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NATO Standardization and Licensing Policy — Exploratory Phase

VOLUME III: SUPPLEMENT

by

Hoagland, MacLachlan & Co., Inc., Subcontractor
8 Grove Street, Wellesley, Massachusetts 02181

Prepared for:

European/NATO Directorate
Office of the Assistant Secretary of Defense
for International Security Affairs

November 1976

Contract No. MDA 903-76-C-0284
Contract Expiration: 31 December 1976
Short Title: NATO Standardization

Contractor: General Research Corporation
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GENERAL RESEARCH CORPORATION
WESTGATE RESEARCH PARK, McLEAN, VIRGINIA 22101

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This study describes the US and European political, economic and technological context for licensed production as a tool for standardization or interoperability, identifies particular problem areas, discusses potential candidate systems, and recommends policy approaches to further the goals of NATO standardization and interoperability. Particular attention is focused on (1) US political and economic framework for licensed production, (2) European political, industrial

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and technological factors.

Volume I is the executive summary; Volume II contains the main report and appendices; Volume III supplements the main report by GRC with an extensive survey of European industrial capacities and perspectives on standardization conducted by Hoagland, MacLachlan & Co., Inc., subcontractor to GRC.

PREFACE

Weapons standardization has been an elusive goal of NATO since its founding in 1949. It is widely recognized that NATO suffers diminished combat capability as a result of lack of standardization. Standardization and interoperability have recently been given new urgency in the light of Soviet and Warsaw Pact conventional force modernization programs. Also, the cost-budget squeeze in NATO countries, caused by competing domestic priorities and increasing R&D, procurement, and manpower costs, has added economic incentives to the military incentives to achieve greater collective military effectiveness and more efficient use of collective resources through weapons standardization and improved interoperability. New initiatives have been taken on both sides of the Atlantic to develop better NATO policies, institutions, and procedures to address the long-standing problems of standardization and interoperability.

Both the US Congress and the Executive Branch have committed the United States to greater cooperation with European allies in achieving the goals of NATO standardization and interoperability on the basis of a "two-way street" across the Atlantic in weapons selection and acquisition. Both have also singled out licensed production or co-production of weapons developed by another country as a promising device to this end. Because of this emphasis on licensing, the Office of the Assistant Secretary of Defense for International Security Affairs (ISA) contracted with the General Research Corporation (GRC) in June 1976 for a two-months exploratory phase of assistance in evaluating weapons licensing policy within NATO. To perform the study, GRC augmented the capabilities of its own staff with the assistance of a subcontractor and consultants who have extensive experience in NATO political, military, and industrial matters. Full documentation of the literature examined and of the officials in the US Executive Branch, the Congress, European Embassies, and industry who were interviewed is provided in Volume II, which contains the main report and its appendices. The subcontractor, in Volume III, has provided a survey of the European defense industrial environment within which new US initiatives regarding standardization and interoperability will have to function.

The authors of this report express their deep appreciation to the numerous officials who gave generously of their time to the interviews conducted in this study; to Major General Richard C. Bowman, Director, European and NATO Affairs, ISA, who provided study guidance and encouragement; to Mr. Jerrold K. Milsted, Special Assistant to the Principal Deputy Assistant Secretary of Defense, ISA, who served ably and efficiently as the Contracting Officer's Technical Representative; and to COL Larry J. Larsen, Chief, and COL Harold W. Holtzclaw, Project Officer, in the NATO Standardization Division, ISA, for their many suggestions, documentary search assistance, and support in obtaining interviews with busy officials.

The views and judgments expressed in this report are those of the authors and do not necessarily reflect the views of ISA or any official interviewed in the performance of the study.

SUBCONTRACTOR'S FOREWORD

In July 1976, General Research Corporation commissioned John H. Hoagland, Inc. (now Hoagland, MacLachlan & Co., Inc.) to perform a brief survey of the European defense industrial environment within which new US initiatives regarding NATO standardization will have to function.

This particular study is part of a larger effort by General Research Corporation, on behalf of the Office of the Assistant Secretary of Defense, International Security Affairs, to analyze options available to the United States, in the early future, with regard to NATO standardization and licensing policy. The larger effort by GRC incorporates a number of tasks, dealing with US and European government policies and institutions, NATO and national military service requirements, and governmental perceptions of licensing policy.

The present volume is concerned solely with the industrial setting - especially the European defense industrial scene - as it will affect US policy and actions in the furtherance of NATO standardization. The work statement specified that all of the principal European defense industrial sectors - aircraft, missiles, tanks and guns, electronics, and shipbuilding - be surveyed within a 30-day deadline. The work statement also called for country and corporate profiles in each industrial sector that could lead to valid general conclusions about the probable European industrial response to different types of US activities - especially in the area of direct licensing between Europe and the United States. The undertaking of such a broad task, within a 30-day deadline, obviously calls for selectivity, since any one of the major topics, such as missiles or shipbuilding, could be the subject of a one-year study. At the same time, the authors have considered it essential not to be so selective as to sacrifice consideration of a key feature of the European defense industries - their complexity. A strong effort has been made, in the preparation of the report, to accommodate complexity rather than eliminate it. The essence of the environment in which US initiatives will be introduced is one of competition and duplication among national industries, overlaid with a new trend toward multinational collaboration. The combination of defense budgetary pressures, concerns over full employment, competition for export markets, decline of civil markets, and a host of other factors in each of several countries, creates a complicated industrial situation which must be recognized in the formulation of successful US initiatives. Although the resulting study is rather long, all of the contents are considered relevant to the problem of matching US proposals to European industrial requirements and capabilities.

The report is organized as follows: first, there is a summary of the various findings and recommendations which emerge from each of the topical sections. This is followed by Part I, which discusses the aircraft industry, beginning with a discussion of international collaborative trends, followed by analyses of each national industry. In Part II, the same process is repeated for the tactical missile industry. Part III covers naval shipbuilding; and Part IV describes the European tank and armored vehicle industry. Part V is a subordinate and rather fragmentary section, covering some points about the electronics and gun-making industries. Finally, Part VI provides a discussion of some of the further current industrial issues that are not dealt with in earlier sections.

A wide variety of source materials was employed in preparing the report, but it was necessary, given the very short deadline, to rely a great deal on the personal experience of the authors. The sections on aircraft and missiles were written by John Hoagland, who also acted as project director for the report. As an industrial consultant, he has worked closely with aerospace industries in this country and in Europe and has also served as consultant and contractor to the US Air Force and US Department of Defense on related issues. In the course of writing Parts I and II, he was assisted by personal discussions with several associates in the aircraft and missile industries of France, Britain, and the United States. In addition, he was assisted by Dr. Bernard Udis, head of the Economic Research Bureau at University of Colorado, who shared the results of a number of private interviews in the European defense industry, carried out under a National Science Foundation grant.

Part III, on naval shipbuilding in Europe, was prepared by Robert MacLachlan, who is also the author of a major forecast of the world shipbuilding industry, to be published by Frost & Sullivan, Inc. of New York in the fall of 1976. Mr. MacLachlan was assisted by discussions with US industry associations and shipyards as well as members of the Webb Institute; and, in England, with a retired former head of naval ship procurement.

Part IV, on tanks, was written by Richard Ogorkiewicz, senior lecturer in mechanical engineering at Imperial College, London, who is a recognized authority on armored vehicles. He is a member of the UK Defense Scientific Advisory Board and has also worked, in association with US research laboratories, on advanced concepts for US tanks. He is also a consultant and lecturer to several governments on armored vehicle requirements.

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Summary of Findings and Recommendations

This summary presents briefly, and very broadly, some of the general conclusions to be drawn from the report as a whole. These broad general conclusions are presented under headings which correspond, for the most part, to the chapter headings in the report.

A. The Aircraft Industry

As Part I indicates, virtually all of the major development and production programs, both civil and military, in the European aircraft industry are now collaborative in nature. These collaborations are based on strict cost-sharing and work-sharing formulas, established in advance among the national partners. Although such arrangements are cumbersome, they provide the most satisfactory available solution to the sharing of economic burdens and benefits in the aerospace industries. Any new American overture to achieve greater standardization in the aircraft or missile field should take account of this evolution, which has already begun to improve the standardization of air forces and ground forces in the central European theater.

Experience of the last fifteen years has led to the evolution of a new industrial form in the aircraft industry - an international management company, responsible to ad hoc inter-governmental bodies for the co-ordination and supervision of work performed by designated national industries in the consortium. The most advanced example to date is Panavia in Munich, responsible to a NATO body for managing the development and production of a possible 800 or more variable-geometry fighters for three major European NATO air forces. Panavia is especially important because of its growing vested interest, supported to varying degrees by the participating governments, in identifying further collaborative military aircraft projects with additional partners - e.g. the United States or France.

In the military aircraft field, four major companies have developed the highest degree of expertise in conducting and participating in collaborative programs. In order of experience, these are: British Aircraft Corporation (BAC), Messerschmitt-Bölkow-Blohm (MBB), Dassault-Breguet, and Aerospatiale (or SNIAS).

In general, there have been important bilateral collaborations for military aircraft but relatively few multilateral programs to date - especially programs that would combine British, French, and German industries in a single project. One impediment to date has been the issue of design leadership, especially with regard to aircraft engines, which represent the starting point of any military or civil aircraft program.

An issue of great importance, but still nebulous and of extreme political sensitivity, is potential collaboration among these three governments, in one form or another, on a comparatively inexpensive fighter aircraft to fulfill either an interceptor or air-to-air combat role in the late 1980s and 1990s. This question has been brought to the surface by its inclusion in a list of four topics to be considered by subcommittees of the European Program Group (EPG). Obviously, this issue is also of interest to the United States. Such an aircraft can be described as an F-104G replacement, a replacement to the current generation of Mirage aircraft, or an interceptor for national air defense and policing of national airspace. Typical candidates might be airframes such as the F-16 or Mirage 2000 or, if a twin-engine aircraft were preferred, an F-18 or Super Mirage. Potential engines might be the RB-199, M-53, or a U.S. engine. Panavia and its equivalent engine management organization, Turbo-Union, could provide a useful focal point for trans-Atlantic examination of collaborative opportunities.

The British aircraft industry, with about 200,000 workers, is the largest of all the European national aircraft industries, representing about half the total European aerospace workforce. It is the only European industry with fully developed capabilities in aircraft, state-of-the-art turbofan engines, and aircraft electronics. On the other hand, it has been severely criticized by other national industries for its low rate of productivity in terms of output per worker, a factor which has created difficulties in the negotiation of collaborative programs. Although published analyses of the EC Commission on this problem have somewhat exaggerated the differential between Britain and other countries, there is certainly no doubt that British aerospace worker productivity is lower than in Germany and in France - and certainly than in the United States. (These differentials are described in Part I.) Differences in productivity between Europe and the United States are due primarily to differences of industrial scale.

In Britain, as in other European countries, comparatively low quantitative demand for military and civil aircraft has suppressed major new investment in plant and equipment and has led to trans-Atlantic disparities in manufacturing technology and, as a result, product technology. This situation is a source of friction in licensing from Europe to the United States and a source of cost (and cost accounting) conflicts in licensing from the United States to Europe. In Britain, as in France and Germany, the most severe difficulty currently being encountered by the aircraft industry is under-utilization of capacity on troubled civil aircraft production lines. The company most affected in Britain is BAC, where about half of the factory workers are assigned to Concorde, Airbus, and other civil programs. Although the military lines assigned to Jaguar and MRCA are well capable of supporting the workers currently employed on those programs, BAC faces severe difficulties in utilizing the civil share of its workforce. This problem is echoed at each of the major European airframe firms, such as Aerospatiale and MBB. A rough estimate, based on the discussions which follow, is that about 50,000 workers in the three major aircraft-producing countries are imminently threatened by such problems as the slow-down or cessation of Concorde production and the stretch-out of orders for Airbus. U. S. initiatives for standardization in the field of military support aircraft which take this problem into account will, of course, be especially welcome. However, the main support aircraft initiative that has recently been mounted by the United States - that is, the Boeing E-3A AWACS - offers only a modest amount of work-sharing and also ignores recent trends in European industrial collaborative practice.

The imminent nationalization of the British aerospace industry will undoubtedly lead to a major review of both civil and military collaborative prospects for BAC, Hawker Siddeley, and Rolls-Royce. It also seems likely that this process of nationalization will gradually lead to integration of different company divisions along substantive lines, such as the integration of the tactical missile groups in BAC and Hawker Siddeley. If these integrations are successful, then British military aircraft and tactical missile industry groupings should, within a few years, be larger and more effective than they are now. These new groupings will, however, remain committed to international consortia rather than to purely national programs.

BAC, whose military aircraft division is the British participant in both the Jaguar and MRCA programs, can be regarded as the chief architect and planner of European military aircraft collaboration. The BAC management has accumulated more experience than any other European group in the management of large-scale international military projects.

The national aerospace industries in Britain and France have a vital foreign-earnings role. The British industry has been highly successful on the export market in recent years, setting a succession of annual records. At the end of 1975, over 70% of BAC's total backlog of nearly $2 billion was for export, and Hawker Siddeley's export share may have been as high. Due to the high level of exports, the

British aircraft companies have performed well financially in the last few years. In an 11-year period from 1963 through 1974, the British aerospace industry has exported slightly over 50% of its entire turnover. Nearly half of this backlog represented orders from the United States, France, and Germany as part of license or collaborative programs. This is a significant point for purposes of comparison with France, where a much higher proportion of exports is to the third world. For the moment, British industry is not as sensitive as France to the hazard of third-country export controls resulting from U.S. licenses. but this situation may change rapidly as U.S. manufacturers preempt third world markets.

In Britain and France, and to lesser extent in Germany, the concern over the absence of civil programs, or of military derivatives of civil transport aircraft, is of paramount importance. Military and naval support aircraft projects capable of filling the current order gap could be of vital importance in gaining a higher degree of European aerospace cooperation. For Europe, as many observers have noted, employment is the new measure of industrial achievement.

The French aircraft industry, employing about 100,000 workers, has been more productive than the British industry in terms of output per worker and currently exports about 60% of total industry production, a vast majority of which is military. Although the engine and avionics industries are not as highly developed in France as in Britain, the

French airframe industry has concentrated its resources very effectively in a relatively limited number of programs. Its major difficulty is in establishing a viable role in commercial aircraft development and manufacture. Here, the French government has sought to establish bilateral relationships with the United States.

The two principal manufacturers are Aerospatiale, a nationalized company with about 40,000 workers; and the smaller Dassault-Breguet, a private company with about 15,000 employees. In spite of the deep admiration accorded in the United States to Dassault-Breguet as a developer and manufacturer of supersonic fighter aircraft, it seems possible that Aerospatiale may be the most appropriate future industrial partner for the U.S. in licensing and other collaborative ventures. Aerospatiale's divisions for helicopters, tactical missiles, and ballistic missiles all appear to be operating profitably, but severe difficulties in the commercial aircraft division have kept the company in a state of turmoil. Dassault-Breguet, on the other hand, by concentrating its resources on incremental improvements in a few narrow but highly successful lines, continues to expand its Mirage order backlog while maintaining participation in two important collaborative programs - Jaguar and Alphajet. Nevertheless, the firm has definite limitations of capacity, as well as management and technical depth, to undertake any major licensing or co-development outside its immediate areas of specialization.

Superficially, one exception to this judgment would be the possibility of trans-Atlantic or intra-European licensing or collaboration based on the Mirage 2000 single-engine fighter, which is now scheduled for its first prototype flight in 1977. In fact, however, Aerospatiale will perform at least half the production of this aircraft.* The concept involves a relatively light-weight advanced interceptor with a ratio of total thrust to takeoff gross weight of about unity. The technology of the aircraft calls for the use of carbon fiber in selected structure parts and fly-by wire control systems. The aircraft will use the SNECMA M-53 military turbofan, which is of considerable economic importance to French industry.

In France, as in Britain and Germany, workforce stability is a critical issue. It is an issue that works two ways - both in terms of the political hazards (and in some cases illegality) of workforce reductions, and in a corresponding inability to expand the workforce significantly. Furthermore, it is more difficult in the European countries to shift workforce from one location to another, even in the same company, than it would be in the United States. For these reasons, there are strict limits on European ability to undertake any significant expansion to already well-occupied fighter aircraft production lines.

In Britain and France, the aerospace firms are the largest of the defense industries and the most important in terms of both employment and exports. In Germany, the Federal Government has made a consistent effort to control growth of military production in general and the

* Some French industry observers argue forcefully, however, that Dassault-Breguet will retain the dominant French airframe manufacturing role, and that Aerospatiale will be forced to subcontract most of its airframe production to Dassault.

aircraft industry in particular. As a result, although the aerospace industry numbers about 50,000 workers, its importance as an employer and exporter is not comparable to that of the French or British industries. A little over half the German aircraft industry workforce is employed in the three major airframe companies, MBB, Dornier, and VFW Fokker. In addition, there is a relatively small but important engine industry employing about 7,000 workers. Virtually all German aerospace activity is collaborative in nature, and Bonn has firmly established a policy of reliance on collaboration with the European allies or the United States in major programs. Although Bonn has been generally amenable to a licensee role, especially with the United States, it has also sought to retain a subsistence level of R&D capability so that its own industry would be able to exercise independent critical judgments in collaborative programs, especially those with Britain or France. For U.S. aircraft standardization initiatives with Germany, MBB is the logical partner. MBB, with a workforce of about 20,000, is the German partner in the Panavia consortium and also in the Euromissile consortium. One interesting point about the company is the minority ownership shares held by Boeing and Aerospatiale.

Among the major aircraft firms, severe resentment has resulted from the establishment, in the F-16 project, of U.S. relationships with peripheral manufacturing firms outside the leading industries. These relationships, in the European view, create over-investment in short-term programs and under-utilization of major industrial capacity and sunk costs, all leading to even lower European productivity compared to the United States. The highest degree of acceptance will result from licensing and collaboration with the major factors in the European aircraft industry.

The other two German airframe companies also have some interesting collaborative experience. Dornier is the German partner on the Franco-German Alphajet program. VFW Fokker has been licensee for German production of the Sikorsky CH-53 helicopter; and most important, is a transnational German-Dutch company of which the Dutch arm has a leading role in the F-16 program. For the long-term, it seems likely that there will be further rationalization of the German aircraft industry, resulting in a greater concentration of military aircraft programs in MBB.

B. The Aircraft Engine Industry

The specification of an engine is the starting point for any licensing or co-development of a military or civil aircraft. There is only one aircraft engine company in Europe, Rolls-Royce, which has development capabilities that approximate those of the two principal U.S. engine companies. The two other main European companies - SNECMA and MTU - are much smaller. Although they have impressive manufacturing and test capabilities on a selective basis, their R&D capabilities are very limited. The entire European aircraft engine industry has slightly over 90,000 employees, two-thirds of whom are Rolls-Royce, compared with over 150,000 in the United States. Even Rolls is constrained by limitations on R&D resources which have led to clearly identifiable penalties in product development and manufacturing development, especially in the manufacture of high-temperature turbine components. Nevertheless, the latest military engine, the RB-199, is a technically ambitious project presenting a system with operating temperatures, pressure ratios, and thrust-to-weight ratios roughly comparable to U.S. technology. The maintenance of R&D capabilities at Rolls-Royce will continue to be a primary objective of the British government after nationalization.

Rolls has developed a complicated network of international collaborative relationships, both within Europe and with the United States. With several specific exceptions, Rolls' licensing relationships to and from the United States have proceeded reasonably well, if allowance is made for competitive frictions. Specific difficulties that have arisen in licensing arrangements can, for the most part, be traced to differing experiences with national user standards, as discussed in Part I. For any future U.S. initiatives in the licensing of military aircraft engines, the relationship of Rolls-Royce and MTU in the Turbo-Union consortium represents an interesting candidate for partnership.

