EUROPEAN STAR WARS: THE EMERGENCE OF SPACE TECHNOLOGY THROUGH THE INTERACTION OF MILITARY AND CIVILIAN INTEREST-GROUPS

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Introduction

A fundamental shift for preparing the entry into a new, militarily relevant big technology is currently taking place in West Germany. This technology — its proponents maintain — can be compared in terms of its dimensions, costs, and social consequences with nuclear energy. I am referring to West Germany's plans for manned space flight, which have been outlined by a number of decisions during 1985 and 1986; they will eventually lead to a national space program and thus to a fundamental reorganization of research priorities. While it is still impossible to predict the outcome of these ongoing processes, we have the chance of observing the emergence of a new big technology out of a specific area of social, political, economic, and military interests; we can also observe the actions of those interest-groups, which begin to form a stable pattern of argumentation and legitimation, thus producing, step by step, a self-consolidating social structure with its own interests and its own dynamics.

The space lobby, however, doesn't start from zero; a system (in terms of social force and the power to determine research policy) to some extent comparable to the U.S. military-industrial complex has been established during the last thirty years. It possesses an inner coherence and institutional resistance. The development of this complex is one important point this paper will examine. German plans for

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manned space flight can be regarded to some extent as a continuation of (nuclear) high-tech policy in another field — that is, as a sort of follow-up technology for the defense-nuclear-space complex (1).

In addition, there is a political continuity, for space technology is viewed by many space-lobbyists as a unique chance for West Germany to catch up with the military superpowers again by participation in the postnuclear arms race. Space plans entail a continuity and at the same time a new quality of West German foreign, defense, and research policy. The frequent publicly pronounced reflections about a "European space-power" (Helmut Ulke, in Stellungnahmen, p. 7) under West German "system-leadership" (DGAP 1986:49), with well-known and openly discussed military consequences (2), indicate a new determination of the military-industrial complex, no longer to restrict itself to the development of civilian technologies (which was the trademark of West German research policy up to now [see Haunschild 1986:61]), but to insist on the interchangeability of civilian and military technologies, thus opening a wide field of common activities for science, industry, and the military.

This paper will first take a look back at the history of German space flight from the 1930s up to 1987 (section I), thus providing background information to help us to understand the processes that brought about the recent space plans and the groups involved in the game. These groups and their specific interests and argumentation strategies will be examined in a second step (section II), which will also show the mechanism that brings these different groups together and ties them up into a self-consolidating new social structure. Section III will describe and analyze the political program of the space lobby and discuss the financial and social costs that will emerge from it. The manner in which the space lobby deals with these problems which emerge when it confronts the public and the legitimation strategies used in these public debates form a distinct part of the identity of the space lobby and can be analyzed as a sort of system-environment relation that defines the borders of the structure and provides it with legitimacy. Those processes are analyzed in section IV, which also will discuss the relationship between civilian and military space flight. The final section tries to integrate the argumentation lines of the previous sections and to elaborate on some aspects of a sociological approach that serves as a (mostly implicit) analytical framework.

I. A Short History of German Space Flight

In order to understand the present situation in West German space discussions we need to look back briefly at its history, concentrating on manned space flight. (For illustration, see figure 1.) Though the early pioneers in the 1920s and 1930s often dreamed of man on the moon, the first institutionalization of space activities took place under military sponsorship during the Nazi era. As early as 1932 the Heereswaffenamt (Army Ordnance Department) — "naturally" interested in ballistic missiles of any kind — started support for the Nebel-Braun Group, and it installed one of the first (the world's first?) "Big Science" laboratories in Peenemunde in 1937. On the other hand, the Luftwaffe (Air Force) — "naturally" more interested in any sort of plane-like object — not only supported the construction of the cruise missile called V-1, but starting in 1937 it also gave Eugen Saenger the chance to construct new rocket engines as well as to design his antipodal space bomber, an aircraft similar to the U.S. space shuttle. Just as in the case of the Manhattan Project, in 1942 the command was given to start the mass production of A-4 missiles parallel to the research work still to be done. And in 1944, when the first military version was operational, the A-4 was renamed "Vergeltungswaffe" V-2 (retaliatory weapon) (3).

In 1945 space science, along with military R&D, was abolished in Germany, but research and construction went on in the United States, where Wernher von Braun and his team further developed the A-4/V-2 and finally, many years later, constructed the Saturn rocket. The Saenger shuttle disappeared in the files for a while until its revival in 1964. The German aerospace researchers spent the ten years that were to pass before military, nuclear, aeronautics, and space research were permitted again, in different fields. Some went abroad — for example, to Argentina — to continue research (4), or they worked on joint projects — for example, with France (Büdeler 1978:79). The Dornier company switched over to textile-machine building until they were allowed to continue their aerospace work (Büdeler 1978:109). Ludwig

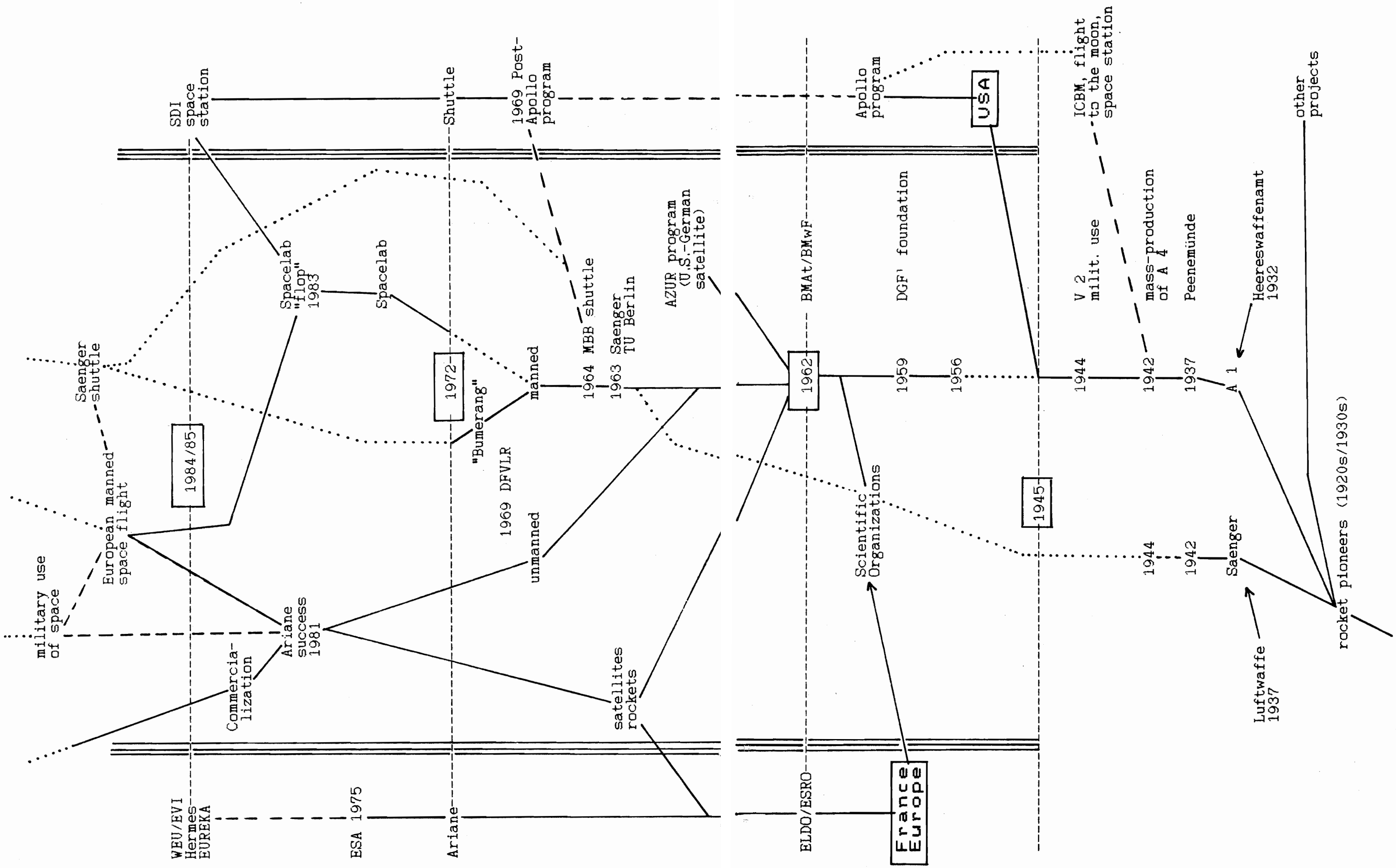

Fig. 1. History of German space flight (Source: Weyer, 1987). [1] Deutsche Gesellschaft für Flugwissenschaften (German Society for Aeronautic Sciences).

Bölkow, the famous aircraft designer, worked for ten years “out of his branch” (Büdeler 1982:71) but reentered aeronautics in 1954 (in the fields of sports planes and helicopters); in 1956, however, he switched back to his original profession and started to construct rocket engines again. This was supported by research contracts from the newly established Department of Defense and the Ministry of Education and Science (Büdeler 1982:74). The Deutsche Forschungsgemeinschaft (German Research Council) also started its support for space research during this period.

With this recognition of space research, including rocket research, and with the beginning of public funding, the era of illegality and of relabeling and sidestepping was definitely over. But another six years would have to pass before space research became an issue for the government — largely due to proposals of European space scientists to establish a European organization for space research, which would include West Germany. The Deutsche Forschungsgemeinschaft was asked by the government in 1960 to put forth proposals for German space activities. This led to German participation in the foundation of the two European space organizations ELDO (European Launcher Development Organization) and ESRO (European Space Research Organization) and to the institutionalization of a department of space research within the Ministry for Nuclear Questions in 1962, which, among other things, can be held responsible for the expansion of that ministry to the Ministry for Scientific Research in 1962 (see Stamm 1981:229—230). From 1967 a special space program has been worked out, usually covering a period of about four years.

The 1960s can be regarded as the phase of reentry into the field. German space policy was concentrated on catching up with the competition — building up a space infrastructure and exploring the niches in the field left to the late-comer. This was achieved when the first German satellite went into space and at the same time the research capacities were concentrated in the Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt (DFVLR); the coincidence of both occurrences in 1969 was probably accidental. During this phase some very important decisions were made. One affected the pursuit of

the more traditional space sciences (those looking up to the stars and exploring the nature of space) and simultaneously the applied space sciences, above all rocket engineering; this was a distinct reorientation of the fields of space science. Another decision was of similar relevance: To accept the invitation to participate in joint European endeavors, but at the same time to start a national space program and different forms of bilateral cooperation (which are naturally less controllable). From the very first, Germany tried to make its space policy independent by way of commitments in different contexts. As figure 1 shows, these decisions in the early 1960s make present politics more understandable.

