from: Judith Reppy, Joseph Rotblat, John Holdren, Vsevolod Avduyevsky (Hrsg.):Conversion of Military R&D, London/New York 1998, p.163-182.

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Dual-Use and Conversion of Military-Related R&D in Germany

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INTRODUCTION

For decades, both West and East Germany had to carry heavy burdens in terms of military forces, maneuvers and deployment of foreign troops close to the iron curtain. Germany was one of the most densely militarized zones in the world; the inner-German border between East and West created tremendous risks and burdens including the threat of extinction in a nuclear war.' On the other hand, after 1945 Germany never possessed a highly militarized industrial base as did the United States, although several sectors were heavily dependent on military contracts (e.g., ship-building, aerospace, machine-building). In the shadow of the superpower competition and within the European Community, West Germany was able to rebuild its economy and gain economic competitiveness. In this respect, Germany, like Japan, profited from the Cold War. With the fall of the Berlin wall a new situation has arisen, in many respects the reverse of the East-West conflict. Most of the security risks of a European military confrontation have vanished, but economic problems have been aggravated due to unification.

Germany does not have a comprehensive conversion program, but at least in theory a broad understanding of the concept of conversion after the Cold War can be found among experts:

> Conversion covers not only the shrinking of military forces due to budget constraints after the end of the Cold War, but also the

> transformation of finances, the modification of research and development (R&D), the reintegration of soldiers, the alternative use of barracks, land property and military infrastructure including the civilian use and the dismantlement and destruction of military equipment.[2]

In the past the conversion debate in Germany concentrated largely on economic and social aspects of converting military production facilities and integrating them into the civilian economy.[3] Little attention was given to the R&D complex which forms the early stages of the weapons life-cycle. But an effective disarmament strategy should also include the conversion of military science and technology. Preventive arms control is also needed to make conversion irreversible and to avoid dangerous military-technological arms races and emerging proliferation problems.[4] In the longer run Germany might profit from reduced military spending by converting its military infrastructure, including the military R&D complex.[5] However, as in other Western countries, theory often does not meet reality: conversion is more difficult than originally assumed. Besides the practical problems of transforming the arms industry into a competitive, market-oriented civilian industry, the biggest obstacle is renewed interest in the development, production and export of arms as pan of an extended security concept.

THE NEW GERMAN SECURITY CONTEXT

At present no specific military threat can be identified for German security. The victorious powers of World War II are removing their troops from German territory.[6] The new Germany is now surrounded by friends and partners seeking economic cooperation; it is integrated into the new European security architecture which includes NATO, the Western European Union (WEU), the European Union, the Conference on Security and Co-operation in Europe (CSCE) and the European Council. Within the CSCE, confidence building measures and arms control agreements with comprehensive verification mechanisms improve military transparency in Europe and encourage disarmament. Since unification the German unified military forces have been reduced from about 650,000 to 420,000 soldiers and they are to be further reduced to 370,000 by the end of 1995. The Treaty on Conventional Forces in Europe (CFE) requires the reduction of more than 10,000 Treaty Limited Equipment (TLE) by the German armed forces.

Germany is an active member of NATO, the most powerful military alliance in the world. Whereas during the Cold War NATO opposed the Warsaw Treaty Organization, now the 'Partnership for Peace' aims at political integration with East-European countries. Based on a diffuse threat perception of 'new risks, uncertainty and instability,' the new NATO strategy aims at creating mobile force structures, which are to be implemented in the member countries to guarantee the capability for counter-offensive and counter-concentration in every point of the defense area. Earlier debates in Germany on a non-offensive force structure and the orientation toward a defensive posture seem to be forgotten.

Without a clarification of the future tasks of the Bundeswehr, long-term budget planning and re-organization of military R&D is difficult. For Germany, the central security task remains the defense of the country and the alliance, but all options for an 'extended defense' outside of the NATO territory are being kept open. The basic goals of security policy and the mission of the Bundeswehr have been defined in the 'Defense Policy Guidelines' of the Ministry of Defense (Bundesministerium der Verteidigung, BMVg).[7] According to these guidelines, the 'vital security interests of German policy' include not only the protection of Germany, strong ties to the alliance, European integration and crisis management, but also the 'continuation of free trade and unimpeded access to markets and resources worldwide as part of a fair world economic order.' Similar objectives have been expressed in U.S. strategy plans.

The constitutional court decided in July 1994 that 'out-of-area' operations of German military forces would be allowed within the framework of a collective security system. Thus, the participation in peacekeeping operations outside *the* country is possible. Before sending troops, the German Parliament has to approve the action by simple majority. Of course, this will have wide-ranging consequences for future procurement and the on-going doctrinal debate in Germany, with a direct impact on future military-related R&D.

Far-reaching structural changes can be observed for the military forces. A number of programs serve the increase in mobility and a fast relocation capability over wide areas. In the army the material planning is directed towards a 'light army of the future,' with air mobility, air relocation and air mechanization playing an increasingly important role in army planning. To achieve this goal improved C^3! capability is required. Various guided weapons and submunitions are in development. Part of the equipment is to be procured for UN actions and, in the peacekeeping context, a military space program is under consideration by the government. Finally, there is an interest in Europe in pursuing integrated

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air and missile defense systems, based on ten years of R&D in the U.S. Strategic Defense Inititative(SDI).

