrent to remain at a relatively modest number of warheads. Thus it was not surprising that China became one of the most vocal critics of US missile defence plans, suggesting that 'the crux of [the] matter lies in the attempt by one certain country aiming at absolute security to press ahead with a national missile defence system (NMD) covering the whole territory and to introduce weapons in outer space on the basis of its outstanding economic, scientific and technological capabilities'.¹³⁵

In June 2001 the Chinese delegation introduced a proposed draft agreement. Under this proposal, states would agree 'not to test, deploy or use in outer space any weapons, weapon systems or their components. Not to test, deploy or use on land, in sea or atmosphere any weapons, weapon systems or their components that can be used for war-fighting in outer space. Not to use any objects launched into orbit to directly participate in combatant activities'. The draft defines 'weapon systems' as 'the collective of weapons and their indispensably linked parts that jointly accomplish battle missions' and components of weapon systems as 'subsystems that [are] directly and indispensably involved in accomplishing battle missions'.¹³⁶ Ambassador Hu candidly acknowledged that, owing 'to the complexity and sensitivity of the verification issue, the paper offers no specific ideas in this connection'. He also suggested that 'missile defense systems will undoubtedly incorporate space weapon systems. Some of these space weapon systems may be based in outer space, providing target information and guidance for weapon systems located on earth'.¹³⁷

Prior to the introduction of the Chinese draft, progress on the PAROS issue in the CD had been almost non-existent, and the events of 2001 provide little encouragement for the future. Part of the problem is the Chinese draft itself, which is extraordinarily ambiguous in defining prohibited activities, possibly reflecting China's ambivalence as to which US activities are of most concern.

components thereof in outer space'. Re-establishment of an ad hoc committee on the prevention of an arms race in outer space and its mandate, Conference on Disarmament document CD/1576, 18 Mar. 1999. An ad hoc committee established in 1994 failed to reach agreement on a set of proposed confidence-building measures for outer space.

¹³³ Russia has suggested that the CD establish an ad hoc committee to negotiate a PAROS regime, which could potentially take the form of an international legal instrument. Statement by Vasily Sidorov, Ambassador of Russia to the CD, Conference on Disarmament document CD/PV.871, 22 Mar. 2001.

¹³⁴ See chapter 10 in this volume.

¹³⁵ Statement by Hu Xiaodi, Ambassador for Disarmament Affairs of China, at the Plenary of the Conference on Disarmament, Geneva, Conference on Disarmament document CD/PV.876, 7 June 2001.

¹³⁶ Delegation of China working paper, 'Possible elements of the future international legal instrument on the prevention of the weaponization of outer space', Plenary of the Conference on Disarmament, Geneva, Conference on Disarmament document CD/1645, 6 June 2001.

¹³⁷ Statement by Hu Xiaodi (note 135).

In contrast to some proposals of the 1980s, the Chinese draft is not simply a ban on anti-satellite weapons, nor is it simply a prohibition on space-based anti-missile interceptor weapons. The Chinese language would appear to correctly appreciate the extraordinarily critical role that space-based sensors play in proposed US ground-based anti-missile systems.

The Chinese proposal, with terms such as ‘directly participate in combatant activities’ and ‘jointly accomplish battle missions’, might be taken as directed against the increasingly intimate and indispensable connection between US military space systems and terrestrial war-fighting capabilities. The expressed Chinese anxieties concerning US hegemony enforced from space would be equally applicable to space-based lasers and space-directed ‘smart bombs’.

Some difficulty would attend any effort to ban space-based interceptor systems or ground-based interceptors capable of destroying satellites. Such a ban would preclude all but the shortest-range interceptors currently projected in US anti-missile plans. Even greater difficulties would confront an effort to ban the space-based sensors that are the key component of wide-area anti-missile systems. The task of banning those space systems that provide targeting support for terrestrial weapons would appear even more daunting.