SNECMA, the main French engine company, has only about 14,000 employees and somewhat limited R&D capabilities. United Technologies Corporation has a minority ownership in the company. SNECMA has, with some U.S. technical help, developed the new M-53 engine to power the next generation of supersonic fighters in France; and it has also formed with G.E. the CFM-56 consortium to develop and produce a 20,000 pound thrust (ten-ton) engine for the next generation of civil transports. In the view of the U.S. engine manufacturers, SNECMA has excellent manufacturing facilities in selected areas (for example, in modern forging and casting techniques) and a thoroughly respected engine-testing capability. With the exception of the ATAR engine series for the current generation of Mirage fighters, future programs will be collaborative - primarily with Rolls-Royce and General Electric.

It would be difficult to prove, either in Britain or France, that new jet engine testing duration or procedures differ significantly from the United States. With regard to the M-53 program, through the spring of 1976, 19 prototypes have accumulated some 5,000 hours of running time, including nearly 700 with afterburner.

In jet engine licensing, which evokes a number of difficult problems in military and industrial security, the French government and SNECMA have been willing to accept the compromise of receiving a "sealed" core engine from G.E. in the CFM-56 program, to which peripheral systems are added by SNECMA. This type of arrangement would, in most cases, be rejected out of hand by Rolls-Royce.

MTU in Germany is the chosen instrument for German participation in licensed manufacture of foreign jet engines and Germany's portion in Turbo-Union. Although the total capacity of the company is rather small, its metal-working capabilities are fairly well advanced (e.g. electrochemical milling, electron beam welding). The principal programs, either current or planned, include the RB-199 collaboration with Rolls-Royce through Turbo-Union, probable participation with Pratt & Whitney and Rolls-Royce on the JT-10D engine to compete with the G.E.-SNECMA CFM-56, and continuing production of the G.E. J-79 engine (which powers both the F-4 and F-104). In addition, MTU participates with the French engine industry on production of the Larzac engine for the Alphajet trainer.

Finally, as the main text will indicate, Turbomeca is an important potential collaborator for small and medium-sized engines.

C. The Tactical Missile Industry

Tactical missiles are especially well suited to the technological skills, the industrial scale and capacity, and military requirements of the Western European countries. In addition, they offer the vitally important potential for large-scale export which is needed, by Britain and France in particular, to maintain defense industrial viability. For Europe as a whole, 50 to 60% of missile production is normally exported, and prohibitions on freedom to export would effectively rule out the prospect of most licensing or collaborative arrangements.

Tactical missile development and manufacture is, consequently, an area of considerable strength among European NATO countries and represents an area in which Europe considers itself the technological equal of the United States. Although there is considerable interest in future trans-Atlantic collaboration, the principal mode envisioned by Europe is one of co-development among equals with regard to more advanced systems, drawing especially on U.S. advances in precision guidance and resistance to countermeasures.

As in aircraft programs, European tactical missile activity is characterized by a fairly high degree of collaboration. The principal example to date is Euromissile, the consortium of MBB and Aerospatiale tactical missile activities. Compared with the Panavia model, however, Euromissile lacks an independent technical and management staff. In addition, MATRA and HSD have formed a cooperative arrangement on the Martel project. However, as in the case of aircraft, no consortia have yet been formed joining Britain, France, and Germany in a unified program. It seems likely that this type of collaboration will emerge, possibly after the nationalization of the British aerospace industry and the potential fusion of the missile divisions of BAC and HSD.

In Britain, there are some 14,000 workers involved in tactical missile R&D and production, about equally divided between BAC and HSD. In addition, the British electronics industry is capable of acting as prime contractor for SAMs and other tactical missiles. The leader is Marconi and its various operating elements. Marconi's semiactive radar guidance system for the XJ-521 British Sparrow and its participation in the radar and homing systems on Sea Dart, Martel, Seawolf, and other missiles indicates a capability that is important in future standardization efforts. British capabilities appear to be particularly strong in SAM systems, especially for naval applications.

Two major trends in British tactical missile industry are apparent: first, the likelihood of eventual merger of the two principal missile divisions in Britain; and second, the growing favor with which the British government views collaborative tactical missile ventures within Europe.

In France, Aerospatiale and MATRA are the principal manufacturers. In the past, MATRA has concentrated on Air Force requirements while Aerospatiale was more concerned with Army requirements, but these distinctions may be diminishing in importance. Aerospatiale is the collaborator with MBB in Euromissile, which is the sales and management organization for three important programs - Roland, HOT and MILAN. These programs, in addition to the Exocet anti-ship missile, are the major activities of Aerospatiale and are characterized by the prospect of long production runs, at fairly high rates, and large export potential. The U.S. licensing of Roland II has, despite difficulties in the working relationship, provided an important boost to industry morale.

MATRA's principal strengths are in air-to-air missiles, as exemplified by the Super 530 long-range interceptor missile, which will enter operational service in 1978, and the R-550 close-in dog-fight missile, which reached operational status in 1975. These are national programs for the French Air Force, but their export potential is substantial. On a collaborative basis, MATRA and HSD developed the Martel ASM for both the British and French military services, with alternative guidance systems. In cooperation with Thomson CSF, MATRA has also produced the Crotale battlefield SAM, which was one of the contenders with Roland II for the U.S. Army competition. MATRA has collaborated with an Italian firm, OTO-Melara, to develop the Otomat anti-ship missile.

In Germany, missile activities will probably be concentrated increasingly in MBB, and both German industry and government will, characteristically, keep pressing for further collaborative projects within Europe and with the United States. MBB's collaboration with Aerospatiale has been harmonious and has been of particular importance in the major programs to date. In addition to those already mentioned, the Kormoran anti-ship missile has been developed in collaboration with

Aerospatiale and Thomson CSF; and there is already discussion of a supersonic replacement, currently designated the FK-80, which would be a Franco-German collaboration but could also include other partners.* In addition, MBB is working on a long-range ASM for use against large or high-value surface targets, which would be carried on MRCA, and here there has been some interest in collaboration with the United States. The main projects at the moment are, however, MILAN, HOT, and other high-volume production activities.

European industry observers seem dubious, at present, about further trans-Atlantic licensing prospects beyond those which have already been established. In a number of tactical missile categories, U.S. and European industries are in direct competition in world markets. There appears to be a general interest, however, in identifying collaborative opportunities for succeeding generations of tactical missiles, due not only to a further interest in a share in the U.S. market but also due to recognition of U.S. technological advantages in certain selected areas, particularly those related to terminal guidance.

Consequently, while there are certainly a number of specific opportunities remaining for the United States to license existing U.S. systems to various European customers, any venture in tactical missile standardization, intended to encompass all of the major countries, would probably require some element of co-development. This is particularly true if France were to be included in future projects aimed at standardization. Among

* Hawker Siddeley Dynamics has shown an interest in such a partnership.

types of future collaborative development activities that have been mentioned by European industry, the following appear to be the most significant:

A second-generation, short-range SAM to replace Roland, Rapier, and Crotale.

A third-generation anti-tank missile to replace HOT and MILAN in meeting standardized NATO requirements.

A medium-range SAM with very low-altitude capability and a high degree of resistance to ECM. (Here, principal European collaborators might be the electronics firms such as Marconi and AEG-Telefunken.)

More advanced AAMs in each principal category - e.g. high-altitude, high-Mach-number interceptor missiles as follow-ons to Phoenix and Super 530; and close-in dog-fight weapons as follow-ons to AIM 9L and R-550.

A second-generation replacement of Lance and Pluton to fulfill the requirement for a 100-kilometer ballistic weapon. Such a system could be based on improved navigation and propulsion technology.

An anti-ship missile to replace Harpoon, Exocet, and Otomat, in which the important specifications would be supersonic speed and increased range.

An anti-missile missile for ship defense.

There is a general recognition of U.S. technological superiority in a number of specific areas of interest such as EO systems and miniaturized target seekers; large tactical missiles in the SAM and ASM roles; in cruise missiles; and RPVs.

Finally, some European industry spokesmen express concern, based on the F-16 experience, that U.S. industry might by-pass the established European missile industry and set up license relationships with firms having little or no background in missile development or production. It is essential, in any licensing or collaborative arrangements initiated by the United States, to concentrate attention on the principal industrial groupings in a given category in order to further the objectives of unification and standardization.

D. The Shipbuilding Industry

In terms of size and turnover, the shipbuilding industries of the European NATO countries are much less important than the aerospace industry. European naval ship design and construction are concentrated strongly in Britain and France due to the fact that the navies of these two countries account for such a predominant share of operating surface ships and submarines. Britain and France together comprise about 67% of naval ship procurement expenditures among six Western European NATO countries.

The collaborative trend has, for a number of reasons, not been applicable to naval shipbuilding. There is a tendency for each country to direct all shipbuilding contracts to its own yards. In Britain, the government has made a decision in recent years to direct all new naval construction to commercial yards. In France, naval ship construction is performed in four government dockyards with the exception of some small diesel electric submarines and patrol craft which are constructed in private yards.

While Britain and France have tended to concentrated in recent years on fewer, heavier ocean-going surface ships in the frigate and guided missile destroyer categories, there appears to have been a general agreement that West Germany, the Netherlands, and Belgium would concentrate on lighter frigates as well as fast patrol boats and mine vessels for in-shore missions. (It should also be noted that France has joined with the Netherlands and Belgium in a collaborative project for a mine-sweeper.)

There has been a general decline in shipbuilding capability in Western Europe. In 1964, there were 13 shipyards in Britain capable of producing naval vessels. By 1976, this number has been reduced to three lead commercial yards plus three additional commercial yards. Although there is a possibility that the changing trend in naval warfare, towards the employment of a larger number of smaller platforms, may permit the European NATO countries to resume affordable shipbuilding programs to replace their aging fleets of larger-size vessels, the absence of advanced R&D and design capabilities may create a necessity to procure technology from the United States.

In Britain, defense shipbuilding accounts for about 31% of total shipbuilding. In the main British shipyards capable of naval shipbuilding, there are now about 45,000 workers.

Naval shipbuilding in France is confined exclusively to naval dockyards, which now have about 35,000 employees, of whom only about 12,000 are actually engaged in naval construction. Total turnover appears to be on the order of $650 million. Of the four major dockyards, Cherbourg concentrates on diesel and nuclear submarines; Toulon on repair, maintenance, and refit; and Brest and Lorient construct all naval survace ships over 1,000 tons. Although these yards are relatively busy, they are not operating at full capacity. One commercial yard, Constructions Mecaniques de Normandie, specializes in small boats such as fast patrol craft and minehunters. They currently have a contract to build 20 new fast patrol missile boats for West Germany.

In Germany, a relatively small proportion of the defense budget is allocated to naval construction; and the German navy is confined mainly to small craft for in-shore patrolling. Germany is the only NATO European country to order naval vessels from outside the country, as exemplified in orders for patrol craft from France and three guided-missile destroyers from the United States. (About 30% of naval ship procurement funds have been spent abroad.) Although there are five major shipbuilding companies in Germany, they have found it extremely difficult to continue competing with Japan and other commercial shipbuilding industries. Currently, the German shipbuilding industry, even with reduced activity, appears to be plagued by manpower shortages.

In terms of technology and capacity, probably the most logical potential future licensees or contractors for U.S. purposes would be the three lead shipyards in the United Kingdom - Vickers, Vosper Thorneycroft, and Yarrow. As indicated by new designs such as the "Harrier Carrier", British industry does retain technological capability and innovative capacity which can be responsive in future trans-Atlantic collaborations.

From the industrial standpoint, three collaborative prospects can be identified: first, an examination of the relatively few unique European designs - e.g. Harrier Carrier - to determine their applicability to licensed production in the United States; second, given the current difficulties in U.S. naval shipbuilding, the possibility of placing orders for construction at leading European private yards that are well capitalized and under-utilized (the three British yards are the main examples); and third, to examine the prospect of participation in the collaborative French-Dutch-Belgian minesweeper project, which is also of considerable interest in the context of EPG.

E. Tanks, Armored Vehicles, and Self-Propelled Guns

As the discussion in Part IV indicates, Britain and Germany in particular regard themselves as the technological equals of the United States in tank development and manufacture, capable of strong independent judgments about technological alternatives. The European tank industries benefit from a strong automotive base and from relatively large military requirements as well as substantial export markets.

Qualified European observers make the following judgments about licensing or collaborative opportunities between Western Europe and the United States in the tank and armored field:

> Compared with the aerospace industry, where workforce stabilization is of the utmost importance in national policy-making, the situation with regard to tanks is based more closely on military requirements and technological alternatives.
>
> The European industrial view is that Britain, Germany, and France have been more successful in developing armored vehicles in recent years than the United States, especially in relation to the resources available. In their collective view, European development efforts are not as fragmented as those in the United States; their military authorities have a clearer idea of what is needed and

practical, a factor which has avoided such false starts as ARSV, T-95, and MBT-70; and European armored vehicle programs have been less vulnerable to changes in senior military personnel and policy.

The European view is that the quality of R&D facilities directly related to armored vehicles is about the same on both sides of the Atlantic, while static engine and vehicle test facilities are superior in Britain and Germany. Proving ground facilities are considered superior in the United States. The U.S. lead in computer modeling of armored vehicle performance is also acknowledged.

Manufacturing capabilities are roughly comparable in the tank industry, with significant exceptions in some major components. British industry suffers labor and management problems in tank production just as it does in other defense industry sectors. German management of production has been extremely efficient, somewhat offsetting the high wage scales and difficulties in currency fluctuations.

Britain has been responsible for a number of major design innovations such as the new type of Chobham armor as well as triple differential tank steering systems and collapsible flotation screens. Other equipment pioneered in Britain includes APDS ammunition, two-axis electrical stabilized gun controls, supine driving position, non-reflective periscopes, and aluminum armor.

France has pioneered in automatic loading systems and oscillating turrets. France was also the only country which, during the 1960s, competed with the United States in the development of gun/missile launchers.

In general, Germany has not demonstrated any great originality in tank design but has been superior from the point of view of automotive performance and reliability due to more thorough detail design of components and testing. In recent years, however, the Federal Republic has also started a program of research into highly mobile tanks with power ratios that are much higher than any other existing tanks. This trend will eventually produce some new and original designs.

With regard to other vehicles, one program of interest is that of self-propelled guns. The jointly-developed

155mm SP-70 is regarded as a serious challenger to SP equipment produced in the United States.

One divergent trend has been the development in all major European industries of wheeled armored vehicles, a category which the United States has not yet entered.

With regard to major tank components, one important category in which the United States has a strong lead is that of electronics-based systems for tanks. Britain, France, and Germany have been quick to follow U. S. leads in such systems as laser rangefinders.

There is no equivalent in Europe of the cannon-launched laser-guided projectiles recently developed in the United States.

France has led in a number of specialized areas such as medium-pressure smooth-bore guns of 90 and 105mm caliber which fire fin-stabilized HEAT projectiles and which are particularly suitable for light armored vehicles. France is also now developing a high-velocity 120mm smooth-bore gun firing APFSDS.

In one particular category, U.S. production scale presents a great cost advantage over any of the European countries.

The scale of commercial engine manufacture in the United States makes tank engines cheaper than those produced in Europe. (This is particularly true of the two-stroke diesels produced by Detroit Diesel Allison.) In addition, the greater development funds available in the United States have made it possible to develop a gas-turbine engine successfully, a trend which is not likely to be duplicated in Europe.

To some extent, the same judgment about cost advantage is true of engine transmissions.

In general, licensed manufacture of complete vehicles is not an attractive proposition for any of the major European countries. In recent years, licensed manufacture has been considered only twice. In both cases it was a U.S. interest in obtaining a license from Western Europe - first, in the possible adoption of the British Scorpion; and second in the recent prospect of a license for Leopard II.

Manufacture of components under license is an entirely different matter which is accepted practice among all the major industries. Examples include U.S. adoption of the British-designed 105mm tank-gun and licenses granted by Hughes for development and manufacture of laser rangefinders in Britain and Germany.

The greatest case for standardization and licensing arrangements can be made in tank-gun ammunition. One European view is that the most immediate opportunity for this purpose would be the licensing to the U.S. of German or possibly French 120mm smooth-bore guns.

In the European view, if the U. S. Army should decide to develop a new light-armored vehicle, there might be an opportunity to license the British 76mm medium-velocity gun or the 30mm RARDEN gun. An alternative might be a license for the French medium-pressure 90 or 105mm smooth-bore gun.

There are also further if somewhat limited opportunities for licensing U.S. fire-control systems to Europe - e.g. stabilized gun control systems such as those manufactured by Cadillac Gage and Honeywell.

Because the tank industry is a mature industry closely associated with automotive production, classical forms of licensing of specialized components have been widely used, due to the capabilities of the different national industries to recognize new advances quickly and take advantage of them. The more current forms of collaboration that have been developed among aerospace industries do not apply to the tank industry, which is a much smaller and more intimate international community of industries. However, one important example of collaboration is that of Britain, Germany, and Italy in the SP-70 self-propelled artillery project. This is a collaboration which could be of potential interest to the United States for purposes of standardization.

The SP-70 is a derivative development of the collaborative FH-70 155mm towed gun. For the three participating governments, it is designed to replace the U.S.-built M-109 155mm howitzer. Industrial responsibility for the program lies with Vickers in Britain and Rheinmetall and Faunwerke in Germany. When the gun goes into production, OTO-Melara in Italy will also participate. This is a situation of potential U.S. interest.

F. Some Industrial Issues Summarized

For European industry, the credibility of the American standardization initiative is inseparably linked with the establishment of a "two-way street". In the last 20 years, there has been a flood of U.S. hardware and licenses from the United States to Europe and a trickle in the other direction. If the latest U.S. standardization initiative comes to be perceived only as a Trojan Horse for a new wave of U.S. licenses (e.g. F-16, F-18, AWACS, Harpoon, Hawk, Sparrow, etc.), then intra-European efforts to exclude the United States may intensify. For European industrial purposes, the two-way street will be defined as a sharing, according to pre-established formulas, of the costs and industrial work benefits, under the supervision of an established transnational body, in selected defense programs. In the sum total of such programs, the major European industries will seek a balance approaching parity in the exchange of products and services.

The focus of the total study being performed by GRC for ISA is the role of licenses in meeting the objective of standardization. To focus on licensing is to concentrate on systems that are now in late development or early production. For that reason, great care has been taken, in each of the substantive sections which follow, to identify European tactical systems programs that are now either in late development in relatively early stages of production - not only to characterize the capabilities of different industries, but to provide a detailed list of the European systems which could, in the next several years, be available for licensing to the United States as part of a two-way street.

These include some very impressive systems, such as the naval SAMs in Britain, advanced AAMs in France, Franco-German anti-tank weapons, British armor and guns, French light armored vehicles, etc. However, to recite such a list even in outline is to recognize immediately the existence of competing U.S. systems. European industry does recognize this fact and for that reason has tended to emphasize the need to reach beyond the competing systems of the current generation and establish shared co-development programs for the next generations in each of the tactical weapons categories. Such an approach would not preclude licensing; but it would subordinate licensing within a larger co-developmental context. The current example of the two trans-Atlantic collaborations on ten-ton engines is useful, since these projects involve both co-development of the total package and specific licensing within that package.

