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Military R&D in the Federal Republic of Germany*

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1. *Introduction*

The Federal Republic of Germany ranges among the five most developed industrialized countries in the world; however, in comparison with the USA and the USSR, the German science system is commonly regarded as being of *minor* importance. Especially with regard to the share of scientific resources committed to military efforts and the role of military R&D in general, the West German case is often said to be similar to the Japanese situation, where only a very small part of the national science system is devoted to military purposes. Thus, in terms of military science policy, a clear separation seems to exist between the USA, USSR, UK and France, on the one hand, and the FRG and Japan, on the other.

Economists like Dumas,[1] DeGrasse,[2] Tirman,[3] Lichtenberg,[4] experts on military research like Judith Reppy,[5] and studies on military research done by the Swedish Peace Research Institute SIPRI[6] emphasize the small scale of military research in explaining West Germany's comparable high productivity rates and its respectable share on the civil world market especially in the field of high-tech products. West German sociology of science does not yet contain any broader analysis of the complex of military R&D in the FRG.[7] In the presentation of the competent industrial and state organs and in the self-perception of the scientific community in the FRG, the military R&D also plays a relatively insignificant role. The following analysis discusses the stated low estimation of the role of military R&D in the Federal Republic of Germany.

After briefly interpreting a few basic terms, I will examine where military R&D figures in West Germany's national science and technology policy. West German science statistics give only a very superficial and — compared with the American situation — very imprecise breakdown of the military R&D expenditures.

Discussing the overall expenditures on military R&D in international comparison, the markedly changing balance between governmental civil and military spending, the distribution of military R&D by areas of work and where the work is done, *it becomes clear that the military research budget in the FRG requires a far larger percentage of the national science resources than is officially declared.*

2. *Low evaluation of military R&D*

2.1. *Problems of definition*

A dispute exists in the international discussion as to which features have to exist

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before one can justify speaking of 'military research'. There are four issues in particular which come to bear:

(1) The nature of the contracting and/or financing *institution* and/or its *intent* of use.
(2) The status of the *performing* institution or person, and
(3) the *cognitive* nature of the scientific/technical project.
(4) The actual military *use* of the scientific result, i.e. its method of application (for instance limiting its spreading by secrecy classification).

The definitions of military R&D in the literature may hence be combined within three groups:

(a) research financed and, with the intent of military use, organized by *military* institutions;
(b) research, promoted and organized with the *intent of civilian and military* application by military *or* civilian institutions;
(c) research promoted without such intent of application by *civilian* institutions, however *utilizable* for military purposes.

Without designing to exclude other accesses, I will, in the following, presume probably the most uncontested definition, that all research financed by military institutions with military use purposes is military research regardless of its cognitive nature and effective applicability.[8] Initially though, an explanation appears to be necessary of how the outlined low evaluation of military R&D comes about. Obviously, there are reasons for the natures of both — *historic and contemporary* reasons.

2.2. *Historic reasons*

After the end of the Second World War, the conducting of military research was *prohibited* for a number of years in Germany, i.e. in the Federal Republic of Germany. Likewise, the remilitarization, effected over three decades ago, could only be enforced by the renouncing of research, development and production of ABC weapons, by the renouncing of the production of a series of conventional weapons and an extension of the operational area of the armed forces of the Federal Republic of Germany beyond Europe. These restrictions had a lasting effect.[9]

They had the effect that, up until recently, armament research in the Federal Republic of Germany, for instance compared to the research in France and England (and, particularly so with the research in the United States and the Soviet Union), *was and still is of minor significance.* Meanwhile though, those restrictions or bans were either *lifted* — such as the stipulations of the WEU-treaty — or they were *circumvented,* such as by building up a defensive ABC research. Only the lack of a strategic nuclear force prevented West German armament research drawing level with the French and British budgets. And since the West German government agreed to take part in the Strategic Defense Initiative (which is obviously the most important military research project at present) there is a growing concern among German scientists and their organizations on the subject of military research for the first time.

2.3. *Low visibility*

Military R&D in the FRG has always been *less visible,* which is based essentially on three factors.

2.3.1. *High percentage of private military R&D*

Primarily, armament research in the FRG has been installed in *private* industry and as an element of the so-called '*free*' research institutions. In contrast to France or the USA, neither large intramural state laboratories nor a prominent sector of the military R&D at the universities, which display a high social visibility, belong to the specific national development pattern of the Federal Republic's military research.

2.3.2. *Efforts at marginalization*

This special feature is underlined by the

portrayal of military research given in the federal state's central documents of research and military policies in the FRG — this means the nine Federal Research Reports ('Bundesforschungsberichte') of the Federal Ministry of Research and Technology (BMFT) and defense White Books ('Verteidigungsweissbücher') of the German Defense Ministry (BMVg) published between 1965 and 1988. Quite surprisingly, they reveal a rather coherent pattern of representation.

All of the publications of the BMFT comprehensively avoid indicating the use of science for military purposes as a relevant object of research policy. At the same time, military R&D is subject to what Roland Barthes has called '*Mechanismus der Entnennung*', meaning the 'mechanism of de-appelation'. It appears under the categories of 'defense' or 'special' research respective technology; or, the comprehensive functional context of separate fields of research — to be determined for military applications — is dissoluted by being divided into single columns like 'long-range communication technology', 'information technology' or 'aviation research'. Thus, it is not possible to figure out the role of these fields with regard to their importance for military R&D. The dimension of the representation in the research reports with regard to the defense R&D in no way corresponds to the actual importance of that field of funding. Altogether these documents devote to the (as we will see later) most important sector of the German science system — the military sector — *not half as many lines as pages.*[10]

The above-mentioned characteristics are the result of a mode of portrayal which is based upon what one might call a *'Technique of Marginalization'*. The use of this technique is obviously selective. In no other field of research funding is it to be found in an approximately similar order of magnitude. With regard to its main addressees — the scientists — the 'purpose' of this technique of marginalization obviously is to play down the importance of military research within the entire science potential. In the most important West German science magazines like *Bild der Wissenschaft, High tech or Umschau,* military R&D is virtually *not* reported or discussed.

2.3.3. *Secrecy*

In the words of the Inspector General of the German Armed Forces, the central 'R&D concept', which since 1986 has been structuring the science policy of the BMVg (Ministry of Defense) and administrates close to a third of the allocated means, must be 'rated very much at the top with regard to secrecy aspects'.[11] The rating is 'VS confidential', with various sections for a few interested 'VS for official use only'. Indeed the individual research contracts to respective university contractors are not secret since results are published in the research reports of the Ministry of Defense. However, they cannot be combined to make up one entire image. This issue is in fact aggravated by the considerable *deficits in the science statistics* of the Federal Republic of Germany, which supplies *far less data* to the military R&D than for instance the science statistics of the United States. Since the corresponding data of the FRG enter international science statistics (EG, OECD, UNESCO, UNO), from where it is again taken over into the national science statistics of other countries (NSF) and into peace research (SIPRI), this process is generalizing a to be demonstrated bias of the national science statistics which in turn leads to an internationalization of data which quotes a *very low* percentage of military research in the national science potential of the Federal Republic of Germany — again seen in international comparison.[12] The concrete foundation of a sociological analysis is, at the outset, very difficult, since, in contrast to the American science statistics, the West German science statistics will not disclose:

- the distribution of military R&D among

different types of *performers* (intramural, industry, university, other),
- contract *sizes* for every institution,
- breakdown of military R&D by *fields of study* and *discipline,*
- distribution by *services,*
- *geographic* distribution of R&D funding,
- distribution by *budget categories* (basic research, development, testing).

There is no accessible list of contracts.

