9. Science- and technology-based military innovation: the United States and Europe

BJÖRN HAGELIN

I. Introduction

The developments in international relations and military doctrines after the 11 September 2001 attacks on the United States and the subsequent wars in Afghanistan and Iraq have raised a number of issues related to the production, transfer and use of military technology, which are covered in this and other parts of the Yearbook.[1] Some of the response to asymmetric or other threats depends on the exploitation of relevant skills for research, development and production; on the efficient organization of such activities at the national and multinational levels; and on sharing the output with friendly states and allies.

Military research and development (R&D) is the most expensive and basic phase in the creation of a new weapon platform: without it there would be no new or advanced military systems or, to use a common term, no 'revolution in military affairs' (RMA). This revolution, which some see as more of a constant evolution, is a process that is today identified with 'network-centric' military solutions, of which the war in Iraq in 2003 has been said to be the first operational test.[2] The war effort benefited from the breakdown of the barrier between civil and military technology in the fields of communications, information technology (IT) and sensors.[3]

Studies and analyses of national and international military production often include comparisons of data on R&D expenditures. The R&D phase is normally seen as the first phase in the production of military equipment. However, there is an earlier stage in the process, which is discussed in this chapter.

This chapter is future-oriented rather than an account of recent developments: it proposes that changes in how nations develop future military capabilities are likely to involve a shift in emphasis, if not in kind, from traditional military R&D of defined weapon platforms towards greater military exploitation of science and technology (S&T).[4] This is referred to as 'S&T-based military innovation', implying cooperation as well as the direct and long-term

[1] For a full discussion of the effects of these wars see the Introduction in this volume.

[2] For an analysis of the RMA see Heurlin, B. *et al.* (eds), *New Roles of Military Forces: Global and Local Implications of the Revolution in Military Affairs* (Danish Institute for International Studies: Copenhagen, 2003). See also chapters 2 and 12 in this volume.

[3] Kaldor, M., Albrecht, U. and Schméder, G. (eds), *Restructuring the Global Military Sector*, vol. 2: *The End of Military Fordism* (Pinter: London, 1998).

[4] It should be noted that S&T has always, to different degrees, been used for military purposes. Military use of S&T is sometimes called 'spin-on' or 'spin-in' in order to distinguish it from civilian 'spin-off' from military activities. The latter term refers to a totally different activitity, but spin-off is also not planned for and occurs only with long delays.

military support—through defence ministries, armed services and related research organizations—of basic research, applied research, and exploratory technology development for achieving and supporting future military capabilities.

This chapter puts forward a thesis on S&T-based military innovation in section II, followed by two country studies. In section III, the United States illustrates the case of a country where the implementation of S&T-based military innovation has been 'standard procedure' at least since World War II. The United Kingdom is the example, described in section IV, of a major European military producer and one with most clear evidence of a new emphasis on S&T-based military innovation.

There is no coordinated European S&T-based military innovation policy. In spite of the European Security and Defence Policy (ESDP) and the declaration of and further developments in the European Union (EU) Headline Goals of 1999,[5] it is not clear how Europe will achieve these goals or what demands they will put on European S&T. Nevertheless, recent developments suggest that change is under way. Section IV first describes developments relevant to S&T-based military innovation in the UK and then discusses emerging EU policies that might constitute steps towards an EU S&T-based military innovation policy. Section V discusses some of the implications of a shift towards S&T-based military innovation for data and transparency, research ethics, competition and control. Section VI summarizes the main points of the chapter.

II. S&T-based military innovation

A general change in terminology reflects the shift of emphasis towards S&T for military innovation. A common term in use today is military research and technology (R&T), as a complement to military R&D. While the 'D' in R&D refers to the development of military *equipment* with defined characteristics, the 'T' in R&T emphasizes the development of military *technology*. The latter might therefore be compared to 'exploratory development', illustrated by technology demonstrators in contrast to more traditional military prototypes. Individual countries in Europe began to formulate military R&T strategies in the 1990s.[6] The North Atlantic Treaty Organization (NATO) R&T Organization (RTO) was formed in 1998 through a merger of the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research

[5] See Lachowski, Z., 'The military dimension of the European Union', *SIPRI Yearbook 2002: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2002), pp. 151–73.

[6] One example is Sweden; see Försvarsmakten Högkvarteret (Swedish Armed Forces Headquarters), *Swedish Armed Forces Strategy for Research and Technology, R&T* (Swedish Armed Forces Headquarters: Stockholm, 1997); and Försvarsmakten Högkvarteret, 'Försvarsmaktens strategi för forskning och teknikutveckling: FoT-strategin 2002' [Swedish armed forces strategy for research and technology development: R&T strategy 2002], URL <http://www.hkv.mil.se/article.php?id=4883>.

Group (DRG).[7] Moreover, one of the topics negotiated in the Letter of Intent (LOI)/Framework Agreement process that began in 2000 was how to coordinate national R&T policies and processes among the six European participating nations—France, Germany, Italy, Spain, Sweden and the UK.[8]

Figure 9.1 is a process-based illustration of the relationships between S&T, military R&D, and the use of commercial and openly available goods and services for the production and use of military equipment. S&T-based military innovation refers to the bottom and the right-hand 'input' parts of the figure, that is, the national S&T base and international coordination, cooperation and exploitation of S&T. At the top of the figure is the 'output': the final product and its maintenance, support and operational use. The civilian products that are used are often called 'dual-use' products, even though they were not developed with any military purpose in mind. This chapter does not deal with the production or commercial aspects of the production process or the operational use of the products.[9] Another output aspect not dealt with here or shown in figure 9.1 is the export control, rather than the acquisition, of S&T, which is often treated in national export policies.[10]

S&T-based military innovation implies military exploitation of both domestic and foreign S&T results in support of new ideas and problem solving related to the development of military capabilities. S&T results, owing to their neutral (rather than dual) character, have always been important for military R&D—whether for defence or offence, or for conventional weapons or weapons of mass destruction (WMD). The S&T-based military innovation thesis advanced in this chapter suggests that the research branches of ministries of defence and armed forces are likely to increase their financial support to and various forms of cooperation with national and foreign S&T organizations in specific areas and disciplines as a result of new capability requirements. However, S&T-based military innovation is relatively inexpensive, since military support generally adds to ongoing S&T projects or, in other cases, the military is one among several supporters of new projects.

The shift in emphasis towards greater use of S&T for military innovation can be explained by a number of changes. The first is the end of the cold war and the risk of a major East–West war. This was a necessary condition for the reductions in military expenditure and the reformulation of military doctrines in the USA and Europe from threat-based to capability-based strategies.

Second, this has resulted in a need to transform the cold war military organizations, inventories and operational 'rules of engagement' to accommodate them to the new security situation. New capabilities are now needed—sometimes to be used by more than one military service—rather than a set of

[7] Holme, N., 'The Research and Technology Agency—RTA: an essential contribution to NATO's future', *NATO's Nations and Partners For Peace*, vol. 47, special issue 4 (2001), pp. 16–18. See also the RTO Internet site at URL <http://www.rta.nato.int/home.asp>.

