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EUROPEAN AERONAUTICS

Strong Government Presence in Industry Structure and Research and Development Support

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The Honorable Tim Valentine
Chairman
The Honorable Tom Lewis
Ranking Minority Member
Subcommittee on Technology, Environment
and Aviation
Committee on Science, Space and Technology
House of Representatives

U.S. preeminence in aeronautics is being challenged by Europe. Over the last decade, European manufacturers have, with the support of their governments, increased their share of the global civil aircraft market to over 30 percent.

In response to your request, we have developed information on (1) the structure of the aeronautics[1] industries of France, Germany, and the United Kingdom; (2) the support that these countries' respective governments give to aeronautical research and development (R&D); and (3) the organization of the countries' respective aeronautical R&D establishments.[2] We also obtained information on other aeronautical R&D efforts sponsored by the European Community and its member nations.

Background

The aeronautics industry is a major contributor to national security, commerce, and transportation. The industry is considered a technology driver that leads to spin-offs of advanced technology products that support other sectors of the national economy. The aeronautics industry comprises three major sectors—airframe, engine, and equipment. This report focuses on the airframe and engine sectors. The airframe sector usually includes final assembly of the aircraft.

In 1992, manufacturers in France, Germany, and the United Kingdom sold aeronautics products valued at about $52 billion. Civil and military aeronautics products contributed roughly equally to that amount, except for Germany, where civil products accounted for about 61 percent of sales. The countries exported aerospace products worth about $31 billion,

[1]In this report the term "aeronautics" excludes space- and missile-related activities. When such activities are included, the report refers to them as aerospace activities.

[2]Senator Barbara M. Boxer, Chair of the former Subcommittee on Government Activities, House Committee on Government Operations, was also an original requester of this report.

roughly a $10-billion increase over 1989. Aeronautics products for France and the United Kingdom made up over 89 percent of their countries' aerospace export totals. Although 1992 data were not available for Germany, 1991 statistics show the total to be in excess of 90 percent. In the three countries, about 310,000 people worked in aeronautics-related activities. As a point of reference, the aeronautics industry in the United States had sales of about $74 billion, exported about $44 billion, and employed about 611,000 people in 1992. Table 1 provides additional details, by country, on aerospace and aeronautics sales, exports, and employment.

Table 1: Aerospace and Aeronautics Sales, Exports, and Employment in France, Germany, and the United Kingdom During 1992

Dollars in billions

	Aerospace			Aeronautics		
Country	**Sales**	**Exports**	**Employment**	**Sales**	**Exports**	**Employment**
France	$22.7	$10.6	111,700	$19.3	$9.4	102,400
Germany	15.6	6.4	78,500	13.9	[a]	61,400
U.K.	18.8	13.5	148,000	18.6	13.3	146,000
Total	**$57.1**	**$30.5**	**338,200**	**$51.8**	**$22.7**	**309,800**

[a]Not available.

Source: Compiled by GAO from data provided by each country.

The major large civil transport aircraft manufacturers in the U.S. are Boeing and McDonnell Douglas, and their principal foreign competitor in the global market for such aircraft is the Airbus consortium (established in 1969). Airbus is a consortium of the major civil aircraft manufacturers in France, Germany, the United Kingdom, and Spain. Recently, Airbus has replaced McDonnell Douglas as the second-largest supplier in the global market for commercial jet transport aircraft[3] (Boeing is the largest supplier). This market, according to one forecast, may be worth almost $2 trillion through the year 2030. In addition, European aircraft manufacturers have made major inroads in the markets for short-haul aircraft—commuter aircraft, rotorcraft, and general aviation airplanes. In fact, European manufacturers dominate the commuter aircraft market and have about one-third of the business aircraft market.

R&D of aeronautical technologies, for potential military and commercial applications, plays a key role in maintaining a competitive aeronautics industry. In the past, R&D performed for military use frequently contributed

[3]Jet transport aircraft are those that weigh over 33,000 pounds and generally hold 150 or more passengers.

to the advancement of technologies for civil aircraft. This trend has changed somewhat. Since the beginning of the jet age, there has been an increasing divergence of military and civil performance, cost, and maintenance requirements. However, there are still some spillovers between military and commercial work, usually at the aircraft subsystem level (for example, engines, avionics, and instruments), in materials and in manufacturing process technology.

This report groups R&D activities into two general categories: technology R&D (basic and applied research and technology validation and demonstration activities) and product R&D (activities targeted to a specific product and the preparation for its production).

Results in Brief

The aeronautics industry in the three European countries we studied has consolidated to a point that there is only one major assembler/airframe manufacturer of large civil transport aircraft in each country. Similarly, each country has only one or two large civil aircraft engine manufacturers. Although consolidation has so far occurred mainly within national boundaries, each manufacturer is also involved in international collaborative efforts. However, these collaborative efforts generally do not involve joint research or information sharing on aeronautical technologies because of national security concerns and the companies' unwillingness to share competitively sensitive data.

The three European national governments support aeronautical R&D by funding (1) technology and product R&D for national security; (2) product R&D as launch aid for civil aircraft and engine manufacturers,[4] generally in the form of success-dependent, repayable loans; (3) civil technology R&D to enhance the national technology base; and (4) technology and product R&D for civil public interest objectives, such as safety and the environment. In the aggregate, the governments have provided about $9.7 billion in R&D support for 1991 and 1992, with most of it going to the first two R&D categories. The European Community and its other member countries also provided some support.

Each of the three European countries has a major, government-supported research establishment that maintains various facilities to conduct military and civil aeronautical R&D. In the past, government accounts were set up to fund these establishments. However, each establishment now relies

[4]Launch aid helps companies cover the high costs of bringing a new, expensive aeronautics product from development into production. It is not intended to support existing products.

extensively on contracts from government and industry customers for its funding. Most of the contracts come from government organizations. Reliance on contracts has two consequences. First, the research establishments are more customer focused. Second, the type and amount of data disseminated to the public domain are reduced.

Structure of the European Aeronautics Industry

Efforts by the European governments to shape the structure of their aeronautics industries have been aimed at consolidation and international collaboration since the end of World War II. The numerous aircraft and engine manufacturers that existed during the 1940s and 1950s in France, Germany, and the United Kingdom had been narrowed down to five major civil aircraft and engine manufacturers by the early 1990s through mergers, takeovers, and bankruptcies.[5]

Table 2 summarizes information on each of the major civil aircraft and engine manufacturers in France, Germany, and the United Kingdom.

[5]According to a recent book by Laura Tyson, currently Chair of the Council of Economic Advisors, that reviewed the civil aircraft industry, the technical and financial risks associated with the development of new commercial aircraft are so great that, without government support, the industry would be driven to a natural monopoly with a single producer dominating the global market. See Who's Bashing Whom: Trade Conflict in High-Technology Industries, Washington, D.C.: Institute for International Economics, (Nov. 1992), p. 156.

Table 2: Major Civil Aircraft and Engine Manufacturers in France, Germany, and the United Kingdom

In billions of 1992 dollars

Manufacturer	Ownership	Total sales	Aeronautics sales	Company R&D (percentage of sales)[a]
Aircraft				
Aerospatiale [France]	80 percent government-owned	$9.9	$6.7[b]	24
Deutsche Aerospace (DASA) [Germany]	private	11.1	4.8[c]	30
British Aerospace (BAe) [United Kingdom]	private	18.2	9.6	5
Engine				
SNECMA [France]	97 percent government-owned	4.3	2.6	33
DASA [Germany]	private	[d]	2.3	[f]
Rolls Royce[e] [United Kingdom]	private	6.2	3.8	14

Note: *All sales figures are approximations.*

[a]Figures are based on total sales, except for SNECMA.

[b]Includes aircraft, helicopter, and avionics sales.

[c]Does not include sales from the defense and systems group that could contribute to aeronautics sales.

[d]Figure is contained in the $11.1 billion DASA total sales figure.

[e]Rolls Royce also has a joint venture with BMW that competes with DASA engines.

[f]Figure is included in the DASA R&D total.

Source: Compiled by GAO from data provided by each company.

Currently, the majority of the European companies' aeronautics sales come from international collaborative efforts. These efforts have generally involved a division of R&D and manufacturing responsibilities between partners, with limited sharing of proprietary technical information. The Airbus arrangement represents perhaps the most well-known example of this type of collaborative effort and accounts for most of the European civil aeronautic sales. Aerospatiale and DASA each own a 37.9-percent share in the Airbus consortium, BAe owns a 20-percent share, and Construcciones Aeronautics S.A.(CASA) of Spain owns a 4.2-percent share. In general, each of the four partners has provided a section of the aircraft. BAe has generally researched, developed, and manufactured the wing section; Aerospatiale, the cockpit; DASA, the fuselage; and CASA, the horizontal tail pieces. Each partner pursues subcontracting and R&D arrangements on its own.

There are other examples of collaboration among European countries. In January 1992, for example, Aerospatiale and DASA merged their helicopter operations into a company called Eurocopter, which is now the world's second-largest helicopter manufacturer.[6] Eurocopter represents the first time that aeronautics companies from different European countries combined R&D and production capabilities.

Collaborative efforts have also taken place in the aeronautics facilities arena. For example, the about $400-million European Transonic Wind Tunnel, currently under construction near Cologne, Germany, will be operated by an independent international company that has France, Germany, the United Kingdom, and the Netherlands as shareholders. Similarly, the wind tunnel in Noordoostpolder, Netherlands, considered by many to be a state-of-the-art aircraft noise research facility, is a joint venture between Germany and the Netherlands. Each partner in these collaborative efforts provided funding to pay for development and an initial operation subsidy.

European Governments' Support of Aeronautical R&D

The European aeronautics industry has had a long history of government assistance and, in some cases, ownership. Government assistance has typically included aid for both technology and product R&D conducted by the aeronautics industry and major aeronautics research establishments. In table 3, we show the total amount of aeronautical support provided by the governments of France, Germany, and the United Kingdom in 1991 and 1992. Table 4 lists the types of aeronautical R&D support provided and the ministries that provide each type.

[6]The U.S. company Sikorsky is the world's largest helicopter manufacturer.

Table 3: Government Aeronautical R&D Support in France, Germany, and the United Kingdom (1991-92)

Dollars in billions

Country	1991	1992
France	$1.8	$1.8
Germany	1.5	1.5
United Kingdom	1.6	1.5
Total	**$4.9**	**$4.8**

Note: All figures are rounded to the nearest $100 million.

Source: Compiled by GAO from data provided by each country.

Table 4: Government Aeronautical R&D Support in France, Germany, and the United Kingdom by Ministry

Government funding	France	Germany	United Kingdom
Technology and product R&D for national security	Ministry of Defense	Ministry of Defense	Ministry of Defence
Product R&D for civil aircraft	Ministry of Transportation	Ministry of Economics	Department of Trade and Industry
Civil technology R&D to enhance the national technology base	Ministry of Transportation	Ministry of Research and Technology	Department of Trade and Industry
Technology and product R&D for civil public interest	Ministry of Transportation	Ministry of Transportation	Department of Transport

Funding Technology and Product R&D for National Security

The largest part of government-funded aeronautical R&D in the three European countries is targeted to military needs. For example, the Ministry of Defense provided 64 percent of about $1.5 billion in 1992 funding for the German federal government's aeronautical research and hypersonic technology promotion area. Governments generally pay most or all of the cost of defense-oriented R&D. Most of the new generation of European military aircraft were developed and produced by international consortia. For example, a consortium formed in 1985 by Germany, Italy, Spain, and the United Kingdom is developing the European Fighter Aircraft.

Funding Product R&D for Civil Aircraft

Investment in product R&D for civil aircraft and aircraft engines generally takes the form of repayable loans called launch aid. Repayment of these loans is "success-dependent"; that is, once an established number of aircraft or engines is sold, a percentage of the profit from sales above that number is used to repay the loan. According to a study commissioned by the U.S. Department of Commerce,[7] by 1990 the governments in France, Germany, and the United Kingdom had invested approximately $13.5 billion in direct support of Airbus products. At that time, less than $500 million of that total had been repaid. As of August 1993, the total amount repaid is estimated to have increased to about $3.5 billion.

Funding Civil Technology R&D to Enhance the National Technology Base

The three European national governments share with industry the cost of civil technology R&D to enhance the commercial technology base. The three European national governments generally contribute a share of this R&D cost (usually not more than 50 percent), if industry will agree to pay the remaining cost. This practice is intended to ensure that the R&D investment is considered sufficiently worthwhile by industry. France's Ministry of Transportation funds civil aeronautical technology R&D within the context of its transportation responsibilities. Germany's Ministry of Research and Technology and the U.K. Department of Trade and Industry fund technology R&D across a broad spectrum of industry sectors, including aeronautics.