The R&D budget of the defense ministry covers only a small number of programs, including a large number of single R&D projects. *It is not possible to break down these program elements.*

3. *The historical development of military research in the Federal Republic of Germany*

3.1. *The predominant pattern of military R&D*

The military use of science has always had the effect of a catalyst of the large structural changes of modern science organization. It has been the central, at times even dominating development form of the four great processes of structural change in science since the end of the nineteenth century: the *politicalization, the capitalization, the industrialization and the socialization* of science. Whoever wants to comprehend the history of science cannot pass up the study of its military history.

Such a study will certainly prove that there are phases of discontinuity within the continuity of militarized science, phases of slow down as well as phases of dynamics. Beyond any doubt, a revolutionary *restructuring of the relationship between science and the military* had been taking place in the USA since 1940/41. The First World War was a 'production war' with relatively minor influence of contemporary science and technology. It was, if you wish, a war of mechanics, perhaps of chemistry. However, in the Second World War, war technologies brought forth particularly by physics played an essential part. *Within a few years a new pattern of regulation and distribution of science resources was created in which military institutions played a dominating part.* This pattern has remained stable across decades and still leaves its mark on the American science system as well as the European science system to this day. It controlled the international science system in the post-war period. What was this pattern like?

As *politicized* science, it was extensively directed to military objectives. It was the pre-war year 1938 in the United States when over 40% of the federal funds for research were supplied by the Ministry of Agriculture. Within half a decade, expenditures for military research and development increased eightyfold; more than half of these expenditures went into the development of the atomic bomb. This trend of unbroken *increases* of expenditures for military research has been a continuing process since that time (apart from negligible tendencies immediately after the end of the war, i.e., the beginnings of the sixties and the seventies).

During that period, *federal military control* of science evolved. Influential military institutions for science control originated on a central state level. *Secret* R&D dominated the science system for the first time. And since the beginning of the Cold War, secrecy in science remained an important feature not only of the science system in the socialist countries, but also in vital parts of the Western science systems.

At times the Manhattan District Project employed up to 125 000 people and is considered as the birth hour of *Big Science,* in which project-oriented, centrally controlled and with grand-scale financing, privately and publicly organized research projects were tied up across all stages of research with a special emphasis on the development of military products. A new instrument of science control, *contract* research, emerges; the traditional practice of the military to conduct military R&D in state laboratories was broken. The *distribution* of contracts no longer followed the traditional pattern of

decentral geographic balance: contracts were concentrated on barely two dozen universities, thus the foundation for stable long-standing, at the same time highly concentrated cooperative relations between university and the military was laid. Eleven of the 19 largest defense research contractors during the Second World War still belong in 1984 to the top twenty contractors of the DoD.

As these universities were often private universities, their inclusion within the military science system must at the same time be regarded as a sign of *privatization* of military research and development, continuing to the present; about four out of five dollars spent today on military research flow into private industry, into privately or privately controlled state laboratories. This pattern, having originated nearly half a century ago, still exists.

During the immediate post-war period such countries expanded their military research (USA, Soviet Union, Great Britain, Canada, Sweden) which had established a corresponding potential during the Second World War. A second expansion wave at the end of the fifties propelled France, the People's Republic of China and increasingly the FRG into the leading group of countries carrying on military research. At the same time, the most developed science systems of the Third World adapted this pattern. Up to the mid-sixties, military research played the dominating part in the science policies of the Western industrialized countries.

3.2. *Problems of periodization*

3.2.1. *Fiscal history*

Analyzing the German pattern of military R&D, we can again find some characteristics of this 'classic' model of military R&D. For the fiscal history of the German military R&D, the almost uninterrupted *increase* of science capital is typical. Germany had never channelled less than one fifth, occasionally even two thirds of her science expenditures into the military since 1870 — with the exception of the beginning of the Weimar Republic. Military R&D took place in approximately one fourth of Weimar's over 100 state research institutions. A share of 15 to 20% of military research in the central state science expenditures has not been exceeded, with the exception of the First World War and subsequently in the period since 1935, but also not fallen below, with the exception of the beginning period of the Weimar Republic. We know that during Fascism almost the entire research potential of Germany was modified to adapt to the purposes of warfare.

As early as at the beginning of the fifties — through contracts placed by the US Department of Defense among others — military research was experiencing its *reconstruction* in the Federal Republic of Germany. After only a couple of years, the military R&D funding dominated science expenditures. Since 1955, there have been slight decreases in the budget during only four years (1977, 1980, 1981, and 1988 (See chart 3) each time enforced by shifts in the military budget); other than that, only the various speeds of the increase seem to make a difference, albeit an essential one.

Thus, at the end of the sixties, not only in the FRG did a new funding pattern begin to prevail, a *diversification* of the funding spectrum, in the light of which the promotion of infra-structural, ecological and welfare — as well as civil-industrial oriented researches advanced to the top of research priorities. This development — particularly distinctive in the FRG — experienced a decline in the USA through the Vietnam War, i.e. a temporal shift had enhanced simultaneous curtailment since as early as in 1974-6; the transition to a third phase did begin in which at the cost of social-welfare and civil-industrial oriented research, the importance of defense research is constantly rising. International armament and science statistics notes with common consent that since the mid-seventies, the share of military research in public research expenses has been on the rise almost exclusively in the EC and even OECD-sector (comprising

24 developed Western industrial states).

The tendency to cut down the shares of military research in the total research and development budget has been stopped and reversed: since 1970 in Sweden, since 1971 in England, since 1972 in France, since 1974/75 in the United States and since 1976 this change has taken place in the FRG as well. Among the 22 countries for which reasonably reliable data over the past ten years are available and which account for the military R&D in Western countries (except from Israel and some Third World countries like Brazil or Argentina), only three nations (Australia, Belgium and Switzerland) didn't increase the level of their spending on military R&D. There is not a single developed Western industrial nation which since the mid-seventies has not increased the percentage of finance for military research in their governmental R&D expenditures — in the European Community from 20% to over 30%, in Great Britain to over 50% and in the FRG from 14.5% to 20.2% (1982/8) of federal spending. Whatever is provided for science in additional means in times of chronic financial and budgetary crises, hence the actual increases, primarily flow into military research.

There is indeed a reallocation of the resources increase and the resources themselves — a turnabout in the promotion and funding of science.

The astonishing shift of science resources into the military sector is most obvious in the United States, where in only one — the present — decade, the total expenditures for military research will about quadruple from $16 billion to close to $60 billion and the percentage of military research in the federal funds will have risen from 50% to 75% in a mere decade.

In 1985/86 this increase is evidently beginning to abate.[13] But nowhere can you see a noticeable *decrease* in the huge funds flowing into military R&D. Military research is already *dominating* the public science system in the US and England; France and the FRG are following suit. In all Western industrial states it is the conflict carried on across more than a decade *not whether, but how fast this change* in trend in the promotion of research is to be enforced and the governmental subsidies of civil industrial research and/or for nuclear energy research is to be reduced.

3.2.2. *Cycles of military R&D*

Asking for the cycles in the entire military R&D history of the post-war period, one will have to direct one's attention *beyond mere fiscal dimensions* to further military, economic and scientific-political determinants which will enter into the shaping of military science policy.

Next to the realization of superior *general military- and security-political objectives,* the military research policy of the FRG has, from the beginning — initially via licensed production, then through cooperation — been endeavoring to imitate the military technology developed within NATO and, on that basis, been increasingly proceeding to a more autonomous *technology policy,* which presupposes the existence of a larger market, essentially safeguarded by the private armament export.

From the beginning until today, the military R&D policy has pursued the *specific economic-political goal of branch advancement* (such as aerospace industry, shipyard industry, ammunition and arms industry), and — until the mid-sixties and again from the beginning of the eighties — the general *industrial policy* to increase the general productivity of the national economy via the civic-technological spin-off of the arms technology. The so rarely thematized *economic warfare* also belongs into that department of the economic function of arms research. Finally, armament research has been presumed a component of *general advancement of science* from the very beginning.