[8] The texts of the Framework Agreement and the Letter of Intent on Measures to Facilitate the Restructuring of the European Defence Industry, 6 July 1998, are available at URL <http://projects.sipri.se/expcon/loi/lointent.htm>. See section IV below.

[9] On these aspects see chapter 11 in this volume.

[10] See chapter 11, section V, and chapter 18 in this volume.

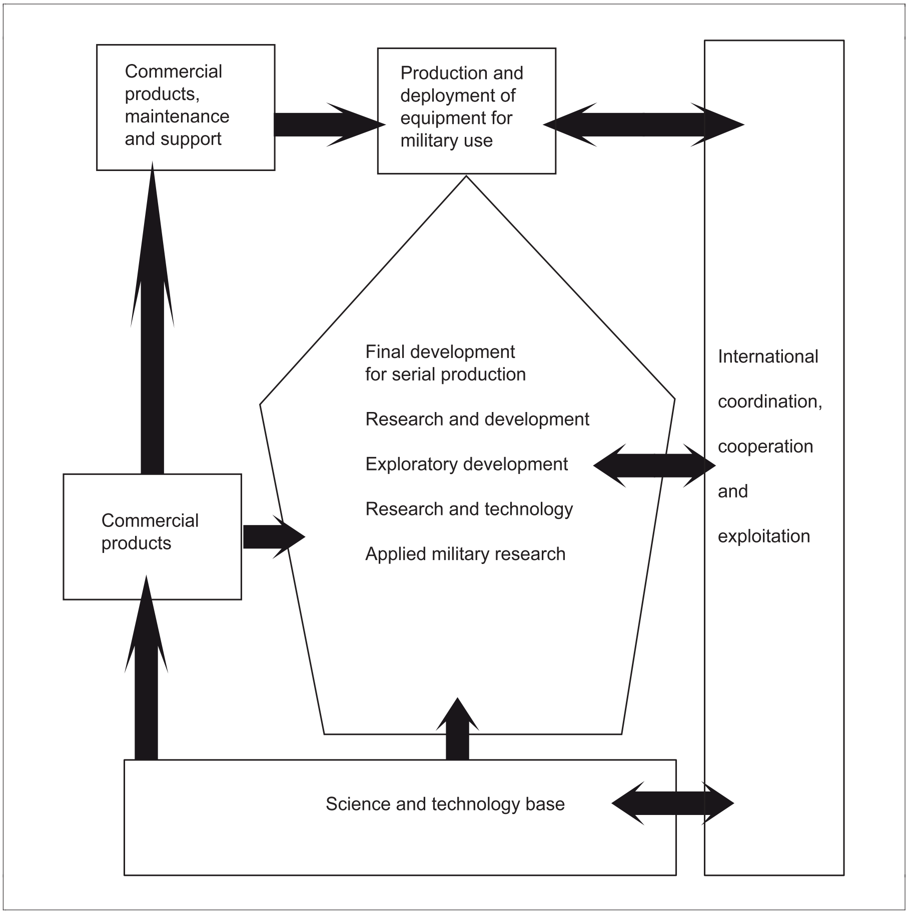

Figure 9.1. S&T-based military innovation relationships

defined military platforms. These changes are supported by new requirements in many countries, formulated around perceptions of asymmetric threats and anti-terrorism policy.

The third element is the political pressure, particularly in Europe, to keep national military expenditures at the relatively low post-cold war levels. This includes blurring the boundary between civil and military research and pressure to make more use of S&T results rather than to allocate large R&D sums for specific, costly military platforms that may be less relevant when they are ready for deployment. Some S&T areas are new and forward-looking, while others are related to commercially available technologies and equipment that have become increasingly relevant for military purposes as a result of the rapid turnover of technologically advanced civilian products compared with the long development and production cycles of major military equipment. Examples include communications, information technology and electronics as well as the psychology and sociology of decision making and leadership. Other relevant areas include nano-technologies; robotics, modelling and simulation; 'smart' materials and structures; and anti-detection technology.[11]

The fourth change is the potential for using S&T and commercially available goods, which is supported by the globalization of scientific exchange and processes for technological development and industrial production, in turn resulting in the potential availability of relevant S&T results from different parts of the world.[12] With the military relevance of a broader range of S&T fields, an individual nation may not constitute a sufficient S&T base for generating the necessary knowledge and skills. However, this also creates a risk: if one country can benefit from such technologies and goods, so can potential foes. Thus, in order to stay ahead of potential opponents and competitors in a globalized world, where relevant S&T advances can be made within short periods of time, military organizations must be directly involved in the production of S&T results or be quickly informed of such results and must have the capacity to exploit such results rapidly for military innovation.

S&T-based military innovation can take many forms, but pursuing it generally implies deliberate, long-term support for basic and applied research and technology development by defence ministries, military R&D and/or acquisition organizations, and armed forces. Such support may be extended to individual scientists or select projects and take the form of, for instance, direct financial support, exchange programmes, shared facilities and joint research programmes, or it may involve the military in 'centres of excellence'. Thus, S&T-based military innovation implies an increasing involvement of non-military participants in military innovation, such as universities and other public and private organizations as well as commercial business enterprises. Since such S&T activities are not defined as military activities, military support, participation and sharing of results are normally not complicated by military security restrictions. The S&T results may be manifested in a variety of forms, ranging from intangible individual knowledge and skills to tangible outputs in the form of scientific reports and other publications, the creation of new research equipment and methods, and the production of final goods.[13]

Only a few nations have the resources to organize broad, systematic and effective S&T-based military innovation. The USA seems to be strengthening its long-term policy and structure for exploiting S&T for military purposes. Section III describes the long tradition, strong focus—not least by specialized

[11] Davies, H., 'Defence research and technology', ed. K. von Wogau, *The Path to European Defence*, (Maklu Publishers: Antwerpen/Apeldoorn, 2004), pp. 265–77.

[12] US Department of Defense (DOD), *Quadrennial Defense Review Report* (DOD: Washington, DC, 30 Sep. 2001), p. 41. See also Gold, D., 'US military expenditure and the 2001 Quadrennial Defense Review', *SIPRI Yearbook 2002* (note 5), pp. 309–22. Six transformational goals were outlined in the report. See Svitak, A. and Kaufman, G., 'DOD outlines service tech goals', *Defense News*, 28 Apr. 2003, p. 14; and Svitak, A. and Kaufman, G., 'DOD may shift science spending priorities', *Defense News*, 24 Mar. 2003, p. 14.

[13] An evaluation of US military agency support and acquisition of S&T was made in 1969 with generally positive conclusions. See US Department of Defense, *Project Hindsight,* Final Report, AD-495905 (Office of the Director of Defense Research and Engineering: Washington, DC, Oct. 1969).

armed services' research organizations—and continued S&T-based military innovation in the USA.