In 1992, the German Ministry of Research and Technology provided about $133 million for technology R&D and facilities supporting the aeronautics industry. The U.K.'s Department of Trade and Industry provided about $46 million for similar purposes. In addition, the European Community funds aeronautical technology R&D under its Basic Research in Industrial Technology for Europe/European Research on Advanced Materials program. From 1990 to 1994, the European Community will have provided about $67 million for aeronautical technology R&D.

Government funding to support the civil technology R&D base also includes funding to construct major test facilities. Construction costs for such facilities are considered too high for industry to undertake on its own. For example, governments of the three countries reviewed, along with the Netherlands, shared the about $400-million total cost to construct the European Transonic Wind Tunnel in Cologne, Germany. (The wind tunnel is scheduled to open in 1994.) Operational cost shortfalls for this tunnel will be fully supported by the governments until 1997, at which time the facility is expected to be self-sustaining through user fees.

[7] An Economic and Financial Review of Airbus Industries, Gellman Research Associates, Inc., (Sept. 4, 1990), pp. 2-3.

Funding Technology and Product R&D for Civil Public Interest

All three European national governments provide modest funding for technology and product R&D for civil public interest objectives, such as improving aeronautical safety, reducing noise, and resolving environmental concerns. In 1992, for example, Germany's Ministry of Transportation provided between $1.3 million and $1.6 million on such R&D, and the U.K.'s Department of Transport provided about $7 million. In France, the Ministry of Transportation's Office of Civil Aeronautics Programs provides funds for technology R&D and facilities related to improving aeronautical efficiency, reliability, safety, and addressing environmental concerns. Available data indicate that about $2.7 million was spent in 1992 to study issues related to public interest objectives.

Major European Research Establishments That Conduct Aeronautical R&D

In addition to supporting industry technology and product R&D through funding obtained from various government ministries, each of the three countries supports a major research establishment that works on a wide range of civil and military aeronautical technologies at various research centers. This work is focused primarily on long-term technology R&D for the next generation of aircraft. The research also includes near-term technology and product R&D, often in close association with industry, and R&D in support of government responsibilities for national security, safety, and environmental issues. Table 5 summarizes information on each country's major research establishment that conducts aeronautical R&D.

Table 5: 1992 Data for the Major Research Establishments in France, Germany, and the United Kingdom

Dollars in millions

Research establishment	Approximate number of employees	Percentage of employees in aeronautical R&D[a]	Annual budget	Aeronautical R&D (percentage of budget)	Percentage of budget funded from contracts
ONERA [France]	2,200	36	$265	43	71
DLR [Germany]	3,200	40	503	23	45
DRA[b] [United Kingdom]	10,500	8	1,396	16	100[c]

Note: ONERA—Office National d'Etudes et de Recherches Aerospatiales
DLR—Deutsche Forschungsanstalt fuer Luft-und Raumfahrt
DRA—Defence Research Agency

[a]Figures represent a percentage of permanent technical and scientific staff only. Contract or administrative personnel are not included.

[b]Unlike research at ONERA and DLR, which is focused primarily on aerospace, aerospace activities account for only about 20 percent of DRA's activities.

[c]Since the government owns DRA and cannot contract with itself, the work DRA does for the government is controlled through business agreements that are treated the same as formal contracts.

Source: GAO compilation of research establishment data.

ONERA, DLR, and DRA conduct both military and civil aeronautical R&D. According to government and industry officials, this arrangement has increased the potential for greater spin-off technology benefits and financial savings, because many of the same scientists and engineers work on military and civil research projects interchangeably.

As indicated in table 5, major research establishments of the three European countries we studied rely extensively on contracts for their funding. Most of these contracts are with government agencies as opposed to industry. For example, in 1992, government contracts represented about 90 percent of the research conducted by ONERA, 69 percent of DLR's research, and almost all of DRA's efforts. Additional funding is also provided by the government to support basic operations, including self-initiated R&D.

The dissemination of research results by these national establishments to the public domain is not a routine occurrence; the extent of dissemination depends on the terms of the contracts. The identification and subsequent protection of competitively sensitive information is left to the research establishments' industry and government customers.

All three research establishments have company-like structures: DLR and ONERA are nonprofit companies rather than government agencies, have executive boards, and do not employ civil servants. Although DRA is a government agency, it functions as a commercial organization by funding investment through borrowing or through its reserves, which consist primarily of revenues from its customers.

According to European research establishment officials, the establishments' company-like structures and dependence on contract funding contribute to a commercial orientation. Government and industry are viewed as customers, and the research establishments are oriented toward meeting customers' technology needs. However, because industry tends to emphasize R&D activities with near-term commercial application potential, some research establishment officials expressed concern that excessive reliance on contract funding could impair their ability to maintain a stable pool of qualified personnel and lead to an emphasis on shorter-term, quantifiable R&D at the expense of longer-term, higher-risk R&D.

Appendices I through IV provide more detailed information on country- and European Community-specific topics.

Agency Comments

In commenting on a draft of this report, the National Aeronautics and Space Administration (NASA) concurred with its contents. NASA stated that the report provided an excellent overview of European Aeronautics. NASA's comments are reprinted in their entirety in appendix V.

Scope and Methodology

To obtain information for this report, we interviewed officials and reviewed materials at NASA, the Departments of Commerce and State, the Office of Technology Assessment, the Aerospace Industries Association of America, the American Institute of Aeronautics and Astronautics, the Delegation of the Commission of the European Communities, and the Washington-based embassies for France and the United Kingdom. We also met with the Washington representative for Germany's DASA, and visited officials at NASA's Langley Research Center in Hampton, Virginia.

We also reviewed relevant studies, reports, and other documents and interviewed officials at U.S. embassies, European government ministries, aeronautics companies, industry associations, higher education establishments, the European Community Commission in Brussels, and national aeronautics research establishments in France, Germany, and the United Kingdom. We were unable to independently verify the accuracy of some information. We did not have access to pertinent strategic planning information, contract data, and/or company financial records. As a result, we could not make a comprehensive assessment of the scope and relative priority of ongoing or planned aeronautical R&D efforts in each of the countries. The organizations we interviewed are listed in appendix VI.

We provided detailed country summaries on the results of our reviews to appropriate government and industry officials in each country we visited and incorporated their comments in this report where appropriate.

We used annual average exchange rates to convert foreign currencies into U.S. dollars. We conducted our review between April 1992 and October 1993 in accordance with generally accepted government auditing standards.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after its issue date. At that time, we will send copies to the NASA Administrator; the Secretaries of State, Commerce, and Defense; the Administrators of the Office of Federal Procurement Policy and General Services Administration; and other appropriate congressional committees. Copies will also be made available to other interested parties upon request.

Please contact me on (202) 512-4587 if you or your staff have any questions concerning this report. Major contributors to this report are listed in appendix VII.

David E. Cooper
Director, Acquisition Policy, Technology
and Competitiveness Issues

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Abbreviations

BAe	British Aerospace
BMW	Bayerische Motorenwerke
BRITE	Basic Research in Industrial Technology for Europe
CASA	Construcciones Aeronautics S.A.
DASA	Deutsche Aerospace A.G. (German Aerospace)
DGA	Delegation General pour l'Armement (Defense Procurement Office)
DLR	Deutsche Forschungsanstalt fuer Luft-und Raumfahrt Gesellschaft (German Aerospace Research Establishment)
DPAC	Direction des Programes Aeronautiques Civils (Office of Civil Aeronautics Programs)
DRA	Defence Research Agency
EC	European Community
EURAM	European Research on Advanced Materials
EUREKA	European Research Coordination Agency
EUROMART	European Cooperative Measures for Aeronautical Research and Technology
GARTEUR	Group for Aeronautical Research Technology
GE	General Electric Company
ONERA	Office National d'Etudes et de Recherches Aerospatiales (National Institute for Aerospace Research and Studies)
MBB	Messerschmitt-Boelkow-Blohm
MTU	Motoren und Turbinen Union
NASA	National Aeronautics and Space Administration
R&D	Research and Development
SNECMA	Societe Nationale d'Etude et de Construction de Moteurs d'Aviation-Partenaires (National Company for the Study and Manufacture of Aircraft Engines)
TST	Telefunken Systemtechnik
VFW	Vereinigte Flugtechnische Werke (Unified Aeronautics Companies)

France

This appendix describes (1) the structure of the French aeronautics industry, (2) the support that the French government gives to aeronautical R&D, and (3) the organization of France's major aeronautical research establishment.

Consolidation and International Collaboration in the Aeronautics Industry

Consolidation

Before World War II, the French aeronautics industry comprised many small aircraft and engine companies. Since the early 1970s, government-approved mergers have reduced the number of French aircraft and engine companies to three key players: Aerospatiale, France's largest civil aircraft manufacturer; Dassault,[1] France's only military fighter aircraft manufacturer; and the Societe Nationale d'Etude et de Construction de Moteurs d'Aviation-Partenaires (SNECMA), France's largest aircraft engine manufacturer. The French government owns 80 percent of Aerospatiale,[2] 46.7 percent of Dassault (and holds 54.7 percent of the voting rights), and 97 percent of SNECMA.

In 1992, Aerospatiale and SNECMA contributed about half of the French aeronautics industry's $19.3 billion in sales, of which about 49 percent were exports. At the end of 1992, Aerospatiale employed about 46,100 persons.[3] Its aeronautics-related activities achieved sales of about $6.7 billion. Exports made up about 76 percent of these sales. At the end of 1992, SNECMA employed about 13,400 persons in aircraft engine activities and achieved sales of about $2.6 billion. Exports made up about 78 percent of these sales.

Created in 1970 when the French government approved the merger between the Sud-Aviation, Nord-Aviation, and Sereb companies,

[1]We did not include Dassault in our review because it does not manufacture large civil transport aircraft or engines.

[2]In 1993, the French government announced that Aerospatiale and SNECMA are among several French companies currently being considered for privatization. As of February 1993, final decisions on how to proceed if the companies are privatized and the role the government will play in any new company structure had not been made.

[3]The number involved specifically with aeronautics-related activities could not be determined.

Aerospatiale manufactures products ranging from light utility and business aircraft to large commercial civil transport aircraft and from light helicopters to heavy-lift, multi-engine helicopters. SNECMA was created in 1945 to design and manufacture aircraft engines for France. SNECMA is a key player in the global engine market for military and civil aircraft with more than 100 seats. According to its annual report, SNECMA had achieved a 17.5-percent share of this global engine market (excluding the countries of the former Soviet Union) by 1991. General Electric (GE) had about a 36.5-percent share; Pratt and Whitney, a 30-percent share; and Rolls-Royce, a 13-percent share.

Further consolidation of the French aeronautics industry is possible, if Aerospatiale and Dassault were to merge. In the past, repeated attempts by the French government to combine the two companies failed. However, current weaknesses in the military and commercial aircraft business have increased the pressure for more collaboration between the two companies, and possibly a future merger.[4]

International Collaborative Efforts

The trend toward aeronautics industry consolidation is not limited by national borders. Cross-border collaboration is a primary strategy used to share the technical and financial risks associated with researching and developing new aeronautics products such as aircraft and engines, as well as to gain access to new markets.[5] In typical international collaborative efforts, two or more companies negotiate to divide R&D and manufacturing responsibilities for components that make that product.

All of Aerospatiale's civil aircraft products in 1992 (42 percent of total sales) were manufactured under international collaborative efforts, either by the Airbus consortium or through a regional jet transport aircraft venture called ATR. Aerospatiale estimates that, during the 1990s, products produced in this fashion will represent 80 percent of its total sales. SNECMA's international efforts accounted for about 70 percent of its aircraft engine sales in 1992.

The following are examples of Aerospatiale's and SNECMA's respective international collaborative efforts:

[4]According to recent news articles, the two companies plan to develop a common R&D program and cooperate on such activities as aircraft design, long-term planning, and issuing work to subcontractors. However, each of the companies is to retain its own corporate identity.

[5]The European Aeronautics Industry Association reports that in some cases the costs to launch a new aircraft or engine product could be greater than the net worth of a company.