It was only in the second half of the sixties when the implementation of new, comprehensive civil research programs and

the foundation of the BMFT as a new ministry, that the BMVg lost what one might justifiably call its *scientific-political leadership function*. Up to that moment, it had influenced the shaping of civil R&D programs (with the exception of the nuclear program), made possible the initial and basic financing of large-scale research institutions such as the Deutsche Versuchsanstalt für Luft- und Raumfahrtforschung (DFVLR) or the Fraunhofer- Gesellschaft (FhG), had controlled scientific key programs such as in the air and space section, i.e. even strongly influenced the development of individual disciplines such as computer science.

As a whole, one may therefore roughly divide the FRG science history into *three* periods: a phase of *construction* and *consolidation* of a bundle of militarily, economic, and science-political basic functions in the fifties and sixties, which was *complemented* in a second period in the past decade. Now, in the eighties, it is a question of *expansion* — the economist would say: of expanded reproduction — of an existing military science system — this differentiates the present period from the expansion phases in the fifties and early seventies. The corresponding chart (chart 1) shows that process of the gradual evolution of the various functions of military research, the forming of a research system, which acquires its self-weight and self-determination and thus increasing *irreplaceableness*.[14]

4. *The funding flows*

4.1. *The total budget*

Under the heading 'Defense Research', national and hence also international science statistics are entered the funds mentioned in chapter 1420 'Wehrforschung, wehrtechnische und sonstige militärische Entwicklung und Erprobung' (Military Research, Military Technology and other Military Developments, Tests and Evaluation) of the chapter No. 14 of the BMVg-Budget. 2.75 billion DM were intended for that purpose 1988.[15]

Not considered though are a series of other cost factors:[16]

1. In particular, the *in-house institutions for tests, evaluation and maintenance* are not included, although these institutions carry out scientific-technological tasks. In the science statistic of the United States, Great Britain or France, they are ascribed to military research; such activities are apparently also included in the science statistic on civil R&D.[17]
2. A correlatively accountable share of research expenditure of the two Federal *Defense Universities* in Hamburg and Munich.
3. *Construction* costs in the research and development field.
4. *Personnel* expenses.
5. Research activities in the sector of *civil defense.*
6. A number of smaller expenditures for *studies* and *research* tasks, as well as *organizations* and *institutes*. For example, as stated by the Federal Ministry of Research and Technology, this Ministry is classifying a share of DM 229 million as funds for military R&D[18] in 1988.

Including these funds in the calculations, the total is 4 instead of 2.8 billion DM (1987).[19]

In an effort to determine the dimension of the total military R&D budget, one must take into consideration additional factors:

7. The especially important funds for *'free research'*, which the Ministry of Defense bestows on procurement contracts, but also on development contracts and sometimes on maintenance contracts to the extent of 2—4%. This program is comparable to the American 'Independent Research & Development Program'.[20]
8. The presumably also increasing, self-financed *industrial* military R&D representing an approximate fifth of the nation's funds for contracts; considerable in size primarily in the industries with a high armament percentage

(hence air- and space industry, ammunition) as well as in electronics and automotive industry.[21]

9. The low-volume orders *from abroad* (DoD, NATO).
10. Finally, *defence-related and dual-purpose* projects which are financed by other federal ministries; their dimension cannot be correctly estimated at the present moment.

These dimensions are computed or published only in part. Only a few single statements dating back to the end of the seventies can be extrapolated.

Altogether, a rough as well as conservative estimate of the total budget of military research has to assume the amount of approx. *DM 7 billion* in the year 1987, about DM 3 billion more than in 1982. *This would mean that presently more than 12% of the entire German national R&D budget is spent on military research. The federal funds for military R&D are equivalent to about 1/4 of the state and 1/3 of the federal R&D expenditures. Thus, they are assumed to be significantly higher than the figures given by the science administration (charts 4,5).* Estimates concerning the scale of the research and development *personnel* working in the field of military research are not yet at hand. Depending on the methods of investigation, the results vary considerably between *36 000 and 60 000 employees,* about 1/3 of them scientists and engineers.[22]

4.2. *Long-term trends in federal spending for R&D*

4.2.1. *Trend development since 1966/67*

Since 1966/67, research policy in the FRG has striven towards strengthening industrial research, thus influencing economic growth directly rather than indirectly via the secondary effects of military technology.[23] Similar to other Western industrialized countries up to the mid-70s, a new funding pattern had been installed which almost completely absorbed the increase of financial and personnel resources. In this period of rapidly growing science expenditures, the relative importance of military research — which had almost unrestrictedly dominated until then — has clearly *declined.* The tendency to cut down the shares of military research in the total research and development budget has been stopped and reversed: since 1970 in Sweden, since 1971 in England, since 1972 in France and since 1974/75 in the USA. As early as 1975, the OECD observed this turning-point.[24] In 1976, this change took place in the FRG as well. The growth was only briefly interrupted in 1980/81 and has continued up until 1987 for more than a decade now.

4.2.2. *Changing funding patterns in the 80's*

According to the Defense Ministry, between 1972 and 1985 the increase in the number of military research projects was 260% and of development projects 88%.[25] Referring to the official data only (that means chapter 1420 of the defense budget) and compared to the basic year 1982 (= 100), the total public funds for R&D has grown to 135% (1987) while the civil share of the federal funds has grown to 111%; the equivalent military share of the federal R&D expenditures was *166%* (1987) (see chart 6). As a consequence, the military R&D share of total federal R&D expenditure has increased remarkably between 1982 and 1988 (from 14.5% to approximately 20.2%, chapter 1420 only (see charts 7, 8). The Ministry of Defense is the only ministry having increased its share on the federal R&D budget since 1982.

A comparison between the federal research priorities in the years 1982 and 1988 evidences the large shift: among the major objectives of federal government's research funding in the FRG, *military R&D has gained first place.* At present, military R&D appears to be the most powerful, most dynamic and most costly sector of the federal funded science system in the Federal Republic of Germany. Following at a great distance are a series of industry-oriented programs which are, in part, also defence-related or at least 'militarily critical' (tech-

nological research, advancement of economy and, most of all, space research). Environmentally and social welfare oriented programs play an altogether irrelevant or secondary part.[26]

4.2.3. *The re-allocation of resource growth*
Still more apparent are the changes when scrutinizing the distribution of the *newly added means* which are most easily to be influenced by the Government. During the period of 1982-1988, *31%* of the federal funds additionally made available by the German government for research programs went into military research. 49.9 percent of the means additionally spent within the time period from 1982 to 1988, compared to the basic year 1982, went into armament research, space research and computer sciences and technology (mainly at the cost of nuclear energy research) (see chart 9).[27] The modifications in the key objectives of research in the Federal Republic of Germany hence primarily take place through the new allocation of additions rather than via cuts into the available substance. Here, we have an essential difference to the United States of America.[28]

5. *Allocation by performers*

Discussing the distribution of R&D among different types of performers (intramural, industry, university, other), the existence of a special basis of military research has been denied in numerous documents pointing out that in FRG, besides universities, there were no important government in-house institutes attached to the Federal Ministry of Defense functioning as national research institutes. The lack of such institutes is presented as being an argument for the minor importance of military research in the national structure of science[29] and as giving evidence of its being productively integrated into civil research. As a matter of fact, there are no huge state-owned, in-house laboratories (like the Los Alamos National Laboratory or the Lawrence Livermore Laboratory) in West Germany. But, on the other hand, the distribution of military R&D funds on performing institutions in the FRG is not very different from the matching pattern in the USA.

