Is the German and European Space Industry Fit to Face the Future?

The space industry is considered to be one of the leading-edge high-tech industries given its very substantial expenditure on research and development as a proportion of turnover. To an extent exceeding that in virtually any other branch, the industry's development depends on government intervention. The public sector is one of the industry's most important customers and exerts considerable influence through primarily politically motivated international agreements on space projects and via financial support. In Germany, space-related activities are largely conducted by private-sector firms. Conflicts between public and private economic interests arise particularly when government changes course and begins to reconsider its involvement in space travel. If government were to comprehensively and swiftly withdraw from space-based activities, firms would be forced to adopt one of two strategies: either they attempt to orientate their products more closely towards the market, or – if they consider this too risky – they scale down those space-related activities. Any significant loss of competence on the part of the German space industry would have negative effects on the economy as a whole if this were to make it more difficult to gain access to growth markets such as information technology.

In order to provide a basis for determining how space activities in Germany should be organised in future with a view to the European and the global market, and in order to provide actors with a better orientation in designing their space-related activities, the *Deutsche Agentur für Raumfahrtangelegenheiten* (DARA) GmbH (a state-owned agency for space-related affairs) commissioned the DIW with a framework analysis of the situation facing and the prospects for the German space industry. The most important results of this study are summarised in this report.[1]

The space industry currently finds itself in a transition phase. On the one hand, important new markets in information technology are opening up via the use of satellites, and, more generally, commercial activities are gaining in importance; on the other, a more sober view is now being taken of the technological importance of the industry in areas in which it had been expected that innovations would also have been initiated by space travel. This is particularly true of laboratory experiments in space, for example experiments with new materials. Not least for this reason, the prospects for manned space flight are now viewed with scepticism. This factor, together with the changed global geopolitical constellation and the increasing scarcity of government funding, has induced the German government to rethink its involvement in space travel, on which it currently spends around DM 1.5 billion per annum. The aim of space policy in the future will be to promote the market orientation of the branch and to ensure that firms take on a greater proportion of the risk involved.

A small industry at the focus of private and public interest

The space industry is a small industry. It is not even considered separately by the official statistics, but only as an aggregate ("aerospace") together with the air-travel industry. In Germany around 5200 people are involved with space-related activities; in 1995 the industry had a turnover of DM 2.4 billion, accounting for less than 0.07% of GNP. Large-scale space-related activities in Germany are restricted to a small number of firms. The most important of these is DASA, part of the Daimler-Benz group, which in 1996 employed around 3400 people in space-related activities. Due to its "systemic" nature the firm is a cornerstone of many German space projects. The second largest firm is MAN Technologie, which has specialised in the field of carriers (rocket technology), but also has systemic know-how. The next largest firms with more than 100 employees in the area of space technology, each with its specific specialisations are: Bosch Telekom, IABG, Kayser Threde, OHB and Teldix. Together, the firms mentioned employ 95% of the personnel in the German space industry. Given the small number of employees in most of these firms, it is often incorrectly claimed that the industry is characterised by small- and medium-sized firms; in actual fact most of these enterprises are part of larger corporate groups.

If only turnover and employment are taken as yardsticks, the industry is of little importance. A very different picture emerges, however, if the environs of the industry and the interests pursued through it are also considered. Traditionally space policy has always been oriented towards technological and foreign-policy aims. The technological aim is that of ensuring that Germany

[1] The full report is available as a manuscript in German from the DIW under the title: Situation und Perspektiven der deutschen Raumfahrtindustrie – Eine ordnungspolitische Analyse. Gutachten im Auftrag der Deutschen Agentur für Raumfahrt-Angelegenheiten (DARA) GmbH, 1997.

is represented in competent fashion in space travel at the international level and does not lose touch in high-tech areas considered to be of great significance. As far as foreign policy is concerned, the idea of European integration plays an important role, as does participation in transnational cooperation projects.