THE GERMAN ARMS INDUSTRY AFTER THE COLD WAR

Germany's arms industry was built up during the 1950s and 1960s, and is capable of developing and producing a wide range of major weapon systems.[8] In particular, Germany has well developed nuclear energy, aerospace and ship-building industries. The arms industry is integrated into various industrial branches, which produce civilian goods as well. Due to the changed security context, it is facing hard times. The burdens of unification, the economic crisis, reductions in investment, reduced defense budgets, export regulations, and attitudes in the public hostile to excessive military activities all lead to the conclusion that the existing military and industrial infrastructure is oversized. A few figures describe the current situation:[9]

- According to official numbers,[10] the defense budget increased nominally from 42.6 billion DM in 1981 to 53.6 billion DM in 1991 before falling to 50.15 billion DM in 1993, which in real terms corresponds to the defense budget of 1986. The defense fraction of the federal budget shrank from 18.3 to 11.5 per cent between 1981 and 1993 and its fraction of the GNP from 2.77 per cent to 1.57 per cent.
- Substantial cost savings of 5.6 billion DM annually are expected from further reductions in the number of employed soldiers and civilian personnel. The number of civilian employees in the BMVg will decrease by about 40,000 by the year 2000. In the same period, half of the 102,000 civilian employees working for the allied forces, could lose their job." The number of military sites in West Germany has been reduced from 720 to 589. However, the savings were not - as planned - directed to defense investments but were mostly used for the consolidation of the federal budget.
- Due to the budget constraints, the restructuring of the European arms industry, and the decline of arms exports, the number of employees in the German arms industry fell from 280,000 in 1989 (including 40,000 in the former GDR) to 180,000 in 1993.[12]

Three major strategies to deal with the current problems can be distinguished: deep reductions in the military arsenals and conversion of the defense industries; a restructuring combined with a qualitative modernization of the military arsenals by pursuing development and production of high-technology weapons at a lower quantitative level, applying the dual-use strategy (see below); and intemationalization of arms production and development, and exports of armament and related technologies, especially to developing countries.

At the level of the firm, some companies are selling their plants and subsidiaries that specialize in armaments and withdrawing completely from the field. Others are diversifying in order to diminish their dependence on military orders, or they are dismissing employees. Larger enterprises increasingly are merging in international consortia in order to raise their share of a decreasing financial budget.[13] The future of Germany's arms industry is seen to lie in the intemationalization of the Western arms industry, in particular, in the collaboration with other European countries and the United States within NATO on new weapon technologies. In the framework of the Maastricht Treaty the path to a 'European Armament Agency' is pursued with some WEU and NATO member states.[14]

The major reasons for international cooperation are reduced budgets, a reduction of procurement numbers, and high R&D costs, which together lead to rapidly increasing costs per unit, and a reduction in demand. Declining demand leads to further dismantling of capacities and a loss of know-how.'[5] European cooperation is an attempt to share R&D costs and create a bigger (European) market for fewer products. In principle the consequences of such cooperation include an international division of labor, standardization and specialization in military capabilities, but, according to defense planners, the existing capacities in the German arms industry are to be protected, in particular a core workforce and production capacities in the tank industry, munitions industry, aircraft and electronic branches.[16]

The state of the German arms industry is exemplified by the air and space industry, which traditionally has a high military share. After a peak in 1989/90, the civil aviation business experienced a sharp decline. Because it was formerly dominated by government demand, the aerospace industry is highly dependent on the financial situation of the state. Compared with the United States or France, there is less consensus in the German society on the need to maintain the aerospace industrial base.

According to the Bundesverband der Deutschen Luftfahrt-, Raumfahrt- und Ausriistungsindustrie, BDLI (Federal Union of the Aerospace and Equipment Industry) the number of employees fell from 95,000 in 1990 to 86,300 persons in 1991, who nevertheless produced an increased turnover of 26.77 billion DM. This trend continued in 1992. In the medium term, a fall in the level of employment by 20 per cent is

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expected, with an increasing civilian share.[17] Spaceflight has stayed constant with 6,500 employees. In the engine industry the number of employees fell by 6 per cent from 9,250 (1990) to 8,590 (1991), with the military fraction sinking by 18.3 per cent. In the equipment industry, with a military share of 55 per cent, the reductions were especially large. Although the number of employees and orders for aerospace defense were reduced (the latter by 14 per cent), an increased turnover was still produced.[18] A number of military aviation programs are being continued:
the modernization of the F-4F PHANTOM, the experimental aircraft X-31, and FANRANGER; and the delayed development of the EFA 2000, the Tornado Emitter Locator System, the NATO helicopter NH-90 and the PAH-1 anti-tank helicopter. For Spaceflight the future is open, with the focus on communications and earth reconnaissance satellites.