5.1. *Industry*
The global distribution of these funds on sectors of performance is quite *stable*. During the last decade, *four fifths* of the military research and development funds in the FRG have gone into industry.[30] Approximately 91-93% of all resources for military research and development flow into the research laboratories of the armament industry. Industry only works on development projects. The Defense Ministry's share of the federal research funds flowing into industry (after having fallen down from about 80% in the early 60s to approx. 20% in the early 80s) has doubled since 1982 to 40% now.[31]

Meanwhile, as research financiers, the economy and defense ministries carry more weight than the BMFT. *The Ministry of Defense has become the most important state funding source for industrial research.*

At least in the armament sector, there is no retreating of the state from industrial research. On the contrary: *more and more, armament research turns into arms industry research.*

The supply of funds for military research is highly *concentrated*. As far back as the early 70s, more than 80% of all the funds already went into two single branches of industry — aircraft and electronics/electrical industry. 1979, 1/3 of the funds for military R&D were forwarded on AEG, IABG, MBB, Dornier, SEL and Siemens, all of them aircraft and electrical industries (apart from IABG). Among them there are the FRG's biggest armament companies, namely MBB, Daimler-Benz and Siemens. The concentration of military research in the FRG on the big armaments firms receiving most of the Government's research funds is obvious, but it cannot be analyzed: the German government suspended pub-

lishing data on the distribution of contracts to the largest companies. These concerns also belong to the group of FRG capital which promote research most intensively (apart from chemical industries, which do not play a role in the military field but have the biggest expenses in the research and development area). These R&D funds capitalize on favorable terms: not only is the research expenditure reimbursed and, increasingly, even advanced, but quite a small number of concerns are able to realize an extra-profit by private control of large state-mobilized research funds.[32]

5.2. *State laboratories*

Mainly concerning universities, but also compared to industrial research, state institutes for military research have continually *gained importance* during the last decade. The means at their disposal have risen above average, their personnel and material potential have been extended and their structure has stabilized. Taking into account only the small funds for research (not development), in 1981 these institutes got a share of 70% (industry 20%, university 10%). In the first place one has to mention the 'Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt' (DFVLR). It is the FRG's biggest Institute of Engineering and Aviation Research, employing more than 3,100 people in 31 institutes and departments. A considerable degree of its research is performed in the field of military aviation research. Of comparable importance is the 'Fraunhofer Gesellschaft' with 28 research institutes and 2,800 employees; six institutes are almost exclusively employed in research work for the BMVg and are 100% financed by it. The 'Forschungsgesellschaft für Angewandte Naturwissenschaften' (FGAN) in exclusively financed by the Federal Ministry of Defense: 365 people are employed in six institutes. There are 128 employees in the 'Forschungsanstalt der Bundeswehr für Wasserschall und Geophysik (FWG) in Kiel, which exclusively works for the Federal Ministry of Defense and is financed by it. There are 468 employees in the German-French Institute Saint Louis (ISL) working mainly in the fields of aerodynamics, ballistics and the technique of measurement. An important role is played by the 'Industrieanlagen Betriebsgesellschaft mbH' (IABG), which, since 1961, has been built as the FRG's biggest centre of systems analysis and testing, working at 80% in the field of military research.[33]

5.3. *Universities*

In 1978, the Ministry of Research and Technology reported the military research potential employed in universities at DM 12 Mio and 290 persons equivalent to 1/2% of the university personnel and 0.2% of the research funds provided for universities. The Defense Ministry itself quotes the size of its research contracts to university institutions as 22.8 million (1975), 9.7 million (1981), i.e. 18.7 million (1987)[34] — not considering the far more comprehensive expenditures for development and testing. According to my assessments, at best *3%* of the federal research funds presently flow into universities, and at best *3000 full time staff members at universities* work in the field of military research — far more than acknowledged, but *far less* than in France and in the USA.[35] In the 70s, 65 institutes carried out research contracts at universities for the Defense Ministry; in the 80s, there are thirty institutes at 18 universities so far. Focal points are the Technical Universities in Aachen and Munich. The Defence universities play a special role as well, the tendentiously important research potential of which is increasingly coming to bear.[36] One may assume that this distribution of research means has remained stable for years. It is to be assumed that, in the face of the densening of the military innovation cycle and the interconnected growing military relevance of the basic research primarily concentrated in the universities, the number of research contracts of the BMVg

for university contractors will grow particularly in aerospace and space research, computer science and military medicine.

5.4. *Regional structure*
Regionally, the military research concentrates in the *south* and *north* of the German Federal Republic: approximately 67.6% of the expenditures for research are assigned to Bavaria and Baden-Wuerttemberg, 18% to Hamburg, Bremen, Lower Saxony and Schleswig-Holstein. Only 14.4% of the means are spent in North-Rhine Westfalia, Palatia, Hessia and in the Saarland.[37] Since the mid-80s, a new development must be noted: an expansion of the military components of the Federal research policy at a state level — most evidently demonstrated by the lower saxonian 'Technologiezentrum Nord'. Only where regional concentrations of the arms industry (i.e. Munich) and research-financing priority-targetting in individual disciplines (i.e. military medicine, aerospace- and space research, computer science) are combined, there will be direct and massive dependencies within the university sector.

Considering these facts, one can confirm that, although industrial military research constantly dominates, the basis of state-financed military research has stabilized and extended. The military force is creating its own basis of research. During recent decades, the system of military research has horizontally and vertically extended into hundreds of laboratories, university institutes, industrial firms, scientific institutes and disciplines. It no longer affects single branches, but the whole structure of science.

6. *Allocation by stage of development and fields of study*

Germany's military R&D is concerned primarily with applied research and development; *basic* research accounts for only a *very small* proportion of military R&D. The Federal Ministry for Research and Technology puts the dimension of military basic research in the FRG at DM 1 million for 1982 and DM 0.8 million for 1986, which would be *extraordinarily little* in international comparison. According to the latest research report, the share of basic research in civil federal R&D is 34.2%.[38] However, underlying there is obviously a different conception of basic research than is customary for instance in the science statistics of the DoD. In the linguistic usage of the DoD, the expenditures of the BMVg for 'research' — again of which a considerable part is devoted to basic research — are to be equated most closely with category 6.1 (Research) and one part with category 6.2 (Exploratory Development). If we look at the distribution of funds according to *services,* it is true that there is no itemization of the means according to services; however, one may safely assume that, on average, the Air Force acquires between 40 and 70% of the means.

7. *Allocation by budget activity*

In contrast to the United States, no official statements are made in the Federal Republic of Germany on the breakdown of military R&D expenditures in disciplines, special areas and projects. Available are the so-called research reports — published only partly and with long time delays — from contracts by the BMVg as well as a few foggy statements on the percentage of growth of a few functional sectors within the framework of the 'R&D-concept' of the BMVg, which comprises close to one third of the funds and is rated secret.

7.1. *Sociology*
The expenditures, directly allocated in the budget of the BMVg, for military research in the areas of medicine, psychology, sociology, political science, history, fluctuate by about 1% of the total expenditures. However, they have been gaining far above the average between 1973 (DM 8.5 million) and 1987 (DM 34.4 million, est.). In the field of sociology, the BMVg is playing a differen-

tiated role. An evaluation of the years 1974-1977 of the sociological studies included in the research documentations of the Informationszentrum Sozialwissenschaften indicates that 3% (n = 110) of the studies are concerned with corresponding topics. More than half (51.8%) of the studies were carried out by army-owned research institutions. It is estimated that the German Armed Forces has spent approximately *DM 200 million for sociological research until the mid-eighties.*

Social science research capacities of the German Armed Forces are located in the 'Militärgeschichtliches Forschungsamt', the 'Zentrum für Innere Führung', the Führungsakademie, the Defense Universities, the School for Psychological Defense, in a department of the Industrie-Anlagen-Betriebsgesellschaft in Munich, as well as in the division for military psychology of the armed services and in the Social Science Institute of the German Armed Forces (SOWI). The SOWI belongs to the largest sociological institutions of Europe. Whereas the BMVg does not play an important role for the development of empirical social research or social science basic research (also as carried out at the universities) and in contrast to the United States, the military service psychology has been intensively promoted at a very early point in time. Contracts by the BMVg go to at least 12 universities in the FRG.[39]