III. The US example

To support its military R&D ambitions the US Government has concluded that, by supporting S&T, potentially relevant knowledge for military innovation can be attained both at a relatively low cost and faster than through the normal channels for distributing S&T results. After the end of World War II a number of institutions were established with the purpose of finding, generating, assessing and supporting promising S&T activities; these include the Office of Technology Assessment (1972–95), Defense Science Board, the Defense Advanced Research Projects Agency (DARPA) and the Office of Scientific Research. In addition, there are two US Department of Defense (DOD) R&D centres administered by universities or colleges: the Software Engineering Institute (under the Office of the Secretary of Defense) administered by the Carnegie Mellon University, and the Lincoln Laboratory (under the Department of the Air Force) administered by the Massachusetts Institute of Technology. There are also several R&D centres under the DOD which are administered by non-profit institutions.[14] The US Army, Navy and Air Force have developed a strong S&T-based military innovation ambition supported by organizations such as the Army Research Office, the Office of Naval Research, the Air Force Office of Scientific Research, the Air Force Technology Division, and the Office of Aerospace Research.[15]

Moreover, the USA is engaged in both domestic and international military S&T activities, the latter involving bilateral relations with countries throughout the world and with multinational organizations such as NATO.[16] In addition, the US military branches established organizations focused specifically on foreign S&T, such as the Army Foreign Science and Technology Center, the Air Force Foreign Technology Division and the Naval European Research Contracting Program. Offices were also established abroad to support US

[14] See National Science Foundation (NSF), Division of Science Resources Statistics, *Federal Funds for Research and Development: Fiscal Years 2000, 2001, and 2002,* vol. 50 (NSF: Washington, DC, May 2002), Section B: Federally funded research and development centers, by agency and type of administration, available at URL <http://www.nsf.gov/sbe/srs/nsf02321/start.htm>.

[15] Hagelin, B., *One for All or All for One? A Study of Pentagon Tapping of Foreign Science and Technology*, Report no. 42 (Uppsala University, Department of Peace and Conflict Research: Uppsala, 1997).

[16] The NATO Science Committee was established in 1957, partly to advance NATO's S&T capability. It has been responsible for the NATO Science Programme (from Nov. 2003 the NATO Programme for Security Through Science), which was designed to support collaboration between individual scientists rather than research work or institutions. NATO, *NATO Handbook* (NATO Office of Information and Press: Brussels, 2001), p. 193. In the 1980s there was an increasing focus on the promotion of international exchanges between industry and university research groups. NATO, *NATO Handbook* (NATO Office of Information and Press: Brussels, 1985), p. 30. In the 1990s the Science Programme was extended to the North Atlantic Cooperation Council (NACC) partners. NATO, *NATO Handbook* (NATO Office of Information and Press: Brussels, 1992), p. 53. Cooperation with Ukraine began in 1991, and in 1998 an agreement was signed on the establishment of a Joint NATO–Russia Joint Scientific and Technological Cooperation Committee (JSTC). NATO, *NATO Handbook* (NATO Office of Information and Press: Brussels, 2001), p. 194.

S&T-based military innovation, such as the London-based Office of Naval Research, the European Office of Aerospace R&D and the Army European Research Office.[17]

The USA has taken new steps to exploit S&T for military innovation, including attempts to generate joint capabilities.[18] Most recently, in 1999, the US Assistant Navy Secretary for R&D and Acquisition established the position of chief technology officer as a faster way to take advantage of new US and foreign technologies.[19] In 2001 Delores Etter, former US Deputy Under Secretary of Defense for S&T—a position that is in itself an indication of the military importance of S&T—concluded that the global access to many new technologies 'forces a run-faster strategy for many areas in which the United States cannot feasibly restrict its adversaries' access to technology'.[20] Later that year, the Quadrennial Defense Review (QDR) argued that the US DOD must maintain a strong S&T programme that supports evolving military requirements and ensures technological superiority over potential adversaries. The DOD therefore embarked on an effort to: (*a*) turn to private enterprises for new ways to move ideas from the laboratory to operating forces, (*b*) gain access to the results of innovations developed in the private sector, and (*c*) blend government and private research where appropriate.[21]

In 2002 a Defense Science Board study presented similar arguments for sustaining US military technological superiority by an active, well-funded and adaptable S&T programme.[22] This policy is reflected in the directives for the Review of Defense Trade Export Policy and National Security, started in 2002, which aims at maintaining the US technological advantages and facilitating fundamental research and rapid, optimal defence exploitation of commercial developments. The review is *inter alia* to identify technology transfer policy changes that will facilitate: (*a*) the ability of the US military to benefit from commercial developments and international cooperation; and (*b*) cutting-edge fundamental research in US academic institutions, government laboratories, private industry and other organizations that engage in fundamental research.[23]

The Multidisciplinary University Research Initiative is one example of a US DOD programme of support for basic science. Although relatively little fund-

[17] See Hagelin (note 15).

[18] The Joint Strike Fighter combat aircraft is one example. See Hagelin, B. *et al.,* 'International arms transfers', *SIPRI Yearbook 2002* (note 5), pp. 395–400; and chapter 10 in this volume.

[19] Scott, W. B., 'Navy accelerates transition of technology to weapon systems', *Aviation Week & Space Technology*, 7 May 2001, pp. 82–83.

[20] Etter, D., '"Run faster" strategy: science, technology gain new status', *Defense News*, 30 July–5 Aug. 2001, p. 31.

[21] *Quadrennial Defense Review Report* (note 12).

[22] US Department of Defense (DOD), *Defense Science and Technology*, Defense Science Board 2001 Summer Study (DOD: Washington, DC, May 2002).

[23] White House, 'Bush Administration Review of Defense Trade Export Policy and National Security', Fact Sheet, Washington, DC, 21 Nov. 2002, URL <http://www.whitehouse.gov/news/releases/2002/11/20021121-5.html>. See also Hagelin, B. *et al.,* 'International arms transfers', *SIPRI Yearbook 2003: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2003), pp. 440–41. Owing to the war in Iraq and the many controversial issues involved, no such review was published in 2003.

ing is offered, it must be seen in addition to the large US military development and procurement budgets.[24] This initiative is designed to address large multidisciplinary topic areas representing opportunities for future military applications and technology options. In 2000 the DOD accounted for almost 13 per cent of all federal obligations for research, allocated mainly in the fields of engineering, mathematics and computer sciences, life sciences, physical sciences and environmental sciences.[25] In March 2002 the DOD announced plans to award 26 grants totalling $14 million in fiscal year (FY) 2002, and up to $24 million per year starting in FY 2003, to 22 academic institutions for multidisciplinary research in almost as many areas of basic science and engineering (S&E, an alternative DOD term for S&T).[26]

In addition, in early 2003 the DOD was in the process of developing the Technology Planning Guidance (TPG), a new budget planning tool for the military services and defence agencies. The TPG should establish DOD S&T priority areas and will be used to craft military services' and defence agencies' spending plans towards such transformational technology areas as aerospace, energy and power, and surveillance systems.

The major category of total federal obligations for academic S&E activities—R&D projects—covers activities from basic research to exploratory development and accounted for more than 80 per cent of total US federal academic S&E support over the past decade.[27] The largest shares are accounted for by what may appear to be two contradictory purposes—saving lives (the Department for Health and Human Services, DHHS) and war (the DOD).[28] However, a basic characteristic of S&T is that the output may be relevant for many purposes, including both offence and defence, both 'killing and caring'. For example, a 2002 US National Research Council study reflects a commitment of the US scientific, engineering and health communities to help respond to the challenges after 11 September 2001.[29] The emphasis on anti-terrorist warfare and homeland defence has had a direct impact on US R&D appropria-

[24] See chapter 10 in this volume.