Conventionally, arms control analysts have spoken of the militarization of space as being an irreversibly accomplished fact and the weaponization of space as a future condition subject to further debate. As initially formulated, the Chinese draft does not appear to acknowledge this conventional distinction.

Problems of definition and drafting aside, a more fundamental problem confronts the PAROS project. Historically, arms control regimes have reflected existing power relationships. Cold war arms control agreements between the superpowers were agreements between equals, as were many multilateral agreements. Some other arms control regimes, notably those in the non-proliferation area, have encompassed restrictions on the weak by the powerful. The annals of arms control are devoid of precedent for a regime imposed on the strong by the weak, as is proposed under PAROS.

VII. Ballistic missile defence¹³⁸

In May 2001 President Bush stated that ‘today’s most urgent threat stems . . . from a small number of missiles in the hands of . . . states for whom terror and blackmail are a way of life. They seek weapons of mass destruction to intimidate their neighbors, and to keep the USA and other responsible nations from helping allies and friends in strategic parts of the world’.¹³⁹

The Bush Administration’s new programme, unlike that of the Clinton Administration, was not focused on a single architecture, but included parallel architectures with air-, land-, sea- and space-based components, as well as

¹³⁸ For more on ballistic missile defence, see chapter 10 in this volume.

¹³⁹ ‘Remarks by the president to students and faculty at National Defense University’, Fort Lesley J. McNair, Washington, DC, 1 May 2001.

multiple technologies in each configuration. Unlike the Clinton approach, under the new Bush plan there was no commitment to specific dates for production and deployment other than for the lower-tier terminal defence elements. As Defense Secretary Rumsfeld noted, 'We don't have a proposed architecture. All we have is a series of, a couple of handfuls of very interesting research and development and testing programs that we believe need to be tested'.¹⁴⁰

The Terminal Defense Segment

The Terminal Defense Segment (TDS) supports the development of capabilities to intercept ballistic missiles in the terminal phase of their trajectory, as the missile or warhead approaches and re-enters the atmosphere. This provides only a brief opportunity for interception—from a few minutes before re-entry to a minute or less after re-entry.

The Patriot is a mobile US Army air and missile defence system, which was first used against ballistic missiles during the Gulf War, with limited success. The Patriot Advanced Capability 3 (PAC-3) was designed from the outset as an anti-missile system. It integrates an entirely new interceptor missile with improved radars and tracking computers. Unlike the earlier versions of the Patriot, which used an explosive warhead, PAC-3 features a high-velocity hit-to-kill interceptor.¹⁴¹ As of mid-2001 the PAC-3 programme had demonstrated seven successes in eight attempts in hit-to-kill intercepts against ballistic missile targets and four successes in four intercepts against cruise missiles and air-breathing targets. PAC-3 interceptor missiles were first delivered to training battalions in 2001.¹⁴²

The Medium Extended Air Defense System (MEADS) is intended to defend against short- and medium-range ballistic missiles, cruise missiles and aircraft. The MEADS acquisition strategy included competition between two transatlantic industrial teams. As presently structured, the programme will integrate the Patriot PAC-3 missile with a lightweight launcher, a 360° coverage radar and a new tactical operation centre, including technology from Germany, Italy and the USA.¹⁴³ With funding approved by the German Parliament in June 2001, the trilateral MEADS programme initiated a three-year Risk Reduction Effort in July 2001. A \$216 million contract was awarded to MEADS International, a joint venture including Lockheed Martin and EuroMEADS (consisting of the Anglo-Italian Alenia Marconi Systems and the European Aeronautic Defence and Space Co.).¹⁴⁴

¹⁴⁰ Press Conference with Defense Secretary Donald Rumsfeld at the Frontiers of Freedom Institute Conference, Washington, DC, 12 July 2001.

¹⁴¹ 0604865C PAC3—EMD, BMDO, RDT&E, Budget Item Justification (R-2 Exhibit), June 2001.