- Aerospatiale and DASA (Germany's only aircraft manufacturer) merged their helicopter divisions in 1992 to form Eurocopter, the second-largest global helicopter company. Eurocopter represents Europe's first merger across national borders in the aeronautics industry.
- Aerospatiale has a 37.9-percent share in the Airbus program. This four-country consortium is a major manufacturer of large civil aircraft in the 150- to 350-seat passenger category. Other participants are Germany's DASA, which owns a 37.9-percent share; the U.K.'s British Aerospace, which owns a 20-percent share; and Spain's CASA, which owns a 4.2-percent share.
- Aerospatiale has a 50-percent share in the regional transport aircraft called ATR. This joint venture manufactures regional commuter aircraft in the 50- to 70-seat passenger category. Italy's Alenia owns the other 50-percent share.
- SNECMA has a 50-percent share in CFM International, which produces the CFM-56 family of aircraft engines. This joint venture with GE has been in place since 1974 and is SNECMA's longest-standing international collaborative effort. The SNECMA-GE relationship is not limited to CFM International. SNECMA has a smaller ownership percentage in other GE engine programs, such as the CF6-80 (20 percent) and the GE36 (35 percent).
- SNECMA has a 25-percent share in the GE-led GE90 program—a development program for heavy-thrust engines for the new generation of wide-bodied commercial aircraft, such as the B777. Other shareholders are Japan, which has a 10-percent share in the program, and Italy's Fiat, which has an 8-percent share.

In all but one of these international collaborative efforts, the respective companies divide R&D and manufacturing responsibilities. Joint research and information sharing on aeronautical technologies has been limited, in part because of national security concerns and companies' unwillingness to share competitively sensitive data. In SNECMA and GE's CFM venture, for example, each company researched and developed the engine components for which it was responsible. Because the components were based on relatively mature technologies, SNECMA and GE shared information on some process technologies but avoided sharing proprietary strategic information.

Increasing R&D costs associated with certain strategic technologies have caused companies to consider future collaborative R&D efforts that might involve sharing more proprietary strategic information. GE, for example, is considering sharing research facilities and research results in future collaborative efforts with SNECMA. A GE aircraft engine manager, however, told us that the extent to which the respective national governments would allow the sharing of such information is unclear. The concern is that certain engine technologies are similar in the military and civil versions. Thus, sharing this strategic R&D information could have potential national security implications.

Eurocopter is the only example we found of a collaborative effort in which two aeronautics companies, Aerospatiale and DASA, merged operations across national borders to conduct joint R&D and production of specific aeronautic products.

Aerospatiale and SNECMA officials believe that an increase in cross-border collaboration will likely continue to take place. They consider such joint activities critical to cope with growing R&D costs, increased international competition, and diminished market opportunities.

Government Support of Aeronautical R&D

The French government has two key ministries that support R&D for the aeronautics industry: the Ministry of Defense and the Ministry of Transportation (see table I.1 for the amount of aeronautical R&D support these ministries provided in 1991 and 1992). In addition, the Ministry of Higher Education and Research funds R&D conducted at higher education and research institutions. This R&D, although not immediately identifiable as aeronautical R&D, could have potential aeronautical applications.

Table I.1: Aeronautical R&D Support Provided by the French Ministries of Defense and Transportation (1991-92)

Dollars in billions

Government Ministry	1991	1992
Ministry of Defense	$1.3[a]	$1.4[a]
Ministry of Transportation	.5	.4
Total	**$1.8**	**$1.8**

Note: Dollar amounts were rounded to the nearest $100 million.

[a]Computed from government officials' estimates. Ministry of Defense would not provide actual figures.

Source: Compiled by GAO from French government-provided data.

The French government supports aeronautical R&D by funding (1) technology and product R&D in the interest of national security, (2) product R&D for civil aircraft and engine manufacturers, (3) civil technology R&D and facilities to enhance the national technology base, and (4) technology and product R&D for civil public interest objectives (such as public and environmental safety). Much of the funding provided by the government ministries is used directly or indirectly to support the research activities conducted at the Office National d'Etudes et de Recherches Aerospatiales (ONERA), France's major aeronautics research establishment.

Funding Technology and Product R&D for National Security Interests

The Ministry of Defense's Delegation General pour l'Armement (DGA) is responsible for funding military technology and product R&D for national security. It generally pays most of the cost of such R&D; however, industry and civil government agencies share the cost for R&D that has dual-use applications. In 1992, the DGA expended about $1.4 billion to fund aeronautical R&D. Of that amount, about $238 million was for technology R&D, and about $1.2 billion was for product R&D.

The DGA, which specifies and develops all materials and systems needed to meet the requirements of France's military services, has two main directorates that support aeronautical R&D. The Directorate of Research and Technical Studies coordinates DGA's technology R&D and is responsible for transferring technology to potential users. This directorate also sponsors ONERA. The Directorate of Aeronautical Construction coordinates DGA's product R&D and is responsible for the design, development, testing, and manufacturing of military equipment. It also provides design, development, testing, and manufacturing services to the Ministry of Transportation and lends its expertise to the Ministry when it contracts with industry.

The Directorate of Aeronautical Construction operates three test centers for military and civil use: an engine test center, a flight test center, and a center for aeronautic testing. The aeronautic testing center, located in Toulouse, France, employs about 900 persons and specializes in product-oriented ground tests of all types of airframes and aeronautical equipment. About two-thirds of the center's work is military, and about 20 percent of its contracts come directly from industry.

Funding Product R&D for Civil Aircraft

The Ministry of Transportation's Civil Aeronautics Program Office (DPAC) funds product R&D for civil aeronautics programs. In 1992, DPAC provided about $318 million to the aeronautics industry. About $257 million of that amount was for the Airbus program and SNECMA's CFM 56 and GE 90 engine programs; the remaining $61 million was for other programs, such as the

Falcon 2000 business jet and equipment for small- and medium-sized manufacturers.

DPAC support of product R&D generally takes the form of "success-dependent repayable loans." Specifically, once a loan recipient sells an established number of products, a percentage of the profit on sales above that number is used to repay the loan. For the Airbus program, DPAC provided about $2.8 billion in loans, primarily to Aerospatiale between 1974 and 1991. As of June 1991, less than 23 percent, or about $678 million, had been repaid. Updated collection data on amounts repaid since 1991 could not be obtained. However, since that time Airbus has received another $0.6 billion in loans for which repayment is not yet due.

The July 1992 bilateral aircraft agreement between the United States and the European Community limits the amount of direct government support to 33 percent of a product's total new development costs. In addition, a European Community regulation limits government indirect product support for a single company to 25 percent of the cost of the basic R&D.

Funding Civil Technology R&D and Facilities to Enhance the National Technology Base

In 1992, the Ministry of Transportation's DPAC provided about $81 million to fund activities in support of civil technology R&D. These nonprogram-specific activities ranged from R&D contracts with industry and the national research establishment to the provision of funds to construct the European Transonic Wind Tunnel in Germany.[6] Contracts with industry accounted for about 61 percent of the civil technology R&D funding. Specific project data could not be provided. The amount DPAC will fund when it contracts with industry is determined case by case; however, DPAC generally contributes no more than 50 percent of the technology R&D costs, with industry paying the remaining costs. This arrangement is intended to ensure that the R&D investment is considered sufficiently worthwhile by industry and, therefore, is supportive of commercial industry objectives. When DPAC shares R&D costs with the national research establishment, it generally funds between 80 percent and 100 percent of these "public good" costs.

[6]The tunnel is a major European R&D test facility located in Koeln, Germany, and funded through cooperation by four shareholders. France, Germany, and the United Kingdom each has a 31-percent share and the Netherlands, a 7-percent share.

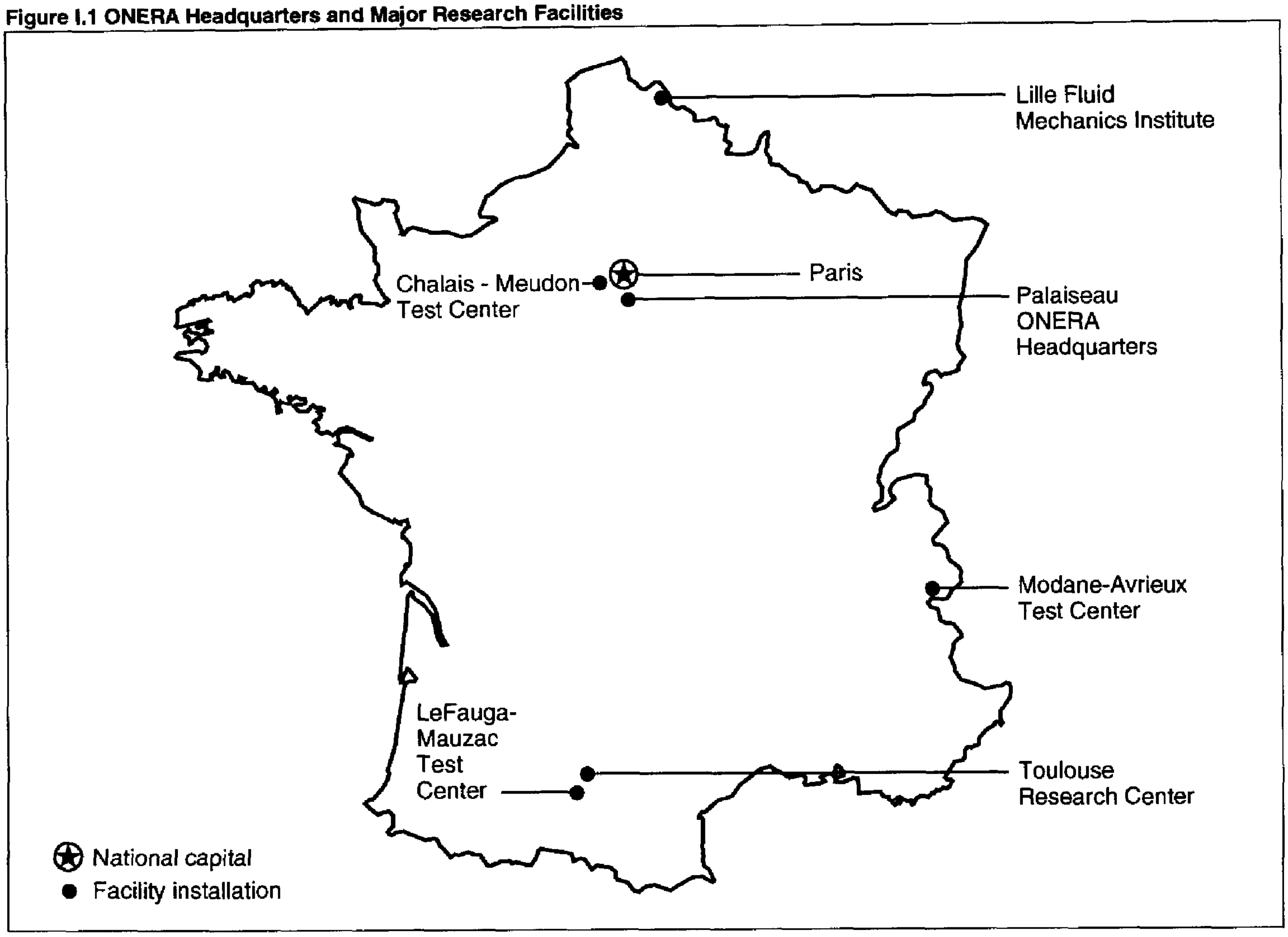
Funding Technology and Product R&D for Civil Public Interest Objectives

The Ministry of Transportation funds R&D activities intended to serve the civil public interest. Examples of such activities are efforts to improve air traffic safety and minimize noise and environmental pollution. The Ministry decides which R&D activities are needed, and, therefore, pays most or all of the R&D costs. Ministry of Defense officials often monitor the contracts for R&D activities in this category. We could not determine the specific technology R&D efforts under contract or the R&D expenditure levels. However, for studies of selected aeronautics research topics alone, about $2.7 million was spent in 1992.

Major Aeronautics Research Establishment

About 12 percent of the government's aeronautical R&D support funds are channeled into France's major government-supported aeronautics research establishment. This establishment, the Office National d'Etudes et de Recherches Aerospatiales (ONERA), was created in 1946 as a public research institute for aeronautics. In 1963, ONERA activities were expanded to include space research. Figure I.1 shows the location of ONERA's headquarters and facilities.