[25] National Science Foundation (note 14), Table C-20: Federal obligations for research, by agency and field of science and engineering: fiscal year 2000, section C.

[26] US Department of Defense (DOD), 'University research awards announced', News Release no. 135-02, 20 Mar. 2002, URL <http://www.defenselink.mil/news/Mar2002/b03202002_bt135-02.html>. For earlier DOD university grants see the information on the DOD Internet site at URL <http://www.defenselink.mil/news/Feb2001/b02022001_bt054-01.html> and URL <http://www.defenselink.mil/news/Feb2000/b02042000_bt051-00.html>. See also *Aviation Week & Space Technology*, 19 May 2003, p. 15.

[27] National Science Foundation (NSF), Division of Science Resources Statistics, *Survey of Federal Science and Engineering Support to Universities, Colleges, and Nonprofit Institutions: Fiscal Year 2001* (NSF: Washington, DC, Apr. 2003), at URL <http://www.nsf.gov/sbe/srs/infbrief/ib.htm>.

[28] Taipale, I. *et al.* (eds), *War or Health? A Reader* (Zed Books Ltd: London and New York, 2002). See also Bennof, R. J., 'Federal academic S&E obligations increased 13 percent in FY 2001: record highs reported in five of six funding categories', National Science Foundation InfoBrief NSF 03-317, Apr. 2003, URL <http://www.nsf.gov/sbe/srs/infbrief/nsf03317/start.htm>. In fact, although certain variations could be detected in DOD and DHHS support for S&T, there were obvious similarities. See Hagelin (note 15).

[29] National Research Council of the National Academies, Committee on Science and Technology for Countering Terrorism, *Making the Nation Safer: The Role of Science and Technology in Countering Terrorism* (National Academies Press: Washington, DC, 2002).

tions for FY 2004,[30] and the US Department of Homeland Security is looking for technologies and expertise at home as well as in friendly nations.[31]

The fact that US policy in support of more efficient S&T-based military innovation is deliberate, focused and continuous does not mean that it will always be successful in all its aspects. At the same time, the results of S&T-based military innovation can only be evaluated against capabilities generated in the future. US S&T-based military innovation has a long tradition, and there is continued military support for the exploitation of both national and foreign S&T. This is reflected in, for instance, the US attempts to develop network-centric military capabilities, which involve civil and military technological overlaps in areas such as information technology, intelligence gathering, and surveillance to gain real-time information from and communicate orders to the battlefield. Another illustration is the creation of a US Army Science Officer position for liaison in order to bring operational experience quickly to the laboratories and help implement new technology requirements.[32]

IV. Europe in search of a policy

Although detailed and comparable data are not publicly available, few countries in Europe are likely to have established S&T-based military innovation as a deliberate, systematic and broad national policy similar to the US policy. The closest similarities are likely to be found in countries with large and multidisciplinary military undertakings, such as nuclear and space-based projects, or where military R&D has taken a relatively large share of public and military expenditure. In such countries, S&T-based military innovation may either exist as a general policy or be focused on certain fields of military innovation. It has been suggested, for example, that France, Germany, the UK and the Netherlands have been aware of the need to make greater military use of S&T and commercial products.[33] France, and the UK in particular, have some

[30] Smith, C., 'Homeland Defense and security big winners in proposed funding for federal R&D', *News & Reporter Help* (American Association for the Advancement of Science, Washington, DC), 19 Aug. 2003, URL <http://www.aaas.org/news/releases/2003/0819rd.shtml>; and American Association for the Advancement of Science (AAAS), 'Congress proposes increases for Defense and Homeland Security R&D, flat funding for other programs', August Status Report on R&D in FY 2004 Appropriations, 19 Aug. 2003, available at URL <http://www.aaas.org/spp/rd/sum81503.pdf>. See also chapter 10 in this volume.

[31] Tigner, B., 'Terrorism concerns prompt talk of EU funding research', *Defense News*, 23–29 Sep. 2002, p. 3; Fournet, J., 'Science and society: a NATO asset in a global world', *NATO's Nations and Partners for Peace*, no. 4 (2002), p. 265; and 'NATO/Russia: agreement by Reykjavik, says Lord Robertson', *Atlantic News*, no. 3373 (4 Apr. 2002). In the period FY 1979–2001, the DOD's R&D share peaked at over 60% of federal R&D in FY 1986. Meeks, R. L., *FY 2001 Department of Defense Share of Federal R&D Funding Falls to Lowest Level in 22 Years*, Data Brief NSF 01-319 (National Science Foundation (NSF), Division of Science Resources Studies: Arlington, Va., 26 Feb. 2001). In 2003 the DOD requested a 9% increase for R&D in 2004 over the money spent in 2003. Tiboni, F. and Kaufman, G., 'Nine percent boost for R&D', *Defense News*, 10 Feb. 2003, p. 22. See also 'US Army aims to accelerate introduction of new technology', *Jane's International Defence Review*, vol. 37 (Mar. 2004), p. 6.

[32] Cox, M., 'US Army to field new science officers', *Defense News,* 15 Sep. 2003, p. 40.

[33] Gummett, P. and Walker, W., 'Changes in defence procurement and the European technology base', eds R. Coopey, M. R. H. Uttley and G. Spinardi, *Defense Science and Technology: Adjusting to Change* (Harwood Academic Publishers: Chur, 1993), pp. 145–69. Sweden should perhaps also be mentioned among these countries. Hagelin, B., 'Sweden', eds P. Gummett and J. A. Stein, *European Defence*

of the world's most advanced R&T systems.[34] British defence statistics show that the Ministry of Defence (MOD) has supported S&T-based military innovation, and during the past few years the UK has strengthened this policy.[35] The UK has most likely benefited from its special military relations with the USA since World War II. One indication of this relationship and the British role in European S&T is the fact that in the early 1970s all three US armed forces research offices in Europe were located in London. Developments in British S&T-based military innovation are described below.

The EU, on the other hand, has just begun to formulate its military capabilities requirements. At the same time, European resources devoted to industrial development have probably also been relevant for national military innovation (see below), as shown by the exploitation of European S&T by the US armed forces.[36] Europe continues to be the main foreign source of S&T for US military innovation. In FY 2000 European countries accounted for 86 per cent of DOD basic research obligations to foreign performers.[37] It has been suggested that the often discussed transatlantic gap is not at the level of basic technologies but at the level of military applications.[38] One question for the future is whether the European countries will in a similar way exploit their common S&T base for EU military innovation.

The British policy

In 2002 the British MOD formulated a defence industrial policy that followed on the 1998 Strategic Defence Review.[39] The importance of S&T is emphasized, reflecting S&T-based military innovation. This policy was further supported in 2003.[40]

> Investment in research and technology is crucial to the future prosperity of the defence industrial base and the capability of the Armed Forces. We will work with industry and academia to co-ordinate our joint resources, to maximise exploitation of civil technology, and to target our investment into areas of military importance . . .

Technology in Transition (Harwood Academic Publishers: Amsterdam, 1997). See also Dresner, S., 'Reforming research systems', *Science and Public Policy,* vol. 29, no. 3 (June 2002), pp. 169–80.