The single most important event in the German military and aerospace industry was the 1991 takeover by Daimler Benz of the companies Telefunken, Domier, MBB and MTU, which were merged to form the Deutsche Aeropace AG (DASA). MBB was restructured in May 1992; in July, DASA and AEG founded TEMIC to fuze their microelectronic activities. The arms sales of Daimler-Benz are more than four times as high ($3920 million 1991) as those of the second largest company, Siemens ($900 million), and third, Rheinmetall ($860 million).[19]

European cooperation is increasingly important in military aerospace, especially between Germany and France (e.g., the Eurocopter International venture formed by Aerospatiale and MBB in December 1991). Examples of cooperation are the missiles Stinger, Roland, Patriot, Milan, HOT, PARS 3, POLYPHEM and Apache. Cooperation also extends to equipment. In all these programs, extensive R&D is required. In December 1993 the French and German Defense Ministers F. Leotard and V. Rime announced the creation of a Franco-German Armaments Agency, which has the task of managing the bilateral armament programs more efficiently.

German policy in arms trade is contradictory. On the one hand, Germany has implemented new far-reaching reforms of export controls on dual-use goods, but on the other, it has increased its direct weapons exports in the early 1990s. According to SIPRI, German arms exports (in 1990 prices) increased from $953 million in 1989 to $1.67 billion in 1990 and $2.41 billion in 1991, before leveling off at around $1.85 billion in 1992 and 1993. In 1992 Germany became the third-largest exporter of major conventional weapons and the largest in Europe, accounting for 41 per cent of deliveries by EC countries versus 24 per cent by France and 20 per cent by the UK.[20] According to the UN

Register of Conventional Arms, Germany was in 1992 the second most important supplier of the main combat weapon systems, with deliveries in each of the seven categories.[21] Most of the exports in 1992 were significant deliveries of second-hand equipment from the former Nationale Volksarmee (NVA) of the German Democratic Republic -mainly tanks and ships - to NATO countries or Finland and Sweden. It remains to be seen if this trend will continue.

CIVIL AND MILITARY RESEARCH AND DEVELOPMENT IN GERMANY

Military-related R&D plays an important role in implementing new strategic concepts in most of the leading industrial countries. Following the end of the bipolar confrontation, the military planning philosophy in Germany as in the United States is to do a lot of research and development, stretch procurement programs, and not build everything immediately.[22] The new 'White Paper 1994' of the BMVg states: 'By concentrating R&D on technological key areas the option is maintained to pursue the required modernization later on.'[23] The German Minister of Defense Volker Riihe said in a speech at the German 'Fiihrungsakademie' (officer's academy) in Hamburg in 1992:

> In the future we need less and - in a wide range of fields -different material ... For that purpose we have to reverse the situation in quantitative and qualitative terms ... we need technology of the highest quality and performance as a 'Force Multiplier.'[24]

For this purpose, civil technology will be increasingly integrated into military development as add-on programs.

The German Science and Technology Budget and Structure

In many fields of research and technology, Germany is among the leading nations in the world. In its share of the gross domestic product (GDP), Germany's R&D expenses in 1990 (2.77 per cent) were behind Japan (3.07 per cent), equal to the United States, but ahead of France (2.44 per cent) and Great Britain (2.21 per cent)." In 1991, the German national R&D expenses amounted to 76 billion DM, corresponding to 2.66 per cent of the GDP. This decline in the R&D share in GDP, which began in 1989, continued in 1992. The largest fraction of R&D expenditures in

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1991 (59 per cent) was paid by the industry, followed by the federal government (22 per cent). 1993 was the first year that the federal R&D budget fell in nominal numbers, from 17.97 billion DM in 1992 to 17.94 billion DM in 1993 according to the government plan.[26]

The agency mainly responsible for research and technology was the 'Bundesministerium fur Forschung und Technologie,' BMFT (Federal Ministry for Research and Technology); which in 1995 was fused with the Ministry of Education and Science. Its 1993 budget was 9.4 billion DM, more than half of the 17.9 billion DM that the German Federal government spent for R&D that year.[27] Other principal German government funders of R&D are the Defense Ministry (BMVg), the Economics Ministry (BMWi), and the Ministry of Education and Science (BMBW).

The BMFT is the main Hinder for Germany's four major publicly funded research institutions, and its priorities and costs are reflected in the research areas they cover. The institutions are:

- The sixteen Grossforschungseinrichtungen (GFEs), or large research organizations, working in a variety of fields from energy to advanced materials, information technology, environment, aeronautics and space.
- The Max Planck Society (Max-Planck-Gesellschaft, or MPG), which performs basic scientific research, mostly in the natural sciences.
- The Fraunhofer Society (Fraunhofer-Gesellschaft, or FhG), the smallest of the four major research institutions, whose task is to pursue applied R&D dedicated to direct transfer into practical use.[28]
- The Blue List, which is not an organization, but a collection of independent research organizations, including a number of new East German institutes, working in various fields.

Military R&D

Since 1954 when rearmament began, military influence in the research and industry sector in Germany has never been as dominant as in the United States. Although military interests played a prominent role for politicians like the former Minister of Defense and of Nuclear Affairs, Franz-Josef Strau/3, throughout the 1960s direct investment in civilian R&D was seen as preferable to indirect spin-offs from military **R&D.**[29] This attitude continued until the late 1980s when former U.S. President Ronald Reagan's Star Wars program had challenged the Europeans to focus more strongly on military high technology. After the end of the East-West conflict, military planners in Germany, as well as in the

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United States, see qualitative improvements of weapon systems as a key element to compensate for the quantitative arms reductions that are expected in the coming years. Consequently, for some planners, R&D forms the basis for new and improved defense products, for the 'automatized battlefields' in particular, as well as 'out of area' conflicts requiring mobility and flexibility.