¹⁴² Kadish, R. T. (Lt-Gen.), USAF, Director, Ballistic Missile Defense Organization, 'The Ballistic Missile Defense Program', Statement before the House Armed Services Committee, Amended Fiscal Year 2002 Budget, 19 July 2000.

¹⁴³ 0603869C MEADS—DEM/VAL (PD-V), BMDO, RDT&E Budget Item Justification (R-2 Exhibit), June 2000.

¹⁴⁴ Gildea, K., 'NATO awards \$216 million MEADS risk reduction contract', *Defense Daily International*, 13 July 2001.

The Arrow system (developed jointly by the USA and Israel) consists of the jointly developed Arrow II interceptor and launcher, integrated with the Israeli-developed fire control radar (Green Pine), battle management centre (Citron Tree) and launch control centre (Hazelnut Tree). In January 1998 Israel requested \$169 million to fund the procurement of a third Arrow battery, and the US Congress provided the additional funding between 1998 and 2001. Since 1988, when the Arrow programme was initiated, Israel has improved the performance of its pre-prototype Arrow I interceptor to the point where it achieved a successful intercept in June 1994. The first integrated intercept flight test was successfully conducted in Israel on 1 November 1999. The Green Pine radar detected a Scud class ballistic target, and the Citron Tree battle management centre commanded the launch of the Arrow II interceptor. The Israeli Air Force declared the Arrow operational on 16 October 2000.¹⁴⁵

The Theater High-Altitude Area Defense (THAAD) system is intended to intercept medium-range theatre ballistic missiles at long ranges and high altitudes. THAAD uses hit-to-kill technologies, can operate in both the endo- and exo-atmosphere, and has a much longer range than the PAC-3 system. In the mid-1990s pressure regarding the schedule led to a string of six flight test failures. The Engineering and Manufacturing Development (EMD) contract was awarded to Lockheed Martin Space Systems Company, with Raytheon as the major subcontractor.¹⁴⁶ After programme restructuring, THAAD achieved successful intercepts in the summer of 1999.¹⁴⁷ THAAD will be deployed in three incremental blocks, and a limited contingency capability could be available in 2005. By 2007 an improved version is intended to defeat all expected threats from short- and medium-range missiles. By 2012 an upgraded version of THAAD is intended to counter more advanced threats.¹⁴⁸

The Navy Area Theater Ballistic Missile Defense (TBMD) is built on the existing capabilities of the Aegis Weapon Systems (AWS) on the CG-47 Ticonderoga Class cruisers, the DDG-51 Arleigh Burke Class destroyers and the Navy Standard Missile II (SM-2) Block IV missile. This medium-range system was intended to provide lower-tier protection to ports, coastal airfields, amphibious operations and other coastal sites.¹⁴⁹ As with the PAC-3 and THAAD, the Navy Area interceptor featured a direct hit guidance to provide hit-to-kill intercepts a large percentage of the time, along with a blast fragmentation warhead to ensure lethality if a direct hit is not achievable. Although the Navy Area Program had experienced various technical, cost and schedule problems, as of mid-2001 flight tests were expected to lead to an operational

¹⁴⁵ 0603875C International Cooperative Programs, BMDO, RDT&E Budget Item Justification (R-2A Exhibit), June 2001.

¹⁴⁶ 0604861C THAAD System—EMD, BMDO, RDT&E Budget Item Justification (R-2 Exhibit), June 2001.

¹⁴⁷ Statement of Lieutenant General Ronald T. Kadish, USAF, Director, Ballistic Missile Defense Organization, Before the House Armed Services Committee, Subcommittee on Military Research & Development, 14 June 2001.

¹⁴⁸ 0603881C Terminal Defense Segment, BMDO, RDT&E Budget Item Justification (R-2A Exhibit), June 2001.