[34] Clevström, J. and Winnerstig, M., *Defence Technology as Security Policy: Defence R&T as Security Policy Tool in Europe, France and the United Kingdom,* FOI Report FOI-R-0813-SE (National Defence Research Establishment: Stockholm, Apr. 2003).

[35] Gross expenditures for 'extramural R&D', including universities and other educational establishments, private industry and public corporations, as well as overseas funding, are presented in British Ministry of Defence (MOD), *UK Defence Statistics* (MOD: London, annual).

[36] Hagelin (note 15).

[37] National Science Foundation (note 14), tables C-80 and C-81; and Matthews, W., 'Looking for the world's best ideas', *Defense News*, vol. 18, no. 10 (10 Mar. 2003), pp. 1–2.

[38] Center for Strategic and International Studies (CSIS), *The Future of the Transatlantic Defense Community*: *Final Report of the CSIS Commission on Transatlantic Security and Industrial Cooperation in the Twenty-First Century* (CSIS Press: Washington, DC, Jan. 2003).

[39] British Ministry of Defence (MOD), *Defence Industrial Policy*, Ministry of Defence Policy Paper no. 5 (MOD: London, Oct. 2002).

[40] British Ministry of Defence (MOD), 'Making defence industrial policy work for the armed forces and UK Industry', *Delivering Security in a Changing World*, Defence White Paper, vol. 2 (MOD: London, Dec. 2003); and 'Partnerships must be "broad and deep", says MOD', *Jane's Defence Industry*, Mar. 2004, pp. 11–12.

We will . . . improve access by industry to foreign technology, and increase the proportion of research collaboration.[41]

From having been a single supplier of relevant research through the former Defence Evaluation and Research Agency (DERA), today the MOD has only a small internal scientific research capability. The MOD Joint Doctrine and Concepts Centre concluded in 2003 that MOD research had declined by 50 per cent in absolute terms since the mid-1980s.[42] Close cooperation with industry and academia has therefore become more important. Two basic methods have been defined for MOD 'partnering' with industry and academia: 'towers of excellence' and 'defence technology centres' (DTCs). Towers of excellence seek to improve the technological excellence of the MOD and the 'vertical' equipment supplier base in key high-priority areas at the system or major subsystem level.

While the towers of excellence are to perform more traditional military R&D and production, aiming at specific equipment requirements, the DTCs have no such obligation.[43] They build on a February 2002 MOD decision to join the forces of industry, academia and the MOD. DTC cooperation is funded jointly by the participants and the MOD, with the purpose of generating and exploiting technologies. The MOD expects to benefit from a source of expertise in specific areas of S&T relevance, while the participants may earn a return on their investment in future defence equipment and civilian applications. The first DTCs were launched in 2003.[44]

According to the British defence industrial policy, the MOD will work closely with industry and research councils to define potentially relevant S&T. In addition to the Defence Diversification Agency, which has since 1999 played an important role in exploiting civil technology for military purposes, the Technology Watch programme seeks to fill gaps through national and international activities in innovation markets where the MOD does not have a strong research programme.[45]

S&T-based innovation is reflected not only in MOD plans but also in the responses to terrorist threats by other ministries, especially in areas relevant to chemical, biological, radiological and nuclear (CBRN) detection and protection. The UK's counter-terrorism research programme, although it is a civilian programme under the Home Office, crosses over civil and military research areas, ministerial responsibilities and government–private–public and national borders. The Defence Science and Technology Laboratory (Dstl) has a central role, together with the Atomic Weapons Establishment and civilian agencies

[41] British Ministry of Defence (note 39), pp. 5, 18.

[42] Joint Doctrine and Concepts Centre (JDCC), *Strategic Trends: The Science and Technology Dimension* (JDCC: Swindon, Mar. 2003), p. 5. See also Gummett and Walker (note 33).

[43] 'A better outlook for R&D?', *Interavia*, July/Aug. 2002, p. 29.

[44] The first DTCs covered data and information fusion, human factors integration and electromagnetic remote sensing. 'UK MoD names two more Defence Technology Centres', *Defence Industry*, June 2003, p. 8; and 'Underwater sensor technology is a new "tower of excellence"', *Defence Industry*, Aug. 2003, p. 11.

[45] Joint Doctrine and Concepts Centre (note 42), p. 6.

and organizations.[46] It is likely not only that the Dstl can bring value to the programme, but also that the programme can bring added value to the Dstl.

Apart from strengthened national research coordination, including military cooperation with academia and industry, the need for strong links with foreign research is emphasized. The USA and the EU, possibly including the sixth Framework Programme (FP), are said to be important for the anti-terrorist research programme.[47] The need to maintain access to US technology is also mentioned in the MOD defence industrial policy, together with the importance of the LOI R&T programme.[48]

Towards EU S&T-based military innovation?

The setting

Because defence was formerly not an EU task, it was not possible to have focused, long-term EU support of military R&D. Consequently, there was no EU S&T-based military innovation policy. This does not mean, however, that the military relevance of S&T was not recognized by European states: it was reflected in the European Cooperation for the Long Term in Defence (EUCLID) cooperative research programme, developed by the Western European Armaments Group (WEAG).[49] EU members have also long been aware of the importance of investing in a 'common knowledge base'.[50] Programmes such as EUREKA and the Framework Programmes were formally motivated by industrial development, but the results were sometimes also relevant for national military or broad security ambitions.[51]

The EU structure of 'pillars' with somewhat overlapping responsibilities has also hampered the formulation and implementation of a coordinated EU policy. Research, industrial and competition policy fall under 'pillar one' of European Community competence, where the European Commission and the European Parliament have key roles. The ESDP, however, falls under 'pillar two', in which member states take decisions. Since decisions about common or coordinated military development and acquisitions are still hampered by conflicting national preferences and rivalry, European industry tends to favour handling the matter in pillar one.

[46] *The Scientific Response to Terrorism: The Government Reply to the Eighth Report from the House of Commons Science and Technology Select Committee*, Cm 6108, Jan. 2004, available at URL <http://www.homeoffice.gov.uk/docs2/stc_report_reply.pdf>.

[47] *The Scientific Response to Terrorism* (note 46), p. 28.

[48] British Ministry of Defence (note 39), p. 21.

[49] See Western European Armaments Group, 'Panel II: research & technology cooperation', URL <http://www.weu.int/weag/panel2.htm>. On WEAG and for its members see the glossary in this volume.

[50] European Commission, Research Directorate General, *Towards a European Research Area: Science, Technology and Innovation, Key Figures 2002* (Office for Official Publications of the European Communities: Luxembourg, 2002), p. 15. For methods to measure European innovation see European Commission, 'The European Innovation Scoreboard', URL <http://trendchart.cordis.lu/Reports/index.cfm?fuseaction=ReportInnovationHome>.

[51] See the national cases in eds Gummett and Stein (note 33). EUREKA was established in 1985 to encourage a bottom–up (industrial) approach to technological development; for the members of EUREKA see URL <http://www.eureka.be/ifs/files/ifs/jsp-bin/eureka/ifs/jsps/publicAboutEurekaMembers.jsp>. The share of FPs in total EU R&D funding has increased since the first FP, in 1985–87.