Expenditures for military R&D are usually taken to comprise all officially declared R&D in the defense budget plus the declared military R&D in other government budgets. Much more is known about the governmental budgets than the military-related spending in industry, although the latter perform the main part of the application-oriented R&D. Table 9.1 presents the official figures for military R&D expenditures for the period 1981-93. As a consequence of the continued interest in defense-related R&D, military R&D is shrinking more slowly than the total military budget. There has been a decline in the military share of federal R&D since 1990, from 22.3 per cent in 1990 to 18.2 per cent in 1992. Between 1981 and 1990, however, BMVg R&D had more than doubled in absolute numbers, and the 1992 share is still much higher than in 1981.

What is counted as military R&D? The official figures omit important categories of spending. At least for 1990 better figures are available." The Federal government has admitted that the costs of running the universities belonging to the Bundeswehr and the technical and scientific offices of the Bundeswehr, funds for international research institutions, and staff costs within the R&D sector have to be added. In 1990, this amount was roughly 400 million DM.[31] Together with some smaller figures this brings the sum up to 4,010 million DM. Furthermore, the government reimburses the industry by between 3 to 6 per cent of the production costs of military goods that it purchases, under the headline 'additional for free research and development.' It is unclear how much was paid in 1990 in this way. But based on procurement figures one could estimate a number of about 500 to 1000 million DM. So it turns out that in 1990 the total amount of military R&D spending by the Federal Government was about 4.5 to 5 billion DM, compared to the official figure of 3.4 billion DM. Estimating the same proportion for 1993 one arrives at around 4.8 billion DM, versus the official figure of 3.2 billion DM. One can assume that the same correction would apply to every year, so that one can add roughly one third or one half to the official number for military R&D. The federal government has admitted that for 1990 the 'true' military R&D budget was at least 4.01 billion DM, but this figure has never been included in official publications.[32] It would correspond to a 16.1 per cent share of total governmental R&D

(26.4 per cent of the federal R&D budget), much higher than the official numbers transmitted to OECD.

Table 9.1
R&D expenditures in Germany, 1981-93 (million DM)*

Year	Federal R&D	Gov. R&D	R&D of Business and Enterprise Sector	Federal Military R&D	Military Share of Gov. R&D	Military Share of Federal R&D
1981	10,371	17,261	22,082	1,528	8.9%	14.7%
1983	11,438	18,379	25,459	1,895	10.3%	16.6%
1987	13,152	21,694	36,831	2,894	13.3%	22.0%
1989	14,036	23,113	41,197	3,128	13.5%	22.3%
1990	15,149	24,780	42,500	3,389	13.7%	22.3%
1991	16,853	28,990	46,045	3,170	10.9%	18.8%
1992	17,969	30,780	47,520	3,263	10.6%	18.2%

* Official figures. Governmental R&D includes expenditures of the German federal government and the 16 state governments.
Source: BMFT, *Bundesbericht Forschung 1993, pp.* 547, 552-59; Bundestagsdrucksache 11/7373 (1992); E. Bulmahn (see footnote 30).

Military R&D Concepts

The priorities and objectives in military R&D are determined by the Research and Technology (R&T) Concept of the BMVg, which was introduced in 1985. Defense-related R&D is divided into three areas:[33]

1. Research oriented towards defense technology,
2. Future key technologies oriented towards military tasks,
3. Systems technology/guiding concepts.

Military tasks in research and future technologies include:

- reconnaissance, command and control (e.g., radar improvements, sensors, GaAs technology, optronics, pattern recognition, friend-foe-identification);

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- mobility (e.g., light-weight construction, fluid-mechanical improvements, remotely piloted vehicles, energy support for electromagnetic guns);
- weapons use and lethality (e.g., electromagnetic guns, weapon lasers, torpedoes and torpedo defense, land mines, kinetic weapons against improved armor);
- protection (e.g., improved armor, ABC protection, protection against microwaves and electronic warfare);
- planning support (e.g., military-technological trends, threat perception, simulation technologies, computer-aided planning, international harmonization of armament programs).

The Fraunhofer-Institut fur Naturwissenschaftlich-Technische Trendanalysen (INT, Institute for Scientific-Technical Trend Analyses) at Euskirchen near Bonn provides an evaluation of relevant literature on a regular basis for the BMVg, which is used as an input to the 'defense technology forecast.' In this forecast, long-term projections of trends in military technology are presented and evaluated by the BMVg. The 'White Paper 1994' states that 'In the Research and Technology Concept of the BMVg, priorities are determined according to military requirements, which include civilian Research and Technology projects of the government, international cooperation and industrial research results.'[34] For a deeper analysis, however, it seems almost impossible to link the official R&D objectives to concrete projects and funding in the federal budget.