¹⁴⁹ 0604867C Navy Area—EMD, BMDO, RDT&E Budget Item Justification (R-2 Exhibit), June 2001.

capability by about 2005. Somewhat surprisingly, in December 2001 the Pentagon cancelled the programme when it emerged that the project was more than 50 per cent over budget and had fallen over two years behind the planned schedule.¹⁵⁰

The Midcourse Defense Segment

In mid-2001 the Bush Administration redesignated the NMD programme as the Missile Defense System, or the Midcourse Defense Segment (the MDS acronym is defined differently by different officials). The MDS includes capabilities for countering ballistic missiles in the mid-course stage of flight, including the Ground-Based Midcourse Project and the Sea-Based Midcourse Project, successors to the NMD and Navy Theater Wide (NTW) programmes.

A major focus of the MDS is the construction of a missile defence test bed that provides a short-term option to employ the test facility's radars, command and control, and interceptor missiles as an operational capability. The system could be put on alert status to provide a contingency capability in FY 2004.¹⁵¹ The MDS amended budget request of \$3941 million represents an increase of \$1455 million over FY 2001 enacted funds, and an increase of \$1237 million over the FY 2002 initial budget submission.¹⁵²

The NTW programme, also known as Upper Tier, is intended to intercept medium- to long-range theatre ballistic missiles. NTW, also known as the Aegis Light-weight ExoAtmospheric Projectile (LEAP) Intercept (ALI) programme, is intended to conduct boost-phase intercepts when a ship is positioned near the missile launch site, mid-course intercepts, as well as terminal-phase intercepts near the defended area. As with the shorter-range Navy Area system that was cancelled in December 2001, MTW builds on the AWS and the Standard missile. However, the SM-2 Block IV is modified with a new third stage and an exo-atmospheric kinetic warhead (KW). Testing has included the Flight Test Round (FTR)-1 in July 2000, which experienced a failure in the new third-stage system. Three additional flight tests were planned for 2001.¹⁵³ The programme successfully executed FTR-1A in January 2001 and was scheduled to conduct an additional flight test, Flight Mission (FM)-2, in the fourth quarter of FY 2001. An additional five flight tests, FM 3–7, were scheduled for FY 2002.¹⁵⁴

Under the Bush Administration's restructured Sea-Based MDS project, the NTW programme is focused on developing a contingency sea-based ascent and mid-course intercept capability that could be deployed by FY 2005 to

¹⁵⁰ Dao, J., 'Navy missile defense plan is canceled by the Pentagon', *New York Times*, 16 Dec. 2001.

¹⁵¹ 0603882C Midcourse Defense Segment, BMDO, RDT&E Budget Item Justification (R-2 Exhibit), June 2001.

¹⁵² 'The Ballistic Missile Defense Program—Amended Fiscal Year 2002 Budget', Prepared Statement of Lieutenant General Ronald T. Kadish, USAF, Director, Ballistic Missile Defense Organization, United States Senate, Committee on Armed Services, 12 July 2001.

¹⁵³ 0603868C Navy Theater Wide—DEM/VAL, BMDO, RDT&E Budget Item Justification (R-2 Exhibit), June 2001.

¹⁵⁴ 0603882C Midcourse Defense Segment, BMDO, RDT&E Budget Item Justification (R-2A Exhibit), June 2001.

provide a limited capability against medium-range ballistic missile threats. The project is also intended to provide a sea-based ascent mid-course phase hit-to-kill capability against intermediate- and intercontinental-range missiles in FYs 2008–10.¹⁵⁵ The sea-based boost programme is also considering an entirely new high-speed, high-acceleration booster using a boost-phase kill vehicle. This booster will also be evaluated (with a different kill vehicle) for the sea-based mid-course requirement.¹⁵⁶