The "interdependence" concept, formulated by DDR&E at the beginning of this decade, called essentially for separate and independent design and development, followed by competitive selection of a single system, for which production would then be licensed in each of the user countries. The current European industrial concept calls for initial agreement on joint specifications, followed by collaborative R&D and, ultimately a production program that typically involves two (or more) final assembly lines supported by a specialized division and cross-vending of subassembles and components. Licensing has an important role in this process, especially in cases where existing major sub-systems and assemblies (e.g. engines, avionics, homing heads, etc.) can be incorporated in a new system. Although this kind of approach may not, in many instances, be accepted in the United States, its long process of evolution in the European defense industries must be noted. Also of great potential importance is the European evolution of ad hoc inter-governmental organizations, such as NAMMO and NAMMA, to coordinate government oversight of the resulting industrial consortia. Experience to date in the licensing of Roland II to the United States demonstrates the need for the establishment of inter-governmental authorities to resolve technical issues and establish industrial product and manufacturing specifications and standards, contracting procedures, and security regulations in advance of major licenses or other collaborative projects. The tendency to push the resolution of these problems down to the industrial level is virtually certain to create frictions which could otherwise be avoided. The intermediary role of government offices or laboratories can be extremely beneficial, as demonstrated by the use of a USAF system program office (SPO) as a clearinghouse for the resolution not only of technical but of management issues. The role of the USAF SPO in the case of the AVS program of the mid-1960s, as well as the activities of the F-16 SPO at the present time, indicate the value of such a group to oversee the work of industry.

Although it would be difficult to support, on any general basis, claims of inferior workmanship by European industry compared with the United States in high-technology fields, there is no question whatever that differences in scale of R&D funding and production have led to U.S. advances in manufacturing development which inevitably affect product development. For this reason, it is often difficult to carry out adaptations needed in licensed production from Europe to the United States; and it is essential that these issues be resolved by government authorities before contracting to industry. The U.S. network of specialized service commands and laboratories can play an important role in this regard.

Another key point to observe, in reading the sections which follow, is that virtually all of the new or recent European projects in high-technology fields are collaborative rather than national, a trend which favors greater efficiency and unification in NATO defense industries in the long run. Collaborative arrangements made with consortia rather than national industries will demonstrate U.S. interest in encouraging and strengthening this trend. The establishment of intra-European consortia is rapidly resulting in greater standardization in Second ATAF, Premier Commandement Aerienne Tactique (1^{er} CATAC), and other forces assigned to the Central European front. For this reason, the consortia represent a very logical focal point for new U.S. initiatives.

Related to this is the urgent necessity for U.S. industry to work with leading defense firms in Britain, France, and Germany rather than companies that are geographically or industrially peripheral. The European defense industries have been very concerned over the differences in rates of productivity, both among the European countries and in comparison with the United States. In order to increase the overall level of European productivity, they have been anxious to achieve economies of scale through collaboration, especially in high-technology programs. Consequently, reaction to the F-16 program has been adverse, because it harms total European productivity in two ways: first by requiring capital investment in relatively small national industries where there is little long-term prospect for sustained aviation production; and second, by by-passing the major, well-capitalized industries of the three large countries, where additional work would lead to fuller utilization of their own capital resources. For future U.S. initiatives in standardization, this is a key issue, requiring primary concentration on the major specialized industries.

With regard to French industrial attitudes, which are important to a widening of trans-Atlantic defense industrial collaboration, the relative ease with which Franco-American agreements have been reached on the CFM-56 and Mercure 200 civil programs indicates the absence of any basic psychological impediment to major collaborations, especially those that offer some hope of long-term beneficial effects on industrial capabilities and employment stability. The lessons to be derived from the Franco-American civil aircraft negotiations are related to the issues of: the promise of increasing work for under-utilized production lines; potential access to the American market; and collaboration on a relatively full-partnership basis. To the extent that these conditions can be met in collaboration for defense standardization, French cooperation can probably be expected.

On the related subject of EPG, national perceptions vary widely. While German and British attitudes may not differ too widely from those of Washington, the declared French policy view is that EPG, far from being simply the European side of a trans-Atlantic dumbbell, is first and foremost an effort to coordinate European military requirements and programs and protect the European defense market against further U.S. encroachments. Behind the declaratory policy level, however, there appears to be a genuine French interest in greater trans-Atlantic cooperation, if the United States is responsive, in particular, to the issues of:

employment and worksharing

R&D collaboration

access to the U.S. market

the 50% export requirement

prior and continuing inter-governmental supervision to avoid frictions at the industrial level.

Finally, the issue of domestic employment is virtually fundamental in current European planning. Although it may not be part of the rhetoric of defense ministers, it is certainly of prime consideration in the voting patterns of parliaments. The issue of stable employment permeates the defense industrial sector in Western Europe and must not be underestimated.

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I. The European Military Aircraft Industry

A. The European Collaborative Aircraft Scene: Some Introductory Observations

B. The National Industries

C. The Aircraft Engine Industry

A. The European Collaborative Aircraft Scene: Some Introductory Observations

A. The European Collaborative Aircraft Scene: Some Introductory Observations

Part I as a whole will deal, in considerable detail, with the programs and capabilities of each national aircraft industry in the NATO countries and France. A recurring theme, in each of these national industry descriptions, will be the increasing role of multinational collaboration, especially within Europe. Even in France, where industrial policies are totally nationalistic, collaborative programs have assumed great importance.

This opening section provides a brief overview of the collaborative trend in Western Europe, in order to provide a much-needed perspective for the national sections. This opening section is qualitative in nature, to complement the more quantitative discussions which follow.

This discussion is especially important as a prelude to assessing industrial opportunities for NATO standardization - whether they involve licensing or other collaborative forms. Broad aspects will be discussed here in Section A, and detailed arrangements will be covered under the national headings in Section B.

Any major new American overture to achieve greater standardization must take account of the collaborative forms that have already emerged in Europe. It would be useless to pretend that the intra-European collaborative process does not exist or to ignore it in formulating U.S. initiatives. The European collaborative experiment has evolved some relatively new industrial forms which need to be recognized and understood.

Starting in the late 1960s, a series of papers was circulated within the EC Secretariat concerning the long-term goal of integrating the European aerospace industry. According to the formulation of EC planners, the 1960s were years of rationalizing the different national aerospace industries, involving the consolidation and merger of numerous smaller companies into large, unified national aerospace companies. The 1970s were perceived as a decade in which these large national entities would engage in a series of major collaborative programs, leading to increasing operational unity. As these projects advanced, they would make it possible, in the 1980s, to achieve actual consolidation throughout Europe, through the creation of perhaps two airframe companies and two engine companies for the entire community. Although these veiws were advanced by EC planners rather than by national ministries or industries, they were treated with considerable interest.

Among most observers of the European aerospace industry, the goal of full consolidation in the 1980s now seems unrealistic, at least partly as a result of difficulties experienced to date in the management of large-scale European collaborative projects. Even the most doubtful (especially in France) would agree, however, that collaboration has become the only serious means now available for the mounting of major new aircraft or missile programs in Western Europe; and there is general recognition that discussions and negotiations of collaborative ventures are now more numerous than they have ever been.

The arguments about the efficiency of multinational or even bilateral projects, compared with separate national programs, are well known. Those who are most critical of multinational efforts argue that the cost, compared with a national effort, will be about 50% higher, a figure which is almost certainly excessive.* One frequently mentioned difficulty is that, even if the prime contractor is completely tooled for the program, much of the work must be assigned to

* One formula now current is: $C_N = C_O\sqrt{N}$, where C_N is the cost of a multilateral program involving N countries; and C_O is the cost of a national program.

inexperienced subcontractors, resulting in inefficient use of resources. In addition, companies with the same specialities - e.g. MATRA and Hawker Siddeley in the Martel missile program - must share work which either one of them could perform adequately with existing personnel and facilities. Another frequently mentioned problem is the difficulty of adequate collaboration between aerospace firms and the electronic companies who act as major subcontractors. These relations are difficult, even in a national setting, but the multinational aspect seems to increase the problems.

Four projects are especially noteworthy:

> Concorde, the Anglo-French SST program, begun under agreements signed between the two governments in 1962, and executed by British Aircraft Corporation and Aerospatiale for the airframe and Rolls-Royce and SNECMA for the engines. In the Concorde program, there are two assembly lines - one each in Toulouse and Filton - but each Concorde is assembled from components and equipment manufactured in equal shares by the two partners. (For example, BAC has the electrical systems and Aerospatiale has the hydraulic systems.)
>
> Jaguar, the Anglo-French training and attack aircraft, for which the "brass plate" company SEPECAT was formed in 1966, mainly as a corporate shell for collaboration between British Aircraft Corporation and Dassault, a program involving at least 400 aircraft, of which more than 250 are already delivered.

MRCA, the European multi-role combat circraft, which effectively began with the formation of Panavia, an international industrial management company, operating under a governmental agency formed jointly by Britain, German, and Italy. Panavia and its corresponding engine group in turn act as program managers for work performed by British Aircraft Corporation, Messerschmitt-Boelkow-Blohm, and Aeritalia for airframes and Rolls-Royce and MTU for engines. This program is now virtually committed to the production of more than 800 swing-wing combat aircraft, and seven of nine development aircraft have already flown.

Airbus Industrie, established in the late 1960s to manage the development, manufacture and marketing of the wide-body A-300 medium-range civil transport by Aerospatiale in France, MBB and VFW-Fokker in Germany, Hawker Siddeley in Britain, and other participants in the Netherlands and Spain. To date, only some 32 orders and 24 options have been received. It may be worth noting that Aerospatiale, which owns 47% of Airbus Industrie, has made a study of a military version of Airbus which would have a maximum takeoff weight of 157.5 tons and which would be designed mainly for in-flight refueling of Jaguar as well as for long-haul cargo and personnel transport.

A learning curve in collaborative management is apparent in this succession of programs. In the Concorde project, the first of the three, the airframe and engine companies in the two countries were simply instructed to cooperate, under the terms of an umbrella agreement between the two governments. The necessary technical and manufacturing liaisons were established at all levels in the airframe and engine firms, but without much of a formal management structure. Nevertheless, a collaborative development and manufacturing project of considerable sophistication and complexity was carried through to successful completion. In the process, the participants, especially BAC, learned a great deal about the management of collaborative ventures.

The Jaguar program began as a collaboration for a training and tactical fighter aircraft for the British and French air forces, to be developed and built by BAC in partnership with Breguet, prior to the Dassault-Breguet merger. Based on experience gained in the Concorde program, a corporate shell, SEPECAT, was established in France as legal contractor of the two governments; and an engine consortium was established in England as the focus for collaboration on the Adour engine to power Jaguar. In essence the progression from Concorde to Jaguar led to the use of single corporate entity as contractor of the sponsoring governments, even though it was not staffed by its own personnel but served only as a legal entity in which the participating companies could coordinate their activities. In spite of difficulties of both a technical and management nature, probably the most severe of which was the merger of Breguet with Dassault after the program had begun, the Jaguar project is now committed to 400 aircraft, of which 250 have already been delivered and 24 export orders have been obtained.

The most impressive collaborative effort to date is the British-German-Italian program to develop and manufacture the MRCA multi-role combat aircraft. In spite of severe resistance both within and outside the MRCA consortium, this program is now firmly set for manufacture of 807 aircraft -

385 for Britain, 322 for West Germany, and 100 for Italy.

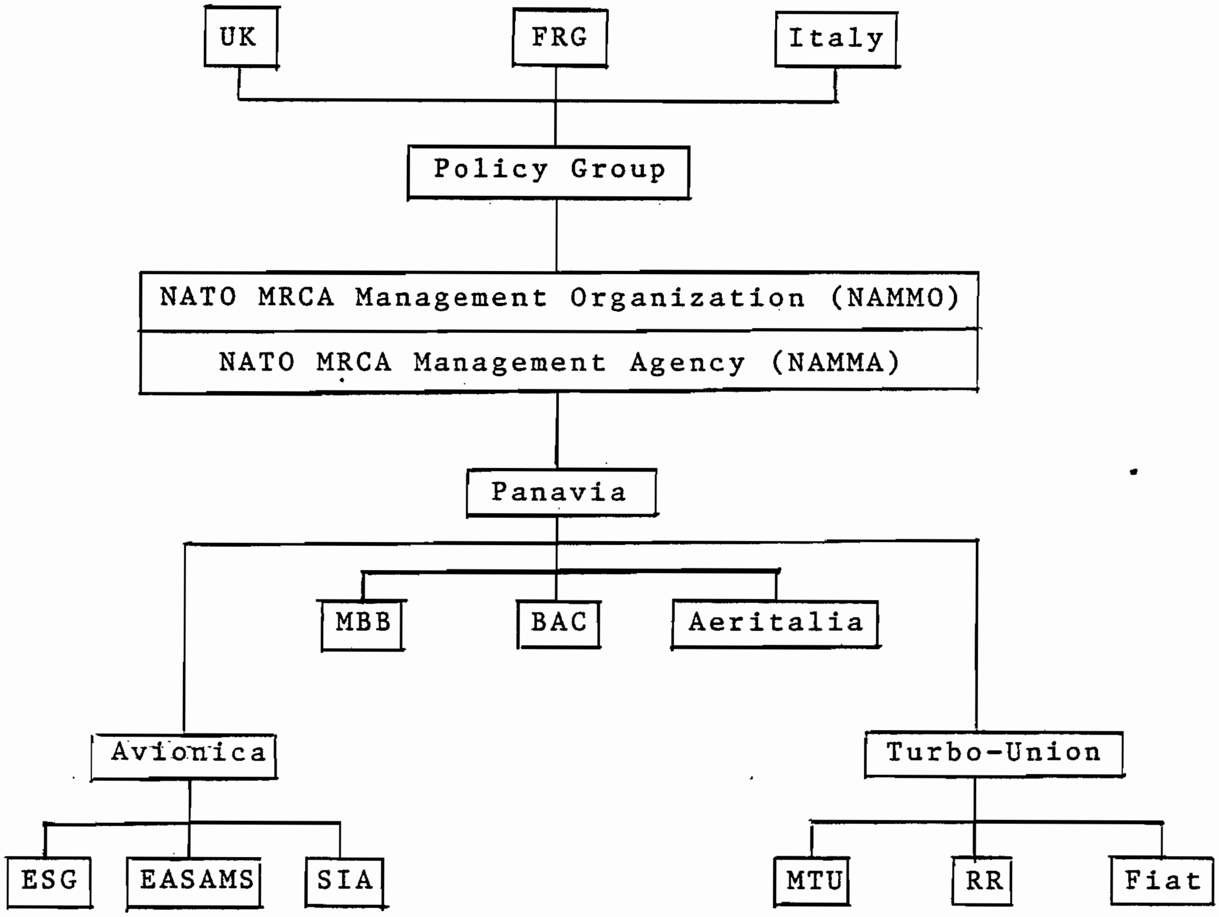
It is instructive to read some of the forecasts that were written in the late 1960s by American observers, pointing out the likelihood that success in the MRCA project would preclude British or German purchases of the F-14 and F-15 from the United States and leave the U.S. industry only with the prospect of the NATO mini-consortium of the Netherlands, Belgium, Norway, and Denmark. This forecast has, at least so far, been amply fulfilled.

In the MRCA case, the British and German governments organized a NATO management structure which oversees the work of a genuine program management company, Panavia, staffed independently rather than by managements borrowed from the participating industrial partners. (See Figure 1). Panavia acts as prime contractor to the NATO management agency to bring together all of the airframe and electronic work performed by BAC, MBB, and Aeritalia; and there is also a separate engine program management company to coordinate the British and German engine manufacturing.

At the beginning of the decade, the aircraft being offered by Western Europe on world markets were mainly national products. Currently, Panavia's sales teams are out with proposals for export versions of MRCA; and two squadrons of Jaguars have been ordered by the less developed countries. On this point, it seems likely that Jaguar's export potential would have been realized sooner were it not for inherent conflicts which developed within France between sales of Mirage and Jaguar after the Dassault-Breguet merger. Some export markets were probably closed initially to Jaguar. Now, however, export interest is belatedly emerging.

Figure 1

MRCA and Panavia Organization



British participants in the successive aerospace consortia argue that the costs of these programs are beginning to approximate those of national programs. Currently, a number of studies are in progress to make more precise comparisons of this kind. Current estimates of the differential range from 33% down to as low as 5% within Western Europe.

Of all the consortia, Panavia is the most interesting and important model, because it offers the greatest potential for follow-on projects, and also because it is a trilateral rather than merely bilateral venture. As noted earlier, the German, British, and Italian governments have set up a supra-national authority known as NAMMO (NATO MRCA Management Organization) and its executive agency NAMMA (NATO MRCA Management Agency) to oversee the work of Panavia. The two very significant points about Panavia are: first, that it has its own independent and very able management; and second, that it is continuing to study potential follow-on activities for military aircraft that would be complementary to MRCA. Although many Panavia employees have been drawn from the parent companies, a substantial effort has been made to encourage Panavia members to think of themselves first as part of the Panavia organization, responsible only to NAMMO and NAMMA. There has also been a strong effort, within Panavia, to encourage the view that the Panavia organization will survive MRCA, based on the introduction of new programs.

Some significance is also attached to the fact that Panavia has supervised the work of contractors and subcontractors not only in Europe but also in the United States - especially for the Texas Instruments airborne radar. As of 1972, Panavia had about 160 employees consisting of management, technical, legal, and other white collar personnel. English is the official language of the company.

Although Panavia has long been studying potential follow-on projects, its attempts are impeded by the constantly shifting alignments of companies and national governments with regard to other collaborations. Both BAC and MBB, for example, have investigated other alignments for future civil and military aircraft; and it is always difficult for Panavia to compete with its own shareholders for future activities. Gero Madelung, Panavia's managing director, has stressed the importance of aircraft engines as the starting point for planning any future civil or military project, a factor which has strongly nationalistic implications.

Like most other major defense programs, Panavia's MRCA project has suffered from cost escalation, a problem which constitutes the major threat to the ultimate size of the project. It is very difficult to get a clear estimate of MRCA unit prices, but it does seem likely that they are well in excess of $10 million per aircraft, making the MRCA price-comparable with the F-14 and F-15. Given the political commitment that has been made to this program in Britain and Germany, there is little likelihood of withdrawal from the project by either partner. However, the escalation in unit costs certainly creates some likelihood that national impositions of ceilings on total procurement budgets will result in reductions in total orders or stretch-outs of the program (e.g. from 10-11 aircraft per month down to six or eight). In this event, there could be a search, both by the British and German military services, for a cheaper aircraft to augment a reduced MRCA inventory. If this were the case, the F-16 might become a strong candidate, except among those planners whose prejudices against single engine aircraft are too strong to permit such an interest.

If there were such a reduction in total orders, a number of different possibilities might emerge, involving either the U.S. industry (e.g. the F-16) or the French industry (e.g. Mirage 2000 or a Super-Mirage). Although this topic is highly speculative, it should be mentioned here because of the considerable policy sensitivities surrounding such a prospect and the need for recognition of these sensitivities.

The British industrial leadership (e.g. Allen Greenwood, Chairman of BAC) has heralded the recent French cancellation of Avion Combat de Futur (ACF) as an opportunity to coordinate two military programs that have been out of phase. (The ACF was to have been a highly advanced twin-engine fighter.) Britain would possibly welcome some form of French participation in Panavia, especially in relation to the proposed air defense version (ADV) of MRCA.

In the MRCA program, the British goal at present is to purchase 385 aircraft, of which 165 would be the air defense version. Prior to the apparently firm commitment of the British parliament to the ADV, one remote possibility was the prospect of a Mirage powered by the RB-199 (i.e. the Rolls-Royce-Panavia power plant rather than the French M-53) to provide the RAF's needed air defense and air-to-air capability. In such a case, Turbo-Union (Panavia's engine equivalent) and SNECMA could have joined together in a work-sharing arrangement.