This diversity of interests is reflected in the organisational structures by means of which space-related activities are steered in Germany and Europe. The DARA has been entrusted with the task of coordinating public activities in this field. Under its statutory commission, the DARA is to undertake the planning of German space activities, implement space programmes and represent German interests in this area at the international level. The institution is currently being fused with the large-scale public aerospace research institute, the *Deutsche Forschungsanstalt für Luft- und Raumfahrt* (DLR), which alone has more than 4 400 employees and a budget of more than DM 730 million. The DLR has a virtual monopoly position in Germany and is consulted on many important decisions relating to space policy. It is financed primarily by the federal ministry for education, science, research and technology, the federal ministry for defence and the federal states in which its facilities are located. German space activities, in turn, are largely integrated within the European Space Agency (ESA) based in Paris. In 1996 more than 60% of public spending on space-related activities in Germany went to the ESA. The ESA, which is financed by contributions from 14 European member states and Canada, distributes its resources in the form of project contracts among the member states according to a formula oriented towards the level of contributions. The aim of this model is to ensure that large-scale space projects can be conducted in Europe and that even smaller countries can participate. The aims of the ESA are exclusively civilian in nature. It has around 2 000 employees, of which 15% come from Germany.

Table 1
Employment in the German Space Industry

Year	R&D	Production	Distribution and administration	Total
1985	4 228	396	823	5 447
1986	4 372	762	419	5 553
1987	4 100	908	888	5 896
1988	4 373	1 024	907	6 304
1989	4 718	883	873	6 474
1990	4 927	1 004	1 075	7 006
1991	5 026	1 100	830	6 956
1992	4 563	1 010	1 014	6 587
1993	4 189	786	934	5 909
1994	3 815	528	660	5 003
1995	3 695	578	904	5 177

Source: Bundesverband der Deutschen Luft- und Raumfahrtindustrie e.V. (BDLI: a federal association of German aerospace and related equipment industries).

Table 2
Turnover in the German Space Industry
in DM millions

Year	With government	With domestic and foreign ASI[1)]	With private customers	Total
1985	667.5	752.0	35.8	1 455.3
1986	382.2	587.3	173.7	1 143.2
1987	434.2	714.8	217.7	1 366.7
1988	697.0	684.7	373.8	1 755.5
1989	893.0	902.9	459.0	2 254.9
1990	453.1	2 121.6	139.8	2 714.5
1991	1 567.7	1 274.7	125.6	2 968.0
1992	1 296.6	740.8	413.3	2 450.8
1993	768.7	971.1	250.6	1 990.4
1994	636.5	1 190.2	67.0	1 843.7
1995	1 139.3	1 145.9	140.0	2 425.2

1) ASI = Aerospace industry.
Source: Bundesverband der Deutschen Luft- und Raumfahrtindustrie e.V. (BDLI: a federal association of German aerospace and related equipment industries); DIW.

The size of the branch is inversely proportional to that of the public institutions dealing with it. The widespread public interest in space travel both in Germany and abroad is evidence of the close attention paid to the industry with a view to overall macroeconomic development prospects. The specific nature of the industry is evident both in terms of production and its products. The production of large-scale technical systems in the space industry calls for an unusually high degree of planning and coordination. The technical complexity of these systems means that the production-technical know-how required is seldom available in a single firm. Usually a large number of firms and institutions work together under the leadership of a so-called "prime contractor". In some cases the coordination process and thus the transaction costs involved are extraordinarily high, because many of the specific products required are unique, tailor-made for a single concrete application.

Against the background of the substantial involvement of governments in space activities, the following questions urgently need to be addressed:

– Are the prevailing structures, heavily dominated as they are by government, still appropriate today?

– Are these goals originally pursued through the industry still valid?
– Is it advisable from a macroeconomic perspective for governments to withdraw from space-related activities, and what consequences would this have for the industry?

The research task and the approach taken

From the point of view of standard economic theory on the economic order there is a clear division of responsibilities in market economic systems between government and the private sector. The activities of private sector firms are steered by the market mechanisms of supply and demand, whereas government assumes responsibility for tasks for which the market fails to offer satisfactory solutions. In practice, however, this theoretical framework does not always provide clear-cut answers. Firstly, there is a grey area between that in which steering can clearly left to the market and that for which government is unequivocally responsible. In the case of research, for example, government is generally held to be responsible for basic research due to its nature as a public good and the improbability of it being directly profitable. The private sector, by contrast, is to undertake research and development (R&D) with the aim of ensuring growth, employment and profitability for the individual company by means of innovation. Even if the subsidiarity principle is applied, i.e. in case of doubt activities should be left to the private sector, a not inconsiderable field of intersection between the two areas remains. Many space-related projects are located in this grey area. In such cases government must decide if they can justify involvement in terms of theoretical considerations and after examining the alternative uses to which funds could be put.