The Clinton Administration's NMD system elements comprised a Ground-Based Interceptor (GBI), ground- and space-based sensors, and a Battle Management, Command, Control and Communication (BM/C3) system. The ground-based sensors included a new X-Band Radar (XBR) and upgrades to existing early-warning radars (EWRs). The NMD system would also use satellites for warning and tracking. Initially, these would be limited to the Defense Support Program (DSP) and subsequently the Space-Based Infrared System (SBIRS). The programme was structured to field an initial capability (IC) by the end of FY 2006 and an expanded capability by the end of FY 2008. The IC included up to 20 ground-based interceptors at a single site in Alaska, a single ground-based XBR, upgraded early-warning radars (UEWR) and DSP satellite support. The expanded capability extended to 100 ground-based interceptors, an upgraded XBR, the upgrading of five EWRs and the SBIRS warning and tracking satellites. However, on 1 September 2000 President Clinton decided to delay a deployment decision and continue testing.¹⁵⁷

The Bush Administration has announced plans for an MDS Test Bed Facility that includes these components at several locations. Five GBIs with supporting infrastructure at Fort Greely, Alaska, would demonstrate the design of a GBI deployment site, although the plans did not call for the launching of interceptors from Fort Greely during the test programme since the missiles would have to fly over populated areas. Two GBI test launch silos would be located at the Kodiak Launch Complex (KLC) in Alaska, a commercial space launch centre owned by the Alaska Aerospace Development Corporation. The upgrades to the existing COBRA DANE phased array radar on Shemya Island would include upgraded software, refurbishment of power plant there, and test-support infrastructure. The UEWR at Beale AFB in California would consist of software upgrades to the existing PAVE PAWS radar.¹⁵⁸

The Boost Defense Segment

The objective of the Boost Defense Segment (BDS) of the Bush Administration's restructured programme is to develop the capability to intercept ballistic missiles shortly after launch. The administration's amended request of

¹⁵⁵ 0603882C Midcourse Defense Segment, BMDO (note 154).

¹⁵⁶ 'The Ballistic Missile Defense Program—Amended Fiscal Year 2002 Budget' (note 152).

¹⁵⁷ 0603871C NMD, BMDO, RDT&E Budget Item Justification (R-2 Exhibit), June 2001.

¹⁵⁸ Statement of Dr Patricia Sanders, Deputy for Test, Simulation and Evaluation, Ballistic Missile Defense Organization, Amended Fiscal Year 2002 Military Construction Budget, 31 July 2001.

\$685 million for the BDS programme was an increase of \$313 million over the FY 2001 enacted funding. The programme includes both directed energy (DE) and kinetic energy (KE) systems. Early activities include an intercept demonstration in 2003 using the Airborne Laser (ABL) and a KE intercept in 2006 under the new Space-Based Interceptor Experiment (SBX) programme.

The ABL programme is intended to develop an air-based laser weapon to intercept ballistic missiles in their boost phase. This weapon system integrates a laser and associated equipment into a modified commercial Boeing 747-400F aircraft. The ABL programme definition and risk reduction contract was awarded to the Boeing/TRW/Lockheed Martin team in November 1996. The initial prototype ABL aircraft, with a laser providing about half of the projected power of the production version, is intended to culminate in boost-phase missile intercepts in 2003. This half-power ABL will be available for deployment as an emergency capability, and two full-power aircraft are to be delivered by FY 2009. Procurement of additional full-power aircraft will be completed by 2011.¹⁵⁹

The Space-Based Laser (SBL) project is intended to accomplish boost phase intercept prior to the deployment of mid-course countermeasures.¹⁶⁰ The Defense Advanced Research Projects Agency (DARPA) began work on the SBL programme in 1977, and in 1984 the programme was transferred to the Strategic Defense Initiative Organization (SDIO). In 1997 the programme was again transferred, from the Ballistic Missile Defense Organization (BMDO) to the Air Force. Despite a major injection of funding during the late 1980s, as of 1997 the programme remained no closer to an orbital flight demonstration than when it was initiated in 1977. On 8 February 1999 a contract was awarded to a team comprised of Lockheed Martin, TRW and Boeing.¹⁶¹ The project is initially focused on a ground demonstration at a new test facility at the Stennis Space Center, Mississippi. In 1999 the programme was structured to support an in-space Integrated Flight Experiment (IFX) in 2012–13. Under the revised Bush Administration plan, the programme will proceed from a component development phase in 2002–2006, to an integrated ground test phase in 2007–10, to an on-orbit test phase in 2011–13.¹⁶² Proponents claim that each SBL platform would be capable of destroying dozens of missiles during their boost phase. A 12-satellite constellation could intercept about 95 per cent of theatre missile threats, and a 24-satellite constellation could provide nearly complete national missile defence.¹⁶³