7.2. *Computer science*

There is a striking increase in this sector in such disciplines as signal processing, pattern recognition, image processing, special computer-structures, -sensors, software, coding techniques, robot technology, laser technique and cryptology. Already *one third* of the means of chapter 1420 go into information technology. With expenditures amounting to approximately DM 847 million (1988), the expenditures of the BMVg are only a trifle below the means of the BMFT for R&D in electronics, information and communication technology. The BMVg realizes part of the integrated information technology program of the FRG — adopted in 1984 — one must recall that the 1967/68 Defense Ministry had lost all influence on the national Research and Technology policy on the section of information technologies. This is a thing of the past. *Two thirds* of the budgetary means additionally allocated between 1984 and 1986 flow into information technology.[40]

7.3. *Space*

The most consequential expansion in military research has been initiated by the closing of the *SDI-treaty*. The sum of SDI-contracts in the FRG of $48 million (end of 1986) may be minimal; however, the Federal Republic of Germany leads the phalanx of foreign contractors, with England in second place; at least 14 West-German companies are SDI-consignees in the meantime.[41] While the FRG so far has essentially been participating as a user in the military space policy (SATCOM, GPS-NAVSTAR), participation in SDI has been the first step from utilization to research.

8. *Concluding remarks*

The most important concepts being used to justify the mobilization of considerable resources for military R&D deal with research policy as part of the West German economic and industrial policy. The central issue in West Germany's science policy is the conflict that has been carried on for more than a decade not on whether but on how fast this shift in the promotion of research is to be enforced and the federal subsidizing of civil industrial R&D is to be reduced in favor of military R&D. The empirical evidence on the economic effects of military R&D is still scarce, no work has yet been done on Germany. But there is some evidence, that — with a delay of about one decade — there is something like an adaptation to the prevalent *American style of research policy: rising importance of defense research at the cost of civil-industrial*

oriented R&D, built-up of military basic research, emphasizing the convergence of civil and military R&D/technologies and the economic effects of military R&D (spin-off).

This extension of the American style of research policy does not yet include the extension of a somewhat old-fashioned *classification* practice, which has been typical for the USA since 1981. But there is growing acceptance of a concept whose political point of origin was a report of the 'Defense Science Board' of 1976 (Bucy-Report).[42] Here the thesis was developed that military and civil technologies increasingly *converge* and a rapidly growing sector of 'sensitive', 'militarily relevant' or 'critical', 'dual-purpose' technology came into being.

This change in the development of modern technology was to have two consequences for science policy. On the one hand, the military technology had a high *spin-off* for civil economy. That thesis of war being the father of all things is nothing new. On the other hand, and that is the far more consequential aspect of the argumentation, according to this view research and technology, up to now utilized only civilly, will be effective militarily, too, and hence become *militarily relevant* — hence ought to be under the control of the military. As a logical consequence, a science policy originated at the beginning of the 80s which systematically subjugates explicitly non-classified, civil research to governmental control and limits its circulation.

The underlying conception that it has become typical for civil- and military research to converge to such an extent that they become almost *indistinguishable,* and that every technology can be doubly deployed — militarily as well as for civil purposes — should be analyzed in detail.

But it seems that there is not only the simple confrontation: here the civil — there the military research.

It is namely since the end of the Second World War at the latest that there was a gradual expansion of the research type, which was generated under military auspices during the war, into two additional sectors: *space* and *nuclear energy*. Civil space research and nuclear research have dominated the non-military science policy in the most highly-developed Western industrial countries since the 50s. Basically, both operate in the same way as military research. Compared to civil research, prevailing until the Second World War, this new research type with a military origin differentiates chiefly by the fact that the *evaluation* of the research achievements was made by neither the *scientific community* nor by the *market.* The place of scientific and economic evaluation, i.e. *performance* criteria, was taken by *political* criteria. *It was no longer scientific truth or economic profit which governed and controlled the research projects but political needs.*

The state, not the scientific community, evaluates the results of scientific and technical work. Since that research is financed by public budgets, the question of *cost effectiveness* is of minor importance, and since the state — concretely: the political administrative elite groups — is the singular contractor, demanding party and user all in one, there will be no independent judgment by those political elites of the technologies, their effectiveness and consequences for those not part of those elite groups. Again, the effect is that huge scientific and technological projects can be initiated without including the public. The science and technology history of the postwar period does, in fact, know a maximum of a handful of technical large-scale projects which had to be terminated on account of public criticism. The making of atomic research and space research as big business has its roots neither in internal science perceptions nor on economic market demand, but is based on political in effect often military decisions. For the presently developed large-scale technical systems (nuclear reactors, reprocessing plants, space stations etc.), there is no civic market, no private demand.

One might perhaps say: this is not military R&D, but it is not civil R&D either; it is pseudo-civil, quasi-military research.[43]

It differs from military research not with regard to the — perhaps global — *catastrophe* potential of the presently developed technical systems. Nor does it differ with regard to the degree of *secrecy* — remember the born classified — rule in nuclear research if you please. And finally, it does not differ in respect to the *centralistic organization* of research, i.e. the technical systems originating in it: security labs are no monopoly of military R&D and the social safeguarding of the results of nuclear or genetic research has long since become a military problem.

The difference to military research can be found in that: (a) their *products* have no immediate military function and (b) their projects are *justified* not by military enemy images, but at random, i.e. by, accordingly, more diffuse, extensively varying, political legitimation rationales (see chart 2).

The above represents a counter to the thesis of the increasing convergence of civil and military technology. Between the pseudo-civil, quasi-military and military research, i.e. technology, there have always been *exchange processes,* science transfer, spin-offs. As military and pseudo-civil research has heavily extended during the past decades, the impression of a convergence has been created. Indeed, there is no growing convergence between civil research, i.e. research controlled directly by social, scientific or economic criteria, and military i.e. research controlled by political criteria.

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5. J. Reppy, 'Military R&D and Technology Gaps in Trade', in T. Lucid, et al. (ed.), *The Economic Consequences of Military Spending in the United States and the Soviet Union,* New York 1987, pp. 52 ff.
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9. See *Task Force on Science Policy,* Committee on Science and Technology, U.S. House of Representatives, 99th Congr., 2nd Sess., Science Support by the Department of Defense, Washington 1987. The continuity of a highly militarized science system is discussed in the excellent article by P. Forman. 'Behind quantum electronics: National security as basis for physical research in the United States, 1940-1960', in: *Historical Studies in the Physical and Biological Sciences* 1/1987, pp. 149-229.
10. The number of pages describing military research amounts to 3.42% (*Federal Research Report* (FRP) I, 1965); 3.14% (*FRP* II, 1967); 1.67% (*FRP* III, 1969); 3.91% (*FRP* IV, 1972); 0.33% (*FRP* V, 1975); 0.79% (*FRP* VI, 1979); 0.90% (*FRP* VII, 1984); 0.60% (*FRP* VIII, 1986). The problems of secrecy in science are discussed in R. Rilling, Militärische Wissenschaftspolitik und Geheimhaltung in den USA', *Technik-Jahrbuch* 4 (1986), Frankfurt 1987.
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tions, and Paradigms in the Interdiffusion of Military and Civil Technologies in the United States of America'. Presented at the Conference on the Relationship Between Defense and Civil Technologies, Sussex, England, 21-25.9.1987, Table II.