Table 3
ESA Budget Receipts by Country, 1997
in ECU millions

Country	Contribution	Structure in %
France	646.9	30.5
Germany	490.9	23.2
Italy	287.7	13.6
Great Britain	153.2	7.2
Belgium	138.0	6.5
Spain	91.4	4.3
Netherlands	85.6	4.0
Switzerland	66.6	3.1
Sweden	54.2	2.5
Norway	20.8	0.9
Denmark	23.2	1.0
Austria	26.8	1.3
Canada	12.5	0.6
Finland	11.7	0.5
Ireland	5.5	0.3
Total	2 115.0	100.0

Source: ESA 1997.

Table 4
ESA Budget 1997
in ECU millions

Programmes	Funding	Structure in %
Technology programme	79	2.8
Micro-gravitation	104	3.7
Telecommunication	280	9.9
General budget	291	10.3
Scientific	358	12.7
Manned space flight	393	13.9
Observation of earth	524	18.5
Space transport systems	798	28.2
Total	2 827	100.0
Uncompleted programmes	96	
Programmes financed by third parties	93	

Source: ESA/AF(96) 45, rev. 3.

The development prospects for the international space industry are determined by, among other things, government technology policy, defence policy, the development of new technologies such as communication technology, and the ability of firms to establish a position in the new markets. The uncertainty surrounding government involvement in this area in the future, which to some extent is due to an inadequate founding of policy in the economic theory of the market order, was what initiated this analysis.

A distinction must be drawn between two levels of analysis. The first focuses on the interests of the industry and its development prospects, the second seeks to evaluate macroeconomic factor allocation. In other words a balance must be struck between industry-specific interests, which are perfectly legitimate from the point of view of firms, and higher-level, macroeconomic aspects.

The analysis is based on information, much of which was provided by the DARA and other industrial sources. A written and oral survey of firms involved in this area was conducted, and the results of the study were discussed at a one-day industry-wide hearing and

within a steering group consisting of representatives of the industry and the DARA, and of the federal ministries of the economy, and of education, science, research and technology.

Activity areas of the space industry

Three main areas of activity for the space industry can be identified:

- Carrier systems. These are used to gain access to space.
- Satellites. In the area of observation satellites are deployed in activity fields such as defence, the environment and meteorology; particularly rapid growth is being experienced, however, in the field of communication.
- Space stations. These are to be used to enable manned experiments to be conducted in space within the framework of international projects.

Carrier systems

With the Ariane rocket, Europe has developed an effective carrier system, one in which the German company MAN plays an important role. Until the 1970s the USA had a monopoly on carrier systems that it exploited for strategic purposes, as the case of the communication satellite SYMPHONIE I confirms: at the time the USA refused to transport this European satellite. Not until Europe declared its willingness to refrain from commercial use were the satellites SYMPHONIE I and II transported into space, where they were only allowed to be deployed for test purposes. Undoubtedly, this case was an important factor behind the decision that Europe should develop its own carrier system. Today the market for carrier systems is characterised by a tight oligopoly, although one in which there are in some cases great differences between the companies regarding quality and reliability. This is reflected in transport costs. Serious competition for the Ariane IV comes from the DELTA 3 from McDonnell-Douglas, the Atlas from Lockheed-Martin, the Russian PROTON and the Chinese carriers of the "Long March" type. In terms of transport safety, the Ariane IV and the Delta occupy pole position. Considering that a satellite constitutes an investment object worth several hundred million dollars and that the time at which it is placed in orbit is frequently important, it is not difficult to judge the relevance of the safety element.

According to the information provided by industry, Ariane IV is now a success in purely commercial terms, too. This is far from self-evident given the massive R&D expenditure required to develop such systems. Because of the very high development expenditure, economies of scale play an important role in the competitiveness of such transport systems, and market entry is difficult due to the risk involved in recouping the costs of development and investment, which are largely to be seen as sunk costs. In the USA, Russia and China, the development of carrier systems has been co-financed by military deployment, unlike in Europe; in this way the possibility of "dual use" has substantially reduced the profitability threshold for civilian deployment.