The American and the European connections were both very prominent for the promotion of different lines of technological development and for providing the frame of reference for a gradual selection from the widespread range of alternatives generated by space scientists. There was a host of sometimes incredible proposals generated in this utopian stage, in which German scientists and aerospace companies could do hardly more than close the gap to competitors, while at the same time preparing ideas for the future. Some of those ideas fitted into the existing framework. For example, Messerschmitt-Bölkow-Blohm (MBB) began in 1961 to design a high-energetic rocket engine (a partly military, partly European-civilian project), which is still used in the U.S. space shuttle (and is well paid) (Büdeler 1982:74—75). Project Neptun — a gigantic rocket, designed to operate in the post-Saturn age — never left the drawing boards in Berlin (5); the idea of achieving a European autonomy by constructing such a vehicle was simply too futuristic. But the plans for the Saenger space shuttle — which was redesigned in 1964 by Junkers (today MBB), and submitted in 1965 as a proposal for German-American cooperation (Büdeler 1978:40; Büdeler 1968:218, 236; Büdeler 1979:463) — and the participation of the aerospace company ERNO (Entwicklungring Nord) in the preshuttle program by designing and testing the shuttle “Bumerang” in the late 1960s (6), indicate that some of the concepts (based on specific German research traditions) were not entirely unrealistic.

Though Germany owed a lot to the United States because of the generous transfer of know-how and the free disposal of launching facilities (see Keppler 1986:532—533, Büdeler 1968:239—246), it was not willing to become a subcontractor in the U.S. post-Apollo program. Simultaneously with the U.S. offer for participation in this program, the Europeans were forced to think about the future of their own space program, since the rocket Europe turned out to be a flop and the conditions under which U.S. launching facilities could be used and the style of behavior became increasingly unfavorable (see, e.g., Büdeler 1979:371).

Decisions taken in 1972 mark the beginning of another stage in German space policy. They were:

— to launch the Ariane rocket program (a French proposal);
— to reorganize European space policy (which resulted in the foundation of the European Space Agency [ESA] in 1975); and
— to contribute to the U.S. post-Apollo program (the shuttle program, also settled in 1972) with the Spacelab, thereby occupying a niche in the program (see Köhler 1976:78).

With Spacelab, plans for a European shuttle were dropped, but the entry to manned space flight was programed. Applied space sciences and space engineering were given a higher priority than before. At the same time, Germany strengthened its position within ESA, because Spacelab was constructed under German leadership (and more than half of the costs were paid by Germany) (see DFVLR 1984:169). The ESA program was given a specific shape, consisting of the French-dominated Ariane program, which led to a breakthrough in the field of launchers and a commercialization of the satellite market, and the German-dominated Spacelab program, leading to future scenarios of manned space flight and other, unforeseeable, applications. Spacelab flew in 1983, but the investments were lost — in that Spacelab now is the property of NASA, and Europe has no access to this field except by using the shuttle every two or three years (e.g., the D-1 mission). Ariane, on the other hand, flew in 1981 and established a solid cornerstone of the so-called European autonomy in space.

The 1970s can be regarded as a stage in which Germany caught up with her competitors by means of different forms of cooperation and

slowly started to stake her own claims in the field, while exercising influence on ESA politics in a way that led to European-American cooperation and to manned space flight. German scientists gained know-how in nearly every field and achieved a top position in some areas (satellite propulsion, space physiology, some fields of remote sensing). Not least important, the German organizational framework was reconstructed as concentration processes in industry left only two big high-tech aeronautics-aerospace-military trusts: Messerschmitt-Bölkow-Blohm and Dornier (nowadays, Daimler-MTU-AEG-Dornier). The forfeited investments in Spacelab are regarded by members of the space lobby as worthwhile because of that program's catching-up function (7).

The next stage, starting in 1984, shows a new style: that of a self-conscious German space policy, which is becoming more and more part of an integral political concept. This is now outlined by some think-tanks, which openly discuss plans for a future German superpower (based on space weapons) and sometimes do not hide their nationalistic, militaristic, and imperialistic attitudes toward the "high frontier" (8). Even if official statements of the government are much more moderate, the concepts of the space lobby are nevertheless compatible with the new politics carried out under the label "autonomy" — that is, Germany is no longer content with its role as a co-player but claims leadership in European space politics. This trend even allows discussion of the military applications of space technology now available (or under construction) in the German or the ESA arsenal. One essential factor of these plans is the pursuit of an independent European access to manned space flight within the next decade — even if a tactical cooperation with the U.S. space-station program is still in the game (9).

The main steps were taken in 1984 when President Reagan invited the Europeans to participate in the project of a space station and thus exerted decisive pressure on them. In 1984, too, the Western European Union (WEU), a defense alliance, discussed plans for a space-based European Defense Initiative, which would use such ESA technologies as, for example, the weather satellite Meteosat. And in 1985 ESA set up a new program containing the new rocket Ariane V and the European contribution to the U.S. space station called Columbus.

This short presentation of the history of German space flight can be divided, as we have seen, into three stages:

(i) 1961—1972: Reentry into the field, construction of the infrastructure for space research.
(ii) 1972—1984: Catching up with competitors, different forms of cooperation.
(iii) since 1984: Claim to a leading role, entry to manned space flight, trend toward a militarization of space flight.

This history also shows that there have always been different lines of technological development that were selected by political decisions. For example, the German shuttle Saenger has been in the game as one potential option for the last fifty years, and yet it has never been constructed (see figure 1). The development decisions were affected by the political and economical frame of reference, policy and research traditions, and different sets of interests.

I will attempt here to analyze the various interest-groups and the way in which they formed, step by step, an interest-alliance to realize the technology of manned space flight. Only an analysis of this kind can tell us why the development, presented above, proceeded in such a straightforward manner and how the space lobby could gain so much strength that is is now in a position to define the future of the nation as dependent on space flight (in much the same way as the nuclear lobby, in recent decades).

II. Constructing Coherence: Interest-Groups in the Space Arena

We can clearly identify four social groups in the space scene, some centers of reference in the environment, and a type of irreversible history characterized — as shown above — by a number of decisions made in the past, a specific tradition, and political inertia (for illustration, see figure 2). My main thesis is: The mechanism producing a novel social structure with a certain type of internal coherence can be defined by processes of adjustment of interests and transformation of arguments. Thus, different actors acting in formerly rather independent fields strengthen their own position inside those fields because they

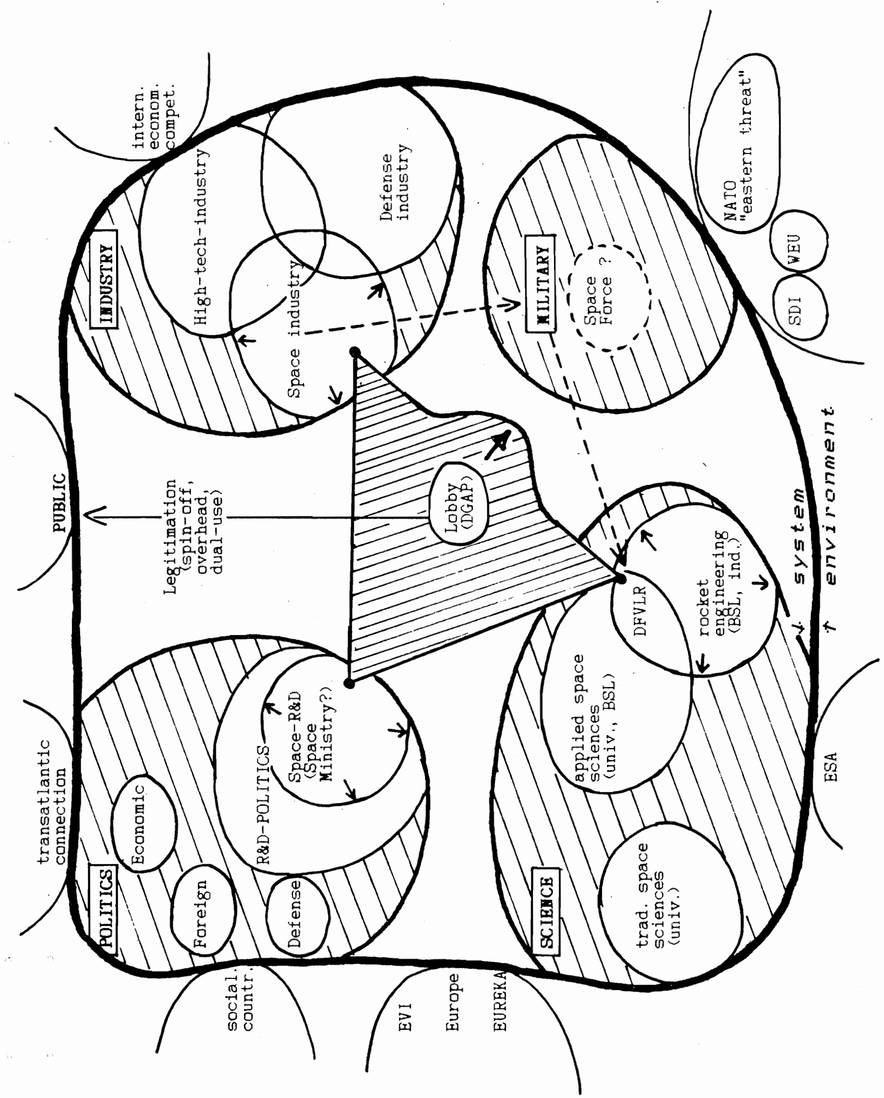

Fig. 2. The structure of the space lobby (Source: Weyer, 1987). BSL — Big Science Laboratories.

become able to import credibility from outside. These processes of mutual reinforcement, which build up hybrid or intermediate structures, subsequently lead to a restructuring of those fields in a way that can be described as a shift in the balance of power (10).

Science

Besides the traditional forms of space science, like astronomy, rocket engineering was established as a systematic purpose in the early twentieth century, and was pushed forward when the German military perceived the implications of that technology for revolutionizing warfare. The technicalization of traditional space sciences by the application of modern rockets (11) allowed the scientists in a first phase to complete their research and to solve puzzles that were unsolvable by terrestrial technology — in a way, to pursue their research paradigm and to achieve some revolutionary discoveries (see Keppler 1986:532). But the constant technicalization of space projects, which was additionally reinforced by manned space flight, on the one hand, and a sort of dynamics of space flight on the other, led to a remarkable paradigm-shift in space sciences due to the fact that, if transported into space, instruments and telescopes could be turned around to look back at the earth. Earth remote sensing came into being as a field of (largely military) interest. The main shift occurred when space exploration was gradually replaced by research in space and research on problems of manned space flight (see Feuerbacher 1984:53, and Köhler 1976). This step was carried out in Germany by the Spacelab program.

The scientists concerned with the more traditional fields, which earlier had profited from unmanned space flight, now complain about space politics and the neglect of their concerns. They have only a few arguments left (mostly the general cultural benefits of science and the technological spin-off from utopian scientific programs [see Keppler 1986]). They have no allies in other fields, and the gradual displacement of scientific organizations from the decision-making process is obvious. In 1960 the Deutsche Forschungsgemeinschaft still outlined the German space program (see Gambke, Kerscher, and Kertz 1961); but with the constantly increasing dominance of the space industry and

applied science and engineering, the traditional scientific organizations (representing the academic branches) have lost their influence. In 1984 the main organizations wrote a letter to the research minister protesting the funding of Columbus out of the research budget (12), which was combined with the cancellation of some basic research projects (e.g., the German infrared telescope GIRL) — but they could not exercise any influence. The classical space sciences are reduced to a marginal position in the field, and former outsiders, who are linked up in a network with other actors and who have the "better" arguments, now have the power to define the course of action.