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26. In the year 1988 the share of ecologically and welfare state-oriented R&D on the federal budget is about 14%, economically oriented R&D funds comprise 46% of the federal budget. The government spends precisely 10 times more on military research this year than on environmental research or on research on renewable energy, 20 times more than on research for the humanization of work and 1000 times more than on peace research.
27. Based on *FRP* VIII and IX.
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APPENDICES

CHART 1 *Military R&D in the FRG: History and functions*

	CYCLES		FUNCTIONS								
Year		Feature	Military			Economy			Science		
1952	+	Informal	Z			I			AS		
1953	+	Prepara-	Z			I			AS		
1954	+	tion	Z			I			AS		
1955	+		Z			I			AS		
1956	*	Formation	Z	O		I	B		AS	P	
1957	*		Z	O		I	B		AS	P	
1958	*		Z	O		I	B		AS	P	
1959	*		Z	O		I	B		AS	P	
1960	*		Z	O		I	B		AS	P	
1961	*		Z	O		I	B		AS	P	
1962	*		Z	O		I	B		AS	P	
1963	*		Z	O		I	B		AS	P	
1964	*		Z	O		I	B		AS	P	
1965	#	Consoli-	Z	O		I	B		AS	P	D
1966	#	dation	Z	O			B		AS	P	D
1967	#		Z	O			B		AS	P	D
1968	#		Z	O			B		AS	P	
1969	#		Z	O			B		AS	P	
1970	#		Z	O			B		AS	P	
1971	#		Z	(O	(A)		B		AS	P	
1972	#		Z	(O	(A)		B		AS	P	
1973	o	Expansion	Z	(O	(A)		B	(K)	AS	P	(D)
1974	o	(I)	Z	(O	(A)		B	(K)	AS	P	(D)
1975	o		Z	(O	(A)		B	(K)	AS	P	(D)
1976	o		Z	(O	(A)		B	(K)	AS	P	(D)
1977	o		Z	(O	(A)		B	(K)	AS	P	(D)
1978	o		Z	(O	(A)		B	(K)	AS	P	(D)
1979	o		Z	(O	(A)		B	(K)	AS	P	(D
1980	/	Transi-	Z	(O	(A)		B	(K)	AS	P	(D
1981	/	tion	Z	(O)	(A		B	(K)	AS	P	(D
1982	/		Z	(O)	(A	(I)	B	(K)	AS	P	(D
1983	$	Expansion	Z	(O)	(A	(I)	B	(K)	AS	P	D
1984	$	(II)	Z	(O)	(A	(I)	B	(K)	AS	P	D
1985	$		Z	(O)	(A	(I)	B	(K)	AS	P	D
1986	$		Z	(O)	(A	(I)	B	(K)	AS	P	D
1987	$		Z	(O)	(A	(I)	B	(K)	AS	P	D

Legend:
Z = Military Politics
O = Military Technology I (Imitation)
A = Military Technology II (Autonomy)
I = Industrial Policy
B = Selective Industrial Policy (Branches)
K = 'Economic Warfare'
AS = R&D Promotion (General)
P = R&D Promotion (Programs, here: Aircraft, Space)
D = R&D Promotion (Disciplines, here: Computer Science)

CHART 2 **Characteristics of military, civil and 'pseudo-civil' R&D**

	Civil R&D	Military R&D	'Pseudo-civilian' R&D
		Financial aspects	
Sources	Primarily private	Primarily public; high share of state capital	Primarily public
Percentage national R&D budget	High, but declining	Low, but growing	Constantly high
Cost structure		R&D share above average	R&D share above average
		Institutional aspects	
Performing institutions: Where R&D is done	Primarily private; Industrial R&D dominant; University	Extensively private Industrial dominance federal state laboratories	Extensively private R&D; federal state laboratories
Sectors	Electronics, Chemistry	Electronics, Aircraft	Electronics, Space Nuclear Industry
Concentration ratio	High	High; no small business program; oligopolistic markets; high regional concentration	Above average
Allocation by type of R&D	All stages	Primarily Development Test	Primarily Development Test
		Regulation	
Type of regulation	Self-regulated Economically regulated	Politically (state) regulated; increasing	Space: state regulation increases Nuclear R&D: state regulation decreases
Power structure	Diffuse (University) Oligopolistic Electronics, Chemistry)	Centre-Periphery-Structure (Military-Industrial-Complex)	Highly concentrated; Build-up of similar complexes
		Legitimation	
Legitimation	Science as culture ('scientific truth'); Market: Industrial and social-welfare policy; public and private knowledge	Science as instrument for political purposes (War; National Security)	Science as instrument for political reasons (Industrial Policy; civilian objectives changing)

		Research process	
Period	Diffuse	Innovation and product cycle above average; (10-30 years); follow-on imperative	Above average
Performance	Product and process oriented	Product oriented	Product oriented
	Value-oriented	Commodity oriented	Commodity oriented
	Cost-conscious	Emphasis on performance; low cost efficiency; Small production line: economics of scale cannot be realized; Profit rates above average	Emphasis on performance; low cost efficiency Small production line; economics of scale cannot be realized; Profit rates above average
	'Solves problems'	Generates problems and stimulates 'anti'-R&D, thus highly internally stimulated	'Solves' and generates problems; no 'anti'-R&D
	Diversification of results	Uniformity and Interchangeability	?
	Concentration on large-scale projects	Same	Same
		External relations	
Diffusion	Growing diffusion (spin-off)	Decreasing diffusion. Exception: Microelectronics	Low diffusion
	Low secrecy	High secrecy	Widespread secrecy
Education	High	Low	Limited
Economy	Diffuse. Increase of productivity	Low. Non-reproductive; small indirect effects	Low

CHART 3

Military Budget and Military R&D Budget Growth Rates 1970-1988 (in %)