All in all, the oligopolistic structure of the market for various systems can be expected to remain for the foreseeable future. Whether the Ariane programme will be able to maintain its good market position will depend, amongst other things, on the success of the larger Ariane V that has been developed, and also on rocket and satellite technology trends. For instance, the possibility of a new market for small carriers to transport non-geostationary satellites of up to 1.5 tonnes could lead to a new constellation of firms and competition within the carrier market.

Satellites

The most important segment in the field of satellites is the market for commercially deployed communication satellites, which account for two thirds of all of the satellites currently in operation. Empirical studies have shown that the construction and operation of communication satellites are subject to economies of scale that exert an effect up to an output of around 25 satellites per annum. This means that firms that manage to achieve such an output level gain a substantial competitive advantage via lower unit trusts and prices. US firms play a very prominent role in the market for commercial satellites, while European and German firms are still bogged down in the production of unique models or those with only small production runs.

Views differ on future market trends for communications satellites. On the one hand, a number of space-based mobile communications projects (IRIDIUM, GLOBALSTAR, TELEDISC) are currently in the planning and development phase; on the other there is concern that this will represent only a one-off boost to demand, which may be maintained for a number of years, but could lead to overcapacity. Strong growth is also expected in the area of small satellites ("Little LEOS") for telecommunications and data transfer. It remains to be seen, however, whether these expectations will be fulfilled, leading to changes in supply structures.

In principle there is a global market for both public and private demand in the field of earth-observation and navigation satellites. In this segment demand is usually

Figure1

Global Space Industry Markets, 1996 to 2006

Expected turnover: US-$ 530 to 760 billion

Areas / Space-industries services	Telecommunications and TV-broadcasting	Localisation and navigation	Earth observation and meteorology
Satellites and platforms	29 41	. (predominantly military)	10 13
Launchers and transport	23 31	. (predominantly military)	6 7
Orbital operations	68 89	. (predominantly military)	1 2
Ground installations	89 137	35 51	7 9
Effects			
Space derived services	164 225	41 61	15 38
	Professional and leisure usage of services provided by information, multimedia and entertainment industries for end users with personal displays		

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Source: Based on Euroconsult.

for tailor-made satellites or small production runs (navigation). Given the very high R&D expenditure per satellite, the barriers to market entry are very high due to the corresponding risks involved with sunk costs.

Space stations

The third major area of space-related activities is that of space stations. In the past it was discussed whether Germany should participate directly in the international space station ALPHA or should rent laboratory time from those running the space station as required. Recently German space policy spoke out in favour of active participation. This decision need not give cause for concern in terms of the market order if the experiments conducted there consist primarily of basic research; yet one might ask whether this decision can be justified in terms of technology and industry policy. Past experience with experiments in space and the opinion voiced by many experts that it is not absolutely necessary to conduct such experiments in space lead one to take a sceptical view of such involvement. It seems plausible to assume that Germany's decision was determined largely by foreign-policy motives.

In view of the substantial financial commitment required, problems could arise with respect to the hopes pinned to the space station. If the German government is hoping that results will soon be achieved that can be sold on the market, it will find itself struggling for arguments if such successes are not realised.

The space industry as a branch that opens up new markets and engenders macroeconomic benefit

Our analyses show that activities linked to space travel have taken on increasing global importance. New markets have been created for the international space industry, particularly via information technology, that can be expected to continue expanding in the coming years. The Euroconsult consulting firm expects that between 1996 and 2006 the market volume of space-based information transmissions will exceed US-$ 500 billion. Even if only a comparatively minor proportion will accrue to the space industry itself, it undoubtedly created the conditions necessary for these markets to

Table 5

Comparison of Government Space Budgets

in DM billions

	Germany*	France	Italy	Great Britain	Netherlands	USA**	Japan
1992	1.785	3.165	1.020	0.468	0.169	45.720	2.327
1993	1.820	3.259	0.888	0.417	0.192	47.774	3.034
1994	1.630	3.507	0.815	0.467	0.175	51.525	3.491
1995	1.582	3.481	0.705	0.423	0.170	45.126	3.472
1996	1.551	3.573	0.780	0.440	0.170	45.968	3.210
1997	1.450	3.722				46.197	3.324
1998	1.444						

*) Including DARA/DLR-PT, IAGB, GUS/MMOEL, DLR basic financing.
**) NASA, DoD and others. In converting to D-Mark, the average exchange rates in each year were used until 1996.
Sources: European Space Directory, 1996; DIW.

evolve in the first place. There are a wide range of such "space-based" markets, ranging from telecommunications transmissions, to observation of the earth's surface to meteorological and environmental observation.