Figure I.1 ONERA Headquarters and Major Research Facilities



ONERA's largest testing centers are in Modane-Avrieux, Chalais-Meudon, and Fauga-Mauzac. These centers contain seven large wind tunnels covering the full range of subsonic, supersonic, and hypersonic airspeeds.[7] In addition, ONERA runs (1) the Toulouse Research Center, which is attached to France's National School of Higher Education in Aeronautics

[7]Subsonic is a range of speed below the speed of sound in air (761.5 mph at sea level), supersonic is one to five times the speed of sound, and hypersonic is in excess of five times the speed of sound.

and Space, and (2) the Lille Fluid Mechanics Institute. In 1992, ONERA employed a total of about 2,200 permanent employees.[8]

ONERA is a nonprofit company, governed by a board appointed by the French government. It is sponsored by the Ministry of Defense's Directorate of Research and Technical Studies and gives priority to military programs. However, ONERA is not a government agency, and its employees are not civil servants. Legally and financially, ONERA is an autonomous public institute. It is similar to a French nationalized company but does not have shareholders (since the only capital investment owner is the French government).

ONERA Sets R&D Priorities in Response to Government and Industry Needs

ONERA serves as a link between scientific research and aerospace manufacturers in the design and production of civil and military aircraft. ONERA's first priority is military aeronautical R&D. Its primary emphasis is subsonic and supersonic technologies; however, some research is also conducted in hypersonic technologies. In addition, ONERA provides technical assistance to industry through contracts that make its testing facilities available, and studies problems encountered during product development or operations.

ONERA's research priorities are established by its Board of Directors, based on consultation with representatives from government and industry. According to ONERA officials, the ultimate responsibility for reconciling any disagreement concerning ONERA's R&D priorities rests with ONERA's Board of Directors. The Board's members are appointed by the Ministry of Defense. The Board comprises ministry officials (mainly from the Ministry of Defense), aerospace experts from industry and elsewhere, and aerospace employees from industry and government. The ONERA officials stated that disagreement at the level of the Board of Directors does not generally occur because ONERA determines its R&D agenda from lower levels upward in consultation with industry and government. According to the officials, consensus has always been reached well before the issues were raised to the level of the Board of the Directors.

Most of ONERA's Funding Comes From Contracts

About two-thirds of ONERA's funding comes from contracts with government and industry; the remaining one-third comes from government agencies and is classified as institutional support. Industry contracts with

[8]For data on the centers' technical capabilities and points of contact, see Aerospace Technology: Technical Data and Information on Foreign Test Facilities, (GAO/NSIAD-90-71FS, June 22, 1990).

ONERA can be grouped into two categories: (1) contracts that industry pays for with its own funds and (2) contracts that industry pays for with funds it received from a government agency, usually the Ministry of Defense. Institutional support is funding for ONERA's basic operations, including the resources that are relatively permanent and not dependent on contract funding. In 1992, ONERA's total operating budget was about $265 million. Of that amount, about $189 million came from contracts and about $76 million came from institutional support funding.

When firms contract with ONERA, the amount they pay for the R&D generally depends on the extent to which they exploit the resulting technology benefits at the exclusion of other firms. If other firms could share the technology benefits, ONERA or the appropriate government ministry generally pays a greater portion of the R&D costs. The extent to which R&D results will be publicly disseminated is negotiated in the contract. Of ONERA's 1992 contract funding, about 10 percent was paid by industry. ONERA does not keep track of whether industry pays for contracts using its own funds or with funds originating from a government agency. With respect to government contract funding, about 78 percent ($132 million) was provided by the Ministry of Defense; about 9 percent ($16 million) by the Ministry of Transportation; and about 13 percent ($22 million) by the Ministry of Space.

ONERA typically initiates the R&D paid for with institutional support funds. Of the institutional support funding that ONERA received in 1992, all of it (about $76 million) was provided by the Ministry of Defense.

ONERA officials stated that in the 1970s ONERA received about 70 percent of its total budget from government institutional support. By 1992, this amount had decreased to about one-third. ONERA officials believe the decrease has contributed to an organizational culture that views government and industry as customers and focuses on meeting their technology needs. A SNECMA management official told us that when ONERA relied more on institutional support, its R&D did not always meet industry's commercial needs. The reduction in institutional funding in favor of contract funding has caused ONERA to be more responsive to industry's needs.

An ONERA official told us that, although ONERA strives to meet contract customer needs, its low institutional funding level could result in difficulties absorbing staff during periods of low contract work. This, in turn, could affect ONERA's ability to maintain smooth operations. Another

ONERA official stated that limited institutional funding reduces ONERA's ability to undertake original and highly innovative and risky, longer-term research. This official said that limited institutional funding causes research scheduling problems.

Germany

This appendix describes (1) the structure of Germany's aeronautics industry, (2) the support that the German government gives to aeronautical R&D, and (3) the organization of Germany's main aeronautical R&D establishment.

Consolidation and International Collaboration in the Aeronautics Industry

Consolidation

Germany was not allowed to engage in aeronautical R&D after World War II until 1955. Shortly thereafter, several companies, many family-owned, returned to aircraft manufacturing. By 1969, mergers had reduced the number of German airframe and engine companies from 20 to 4: (1) 3 airframe companies—Messerschmitt-Boelkow-Blohm (MBB), Dornier, and the German-Dutch Vereinigte Flugtechnische Werke (VFW)-Fokker and (2) a single aeroengine company—Motoren und Turbinen Union (MTU). VFW broke with Fokker in 1979 and merged with MBB in the late 1980s.

In 1989, Germany's largest industrial firm, Daimler-Benz, established Deutsche Aerospace (DASA) as one of its four major corporate units by merging MBB, Dornier, MTU, and the electronic company Telefunken Systemtechnik (TST).[1] By 1990, DASA managers had settled antitrust and monopoly issues with the German federal government and completed the basic organizational structure for DASA. This new structure in Germany's aerospace sector represents a departure from the mix of small- and medium-sized firms that characterizes most of Germany's industrial structure.

As of the fall of 1992, both the TST and MBB identities were defunct because DASA had achieved full takeover of both. Although DASA has also achieved full takeover of MTU, whose activities are those of DASA's Propulsion Group, MTU's name is being preserved because DASA is attempting to exchange MTU shares with Pratt & Whitney as part of its cooperative agreement on aircraft engine programs. Dornier's identity is being continued because family members still control 42.45 percent of Dornier's shares. DASA is now

[1]The other three major corporate units are Mercedes-Benz, AEG (an electronics firm), and DEBIS (a software firm that manages such activities as car leasing).

Germany's only large civil aircraft manufacturer and is also Germany's largest aircraft engine manufacturer.[2]

In 1992, DASA was responsible for about $7 billion of Germany's $13.9 billion aeronautics sales. We did not include DASA's defense and civil systems group's sales in DASA's aeronautics sales figure because we could not determine how much this group contributed to aeronautics sales. However, it is possible that some of the group's $2.3 billion sales could add to the $7 billion. DASA spent about $3.3 billion, or about 30 percent of its total 1992 sales revenue, on R&D. (We could not obtain data on what portion of that amount was spent on aeronautical R&D.) DASA's aircraft and propulsion groups employed at least 55,700 of Germany's estimated 61,400 aeronautics-related employees. A portion of DASA defense and civil systems group's employees may also be involved in aeronautics work.

According to a senior DASA official, the European aircraft industry will no longer be internationally competitive in 5 years unless Europe further reorganizes its civil aircraft industry. He believes that military cooperative programs, such as the European Fighter Aircraft and Tornado, have triggered a general merger trend and that European industry must further merge and eliminate excess capacity if it is to remain competitive.

International Collaborative Efforts

The majority of the German aeronautics industry's market is outside of Germany, and DASA is typically a partner in international efforts to build aircraft. According to DASA's 1992 Annual Report, about 72 percent of DASA's aircraft group sales represent exports. One of DASA's most successful cooperative ventures is its 37.9-percent share in the Airbus program. Other key DASA cooperative ventures include the following:

- DASA has a 40-percent share in Eurocopter, the company formed by DASA's 1991 merger with Aerospatiale's helicopter operations.
- DASA has a 51-percent share in the Dutch Fokker aircraft group (acquired in 1993). According to a February 1993 Aviation Week & Space Technology article, Fokker products include aircraft in the 50- to 58-seat twin-turboprop category to compete with similar products produced by France's Aerospatiale. According to DASA, this acquisition makes it possible for the company to set up an internationally competitive European structure in regional aircraft manufacturing, in which it hopes to include Aerospatiale and other partners.

[2]The German company Bayerische Motorenwerke (BMW) has a joint aero-engine venture with Rolls-Royce, which competes with DASA in some engine markets.

- DASA collaborates with Pratt & Whitney on engines for commercial and executive aircraft. Since 1991, a partnership has existed between DASA's MTU and Pratt & Whitney. MTU is the preferred partner in all current and future Pratt & Whitney engine programs.
- DASA participates in a joint study with Boeing and other aircraft manufacturers to assess the feasibility of developing a new generation super-jumbo aircraft with a potential range of 600 to 800 seats.

In addition to international industry collaboration, the German government cooperates with other countries in funding two key wind tunnels for aeronautical R&D. The German-Dutch Wind Tunnel, located in the Netherlands, has been in operation since the early 1980s. The $63-million, low-speed wind tunnel is the largest of its kind in Europe. It is jointly owned by the national aeronautics research establishments in Germany and the Netherlands.

The European Transonic Wind Tunnel, located in Cologne, Germany, is estimated to cost about $400 million. It is currently under construction, and initial operation is planned for 1994. This tunnel is significantly more complex than the German-Dutch tunnel and will use pressurized nitrogen to achieve more accurate testing results at transonic speeds.[3] Four countries are shareholders in the nonprofit company that is constructing and will operate the tunnel. France, Germany, and the United Kingdom each have a 31-percent share; the Netherlands has a 7-percent share.[4]

Government Support of Aeronautical R&D

The German government has grouped federal R&D funding into almost 20 areas, 1 of which is the aeronautical research and hypersonic technology. Four government ministries fund R&D in this area: the Ministry of Defense, the Ministry of Economics, the Ministry of Research and Technology, and the Ministry of Transportation (see table II.1 for the amount of aeronautical R&D support these ministries provided in 1991 and 1992).

[3]Transonic speed is a range of speed between about 0.8 and 1.2 times the speed of sound in air. The European Transonic Wind Tunnel will operate from 0.15 to 1.3 times the speed of sound in air.

[4]Because the European Transonic Wind Tunnel is being constructed in Germany, thereby providing Germany the benefit of the majority of the construction jobs, Germany is funding 38 percent of the construction cost. France and the United Kingdom are funding 28 percent each, and the Netherlands is funding 6 percent.

Table II.1: German Government Aeronautical R&D Support (1991-92)

Dollars in millions

Government agencies	1991	1992
Ministry of Defense	$945	$923
Ministry of Economics	387	397
Ministry of Research and Technology	132	132
Ministry of Transportation	1	1
Total	**$1,465**	**$1,453**

Note: Dollar amounts were rounded to the nearest million dollar.

Source: Compiled by GAO from German government-provided data.

The German national government supports aeronautical R&D in the following four ways:

Funding Technology and Product R&D for National Security Interests

The Ministry of Defense is responsible for funding military technology and product R&D for national security. It generally pays most or all of the cost of such R&D. It funds basic R&D only if such R&D is not being conducted on the civil side and is judged of potential importance for future national defense or security needs. In 1992, the Ministry of Defense spent about $923 million to fund aeronautical R&D. Of that amount, $91 million was for technology R&D, and the remaining $832 million was for product R&D.

In part because the German postwar constitution and public opinion have resisted military influence over national research policy, the Ministry of Defense has no in-house facilities for conducting aeronautical R&D. To accomplish this R&D, the Ministry uses the national aeronautics research establishment (DLR) and contractor research facilities.

Funding Product R&D for Civil Aircraft

The Ministry of Economics provides product R&D funding for civil commercial aircraft, in particular Airbus, as part of the Ministry's larger objective of ensuring an adequate German industrial structure.[5] These funds generally take the form of "success-dependent repayable loans." Once the sale of an established number of products is reached, a percentage of the profit on sales above that number is used to repay the loan. Although in the past this funding has amounted to over $350 million a year, it fell from about $387 million in 1991 to $232 million in 1993. Of the

[5]This is accomplished by the Office of the Coordinator of German Aerospace Policy, who is a member of the German Parliament. The office coordinates government industrial policy to prevent unfair distortions in global aeronautics competition, and provides support for Airbus.

latter amount, the ministry planned to spend about $204 million for Airbus programs and about $28 million for other aircraft programs, such as the Dornier 328 commuter aircraft.