The Space-Based Kinetic Energy Experiment is the only major initiative of the Bush Administration's missile defence programme that was not included in the Clinton Administration plans. The programme represents a revival of

¹⁵⁹ 0603883C Boost Defense Segment, BMDO, RDT&E Budget Item Justification (R-2 Exhibit), June 2001.

¹⁶⁰ More information is available on the Space-Based Laser-Integrated Flight Experiment Internet site at URL <<http://www.sbl.losangeles.af.mil>>.

¹⁶¹ 0603174C Space Based Laser, BMDO, RDT&E Budget Item Justification (R-2 Exhibit), June 2001.

¹⁶² 0603883C Boost Defense Segment BMDO (note 159).

¹⁶³ BMDO, 'Space-Based Laser', Fact Sheet 301-00-11, Nov. 2000.

the Space-Based Kinetic Kill Vehicle (KKV) and 'Brilliant Pebbles' projects of the Reagan and first Bush administrations. The initial objective of this project is to conduct a single test (in 2005–2006) in which a KKV engages a thrusting target against a below-the-horizon background. Such a test is intended to demonstrate the feasibility of intercepting missiles in their boost phase. The programme plan is to develop a space-based kill vehicle that would be launched on an existing booster and fired against a representative missile target (the interceptor itself would be launched on a ballistic trajectory, rather than being placed into orbit). The development of other space-based interceptor components would be initiated following initial ground-launched tests.¹⁶⁴

The SBIRS is a network of several types of satellites to provide detection and tracking of long-range and tactical ballistic missiles. The SBIRS network includes the SBIRS–Low satellites, in low earth orbits, and SBIRS–High satellites (developed by the US Air Force), in geosynchronous and highly elliptical orbits. An integrated centralized ground station supports all SBIRS space elements and Defense Support Program (DSP) satellites.¹⁶⁵

The SBIRS–GEO programme is intended to replace the current Defense Support Program early-warning satellites in geostationary orbit, while the SBIRS–HEO will replace the HERITAGE intelligence collection sensors currently hosted on other spacecraft in highly elliptical orbits. Unlike the scanning sensors of DSP, the SBIRS will use large focal plane array staring sensors, which provide continuous coverage of the earth. SBIRS will use a common spacecraft design for both HEO and GEO, with four spacecraft in GEO and a pair of spacecraft in HEO. By late 2001 it appeared that the \$2 billion SBIRS–High programme was facing a \$2.2 billion cost overrun and a three-year schedule delay, with the first spacecraft slipping from 2002 to 2004 or later.¹⁶⁶

While SBIRS–High supports both traditional early-warning and missile defence applications, SBIRS–Low is primarily for missile defence. It provides initial warning of a ballistic missile attack against the USA, its deployed forces or its allies. SBIRS–Low satellites provide continuous tracking of targets, from launch to impact or intercept. Their capabilities include booster detection, mid-course tracking, target discrimination and intercept hit/kill assessment. This satellite network will pass data to boost, mid-course and terminal defence interceptors. The planned tracking and discrimination capabilities are essential components for the projected multi-layer defence system.¹⁶⁷ SBIRS–Low began programme definition activities in August 1999 with the award of two contracts. In 2000 the US Air Force delayed the launch

¹⁶⁴ 0603883C Boost Defense Segment BMDO (note 159).