Expenditure on the space industry can also be justified with the public-good argument with reference to the macroeconomic utility derived, as the application of a model developed by Nordhaus[2] shows: within the framework of his analyses he has estimated and calculated the macroeconomic value of improved information on climatic changes. According to this model the social value of gaining complete information on climatic changes one decade earlier than would otherwise have occurred can be put at around DM 100 billion. If it is assumed that space travel accounts for around 30% of this improved database, it can be concluded that the macroeconomic benefits of the information gained by space-related activities by far exceed the costs of installing observation satellites.

The examples of environmental observation and the dynamic trends in space-based communications technology alone suggest that the international space industry is an area of the economy that has engendered macroeconomic benefit and one that will become increasingly important in the context of modern transmission technologies and the trend towards globalisation. Within the framework of our analysis we now turn to address the following two questions:[2]

– Given the substantial financial involvement of government, what reasons are there for maintaining a German/European space industry?
– Are the structures of the German/European space industry in accordance with the challenges facing it?

National space industries: the predominance of the USA

The USA is by far the most important actor in the global space industry. In 1995 the US space industry recorded turnover of US-$ 30.6 million. Around 123 000 employees were involved in space-related activities. 47% of 1994 turnover was accounted for by the military, 46% by the civilian public sector and 7% by the commercial sector. By comparison, the European space industry, with a turnover of DM 5.6 billion and around 40 000 employees, is far smaller, and has a very different structure: accounting for 57%, the industry is dominated by the civilian public sector, followed by commercial civilian activities at 34%, with just 9% dedicated to military purposes.

Within Europe, France is the economy most heavily involved in space-related activities, with a turnover of US-$ 2.6 million, followed by Germany, Italy and Great Britain (with a turnover of US-$ 918 million, 634 US-$ million and 412 US-$ million respectively).

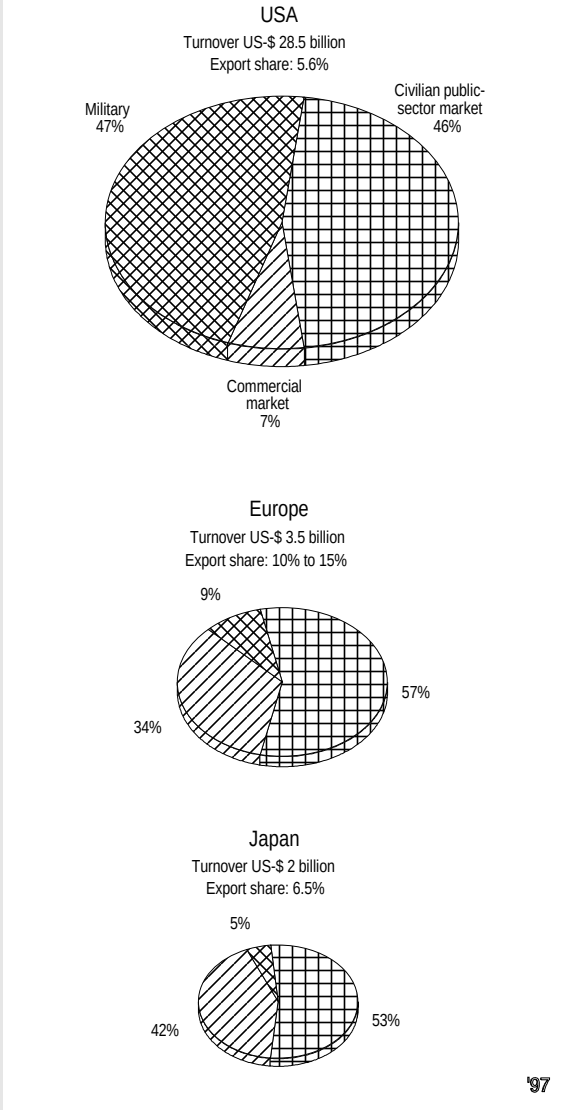
Other important countries, measured in terms of employment, are Russia and China, which each employ around 124 000 people in the space industry, followed by India with 21 000 and Japan with more than 13 000.