Two decisions in 2003 and early 2004, respectively, point to not only Commission support of, but also direct Commission involvement in, S&T in support of military innovation. The first is the decision in 2003 to create an armaments-related agency within the EU framework in 2004.[52] Among other things, it is expected to support research on defence technology and to encourage capability improvements.[53] The EU Research Commissioner, Philippe Busquin, remarked in early 2004 that part of its justification is to avoid fragmentation and duplication of effort, developing common initiatives towards civilian–military synergies and, above all, achieving scientific and technological excellence through competition at the European level.[54]

There was thus strong Commission support for the new armaments agency, although it will be closely linked to the second, intergovernmental pillar. The other decision was the launch by the Commission in early 2004 of a three-year preparatory action programme to enhance European industrial potential in the field of 'security research'. Its two objectives are to provide a solid S&T base for European decisions about citizens' security (i.e., homeland defence), and the international competitiveness of Europe's defence industry.[55] In October 2003 Busquin said that the EU needs 'to adopt a more structured and European approach to security research. Europe is paying a very high price for the artificial and uniquely European separation between civil and military research'.[56] The decision had the support of the European Parliament as well as the European Association of Aerospace Industries (AECMA).[57]

[52] Council of the European Union, 'Council decision of 17 November 2003 creating a team to prepare for the establishment of the agency in the field of defence capabilities development, research, acquisition and armaments', 2003/834/EC, *Official Journal of the European Union*, L 318 (3 Dec. 2003), pp. 19–21. See also chapter 11 in this volume.

[53] 'Council Decision of 17 Nov. 2003 creating a team to prepare for the establishment of the agency in the field of defence capabilities development, research, acquisition and armaments', *Official Journal of the European Union*, L 318 (3 Dec. 2003), pp. 19–21; see also 'Draft articles on external action in the Constitutional Treaty, Note from the President to the European Convention', CONV 685/03, European Convention, Brussels, 23 Apr. 2003, Article 30.3, p. 16, URL <http://foreignaffairs.gov.ie/eu/CV00685.pdf>; and 'Final Report of Working Group VIII–Defence', WG VIII 22, CONV 461/02, European Convention, Brussels, 16 Dec. 2002, URL <http://register.consilium.eu.int/pdf/en/02/CV00/00461en2.pdf>. There will initially be a mix of national and EU financial support along with support in kind from industry to fulfil extended Petersberg tasks and 'global security needs'. These latter needs are to be defined by the European Commission and national experts, and have been said to include projects in aerospace, intelligence gathering and information technology, offering wide defence and civil protection applications. Tigner, B., 'EU moves to directly fund research', *Defense News*, 10 Mar. 2003, p. 14; and Tigner, B., 'EU to shift research funds into defense', *Defense News,* 19 May 2003, p. 14.

[54] Busquin, P., 'Security research in the European Union: current status and strategic prospects', ed. von Wogau (note 11), pp. 54–60.

[55] Busquin (note 54), p. 58. See also chapter 11 in this volume.

[56] Quoted by Tigner, B., 'EU to unveil its first defense research projects in November', *Defense News*, 20 Oct. 2003, p. 13. See also Schmitt, B., 'Armaments: new opportunities, new challenges', *Newsletter* (EU Institute for Security Studies), no. 8 (Oct. 2003), p. 4.

[57] European Association of Aerospace Industries (AECMA), 'Security research addresses a fundamental need for Community action', AECMA Press Information, Sky & Space Intergroup Meeting, European Parliament, 19 Dec. 2003, URL <http://www.aecma.org/News.htm>. See also Sparaco, P. and Taverna, M. A., 'Propping up R&D: homeland security program, French spending hike bolsters prospects for European research', *Aviation Week & Space Technology*, 27 Oct. 2003, p. 60; and Tigner, B., 'Terrorism concerns prompt talk of EU funding research', *Defense News*, 23–29 Sep. 2002, p. 3.

Defence research and industry activities lie at the juncture of Community and member state competence. The creation of a 'security research' agenda with Community funding has extended Commission and Parliament roles into defence research.[58] The taboo of supporting military research now seems to belong to the past. The distribution of institutional competence between pillar one and two will depend on how the term 'security-related' is defined, on how the armaments-related agency's research mandate is formulated and implemented, and on the decision-making structures established in a future constitution.

In parallel, the traditional programmes continue, but they are also reshaped and refocused in a direction of more coordination as well as civil-military overlap. European cooperation in defence research is still primarily national or intergovernmental, all of it today basically under the umbrella of WEAG. The only European arrangement compliant with the R&T ambition of the LOI process is the first European Research Group (ERG-1) under the WEAG EUROPA MOU (European Understandings for Research Organisation, Programmes and Activities, an umbrella memorandum of understanding signed on 15 May 2001). It is not unlikely that the LOI R&T process may be incorporated into the EUROPA MOU. Although WEAG R&T also incorporates MOUs on Technology Arrangement for Laboratories in European Defence Studies (THALES), on test facilities and on the Western European Armaments Organisation (WEAO) Research Cell (WRC), it does not reflect a deliberate, long-term and EU focused exploitation of S&T for military innovation.[59]

The EU also has an ambition to better coordinate EUREKA and the FP.[60] The background to the European Research Area (ERA) initiative in 2000 was the lack of regional coordination between Europe's 'centres of excellence'. The ERA structure tries to regroup all EU support for better coordination of research activities and for the convergence of research and innovation policies.[61] Furthermore, the implementation of the sixth FP introduced 'networks of excellence' and 'integrated projects', and it does not exclude projects connected with defence. This means, in effect, that what were informal but real linkages have now become formally accepted.

For the time being, most S&T-based military innovation in Europe will be decided nationally. The British model is one example, and other European countries may try to formulate and implement similar policies. Although there is likely to be a certain convergence of different national S&T and R&D poli-

[58] The new role may also be illustrated by the EU space policy, linked to the security and defence policy decided in 2003, which created a transatlantic controversy over the use of the US Global Positioning System (GPS). Annati, M., 'GALILEO vs. GPS: battle over navigation warfare?', *Military Technology*, Dec. 2003, pp. 10–19. See also Commission of the European Communities, *Space: A New European Frontier for an Expanding Union, An Action Plan for Implementing the European Space Policy*, White Paper, COM(2003) 673 (European Commission: Brussels, 11 Nov. 2003).

[59] See the WEAG Internet site at URL <http://www.weu.int/weag/panel2.htm>. The EUROPA MOU is designed to cover a wide variety of different R&T projects and programmes.

[60] 'Guidelines EUREKA 2000plus', adopted by the 18th Ministerial Conference, Hanover, Germany, on 23 June 2000, URL <http://www.eureka.be/ifs/files/ifs/jsp-bin/eureka/ifs/jsps/publicHome.jsp>.

[61] European Union, 'What is the European Research Area?', URL <http://europa.eu.int/comm/research/era/index_en.html>.

cies, as well as European cooperation based on common ambitions, new Commission support and the 2003 European Security Strategy[62]—EU 'centres of excellence' and the sixth FP are referred to in British anti-terrorist and defence industrial policies—intra-European competition will remain. The EU's attempts to achieve increasing S&T coordination will remain inefficient as long as they are voluntary, unfocused and unguided by any explicit, deliberate and long-term S&T-based military innovation policy.[63]

Foreign EU S&T-based military innovation?