For Germany, as prices continue to escalate, there may be a question about the extent to which MRCA can serve as a replacement in all the Luftwaffe squadrons now flying the F-104G. An alternative might be the purchase of a cheaper aircraft for use in some of these squadrons. In such a case, the German policy preference would probably be to emphasize the role of Panavia in such an aircraft. Alternatives might be to draw on the corporate role of the German-Dutch firm, VFW-Fokker, whose Dutch arm is the major subcontractor on the F-16 project; or to look to France for collaboration on one of the later Mirage versions - or, best of all from the German standpoint - some widely multilateralized project that incorporates many of the elements above. The hope has occasionally been expressed, in German industry, that an American role in Panavia might ultimately emerge.

In addition to Panavia, Sepecat, and Airbus Industrie, a few other models of multinational aerospace collaboration deserve mention. One of these is Heli-Europe Industries Limited, a joint company established in 1973 by Aerospatiale and Westland. This company acts as clearinghouse for the industrial cooperation between the two companies, especially with regard to future collaborative programs in the helicopter field. With regard to helicopters, market studies performed for U.S. industry have indicated that Europe will meet its own civil and military requirements in the next decade and considers its capabilities equal to those of the United States. Through license agreements, there has historically been a very important role for U.S. technology in European helicopter development and manufacture, but this is now diminishing. The success of Aerospatiale and Westland in cartelizing the military market is of special importance. There may, however, be opportunities for license agreements from the U.S. to Europe, particularly in the dynamic elements of the helicopter. The cross-purchasing, between Britain and France, of Lynx, Gazelle, and Puma for different missions represents what Thomas Callaghan would term a "common market" approach to collaboration and standardization. As Table 1 indicates, U.S. licenses to Europe for helicopter production over the 20-year period 1955-1975 have been of vital importance. For the future, however, it seems very unlikely that such a share will be

Table 1

Military Helicopter Sales in Western Europe, 1955-1975
(numbers of units)

	France	Italy	Germany	U.K.	Other	Total
Helicopters of European Origin	1,000	25	340	770	465	2,600 (45%)
U. S. Helicopters Built Under License in Europe (totally or partially)	235	580	500	970	235	2,520 (45%)
Helicopters Imported From U. S.	245	15	190	20	275	745 (15%)
Totals	1,480	620	1,030	1,760	975	5,865

Source: French aerospace industry

repeated. The European industry has achieved a remarkable degree of cooperation, and the technical level is very high.

Another important collaboration is the Franco-German Alphajet program, in which the industrial partners are VFW-Fokker in Germany and Dassault-Breguet in France. This program is discussed in detail in the French and German sections. Here, it is worthwhile only to point out that this is a major program, involving collaborative production of over 400 trainer and close support aircraft for Armee de l'Air and Luftwaffe, not including potential export orders.

In Part VI, which raises some critical industrial issues which will affect U.S. standardization initiatives, the potential U.S. role in the European collaborative trend will be discussed. Also discussed in Part VI is the European view of American initiatives which run counter to that trend, especially the F-16 consortium, which is widely viewed as having a negative impact on the total European industry's strength and productivity. That section of the report will also deal with the new French interest in direct bilateral cooperation with the United States on civil transports, and the implications of that trend for Alliance standardization.

Some gross comparisons of size, prepared by the EC Commission in 1974, based on 1971 figures, are shown in Tables 2 and 3. Although these are now somewhat out of date, they are essentially accurate in terms of broad comparisons and have the virtue of being based on European rather than U.S. data. These figures remain compelling to Europe in its search for consolidation.

Table 2

European Airframe, Missile and Aircraft Equipment Sectors

Output and Employment (1971)

	Britain	France	Germany	Italy[a]	Holland	Belgium	EEC total	USA
Airframes and Missiles Output[b] ($ million)	896	937	598[c]	123	132	42	2,728	n.a.
Employment (000)	100	61.9	38.1	16.8	8	4.1	226	588
Equipment Output[a]	77	189	231[d]	45	-	20	562	n.a.
Employment (000)	58	23.6	11.7	5.6	-	0.8	99	228

a Estimated.

b Excluding intra-industry sales.

c Includes aero-engines.

d Provisional.

Source: IISS 1975 from EC Commission.

Table 3

European Aero-engine Companies, Output, and Employment

Company	Country	Turnover (1971) $ million	Employees (1972)	Ownership
Rolls-Royce (1971)	Britain	937[a]	64,000	Government
SNECMA	France	296	14,600	80% Government 10% United Aircraft (Pratt & Whitney)
MTU	Germany	118	5,750	50% Daimler-Benz 50% MAN
Turbomeca	France	67	4,000	
Fiat	Italy	n.a.	2,500[b]	
Alfa Romeo	Italy	50[c]	2,000[c]	100% IRI-Finmeccanica
Piaggio	Italy	19	1,300	

[a] 1972
[b] Aviation divisions only: total turnover in 1971 was $2,910 million, and workers employed numbered 182,500
[c] Aero-engines only: total turnover was $418 million and workers employed 22,750.

Output and Employment (1971)

	Britain	France	Germany	Italy	Holland	Belgium	EEC total	USA
Output ($ million)	661	292	n.a.	56	-	16	1,025[a]	n.a.
% of country's aerospace output	40	21		25	-	19	24	
Employment (000)	62	20.4	7	5.6	-	1.4	96.4	153.4
% of country's aerospace employment	28	19	12	20		22	24	16

[a] Less Germany.

Source: EC Commission

Table 4

Principal West European and American Airframe and Missile Companies

Company	Country	Turnover (1971) ($ million)	Employees (1972)	Ownership
EUROPE				
Société Nationale des Industries Aérospatiales (Aérospatiale)	France	706	44,000	nationalized (with some participation by private banks)
Hawker-Siddeley Aviation	Britain	567[a]	(25,000)[a]	parts of the Hawker-Siddeley Group
Hawker-Siddeley Dynamics	Britain		(7,000)	
British Aircraft Corporation (BAC)	Britain	382	34,000	50% GEC 50% Vickers
Messerschmitt-Bölkow-Blohm (MBB)	Germany	317	18,000	24·85% Blohm family 21·3% Messerschmitt family 13·45% Bölkow family 8·9% Boeing 8·9% Aérospatiale 8·35% Siemens 8·35% Thyssen-Hütte 5·91% Bavarian Reconstruction Finance Institute
VFW/Fokker	Germany/Holland	293	19,200[b]	17·6 Krupp 13·15% United Aircraft 10·0% Northrop
Dassault-Brégeut	France	316	15,000	89% Société Centrale d'Etude Marcel Dassault
Westland	Britain	139	12,500[c]	
Aeritalia	Italy	83[d]	8,250	50% Fiat 50% Finmeccanica/IRI
Dornier	Germany	111	7,700	
Short Bros. & Harland	Britain	50[d]	6,000	69½% government 15¼% Rolls-Royce 15¼% Harland & Wolff
Fairey	Britain/Belgium	43	3,800[e]	
Matra	France	70	3,000	
Scottish Aviation	Britain	n.a.	2,500	100% Laird Group
Agusta	Italy	77	2,400	32% EFIM (state holding company)
SABCA	Belgium	n.a.	2,000	50% Dassault 50% Fokker
Aermacchi	Italy	25	1,350	20% Lockheed
UNITED STATES				
McDonnell Douglas	United States	2,700	92,800	
Lockheed	United States	2,470	71,500	
Boeing	United States	2,370	64,000	
General Dynamics	United States	1,539	32,800	

[a] Turnover of the whole group is $1,025 million and number of employees worldwide 79,000.
[b] 6,100 are employed in Holland.
[c] Of whom about 6,000 are employed in helicopter manufacture.
[d] 1970.
[e] Of whom 1,400 are employed in Belgium.

Source: IISS 1975 from EC Commission

Table 5

European Aerospace Industry -
Defense Turnover as % of Total Turnover

(average for 1968-69)

	Defense Turnover		
	Domestic	Export	Total
Britain	41	13	54[a]
France	46	27	73[a]
Germany	97	-	97[a]
Italy	n.a.	n.a.	68
Holland	21	n.a.	n.a.
Belgium	34	n.a.	n.a.
USA	75	4	79

Source: IISS 1975 from EC Commission

B. The National Industries

1. The British Aircraft Industry

2. The French Aircraft Industry

3. The German Aircraft Industry

4. The Italian Aircraft Industry

1. The British Aircraft Industry

The British aircraft industry remains the largest of all the European aircraft industries, about the size of all of the other countries combined. The British industry currently employs more than 200,000 workers compared to about 100,000 in France, slightly over 50,000 in West Germany, and far less in any of the other European countries. In view of the fact that the annual turnover of the British and French industries are not very different, these employment figures are often used to argue that the British industry is significantly less productive than the French or German industries. Although, as subsequent discussion and tabular data will indicate, the British industry probably is somewhat less productive than the others, it also seems likely that available data from the European community are distorted, due partly to the fact that the French aircraft industry subcontracts much of its production to vendors who are classified as being outside the aircraft industry. As a result, the industry turnover is credited to a workforce which is smaller than what has actually been employed. In Britain, by contrast, there has been an excessive tendency to concentrate and integrate the industry, bringing many components and functions into the prime contractor's facilities which are purchased from major subcontractors or vendors in other countries. This practice has a genuinely negative effect on productivity, in addition to creating a statistical distortion. The productivity issue becomes cricially important in planning international projects.

On the basis of gross industrial data, the EC Commission has prepared the comparative productivity data shown in Table 6. This table suggests

Table 6

European Aerospace Industry - Output and Employment

		Britain	France	Germany
Output	1964	1,345	842	270
($m at current	1969	1,647	1,252	598
prices)	1971	1,634	1,418	829
Employment (000)	1964	261	(90)	28
	1969	237	99·9	55·5
	1971	220	105·9	56·9
Output per man ($)	1964	5,150	(9,350)	9,650
	1969	6,950	12,530	10,800
	1971	7,430	13,400	14,600
Output per man as	1964	77	139	144
% of 6 countries'	1969	78·5	141	122
average	1971	73	132	144
Growth in output	1964	100	(100)	100
per man	1969	134	(134)	112
(1964 = 100)	1971	144	(142)	182

SOURCES: 1964 figures: Harlow (see note 45). Figures in brackets are estimates. In this author's opinion, Harlow over-estimated output in Italy and Holland and employment in Belgium.
Other figures: EEC Commission.

Source: IISS, 1975

that over the last decade, the output per man in the British aircraft industry has been roughly one-half that of their French and German counterparts. Worker productivity is a difficult problem for all of British industry but may not be as bad as it is portrayed here. British economists have attacked, with considerable justification, the use of gross sales per person in the industry as a measure of productivity. The difficulty is that such a measure makes no allowance for equipment and parts purchased from vendors outside the industry. Because the French engine and equipment sectors are much weaker than those of Britain, there is a great deal of purchasing from outside the French aircraft industry, yet the value of these purchased items is assigned to workers within the industry, which leads to a skewed presentation of productivity. Nevertheless, as shown in Table 7 , even when adjustments are made to show comparative value added per worker, a factor which eliminates purchased items, the French value added per man is still 39% above the British figure.

The quantitative demand for military and civil aircraft in Britain, as in the rest of Western Europe, is so low compared with the United States, that major new investment in large-size plants with modern equipment has not been viewed as a justifiable expense. As a result, even though there has been a great deal of administrative amalgamation of the British aircraft industry, the manufacturing work itself is still scattered among many small plants throughout England. One British observer pointed out recently that no British aircraft plant employs as many as 10,000 workers. The result is duplication of effort, inefficiencies of manufacturing due to low capitalization and excessively high labor content, and other factors related to limited scale and an inactive industry.

Table 7

SBAC Adjustment of EEC Aerospace Productivity Figures

	France AU**(£)	France/UK ratio	UK AU(£)
EEC sales per employee	13,167(5,480)	2.00	6,566(2,740)
Value added per employee	9,317(3,880)	1.39	6,699(2,780)
Corrected for production run	9,317(3,880)	1.17	7,841(3,270)
Average wage	5,556(2,320)	1.28	4,350(1,810)
Personnel cost per employee	7,496(3,120)	1.53	4,900(2,040)
Value added per unit of personnel cost***	1.24	0.77	1.60

*In 1969 prices.

**EEC Accounting Units converted at 1969 rate of AU1 = £0.416.
Data provided by SBAC

***Corrected for French production run.

Source: Society of British Aerospace Constructors, 1975

Other than Rolls-Royce, which is discussed in the section on aircraft engines, the principal aircraft manufacturing firms in Britain are:

The Hawker Siddeley Group, consisting of Hawker Siddeley Aviation with about 25,000 employees and Hawker Siddeley Dynamics with about 7,000 employees.

British Aircraft Corporation, with about 34,000 employees.

Westland, a helicopter manufacturing firm, with about 12,000.

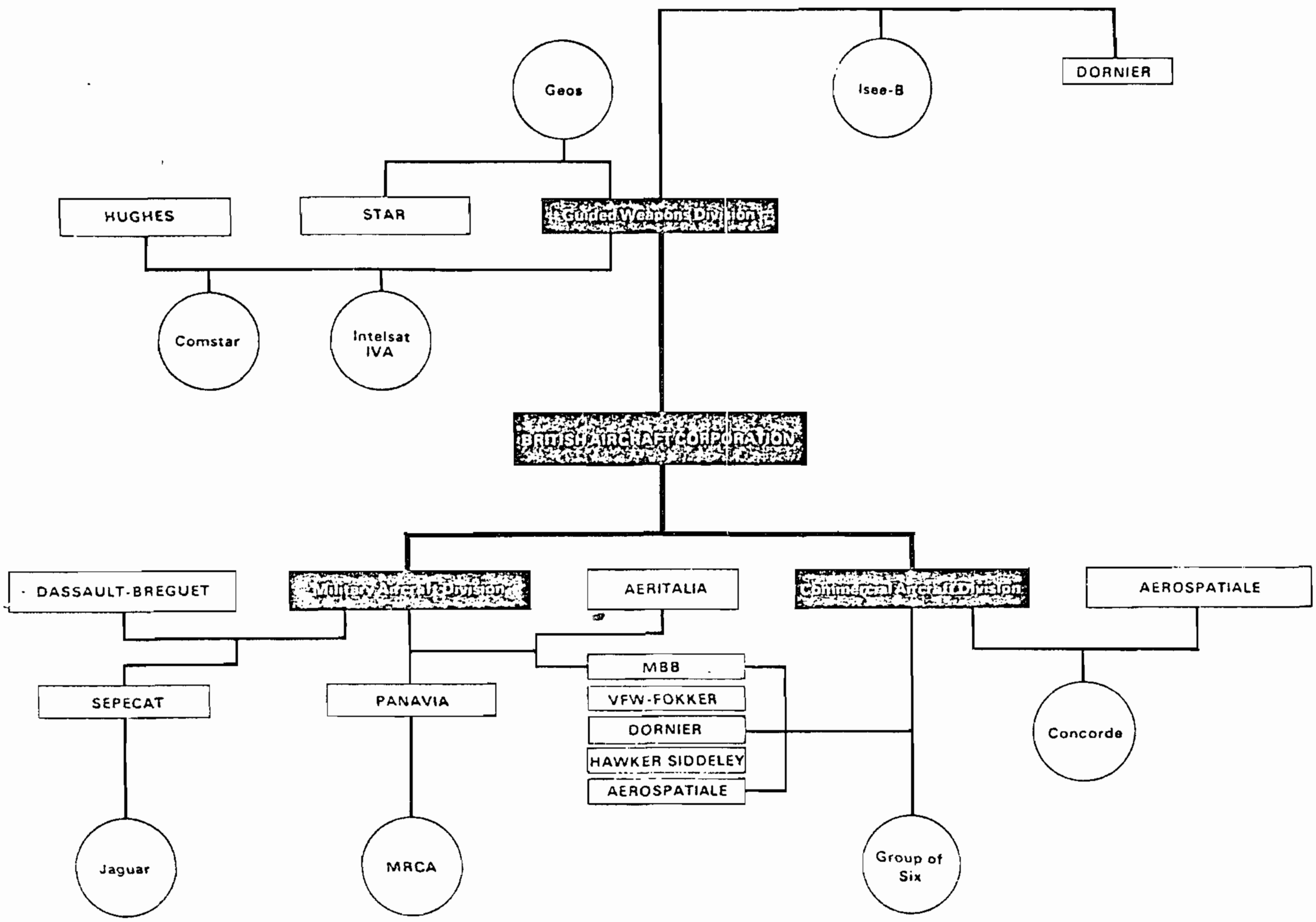
Shorts Brothers and Harland, a firm which has already largely been nationalized, with about 6,000.

It is becoming increasingly difficult to discuss the British industry as an entity separate from European international collaboration. Shown in Figure 2 is a presentation of BAC's role in various international consortia of the last decade. The management of BAC, including such luminaries as Sir George Edwards and Allen Greenwood, has been instrumental in the creation and successful evolution of intra-European aerospace collaboration. Their evolving knowledge of how to organize and manage such consortia could be of considerable help in any future U.S. collaborative ventures in Western Europe.

Until the process of nationalization is completed, BAC remains under the joint ownership of General Electric Company, Ltd. of England and Vickers, Ltd. The company is organized in three main divisions: the Commercial Aircraft Division, Military Aircraft Division, and Guided Weapons Division, each of which is headed by separate and distinct management. The Commercial Aircraft

Figure 2

Schematic of BAC's International Relationships



Source: Flight International, 2 October 1975

Division, with some 12,000 employees, is involved mainly on the Concorde program and the BAC-111 short-haul passenger transport. Although there are a few remaining outstanding orders for the 111, the program is obviously nearing its end; and the heavy commitment of funding and manpower to development and production of Concorde has become an extremely painful problem due to the absence of orders after the initial 16 aircraft are completed. Consequently, the outlook for BAC's Commercial Aircraft Division is a very pessimistic one, leading to considerable concern about the future of the workforce. The Military Aircraft Division, also with about 12,000 employees, is the British participant in both the Jaguar and MRCA programs, whose prospects remain fairly secure. Jaguar is currently the British industry's biggest production program, with 202 on order for the UK, 170 for France, and 12 each for Ecuador and Oman. In addition there are still orders outstanding for the BAC 167 Strikemaster, a light counter-insurgency and ground-attack aircraft based on the earlier Jet Provost trainer.