Significant concentration processes have occurred among companies involved in this industry in both the USA and Europe. There has been a substantial reduction in recent years in the number of firms producing

[2] W. Nordhaus, Managing the Global Commons, Cambridge Mass., 1994.

Figure 2

Space Industry in USA, Europe and Japan
Turnover Export Shares and
Market Shares by Area in 1994



Source: Euroconsult.

satellites: from 13 to 7 in the USA, from 6 to 4 in France and from 6 to 3 in Germany. Once the market volume of satellite production is taken into account, the predominance of the USA becomes very clear. The seven US firms share a market volume of DM 43 billion; in France four firms have together a market volume of DM 4 billion, while in Germany three firms together have a market volume of DM 1.4 billion. Given that the commercial satellite market is likely to continue to expand in the coming years and that economies of scale play an important role, the position of European firms in the satellite segment compared with their American competitors cannot be viewed very favourably in the light of these size differences.

The European and German space industry at the crossroads

In a nutshell the situation currently facing the German and European space industry is as follows: it has a high level of technological excellence and has even achieved a leading position in certain segments, but there are still too many firms seeking to attain a "systemic competence" for large projects (i.e. play the role of prime contractor), although given the importance of economies of scale there is only room for markedly fewer actors. The institutional and corporate structures of the European space industry reflect Europe's specific situation. National interests are combined with European interests as the only way in which to achieve the magnitudes and financial scope for a European space industry. The ESA needs to be mentioned in this context. Initially the ESA quota model, under which even smaller partner countries are able to acquire production shares in space projects in line with their financial participation, made sense as a means of overcoming political/economic barriers and of enabling Europe to perform space projects at all. Today, however, it has the serious disadvantage that such a quota system pays too little attention to efficiency considerations. As appropriate as the ESA quotas system may have been at the outset, it is now vital that it is dropped as quickly as possible and more efficient structures are put in its place. This requires cooperation at European level in which political goals are abandoned in favour of a more economic orientation.

Europe will only be able to face global competition if its institutional structures are reformed, and markets and enterprises are established that, as in the USA, can exploit economies of scale. Here the focus is on the so-called system and subsystem firms. Such companies must be in a position to utilise their comprehensive know-how capacities as continuously as possible. If this is not possible, orders will cease to be placed, and a downwards spiral will be initiated in which the capacity as a prime contractor atrophies in a relatively short time. If this downward spiral affects all the companies in a country, the role of prime contractor, and thus a high value-added stage of production, will be relocated abroad. What remains is the production of inputs. The danger of such a process is present for the European

space industry in general and its German counterpart in particular. Yet systemic competence is of central importance for two reasons. On the one hand it is the key without which it is impossible to conduct technologically complex projects; on the other, such firms subcontract a great deal of work and thus perform a market-opening function for national suppliers.

Competitive distortions through dual military and civilian use

German industry has repeatedly drawn attention to the competitive disadvantages resulting from the military deployment of space technology in the USA. These arguments cannot be dismissed out of hand. Firstly, in the case of military use international competition can be excluded for security reasons, without this being interpreted as an attempt at discrimination. Secondly, military use enables the costs for civilian areas of deployment to be cut significantly. According to Euroconsult, the US Department of Defense (DoD) has spent US-$ 5.5 billion in the field of satellite communication and more than US-$ 7 billion in the area of Earth observation in the last five years. By comparison, the budget allocations for NASA – which is responsible for civilian deployment – over the same period amounted to around US-$ 1 billion for each area. Private US companies spent less than US-$ 0.5 billion on R&D in telecommunications. To this extent one is forced to the conclusion that the technological successes and the competitiveness of the American space industry are largely due to military programmes.

Yet the solution for Europe cannot consist of "construing" similar military fields of deployment for space technology in order to raise competitiveness by means of dual use. Such tasks can only result from political/military constraints. From a macroeconomic perspective the deviation via the military sphere always involves a waste of resources. Consequently it is actually an advantage for Europe if it can take the direct path to the market. On the other hand, European producers will only achieve competitiveness if the advantages derived by their American competitors from dual use are offset by means of subsidies. The example of Ariane clearly shows that European industry can be successful without dual use.