Cooperation Within NATO and WEU

International cooperation in military-related R&D is seen as essential by the BMVg: 'The BMVg focus is on cooperation: 70 per cent of the large projects were realized in international cooperation.'[35] In June 1989 the NATO Independent European Programme Group (IEPG) established a military cooperation program, the European Co-operation for the Long Term in Defence (EUCLID), which consists of 11 so-called Common European Priority Areas or CEPAs (e.g., new radar technologies, artificial intelligence, stealth, etc.).[36] Since then the number of CEPAs has further increased. In the Program Memorandum of Understanding, signed at the end of 1990, 26 Research and Technology Projects (RTPs) were included to structure the CEPAs. At the end of 1990, 35 RTPs were under preparation in Germany with spending at 55 million DM. In 1992, the volume had increased to 72 million DM, with a projected annual increase of 20 million DM.[37] The ministers of the IEPG agreed in

1992 to transfer the functions of the IEPG to the WEU, and the IEPG is now known as the 'Western European Armaments Group' (WEAG). This marks a step towards European armament cooperation in terms of harmonising requirements for joint programs, research, and trade as a step towares developing a European defense market.

More specific information than this on German **R&D** projects and contractors is unavailable. Military R&D in Germany is still planned and performed under secrecy, and information on concrete projects is hardly available. Improved transparency on military R&D is a prerequisite for detailed consideration of conversion of related research projects and institutions.

THE DUAL-USE STRATEGY AND ITS IMPACT ON R&D CONVERSION

Scarce resources, technological dynamics, and political pressures, combined with the converging demand profiles of civilian and military technologies, all support the recourse to a 'dual-use strategy,' whereby a technology is developed first for the civilian sector and then used for military purposes. For some planners 'dual-use' is a magic word that keeps the paths for further military-technological developments open. In Western Europe, as well as in the United States, the dual-use strategy aims at combining military interests in cheap and effective armament technologies with commercial interests in the high-tech sector. Research programs like EUREKA, ESPRIT and EUCLID have been designed as dual use from the beginning.[38]

The specific character of Germany's dual-use strategy was already outlined in 1986 by the then Permanent Secretary in the BMFT, Hans-Hilger Haunschildt:

> Given the importance of modem technologies for military as well as for civilian applications, both domains of responsibility, the BMFT and the BMVg, are closely working together in some subfields . . . The dominant basic technologies (are) often identical, e.g. the fundamental physical technologies, the materials sciences, the machining technologies, the semiconductor technology or data processing . . . Especially Germany and Japan have successfully demonstrated after the war that civil technological developments do not need the detour via government-funded military research and development. The

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> 'American way' is no alternative for us ... The primary civilian way also works.[39]

The philosophy that civilian R&D should be planned for the fulfillment of military goals has been realized in various programs, in particular, in the space program (e.g., by using civil satellites for military reconnaissance and communication) and in the 1989 concept for future information technologies.[40] In 1990, the German government stated that dual-use is a basic ingredient of its research policy: 'The Minister of Defense bases as a matter of principle his science and technology programs on civilian science and technology. Only when unavoidable the civilian scientific-technological base is complemented by specific programs.'[41]

The German government has repeatedly announced its intention to include military requirements early within civilian R&D programs and then exploit the results in 'add-on programs' for military applications. This implies not only that converging civilian and military development paths are used, but also that civilian research will be adapted to military purposes. Based on this strategy a 'grey area' of civil-declared but military-used R&D could develop. An essential element of this strategy is closer cooperation between the BMFT and the BMVg:

> With the BMFT the dialogue about research and technology cooperation must be intensified and deepened. The R&T activities with the potential for dual-use applications must be coordinated more thoroughly in advance between both ministries and initiated jointly, if necessary. So-called add-on programs of the BMVg are only possible, in principle, if the BMFT or/and the industry have created the appropriate basis.[42]

How the coordination process between the ministries works in detail, which programs - besides those officially mentioned - are integrated into dual-use concepts, is not known. Only the existence of the concept itself is documented.

In the context of the dual-use policy, diversification, which is a strategy to mix civilian and military R&D, will be more probable than irreversible conversion in the next few years. In this way, military objectives could profit from both civilian and military R&D activities and, even more, the reshaping of powerful military R&D programs is always possible. Obvious impacts of this diversification strategy in the field of arms production and arms industry are:

- the persistent option for militarily useful outputs of diversified R&D;

- reversibility of 'conversion' activities;
- continuation of secrecy for parts of R&D;
- persistent distrust.

As a result of the dual-use strategy, civilian R&D is increasingly amalgamating with military R&D. The R&D work of the BMVg, which cannot fund basic research, is increasingly based on civilian resources, which in turn are also influenced by military purposes. Unlike the United States, where dual-use is closely connected with preventing deep cuts into military R&D, in Germany the dual-use strategy could result in expanding the influence of the military on some part of civilian R&D. The extended notion of military-related science and technology is, in general, contrary to further disarmament and conversion efforts, as it further blurs the differences between civilian and military R&D and allows the performance of military R&D under a civilian cover. The spin-offs from the military to the civilian sector have been disappointing;
now the transfer into the opposite direction, or 'spin-on' is organized. Civilian R&D has become a priority for the military, which can use the outcomes for its own parallel military R&D. The question is to what degree the dual-use concept leads to a clandestine militarization of R&D in Germany, which would undermine efforts for conversion and disarmament in the longer run.