Those former outsiders are: (i) the applied space sciences, which emerged as a by-product of the new space technologies (partly as quasi-civilian copies of military fields of interest), and (ii) other subfields in the area of rocket engineering, which have been systematically built up during the 1960s (see Büdeler 1968:233—234). Both types of research are institutionalized in the German Grossforschungseinrichtungen (Big Science Laboratories), the most prominent of which is the Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt (DFVLR); this is not only a large research center, but the parent organization of nearly all space research, with executive and advisory functions as well. The DFVLR acts as a brain-trust for the government, and it is connected in different ways with industry and the military. It receives one-fourth of its federal funding from the Defense Ministry (BMVg) and the remaining three-fourths from the Ministry of Research and Technology (BMFT) (in some fields, like microwave remote sensing, the BMVg pays even more). Only in space flight is the military totally absent, a fact that will be discussed later (see DFVLR 1986:9/2).

In a "Strategy Study of Space Flight," released in 1984 as an expertise for the BMFT preparing the European decisions for 1985, the DFVLR recommended German participation in manned space flight as the best of a large range of alternatives. In the study those alternatives are seriously discussed, the costs are carefully calculated, and the conclusions are rather cautious. For example, it is estimated that a final decision about the worthiness of manned space flight cannot be passed before the end of the century; the study also recommends viewing participation in the U.S. space station as "an experimental bridging phase" (DFVLR 1984:xii), which doesn't require the building up of a separate infrastructure. A comparison of these considerations with the argumentation presented by the chairman of the DFVLR, Prof. Hermann L. Jordan, during the parliamentary hearing in 1985, shows distinct variations. Here he characterized manned space flight as "indispensable" (Anhörung, p. 153) and the construction of a European hardware as "a necessary step" (*ibid.*). A "simple alternative" (p. 157), he continued, doesn't exist; when asked for the costs, he answered: "It costs money" (p. 233). In his written opinion he even demanded a "better connection of civilian and military projects" (Stellungnahmen, p. 7) in the German space program and a participation of the BMVg "in using surveillance satellites" (p. 4). During the hearing it was apparently not opportune to push that argument too strongly (Anhörung, p. 36).

From this we can deduce two facts: (i) Argumentation strategies change depending on the context. Confronted with the public, a representative of a research body must be able to show some results — not just considerations fraught with uncertainties (see Krohn 1986:24—26). (ii) the choice of the selected argument is not made in an accidental manner. It depends on the environment, and on other groups of actors who might be helpful in pushing the arguer's own interests (which actually might be served in different ways). Thus the hints given by Jordan concerning a future military space policy (as the DFVLR has a good deal of experience with military research) possess a certain logic.

Political actors are using the scientific arguments given by the DFVLR as sources of legitimation; in return, they furnish this institute with political concepts such as "autonomy," "leadership," or "space defense," which serve as legitimation for certain types of R&D. It is thus that the DFVLR's lead in the space sciences can be attributed to the fact that it is part of a network.

Politics

In politics we can see a similar development. In the 1970s a major decision was taken in German space politics: to concentrate on the commercial use of space flight and to take the first steps toward manned space flight (see Büdeler 1978:25, 61). But when discussion about the Strategic Defense Initiative (SDI) and the space station

emerged, Research Minister Riesenhuber was not really willing to join those projects because he couldn't see any R&D-like justification (13): he preferred to continue unmanned space research or to construct a much smaller station than Columbus (14). Riesenhuber had no allies in the field to push through that point of view except some "outsider" scientists (15) or the Green and the peace movements. The contrary view, however, gained strength during the SDI-discussion (see Weyer 1986) that helped to minimize the resistance to space politics (even military) and brought about a specific European interpretation of space technologies as keys to the future (16). Baden-Württemberg's Minister President, Lothar Späth, is one of the spokesmen of that viewpoint, and he characterizes the space and defense technology industries as the "pulse generator for technological progress as a whole" that a modern, competitive economy must not miss (17). His argumentation actually continues a trend in former space-research policy, which since the 1970s has been characterized by an economic orientation — that is, a direct support of the space industry (see "Faktenbericht," pp. 91—93). But now the argumentation has shifted, for (i) defense issues are regarded as equivalent, and (ii) the fall-out benefits from space flight, formerly anticipated to accrue to a small sector of the space industry, are now extended to the industry as a whole.

This reference of space politics to international economic competition, to defense problems, to international obligations (concerning ESA and the transatlantic connection), and to the "future" have made it difficult for Minister Riesenhuber to resist the trend (which may in a few years become a serious threat to his research policy [18]). The field of "research policy" thus has been restructured by the recent space decisions, which did not follow the internal logic of the field but were based on arguments imported from outside (international relations, defense policy, economic). And the relations within the larger field of politics have been rearranged too — for example, in favor of defense and to the disadvantage of détente policy.

In public statements, Riesenhuber finally took over the arguments in an apodictic manner that formerly was uncharacteristic of him (19). The restructuring of research politics has not yet been completed, however. The recent discussions about the foundation of a German space agency, or even a space ministry (20), indicate that there is still a strong drift toward a closer connection of politics with space issues. This would probably weaken other areas (such as the BMFT) to the advantage of the hybrid space community.

The Space Industry

The space industry — which in Germany is almost identical to the technologically advanced parts of the defense industry, with significant overlaps with the nuclear industry — naturally has primarily economic interests, and thus some interest in maintaining a suitable political milieu in the future as well. But such a forecast doesn't extend the planning-horizon to more than about five years (see, e.g., Steinecke 1986); every measure that gives returns only after ten, fifteen, or more years is viewed as irrelevant to industry's interests. So it can be understood, that the cost of the space program must be paid by governmental budgets. On the other hand, the space industry has built up remarkable capacities in terms of highly trained staff and technically sophisticated apparatus, which (after having finished former contracts) call for follow-up actions on an ever-higher level, especially in those industries that operate nearly exclusively under governmental contracts. Since almost no relevant private market exists for the products of the defense, nuclear, and space industries, they are inevitably dependent on steady governmental support, which could better be allocated by long-term programs than by sporadic measures (see Steinecke 1986).

But the space industry is only a very small (although powerful) sector of German industry, with only about 4,500 people employed (Weltraumforschung, p. 35). Even at Messerschmitt-Bölkow-Blohm, which as a whole is dependent on governmental support at a rate of 80% (Büdeler 1982:66), the space sector covers only 4% of the group (p. 71). Therefore the steady promotion of the potential benefits of space technology for the total economy and for the future of the whole society is a crucial tactic in maintaining the space industry's public image (see BDLI 1984:6, 14). And the phantom of a so-called user-industry waiting for the opportunity to utilize space for production, and so on, also plays a great part. The argumentation strategies of the aerospace industry are fixed around one essential point: avoiding the application of the internal logic of economics to the field (that is, the market laws). A memorandum of Bundesverband der Deutschen Luftfahrt-, Raumfahrt- und Ausrüstungsindustrie (BDLI) (Federation of German Aeronautics, Astronautics, and Equipment Industry), released in 1984, argues in that way and calls for permanent subsidies (BDLI 1984:46), for protectionism (p. 44), and for a nationalization of the market (p. 31). It is openly admitted that the commercial market is not sufficient. Consequently, the BDLI calls for political measures that could open the European and the world markets as well as the home market. Frequent remarks about the necessity of a military use of space are part of this strategy.

Here again, we can see externally borrowed arguments working as amplifiers for one's own interests, which have been transformed in a specific way. It is rather striking that K. H. Allgaier, top manager of MBB in the field of defense initiatives, declares: "For me the threat becomes more critical than could be expected by the Bundeswehr plan for the next fifteen years" (21). And one of his recommendations is to build up a European ATM (Anti-Tactical Missile Program) combined with an early warning system consisting of about 100 reconnaissance satellites (22). It is obvious that it is not "military needs" (WEU 1984, 1:14) but primarily industrial interests that are pushing the formation of a military space market. And there is hardly any other actor on the stage (except the WEU) who draws attention to the military use of existing of future space technologies in the openhearted manner of the space industry (see BDLI 1984:40, 45, 49). In public, however, these arguments are hidden behind other scenarios, such as environmental protection, development aid, weather forecasting, securing the future, and so on (23).

This transformation of the immediate interests of the space industry into the language of economics and defense again reveals the mechanism, that arguments borrowed from external areas help to redefine the problem of the space industry (making a profit by being the technologically most advanced player in the competition game) in terms of the problem-perception of another actor — a mechanism that imports credibility from outside and together puts pressure on this actor, in that he loses a part of his legitimacy if he cannot show a solution to the problems defined in this way. And the mechanism also explains the political impact that a very small sector of the high-tech industry has gained. Finally, it can be proved that the German aerospace industry is a major driving force in the process of bringing about manned space flight on the one hand, and military uses of space on the other.

The Military

One remarkable fact that emerges when we compare the German and the U.S. or French situations, is the total absence of the military in the public debate about space flight. This is mainly due to the special situation of West Germany after 1945, which hampered the continuation of a militaristic policy. In the course of time, the peaceful image of West Germany made itself independent in some way and began to form a distinct part of traditions that — for example, in research policy — are difficult to bypass (see Haunschild 1986:61). But the intense debate launched among historians in 1986 shows the attempts of some groups to change the conception of history and the attitude toward imperialistic and militaristic politics — a process that is intended to make Germany equal (e.g., to the French) in terms of freedom of action in every field of politics.

While direct intervention of the military into the field of space flight is very restricted, it has to be considered that:

(i) There is a long tradition of military involvement in space flight (24).
(ii) The German military has a far-reaching influence on the civilian space program.
(iii) Plans of nonofficial organizations or individuals, but also of the well-authorized Western European Union, for a future military use of space in no way have to stand outside the international state of the art.
(iv) Many suspicions may be raised about the civilian use of the space programs of the European Space Agency (ESA) and the German Research Ministry (BMFT) (25).

The present situation in German space projects is characterized by different ways of informal incorporation of the military into the decision-making process on the one hand (IABG 1986:8), and by an evident orientation of space R&D toward the so-called "utilizing body" BMVg (Ministry of Defense) on the other (DFVLR 1986:5/2). The latter can be found even in cases where the military doesn't pay for the research projects (see DFVLR 1986:1/1—6, 9/2). And it is a remarkable tendency to be discovered in the DFVLR budget that the civilian BMFT totally finances the (partly international) basic research — for example, in microwave remote sensing (DFVLR 1986:6/5) — while the military application of that technology is exclusively BMVg-financed (*ibid.*:6/2, 9/2). Such indications may raise the suspicion that civilian programs, especially when conducted in international, peaceful cooperation, are at least closely coordinated with military interests. The IABG (Industrieanlagen-Betriebsgesellschaft) — one of the government-related brain trusts — provides us with a logical explanation of these facts: "A further reason for the restrictive attitude of the BMVg may be seen in the fact, that the announcement of a demand within the BMVg would lead to the announcer's taking over the costs to the total extent" (IABG 1986:30).