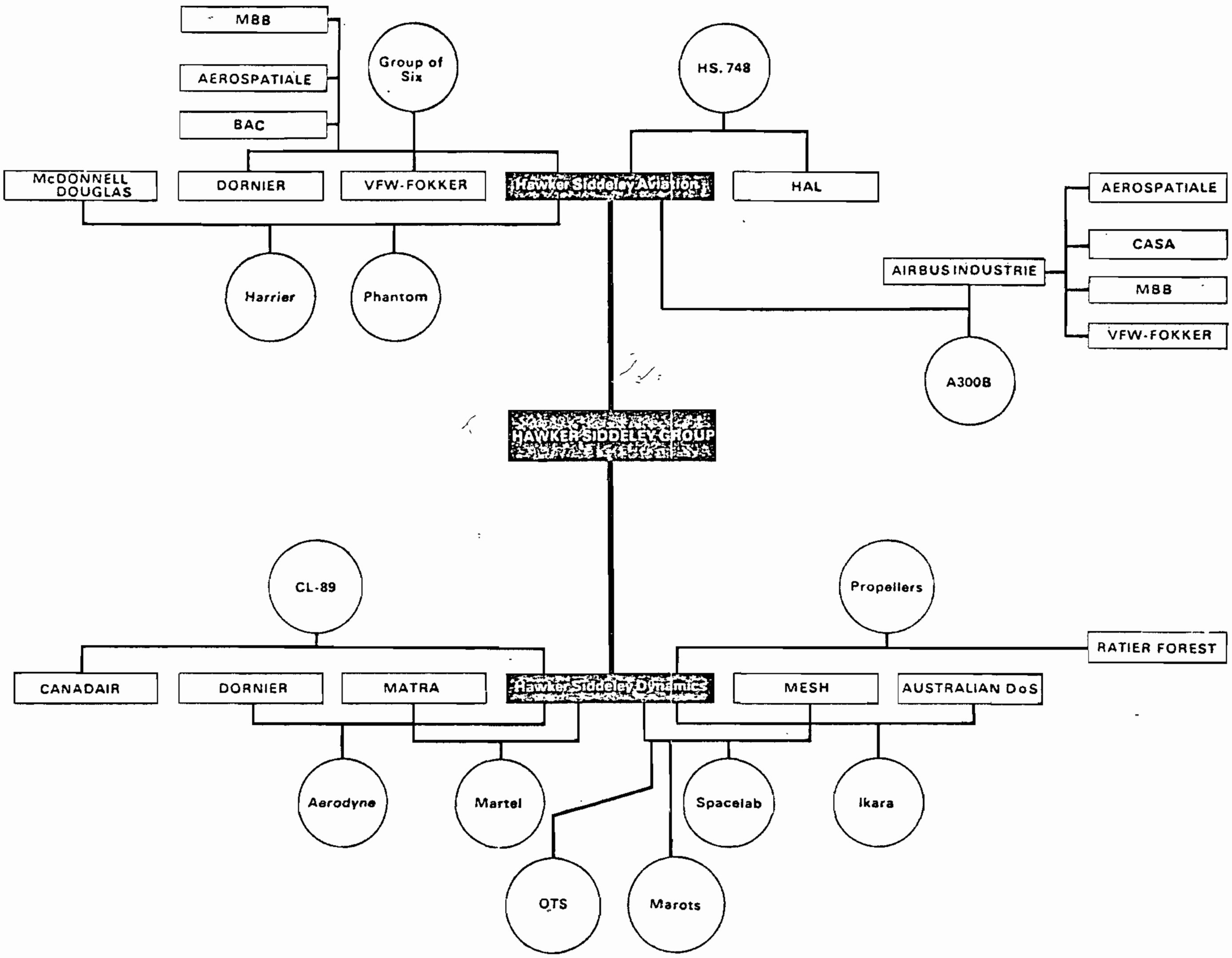
Within the Hawker Siddeley Group, of particular interest, in this section of the report, is Hawker Siddeley Aviation, Ltd., with headquarters at Kingston-upon-Thames. On the civil side, Hawker Siddeley has developed and is manufacturing the HS-125 business jet, HS-748 turboprop transport, and the Trident medium-range civil transport. (There are apparently a few orders still outstanding for the latest version of the Super Trident 3B, especially by the Civil Aviation Administration of China). On the military side, the most active new or current programs are the Hawker-Siddeley Hawk multi-purpose jet trainer and the Harrier for the Royal Navy and the U.S. Marine Corps. The Hawk, which can serve both as a straight-through trainer or a ground-attack aircraft, is powered by a non-afterburning version of the Rolls-Royce Turbomeca Adour engine.

The RAF has ordered 176 of these aircraft, of which deliveries are due to start in late 1976. Finally, Hawker Siddeley is also responsible for the Nimrod maritime reconnaissance aircraft, now in production.

Possibly the most innovative European military aerospace program of the post-war period has been the Hawker Siddeley Harrier VTOL fighter. This aircraft is also the most significant example of U.S. direct purchase and licensing from Western Europe. The initial U.S. order for the AV-8A - that is, the existing Hawker Siddeley version - has been 110 aircraft. There is also, however, a strong potential for future licensing rights to McDonnell Douglas for an improved AV-8B version; and conceivable future co-development activities for a more advanced aircraft. Harrier presents the most compelling single success story of European penetration of the U.S. military market of the last decade. In late July 1976, the Pentagon authorized the development and testing of two prototypes of the AV-8B Harrier by McDonnell Douglas. If the new development is successful, the Marine Corps has announced its plans to purchase "several hundred" of the aircraft, perhaps as many as 340. Hawker Siddeley would be a major subcontractor on the program, and the Pentagon has already specified "mutual cooperation in the procurement of supplies and services and the exchange of information." The major change in the proposed AV-8B, compared with the AV-8A, lies in the use of a higher aspect ratio wing with a supercritical airfoil and the greater use of composite materials, especially graphite epoxy, as a means of reducing structural weight. Other changes include a relocated undercarriage, extra hardpoints, and larger inlets. A thicker wing section permits an increase in internal fuel tankage from 5,000 pounds to well over 7,000 pounds. Furthermore, improvements in overall lift performance have been achieved for both vertical and STOL modes. In addition, Rolls-Royce is providing further modification of the Pegasus engine,

Figure 3

Schematic of Hawker Siddeley's International Relationships



Source: Flight International, 2 October 1975 to increase thrust from about 21,500 pounds up to 22,500. Third-country export of such an aircraft, and work-sharing on it, could become an issue in the early future.

On the European side, the most important recent decision regarding Harrier is the announcement, in May 1975, of a decision to proceed with full development of a maritime version, the Sea Harrier. The initial requirement is for 25 aircraft to equip the Royal Navy's new Invincible class of through-deck cruisers. The flight phase of the Sea Harrier development program will begin in mid-1977 and will continue for 18 months. The Sea Harrier is changed very little from the basic Harrier for the Royal Air Force. Changes involve some nose and cockpit redesign to accommodate different sensors and instruments. There will presumably be a lag at Kingston of about six months between completion of existing Harrier orders and build-up of Sea Harrier production, but it is the view of Hawker Siddeley that the build-up of Hawk production will absorb any slack in capacity.

There is considerable hope in the British industry that, as a result of the Sea Harrier program and growing support for the AV-8B in the United States, Harrier and its derivatives could remain active programs, with a great deal of British participation, through the 1980s.

The Nimrod is still in production, at a low rate, for the RAF Strike Command, where it will serve as the principal maritime reconnaissance aircraft until the 1990s. It is concern over the Nimrod program that has led the British Ministry of Defense to question British participation in licensed production of the Boeing E-3A AWACS.

Shorts, with headquarters in Belfast, has been strongly supported by the British government, possibly due to regional considerations. In addition to a variety of subcontracting work for European and American aircraft firms, Shorts has developed a series of twin-turboprop light STOL transports for cargo and passenger use.

In addition to BAC and Hawker Siddeley, the other firm of major importance to the United States, in considering future collaborative possibilities, is Westland Aircraft, Ltd., a helicopter manufacturing firm with headquarters in Yeovil in Somerset. Westland, with some 12,500 employees (of whom about half are actively involved in helicopter manufacture), has collaborated closely, in a variety of ways, with the U.S. and continental helicoper industries. Much of its early success in such programs as the Sea King for the Royal Navy depended on technical support and licensing of dynamic elements of the helicopter from Sikorsky in the United States. In fact, Westland entered the helicopter industry in 1947 by acquiring a license to build the Sikorsky S-51, of which it produced about 130 units as the Westland Dragonfly.

Westland has been the British instrumentality in the very successful Anglo-French helicopter cooperation program involving the Gazelle, Lynx, and Puma helicopters, which are produced under a cross-purchasing arrangement for both the British and French armed forces. In the helicopter deal, Westland makes 60% of the Gazelle and 20% of the Puma, of which respectively about 600 and 400 had been sold through 1975. In the Lynx program, 35% of each aircraft is made in France by Aerospatiale. Firm orders stand at 50 for the British Army, 30 for the Navy, 13 for the RAF and 18 for the French Navy. For the future, British MOD has been considering enlarged cooperation on helicopters involving not only the UK and France but also Germany and Italy.

Turning now to broader issues in the British industry, the first point to make is the importance of aerospace exports to the national economy. Offsetting whatever negative views the British public may have of aerospace industry productivity, the industry has been very successful on the export market, setting a succession of annual records in the export category. Final British aerospace export figures for 1975 were on the order of Ŀ800 million, a level which is nearly triple that of 1970. Of this, the United States was the largest recipient, accounting for nearly Ŀ197 million, France 97 million, West Germany 73 million and China 23.7 million. Military exports account for about half of the total.

Some idea of the importance of exports can be gained by the fact that, at the end of 1975, 72% of BAC's total Ŀ900 million backlog was for export. Due to the high level of exports, the private British aircraft companies have actually been performing very well finanacially in the last few years in spite of a downturn in domestic prospects. For the 1974 financial year, for example, BAC achieved a profit of over Ŀ24 million on sales of Ŀ270 million, of which Ŀ170 million was for export.

In an eleven-year period from 1963 through 1974, the British aerospace industry as a whole has exported slightly over 50% of its turnover.

One key criterion of an industry's value to the national economy has been the conversion ratio of exports over imports. Although these ratios vary, it is nevertheless useful to review statistics provided in the publication "National Income and Expenditure 1968" classifying a number of industries as follows:

Table 8

<u>Comparison of Military Equipment Exports ($ million)[a]</u>

	1967	1968	1969	1970	1971	1972
Britain[b]	412	499	552	480[c]	675[c]	862[c]
France[d]	529	824	486	1,298	1,284	830[e]
Germany	91	114	92	(120)	(100)	(100)
Italy	110	120	120	(130)	(130)	(140)
Total	1,142	1,557	1,250	2,028	2,189	1,932
USA[f]	981	1,019	1,314	1,410	1,454	1,492

Figures in parentheses are estimates.

[a]Deliveries (except where stated).

[b]For the financial years 1967-68, 1968-69 etc.

[c]Official estimate.

[d]Orders taken.

[e]Estimate based on projection of figures for first six months.

[f]Excluding Military Assistance Program exports.

Source: IISS, 1975

Aircraft manufacture	13.8
Shipbuilding	11.6
Vehicles, other than cars and aircraft	9.2
Other engineering	9.0
Motor vehicles	7.4
Beverages and tobacco	5.3

These comparisons are compelling to British government planners.

A second critical issue is nationalization, which appears to be imminent. Although there have been disclaimers of any substantive change following the planned merger of BAC, Hawker Siddeley, Shorts, and Rolls into British Aero/Space, some changes are in fact likely to occur. A new look could be taken, for example, at international alignments.

There is also some thought, for example, that British Aero/Space would seek to rejoin the European Airbus consortium. There has also been speculation about future collaborations between the nationalized firm and the United States - e.g. a Boeing-UK cooperative development of the 7N7 for British Airways as a replacement for the Trident 3B. Such an aircraft would, of course, be powered by the JT-10D. There could also be a later partnership on the 7X7 180 to 220-seat twin-engine aircraft. (The 7N7 would have the same fuselage cross-section and flight-deck as the 737 but a new advanced airfoil wing and two CFM-56s or JT-10Ds. Passenger variations would range from 126 up to 188 seats.) At this point, the only certainty about nationalization (which is opposed by present managements) is that existing international relationships will be reexamined.

A third and related issue is the deep concern over the absence of civil programs, due in part to the difficulties of Concorde. The earliest solution appears to be a collaborative medium-range, medium-capacity transport, developed either with U.S. or European industry.

At present, both HSA and BAC are working hard to keep their existing Trident and 111 lines in operation to sustain the workforce until development of a 180- to 200-seat collaborative transport aircraft for the 1980s. This is certainly an area in which the United States could play a strong role, one which could serve as a quid pro quo for other forms of licensing or military standardization.

For Europe, as many observers have noted, employment is the new measure of industrial achievement. Although this particular measure of corporate social responsibility has not yet been fully adopted in the United States, it is a very real measure in Europe and must be recognized as possibly the dominant criterion in any collaborative project. It is for this reason that feeling about the success or failure of Concorde runs so high - in view of the fact that over 40,000 jobs are dependent on the continuation of the program.

In closing, it is worth pointing out that Britain regards its aerospace industry as a unique and self-sufficient group - in effect the only complete aerospace industry outside the two superpowers capable of providing the nucleus for European collaboration. The British view is that its aerospace industry has the technical capability to design and manufacture any aero-space project but lacks two essential features - capital, and markets of sufficient size to provide feasible unit prices. It is these needs to which international collaboration is responsive. Such collaboration is especially desirable when Britain retains the design lead. In explaining the higher American rates of productivity, British aerospace industry officials are normally inclined to attribute the difference primarily to scale of manufacturing. Sir George Edwards cites figures showing that American productivity usually comes out about 150% higher per man than in Britain. Of this, typically, 50% might come from higher capital per man employed, 50% from longer production runs due to a much larger domestic market, and 50% from better production engineering on the shop floor.

2. The French Aircraft Industry

The French aircraft industry currently employs about 100,000 workers, roughly half the number employed in the British industry. Although recent analyses of comparable productivity may show the French industry in a more favorable light than real circumstances warrant, there is certainly no question that the French industry is more productive in terms of output per worker and has had a higher ratio of successful ventures to project starts, especially in the military field. The French aircraft industry depends even more heavily than its British counterpart on exports in order to maintain its viability. It seems likely that exports currently represent about 60% of total French aerospace production and that by far the major share of these exports are military in nature.

The engine and avionics industries are not as highly developed in France as in Britain. However, as subsequent sections of this report indicate, they are adequate to support the very strong airframe industry.

The purpose of this section is to concentrate on the two principal aircraft manufacturers, Aerospatiale (SNIAS) and Dassault-Breguet. The two engine firms as well as the missile manufacturers, are discussed in later sections. Aerospatiale, a nationalized company which has evolved from the successive aircraft industry reorganizations since World War II, now has more than 40,000 employees. Although there is some participation by private banks, Aerospatiale is for all practical purposes a nationalized industry. The second firm is Dassault-Breguet, a much smaller firm of 15,000 employees, owned largely by Marcel Dassault - a firm which has won world reknown for the success of its light supersonic fighter designs as well as its manufacturing efficiency. While Aerospatiale is diversified in several different types of aircraft and missiles, Dassault-Breguet has concentrated primarily on fighter aircraft, with one derivative and successful business jet program and a so far unsuccessful commercial transport project.

In spite of the success of Dassault-Breguet over the last two decades and the continuing financial losses of Aerospatiale, it does seem clear that Aerospatiale is the chosen instrument of the French government for major future aerospace activities, especially those that demand collaboration. The success and efficiency of Dassault-Breguet have depended, in large measure, on the small size and high degree of concentration of its activities. Added to this, as will be discussed below, are the special characteristics of a unique management.

Aerospatiale is divided into four divisions, one each for aircraft, helicopters, tactical missiles, and ballistic and space systems. In addition, it has American sales subsidiaries - European Aerospace Corporation and Vought Helicopter Corporation. In the Aircraft division, two collaborative programs are the largest and most important at the present time: the Concorde program with BAC, and the A-300

Table 9

French Aircraft Industry Manpower, 1975

Airframes and Missiles	60,174
Engines	22,295
Equipment	25,350
Total	107,819

Source: GIFAS, 1975

European Airbus, in cooperation with the German Airbus consortium and Hawker Siddeley. In addition, there are some light business and third-level transport aircraft in production. The decline in sales prospects for Concorde, and the slowness in the growth of orders for Airbus, have created serious problems for Aerospatiale in maintaining the employment of this division at established levels. The firm has repeatedly lost money and in 1974 reported a total loss of $78.5 million. Apparently all of the losses can be attributed to the Aircraft division, since the helicopter, tactical missile and ballistic systems divisions are all operating profitably. The difficulties stem, of course, from the Concorde and A-300 projects. This helps to explain the urgency with which France has pursued the issue of U.S. civil aircraft collaboration. The helicopter division of Aerospatiale, with its headquarters at Marignane, is one of the leading success stories of French aircraft production. The various helicopters produced by the firm have received very wide acceptance on the world markets, and about 70% of the division's production is exported. Principal types are the Alouette series as well as the co-production that has resulted from British-French agreement on military helicopters - involving cross purchases of the Puma, Gazelle, and Lynx military helicopters for the British and French armed forces, as already described in the British section. In addition, there are the Super-Frelon heavy helicopter and the new Dauphin helicopter series. The helicopter division, with 8,200 people, is now second only to Bell in world helicopter production.

Table 10

Aerospatiale Helicopters

Type	Performance: Maximum Cruise Speed	Endurance	Capacity	Turbomeca Engine: Type	Power (hp)	Sales to 01-01-76
SA 315 B Lama	190 km/h	3 h 20	1 + 4 passengers	1 Artouste IIIB	570	184 sold
SA 319/316 Alouette 3	220 km/h	3 h 50	1 + 6 passengers	1 Astazou XIV Artouste III	870 600	1323 sold
SA 330 Puma	260 km/h	2 h 50	2 + 21 passengers	2 Turmo IV C	2 x 1580	406 sold
SA 341 Gazelle SA 342 Gazelle	265 km/h 270 km/h	5 h 10 4 h 50	1 + 4 passengers 1 + 4 passengers	1 Astazou III 1 Astazou XIV	600 870	718 sold
SA 360 Dauphin	275 km/h	3 h 50	1 + 13 passengers	1 Astazou XVIII	1050	26 sold. Series production starts 1976
SA 365 Dauphin	272 km/h	3 h 30	1 + 13 passengers	2 Arriel	2 x 690	Series production in 1977, 23 sold
SA 321 Super-Frelon	250 km/h	4 h 20	3 + 30 passengers	3 Turmo III C.6	3 x 1570	90 sold

Source: Defense Nationale, 1976

It is larger than Westland (7,000 employees), Agusta (with 6,000), and MBB with 1,500 in their helicopter operations. In 1974, the company delivered 330 helicopters and about the same number in 1975. To the end of 1975 Aerospatiale had sold over 4,500 helicopters in 86 countries to 350 clients. Of these sales about 3,300 were military. Sales trends, as distinct from deliveries, have been as follows:

1972	-	176
1973	-	241
1974	-	538

Dassault-Breguet is noted mainly for the successive versions of the Mirage supersonic fighter, the backlog of which now accounts for several years of production capacity. Through 1974, about 1,300 Mirage IIIs had been produced, about 400 Mirage Vs, and about 60 Mirage F-1s. In addition, Dassault-Breguet is the partner with British Aircraft Corporation on the Jaguar attack-fighter program. It should be noted, that this collaboration was inherited during the merger of Dassault with Breguet. It is unlikely that Dassault itself would have taken part in the establishment of such a collaboration; and the merger probably had a negative effect on the export potential for Jaguar, since it was seen by the Dassault sales office to conflict with the market for Mirage.

Dassault-Breguet is also the designated French partner in the Alphajet trainer program with Dornier in Germany, a collaboration which has encountered administrative and management problems. Currently, the company is also involved in a relatively short production run of a revived and modified version of the Etendard, a carrier-based fighter for the French Navy. Deliveries of production Super-Etendards are expected to begin in mid-1977, following a decision to re-tool for production of the aircraft in 1974.

With regard to Alphajet, the first series production version of the aircraft will be delivered in July 1978, and deliveries will stretch into the 1980s. France is projecting production at the rate of four aircraft per month. Both Dornier and Dassault are extremely optimistic about the export potential of the aircraft. According to current planning, France will build 200 Alphajets for use as trainers and the Federal Republic will build 200 as G-91 replacements in the tactical role. Deliveries to the French Air Force will continue through the end of 1982. In France both SNECMA and Turbomeca are participating in the production of the Larzac engine, and in Germany production is divided between MTU and KMD. A total production of 1,800 engines, at a rate of 30 per month, is foreseen, with the first series engine coming off the line in 1977. In the Alphajet program, the work assignment is as follows:

Dassault makes the forward fuselage and various fittings, and assembles complete fuselages;

Dornier builds the aft-fuselage, the wing and and tail unit;

Fairey and SABCA in Belgium build the nose section and flaps (in exchange for a 33-aircraft order by Belgium).

Totally, about 4,500 workers in Germany and about the same number in France will be working on the program.