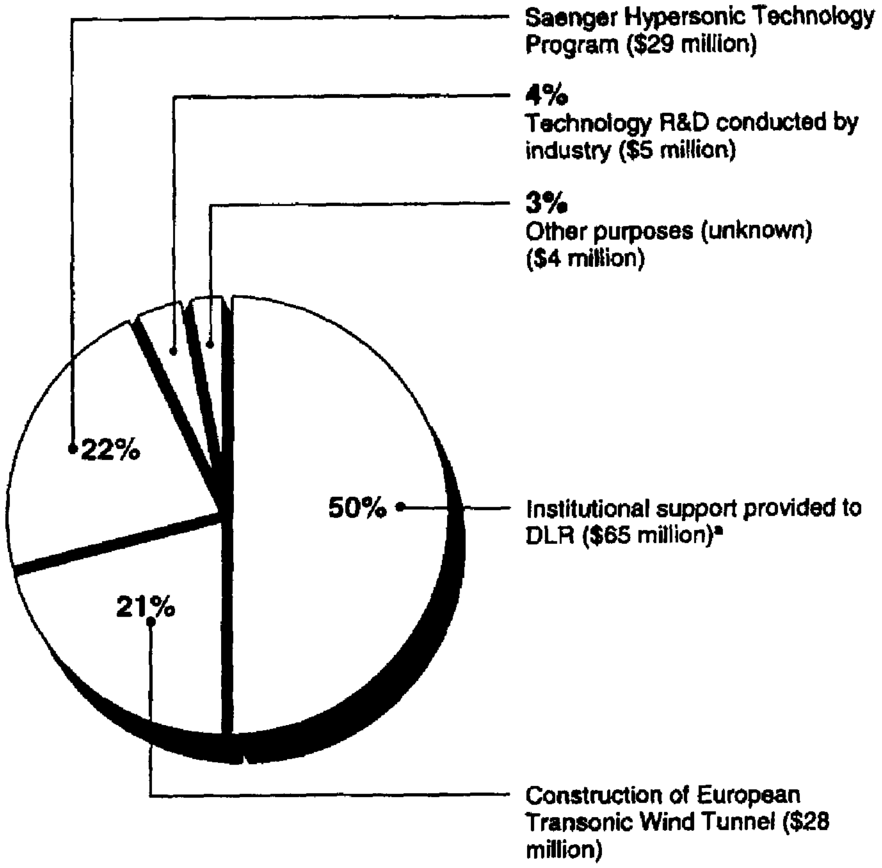
The July 1992 bilateral aircraft agreement between the United States and the European Community limits direct government support for product R&D of civil aircraft to 33 percent of a product's total new development costs. In addition, a European Community regulation limits indirect government product R&D support for a single company to 25 percent of the cost of the basic R&D. As a result of these new developments, a German government and DASA official stated that some technology validation and demonstration activities, currently conducted as part of product R&D activities, may be conducted as part of technology R&D activities in the future. This would ensure continued government support of these activities.

Funding Civil Technology R&D and Facilities to Enhance the National Technology Base

The Ministry of Research and Technology funds R&D and support facilities across a broad spectrum of industry sectors, including aeronautics, to enhance the national technology base. Its support for aeronautical research and hypersonic technology is intended to (1) support Germany's national aeronautics research establishment to improve the technology base for future projects; (2) improve civil aircraft critical components, in part through demonstration and validation of aeronautic technologies; (3) improve avionic and flight guidance/flight safety technologies; and (4) support planning and construction of major R&D test facilities.

The Ministry of Research and Technology's 1992 R&D budget was about $5.9 billion. Of this amount, about $133 million was targeted to the federal government's aeronautical research and hypersonic technology area. Figure II.1 identifies how these funds were allocated.

Figure II.1: Aeronautical R&D Support by the German Ministry of Research and Technology in 1992



[a]Total 1992 DLR institutional funding from the Ministry of Research and Technology was about $204 million. The remaining funds were for DLR's space and energy activities.

Source: Compiled by GAO from German government-provided data.

Contracts with industry for aeronautical technology R&D, excluding those under the Saenger hypersonic technology program, accounted for less than 4 percent of the ministry's funding for civil aeronautical technology R&D and facilities in 1992. The Ministry of Research and Technology generally contributes not more than 50 percent of the R&D costs for these contracts,[6] with industry paying the remaining cost. This is intended to

[6]The Saenger hypersonic technology program is generally for R&D with longer-term, relatively uncertain payback. Therefore, the Ministry pays about 80 percent of its costs, with industry paying the remaining 20 percent. Also, when the Ministry funds technology R&D conducted by a university, it can pay 100 percent of the university's project costs.

ensure that the R&D investment is considered sufficiently worthwhile by industry and, therefore, supportive of commercial industry objectives. Activities funded are typically demonstration and validation of technologies and often involve development of a generic component for use in tests. For example, the Ministry of Research and Technology has funded development and performance testing of a generic carbon fiber fin.

The Ministry for Research and Technology also helps facilitate technology transfer by supporting practical application of research findings. It has established demonstration centers where smaller companies can obtain information about the latest technological developments in areas such as computer use for production purposes. Such demonstration centers are typically intended for broad application with potential benefit to several industry sectors, rather than to a specific industry sector such as aeronautics.

Funding Technology and Product R&D for Civil Public Interests

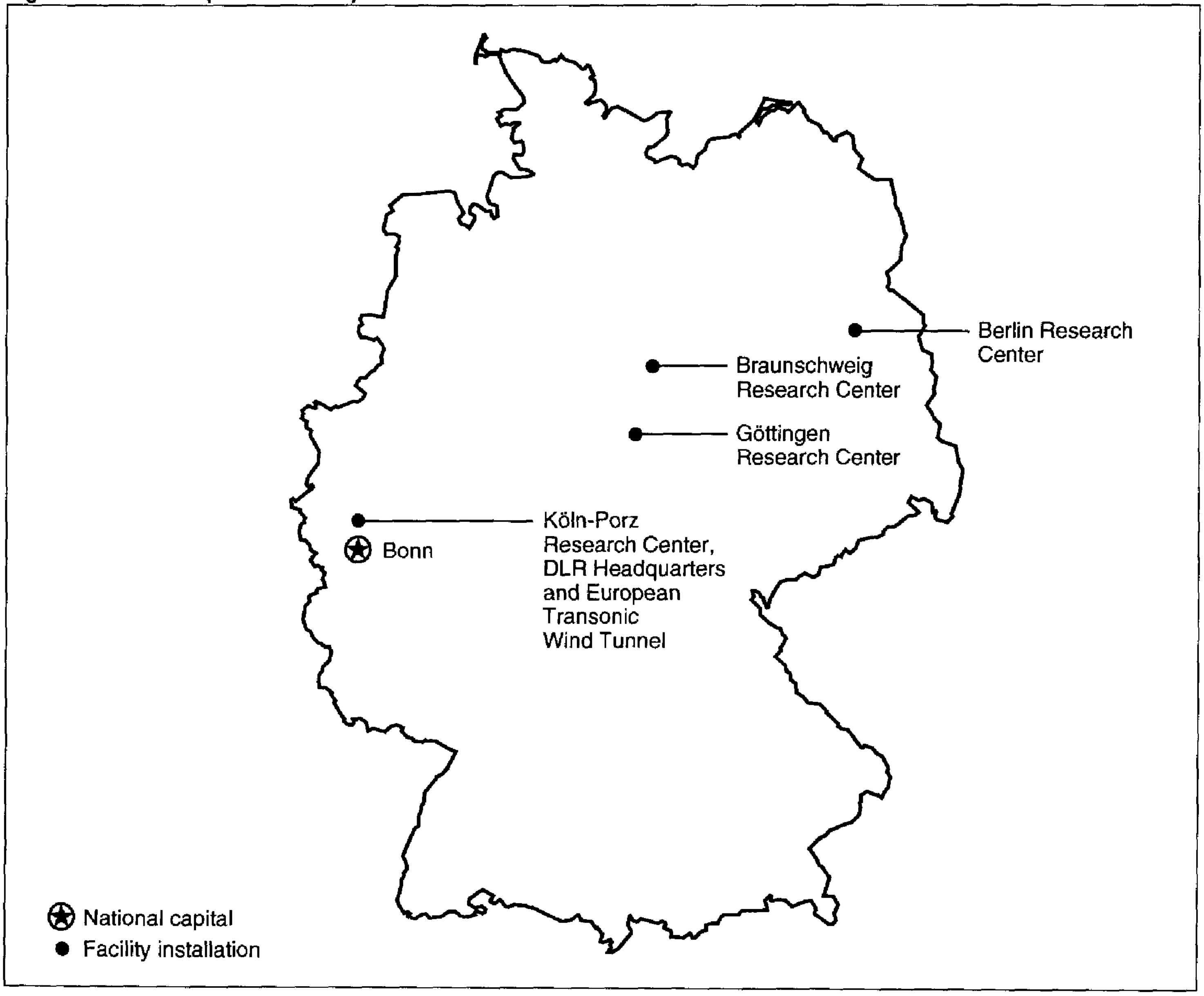
The Ministry of Transportation annually provides between $1.3 million and $1.6 million (using the average 1992 exchange rate) for R&D activities intended to serve the civil public interest. Examples of civil public interest R&D activities include efforts to improve aircraft certification criteria, air traffic and airplane safety, and to reduce noise and environmental pollution.

The Ministry of Transportation's aeronautical R&D projects are intended to support a solution benefiting the general public. Because the government decides which R&D activities are needed, the ministry generally contracts out to industry and universities and pays most or all the R&D cost.

Major Aeronautics Research Establishment

Germany's major government-supported aeronautics research establishment is the Deutsche Forschungsanstalt fuer Luft-und Raumfahrt (DLR). DLR is the only one of the 16 large German research establishments that conducts aerospace R&D. Figure II.2 shows the location of DLR's headquarters and its major aeronautics research facilities.

Figure II.2 DLR Headquarters and Major Aeronautics Research Facilities



The DLR has its major aeronautics research facilities located in Braunschweig, Goettingen, Koeln-Porz, and Berlin. The first three locations contain about 22 wind tunnels and testing facilities covering the full range of subsonic-, supersonic-, and hypersonic-related technologies.

Koeln-Porz is also the location of the European Transonic Wind Tunnel.[7] In 1992, DLR employed a total of 4,135 persons, of whom about 3,200 were permanent staff. About 40 percent of DLR's staff were engaged in aeronautics-related activities.[8]

DLR has a matrix organization with technical competence allocated to five research departments and applications to three program sectors: aeronautics, space, and energy technology. DLR's five research departments are (1) flight mechanics/guidance and control, (2) fluid mechanics, (3) materials and structures, (4) telecommunications technology and remote sensing, and (5) energetics. Each department has 4 or 5 institutes, making up a total of 23 institutes, each employing about 150 to 200 people.

DLR is a nonprofit company. It reports to the Ministry of Research and Technology and receives over two-thirds of its funding from federal and state government. However, DLR is not a government agency, and its employees are not civil servants.

DLR Sets R&D Priorities in Response to Government and Industry Needs

DLR serves as a link between scientific research and industry by conducting technology R&D for long- and medium-term applications and providing technical assistance activities for industry. DLR's primary mission is to conduct applied longer-term technology R&D to enhance Germany's technology base for the development and use of future aircraft and spacecraft. In addition, DLR conducts shorter-term generic R&D not yet targeted to specific aeronautics products. It also conducts some product R&D, in particular when under contract from industry.

According to a DLR official, DLR's aeronautic R&D focuses primarily on high-risk, long-term technologies involving the subsonic, supersonic, and hypersonic areas. The official stated that, although specific programs such as Germany's Saenger program for hypersonic technologies may not continue, DLR will continue to conduct R&D of hypersonic-related technologies. In contrast to DLR, industry primarily conducts R&D targeted to products, and therefore focuses primarily in subsonic technology areas. The Ministry of Defense, on the other hand, funds R&D primarily in the supersonic area for fighter aircraft, but also funds R&D in the subsonic area for helicopters.

[7]Our report entitled Aerospace Technology: Technical Data and Information on Foreign Test Facilities, (GAO/NSIAD-90-71FS, June 22, 1990) provides information on the technical capabilities and programs.

[8]About 50 percent of DLR's employees worked on space-related activities and about 10 percent worked on energy-related activities.