As space projects do not possess the highest priority within present "Bundeswehr" planning, and concrete military requirements transformable into research or procurement orders are not at hand (see IABG 1986:8, 30), it seems to be reasonable that the military remains in a waiting position as long as the technologies developed by BMFT and ESA do not drift in a direction that would be useless to the military. There is a prominent reason for the absence of the military in the discussion: The frame of reference of the space debate — be it the U.S. or the French space program — is fundamentally military-oriented, so that the military as an actor need only come into play if the plans of the other groups involved deviate substantially from copying, for example, the U.S. model. In this way the German military profits from the military character of the space discussion elsewhere. Why should the military risk direct intervention into space projects if even the planned space station is connected in the DFVLR plans with the "utilizing body," the BMVg? (26).

On the other hand, there exists a specific German interest in a so-called extended air-defense (also named European Defense Initiative, EDI), which is not only SDI-related, but also necessarily partly space-based, even if the defense minister hesitates to admit that in public. His undersecretary, Lothar Rühl, knows the correlations very well (see BMVg 1986:59—60, 63); he is also one of the authors of a memorandum that outlines a future military involvement in space from the perspective of Germany as a new superpower (see section III, below). But apart from these future scenarios, which sometimes do not conceal their references to certain political traditions or their radical militarism (27), the international military integration plays a decisive role in future space-defense politics. It is not only, as mentioned above, the SDI program that made access of the military in Europe to outer space more acceptable: the BMVg also participates in the NATO satellite systems Satcom and Navstar (IABG 1986:8, 30; see also Althainz et al. 1984, and Scheffran 1984 and 1985).

The most prominent step toward the creation of an independent European space power was the revitalization of the WEU and the dealing of that body with military space matters. In 1984 a recommendation of the WEU was passed calling for "a defensive European military space programme" inside "an institutional framework untrammelled by the political inhibitions of the ESA convention" (WEU 1984, 1:2), but nevertheless making use of nearly all the ESA-founded space technologies, such as ERS-Statellite (microwave remote sensing), Meteosat (weather satellite), space station, shuttle Hermes, and so on (pp. 3, 14—15). The report given to prepare the WEU decision passionately argued against the hope of a "considerable technological spin-off" (p. 14) from the space station and called instead for a military use of space, which would make the enormous amount of money to be spent more reasonable. The report also showed that priorities should be given to the following four elements: (i) telecommunication satellites (soon available), (ii) a military observation satellite system (prototypes in construction), (iii) a navigation satellite system (planned), and (iv) attack satellites (no priority) (pp. 13—15). Antisatellite weapons, large-payload launchers (Ariane), and the shuttle Hermes were added to the list of wishes of the military, too. Here again it can be seen that ESA

technologies are at least compatible with military interests, and the military is now going to lay claim to those — all civilian-financed — projects.

It can only be speculated that the German military plays a part in these plans. But the minimum that can be concluded is this: The frame of reference for the decisions of the military has seriously changed since Star Wars, and space defense is on the agenda. It has become increasingly easier to demand certain types of space techniques if such demand can be supported by establishing links to other reference groups.

Hence we can analyze this actor, too, in the same way as the others above. The changing ambience has deeply influenced the structure of the field to the extent that space defense is now a matter of political debate. The support from outside (especially by means of international military cooperation, as in NATO and the WEU) has strengthened — or is going to strengthen — those elements within the military who put emphasis on future space-based defense scenarios. The mutual relations with other groups of actors are consolidating (which means the network grows and becomes tighter), so that those actors now can refer to a military demand that helps to legitimate political strategies and — above all — industrial requests.

Conclusion

In reviewing the German space program and the actors engaged in it we have a situation similar to that which other analysts of technological dynamics have previously found (see Kitschelt 1979, Radkau 1983 and 1986): There is no clearly identifiable steering-center; instead, there is a sum of actors with initially different interests, merging together by processes of mutual reinforcement of their positions and interdependencies in a way that can be shown as a translation of arguments into the language and terms of the partner, thus initiating new problem-perceptions on the one hand and borrowing legitimacy on the other. The mechanism analyzed works in two directions: first, by rearranging the frame of reference the co-players make use of when reaching their decisions; and secondly, by using the external environment as a resource that supplies the power to restructure the field one belongs to (these being two ways of viewing the same mechanism). In the final section of this paper the idea outlined here will be discussed again.

But first it is essential to look at the hybrid structures and the new institutional settings emerging in the space field. We will take a memorandum released in 1986 by the Deutsche Gesellschaft für Auswärtige Politik (DGAP) (German Society for Foreign Policy) as an indicator of the state of the discussion inside that hybrid structure. The DGAP memorandum unites representatives from all the areas mentioned above; it can be viewed as one attempt to harmonize the different positions and to find some sort of common phraseology, which is indispensable for a confrontation with the public outside the space lobby. (For localization of the DGAP in the field, see figure 2.)

III. German Space Plans and Their Financial and Social Costs

The technological and political aims of the West German space lobby are frequently described by representative bodies of this group that exert an intermediary function and thus form a sort of inner core. They can be located in political research institutes, foundations, and other organizations of that kind, which are not (or not primarily) part of one faction. These hybrid organizations usually not only serve in coordinating the space lobby, they also aim at influencing public opinion. They thus serve an important function for the public relations of the space lobby that exceeds that of the individual inner-systemic actors. It is important to mention that the legitimation of the space lobby's requests with reference to the environment (society, public, politics) requires other forms of argumentation strategies than those needed in the inside relations between the different groups — a phenomenon already mentioned above.

One central demand to be found in this context is the goal of making Western Europe a "space power of the twenty-first century" — a demand that calls for an enforced European and German "engagement in space" (DGAP 1986:43). Though Germany is working toward these aims within a European structure, it becomes evident that such cooperation has only a tactical importance for the final goal: "to realize West German space power *by means of* a European cooperation" (*ibid.*, emphasis added). Within the frame of the European Space Agency with its already advanced rocket program Ariane, the planned European contribution to the U.S. space station Columbus, and the 1986 predecided plans for building a minishuttle called Hermes, Germany shall — following the words of the space lobby — play a greater part in deciding, financing, and performing future projects.

The self-perception of the lobby — as among others presented during a parliamentary hearing in 1985, or in the DGAP memorandum "German Space Policy at the threshold of the Century" (released in 1986) — about the importance of the period of the mid- and late eighties is that West Germany needs a long-range political program based on a "reorientation of German space policy" (DGAP 1986:38), if the country does not want to risk losing its political and economic position in the world and if it wants to profit from the military potential of space flight. In the words of the cited memorandum, space activities enable the countries engaged "to strengthen substantially their political and economic influence and thereby their position within the international community"; and some sentences later, with greater clarity: "At the bottom of that race for predominance in space are . . . primary geopolitical and military profits" (DGAP 1986:21).

This basic assumption, that Germany is forced to participate in the space race in a more intensive way and in a more competitive manner, leads to the following consequences:

(i) Europe has to gain "autonomy" (Anhörung, p. 112) in space. This means getting rid of the dependence on U.S. space flight, which has sometimes been shamelessly exploited by the United States in the past. As the principles of space flight are the same for all countries, Europe must install a perfect copy of the U.S. technical configuration; this means constructing the "triad" of Ariance (the launching system), Hermes (the transport system for manned missions, too), and Columbus (the space platform in a lower orbit).

(ii) Europe must change direction and enter the sphere of manned space flight. Though everyone knows that "space sciences would prefer unmanned stations or space probes," manned systems are estimated to be irreplaceable because of their "higher political symbol — effect" (DGAP 1986:38). Even if there exist no more arguments for manned space flight than national identity and international symbolic competition, the entire European space concept and its enormous costs are centered on "man in space."

(iii) If geopolitical power will depend in future not only on the possession of atomic weapons, but more and more on the possession of space weapons, then participation in the space race is unavoidable for a country that is defined — at least by the space lobby — as a future world power. The memorandum thus calls for an "adaptation of the defense concept to technological development in the East and West" (DGAP 1986:42), as a part of the notion that West Germany should be "a shaping force of the Western European space power" (*ibid.*). The demand "partially to correct the political power imbalance between the superpowers and the European states . . . in the area of space policy" (p. 22) shows a policy-conception, underlying the space program, whose fixed points are the correction of the postwar political constellation and the reentry of Germany into the club of superpowers (28).

The realization of this concept means — and the space lobby is well aware of this — a far-reaching reorientation of West German and European space policy. Both have in former times focused on peaceful space research, with an emphasis on such scientifically useable and commercializable projects as, for example, the most successful rocket Ariane. But the described aims require a fundamental shift in program structure and research priorities, in technical configuration, and — last but not least — in the financial volume of space research. The recent decision for the new Ariane V shows that the ESA program is headed in the direction promoted by the space lobby (29).

The decision for the space trio of Ariane, Columbus, and Hermes can in no way be compared with any previous decision for other big technologies (30). The amount of money required is hardly foreseeable, and the financial consequences will probably lead to sociopolitical measures and to reorientations of research priorities that are even now (before any social opposition has formed) being anticipated and intensively discussed by the space lobby. Let us look at the costs:

It is assumed that the German share of the R&D costs of all three projects (31) will be about 6.5 billion DM, to be paid within about eight or ten years. It results from the following items: The development of

Ariane V will require, up to 1994/95, about 7.5 billion DM, with a German share of 22% (1.65 billion DM); for Columbus the same amount has to be spent, but Germany will contribute 38% (2.85 billion DM). The fulfillment of these obligations already requires a raise in the German space budget from 1.1 billion DM (1986) to 1.6 billion DM (1992), which is frequently demanded by representatives of the space lobby (32). There are even some who insist on a "doubling of the space budget within the next ten years," thus reaching the U.S. rate of 55 DM per inhabitant per year, or in other words, a German space budget of about 3.3 billion DM (33).

But the story doesn't end here; there is still Hermes to be paid for (34). It is estimated that Hermes will cost about 5 to 6 billion DM , but insiders know that this assessment is much too low. As the well-informed *Frankfurter Allgemeine Zeitung* states, the experts "even today calculate with sums twice as high *or more*" (25 August 1986; emphasis added). If the costs were to remain constant (which nobody expects), Germany would have to pay, at the rate of 30 to 33%, the sum of about 2 billion DM for Hermes — which means a total contribution of about 6.5 billion DM to the Western European space program. No one knows where to acquire such funds, and when the members of Parliament asked the lobbyists during the hearing in the German Bundestag in 1985 they got neither answers concerning the total amount of money to be spent, nor any sign of willingness on the side of industry to contribute financial support. The lobbyists simply refused to give answers or side-stepped (Anhörung, p. 205), as shown in the following example: "It requires time and costs money. The efforts are worthwhile, however" (Anhörung, p. 233).