While there are EU policies and statements that reflect a move towards S&T-based military innovation, there is as yet no such EU policy. Nor has the EU formulated policies or statements on the exploitation of S&T knowledge *outside* Europe, with the notable exception of the many references to US technology. However, despite its enormous resources, even the USA exploits foreign S&T for military innovation, not least in Europe. That has been possible because of the international activities of the DOD and the armed forces' research organizations and the location of technology experts abroad for seeking relevant and potential foreign projects, establishing cooperation and channelling results into military innovation. The DOD has therefore been referred to as a 'multinational agency'.[64]

All the European countries have to some extent built their military capabilities on US equipment and technologies.[65] However, transatlantic technological cooperation has been plagued by complications.[66] Even if there is no serious rift in transatlantic cooperation in the future, it is questionable whether the EU will accept long-term transatlantic dependence in technology and operational capabilities.[67] In either case this could push for the formulation and implementation of an EU policy on S&T-based military innovation. Other foreign S&T (non-US) could be regarded as a complement to European S&T-based military innovation, especially if US technology transfer policy and controls remain restrictive. In comparison with some of the smaller European countries, even after EU enlargement, there may be equally or even more relevant S&T partners outside Europe. In 2003 Javier Solana, EU High Representative for the Common Foreign and Security Policy, suggested that the EU should develop 'strategic partnerships' with Russia, Japan, China, Canada and India as well as

62 Council of the European Union, 'A Secure Europe in a Better World: European Security Strategy', Brussels, 12 Dec. 2003, available at URL <http://ue.eu.int/cm3_fo/showpage.asp?id=391&lang=EN.asp>; see also chapter 1 in this volume.

63 Schmitt, B., *The European Union and Armaments: Getting a Bigger Bang for the Euro*, Chaillot Papers no. 63 (Institute for Security Studies: Paris, Aug. 2003).

64 Hagelin (note 15), p. 26.

65 It has been argued that some countries have gone further than the USA in developing central aspects of network-centric warfare capabilities, Sweden being the European example. Other examples mentioned are Israel and Australia. Hughes, D. 'Swarming: sting like a bee', *Aviation Week & Space Technology*, 29 Sep. 2003, pp. 52–54.

66 Mulholland, D., 'Drive for a transatlantic market stalls in the US', *Jane's Defence Weekly*, 29 Oct. 2003, p. 19. See also chapter 11 in this volume.

67 These and other complications are discussed in Brimmer, E., *The EU's Search for a Strategic Role* (Center for Transatlantic Relations: Washington, DC, 2002).

with other non-specified countries which share EU goals and values and are prepared to act in their support.[68] Although military innovation was not one of the explicit goals, it could be a part of such partnerships.[69]

V. Implications of EU S&T-based military innovation

Data and transparency

The boundaries between what is and what is not militarily relevant are changing. Similar to the broadened and deepened perception of security, terms such as dual use, military R&T, S&T-based military innovation and centres of excellence complicate the use and relevance of traditional military R&D data.[70] They seem to refer to activities that are different from traditional military R&D, although there is not sufficient data to show what or how much is actually changing.[71] This influences definitions, the availability and transparency of data, and the possibilities for quantitative research and democratic control.[72]

These complications are substantial on the national level but are further complicated by international cooperation.[73] While comparable data on military

[68] Council of the European Union (note 62); and 'Making multilateralism matter: the EU Security Strategy', *European Security Review* (International Security Information Service, Europe, ISIS Europe) no. 18 (July 2003), pp. 1–3.

[69] Council of the European Union (note 62). Among the 5 nations mentioned in the European Security Strategy document, Russia was named as a major factor in the consideration of Europe's security, and steps have been taken towards cooperation between European and Russian companies in military innovation. Russia's role is emphasized in the Belgian contribution to the discussion of the European Security Strategy in *A European Security Concept for the 21st Century* (Royal Institute for International Relations: Brussels, Oct. 2003), p. 7. See also *The Twain Shall Meet: The Prospects for Russia–West Relations,* The Report of a Joint Working Group of the Atlantic Council of the United States, the Centre for European Reform, and the Institute for the US and Canadian Studies at the Russian Academy of Sciences, Policy Paper (Centre for European Reform: London, Sep. 2002). See also chapter 12 in this volume; and Dwan, R. and Lachowski, Z., 'The military and security dimensions of the European Union', *SIPRI Yearbook 2003* (note 23), especially pp. 234–35.

[70] See Hagelin, B. and Sköns, E., 'The military sector in a changing context', *SIPRI Yearbook 2003* (note 23), pp. 281–300.

[71] E.g., it has been argued that Canada's defence requirements are relatively modest and less well defined in terms of military-specific applications. As a result, parts of Canada's Department of National Defence have moved towards a dual-use policy. See de la Mothe, J. and Paquet, G., 'Critical technologies, policy and scarcity in a middle power country: a case of avionics and systems integration in Canada', eds P. Gummett *et al., Military R&D after the Cold War: Conversion and Technology Transfer in Eastern and Western Europe*, NATO Advanced Science Institutes Series 4: Science and Technology Policy, vol. 6 (Kluwer Academic Publishers: Dordrecht, Boston, London, 1994), pp. 107–18. Tarja Cronberg concluded in 1996 that a dual-use strategy will have very different meanings in different countries. This suggests that what may be of high military relevance in one country may seem of low or no military relevance in another. Cronberg, T., 'Concepts of military technology: contesting the boundaries between the civilian and the military', eds Gummett *et al.*, *Military R&D after the Cold War* (above), p. 61.

[72] Potential problems with both definitions and data were noted in 1993. See eds Coopey, Uttley and Spinardi (note 33), p. 2.

[73] Although the USA is generally an exception with regard to access to information, a National Science Foundation workshop concluded that available data on US strategic research partnerships and similar forms of cooperation are limited in several respects, not systematically gathered or coordinated, and uneven in quality and degree of coverage. Among the important data needed were data on international collaboration. National Science Foundation (NSF), Division of Science Resources Studies,

R&D expenditure are available from the Organisation for Economic Co-operation and Development (OECD), data on military funding of S&T are not compiled regularly by all nations, are not easy to come by when they do exist, and are not available on a regional European level. It is therefore not possible to make comparisons between individual European countries or between the EU and the USA or other countries outside the EU with regard to the implementation of S&T-based military innovation policies.

Does this matter? The financial value of military support of S&T is generally low, especially when compared to traditional military R&D expenditure. The question is relevant only if the assumption is that high expenditures equal high military returns and low expenditures equal low military returns. In fact, in the area of S&T-based military innovation the potential military net returns may be high exactly because expenditures are low. It has been estimated that the British MOD receives at least a 5 : 1 return on its investment in joint research programmes.[74] This suggests that Europe could receive substantial returns from a focused and continuous S&T-based military innovation policy.

The neutral character of S&T and the open sharing of results means that other countries may obtain the same results. Will this openness remain when military (security) and company (commercial) interests are considered together with academic interests? The answer is all the more important at a time when anti-terrorist ambitions tend to compromise values such as human rights, personal integrity and democracy—it has in the UK been noted, for example, that scientific communication must not become a casualty of the 'war on terrorism'.[75] It is important for governments to protect openness of academic research and public freedom of information.