EXAMPLES OF THE CONVERSION OF R&D

As mentioned above, a planned and integrated conversion strategy for Germany does not exist. This is especially true for R&D conversion, which is not seen by the Federal government as a major problem. In general, there is little interest in the conversion of R&D and adaptation to the changed situation is mostly left to the individual institutions. However, tentative approaches to deal with the problem of conversion do exist. The Bonn International Center of Conversion (BICC) was established in April 1994 by the state government of North-Rhine Westphalia with the assistance of the UN. One of the areas of activity will be focused on 'the reorientation of military research and development (R&D) facilities and making this R&D knowledge available for non-military purposes,' and there are the efforts by the German parliament (Subcommittee on Disarmament and Arms Control) in regard to preventive/qualitative arms control, which in the long-run could also include considerations of conversion of military-relevant R&D. These activities started in late 1992 and have led to a study project of the 'Büro

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für Technikfolgenabschätzung beim Deutschen Bundestag' (TAB, the Office for Technology Assessment at the German Parliament) on arms control criteria that is still underway.

Unavoidably, military-related R&D must adapt to the post-Cold war environment. The example below illustrates how the structure and the objectives of military-oriented institutions are influenced by the end of the Cold War and how efforts are undertaken to initiate conversion.

Fraunhofer-Institut für Angewandte Materialforschung (IFAM)

Bremen, the smallest German Federal State, has in the past been very dependent on arms production. In 1991, its arms industry consisted of ten major companies (with more than 100 employees) and several smaller ones. In the large companies, on average, some 30 per cent of the workforce was dependent upon defense for their employment. Those jobs were spread across a number of different industries. For the ten major companies, 40 per cent of defense employees were employed in electronics, 31 per cent in military shipbuilding and repair, around 25 per cent in military aircraft and vehicle construction/repair and 4 per cent miscellaneous.[43] Bremen also has a significant number of military bases and establishments. Perhaps 10,000 of the approximately 25,000 defense related jobs in the state are at risk in the next few years.

To support the conversion process, a foundation for conversion ('Stiftung Riistungskonversion') was set up, and a representative for conversion was appointed. In the following years, it is intended to save jobs by converting various branches from the production of military to civilian goods. Among others, this affects an institute for materials research, Ae Fraunhofer-Institut fur Angewandte Materialforschung (IFAM). IFAM has been based in Bremen for more than 20 years. Until recently the institute has been almost totally dependent on BMVg for funding, but now it is attempting to become less reliant upon defense R&D by seeking civilian projects. The research, done by 130 scientists, technicians and other employees, focuses on the improvement of advanced materials, composites and the engineering construction of defense equipment. The main expertise has been in technology for the penetration of and protection against conventional munitions, thus combining the development of new weapons with research on countermeasures against them. Special adhesive techniques, powder metallurgy and casting practices for composites and advanced materials are fundamental methods that were introduced and improved in Bremen. Most of these procedures are well developed now, but are not efficient or applicable economically.

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In 1990 it was decided by the federal government and the state of Bremen that the IFAM should no longer get its basic funding from the BMVg but from the BMFT (30 per cent of the budget of the institute), phasing out after five years.[44] Now the BMVg only funds specific projects whose results could be made available for the civilian market. IFAM is officially seen as a pilot project for the conversion of military research institutes in Germany. The state of Bremen is supporting the transition phase (1992-1996) with 11.3 million DM (about 10-15 per cent of the institute's budget). The management of the institute is optimistic that it can succeed in applying part of its know-how to civilian products. For example, metallic foams for light-weight construction and composite fiber materials for the optimization of rotor blades for wind energy are being developed. Nevertheless the research on light-weight construction, high-temperature ceramics etc. can be regarded as highly civil-military ambivalent.[45]

One of the main problems for conversion of such an institution is that weapons researchers, who for a long time had privileged positions, now have to compete in existing civilian markets. Under the conditions of defense research (e.g., secrecy, command structure, no presence on the open market), the name and expertise of the institute were not well known in the industry. Today, there is a strong competition in the materials sector, and IFAM employees are not used to taking into consideration the diversity and interests of their customers; they have had no experience in how to acquire orders and civilian contracts.

An agreement for cooperation has been reached with the University of Bremen, despite some problems with the university law due to the civilian orientation of the university. The deal provides that IFAM directors can become professors at the university and that studies of students and diploma theses can be performed at IFAM. The institute is obliged to report annually on the status of the conversion process and to restrict its university-based work to exclusively civilian purposes. The fulfillment of these 'essentials' is a precondition for further cooperation after five years.

It is not obvious that the aim of irreversible conversion of IFAM is achievable. The BMVg aims to establish a precedent that could be attractive for other defense-related research institutions. Given the basic assumption that applied R&D will be dual-use capable, it is not yet clear whether this first R&D conversion example will lead to a totally independent civilian research institute or an institution which is partially doing military-oriented research.[46] Nevertheless this case deserves support by the public if the institute and its personnel are to succeed in converting its military character to civilian purposes.