A very popular argument — well known from the U.S. shuttle — is the promise of reducing space transport costs in some twenty or thirty years (see Anhörung, p. 246) which is one of the major arguments to support Saenger (35). But the fact is that the total system will cost West Germany *at least* 6.5 billion DM, or one entire annual research budget (which in 1987 is at a level of about 7.5 billion DM). This fact makes space technology an absolute novelty in the history of German research policy; even the fast breeder, when contracted in 1972 (with total costs estimated at 1.54 billion DM), demanded "only" half of the annual research budget (1973: 3.14 billion DM) (see Keck 1984:206).

We also have to take into consideration the fact that Hermes — and probably the other components of the system, too — will effectively cost twice as much or more. If we characterize space technology as being in many ways an unpredictable line of technological development similar to the fast breeder (36), and if we take into consideration the cost explosion of the German breeder from 310 million DM (first plans in 1961), to 1.535 billion DM (contract in 1972), to 6.05 billion DM in 1982 (see Keck 1984:203—208) and some billions more in 1986, with a gradient factor of about 5 (from 1972 to 1986), we can easily produce three alternative scenarios of estimation and assessment of the sums to be spent for the space program. This will enable us to draw some conclusions concerning further research policy.

Tables 1 and 2 show the development of the German space research

TABLE 1
Development of the German Space Research Budget
(compared with the total and the nuclear research budget)

Year	BMFT (total)	a.i.	Space R&D	a.i.	Nuclear R&D	a.i.	Space % BMFT	Nuclear % BMFT
1973	3,140		600		770		19.1	24.5
1974	3,680	17.2	590	−1.7	810	5.2	16.0	22.0
1975	4,080	10.9	580	−1.7	1,200	48.1	14.2	29.4
1976	3,960	−2.9	650	12.1	1,310	9.2	16.4	33.1
1977	4,210	6.3	610	−6.2	1,410	7.6	14.5	33.5
1978	4,950	17.6	660	8.2	1,530	8.5	13.3	30.9
1979	5,570	12.5	730	10.6	1,650	7.8	13.1	29.6
1980	5,840	4.8	790	8.2	1,810	9.7	13.5	31.0
1981	6,070	3.9	800	1.3	1,980	9.4	13.2	32.6
1982	7,080	16.6	880	10.0	2,700	36.4	12.4	38.1
1983	6,920	−2.3	900	2.3	2,570	−4.8	13.0	37.1
1984	7,050	1.9	900	0.0	2,620	1.9	12.8	37.2
1985	7,200	2.1	960	6.7	2,650	1.1	13.3	36.8
1986	7,410	2.9	1,111	15.7	2,470	−6.8	15.0	33.3
1987 D	7,560	2.0	1,261	13.5	2,323	−6.0	16.7	30.7
Inc. 1983—87 (average)		2.2		9.0		−2.4		

a.i. = annual increase; all references in million DM.
(Source: Bundeshaushaltsgesetze 1973 passim)

TABLE 2
Linear extrapolation of the German Space Research Budget up to 1995 based on the average increase 1983—1987
(compared with the total and the nuclear research budget)

Year	BMFT (total)	a.i.	Space R&D	a.i.	Nuclear R&D	a.i.	Space % BMFT	Nuclear % BMFT
1981	6,070		800		1,980		13.2	32.6
1982	7,080	16.6	880	10.0	2,700	36.4	12.4	38.1
1983	6,920	−2.3	900	2.3	2,570	−4.8	13.0	37.1
1984	7,050	1.9	900	0.0	2,620	1.9	12.8	37.2
1985	7,200	2.1	960	6.7	2,650	1.1	13.3	36.8
1986	7,410	2.9	1,111	15.7	2,470	−6.8	15.0	33.3
1987	7,560	2.0	1,261	13.5	2,323	−6.0	16.7	30.7
1988	7,726	2.2	1,374	9.0	2,267	−2.4	17.8	29.3
1989	7,896	2.2	1,498	9.0	2,213	−2.4	19.0	28.0
1990	8,070	2.2	1,633	9.0	2,160	−2.4	20.2	26.8
1991	8,248	2.2	1,780	9.0	2,108	−2.4	21.6	25.6
1992	8,429	2.2	1,940	9.0	2,057	−2.4	23.0	24.4
1993	8,614	2.2	2,115	9.0	2,008	−2.4	24.5	23.3
1994	8,804	2.2	2,305	9.0	1,960	−2.4	26.2	22.3
1995	8,998	2.2	2,513	9.0	1,913	−2.4	27.9	21.3
Inc. 1983—87 (average)		2.2		9.0		−2.4		

a.i. = annual increase; all references in million DM.
(Source: Bundeshaushaltsgesetze 1981 passim)

budget in the past and a linear extrapolation up to 1985, based on the average increase rate of the last five years. Table 3 and figure 3 try to assess the future development of the space budget: scenario A supposes constant prices, scenario B assumes a doubling of costs, and scenario C hypothesizes an explosion of costs by a factor of 5. All three scenarios entail attempts to manage the growing problems by redistribution of funds within the research budget. There is also the underlying assumption that funds have to be spent, not constantly, but with a maximum in the years 1992/93.

With the help of these three scenarios the problems of the German space commitment can clearly be shown. Even the sums resulting from scenario A could be managed only by a constantly increasing space

TABLE 3
The West German Space Research Budget up to 1994 (Estimation)
(Three alternative scenarios)*

Year	BMFT	Scenario A			Scenario B			Scenario C		
		NSP	SP. R&D	%	NSP	SP. R&D	%	NSP	SP. R&D	%
1986	7,410		1,110	15.0		1,110	15.0		1,110	15.0
1987	7,560		1,260	16.7		1,260	16.7		1,260	16.7
1988	7,726	300	1,500	19.4	500	1,500	19.4	500	1,500	19.4
1989	7,896	700	1,700	21.5	900	1,800	22.8	1,500	2,400	30.4
1990	8,070	1,000	1,950	24.2	1,800	2,650	32.8	3,000	3,700	45.8
1991	8,248	1,000	2,000	24.2	2,300	3,000	36.4	5,000	5,500	66.7
1992	8,429	1,300	2,200	26.1	2,600	3,250	38.6	7,500	8,000	94.9
1993	8,614	1,300	2,300	26.7	3,200	3,700	43.0	9,500	10,000	116.1
1994	8,804	1,000	2,100	23.9	1,700	2,300	26.1	5,500	6,500	73.8
sum		6,600			13,000			32,500		

BMFT = Bundesministerium für Forschung und Technologie; NSP = New Space Projects (Ariane V, Columbus, Hermes); SP. R&D = total Space Research Budget; % = Space R&D share of the total research budget; All references in million DM.
* For graphic illustration, see figure 3.

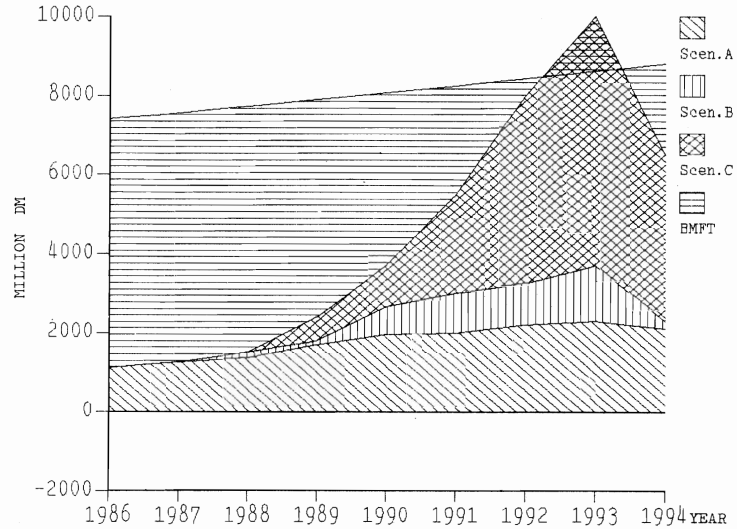

Fig. 3. Assessment of costs of space-scenarios.

budget; scenario B can only be performed by a new distribution of funds both within the space budget (to the disadvantage of other programs, such as space science), and within the entire R&D budget (to the disadvantage of such areas as health, ecological, social, and other research). But scenario C — which may be the realistic one — shows how the space budget will "eat up" the R&D budget from the inside, thus provoking a search for other sources of financial support. Herein lies the major force affecting future German research policy, even if the entry into space flight is less spectacular than in the United States (or in science fiction). Given the case of an explosion — either of costs or of the launching system — the hold of other projects with more reserve capital on the space program is practically preprogrammed, which would probably lead to an altogether new strategy of space flight and space research (37). And as has been shown above, these considerations are no mere speculation.

We can conclude, simply by looking at the financial situation of the space program, that a shift in balance from civilian to other types of space research (which may be military) and a massive burden on the federal budget are preprogrammed. If they come about, these incidents would create an important restructuring of the whole field. The space lobby is well aware of these problems, as the DGAP memorandum points out: "An essential intensification of Germany's space engagement will make sensitive displacements in the federal budget necessary . . ." (DGAP 1986:39). Because the decisions of the mid-eighties are regarded as fundamental determinations that will commit a great amount of money and research personnel to space activities for a period of at least fifteen years (see Anhörung, p. 204), the space advocates see quite clearly that the government "would be forced to cancel considerable sums in other relevant political areas" (DGAP 1986:43).

To avoid foreseeable political trouble, the DGAP memorandum recommends that the German population should be convinced of the necessity of space flight (DGAP 1986:39—40) and that the space lobby should concentrate its political activities on the public "legitimation" (*ibid.*, p. 13) of space policy. Here we can see an interesting example of plans to use public debate as a source of support for the space program, and of well-thought-out ideas of modern sociomanagement aimed at convincing people to favor a policy they would normally resist. The space lobby is well aware that the management of their outside relations is a crucial point for succeeding with their politics, and that organizations specialized in public relations are required. But the major aim of the lobby is to keep the ongoing discussions on a level that does not advance to a principled jeopardizing of the space program.

Because it is obvious that, once they are fixed, decisions have a kind of irreversibility and self-dynamics, the principal appointments should — according to the space lobby — be made now, programmatically, without any technology assessment. Or, in the words of the research minister: "It will later be the task to decide whether the expenses were profitable" (38). The motto "decide now, and think about it when nothing can be discussed any more" is very popular in the debate. But at the same time one is conscious of the fact that such a mechanism cannot work forever. Similar to U.S. models of multiyear authorization, the German space lobby is attempting to decouple the space program from public control on the one hand, and from incalculable discontinuities in the democratic and parliamentary procedure on the other. The president of the Berlin Technical University, Manfred Fricke, declared in his opinion before the parliamentary committee: "Nothing is more harmful to a long-term protection of existence than turning only towards partial solutions oriented to election dates" (Stellungnahmen, p. 7). Space scientist Klaus Pinkau of the Max Planck Institute reflected publicly about the incompetence of the research ministry to plan and to carry out the space program (Anhörung, pp. 124—125) — reflections that led to the idea of a national space center by strengthening the DFVLR on the one hand, and by a partial reorganization of the European Space Agency (ESA) on the other hand, in such a manner that public controls on both levels are diminished (DGAP 1986:54—55; Anhörung, p. 158). Here, as well as in the budget discussions, we can see the space lobby busily trying to extend the area of their influence into other fields.