It could also be argued that the field of space travel should be left entirely to the USA, as this superpower, via military deployment, enjoys a quasi-natural competitive advantage over Europe. Instead of subsidising space-related activities, the European economy would do better to specialise on other forms of production in order to achieve higher overall welfare through trade. These arguments only hold water, however, if it is assumed that:[2]

- Europe does not suffer sustained competitive disadvantages from this position, i.e. the USA does not exploit any monopolistic position it may gain for industrial/strategic purposes and
- Europe is not in a position to develop an equally efficient space industry.

There is considerable evidence for the view that in the foreseeable future, at least, space travel will be an area that will be used for international strategy as the relevant nations jostle for favourable positions or seek to prevent what they consider to be "negative" developments. The above-mentioned example of the Symphonie I and II satellites shows that the USA, as the strongest nation in the field, might be able to use its power for strategic ends. Particularly in developing new satellite based navigation, observation and communication systems, it will not only be important whether a country is able to install such systems at all; at least equally important will be the time and cost factor. Those firms who are able to develop the infrastructure in space necessary to provide their services first will be in a position to set standards and achieve quasi-monopolistic positions. This illustrates the fact that access to space and the ability to deploy the necessary satellites are so-called "essential facilities", i.e. resources that are vital for production, but that cannot be duplicated in the short term. To this extent, the importance of space-related activities is underestimated if the analysis is restricted to the industry itself, and ignores the potential markets initiated by it.

If the importance of the essential facilities for space travel is accepted, it is clear, given the other specific characteristics of the industry, that withdrawal from this area would be highly risky, as such a step would be irreversible, at least for the foreseeable future. Factors supporting this view include:[2]

- The need for systemic competence. This means that the required know-how must be created and maintained by means of substantial investment over an extended period, which subsequently constitutes a fixed cost. Such knowledge cannot be regenerated overnight. Closely linked to systemic competence is the economic phenomenon of path dependency that has played a growing role in recent research, and according to which processes that are underway cannot be reversed, or only at high cost;
- the importance of economies of scale, leading to oligopolistic or monopolistic structures, whereby market power is used to charge excessive prices either in the space industry itself or in areas located immediately downstream.

– the high barriers to market entry caused by the very substantial R&D costs and learning effects. For competitors leaving this market at an early stage, these costs are irrevocably lost. The concentration in the space industry is due not least to this fact.

The greatest commercial potential for the space industry is likely to lie in space-based polyvalent services, in particular telecommunications, observation of the earth and navigation. Those who have access to space are able to offer these services and can, if they are the only ones to have this access, exclude others from producing such lucrative services or prevent them from entering such areas by charging excessive prices or imposing unfavourable conditions. Thus competitors who, through dual use, have advantages in terms of time and price, have the opportunity to exploit long-term market potential. This is to draw attention to the problem of "vertical foreclosure" that is well-known in competition policy.

These examples show that the economic importance of the space industry probably lies less in the turnover it generates and the jobs it itself creates, than in the access it provides to the market potential of space-based services.

In the field of carrier systems, the European space industry has a good competitive position that it should not simply abandon. With a view to likely market developments, it is also important that Europe remains present in satellite construction. Longer production runs must be achieved here, however, if firms are to be competitive. The foreseeable economic utility of space stations remains unclear. What is in any case important is that the genuine reasons for involvement in this area are made clearer, if longer-term public acceptance is to be created.

Policy options for the German space industry

In the light of the phenomenon of systemic competence, three longer-term scenarios are conceivable for German space policy:

(1) The German space industry attempts to retain its systemic competence. This will probably only be possible in cooperation with European partners, whereby governments, in view of the economic specificities associated with the phenomenon of systemic competence, will be obliged to provide support until more efficient structures have developed.

(2) The German space industry is relegated to the role of a supplier of inputs. At first sight this may appear to be an economically rational strategy, yet it must be doubted whether this option can be maintained in the longer run, as relinquishing systemic competence will make it more difficult to gain entry to the – then exclusively international – market for inputs.

(3) Complete withdrawal from the space industry. If this is a realistic option at all, then only in the longer term. In the short term, obstacles to this strategy exist in the form of, if nothing else, political ties. In the longer term, however, withdrawal could occur in one of two ways: either by virtue of a conscious political decision-making process, or via an extended process of erosion, initial signs of which have already emerged.