CONCLUSIONS

Germany's dual-use strategy for R&D could lead to an emerging use of civilian technologies for military purposes, thus undermining efforts at irreversible conversion of R&D. Dual-use concepts are particularly problematic because they could counteract the conversion process by pursuing military interests while simultaneously seeking economic competitiveness in the civilian market.

Transparency in military-related R&D is an important prerequisite for a comprehensive program on efficient conversion. The lack of information and the secrecy about detailed budget figures and the purpose and institutions of military-related research are serious obstacles to pursuing R&D conversion. To overcome the blurring of the lines between civilian and military paths of the scientific development, new tools of science and technology assessment have to be introduced and used by decision-makers in the national and international arms control communities.[47] An 'ambivalence analysis' could reveal nodal points, which permit the analyst to distinguish between different paths of scientific evolution, and could open alternatives for decision-making. External decision points also need to be identified to weaken the influence of the military on civilian R&D. Additionally, preventive arms control measures and restrictions on military-related R&D in the international sphere are necessary to overcome the shortcomings of an isolated and unreflective promotion of R&D, thus preventing new technological arms races, new arms exports, and any ongoing use of science and technology for future wars.

NOTES

1. In 1990 around 1.35 million soldiers were deployed on German territory, decreasing by half to around 570,00 at the end of 1994. K. Francke, 'Die Senkung der Verteidigungsausgaben und ihre sozialen und wirtschaftlichen Folgen,' *NATO Brief (August* 1994), p. 14.
2. See H. Wulf, 'Konversion - wirtschaftliche und soziale Folgen,' *Spektrum der Wissenschaft* (September 1994), pp. 96ff.
3. See K. Francke, 'Die Senkung,' pp. 13-16. See also H.-J. Gießmann, ed., *Konversion im vereinten Deutschland. Ein Land - zwei Perspektiven* (Baden-Baden: Nomos-Verlag, 1992).
4. See chapter 15 this volume.

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5. More about conversion in *Abrüstung und Konversion. Politische Voraussetzungen und wirtschaftliche Folgen in der Bundesrepublik,* ed. L. Kollner and B. Huck (Frankfurt a. M./New York, 1990). For a comprehesive literature review see U. Albrecht, *Riistungskonversions-forschung; eine Literaturstudie mil Forschungsempfehlungen* (Baden-Baden: Nomos-Verlag, 1979).
6. Whereas the last Russian troops left in 1994, in the NATO framework NATO troops are still deployed on German territory. In 1994 these were: United States (100,000), France (15,000), Netherlands (3,000), United Kingdom (38,200). *See Military Balance 1993/94,* (London: International Institute for Strategic Studies, 1994).
7. *Verteidigungspoitische Richtlinien* (Bonn: BMVg, 26 November 1992).
8. Initially this build-up was supported by technology imports, mainly from the United States. See H. Wulf, 'Western Europe: Facing Over-capacities,' in *Arms Industry Limited,* ed. H. Wulf (Oxford: Oxford University Press, 1993), p. 145.
9. A. Fischer, 'Zur Finanzlage der Verteidigungsausgaben,' *Wehrtechnik,* no. 9 (1993), pp. 5-6.
10. Note that some defense-related expenditures are hidden within other budget items.
11. K. Francke, 'Die Senkung,' p. 14.
12. K. Francke, 'Die Senkung,' p. 14.
13. H. Wulf, 'Western Europe: Facing Over-capacities,' pp. 96-101.
14. See 'Towards an European Armament Agency,' *Military Technology* (June 1994), pp. 10-20.
15. 'Co-operation is the only way of coping with the steady shrinkage in national defence budgets, notably in the fields of space, strategic transport, logistics and telecommunication.' From the address given by the WEU Secretary-General, W. van Eekelen, to the Royal Institute for International Relations, Brussels, 2 January 1994, in *Military Technology* (June 1994), p. 20.
16. W. Burr, 'Der Rüstungsbereich im sich wandelnden Umfeld,' *Wehrtechnik* no. 4 (1992), p. 5.
17. Erhard Heckmann, 'Luft- und Raumfahrt in der Krise,' *Wehrtechnik no. 6* (1993), pp. 17-25.
18. Heckmann, 'Luft- und Raumfahrt.'
19. H. Wulf, 'Western Europe: Facing Over-capacities,' pp. 96-101. Continuing over-capacity has forced DASA to shrink in size. See Pierre Sparaco, 'Billions in Losses Force DASA Job Cuts,' *Aviation Week & Space Technology* 143 (30 October 1995), pp. 26-27.
20. I. Anthony et al., *Arms Production and Arms Trade, World Armaments and Disarmament, SIPRI Yearbook 1993* (Oxford: Oxford University Press, 1993), p. 444.
21. EJ. Laurance, S.T. Wezeman, and H. Wulf, *Arms Watch. SIPRI Report on the First Year of the UN Register of Conventional Arms,* SIPRI Research Report No. 6 (Stockholm: SIPRI, 1993). See also M. Chalmers; E.

Laurance, and H. Wulf, eds.. *Developing the Register of Conventional Arms,* Bradford Arms Register Studies No. 4 (Department of Peace Studies, University of Bradford, 1994).