Loud voices are proposing that space policy should be nationalized (against ESA) while at the same time the space program should be carried out under a new authority that is not obliged to the research policy of the Research Ministry alone, but is also open to other interests, which — following the proposals of space advocates — should be military, too (39). As Dornier manager Helmut Ulke points out, "more ministries should engage in space flight (postal services, defense, interior, development aid)"; he continues: "It would be necessary to build up a German space agency to conduct these tasks of coordination and goal formulation" (Stellungnahmen, p. 9). In the same way, the DGAP memorandum calls for other ministries to engage in, and to pay for, German space activities (DGAP 1986:56) — though there can be no doubt that it is the defense ministry that is primarily meant.

There exists, thus, a large amount of evidence for potential future military involvement in space flight, which indicates that the center of gravity within the field will be shifted in the direction of the military (see figure 2). This analysis also shows, however, that the public is a crucial factor that shapes the strategy and tactics of the space lobby in an important manner. At times one truly has the feeling that the lobby is playing a game with the public, as when one reads: ". . . confronted with the public . . . one should point out in the first instance the economic and social advantages" of space flight (DGAP 1986:40) — a statement to be found only a few sentences after explanations of the redirection of funds in the federal budget to the disadvantage of social, health, ecological, and other issues.

The next section will discuss some recent legitimation strategies and will include considerations about the relation of civilian and military use of space, because problems of legitimation can arise only if there is a barrier between two areas (consisting of the lack of direct connections or applications) that must be bridged argumentatively.

IV. The Problem of Public Legitimation and the Military Use of Space Flight

Two facts must be borne in mind. First, German research policy is aiming for development of the same technologies as the SDI program, because these technologies are estimated to be the key for the future; this assertion applies equally to the European EUREKA program (40). The frequent hints that Europe has to counterbalance the U.S. efforts (which are carried out within a military program) by its own research activities (41) point out this close connection of research goals. The only clear difference lies in the fact that any sort of concrete goal-definition comparable to the "construction of a strategic missile defense" is missing in German and European programs, which thus seem to demand the development of rather unspecific technologies.

Secondly, there no longer exists a general resistance to the publicly pronounced promotion of military research. As R&D Undersecretary Hans-Hilger Haunschild has pointed out, he sees "a clear separation" of civilian and military research, but his reference to the equality and interchangeability of both "fields of responsibility," as he calls it (1986:61), shows a remarkable upgrading of military research, which can thus be considered as legitimate as civilian research. Former barriers are being dropped, as Research Minister Riesenhuber did when he declared that EUREKA-sponsored research "could be applied in the military sector, too" (42). We find this trend also in space

research, where the lobbyists complain that the situation of German industry in international competition is "today unbalanced, since only West Germany . . . doesn't carry out military space projects" (43) — and yet, at the same time, there exist detailed plans for a European Anti-Tactical Missile Program (ATM) (DGAP 1986:30, 48—49), which will lead to a European Defense Initiative (EDI) that can be combined with SDI (44).

Besides a number of hidden hints, we can find a frank and open-hearted description of the military character of the European space program given by Ernst Högenauer, a leading scientist of the biggest aerospace trust in Germany (Messerschmitt-Bölkow-Blohm), in a widely circulated public magazine — a procedure that has some of the character of launching a test-balloon to explore the public acceptability of military space plans. Högenauer points out that hypersonic space-crafts like the European shuttle Hermes are of great importance for both military and civilian aeronautics, thus focusing not on the direct military use of space technology but on a celestial spin-off for terrestrial purposes. Concerning military fields of application he writes: "For military aeronautics, hypersonic planes represent the perspective for the next generation of combat fighters"; these fighters would be able to reach "any point of the world within one hour," to "move above a low orbit" or to "stay for longer periods combat-ready in this orbit" (45). On the other hand, the perspectives for a civilian hypersonic transport plane are so vague that even Högenauer admits:

> Though the civil application of hypersonic technology may seem possible only after this development has been sufficiently qualified by space flight and the military, the civilian concept has at least got an adequate name for the present: Orient Express (46).

There exist, as the Concorde disaster shows, no reasonable civilian applications of that technology, and probably there never will be any (despite the weak comfort of giving the "project" a name) — and the cited representative of the military-industrial complex is fully aware of this fact. The problem is: How can we justify plans of this kind?

It is my hypothesis that space flight nowadays is no more than the continuation of a former exclusively military technology with a new civilian label, a sort of (additionally "invented") external defense belt (47) constructed around the hard core of military space flight — thus protecting military purposes from public inquiry and broadening the ways of acquiring funds for this very expensive research and technology. This switch in labeling and legitimation (but not in fields of application, as I will show below) was accentuated by Undersecretary Haunschild, who characterized hypersonic research as a "classic field of activity of military research" (1986:62). It was only after the discussion about a European shuttle, Haunschild believes, that another field of application emerged (he avoids the term "civilian"!), though it is still "unproven" that anything in this sphere makes sense in economic terms. But the following sentence is remarkable: "Obviously the primary foundation for such technologies can reverse to defense technology" (*ibid.*).

Here the dual-use thesis in its latest version — the assertion of the interchangeability of application and legitimation — is used to establish the equality of both types of research as different means to serve the common goal: the development of high technology. If a former military technology can be pursued in a civilian context, then — according to this thesis — it doesn't matter in which area the research is done. This thesis has replaced the untenable spin-off thesis during recent years, but it is based on the premise that underneath the interchangeability of legitimation strategies (a case whose functioning still has to be explained) there exists a factual interchangeability of technologies between the different fields of application. This thesis only works in our context because space flight is regarded as a civilian purpose, but the suspicion arises that military technology has found a convenient label — especially in a country where military research was forbidden for a time (48).

If, for the time being, we accept the assumption that space flight is a civilian undertaking, then it is our task to ask for reasonable projects in space flight and space research that will support civilian interests; these interests might be primarily economic and scientific, but could be cultural, ecological, social, and international-relations as well. If you ask the space advocates to deliver civilian-based arguments for space flight, you will very quickly be confronted with the fact that there are none,

except for some vague hopes and speculations that are in no way comparable to the very concrete plans for military use — for example, for a European ATM Defense System (EDI).

This is the lesson that the members of the German Bundestag learned when examining the arguments of the space lobby in 1985. Without reproducing and commenting on the whole affair here at length, the core argument is: There is no convincing argument for entry into manned space flight, but just *because* there is "no logical evidence" (Anhörung, p. 142) we should take exactly this risky step to get rid of our knowledge deficit. The space scientist Erhard Keppler called this argument (which was nonetheless also his own) a "logical crack" (*ibid.*), to follow which one required a whole portion of irrationality and metaphysics.

The best way to answer the question about potential civilian uses of space technology is to ask the carefully calculating industry whether an aerospace firm would enter the field of manned space flight and make investments in the hope of getting a profitable return. The answer again is disappointing: neither the U.S. nor the German aerospace industry spends a penny on any space project in which the government does not invest more than one-and-a-half times as much, and the nonspace industry has no interest at all (49). In the German D-1 mission in 1985, only three experiments came from German industry. During the parliamentary hearing, the MBB representative Othmar Heise presented the calculations of industry as follows: "Space flight . . . is a technology that upon application today cannot be said to yield a sufficient return on investment" (Anhörung, p. 206).

At this point one cannot identify any civilian application of manned space flight. For scientific purposes man is only an interference factor, as James Van Allen pointed out very convincingly (50). The economically profitable sector of space nowadays is the geo-constant orbit, which can be reached by "simply," "cheap," and unmanned throw-away rockets available today (51). Material experiments in space laboratories still have few or disappointing results (Anhörung, p. 178), and even if success is attained there will be no prospect for removing the motor industry to space, as the critical scientist Hans-Peter Dürr remarked (Anhörung, p. 180). Not least important: celestial spin-offs for civilian applications, such as the successful Dornier Nierenlithotripter, are so scarce that they cannot justify the enormous costs of today's space flight, nor those of future projects. Further, these spin-offs mostly come into existence by pure chance, like the new material for an artificial hip-joint that came out of Tornado aircraft research (see Abstein 1986).

One potential objection against these arguments is that in some fifteen or twenty years manned space flight might be commercially viable, too, thus following the example of the Ariane success (see Junker 1986) — but this objection is valid only if you exclude from the calculation the billions of dollars spent before (which governments usually do, as with space flight or nuclear energy). Under the conditions of an independent cost-benefit analysis, enterprises (German as well as U.S.) are simply disinterested in the utilization of space (52). There is no civilian, commercial, or scientific demand for manned space flight, even if in some unforeseeable future an artificially produced "market" (which is really a balance of different modes of subsidies) may emerge.

Another potential objection might be the question of military uses of manned space flight. Obviously all military missions may be performed by automatic systems, and such ideas as the use of the shuttle for a battle-observation and battle-management platform seem to be a bit antiquated in times of worldwide data communication. But there are some reasonable arguments for the military use of manned space flight (which are at least more reasonable than the arguments for civilian use):

(i) During the construction, installation, and testing of new automatic weapons systems in space, man could be a help.

(ii) It is unavoidable for the military to keep up with the state of the art in the field of weapons technology, which means being prepared for the future option of a new battlefield in space.

(iii) Research done in space projects has several applications (spin-offs) in the field of so-called conventional military technology — that is, in constructing new "intelligent" weapons with novel features and new missions that might be superior to the enemy's capabilities.

(iv) Last, and not least: even the military profits from the symbolic effect of manned space flight and from the public enthusiasm and willingness to pay for rather expensive space projects.

We can summarize here that it will remain a difficult task for the space lobby to justify all the planned space research in view of the lack of civilian uses. The public seems to be a crucial frame of reference for the strategies of the space lobby that determines their actions in a certain way — for example, forcing the lobby to increase the acceptability of space projects by relabeling them. On the other hand, we see the lobby's attempt to influence public opinion and decrease the general resistance to military plans (which had been increased by the so-called Nachrüstung with Pershing 2 and cruise missiles). Here we can see an example of the "struggle for borders" (Krohn and Küppers 1987:5) taking place between different systems and their respective environments.

V. Conclusion

In this paper an attempt has been made to analyze the emergence of a novel space technology (manned space flight) and to interpret current changes in R&D policy in West Germany by using elements of the concept of self-organization. The so-called space lobby has been described as a social structure that emerged through the interplay of (for the present) quite different interest groups; parallel to the generation of a new production (a novel big technology), this structure gained coherence and obtained a specific stability and self-dynamics, thus producing irreversibilities. The mechanism that brings this hybrid community together can be analyzed as a complex process of adjustment of interests and transformation of arguments. One or the major efforts of the actors in this process is to reformulate arguments in a way that makes them suitable for the pregiven social constellation and interest structure.