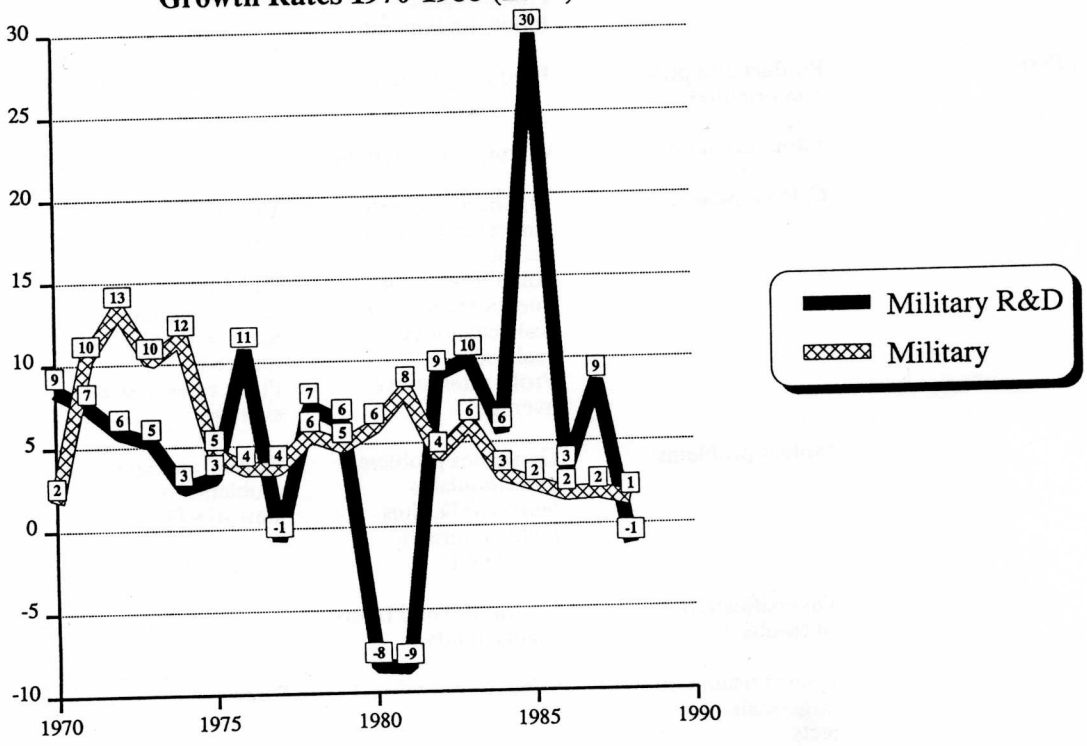


CHART 4

Public Military R&D-Expenditures

<Request 1988; in Mio.DM>

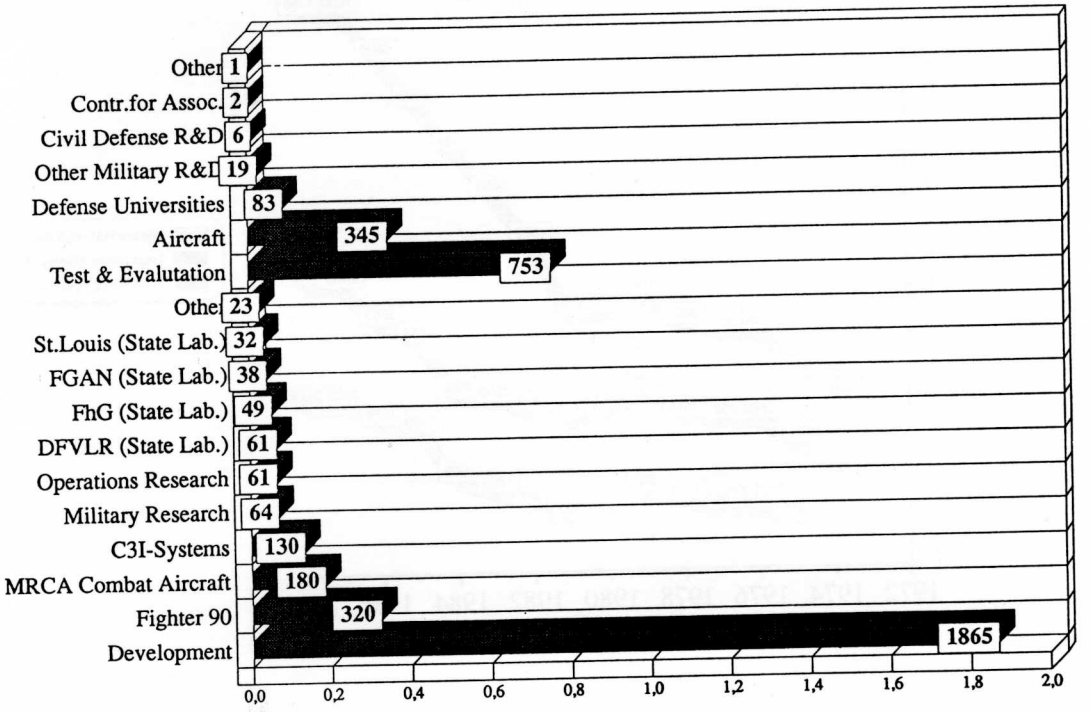


CHART 5

Military R&D Expenditures in the FRG

1973-1988 (in Mrd. DM)

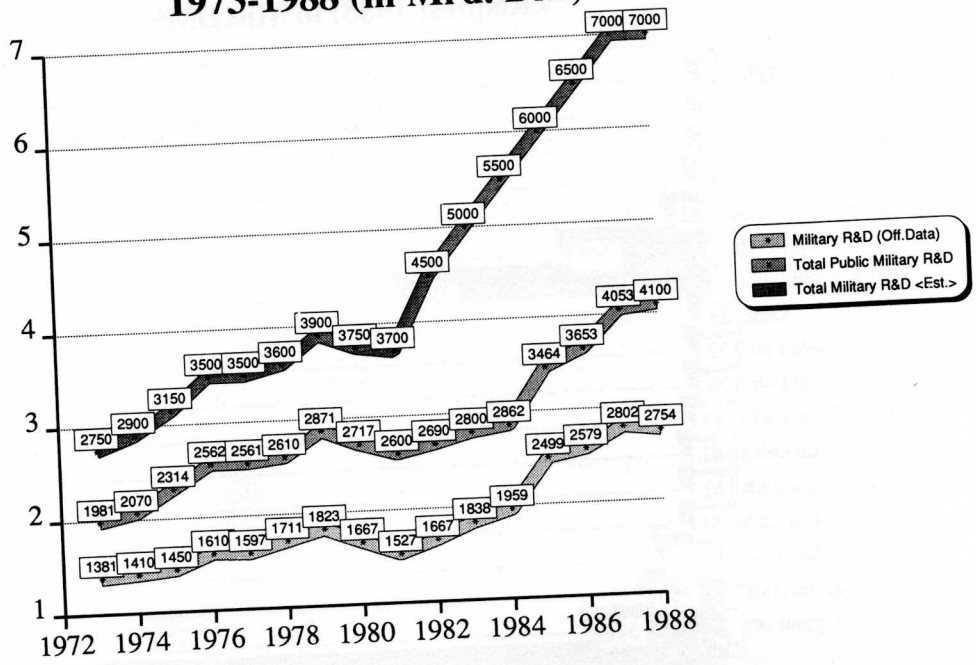


CHART 6

R&D-Expenditures 1982/88

(1982 = 100; in %)

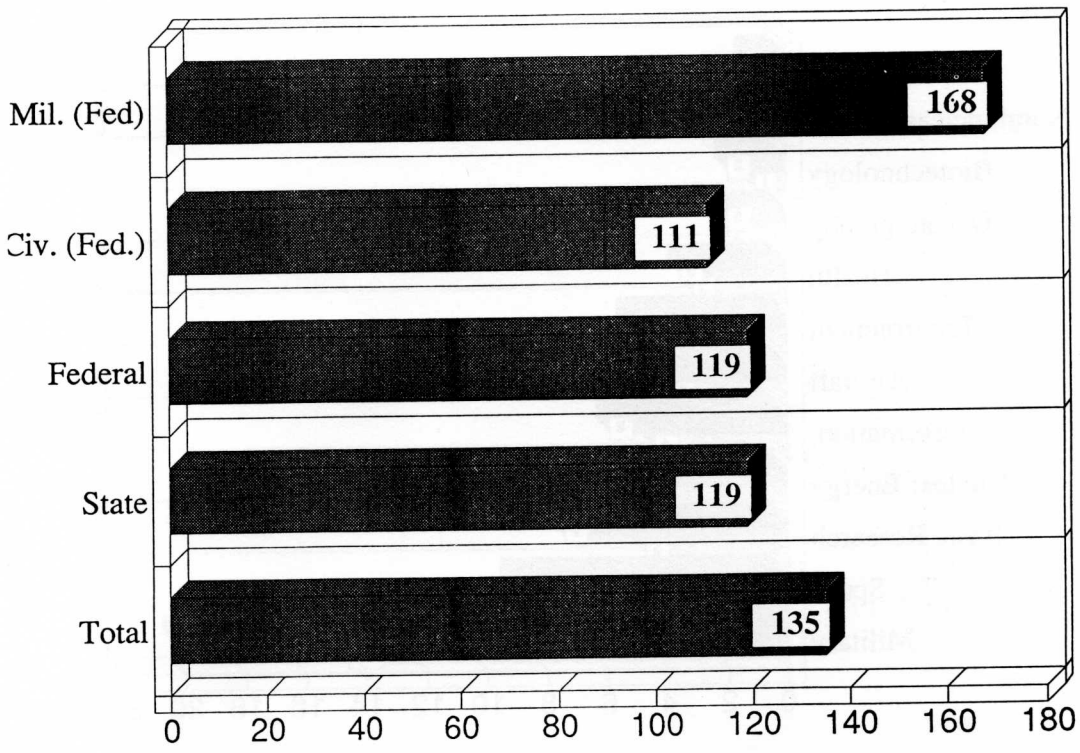


CHART 7

Federal R&D-Expenditures by Function

1982/88 (in %)