In addition, the company has been successful in marketing its Falcon business jets in the United States and elsewhere. Of the 320 Falcon 20 business jets delivered to mid-1975, over 200 have been delivered through the U.S. sales subsidiary. Less likely of independent success is Dassault's first post-war venture into commercial transport aviation - the twin-turbofan short-range Mercure transport. This aircraft has encountered stiff competition in world markets which has severely diminished the estimates of first-round orders; and currently discussions are underway with a U.S. manufacturer concerning possible collaboration on a more developed version. The potential for a Mercure 200 version, to carry up to 160 passengers, is of considerable importance to Dassault-Breguet and also to the French government. It is here that the most interest in trans-Atlantic collaboration exists. Discussions that have been held with McDonnell Douglas about the further development of this aircraft have been given very high priority by the various French ministries. Such an aircraft might be fitted with GE-SNECMA CFM-56 engines.

The area of greatest future interest to the company is the next generation follow-on to the Mirage F-1. Following the government's recent cancellation of the advanced, and potentially costly, ACF (Avion Combat de Futur) the company has, with government approval, placed primary emphasis on the single-engine Mirage 2000, a less sophisticated aircraft with a large potential for export to the third world.

One view expressed by senior French aerospace management in late 1975 was that the Mirage 2000 should be complementary with MRCA - meaning, presumably, that it should be lighter, cheaper, simpler, and more adaptable to the air-to-air role than the MRCA. One conjecture that has been made occasionally in recent months has been the possible future collaboration of Panavia with France on a Mirage 2000 type of aircraft. One difficulty in such a venture would, of course, be British reluctance to accept a French engine. Since the future role of the M-53 military turbofan is of tremendous importance to French industry, this could be the major stumbling block.

According to present thinking, the Mirage 2000 can enter series production in 1982, following its first prototype flight around mid-1977. Apparently, the selected use of carbon fiber is being considered for structural parts, as well as fly-by wire. It will be equipped with a Thomson CSF radar with a range on the order of 80 kilometers and will carry Matra Super 530 and R-550 air-to-air missiles. The principal roles of the Mirage 2000 will be high-level interception, reconnaissance, and possibly air superiority. Low level attack and penetration missions will not be included, and for this role the French Ministry of Defense may be considering a Jaguar follow-on. The thrust envisioned for the M-53 engine in the Mirage 2000 is 20,500 pounds dry and about 25,000 pounds with afterburner. Some idea of the concept of the aircraft can be gained by noting that the planned gross weight of the aircraft is no greater than 24,000 pounds - based on substantial use of composite material for weight saving. It is increasingly obvious that Aerospatiale will play a large role in the development of this aircraft, representing perhaps as much as 40% of the value of the work.

At the time that the Mirage 2000 concept was announced by the French Government, Dassault also announced that it would carry on a twin-engine fighter development with its own funds. This aircraft would be aimed more at a low-level penetrator capacity. Much has been written in the United States about Dassault's approach to aircraft development. It is vital, in any such assessment, to avoid euphoria. Dassault has concentrated on performance parameters and physical characteristics of moderate complexity and has been careful to carry out new R&D only on an incremental basis, relying heavily on experience gained in previous production aircraft. Consequently, the successive aircraft do not represent full generations. Instances in which Dassault has made advances of greater complexity, such as the Mirage G, have been less successful.

The effectiveness of the Dassault organization, with regard to single-engine Mach 2 fighters, has depended considerably on the personal relationships of a handful of men of great ability and mutual confidence in one another. One strong feature of the Dassault organization is an absence of documentation. In the United States, and in other countries, each program is accompanied with literally thousands of pounds of documentation. Within Dassault, authorizations to proceed are often given verbally, based on trust and long experience. Marcel Dassault has expressed the view that a group of about 2,500 employees is the largest in which the impact of a single leader can be felt. Consequently, the various units of R&D, production, and other activities are limited to 1,500 to 2,500 people with a single strong operating head who has absolute control over his group. Dassault has, through techniques such as these, managed to remain in the top rank of the world's companies on the basis of dollar output per employee. (In the early 1970s, this figure was running at about $35,000 per employee.)

There is also a strong effort within the Dassault organization to resist specialization. Dassault's view is that, while specialists tend to dig far deeper into their own narrow field, the ultimate result is that they lose their ability to communicate with other elements of the firm. They argue that 20 American engineers are required to handle the work of two engineers in Dassault. While this may be true in a superficial sense, it may also suggest that Dassault does not have the engineering depth to work on highly-advanced projects.

As a result, although Dassault is often viewed as being obstructionist in terms of large-scale international collaborations, the actual fact may be that it is not really very capable of adapting to larger scale enterprises with other partners, given the inherent personalities and organizational structures.

One firm operating criterion of Dassault which is not always obvious to outside observers is its strong dependence on subcontracting. The Dassault view is that, while it is very difficult to squeeze costs out of one's own operations, it is far easier to squeeze competitive subcontractors on their prices. Furthermore, subcontractors provide a cushion to keep the prime contractor's workforce stable. When the backlog is low, subcontractors can be cut out and the work shifted to the internal force. Dassault has a reputation, within French industry, of being absolutely ruthless in its handling of subcontractors - who, being primarily specialists in various types of equipment, have little choice but to comply and shave their margins.

In 1974, Dassault received $1.52 billion in new aircraft orders, a 75% increase over the previous year. Of these total orders, about $1.05 billion were for export, representing a 90% increase over the previous year. This military order growth appears to be translated into a growing backlog rather than stepped-up output, due to limitations in manufacturing capacity. In 1975, the Dassault facilities at Bordeaux produced 88 Mirage aircraft of all types. In addition, 58 business jets were produced. Including 12 refurbished military aircraft, the total production was 158 units, or roughly 15 units per month. At Toulouse Colomiers, the Dassault factory employing

1,500 delivered 28 Jaguar aircraft in 1975. In addition, this factory furnished, at a rate of five per month, parts kits for the British production line.

Under severe pressures created by difficulties in the Concorde and Airbus programs and loss of the NATO fighter competition to the F-16, French government and industry have, as one of several solutions, been pressing hard for collaboration with U.S. industry on future civil transport aircraft. This initiative has also been spurred by the established government policy of shifting the emphasis of the aircraft industry from military to civil projects, in the attempt to establish a stronger French share of what is expected to be a burgeoning civil aircraft market in the 1980s. The initiative is further influenced by a sense of malaise with regard to intra-European collaboration. Finally, there is a perception in France, as in other European countries, that a share of the U.S. domestic commercial transport market provides a virtual sine qua non for the establishment of viable commercial programs; and the hope is that a bilateral relationship with the United States will provide such an access.

The U.S. industry, for its part, has also been facing greater uncertainties about future civil markets, resulting in a new interest in collaborative programs as a means of sharing development costs and gaining access to markets.

In any future civil aircraft, French interest centers around use of the CFM-56 ten-ton engine, which is discussed in Section I-C. Also of particular interest in the civil side would be adaptation of the Mercure 200 or the A-300B Airbus to reach the American market. The logical partners would be either Boeing or McDonnell Douglas.

One possible collaborative aircraft that has been discussed would be an adaptation of the Boeing 7N7, based essentially on the 737, which could be made available in various versions seating 125 up to 156 passengers, and powered by two CFM-56 engines. Another possibility would be an aircraft based both on the Boeing 7X7 design and the A-300B, to seat 180 to 200 passengers. (It should be noted, by the way, that Aeritalia has a 20% interest in the 7X7 program.) McDonnell Douglas and Dassault have also apparently discussed cooperation on a derivative of the Mercure 200 which would seat from 160 to 186 passengers and be powered by two CFM-56s. Although there was originally some thought that the French government would arrive at a decision for one of these programs by mid-1976, the timetable has clearly been delayed.

Simultaneously, talks have also been underway between Britain and France, relative to future collaborations after the nationalization of the British industry. One possibility would be a broadened British participation in the Airbus program. (At the moment, this collaboration is limited to wing production by Hawker Siddeley.)

3. The West German Aircraft Industry

Bonn's efforts, over the last two decades, to avoid the creation of industrial vested interests in the growth of military production, have been manifested in three ways in the German aircraft industry: first, in clear limits on the size of the industry; second, in a predominance of collaborative projects, both with the European allies and with the United States, wherever a major procurement is involved; and third, in an attempted balancing of civil and military projects. With the United States, the West German industry has been engaged in a number of major licensed production programs including the Lockheed F-104, the Sikorsky CH-53, and the McDonnell Douglas F-4. With the European allies there are several important co-development and co-production programs, including the Anglo-German MRCA and Franco-German Alphajet. In addition to their restraining role on the defense industrial infrastructure, these collaborative programs have also played an important role in cementing alliance relationships.

Provided in Table 11 is a breakdown of employment in the German aerospace industry, indicating a total of 52,000 workers planned for the end of 1975, compared with nearly 60,000 in 1970. Over 60% of the workers are employed in the airframe industry, especially in the three major companies: Messerschmitt-Bölkow-Blohm (MBB), Dornier, and VFW-Fokker. The engine industry, employing about 6,800 workers, is described in a later section. The largest and most important firm,

Table 11

German Aerospace Employment*

Activity	End 1974	Percentage of total	End 1975	Percentage of total	Variation (per cent)
Airframes	34,977	66	34,093	65.7	-2.5
including space	2,559	4.8	2,564	4.9	0
Engines	6,902	13	6,783	13.1	-1.7
Equipment	9,676	18.3	9,721	18.8	+0.5
Accessories and materials	1,427	2.7	1,317	2.4	-7.7
TOTAL**	52,982	100	51,914	100	-2

*Working full-time in aerospace, including staff and apprentices.

**1970, 57,253 (+9.6 per cent); 1971, 56,678 (-1 per cent); 1972, 52,456 (-8 per cent).

Source: Flight International, 1 May 1976

Table 12

West Germany Aerospace Industry, 1970-73

	1970	1971	1972	1973
Turnover, DM million	2881	3075	3565	3900
Total manpower	57253	56678	52456	52985
Manpower by sector -				
airframe	39580	38139	34524	34230
engines	6442	7059	6832	7186
equipment	11231	11480	11100	11569
Manpower % working on				
civil projects	25.0	25.5	21.6	28.2
military projects	67.2	66.3	69.8	65.1
space projects	7.8	8.2	8.6	6.7
Manpower % involved in				
development	37.1	33.4	34.6	30.1
production	41.6	43.2	39.1	43.4
maintenance/overhaul	21.3	23.4	26.3	26.5
Government contracts, DM million:				
military	1886.0	2072.0	2625.0	2758.0
space	193.6	343.3	326.0	330.1
civil research[a]	-	-	-	5.0
Federal development subsidies, DM million:				
A300 airbus	95.5	146.4	167.9	183.3
VFW 614[b]	45.0	40.0	41.5	27.0
Other programs	9.5	3.6	0.6	4.2
Total	150.0	190.0	210.0	214.5
Federal guarantees for A300, DM million[c]	-	-	90.0	125.0

[a]Contracts for industry companies, does not include purely research institutes

[b]Includes contribution to Rolls-Royce for engine development

[c]Maximum envisaged DM 500 million, of which DM 215 million had been taken up by end 1973

Source: Federal German Government Basic Program, Dec. 1974

Table 13

German Military Aerospace Procurement Funding, 1973-77

(In DM million)	1973	1974	1975	1976	1977	Total program cost	Foreign industry share
Bell/Dornier UH-1D	8.4	28.5	10.6	0.3	-	852.3	30%
Sikorsky/VFW CH-53	384.9	387.0	55.0	24.5	-	1622.0	40%
Transall C.160	49.4	106.2	33.4	20.9	-	2809.0	43%
Do 28 Skyservant	51.5	13.6	-	-	-	213.0	20%
McDonnell Douglas F-4F	572.2	553.1	599.5	430.8	204.6	3800.0	90%
Other aircraft	36.9	15.8	53.0	20.0	-	126.0	55%
MRCA	21.8[4]	106.0[4]	N/A[5]			See note 1	
Alpha Jet	-	114.0[4]	N/A[5]			N/A	52%[2]
Milan	35.3	93.6	N/A[5]			See note 3	
Kormoran	-	72.0	N/A[5]			N/A	45%
Roland	-	17.0	N/A[5]			See note 3	
HOT		27.0	N/A[5]			See note 3	

NOTES:
1 - West German industry share not yet precisely fixed
2 - Planned foreign participation in German share of the program
3 - German industry seeking work-share proportional to national participation in total program cost
4 - Production preparation cost
5 - Detailed figures for 1975 onwards are classified

Source: FRG Basic Program, Dec. 74

for purposes of the present study, is MBB, which plays a vital role as German partner in international programs, which account for about 60% of corporate turnover. MBB has a workforce of about 20,000.

The membership of MBB reflects its international character. Willy Messerschmitt owns 16.3%, Ludwig Bölkow 13.42%, the Blohm Family 15%, the Boeing Company 8.9%, Aerospatiale 8.9%, Siemens 8.35%, August Thyssen-Hutte 8.35%, the Bavarian Reconstruction Finance Institute 5.93%, and the Bavarian state 7.8%, and the state of Hamburg 7%.

The company has seven divisions, the largest of which is the aircraft division responsible for military combat aircraft. This group, located in Augsburg, has about 6,000 employees. A second division is the former Hamburger Flugzeugbau group, concerned mainly with commercial transport aircraft, with about 5,000 employees, located in Hamburg. The Dynamics division, which works on missiles systems and civil electronics, has about 2,200 employees. The Surface Transportation division is concerned mainly with systems such as railroad equipment and subway cars. It has about 3,000 employees.

The Space division has about 1,500 employees and the helicopter division has about 450 employees. Finally, the corporate headquarters has about 1,700 employees. (This is also called the Administrative Services division.)

As of 1972, about two thirds of MBB's sales were military. The distribution of the workforce has not been proportional to these figures. The higher concentration of employment in the civil area reflects the goal of building a substantial civil aircraft business to balance the military. Over the period 1975 to 1980, MBB has forecast an annual growth rate of 4% with activities divided among four programs: MRCA, the A300B European Airbus, tactical missiles, and a miscellaneous category which includes helicopters, spacecraft, and diversified products.

As an instrument of national policy, MBB has a strong internal commitment to joint European ventures, especially through the Panavia consortium. MBB is perhaps second only to BAC in its knowledge of and experience in the management of multinational consortia. As a founding member of Panavia, Airbus Industrie, and Euromissile, MBB has occupied a unique role in intra-European collaboration and therefore has a strong vested interest in European aerospace industry collaboration.

MBB has been especially strong in joint missile programs, especially with Aerospatiale, in the Euromissile consortium, which accounts for 25-30% of MBB's current turnover. These programs include the Milan second-generation antitank missile; the HOT antitank missile on helicopters; and the Roland series of antiaircraft missiles. MBB also continues to work on one purely national programs: the Kormoran air-to-surface antiship missile. (The Jumbo TV-guided air-to-surface system, intended as a standard weapon for MRCA, has been cancelled.) These are discussed in a later section.

The breakdown of the Dornier workforce, as of 1972, was about as follows:

Dornier Reparaturwerft (overhaul/repair)	2000
Dornier Systems	700
Lindauer Dornier	800
Dornier AG	4000

As of 1972, about 65% of this workforce was engaged mainly in military activity. Although total numbers have declined slightly, the proportions probably remain unchanged.

One small but interesting part of the Dornier organization is Dornier Systems, which presently employs about 700 people to do advanced systems development. Dornier Systems has worked on such projects as reconnaissance pods and other sensor systems, primarily as a systems integrator rather than a basic R&D house. It could be a useful group in the definition and development of future airborne systems.

Dornier is the German partner, with Aerospatiale of France, in the Alphajet Trainer Program. The program calls for 433 aircraft, which are due to be completed by 1981. Consequently, Dornier is already looking hard for new programs to replace Alphajet. With regard to Alphajet, there has been some indication that Franco-German administrative and contractual relationships have not proceeded as smoothly as the Anglo-German relationships of the MRCA program. However, the technical development of Alphajet has apparently proceeded very well, and an export potential exists which may extend the program.

VFW-Fokker, which, as the name implies, is the outgrowth of a merger between West German and Dutch aircraft firms, has about 10,000 employees in Germany. (The Dutch arm of the company is the principal licensee of General Dynamics for the F-16 program.) In Germany, VFW Fokker is engaged primarily in civil transport aircraft production - in particular the VFW614 light jet transport and also as an important participant in the A300B program of Airbus Industrie. If the Franco-German Transall military cargo transport program is reinstated at some future time, VFW-Fokker will be the German partner. In addition, VFW is licensee for German production of the Sikorsky medium-lift CH-53 helicopter, of which more than 110 units have already been built. Because the CH-53 helicopter program is nearing its end, VFW-Fokker is in need of early future work. Consequently, the company is very dependent on the fortunes of the A300B program and a possible Transall re-start.

National programs within the German aircraft industry tend to be small. Perhaps the most interesting of these is the series of MBB rigid-rotor helicopters, developed with the assistance of Boeing, starting with the BO-105. Some 300 of these helicopters have already been sold, of which, through the summer of 1976, over 250 have been delivered. Production is now scheduled for about 80 per year. Another interesting national program would be a revival by Dornier of the DO-24 flying boat, which could eventually become a joint program with Aerospatiale. Such an aircraft, roughly resembling the old Martin PBY, but significantly improved in technology and powered by three turboprop engines, would fill an interesting gap in world markets and could conceivably be of interest to the United States for patrol and rescue work.

The West German aircraft industry has not yet arrived at its final form of rationalization. There may still be a further integration of the main aerospace companies as a result of recent planning studies. Recent speculation would suggest a general plan to keep MBB Munich and Dornier in combat aircraft and missiles and assign civil transport and space projects to VFW-Fokker (including ERNO) and MBB's northern division, the former HFB.

A second part of future planning is to strengthen the role of Panavia, Airbus Industrie, Euromissile, and Heli-Europe. One very significant point, for purposes of this study, is that German government and industry continue to urge on other European partners the entry of U.S. manufacturers into these consortium relationships. It is interesting to note that the Managing Director of MBB's Aviation Division has made public statements in 1976 as supporting the established management structure of Panavia as the key to future expansion, rather than the separate companies. It does seem clear that German government and industry are generally satisfied with the progression of learning experience in collaborative projects, especially with Britain.

In general, the view of German industry leaders is that although their firms must depend on collaboration, they must also have enough indigenous R&D capability to give them a basis of independent judgment and a means of participating in early decisions, rather than being completely at the mercy of the foreign partner. It may be largely for this reason that MBB and Dornier have insisted on maintaining substantial design and development staffs.

Following a strenuous review of the West German aerospace industry, it is clear that the Bonn Government has come to the decision, in the first half of 1976, to maintain the industry at about its present level of at least some 50,000 workers. The various alternatives, such as cutbacks in the workforce or greater direct purchase from other countries, have essentially been ruled out. However, it is equally clear that Bonn has no desire for expansion of the aerospace industry - quite the contrary. Consequently, the primary issue in Germany, as in Britain and France, is maintenance of the existing industries through adequate utilization of manufacturing facilities and also through the retention of existing design and development teams.

It should be noted that, following the rapid buildup in employment from 1968 through 1972, the German industry employment level has been in a steady state of decline since that time - from over 58,000 in 1972 to the proposed 52,000 to 53,000 in 1975. At the same time, however, sales have continued to increase - from less than $600 million in 1968 to about $1,900 million in 1975.

Many industrial observers in Germany feel that this number is below the minimum size needed to work effectively on an equal basis with the British and French industries, which number about 200,000 and 100,000 respectively.

The need for employment stability is virtually paramount. Government restrictions on industrial reductions in workforce are even more severe in Germany than in the rest of Europe. This factor, combined with the great difficulties of transferring workers between sectors, and the inability of companies to diversify outside their basic fields of specialty, puts a premium on the company's ability to maintain orders at a constant level within a specified product line.