¹⁶⁵ Kadish (note 142).

¹⁶⁶ Wall, R. and Fulghum, D. A., 'New sensor targets high-profile missions', *Aviation Week & Space Technology*, 21 Dec. 2001, p. 41; and *Report to Accompany H.R. 3338, Department of Defense Appropriation Bill, 2002 and Supplemental Appropriations, 2002*, 107th Congress, 1st Session, Senate Report 107-109, 5 Dec. 2001.

¹⁶⁷ Robbins, C. A., 'Troubled system shows hurdles missile-defense plans will face', *Wall Street Journal*, 15 June 2001, p. 1.

of the first SBIRS–Low spacecraft from 2004 to 2006.¹⁶⁸ In response, at the direction of Congress, in early 2001 responsibility for SBIRS–Low was transferred from the Air Force to the BMDO. The SBIRS–Low contract is intended to support full-constellation deployment by FY 2011.¹⁶⁹ The estimated life-cycle cost of the programme, to consist of 27–30 satellites, is as much as \$23 billion (as against the official \$10 billion estimate in early 2001).¹⁷⁰ While the FY 2003 request for SBIRS–Low was \$385 million, Congress appropriated only \$250 million.

VIII. Conclusions

Space-based systems are becoming an increasingly important component of military power, above all for the United States. The USA is currently investing billions of dollars annually in development and deployment of a wide range of new precision-guided weapons which are revolutionizing the conduct of warfare. These weapons rely heavily on an integrated ‘system of systems’ that combines intelligence, communications, navigation and other military space systems.

At present no country can rival or contest US space dominance or the advantages that this provides to its terrestrial military operations. At the end of 2001, the USA had nearly 110 operational military-related satellites, accounting for well over two-thirds of all military satellites orbiting the earth; Russia had about 40 and the rest of the world about 20.

While it is difficult to overstate the singular advantages of US military space systems relative to those of the rest of the world, it would be a mistake to underestimate the rapidity with which other states are beginning to use space-based systems to enhance their security. Although commercial satellite imagery provides capabilities that are almost trivial compared to those of advanced US systems, these capabilities are revolutionary compared to what was available a decade ago.

The issue of the ‘weaponization’ of outer space has reappeared on the arms control agenda. There is growing international concern that the USA’s quest for ‘full-spectrum dominance’—a key dimension of which is the USA’s ability to dominate space and to deny its use to other countries—will give rise to a destabilizing arms race in space. This concern has become more urgent in the light of the Bush Administration’s plans for an expansive ballistic missile defence system architecture featuring space-based components. China and Russia have taken the lead in calling for the negotiation of a new multilateral treaty prohibiting the deployment of weapons in space and restricting its use for peaceful purposes. For its part, the USA has shown little interest in agreements that would constrain its military activities in space, where it enjoys unrivalled superiority.

¹⁶⁸ Newman, R. J., ‘Space watch, high and low’, *Air Force Magazine*, July 2001, p. 35.

¹⁶⁹ 0603884C Sensors Segment, BMDO, RDT&E Budget Item Justification (R-2A Exhibit), June 2001.

¹⁷⁰ *Report to Accompany H.R. 3338* (note 166).

IX. Tables of operational military satellites

Conventions

()	Uncertain data or information
..	Data not available or not applicable
+	Payload in addition to the payload for the primary mission

Abbreviations and acronyms

CCAFS	Cape Canaveral Air Force Station
Comm.	Communications satellite
deg.	Degrees
design.	Designation
ELINT	Electronic intelligence
GeoSat	Satellite in geostationary orbit
Incl.	Orbital inclination
Intl	International
km	Kilometres
KSC	Kennedy Space Center
min.	Minutes
Nav.	Navigation satellite
NORAD	North American Aerospace Defense Command
poss.	Possibly
prob.	Probably
SHAR	Sriharikota High Altitude Range
VAFB	Vandenberg Air Force Base