Germany's space-related activities could be performed under more efficient structures if a 3-phase model were implemented, the aim of which would be to achieve an international space industry whose structures reflect competitive processes to a greater extent than has been the case to date.

Phase 1: European consolidation

Creation of a single European market in the space industry and abolition of the ESA quota system. Consequently, German space policy during this phase would be far more a "politically support" than a "financial-support policy". This also applies to the political support given to European cooperation, particularly with a view to ensuring the equality of opportunity in the prospective partnerships.

Phase 2: European competition with partial external liberalisation

The single European market for the space industry has been largely realised and the effects described above have begun to make themselves felt. Now is the time to consider whether to open the market to non-European partners. This decision should be taken, though, with a view to the willingness of the non-European countries to open their own markets and to remove existing industrial and trade-policy restrictions. A highly differentiated approach is required here. Within the space sector, markets differ greatly from product to product. The US market, for example, is largely open at the level of parts and components, but this is less true of systems.

Phase 3: Free international competition

This phase constitutes so to speak the "concrete utopia" of space policy. Its realisation implies a free global market for public and private space activities. Commis-

sions would be fulfilled by individual space industries on the basis of global competition. Given the global cooperation expected to occur, it seems likely that national space industries in the narrow sense of the word would have ceased to exist. In short, the space industry would be "globalised".

These phases sketched out above should not be conceived as a strict succession of discrete stages; numerous aims are to be pursued at one and the same time. For instance we are already beyond phase 1 in certain areas.

Thus what is required is a market ordering policy rather than an industrial or support policy, and one for which responsibility could be assumed by the organs of the EU. This would be perfectly compatible with the subsidiarity principle, because the subsidiarity principle means that the EU should only assume responsibility for those activities that – for example because of economies of scale or external effects – would lead to suboptimal results if they were left to the policies of individual countries alone.

Conclusion: the contours of a European space initiative oriented towards market ordering

A dramatic increase is occurring in the civilian deployment of space-related activities. Although estimates vary of the volume of the markets to be opened, experts are agreed that the so-called polyvalent services will expand very strongly throughout the world. Faced with this trend, economic policymakers are called upon to develop a new framework for German space policy as one element of European space policy.

Taking into account the sceptical view that needs to be taken of the effectiveness of international markets in the space sector, it would at present appear to be a matter of economic sense to maintain systemic competence in Europe in the fields of carrier systems and satellites. The international markets are characterised by an often impenetrable network of political and private economic interests that can be deployed for power-political and strategic ends. Europe faces the danger of exclusion from the potentially lucrative markets for space-based polyvalent services. Yet in no way should a policy in support of the space industry be restricted merely to an economic support policy. Rather, the aim must be to raise the economic efficiency of the national and European space industry in order to reduce its dependence on public funding; it must also ensure that policies that lead to trade conflict are avoided where possible. To these ends, initiatives should be taken in the following areas, amongst others:

- Removal of the ESA quota system. This is vital if Europe's production structures are to be made more efficient by increasing specialised production and exploiting economies of scale. This step alone would make a significant contribution to raising the competitiveness of the space industry in Europe.
- Implementation of the three-phase model in order to bring about a single European market in the area of space technology, while the same time pursuing a selective external liberalisation. A whole range of accompanying policy measures is called for here, partly with respect to European partners, but also with respect to the other nations involved in space travel.
- Opening up of new sources of finance by providing support for a Europe-wide venture capital market for space projects.

Thus the recent fusion of the DARA with the DLR is to be welcomed to the extent that it serves to reduce excessive bureaucracy. Yet it is still not apparent whether this step will really bring about a breakthrough towards more efficient structures. For an industry with such long research and development periods as the space industry, it is important that it can rely on stable external parameters. To this end it is necessary that government becomes more keenly aware of the aims it is pursuing with its space policy than has so far been the case. It is only then that it can create the basis for a stable medium-term financial framework and determine the instruments to be used for this purpose. This is also necessary if policy is not to be faced with virtually irresolvable conflicts. It would also be conducive to efficient resource deployment if research tasks performed by the space industry on behalf of other areas were allocated to these research areas rather than to the space sector. This would automatically improve monitoring of the scientific utility of such projects, and the space industry would avoid the charge of consuming public funds where these actually serve other purposes.

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