Most of the recent planning for the aerospace industry has come from a committee appointed in 1975 under the chairmanship of Mr. Martin Gruener, Parliamentary State Secretary to the Economics Ministry. The work of this staff has resulted, in part, in a position paper entitled "A Basic Program for the German Aerospace Industry 1974-78." The Gruener report specified in particular the need for retention of some subsistence level of R&D capability in the Federal Republic. According to the report: "The capability of cooperating on an equal basis in the development of complex weapons systems will be insured by the maintenance of a high level of know-how." One result of the Gruener study is likely to be a growing division of the German industry into "spheres of interest" in which each will develop specialties and overlaps will be eliminated.

In the past, the German aerospace industry has carried out a number of highly advanced programs, especially in VTOL, which had a very tenuous hope of economic return. The present emphasis is on a tighter control over the industry and, in the case of civil projects, the hope of a stronger economic potential. For this reason, there is a growing emphasis on the civil field, especially on collaboration with the United States, since it is recognized in Germany, as elsewhere in Europe, that future economic feasibility will depend on access to the American civil market in the 1980s.

4. The Italian Aircraft Industry

As shown in Table 2 , the aerospace industry of Italy has historically been far smaller than those of Britain, France, or Germany. The new, quasi-nationalized aerospace company, Aeritalia, with some 9,500 employees, probably accounts for about one-third of total Italian aerospace industry employment. Aeritalia, which is owned equally by Fiat and Finmeccanica-IRI, began in 1969 as an amalgamation of Fiat's aerospace activities (except aircraft engines) with Aerfer and Salmoiraghi of the Finmeccanica group. In addition to the existing Fiat aircraft facilities in Turin, the company has established operations in the south of Italy, and one purpose of the firm is to create job opportunities in the south.

The mix of programs in Aeritalia illustrates clearly the split of official attitudes about future directions of the Italian aircraft industry. On one hand, many government planners have, since the late 1960s, favored a greater Italian commitment to intra-European collaborative programs and an abandonment of the Italian aircraft industry's classical post-war role as a machine shop for American industry. Others, recognizing the viability of the Italian industry's subcontractor role, have fought strongly for a continuation of bilateral American ties. Thus, within Aeritalia, one finds both the commitment to Panavia and the MRCA program, side by side with an agreement between Aeritalia and Boeing to develop an advanced commercial subsonic transport. Also of considerable importance to Aeritalia are strong relationships with Lockheed, with regard both to licensed production of the F-104S fighter for the Italian Air Force as well as technical support and marketing of the G-222 transport. Another important program is continuation of the G91 series of aircraft, in the form of the G91Y tactical fighter-bomber, for the Italian Air Force and for export. The development of this aircraft was strongly based on earlier Italian experience in the maintenance and overhaul of the F-86 aircraft.

It is also worthwhile to note that the G222, G91Y, and F-104S are all powered by General Electric engines.

To summarize very briefly the main facilities of Aeritalia:

The factories in the Turin area, previously operated by Fiat, are engaged in production of the G91Y, the F-104S, and the G222; also in the design and construction of the structural components for the MRCA; and collaboration with Dassault-Breguet for the design and construction of structural parts of the Mercure transport.

The plants in the Naples area are involved in construction of fuselage structural panels for the McDonnell Douglas DC-9 (originally as part of an offset for Italian purchases of the DC-9), vertical tail surfaces of the DC-10, engine support pylons for the Boeing 747, parts construction for the G 222 and F-104S.

A large new plant in the Foggia area is currently under construction, as part of the government program to create more employment in southern Italy.

In addition to Aeritalia, there are several small but relatively successful Italian manufacturers of light aircraft of varying degrees of sophistication, all operating on a rather limited production scale. Possibly the most interesting of these is Aeronautica Macchi in Varese, where the most important program is the AerMacchi MB326 light jet trainer and counter-insurgency aircraft, which has found a fairly wide export market in the developing world. In addition to direct sales, aircraft is also built under license in South Africa and Brazil. There have been direct sales to the air forces of Tunisia, Ghana, Australia, Argentina, Zaire, Zambia, and several other countries. The MB326 is likely to be succeeded by an MB339, prototypes of which have already been ordered by the Italian Air Force for trials as a new operational trainer. AerMacchi is limited in its production capacity (it currently has less than 2,000 employees). Within these limits, it has excellent productive and marketing ability.

Like other Italian aircraft companies, AerMacchi has maintained close ties with the United States - for example, as maintenance and overhaul contractor for the T-33 jet trainer for the Italian Air Force and other NATO air forces. Macchi has also been subcontractor for parts and components on the F-84 and the F-86 programs for the Italian Air Force and is now involved in subassembly manufacture for the F-104, G222, and other aircraft.

Another important company is Agusta in Gallerate, which is the leading Italian helicopter manufacturer, primarily as a licensed producer of successive Bell designs. This firm provides a typical example of Italian aircraft industry philosophy. Agusta has developed a prospering helicopter-manufacturing operation, largely for export. Through the early 1970s, most of the helicopters were manufactured under Bell license, but Agusta has also become the licensee of Sikorsky and Vertol as well. Agusta typically manufactures the entire unit except the dynamic elements (engine, rotor, etc.) which are imported directly from the United States. About 50% of the value of each Agusta-Bell helicopter is imported from the United States. During its association with Bell, Agusta has built up a complex of machine shops containing the largest grinding capacity of any plant in Europe (45 grinding machines). It has also established an overhaul facility in Tehran for the Iranian Air Force and has trained many Iranian engineers in Italy.

Not all of the engines are imported direct from the United States. Lycoming has provided a license to Piaggio in Italy for production of the T-55 and other engines for Agusta helicopters. In addition, Agusta purchases engines from Allison, Rolls Royce, and SNECMA.

Agusta employs about 3,000 people in two plants - one at Cascina Costa, and a smaller plant at Frosinone near Rome. About 90% of Agusta's work is military.

A third company of some importance is Piaggio, located in Genoa, which employs about 1,300 people and also manufactures twin-engine light transport aircraft with power plants ranging from light piston engines through light turbojet (Rolls-Royce Viper) engines. Piaggio, like the other smaller Italian firms, appears to be capable of producing reliable aircraft and components of rather basic technology on a modest production scale.

Finally, it is important to mention SIAI-Marchetti in Sesto Calende, which manufactures a series of light piston trainers and utility aircraft. About 30% of the stock was purchased by Agusta in 1970, and SIAI Marchetti now allocates about 50% of its work to Agusta, which in turn subcontracts to Aeritalia and Fiat. Nearly 90% of the work force, in the early 1970s, was engaged in the manufacture and overhaul of military light aircraft and helicopters as well as Italian Air Force C-130s. There are about 2,000 employees in four small plants. SIAI Marchetti has sold its light utility aircraft to a number of foreign governments including Belgium, Burma, Dubai, Morocco, the Philippines, Singapore, Thailand, Tunisia, Zaire, and Zambia. The list of clients of the smaller Italian aircraft firms gives the strongest possible evidence of Italy's remarkable acceptability to third world governments as a supplier of military hardware.

In spite of this proliferation of competent but very small companies, it is difficult to identify major potential licensing roles for any of them beyond the relationships that have been established already by American companies to gain price advantage or to create access to markets that might otherwise be difficult or closed. For purposes of this study, Aeritalia merits the most detailed assessment for any consideration of licensing to gain further NATO standardization.

Aeritalia, like the rest of the Italian industry, has considerable capabilities as a manufacturing partner on a subcontract basis. It has little capability for design and development. The participation of Aeritalia in the MRCA consortium has raised it quickly to the level of a full-scale partner in the European collaborative system; but the firm also still maintains close and mutually valuable ties to the U. S. industry. One evidence of this commitment has been the presence of some 50 Italian engineers at Boeing to participate in early development of the 747 transport, in which the Italian government has a 20% share. These factors, in combination, suggest the future utility of Aeritalia as a link between the European and American industries.

The Italian share of the MRCA program is 11% of the cost and 15% of the work - an imbalance which reflects the considerable anxiety of Germany, and to a lesser extent Britain, to have another continental power involved in the project. According to current planning, the Italian Air Force will purchase at least 100 of the aircraft by 1985.

For Italy, a main consideration in future licenses or co-developments will be the maintenance of stable employment, especially if jobs can be found on an adequate scale to occupy the new Aeritalia plant in Foggia. The Italian government and industry are much less likely than Britain or France to demand U. S. offset purchases of Italian products or a strong Italian voice in preliminary design or development. On the other hand, a greater Communist role in the Italian government may have deleterious effect, either in the form of increased resistance within Italy to ties with the United States, or, on the other hand, greater concerns about industrial security in Washington. (The latter seems more likely).

Senior observers in Italy point out that, while the Italian government views favorably new defense programs that are intended to maintain the established level of employment, strong governmental resistance is encountered in most efforts to expand facilities or employment. The point here is clear - that for low-volume production, Italian industry is a highly-qualified licensee and subcontractor. However, the number of units involved in Italian programs is typically rather small. The question of scale must, therefore, be carefully analyzed in any licensing program.

In conclusion, the machine shop capabilities of Italian industry are indeed impressive. Within the Italian aerospace industry there is a well established preference to buy license rights to already proven products rather than to undertake the risk of original development. There is also a strong preference for American products.

C. The Aircraft Engine Industry

1. Rolls-Royce (1971) Ltd.

2. SNECMA (Société Nationale et de Construction de Moteurs d'Aviation)

3. Turbomeca

4. Motoren-und Turbinen Union (MTU)

C. The Aircraft Engine Industry

Central to any discussion of independent European capabilities in the development and manufacture of military aircraft is the question of aircraft engines. The availability of a powerplant is the starting point for any military or civil aircraft project and, in many instances, represents the constraining feature on size and characteristics of the aircraft. (The Concorde is only one example of an aircraft which was constrained, in important economic parameters, by the performance and characteristics of the available engine.)

In aircraft engine development and production, far more than in airframe fabrication, European industry lags behind the United States and has grown increasingly dependent on U.S. licenses and collaborations to assure suitable propulsion systems for future aircraft.

There is only one aircraft engine company in Europe, Rolls-Royce, which has development capabilities that approximate those of the two principal U.S. engine companies, Pratt & Whitney Division of United Technologies Corporation and General Electric. Nevertheless, even Rolls-Royce, in attempting to maintain technological parity with the United States (for example, in the development and manufacture of a 40,000-lb., high-bypass engine), encountered almost intolerable strains on its resources which finally resulted in receivership and nationalization. Still, as shown in the development of the RB-199 engine to power the Anglo-German MRCA, Rolls-Royce still retains an independent engine development capability which must be taken strongly into account in any assessment of European competence in this field.

As shown in Table 14, Rolls is by far the largest of the European engine companies, representing virtually 40% of the entire British aerospace industry. The two other principal engine manufacturers are SNECMA of France and MTU of Germany, both of which are relatively limited in their development capabilities. A fourth company, Turbomeca, is also of some interest because of unique capabilities, due primarily to its president, in the development and manufacture of light turbine engines.

The Italian engine firms identified in Table 14 are effective as licensees of American firms for the manufacture of components and subsystems, as well as assembly, of aircraft engines, but not as developers. The list shown in Table 14 is not a complete representation of the European aircraft engine industry. Fabrique Nationale (FN) in Belgium, for example, has an aircraft engine division engaged in parts manufacture; and there are other important engine subcontractors such as Klockner-Humboldt-Deutz in Germany.

A principal point to be kept in mind is the limited size of the European aircraft industry compared with the United States, and its comparative inability to develop and manufacture advanced gas turbine engines. As shown in Table 14, based on figures available in 1971, the entire European aircraft engine industry had about 96,000 employees, two-thirds of them

Table 14

European Aero-engine Companies

Company	Country	Turnover (1971) $ million	Employees (1972)	Ownership
Rolls-Royce (1971)	Britain	937[a]	64,000	Government
SNECMA	France	296	14,600	80% Government 10% United Aircraft (Pratt & Whitney)
MTU	Germany	118	5,750	50% Daimler-Benz 50% MAN
Turbomeca	France	67	4,000	
Fiat	Italy	n.a.	2,500[b]	
Alfa Romeo	Italy	50[c]	2,000[c]	100% IRI-Finmeccanica
Piaggio	Italy	19	1,300	

[a] 1972.
[b] Aviation divisions only: total turnover in 1971 was $2,910 million, and workers employed numbered 182,500.
[c] Aero-engines only: total turnover was $418 million and workers employed 22,750.

Source: IISS, 1975

at Rolls-Royce, compared with over 150,000 in the United States.

In order to arrive at valid qualitative judgments about the European engine industry, it has been useful, in the present study, to hold interviews in the U.S. aircraft industry with individuals who have long-time experience with European companies. These interviews have helped to augment the available documentary information.

1. <u>Rolls-Royce (1971) Ltd.</u>

Rolls-Royce, in spite of the financial difficulties it has experienced in the 1970s, is still regarded by both Pratt and Whitney and General Electric as being extremely capable technically. Essentially, the company is divided into three divisions. The Bristol division, which is probably the strongest in the development of military engines, is now engaged both in production of the Olympus engine for Concorde and development and production of the RB-199 for MRCA as well as the M-45H collaborative Anglo-French turbofan and the Pegasus vectored thrust engine for Harrier. The Derby division is occupied in the further development and manufacture of the RB-211 high-bypass turbofan for the civil wide-bodied market, as well as continuing production of the Adour and Spey engines. The Industrial and Marine division in Coventry, as the name implies, is involved in adaptations of existing gas turbine engines for industrial and marine use.

Following the bankruptcy which resulted, in part, from the Lockheed L-1011 crisis, the company was reconstituted as Rolls-Royce (1971) Ltd., with the British Government acting as the sole shareholder. Shown in Table 15 is the breakdown of programs and employees by division in 1974.

The fact that Rolls engines have been purchased by over 200 airlines and some 80 air forces assures a profitable continuing business for spare parts and engines; and the future of this business is in fact fairly optimistic. The recent Chinese contract for a turnkey plant to manu-

Table 15

Rolls-Royce Divisions and Main Products, 1974

Division	Programs	Employment
Headquarters	-	350
Bristol Engine Division	Olympus, Viper, RB.199, M-45H, Pegasus, Odin	20,500
Derby Engine Division	RB.211, Avon, Dart, Tyne, Adour, Spey, RB.162	34,500
Industrial & Marine Division	Industrial & marine adaptations of Avon, Olympus, Tyne, RB.211, Spey, etc.	1,250
Small Engine Division	Gem, Gnome, Artouste, Palouste	3,500

Source: Rolls-Royce, 1974

facture the Spey engine in China increases the prospects for a continuing spares business to provide a base for new programs.

In spite of the acknowledged excellence of the engineering design teams at Rolls, there are occasional evidences of technological lag in design or manufacturing compared with General Electric or Pratt & Whitney. Until recently, for example, Rolls-Royce designers continued to use forgings in hot parts of the engine where U.S. designers had shifted to high-temperature castings. This conservatism tended, in turn, to penalize turbine life in the blade and vanes. Because of constraints on R&D resources, it is natural that Rolls has tended to be conservative in its design and development methods, relying on proven techniques and materials wherever possible. This tendency was reinforced by the bitter experience of the RB-211 development program, in which the company - at the urging of the British Government - abandoned caution and promised engine specifications which could not be met within the contract price. (The prevailing U.S. view is that the Wilson government urged Rolls-Royce to get the L-1011 contract first and solve its technical problems afterward. Given the limitations on R&D resources, the promise of using composite materials to replace high-temperature metals proved to be a costly failure; and a great deal of redesign was ultimately required.)

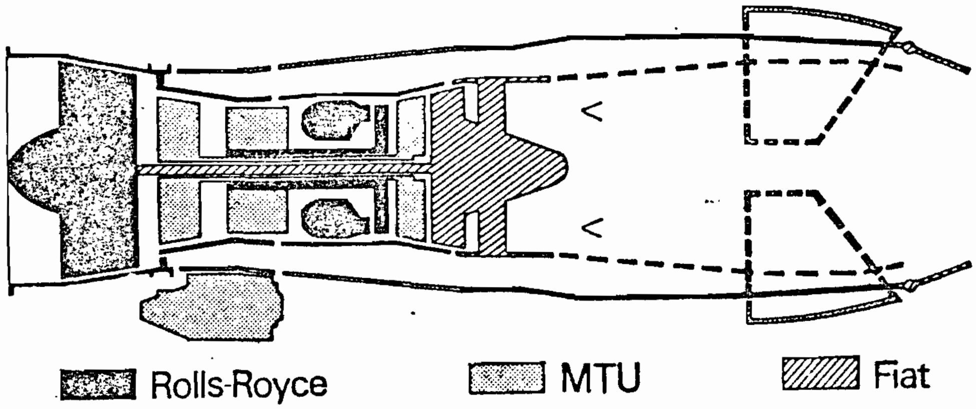
The latest military engine, the RB-199 turbofan for MRCA, is very ambitious technically. Turbine temperatures and the pressure ratio are about as high as current U.S. military engines, and the 7:1 ratio of engine dry weight to total thrust is comparable to U.S. technology. Consequently, it represents a very significant technological effort, under difficult financial and political conditions. The fact that Rolls has been able to bring the engine to the flying prototype stage is itself a mark of considerable technical competence.

Like most major British aerospace and defense programs, the RB-199 is a collaborative venture, involving Rolls-Royce, MTU, and Fiat in the Turbo-Union consortium. Although manufacturing of the engine will be shared according to the breakdown shown in Figure 4 , the development has been virtually the exclusive province of Rolls-Royce as design leader of the program; and the British Government can be expected, in future collaborations, to treat the engine design leadership of Rolls as a sine qua non of cooperation. The overall worksharing on the RB-199, within Turbo-Union, is broken down as follows: Fiat 15%, MTU 42.5%, and Rolls-Royce 42.5%.

Although development of the engine was attended with some difficulties, especially in the high-pressure turbine rotor blades and intermediate pressure turbine disc, development problems in advance-technology engines are scarcely unique. The prototype aircraft flew for the first time in August 1974, by which time more than 2,000 hours had already been logged in static testing, in addition to 320 hours in flight testing on a Vulcan testbed. (These figures seem somewhat smaller but roughly comparable to the test hours amassed on a U.S. engine prior to the Preliminary Flight Rating Test).

Figure 4

Schematic of RB.199 Work Sharing



For the future, Rolls will necessarily emphasize international collaboration, preserving, wherever possible, a leading role in the design stage. In fact, Rolls is now one of the world's most experienced companies in the matter of international collaboration. In addition to the RB-199, other major international collaborations are the following:

With Turbomeca, the Adour engine to power the Jaguar.

With Allison, the XJ-99 experimental program for a third-generation lift engine.