DLR's research priorities are established by its four-person Executive Board, based on consultation with representatives from government and industry. The Executive Board is advised by the Supervisory Board, which is chaired by a representative from the Ministry of Research and Technology and includes representatives from industry, the Ministry of Defense, and other federal ministries. However, DLR decisions regarding its R&D agenda are typically formed primarily by lower-level working circles that address various technology areas such as helicopter technologies. These working circles comprise interested technical expert officials from research establishments, government agencies, and industry.

Significant DLR Funding Comes From Contracts

About 45 percent of DLR's funding comes from contracts with government and industry; the remaining 55 percent comes from government institutional support. This support is funding for DLR's basic operations, including R&D it self-initiates that is relatively permanent and not dependent on contract funding. Industry contracts with DLR can be grouped into two categories: (1) contracts that industry pays for with its own funds and (2) contracts that industry pays for with funds it received from a government agency, usually the Ministry of Defense. In 1992, DLR's total annual budget was about $503 million. Of that amount, $224 million came from contracts and $279 million came from institutional support funding.

Of DLR's $224 million in 1992 contract funding, industry contracts represented about $42 million. DLR does not keep track of whether industry pays for contracts using its own funds or funds from a government agency. DLR also received about $154 million from German federal and state government contracts, about $19 million from international organizations such as the European Space Agency and the European Community, and about $10 million from other sources.

When firms contract with DLR, the amount they pay for R&D generally depends on the extent to which they can appropriate the resulting technology benefits to the exclusion of other firms. If other firms can share in the resulting technology benefits, DLR or the appropriate government agency generally pays a share of the R&D cost. The extent to which R&D results will be publicly disseminated is negotiated in the contract.

DLR typically initiates R&D paid for with institutional support funds. Of the $278 million that DLR received in 1992 for institutional support funding,

$204 million was from the Ministry of Research and Technology, $40 million was from the Ministry of Defense, and $34 million was from German state governments.

In the 1970s, DLR received about 90 percent of its total budget from government institutional support funding. By 1992, this amount had decreased to about 55 percent. DLR officials stated that this decrease has contributed to an organizational culture that views government and industry as customers and is oriented toward meeting their technology needs. However, according to DLR, the advantage of closer orientation to customer needs through contract funding must be weighed against the advantage of institutional support funding—that of providing continuity for the basic R&D essential to maintaining the country's aeronautical technology base for future generations of aircraft. According to a DLR official, an excessive amount of institutional funding could jeopardize the institution's usefulness to its industry and government customers. On the other hand, an excessive amount of contract funding could jeopardize the continuity of basic R&D in support of the country's technology base. It was his opinion that a 50/50 mix would represent the most appropriate tradeoff between contract and institutional support funding. This official said that DLR was probably heading toward that mix in the future.

R&D Activities Outside of DLR

In addition to DLR's R&D activities, government agencies and state governments fund R&D at higher education and other research establishments. This R&D, although not identifiable as aeronautical R&D, can have potential aeronautical applications. One such establishment is the Fraunhofer Society for the Advancement of Applied Research. This establishment conducts commissioned projects and technology R&D in its 45 research institutes.

In 1992, the Fraunhofer Society had a budget of about $640 million and employed about 7,600 people. About 70 percent ($488 million) of the budget was used for research, with more than two-thirds of the budget funded by contracts from industry and state and federal governments. The R&D performed covered a broad spectrum of technologies, including those relating to microelectronics, materials and components, and production technologies. The potential spin-off benefits from this R&D to aeronautics applications cannot be measured because the Society does not track the ultimate application of its R&D.

United Kingdom

This appendix describes (1) the structure of the United Kingdom's aeronautics industry, (2) the support that the United Kingdom's government gives to aeronautical R&D, and (3) the organization of the United Kingdom's major aeronautical research establishment.

Consolidation and International Collaboration in the Aeronautics Industry

Consolidation

After World War II, the United Kingdom's aeronautics industry comprised about 70 aircraft manufacturers. By the early 1960s, this number had been reduced significantly through takeovers, mergers, and bankruptcies. For example, Bristol Aero Engines and Armstrong-Siddeley Motors merged to form Bristol-Siddeley in 1958, which then absorbed other engine companies in the 1960s. In 1966, Bristol-Siddeley was, in turn, bought by Rolls-Royce, which today is the United Kingdom's only manufacturer of large civil aircraft engines. In addition, British Aerospace (BAe) was created in 1977 by the merger and nationalization of the United Kingdom's two remaining major airframe companies: Hawker-Siddeley Aircraft and the British Aircraft Corporation. BAe was privatized in 1985 and is by far the United Kingdom's largest civil aircraft manufacturer.

In 1992, BAe and Rolls-Royce contributed over two-thirds of the United Kingdom's aeronautics industry's $18.6 billion in sales, the majority of which were exports. At the end of 1992, BAe employed about 63,000 persons in its aircraft group. Its aircraft-related activities achieved sales of about $9.6 billion.

BAe exports the majority of its products, with about 64 percent of its 1992 sales achieved overseas. Rolls-Royce, the world's third-largest aircraft engine manufacturer, employed about 29,500 persons in this capacity. About 70 percent of Rolls-Royce's 1992 sales represented exports.[1]

BAe is responsible for the majority of the United Kingdom's major military and civil aircraft programs. The company manufactures aeronautics

[1]Rolls-Royce also has an industrial power group, which designs, constructs, and installs power generation, transmission, and distribution systems, and major equipment for mining and marine propulsion. In 1992 it employed about 22,300 persons and had sales of about $2.5 billion.

products ranging from combat aircraft to supersonic and subsonic commercial aircraft and jet trainers. Its major aeronautics-related business divisions are defense (which includes military aircraft) and commercial aircraft.[2]

International Collaborative Efforts

BAe does not typically build aircraft alone but rather is usually a partner in international efforts to build them. The company is currently in partnership with aeronautics companies from more than 20 countries. One of its most successful collaborative efforts is its involvement in Airbus, for which it designs and constructs the aircraft's wings.

Another key civil international collaborative effort is the joint venture agreement between BAe and Taiwan Aerospace Corporation to assemble and market the new RJ regional transport aircraft. Under this agreement, BAe and the Taiwan corporation are to be equal partners in a company called Avro International Aerospace, which will produce the RJ regional transport aircraft as the successor to the BAe 146. Pending finalization of this joint venture, the final assembly of this aircraft will take place in Taiwan and the United Kingdom. According to BAe, the about $210-million joint venture will enable the company to save thousands of U.K. jobs that would otherwise be lost.

Rolls-Royce is involved in two other major international collaborative efforts in civil aeronautics. One such effort is International Aero Engines, a joint venture with Pratt & Whitney of the United States, Fiat Avio of Italy, DASA of Germany, and Japanese Aero Engines to produce the V2500 engine designed for up to 200-seat jet transport aircraft. This engine is currently in service on the Airbus A320 aircraft and has also been selected for Airbus A321 and the McDonnell Douglas MD-90 aircraft. In 1992, International Aero won an order worth over $1 billion from United Airlines to provide engines for up to 100 A320 aircraft.

The other collaborative effort involves a joint venture with the German company Bayerische Motorenwerke (BMW) to produce the BR700 series of engines for business aircraft. According to Rolls-Royce, an order from a U.S. business aircraft jet company (Gulfstream) for 200 engines valued at about $500 million officially launched the BMW/Rolls-Royce BR700 series of engines. The first aircraft carrying this new engine is scheduled for flight in late 1995.

[2]Other BAe business divisions include motor vehicles, property and construction, and space systems.

According to a British Aerospace official, collaboration between European aerospace companies has been well-established over the last 30 years and is likely to increase in Europe and beyond. They said collaboration could take several forms, such as joint ventures, partial mergers, or full mergers.

Government Support of Aeronautical R&D

The United Kingdom's government has three agencies that support aeronautical R&D: the Ministry of Defence; the Department of Trade and Industry; and, to a lesser extent, the Department of Transport (see table III.1. for the amount of aeronautical R&D support these ministries provided in 1991 and 1992). In addition, government agencies fund R&D conducted at higher education and research establishments. Although this R&D is specifically not identifiable as aeronautical R&D, it can have potential aeronautical applications.

Table III.1: United Kingdom's Government Aeronautical R&D Support (1991-92)

Dollars in millions

Government agencies	1991	1992
Ministry of Defence[a]	$1,300	$1,400
Department of Trade and Industry	248	101
Department of Transport	9	7
Total	**$1,557**	**$1,508**

Note: All figures are rounded to the nearest million dollar.

[a]Relates to product development only. We could not obtain funding information on defense aeronautical technology R&D activities.

Source: Compiled by GAO from U.K. government-provided data.

The United Kingdom's government supports aeronautical R&D in the following four ways:

Funding Technology and Product R&D for National Security Interests

The Ministry of Defence is responsible for funding military technology and product R&D to meet the needs of the U.K. armed services. This ministry is the United Kingdom's primary sponsor of public aerospace R&D and test facilities for civil as well as military use. In 1992, the Ministry of Defence expended about $4.9 billion to fund R&D in all technology areas. Of that amount, about $1.4 billion was for aeronautical product development activities.

The Ministry of Defence owns the Defence Research Agency (DRA) and typically funds about 90 percent of the aeronautical R&D it conducts annually. In addition, the Ministry of Defence funds some aeronautical R&D conducted by private industry and universities.

Funding Product R&D for Civil Aircraft

The Department of Trade and Industry funds product R&D for civil aeronautics programs. These funds generally take the form of success-dependent repayable loans. Specifically, once the sale of an established number of products is reached, a percentage of the profit on sales above that number is used to repay the loan. Although in the past this funding has averaged to over $160 million a year (in 1992 dollars), it dropped to about $55 million in 1992. Of the latter amount, about $50 million was for Airbus products, and the remaining about $5 million was for the EH101 helicopter program.

According to the Department, between 1990 and 1992, it disbursed about $495 million (in 1992 dollars) in success-dependent repayable loans for Airbus products. The Department does not expect to provide any additional loans for the Airbus program. During the same time period, the industry had repayed about $230 million.

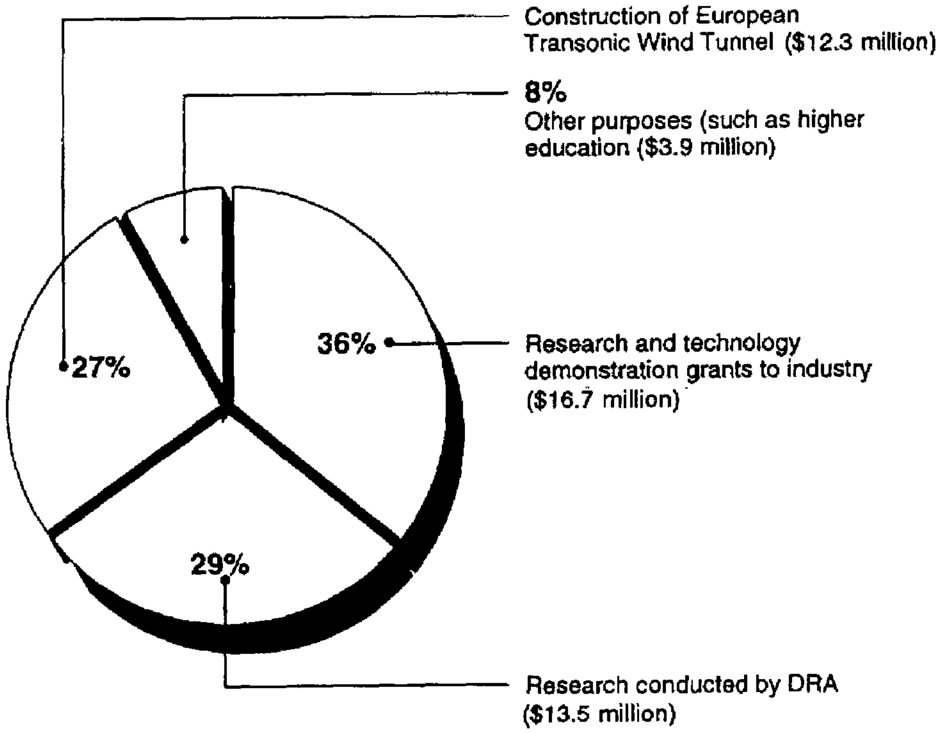
The July 1992 bilateral aircraft agreement between the United States and the European Community limits direct government support for product R&D of civil aircraft to 33 percent of a product's total new development costs. In addition, a European Community regulation limits government indirect product R&D support for a single company to 25 percent of the cost of the basic R&D.