The transformation of one's own arguments into the language of another co-actor serves the following purposes:

(i) it imports credibility, and thus legitimation, by the appeal to external arguments that are used as unassailable resources;
(ii) it enables the carrying out of (internal) innovation processes

because they can be defined in respect to the outside as follow-up actions;

(iii) it helps to relabel planned actions and programs, thus immunizing them against critics and other risks; and

(iv) it makes the co-actor jointly responsible for the maintenance of one's own position and forces him to act.

Thus the transformation of arguments helps to bring formerly inconsistent positions together — such as military and unemployed (because of the jobs the military industry can supply), or military and ecology (because of the capabilities of pollution detection by space satellites), and so on. But while producing a great deal of external support, the adjustment of interest entails also the necessity of political and technical compromise. It is no longer possible to pursue one's own interests in a straightforward manner, for the redefinition of problems in terms of the perceptions of the co-actor also means a partial departure from strong selfish interests. For example, the German defense industry would prefer national arms programs; but because these are not politically acceptable, the industry is forced into international cooperation despite such perceived hazards as, for example, the danger of "technological impoverishment" (Lamatsch 1986).

Compromises are often painful if compared with short-term interests. But in the long run, the way of compromise mostly serves to better all interests. Through negotiation the perceptions of other actors and of potential refusers come into play, and the outcome of the negotiation process is more stable than pigheadedly enforced politics. Because the result of successful negotiations is an emerging process of mutual reinforcement, the system then gains a strength and self-dynamics that a sole actor could never gain. And the resources of mutual legitimation are — as has been shown above — much more manifold in such a social structure than in a monolithic system. This may explain the dynamics and innovation capacities of such structures, as well as their stability and resistance to "ex"-external influences.

But is has to be asked how innovations (technical as well as social) of this kind can emerge, given that the different co-actors stem from fields far removed from each other. The construction of social networks can

be explained as follows (53): Each social system (politics, economy, science, and others) is conservative, to the extent that the working of the internal mechanism does not produce any innovation or change. But the maintenance of a system entails a dependence on resources supplied by the environment, and the inclusion of the environment leads to disorder inside the system. (Some environmental facts may be results of the actions of other systems, which in that way rearrange the frame of reference for their co-actors.) Innovation can now take place if this disorder works as an amplifier for nonconservative, mostly marginal, positions. The balance of power within the field can be rearranged if such positions make use of the environment by importing arguments, or resources (e.g., research funding), or credibility (as in the case analyzed above). A special situation occurs if, in different fields, actors are in the play who have analogous or even common interests; this may lead to hybrid structures (as in the space field), which may even make themselves independent. These processes are intensified by the fact that each system is forced to speak to its environment in a non-systemic, but common, language. Special problems cannot be represented to the outside without this language. Such transformations to another language, or even another problem's perception, in turn shape the self-image of the system (as, for example, the notion of the social usefulness of science has increasingly become part of its image, even if it is not necessary for the functioning of its internal logic).

When an innovation has been achieved and a network has been constructed, in a second stage the new social structure begins to stabilize itself by processes of autonomization and immunization. The network increasingly becomes the frame of reference, though the actors are still part of the field they depend on. But attempts to extend the borders of the hybrid structure (even if not a social system in a strict sense), and to expand the area of influence, show a distinct shift from the construction of internal coherence to the struggle with other external claims. The mid-eighties may be regarded as the transition from the first to the second stage in space policy in Germany. Manned space flight has gained a self-dynamics that begins to exceed even the genuine interests of the different actors and thus seems to be unstoppable. The build up of military space technology (which many of the actors surely do not ask for) appears more and more inevitable in order to avoid risking jobs, security, the future, and so on.

We can only speculate about the consequences for science (and for R&D policy as well) if the involvement into structures (such as the space lobby) grows, or, more generally, if network structures, affecting science in a similar way, become tighter. The externalization of the definition of problems (54) and the partial dissolution of the internal logic of science are, in themselves, not the crucial problem, as the model "finalization of science" has already pointed out (see Böhme, Daele, and Krohn 1973). If science generally is open for external control, then militarization is one of the results possible. But it is in no way a constraint, for other alternatives exist. And the model used in the present analysis shows a mechanism that may just as easily lead to the current situation in space policy as it may lead out of it again. The public has been confirmed as a crucial factor, together with the peace movement, and scientific and political organizations. All these elements are part of the process, even if they sometimes feel helpless in view of the power of the military-industrial complex. Every actor in the field actively shapes the frame of reference inside which the other actors can only move. The case of manned space flight in Germany is proof of the fact that the emergence and development of technology can be reconstructed as a line of selection of alternatives that are generated and shaped by social processes. Science is both part and object of the game, the outcome of which depends on the force of each actor to shift the balance of power.

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Notes

1. Because several defense and space projects of the 1970s, as well as the contracts for building nuclear-energy plants, will run out during the late 1980s, this complex

calls for follow-up orders visionary enough to allocate resources for at least ten or fifteen years (comparable to U.S. Star Wars). The chairman of the German Fraunhofer-Gesellschaft, Max Syrbe, referred to this point when he said: "The research capacities that became idle due to the decline of nuclear reactor technology, are already budgeted for these projects [Hermes, Columbus, etc.]" (*Bild der Wissenschaft*, May 1986, p. 79). And the president of the German aerospace research organization (DFVLR), Hermann L. Jordan, proposed a simple measure: "redirection in the personnel sector: from nuclear technology to space flight" (Stellungnahmen, p. 9). (All German-English translations are by J. W.).
2. Recent news confirms this: Foreign Minister Genscher has made himself a spokesman for German participation in manned space flight and the military use of space technologies (*Frankfurter Allgemeine Zeitung* [hereafter, *FAZ*], 28 March 1987). The government increasingly seems to be adopting the plans of the space lobby, even though the terminology used in public is slightly more moderate.
3. See Brauch 1984:34, and Weyer 1985.
4. See *Bild der Wissenschaft*, 1968, p. 836.
5. See *Bild der Wissenschaft*, 1971, pp. 691—697.
6. See *Bild der Wissenschaft*, 1972, pp. 809—817.
7. See, e.g., Anhörung, and Feuerbacher 1984:52.
8. For details, see section IV, below.
9. For details, see section III, below.
10. See also Daele, Krohn, and Weingart 1979b, and Hoch 1988. The concept "hybrid structures" was first used by Daele et al. (p. 27) in the context of R&D policy. Krohn further developed this idea and added the concept of a feedback mechanism, thus going beyond classical concepts of unidirectional steering (see Krohn 1981).
11. Even if stimulated by military interests; see Wilkes 1978:5.
12. *Der Spiegel*, February 1985, p. 79.
13. See *Der Spiegel*, March 1984, pp. 61—62, and February 1985, p. 77.
14. *Bild der Wissenschaft*, 1984, p. 54.
15. See above.
16. Which can hardly be justified, because the technologies used in space flight are usually those of yesterday; see Keppler 1986:536, and Köhler 1984:51.
17. *Wehrtechnik*, March 1987, p. 16.
18. See below.
19. *Bild der Wissenschaft*, May 1986, p. 145.
20. See the scenarios in IABG 1986.
21. *Wehrtechnik*, July 1986, p. 39.
22. *Ibid.*, p. 40.
23. See Anhörung. Here again, the written opinion of the MBB representative Othmar Heise shows a more realistic viewpoint when he admits that positive effects of space research on economics cannot be proved (Stellungnahmen, p. 13).
24. The first common NATO satellite was launched in 1970, nearly coincident with the first German civilian satellite; see Büdeler 1979:369.
25. See below.
26. DFVLR 1986, pp. 5/2, 6/2—4; see also *Wehrtechnik*, March 1987, p. 65.
27. See Schreiber 1986. This article was published in *Europa Archiv*, which can be regarded as a semiofficial organ of the federal government. A short sample:

"Thereby space research is of the highest importance in terms of security and power policy, because it corresponds to the conquest of the seas and of airspace in the past" (pp. 636—637).

28. See also Dickson 1985:1244.
29. This shift can easily be shown by looking at the technical outfit of the Ariane family:

Model	*Payload*	*Orbit*	*Comments*
Ariane I	1,780 kg	GTO	production ends 1988/99
Ariane II	2,177 kg	GTO	further devel. of A I
Ariane III	2,580 kg	GTO	further devel. of A I
Ariane IV	ca. 4,500 kg	GTO	further devel. of A III; 1st flight planed 1986/87
Ariane V	5,200 kg	GTO	new devel., for the 1990s
	or 15,000 kg	LEO	

(Data from *Bild der Wissenschaft*, February 1986, p. 50; *FAZ*, 28 May 1986.)

If we assume (a point I cannot discuss here at length) that the geo-orbit is primarily interesting for commercial users, while the low orbit can contribute very little to commercial, scientific, and probably economic concerns, and if we further take into consideration that the heaviest communications satellites ever built weighed about 2,000 kg, while military satellites weigh 12,000 kg or more, we can easily see that the new technological system the Europeans have decided to construct, Ariane V, has only little use for actual commercial or scientific purposes, but much more for military interests and/or for manned space flight by carrying the shuttle Hermes or elements of a space station into low orbit.

30. This example of European space projects also shows the enormous self-dynamics that a program of this kind can gain. When the German government decided in January 1985 to participate in the Ariane V program and the Columbus program, but refused at the same time to do any other projects, everyone knew — and the space lobby used this argument with vehemence during the parliamentary hearing (see Anhörung, pp. 111, 165) — that the space program only makes sense if it is completed by the missing link: a shuttle, launched by Ariane to transport materials and astronauts to Columbus. So predecisions were made that produced irreversibilities and constraints to continue on the preestablished path.
31. A new launching plant, a set of satellites, and other details had to be added; see DFVLR 1986, and Johanson 1987.
32. *FAZ*, 25 August 1986; DGAP 1986:55—56.
33. Fricke, in Stellungnahmen, p. 11.
34. Here even ignoring the German plans for a futuristic shuttle called Saenger, to be developed during the construction period of Hermes.
35. See *FAZ*, 21 June 1986.
36. As the *FAZ* (20 June 1986) does it.
37. The case of the discussion about a military version of the German Airbus-plane, carefully launched in 1986, shows the way this mechanism works, or starts to work, especially in a situation of economic crisis and unemployment.
38. *Bild der Wissenschaft*, May 1986, p. 146.
39. Heise, in Stellungnahmen, pp. 8, 14.
40. Heise, *ibid.*, p. 19; Hartbaum, *ibid.*, p. 6.
41. See, e.g., Riesenhuber, in "Das Parlament," p. 3.
42. *FAZ*, 17 December 1986.
43. Schmidt, in Stellungnahmen, p. 3.
44. Heise, *ibid.*, pp. 17—18; for more details, see Fuchs 1986.
45. "Das Parlament," p. 12.
46. *Ibid.*
47. The notion "shelterbelt" has been borrowed from Lakatos (1974) — not in a strict interpretation, but in an analog transfer.
48. If we look at the history of space flight, this suspicion is very quickly confirmed; see Brauch 1984, and Büdeler 1968.
49. See *FAZ*, 4 August 1986.
50. In *Spektrum der Wissenschaft*, March 1986.
51. This sector is even so profitable that government can, after having paid enormous costs for R&D, withdraw from this field, leaving the profit-collecting to the industries.
52. See Anhörung, and *FAZ*, 4 August 1986.
53. I refer to the recent research of Wolfgang Krohn and Günter Küppers; see Krohn 1985, Krohn 1986, Krohn and Küppers 1987, and Küppers and Paslack 1986.
54. In R&D policy a similar externalization can be discovered, if we look at the step-by-step replacement of the definitions of social problems (such as health, work, ecology) by external problems (such as world market, foreign policy, conquering the deep seas or outer space).