Military innovation and research ethics

S&T-based military innovation implies the increasing military importance of basic and applied research and commercial technology, with more involvement of non-military participants in military innovation. Does this result in an increasing militarization of society or in more 'civilianized' military organizations? The answer is likely to be different depending on who is asked, but the question illustrates that S&T-based military innovation might have ethical implications for the non-military performers in particular. For instance, it is acknowledged by the British Government that the anti-terrorist research programme involves ethical problems including the wider applications of science, and the introduction of an ethical code has been proposed.[76]

The ethical problems emanate from the many fields of S&T that are of potential military relevance, international cooperation and the unawareness or

Strategic Research Partnerships: Proceedings from an NSF Workshop, NSF 01-336 (NSF: Arlington, Va., 2001).

[74] British Ministry of Defence, *Maximising the Benefits of Defence Equipment Co-Operation*: Report by the Comptroller and Auditor General, HC 300, Session 2000–2001 (Stationery Office: London, 12 Mar. 2001), pp. 15–16.

[75] *The Scientific Response to Terrorism* (note 46), p. 30.

[76] *The Scientific Response to Terrorism* (note 46), p. 30.

even naivety of many individual researchers and scientists regarding the importance of S&T for military innovation. For instance, the US military involvement in the Viet Nam War, from around the middle of the 1950s until 1973, became an ethical awakening for many researchers and scientists sponsored by the DOD, both in the USA and abroad. Similarly, S&T-based military innovation in support of stronger European military capabilities could become controversial, especially if European nations become engaged in military operations abroad with low or no public support.

Part of the ethical problem is knowing what kind of military innovation is supported by the S&T activities to which one is contributing, such as conventional arms or WMD, the category of weapons defined as the main threat today.[77] The answer may be known only to the S&T sponsor. The full effect from S&T-based military innovation becomes clear first when the results from different performers are channelled into military R&D. This makes transparency of S&T-based military innovation all the more important, not only with regard to the sponsor, recipient and expenditures, but also with regard to how those expenditures relate to anticipated military capabilities.

However, even if it is known that a particular S&T undertaking is potentially relevant for a particular military capability, the ethical problems remain. This is because of the often complicated relationship between 'defensive/preventive' or 'offensive/intervenient' capacities. Is an anti-ballistic missile system to be regarded only as 'counter-proliferation'—and participation in such S&T-based military innovation therefore 'ethical'—or should such systems be regarded as an 'unethical' part of an 'offensive-defensive' arms competition? Or are all S&T activities in support of national military innovation legitimate, while support of foreign or international military innovation is not? Questions such as these may become increasingly relevant in Europe in parallel with increasing European military cooperation and involvement in other parts of the world.

Another complication could be if international S&T cooperation for military innovation is used for competitive purposes rather than for national or common security.

Competition, security and control

The main purpose of S&T-based military innovation is to strengthen security. However, activities aimed at keeping technologically ahead of potential opponents are related to another, less explicit purpose: namely, to gain commercial benefits over military competitors. While international cooperation to support the security of all partners is a common goal, cooperation in order to gain commercial benefits over one or more partners is not. Many arms competitors are companies based on opposite sides of European national borders or the Atlantic. The national or regional S&T-base has not been seen from this com-

[77] See chapter 13 in this volume.

petitive perspective.[78] However, with increasing internationalization or even globalization of military production, it may not always be easy to distinguish between cooperation and competition even among friends.[79]

Furthermore, the use of S&T results for a variety of military capabilities means that S&T results may not only be relevant for a particular category of weapons technologies such as conventional weapons, but also for WMD. This has resulted in a debate about definitions and export control coverage. Some observers argue that WMD should not only include the traditional types of nuclear, biological and chemical weapons, but also other means to kill large numbers of people, illustrated by low-frequency radio devices. However, formally broadening the definition of WMD could blur the distinction between WMD—for which there is broad international agreement about the necessity for strict controls—and conventional weapons, where exports may be used as a policy tool and are deemed necessary in order to support national industries, military capabilities, and/or technological developments.[80]

VI. Conclusions

This chapter suggests that there is a shift in emphasis in the major arms-producing countries towards greater use of S&T for military purposes, that is, towards S&T-based military innovation. This may be seen as the third stage, as reflected by an evolution of terminology—from military R&D of defined military platforms and, during the 1990s, military R&T illustrated by technology demonstrators.

The USA and the UK are examples of nations with a national S&T-based military innovation policy. Despite their differences, both policies reflect the overlap between what is to be considered civil and military S&T areas, and a crossing of the borderline between ministerial responsibilities and government–private–public and national responsibilities.

The EU does not have a similar policy, partly because of the recent inclusion of defence as an EU task. The EU organization also mirrors overlapping and unclear boundaries between its pillars. Yet another difficulty is national competition within Europe: attempts to preserve national skills rather than pool them. However, this chapter suggests that there are changes that might constitute steps towards the establishment of a more coordinated EU S&T-based military innovation policy. Should such a policy be formulated, the enlarge-

[78] It has been noted that questions regarding the reduction and restructuring of inherited scientific and industrial capabilities have not been subject to any systematic international discussion. Bailes, A. J. K., Melnyk, O. and Anthony, I., *Relics of Cold War: Europe's Challenge, Ukraine's Experience*, SIPRI Policy Paper no. 6 (SIPRI: Stockholm, Nov. 2003), p. 19, URL <http://editors.sipri.se/recpubs.html>.

[79] The potential loss of US technological advantage has been raised as an issue in recent transfers to the United Arab Emirates and South Korea of combat aircraft, since they contain radar and avionics that are superior to systems in the DOD inventory. US General Accounting Office (GAO), *Defense Trade. Better Information Needed to Support Decisions Affecting Proposed Weapons Transfers*, GAO-03-694 (GAO: Washington, DC, July 2003.

[80] 'Threat watch', *Aviation Week & Space Technology*, 30 June 2003, p. 23.

ment of the EU in 2004 may bring both S&T benefits and competitive drawbacks.

Will European S&T be sufficient to play its part in enabling the EU to reach its military capability targets?[81] There is, of course, a certain balance between ambitions and performance, but history seems to suggest that resources are created to achieve higher military goals rather than lowering the level of ambition to match available resources. Exploiting foreign S&T for EU military innovation could add on to national S&T-based military innovation and multinational research programmes. The potential 'strategic partners' mentioned by Javier Solana in 2003 could point to possible partners in S&T-based military innovation.

There are three long-term implications of a shift towards EU S&T-based military innovation: for data and transparency; for research ethics; and for finding a political balance between cooperation, competition and technology controls among both friends and foes. The data and transparency problem—a general problem in military and security studies—is further complicated by S&T-based military innovation. The ethical problem is basically one mainly for non-military actors involved in S&T-based military innovation. The neutral nature of S&T and the many uncertainties with regard to its potential military use will involve difficult considerations for such actors, especially if transparency remains low. The problem of finding an acceptable political balance between the free sharing of S&T results, trying to gain commercial and technological advantages over military competitors, including friends, and preventing or delaying military innovation by potential enemies, is likely to become a delicate task.

[81] See section IV of chapter 1 in this volume.