Funding Civil Technology R&D and Facilities to Enhance the National Technology Base

The Department of Trade and Industry also funds civil technology R&D and research facilities to enhance the national aeronautical technology base, primarily through its Civil Aircraft Research and Demonstration program. Established in 1990, the program is intended to help key manufacturers within the U.K. aircraft and engine sectors by funding civil technology R&D.

In 1992, the Department provided about $46 million for support of aeronautical technology R&D and facilities. Figure III.1 identifies the support provided.

Figure III.1 Aeronautical R&D Support Provided by the U.k. Department of Trade and Industry in 1992



Source: Compiled by GAO from U.K. government-provided data.

Grants to industry for research and technology demonstration accounted for about 36 percent of the Department's total support for aeronautical technology R&D and facilities. Under the civil aircraft program, the Department contributes no more than 50 percent of the R&D cost, with industry paying the remaining cost. This practice is intended to ensure that the R&D investment is considered sufficiently worthwhile by industry and, therefore, supportive of commercial industry objectives. Research program grants to industry include funding of activities related to such technologies as aerodynamics, propulsion systems, materials and structures, and avionics.

The research program is part of the Department's Industrial Innovation Program, which is intended to stimulate innovation across a broad spectrum of industry sectors by encouraging research and technology transfer and by creating closer links between business and the science base.

Funding Technology and Product R&D for Civil Public Interests

The Department of Transport funds R&D activities intended to serve the civil public interests. Between 1990 and 1992 the Department of Transport provided about $19.4 million to serve these interests. Examples of civil public interest R&D are efforts to improve helicopter safety, reduce aircraft noise and environmental pollution characteristics, and promote aviation security.

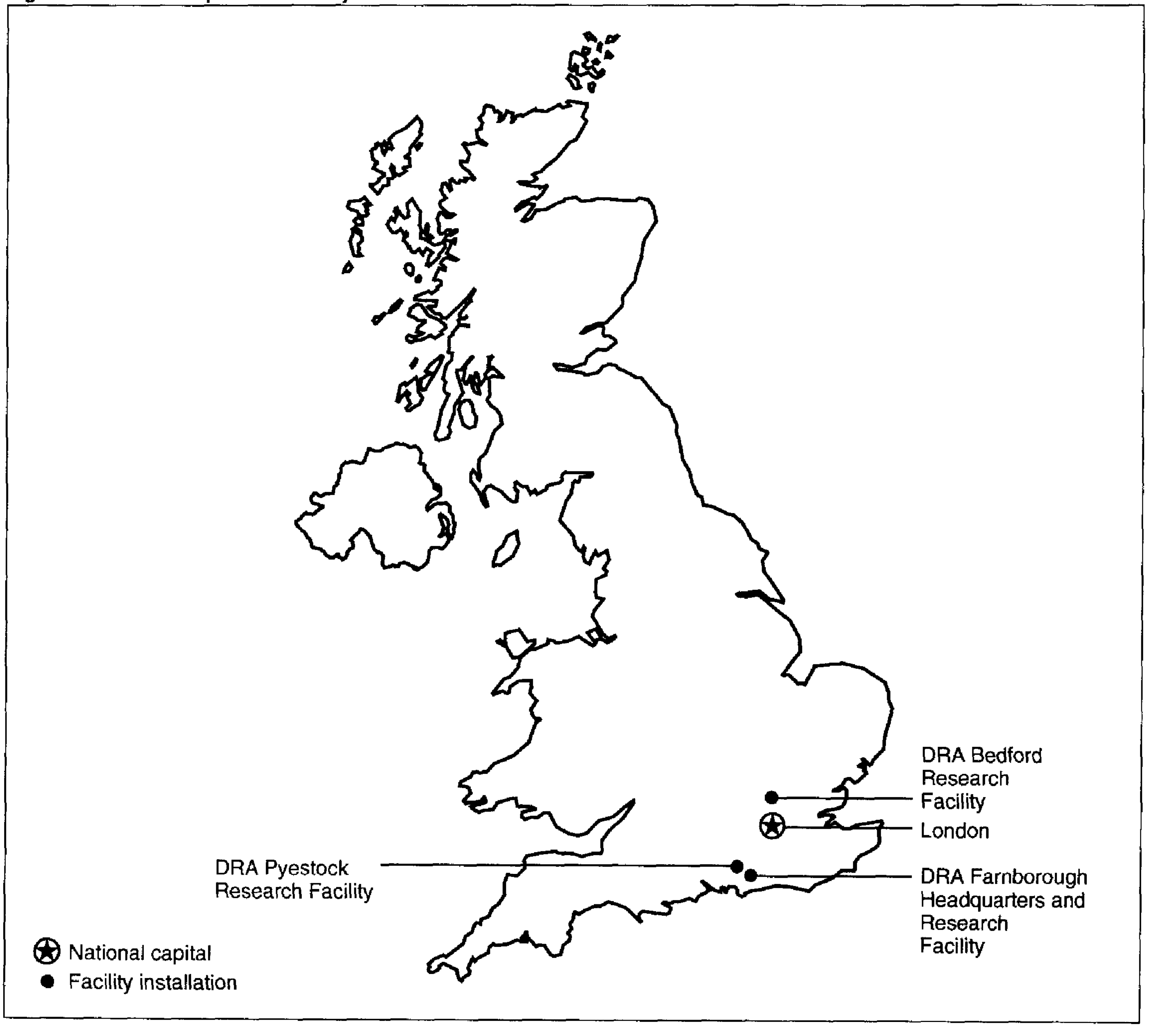
The Department of Transport's funding for aeronautical R&D is not solely intended to support commercial industry objectives, but rather to support a solution benefiting the general public. Because the Department of Transport decides which R&D activities are needed, it generally pays for most or all of the R&D cost. It coordinates most of the aeronautical R&D it funds with the U.K. Civil Aviation Authority.

Major National Aeronautics Research Establishment

The U.K.'s major government-supported aeronautics research establishment, formerly the Royal Aerospace Establishment, is now part of the DRA. Established in 1991, DRA serves as the Ministry of Defence's primary source of research and technical advice relating to procurement in a wide range of technology and defense systems areas. Even though R&D in support of military commitments is DRA's primary focus, it does conduct civil R&D for government and industry. Unlike the national aeronautics research establishments in Germany and France, which focus on aerospace R&D, aeronautics and space together account for about 20 percent of DRA's R&D activities.[3] In 1992, DRA had total revenue of about $1.4 billion, of which about $233 million was for aeronautical R&D-related activities. Figure III.2 shows the location of DRA's headquarters and major research facilities.

[3]DRA's primary activities focus on research and technical advice related to weapons and defense equipment, international research collaboration, and other operational matters.

Figure III.2 DRA Headquarters and Major Research Facilities



The DRA's testing facilities include 10 major wind tunnels covering a range of subsonic- to high supersonic-related technologies but generally not covering hypersonic-related technologies. Its low-speed subsonic wind tunnel in Farnborough is state-of-the-art and used by industry worldwide. In fiscal year 1992,[4] DRA employed a total of about 11,000 persons, of whom less than 5 percent were contract staff. Of the permanent staff, about 800 persons were employed in aeronautics-related R&D.

Most DRA aeronautical R&D activities are conducted by its Aircraft Systems Sector, which conducts R&D related to the full range of aeronautics-related technologies. These include flight systems, materials, aerodynamics, and propulsion technologies.

DRA is a government agency owned by the Ministry of Defence. However, DRA is considered a public corporation for the purposes of public expenditure planning and control. It has operated since April 1993 through a U.K. government trading fund, which allows DRA to function as a commercial organization by funding its investment through borrowing or through its established reserves. DRA's reserves consist of revenues received from contracts with the Ministry of Defence and other customers for its R&D services.

DRA Sets R&D Priorities in Response to Government and Industry Needs

DRA serves as a link between scientific research and industry by conducting technology R&D for long- and medium-term applications and providing technical assistance to the Ministry of Defence and industry. In general, civil technology R&D projects account for about 9 percent of DRA's activities. DRA does on occasion conduct civil product R&D, but such activity has to comply with guidelines established by the Ministry of Defence.

DRA does not receive direct oversight or funding from the U.K. national legislature. Its research priorities are established primarily by the Ministry of Defence, which has the ultimate responsibility for determining DRA's R&D agenda. As DRA's primary customer, the Ministry of Defence acts on behalf of the U.K. Defence Secretary—in particular, the Deputy Chief of Defence Staff (Systems), Deputy Chief Scientific Adviser, and the Chief of Defence Procurement. DRA is headed by a chief executive who is accountable to the U.K. Defence Secretary for the use of resources and accounting and financial procedures.

[4]DRA refers to this fiscal year as 1992-93. It runs from Apr. 1, 1992, to Mar. 31, 1993.

The Ministry of Defence established DRA to introduce more efficient and effective management of defense research and to ensure better value for DRA's customers. Before operating through the government trading fund, DRA received most of its funds directly from the Ministry of Defence, which had also set a ceiling on the number of staff DRA could employ. Although DRA employees are still civil servants, DRA no longer has an employment ceiling. DRA may recruit extra staff or pay for overtime during heavy workload periods.

In line with the Ministry of Defence's expectations that DRA operate as a commercial organization in a competitive environment, DRA has introduced a new commercial accounting system, issued its first annual report, and recently completed its first major customer satisfaction survey. Although we could not obtain the results of the survey, officials stated that it was intended to aid in determining whether DRA's R&D services were meeting customer needs.

All of DRA's Funding Comes From Contracts

Unlike the research establishments in France and Germany, DRA does not receive institutional support. Instead, DRA receives all of its income from contracts and does not conduct self-initiated R&D apart from these contracts.[5] Of the total $1.4 billion DRA received in 1992, the vast majority (about $1.2 billion) was from the Ministry of Defence; about $81 million was from other government ministries; and about $39 million was from nongovernment organizations, which includes industry.

The Ministry of Defence expects DRA to seek contracts from industry customers and to abide by its guidelines when bidding for industry work. DRA's industry contracts can be grouped into two categories: (1) contracts that industry pays for with its own funds and (2) contracts that industry pays for with funds it received from a government agency, usually the Ministry of Defence.[6]

DRA generally does not transfer its R&D results to the public domain. When firms contract with DRA, the amount they pay for R&D generally depends on the extent to which they can appropriate the resulting technology benefits to the exclusion of other firms. If other firms can share in the resulting

[5]According to DRA, the U.K. government cannot contract with itself. However, the agreements under which DRA undertakes work for the Ministry of Defence and other government departments are treated by both parties as if they were formal contracts.

[6]We could not determine whether the nongovernment contract funds were directly from industry or subcontracts backed by government funds.

technology benefits, DRA or the appropriate government agency generally pays a share of the R&D cost. The extent to which R&D results will be publicly disseminated is negotiated in the contract.

According to Ministry of Defence and industry officials, DRA competes with industry for R&D contracts. Although U.K. aeronautics industry officials did not identify any major concerns about competing with DRA, a British Aerospace official stated that DRA staff have shown more reluctance in the past few years to exchange information with industry about work in which they may have a competitive advantage. However, both British Aerospace and Rolls-Royce also cooperate with DRA in areas of mutual interest. According to a Rolls-Royce official, because DRA has a more comprehensive range of facilities and technical expertise than private companies, competition is likely to be limited.

DRA officials believe that their dependence on contract funding has contributed to an organizational culture that views government and industry as customers and is oriented toward meeting their technology needs. However, they agree that there is a risk that DRA may sacrifice the longer-term technology R&D essential to maintaining the country's aeronautical technology base for future generations of aircraft. To minimize this risk, a DRA customer within the Ministry of Defence—the Deputy Chief Scientific Adviser—has been assigned responsibility for long-term strategic research. Specifically, this scientific adviser is responsible for justifying an appropriate allocation of funding to longer-term research and managing the Strategic Research Program.

DRA officials also commented that they expect the new contracting relationships to support DRA's longer-term technology R&D programs better than in the past. Previously, DRA tended to give highest priority, in terms of funding, to activities that supported equipment procurement and in-service trouble shooting. Whatever resources remained went to longer-term R&D. As a result, such R&D was limited. Further, DRA expects the current, more formal contracting relationships will better support DRA's applied technology R&D program.

According to the Director of DRA's Aircraft Sector, DRA expects to see a reduction in scheduling problems under its new method of operation. Under the old system, Ministry of Defence customers received free service from the research establishments, so there was less incentive for them to plan their requests in advance. Also, there was no procedure for matching research establishment resources precisely to customer needs. He expects that DRA's new method of operation will overcome these problems.