Bibliography

Abstein, Günter. 1986. "Zivile Nutzung von Rüstungsprojekten." Paper delivered at conference on "Economic and Technological Aspects of Armament," 8—10 December 1986, Wildbad-Kreuth.

Althanz, Peter, et al. 1984. *Militarisierung des Weltraums.* (Schriftenreihe Wissenschaft und Frieden, vol. 2). Marburg: Bund demokratischer Wissenschaftlerinnen und Wissenschaftler.

Anhörung: Deutscher Bundestag. 1985. "Weltraumforschung — Weltraumtechnik." *Ausschuss für Forschung und Technologie, Stenographisches Protokoll der 46. Sitzung des Ausschusses, 11—12 November 1985*, öffentliche Anhörung. (Mimeographed manuscript.)

BDLI (Bundesverband der Deutschen Luftfahrt- und Ausrüstungsindustrie, e.V.). 1984. *BDLI-Memorandum zur Zukunft der Raumfahrt in der Bundesrepublik Deutschland.* Bonn.

BMVg (Der Bundesminister der Verteidigung). 1986. *SDI: Fakten und Bewertungen, Fragen und Antworten, Dokumentation.* Bonn.

Böhme, Gernot; van den Daele, Wolfgang; and Krohn, Wolfgang. 1973. "Die Finalisierung der Wissenschaft." *Zeitschrift für Soziologie* **2**:128—144.

Brauch, H. G. 1984. *Angriff aus dem All: Der Rüstungswettlauf um Weltraum*. Bonn: J. H. W. Dietz.

Büdeler, Werner. 1968. *Aufbruch in den Weltraum*. Munich: Ehrenwirth.

—— 1978. *Raumfahrt in Deutschland: Forschung, Entwicklung, Ziele*. Frankfurt/Berlin/Vienna: Econ Verlag.

—— 1979. *Geschichte der Raumfahrt*. Künzelsau/Talwil/Strassburg/Salzburg: Singloch.

—— 1982. "Transportsysteme bis ins All: Forschung und Entwicklung in der deutschen Industrie. Zum Beispiel: MBB." *Bild der Wissenschaft*, 1982, pp. 64—79.

Bundeshaushaltsplan für das Haushaltsjahr. Bundestagsdruckasche. Bonn.

Daele, Wolfgang van den; Krohn, Wolfgang; and Weingart, Peter. 1979a. *Geplante Forschung: Vergleichende Studien über den Einfluss politischer Programme auf die Wissenschaftsentwicklung*. Frankfurt am Main: Suhrkamp.

—— 1979b. "Die politische Steuerung der wissenschaftlichen Entwicklung." in Daele, Krohn, and Weingart 1979a:11—63.

DFVLR (Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt). 1984. *Strategiestudie Raumfahrt*. Cologne.

—— 1985. *Jahresbericht 1985*. Cologne.

—— 1986. *Programmbudget 1986*. Cologne.

DGAP (Forschungsinstitut der Deutschen Gesellschaft für Auswärtige Politik). 1986. "Deutsche Weltraumpolitik an der Jahrhundertschwelle: Analyse und Vorschläge für die Zukunft." Experts' Group Report (Chairman: Karl Kaiser). Bonn.

Dickson, David. 1985. "A European Defense Initiative: The Idea That European Nations Band Together for a Strictly European Version of SDI is Gaining Support." *Science*, 20 September 1985, 1243—47.

"Faktenbericht 1986 zum Bundesbericht Forschung." Bundestagsdrucksache 10/5298. Bonn.

Feuerbacher, Berndt. 1984. "Die neue Raumstation: Lohnt sich der Flug ins All?" *Bild der Wissenschaft*, 1984, pp. 48—55.

Fuchs, Katrin. 1986. "'Europäische Verteidigungsiniative': Einstieg in SDI." In *Sozialdemokraten fordern: Aus Friedenssehnsucht praktische Friedenspolitik machen* ed. Rolf Seeliger, pp. 82—91. Munich:

Gambke, G.; Kerscher, R.; and Kertz, W. 1961. "Denkschrift zur Lage der Weltraumforschung." Commissioned by the Deutsche Forschungsgemeinschaft. Wiesbaden.

Haunschild, Hans-Hilger. 1986. "Zivile Forschungsförderung und Perspektiven der Technologieentwicklung." *Wehrtechnik*, July 1986, pp. 61—64.

Hoch, Paul K. 1988. "The Crystallization of a Strategic Alliance: The American Physics Elite and the Military in the 1940s." In this volume.

Högenauer, Ernst. 1986. "Mit Hyperschall ins All: Europas Beitrag zur Eroberung des Weltraums." In "Das Parlament," p. 12.

IABG (Industrieanlagen-Betriebsgesellschaft mbH). 1986. *Entscheidungsstrukturen und Entscheidungsprozesse im Raumfahrtbereich der Bundestrpublik Deutschland*. Ottobrunn.

Johanson, Anatol. 1987. "Bemannte Raumfahrt: Zweifel an Europas Träumen." *Bild der Wissenschaft*, January 1987, pp. 38—44.

Junker, Reinhard. 1986. "Forschung in der Bundesrepublik — Entwicklung, Strukturen und politische Steuerung." Paper delivered to science policy conference: "Zwischen Hoffnung und Bedrohung," 5—7 December 1986, Cologne.

Keck, Otto. 1984. *Der Schnelle Brüter: Eine Fallstudie über Entscheidungsprozesse in der Grosstechnik*. Frankfurt/New York: Campus Verlag.

Keppler, Erhard. 1986. "Raumfahrttechnik 1986 — Entwicklungsstand und Perspektiven." *Gewerkschaftliche Monatshefte* **37**:532—541.

Kitschelt, Herbert. 1979. *Kernenergiepolitik: Arena eines gesellschaftlichen Konflikts*. Frankfurt/New York: Campus Verlag.

Köhler, Horst W. 1976. "Neue Werkstoffe aus dem Skylab-Schelzofen." *Bild der Wissenschaft*, 1976, pp. 78—84.

—— 1984. "Amerikas nächster Schritt im Weltraum — die Raumstation." *Bild der Wissenschaft*, 1984, pp. 50—51.

Krohn, Wolfgang. 1981. "Thesen zur politischen Steuerung der Entwicklung von Wissenschaft und Technologie." In J. v. Kruedener and K. v. Schubert, *Technikfolgen und sozialer Wandel*, pp. 167—176. Cologne: Verlag Wissenschaft und Politik.

—— 1985. "Wie konstruktiv ist der Konstruktivismus? Eine epistemologische Auseinandersetzung." Conference at the meeting of the DGS section, "Science Studies", 16 November 1985. (Unpublished paper.)

—— 1986. "Zur Entwicklung der Wissenschaft." (Unpublished paper.)

Krohn, Wolfgang, and Küppers, Günter. 1987. "Wissenschaft als selbstorganisierendes System." Bielefeld. (Discussion paper.)

Küppers, Günter, and Paslack, Rainer. 1986. "Theoriendynamik und Weltbildwandel am Beispiel der Selbstorganisation." (Unpublished paper.)

Lakatos, Imre. 1974. "Falsifikation und die Methodologie wissenschaftlicher Forschungsprogramme." In *Kritik und Erkenntnisfortschrift*, ed. Imre Lakatos and Alan Musgrave, pp. 89—189. Braunschweig: Vieweg, Fried., & Sohn Verlagsgesellschaft.

Lamatsch, Hagen. 1986. "Die Bedeutung der Rüstungsindustrie für die Bundesrepublik Deutschland." Paper presented at the conference: "Economic and Technological Aspects of Armament," 8—10 December 1986, Wildbad-Kreuth.

"Das Parlament: Die Woche im Bundeshaus." 1986. Thematic issue of *EG-Forschungspolitik*, nos. 33—34.

Radkau, Joachim. 1983. *Aufstieg und Krise der deutschen Atomwirtschaft 1945—1975: Verdrängte Alternativen in der Kerntechnik und der Ursprung der nuklearen Kontroverse*. Reinbek bei Hamburg: Rowohlt.

—— 1986. "Angstabwehr: Auch eine Geschichte der Atomtechnik." *Kursbuch* **85**:27—53.

Scheffran, Jürgen. 1984. "Die Europäische Weltraumgemeinschaft — Aufbruch in die Zukunft?" *Informationsdienst Wissenschaft und Frieden* **5**:8—10.

—— 1985. "Die Europäische Weltraumgemeinschaft — Aufbruch in die Zukunft?" *Blätter für deutsche und internationale Politik*, 1985, pp. 169—185.

Schreiber, Wolfgang. 1986. "Die Bedeutung der Erforschung und Nutzung des Weltraums für die militärische Sicherheit." *Europa Archiv* **21**:629—638.

Stamm, Thomas, 1981. *Zwischen Staat und Selbstverwaltung: Die deutsche Forschung im Wiederaufbau 1945—1965*. Cologne: Wissenschaft und Politik.

Steinecke, Wolfgang. 1986. "Möglichkeiten und Grenzen internationaler Rüstungskooperation." Paper delivered at the conference: "Economic and Technological Aspects of Armament," 8—10 December 1986, Wildbad-Kreuth.

Stellungnahmen der Experten. 1985. Submitted in preparation for the 46th meeting of the Committee on Research and Technology of the German Bundestag on November 11—12, 1985, in Bonn. (Unpublished papers.)

Van Allen, James A. 1986. "Bemannte Raumstation: Schaden für die Forschung?" *Spektrum der Wissenschaft*, March 1986, pp. 36—44.

Weltraumforschung. "Nutzen für Alle." An exhibit by the Federal Minister of Research and Technology. (n.p., n.d.)

WEU (Western European Union, Assembly of). 1984. Thirtieth ordinary section, "The Military use of Space." Report submitted on behalf of the Committee on Scientific, Technological, and Aerospace Questions by Mr. Wilkenson, Rapporteur. Doc. 976 (15 May 1984) (First part); Doc. 993 (8 November 1984) (Second part).

Weyer, Johannes. 1985. "Chaos oder System? Anmerkungen zur Wissenschaftspolitik der Faschismus." *Forum Wissenschaft*, no. 2, 1985, pp. 31—35.

—— 1986. "Die Bundesrepublik am Scheidewege: Forschungspolitische Alternativen im Kontext der SDI-Diskussion." Paper delivered at the forum, "Science for Peace," 14 July 1986, Bielefeld. (Unpublished paper.)

Wilkes, Owen. 1978. "Military Research and Development Programs: Problems of Control." *Bulletin of Peace Proposals* **8**:3—10.