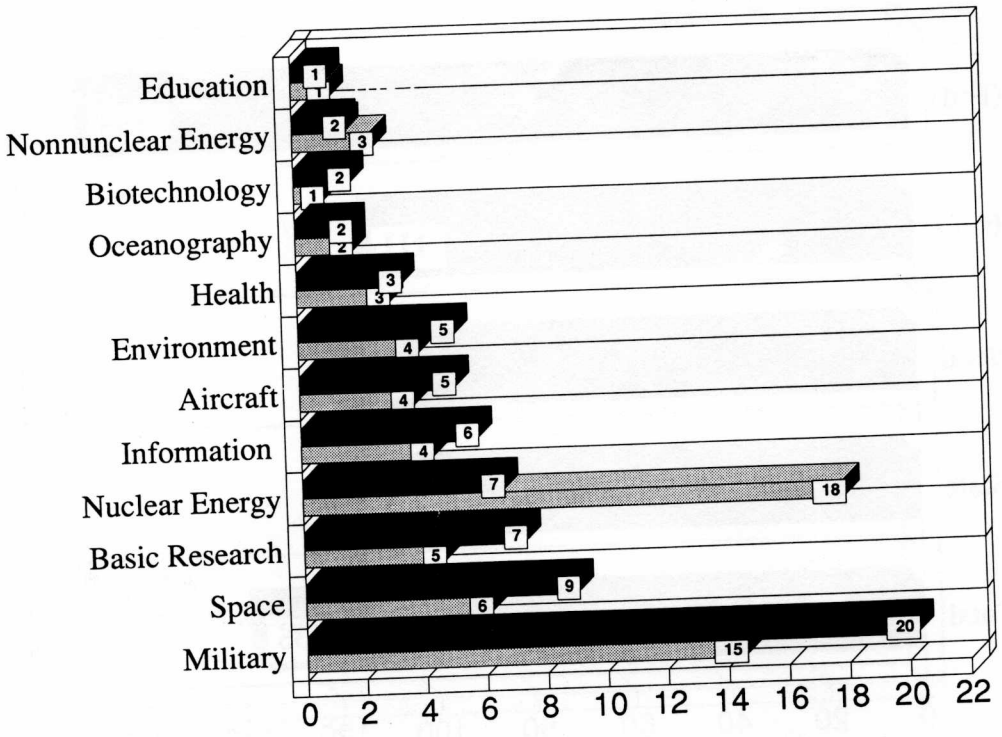


CHART 8

Federal R&D Expenditures by Objectives

FY 1988 (Request) in Mio. DM

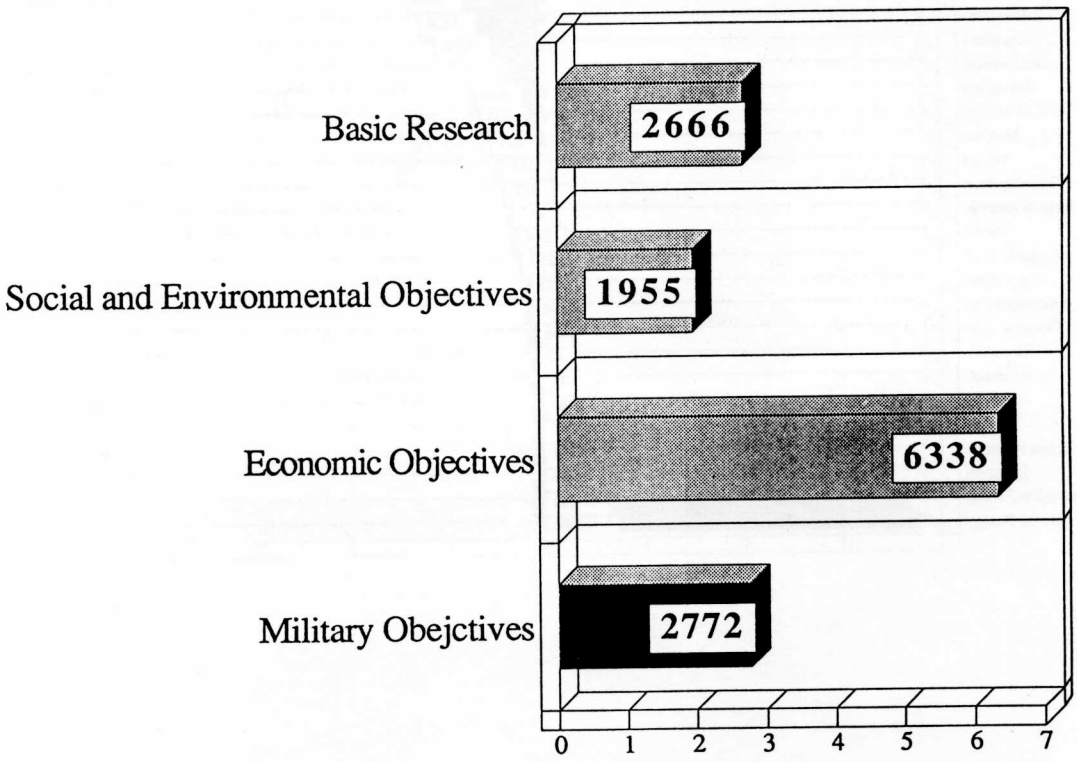
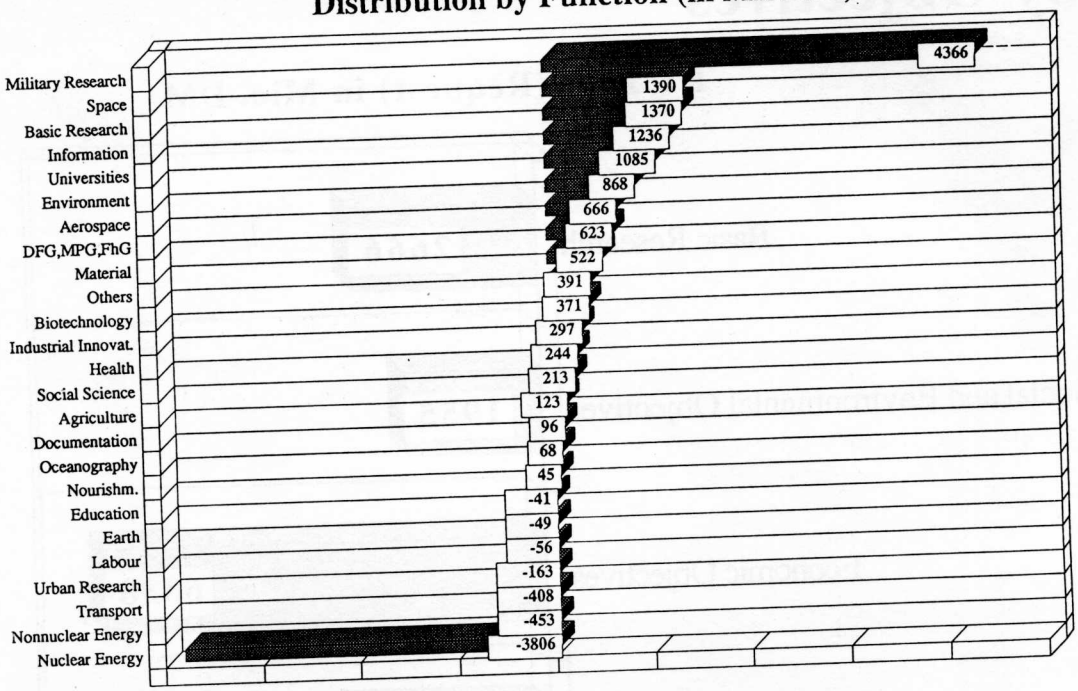


CHART 9

Increase of Federal Expenditures 1982/88

Distribution by Function (in Mio.DM)