European Community and Other Collaborative European Aeronautical R&D Programs

Aeronautical R&D in Europe is principally an enterprise of national governments and industries. The European Community (EC) is not extensively involved in funding this type of research, and before 1989, was not involved at all. Today, the EC funds a modest aeronautical research effort designed to stimulate R&D cooperation among community member countries and improve the Community's overall aeronautical technology base. The EC efforts complement other parallel European collaborative aeronautical R&D efforts.

Structure of the EC's Aeronautical R&D Program

The EC's primary umbrella program for R&D cooperation between member countries is the framework program.[1] In 1989, the EC modified the framework program to include aeronautical R&D. This decision implemented recommendations of the 1988 EUROMART study.[2] The study noted that the fragmented European technology R&D base could not effectively support a globally competitive European aeronautics industry. EUROMART concluded that to develop and sustain such an industry, the European community as a whole should financially support aeronautical research. Following this study, two existing framework programs were consolidated and an aeronautical R&D component was added. The two programs are Basic Research in Industrial Technologies for Europe (BRITE) and European Research on Advanced Materials (EURAM).[3] The aeronautical R&D component ($67 million) is about 8 percent of BRITE/EURAM's funding and about 1 percent of the framework program's funding for the 1990-94 period.

The EC, aeronautics associations, and national government officials told us that while the EC's aeronautical research programs have increased cooperation within the community, they so far have not been particularly successful. This is because (1) modest funding has kept participation lower than desired, (2) large European companies focus on

[1]The framework program provides the overall objectives, priorities, and budget for the EC's technological R&D activities. It is a multiyear program covering either 4- or 5-year periods. The proposed fourth framework program (1994-98) is being reviewed by the European Parliament.

[2]The EUROMART (European Cooperative Measures for Aeronautical Research and Technology) study was initiated in February 1987 by the Commission of the EC and nine European aeronautics companies. The study was in response to a perceived resurgence in U.S. aeronautical R&D activities and the emergence of government-backed aeronautical industries in newly industrialized countries. The main study topics were the status of, and future need for, technology R&D in the European aeronautics industry.

[3]BRITE/EURAM builds on experiences gained from the separate programs and covers EC cost-shared research projects. BRITE/EURAM focuses on advanced materials technologies, design methodology, and assurance for products and processes, application of manufacturing technologies, and technologies for manufacturing processes.

product-related technologies that are outside the EC framework, and (3) the costs of the EC bureaucracy are too high.

EC Support of Aeronautical R&D

The EC supports aeronautical R&D primarily with shared-cost contracts between itself, private industry, and member countries' research facilities or universities. Under this type of contract, the EC typically pays for up to 50 percent of the R&D costs and, in some cases, 100 percent of the administrative costs. The other participants in the contract provide the remaining costs. The EC requires that at least two research entities from two member countries jointly participate in an R&D project as a precondition for EC support. Under the second framework program (1987-91), the EC provided about 53 percent of the support for the program's 28 aeronautical research projects. There was an average of 12 partners per project during this program.

The EC's Aeronautical Research Program

The principal objective of the EC's overall R&D policy is to maintain and strengthen the international competitiveness of European high-technology industries. This policy stresses (1) cross-border cooperation, (2) coordination and mobility between industry and science, (3) support for the research budgets of small- and medium-sized enterprises, and (4) integration of research and technology within the context of a single European market.[4]

The R&D of aeronautical technologies within the EC's framework program focuses on near- to mid-term technologies and manufacturing processes prior to commercial development. The EC seeks wide dissemination of researched technologies to its member countries so that they are applicable to more than one country or company, rather than targeted to a specific product.

In 1989, under the second framework program, the EC selected and funded 28 projects from 112 proposals submitted by member countries. As shown in table IV.1, these projects fit in four program categories.

[4]The single European market refers to efforts underway in Europe to standardize international organizations and operations in order to advance community objectives and cooperation.

Table IV.1: Categories and Funding of EC Aeronautical R&D in the Second Framework Program (1987-91)

Dollars in millions

Program category (number of projects per category)	Program category's cost	Percentage of program category's cost to total cost of projects
Aerodynamics (9)	$32.8	40
Acoustics (3)	12.1	15
Onboard systems and equipment (7)	19.8	24
Propulsion (9)	17.1	21
Total	**$81.8**	**100**

Source: Compiled by GAO from data provided by the Commission of European Communities.

The largest single project ($12 million, 24 partners) is the European Laminar Flow Investigation.[5] This four-phase project in the aerodynamics program category, led by DASA, seeks to produce an airfoil that would improve fuel consumption by 15 percent and reduce pollution in subsonic and supersonic flight. Other relatively large programs studied the effects of future technologies on cockpits ($4.6 million, 14 partners), film sensors for aircraft engines ($2.1 million, 6 partners), and active noise control in aircraft ($4.5 million, 22 partners). So far the EC has approved and funded 50 aeronautics research projects and authorized total funding of $111 million. None of these programs has been completed.

Other European Collaborative Aeronautical R&D Efforts

In addition to the EC-led framework program of multinational technology R&D, some of the EC member countries are involved in aeronautical R&D through organizations and programs that, while not EC-led, complement EC R&D initiatives. Two of the more significant efforts are the programs conducted by the European Industrial Cooperation Initiative (EUREKA) and the Group for Aeronautical Research Technology (GARTEUR).

EUREKA

EUREKA is an industry-led program designed to promote cross-border cooperation in European R&D. EUREKA, which was started in 1985, is targeted on technology R&D for products and services that are considered reasonably close to commercial use. The program is financially supported by the European Community Commission and 20 European countries.

[5]Laminar flow is a measure of airflow over an airfoil (wing). When the airflow is smooth, it is laminar. Turbulence occurs where the airflow is no longer laminar. This, in turn, increases drag, which decreases fuel efficiency.

Whereas EC research is based on fixed institutional rules and long-term goals agreed to by the member countries, EUREKA projects arise spontaneously without detailed overall planning. In the aeronautical area, a key project is Eurofar, a 30-seat tilt-rotor aircraft designed to serve regional routes, land in the cities, and serve off-shore platforms.

The project, initiated in 1987, will be accomplished in several phases. In phase 1 (1987 to 1992), the feasibility phase, a multinational engineering staff determined that a fixed-wing, fixed-engine tilt rotor design would best satisfy the project's goal of a vertical takeoff and landing high-cruise-speed civil transport plane. Phase 1 cost about $38 million. Phase 2 (1992 to 1996) will be devoted to further research on the tilt rotor system and preparation of a demonstrator vehicle. Subsequent phases will include production of a prototype aircraft and flight testing. The first certified aircraft is expected to fly in 2009.

GARTEUR

GARTEUR (created in 1973) was formally established in 1981 by a signed memorandum of understanding between the governments of France, Germany, the United Kingdom, and the Netherlands. Sweden joined in 1991. GARTEUR was started in 1973 as an information exchange and limited cooperative program between major research establishment experts. The major aeronautics research establishments in each country make up GARTEUR's current membership. GARTEUR organizations do not pool financial resources for a specified research agenda.

GARTEUR's goal is to strengthen collaboration among EC member countries through the exchange of technical and scientific information, identification of gaps in technology and facilities, and avoidance of duplicative efforts. To accomplish this, GARTEUR has brought together over 200 specialists from five major aeronautics disciplines. Research work conducted by GARTEUR is applications-oriented technology R&D. Major projects include activities in aerodynamics, flight mechanics, helicopters, structures and materials, and propulsion technology. Information on specific R&D projects within those technological areas could not be obtained; however, the GARTEUR chairman provided the following example to illustrate coordination among its members: If two members were conducting research of a technology for which expensive wind tunnel tests were required, one would agree to pay for construction of the demonstration model, while the other would fund use of the test facility. The participants would share the R&D results.

After the memorandum of understanding was signed in 1981, industry representatives within the GARTEUR member countries developed an industry organization, the Collaboration on Aeronautical Research and Technology, that on occasion provides input to GARTEUR. The organization consists of representatives from the major airframe manufacturers in France, Germany, the Netherlands, and the United Kingdom. Organization members are primarily concerned with applied research for fixed-wing aircraft and R&D management. However, it also represents helicopter interests through BAe and Aerospatiale. Like GARTEUR, the organization coordinates research efforts to minimize duplication of technological research and product testing by entering into agreements to pool research funds and share research results. We could not obtain information on the types of projects being funded, because such information is considered proprietary.

Comments From the National Aeronautics and Space Administration

National Aeronautics and
Space Administration
Office of the Administrator
Washington, DC 20546-0001

. . 1 . 1994

Mr. Frank C. Conahan
Assistant Comptroller General
National Security and
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U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Conahan:

As requested in your letter of December 21, 1993, we have reviewed your draft report entitled "EUROPEAN AERONAUTICS: Strong Government Presence in Industry Structure and R&D Support", dated October 1993.

The report provides excellent background information on the structure of the primary European aeronautics industry and research organizations. It also properly highlights the success that these organizations have achieved through their well-funded, highly focused cooperative efforts, particularly evidenced by the advanced test facilities that have been constructed and the products of Airbus Industrie. The Airbus consortium has utilized an effective government/industry relationship to develop advanced transport aircraft that have captured an increasingly large share of the world market, largely at the expense of the U.S. industry.

As indicated in the draft report, the European government/industry relationship is very interwoven, and it is extremely difficult to determine the actual extent of government support. Some companies are primarily owned by their governments, and although the research organizations obtain contract funds from the companies, it is impossible to determine how much of that "contract" funding may actually represent only a pass-through of government funds.

It is unfortunate, but not surprising, that the European companies and research organizations were very protective of their strategic planning information and that the report was unable to make a comprehensive assessment of the European aeronautical R&D efforts. In the U.S., although we protect competitively sensitive technology, our Government funding process provides readily available information on the direction and extent of our aeronautical R&D efforts.

- 2 -

In summary, we appreciate the opportunity to review the draft report. In our view, the report provides an excellent overview of the nature and extent of the tightly focused European efforts in aeronautics--aimed at capturing an increasing share of the large and valuable world market. This is a challenge to the United States that requires a strong response. In NASA, we are dedicated to working closely with the U.S. [illegible]st. to provide the appropriate response and to ensure that our industry will remain competitive in the future.

Sincerely,

J. R. Dailey
Associate Deputy Administrator

Organizations GAO Contacted

United States

Department of Commerce, Washington, D.C.

Department of State

- U.S. Embassy, Paris, France
- U.S. Embassy, Bonn, Germany
- U.S. Embassy, London, England
- U.S. Mission to the European Communities, Brussels, Belgium
- U.S. Mission to NATO, Brussels

National Aeronautics and Space Administration, Washington, D.C.

National Science Foundation, Paris

Office of Defense Cooperation, Paris, Bonn, and London

Office of Technology Assessment, Washington, D.C.

U.S. Air Force Research and Development Liaison Office, Bonn

American Institute of Aeronautics and Astronautics, Washington, D.C.

Aerospace Industries Association of America, Washington, D.C.

International Organizations

Commission of the European Communities, Brussels

Delegation of the Commission to the European Communities, Washington, D.C.

NATO Advisory Group for Aerospace Research and Development, Paris

France

Aerospatiale, Paris and Toulouse

Association of French Aeronautical and Space Industries, Paris

French Auditors General, Paris

French Embassy, Washington, D.C.

GE Aircraft Engines, Paris

Ministry of Defense, Paris

Ministry of Transportation, Paris

National Center for Scientific Research, Paris and Toulouse

National Higher School of Aeronautics and Space, Toulouse

National Institute for Aerospace Research and Studies, Toulouse

SNECMA, Paris

Germany

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Fraunhofer Society for Applied and Industrial Research, Munich

German Aerospace Industries Association, Bonn

German Aerospace Research Establishment, Koeln, Braunschweig, and Goettingen

German Auditors General, Frankfurt

Hughes Aircraft, Bonn

McDonnell Douglas, Bonn

Ministry of Economics, Bonn

Ministry of Defense, Bonn

Ministry of Transportation, Bonn

Ministry of Research and Technology, Bonn

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European Transonic Wind Tunnel Establishment, Koeln

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British Aerospace, London

British Embassy, Washington, D.C.

British National Audit Office

Defence Research Agency, Farnborough

Department of Trade and Industry, London

Imperial College of Science, Technology, and Medicine, London

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