22. Defense Minister V. Rune in an interview with *Siiddeutsche Zeitung,* 8 May 1992.
23. Bundesministerium der Verteidigung (BMVg), *Weil3buchI994(Bor\n:'BMVg,* 1994), p. 103.
24. Speech of V. Rühe at the Bundeswehr-Führungsakademie Hamburg, 16 December 1992, p. 15.
25. Bundesministerium für Forschung und Technologie (BMFT), *Bundesbericht Forschung 1993* (Bonn: BMFT, 1993). **In** the years 1987-1989, Germany's R&D share of the GDP was ahead of the United States.
26. BMFT, *Bundesbericht Forschung 1993.*
27. A critical analysis of the 1993 Federal R&D budget is given in R. Rilling and J. Stadlinger, 'Die Sprache der Ökonomie, Ein erst Bewertung des 'Bundesbereicht Forschung 1993',' *Dossier, Forum Wissenschaft,* no. 3 (1993).
28. The FhG is discussed as a potential model for U.S. R&D conversion in U.S. Congress, Office of Technology Assessment, *Defense Conversion: Redirecting R&D* (Washington, DC: U.S. Government Printing Office, 1993), Appendix A.
29. According to the then Minister of Science and Research, Gerhard Stoltenberg as reported in *Press Service of the BMWF,* no. 6 (1967).
30. See E. Bulmahn, 'Volkvertreter ohne Information. Transparenz - ein Fremdwort in der militärischen Forschung und Entwicklung,' in *Die Januskopfigkeit von Forschung und Technik - Zum Problem der zivil-militdrischen Ambivalenz.,* ed. W. Liebert, R. Rilling, and J. Scheffran (Marburg: Bund demokratischer Wissenschaftler, June 1994).
31. Deutscher Bundestag, 'Die Entwicklung der Ausgaben für militärische Forschung und Entwicklung sowie fiir Friedens- und Konfliktforschung' (Response of the Federal government to a parliamentarian request by the SPD), Bundestagsdrucksache 11/7373 (Bonn, 12 June 1990), p. 20. Other items in the budget of the BMVg increase this by another 70 million DM. Additionally, 146 million DM from the budget of the BMFT should be added, since it has been declared military R&D spending under NATO criteria. See Bulmahn, 'Volkvertreter ohne Information.'
32. Bulmahn, 'Volkvertreter ohne Information.'
33. R. Schreiber, 'Wehrtechnische Forschung und Technologie im Europäischen Rahmen (EUCLID),' *Wehrtechnik* no. 12 (1990), pp. 76-92; P. Kraus, 'Die Luftwaffe und das FuT-Konzept der Bundeswehr,' *Soldat und Technik* no. 6 (1993), pp. 340-46.
34. BMVg, *Weiftbuch 1994* (Bonn: BMVg, 1994), p.106.
35. BMFT, *Bundesbericht Forschung 1993, p.* 265.
36. For details see Schreiber, *Wehrtechnische Forschung;* and I. Davis, *Military R&D in Europe. Collaboration without Control?* Current Decision Report, No. 11 (Oxford: Oxford Research Group, October 1992).

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37. J. Heyden, 'Forschung und Technologie im Riistungsbereich,' *Wehrtechnik* no. 4 (1992), pp. 13-17.
38. See D. Fondran, 'Bündelung verteidigungspolitischer Forschungs-und Technologieresourcen,' *Wehrtechnik* no. 11 (1989), pp. 40-41; A. Seller, *The Civilian-Military Ambivalence of High-Technologies and its Significance for Transnational Cooperation in Western Europe*, IANUS Working Paper 11 (Darmstadt: IANUS, 1992). EUREKA: European Research Coordination Agency; ESPRIT: European Strategic Programme for Research in Information Technology; EUCLID: European Co-operation for the Long Term in Defence. *Wehrtechnik* no. 7 (1986), p. 61.
39. BMFT, BMWi, *Zukunftskonzept Informationstechnik* (Bonn: BMFT, BMWi, 1989).
40. Deutscher Bundestag, 'Die Entwicklung der Ausgaben,' p. 20. Heyden, 'Forschung und Technologie.'
41.W. Elsner and G. Voss, *Bericht zu. den Abriistungsfolgen für das Land Bremen und w den Handlungsmoglichkeiten* (Bremen: Ausschuß fiir Wirtschaftsforderung, 1991), p. xi.
42. H.D. Kunze, 'Konversion eines Instituts der Fraunhofer-Gesellschaft,' *Spektrum der Wissenschaft* (September 1994), pp. 104-07. Cf. Statement of the IFAM director H.D. Kunze before the Subcommittee on Arms Control and Disarmament of the German Parliament. Deutscher Bundestag, 12. Wahlperiode, Unterausschuß für Abriistung und Riistungskontrolle, Protokoll no. 22, 9 November 1992. Kunze, Statement before the Subcommittee on Arms Control. See W. Liebert and G. Neuneck, 'Civil-Military Ambivalence of Science and the Problem of Qualitative Arms Control - An Example of Laser Isotope Separation,' in *Controlling the Spread of Military Technology. Lessons from the Past and Challenges for the 1990s,* ed. H.G. Brauch, H.J. van der Graaf, J. Grin, and W. Smit (Amsterdam: VU University Press, 1992), pp. 43-57.