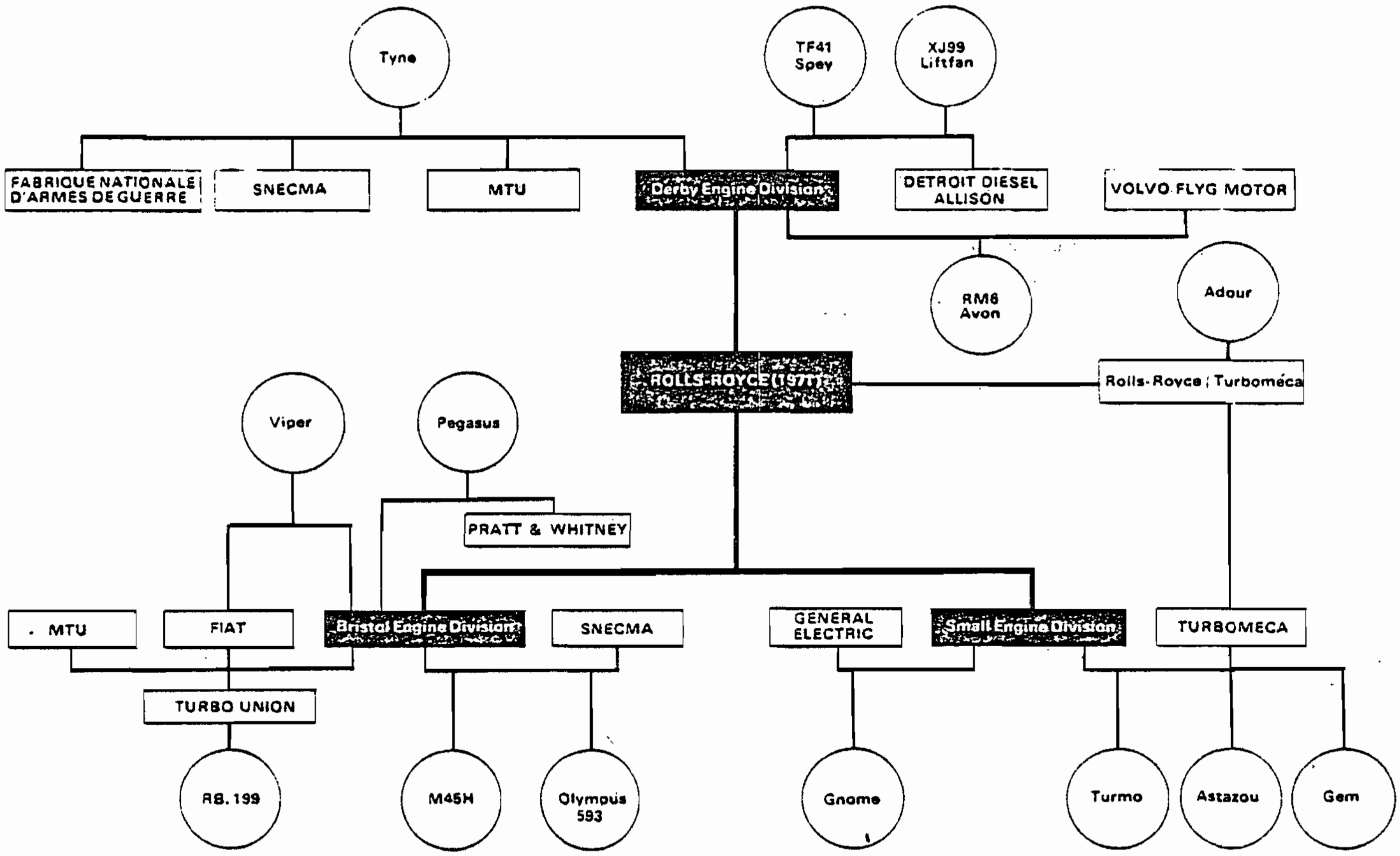
With SNECMA, the Olympus engine for Concorde.

However, the continuing impediment to collaboration is the unfavorable comparison of costs and labor productivity which are a serious problem throughout British industry, including Rolls-Royce. The manufacturing facilities and techniques are old compared with the United States, and the labor content is resultingly high. Lack of numerical control is a major issue and may be the most important single cause of low productivity compared with U.S. industry. In addition, Rolls-Royce has always, in the view of U.S. industry, inflated its work force in relation to production - possibly as a result of government pressures.

One feature of Rolls, compared with other major engine companies, is its very small vendor base and its tendency to integrate manufacturing within the company itself. Pratt & Whitney, for example, employs some 45,000 people, who are supported in turn by perhaps another 50,000 workers in

Figure 5

Schematic of Rolls-Royce International Collaboration



Source: Rolls-Royce, 1975

the vendor and subcontracting network. The Rolls-Royce workforce of about 60,000 is highly integrated and therefore lacks the flexibility that can be derived from a higher proportion of subcontracting. U.S. observers believe that, as a result of recent crises, the British labor unions are becoming more realistic about the need to improve productivity and are more inclined to cooperate with the government to restore the competitive position of British industry.

Rolls-Royce has had a number of close working relationships with U.S. industry, ranging from relatively harmonious to somewhat acrimonious. Relationships as licensor to Allison, in the TF-41 program, were initially difficult. The TF-41 is an advanced version of the Spey engine to power the LTV A-7. The agreement called for an equal division of manufacturing effort. Production will number in the thousands, continuing into the 1980s. Early in the program, the quality and durability of turbine and combustor parts manufactured by Rolls were questioned by the American partner. To some extent, this problem may have arisen from different operational standards of USAF and the RAF. Typically, the RAF has specified 500 hours for critical engine components, which is apparently below normal USAF requirements. Subsequently, in the RB-211 program, Rolls-Royce changed its specifications and has, in the view of the American operators, solved the critical component durability problem. In the view of highly qualified U.S. observers, the RB-211 is generally equal both to the JT-9D and CF-6 in engine durability; and U.S. airline users of the RB-211 are generally happy with the economics of the engine as it has evolved.

Rolls also has long-standing relationships with General Electric and Pratt & Whitney. Over the last two years, for example, there have been sustained negotiations between Pratt & Whitney and Rolls-Royce for co-production and joint marketing of the RB-401 light turbofan and also of the Pratt & Whitney JT-10D, which would be a collaborative 10-ton engine to compete with the GE-SNECMA CFM-56. Pratt & Whitney was interested in the RB-401 as a replacement engine for such aircraft as the Dassault Falcon 20 and Rockwell Sabreliner 25. Recently, however, the U.S. Justice Department effectively precluded Pratt & Whitney from participating in a collaborative program on the RB-401, on the basis that such a collaboration would restrict commercial competition.

As part of the JT-10D program, Pratt & Whitney and Rolls have proposed that Fiat and MTU join in a work sharing arrangement. Pratt & Whitney would be responsible for the core compressor and turbine; Rolls for the fan, combustor and diffusor; MTU for the low-pressure turbine; and Fiat for accessory gear box and externally mounted equipment. The sharing ratio of the four companies was 54:34:10:2. Subsequently, the transfer of Pratt & Whitney JT-10D engine technology to Western Europe has been questioned by the Department of Defense on security grounds, just as the General Electric core engine technology transfer to SNECMA was challenged earlier. Although SNECMA ultimately agreed to work with a sealed core in the CFM-56 program, Rolls-Royce has repeatedly been adamant in its refusal to do so, insisting on participation in the hot sections of the JT-10D core.

Rolls and Turbomeca signed a follow-on ten year agreement, in mid-1975, for co-production of the Adour engine. They anticipate further uprated versions both for aircraft and maritime - industrial uses. In addition to Jaguar, the Adour also powers the Hawker Siddeley Hawk and the Mitsubishi T-2 trainer.

Turbo-Union has engaged in an active marketing effort for the RB-199 outside of Europe. In the United States, a sales effort was made to consider the engine for the McDonnell Douglas F-18 in its export versions or for installation in the F-18 in foreign joint production programs.

In summary, Roll-Royce is the only West European engine company with independent development capabilities in advanced turbine engines for aircraft. These capabilities are generally comparable with those of U.S. industry. The differences that occasionally emerge result either from differences in user standards and specifications or from limitations on R&D or manufacturing facilities. Both of these problems can, of course, be corrected if a sufficient market exists.

The network of international relationships that has been created by Rolls is virtually unique, involving the United States, Germany, France, Italy, China, and, possibly in the future, the Soviet Union.

For purposes of the present study, the MTU relationship may be the most significant, since this liaison, through Turbo-Union, offers a potential focal point for licensing aimed at greater NATO standardization.

2. <u>SNECMA (Société Nationale d'Etude et de Construction de Moteurs d'Aviation)</u>

The major French aircraft engine firm, SNECMA, is largely nationalized but has some U.S. ownership participation. According to 1974 data, the French government owned about 84% of the shares and United Technologies Corporation in the United States about 9%, with remaining shares in the hands of a private French holding company. The company is a relatively small one, with only about 14,000 employees compared with over three times that number at Pratt & Whitney or General Electric. In spite of the Pratt & Whitney ownership share (as a division of UTC), the main current U.S. collaboration is with General Electric Company on the ten-ton engine.

In characterizing SNECMA, American industry observers point out that, despite their admiration for its production efficiency, SNECMA's development capabilities are rather limited. They credit SNECMA with only one and a half engine developments. The Atar, which has powered successive versions of the Mirage supersonic fighter, was first adapted in 1946 from a design acquired from Curtiss Wright.

More recently, however, SNECMA has been almost solely responsible for the development of the M-53, an advanced development based on Atar, to power a second-generation version of the Mirage F-1 and the forthcoming Mirage 2000. Preliminary design of the M-53, which will have a maximum thrust with afterburner of 18,700 pounds, began in 1967. The first prototype engine was tested in 1970. Although this engine is largely a SNECMA development, it must be pointed out that Pratt & Whitney provided a great deal of design engineering support, in addition to testing the entire turbine section of the prototype engine at its East Hartford test facilities. In the design phase, it seems likely that Pratt & Whitney provided much of the aerodynamic design of the aft section of the engine, as part of its overall technical exchange agreement with SNECMA.

American industry observers do credit SNECMA with considerable skill both in testing and manufacture. SNECMA, like other European advanced technology firms, customarily engages in more intensive testing of prototypes than its American counterparts to offset lower expenditure levels on preliminary R&D. Consequently, SNECMA has developed test techniques that provide an even greater yield of data per testing hour than its American counterparts.

SNECMA's test facilities, for example the altitude test chambers at Saclay, are highly regarded by U.S. industry; and the general expectation is that the collaboration with General Electric in the CFM-56 ten-ton engine program will further improve French capabilities in engine testing and manufacture, since General Electric will demand certification and endurance testing to U.S. commercial standards.

In summary, the most important early future program is the CFM-56 high by-pass ratio, ten-ton engine. This is being developed as part of a consortium known as CFM International, in which General Electric and SNECMA hold equal shares. The purpose of the collaborative company itself is to provide program management for the engine and provide the customer interface for sales and service. The company is staffed by teams from the two participating companies. In the division of work, General Electric is responsible for design integration, the core engine (which is essentially the same as the F-101 turbofan for the B-1 bomber), and the main engine controls. SNECMA is responsible for the low pressure system, reverser, gear box, and accessory integration and engine installation.

The hope of the participants is that the CFM-56 will be the engine around which a number of new commercial transport aircraft can be designed in the 1980s and the 1990s. In addition to civil transports, the engine is seen as being applicable for military transports, tankers, as well as long-duration patrol and reconnaissance aircraft. For General Electric, the collaboration provides access to the future European commercial market as well as sharing of development costs. For SNECMA, the project provides access to the latest technology of much higher by-pass ratios in fan engines (5:1), high thrust-to-weight ratios, higher internal pressure ratios, and higher operating temperatures.

In summary, SNECMA is not strong in development capabilities but has won the respect of U.S. industry in both testing and manufacturing. For example, the company has developed modern forging techniques which are generally comparable to the capabilities of Pratt & Whitney or General Electric - e.g. the forging of large parts such as a ten-foot-diameter ring for the RB-211 nacelle. SNECMA also has a foundry capable of super-alloy castings for high temperature applications; and U.S. industry has occasionally subcontracted to SNECMA for aluminum forging and castings when plant capacity in the United States was limited. However, in spite of these qualitative strengths in manufacturing, it must also be kept very much in mind that total productive capacity is limited due to the size of the enterprise.

In summary, the main programs of SNECMA at the present time are the following:

> The Atar engine series for the Mirage III, Mirage V, Mirage F-1, and Super Etendard;
>
> The M-53 development program for the Mirage F-1E and future generations of Mirage fighters;
>
> Collaboration with Turbomeca on the Larzac light turbine engine for the Franco-German Alpha jet trainer;
>
> Collaboration with Rolls-Royce in the co-production of the Olympus 593 engine for the Concorde supersonic transport;
>
> Collaboration with General Electric in the development of the CFM-56 20,000-pound turbofan civil engine;

Licensed production of part of the GE CF-6 40,000-pound engine as an alternative powerplant for Airbus, DC-10, and Boeing 747 purchased in Europe;

Collaboration with Rolls-Royce on the M-45H turbofan engine to power the German VFW 614 transport (a program that is likely to collapse);

Licensed production of the afterbody of the Pratt & Whitney JT-8D engine to be used on the Dassault-Breguet Mercure transport.

Perhaps some additional background is worthwhile on the M-53, since this could have a future role in European collaborative military programs. Through the spring of 1976, 19 prototypes of the engine have been built which have accumulated some 5,000 hours of running time, including nearly 700 with afterburner. The Mirage F-1 testbed engine has achieved an altitude of 53,000 feet and maximum speed of Mach 2.1. By the time the aircraft reaches the production stage, it will have a maximum thrust with afterburner of about 18,700 pounds and maximum dry thrust of about 12,350 pounds, with an engine dry weight of only a little over 3,000 pounds. Consequently, the engine could be available after 1978, for application in various different future supersonic fighter designs.

It may be useful to digress briefly in order to draw some lessons from the complex negotiations that resulted in the GE-SNECMA agreement on the CFM-56 engine. Recent unpublished case studies of this negotiation suggest the following conclusions relevant to the current project:

> First, the French government has been prepared to act quickly and decisively when national interests were perceived in a particular collaboration. Given a need due to a policy established in the early 1970s to shift the French aerospace industry's workload from military to civil programs, and in view of potential technology acquisitions, France was decisive in funding the CFM-56 project - initially in the amount of $200 million.
>
> As a necessary compromise, both SNECMA and the French government agreed to the requirement of receiving a "sealed" core engine around which to add their own peripheral systems. The series of reviews within the U.S. government resulted, eventually, in several creative technical steps which permitted general agreement on the transfer. For example, the F-101 core engine technology was in fact downgraded in a number of ways, related to operating temperatures and by-pass ratios, so that concerns about disclosure could be assuaged.

Second, the momentum of the negotiation was sustained by the direct personal interest of the two heads of state, who were able to revitalize the process when it flagged at lower levels.

3. Turbomeca

No discussion of the European aircraft engine industry would be complete without a mention of this small and highly specialized developer and producer of light aircraft turbine engines, Turbomeca. This privately-owned company has prospered largely as a result of the managerial and technological skill of its President, M. J. Szydlowski. The company has remained at the technological forefront in developing light turbine engines, with transonic aerodynamics in the compressor stage, for helicopters and military trainers; and its designs have been licensed to several countries, including the United States, for civil and military engines. The entire current line of French helicopters is powered by Turbomeca turboshaft engines. Turbomeca has teamed with SNECMA for development and production of the Larzac engine to power the Franco-German Alphajet trainer. More important, as ostensible junior partners on the Adour program with Rolls-Royce and SNECMA, they asserted themselves when major technical choices were to be made and, according to U.S. observers, played a critical role in developing this engine. Szydlowski holds a number of patents on compressors with transonic aerodynamics.

Among current development projects, of considerable interest is the new Arriel helicopter turbine engine. In addition, the Astafan light turbofan engine, of 4500 pounds thrust, is now flying experimentally on an Aero Commander and possibly has some future market potential which would be, however, in competition with Garrett, Lycoming, and Canadian Pratt &

Whitney. Consequently, although Turbomeca is highly competent, any export licensing would run into fairly stiff overseas competition. As far as direct sales are concerned, Turbomeca's productive capacity is very limited. However, in any collaborative program, they would have great technical ability either to lead in specialized areas or to follow an overseas design lead. Their strong point in engine design has been in the compressor stage, while their weak point is, naturally enough, in the turbine stage due to lack of R&D capability and high temperature materials.

Turbomeca has a total of about 1.3 million square feet of covered floor space in three plants located in the south and west of France. In addition, Turbomeca holds a 51% share of Bet-Shemesh Engines, an aircraft engine factory in Israel. The company is capable of producing only about 1,000 motors per year, not including about 800 motors which are brought in for refurbishing. The workforce is only about 4,600 employees. Consequently, its manufacturing capabilities are very limited; and presumably any major new business would have to be accommodated through licensing or collaboration with a larger firm.

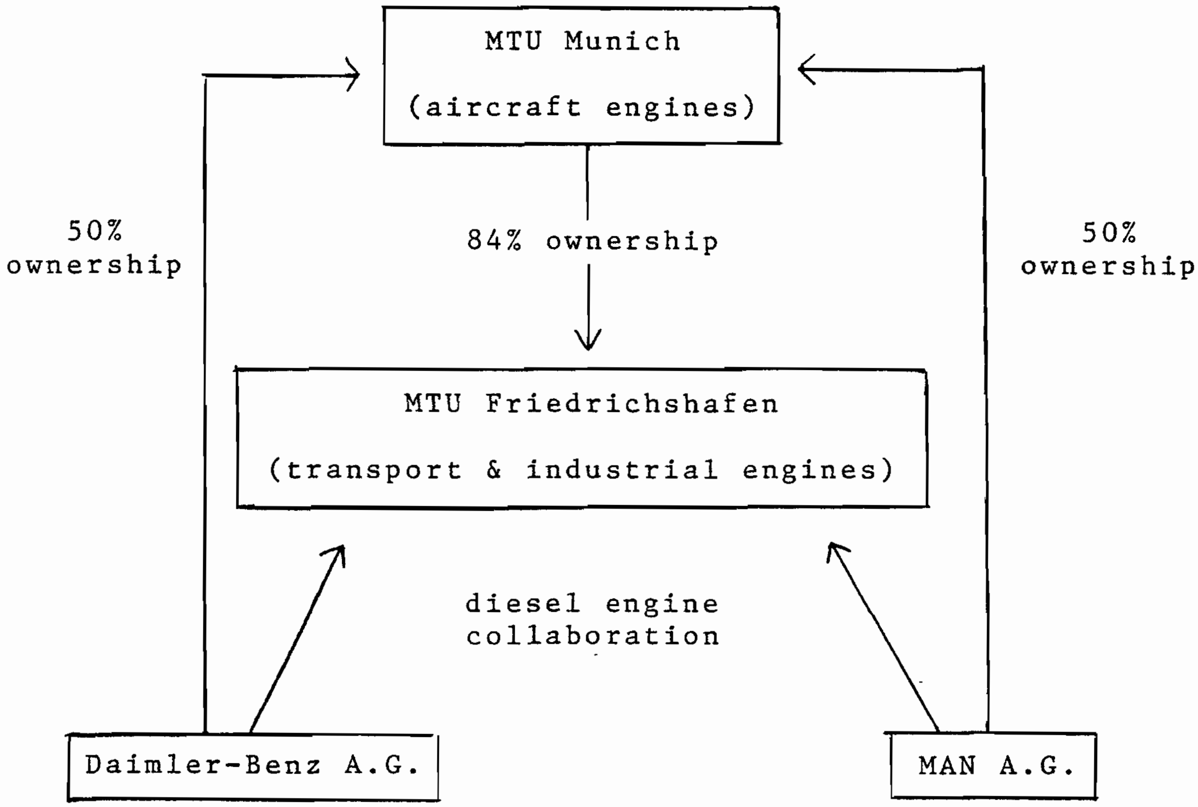
4. Motoren-und-Turbinen Union (MTU)

As Table 14 indicates, MTU is the third largest aircraft engine company in Europe, a firm which has resulted from the successive mergers of other aircraft engine manufacturing facilities in Germany. The firm currently employs about 6,000 workers, representing virtually the entirety of the German aircraft engine industry. As is characteristic of other major German defense firms, MTU is engaged almost totally in collaborative ventures with British and French companies. Probably the most important is its participation, through the consortium known as Turbo-Union, in which it owns 40%, in the manufacture of the RB-199 engine to power MRCA. Although German industry and government are desirous, in aircraft engines as in other advanced technology fields, to attain some advanced design and development capability, they are for the most part willing to assign design lead to their British, French, or American partners.

MTU in Munich has grown out of the BMW tradition of aircraft engine manufacture and has gradually incorporated the aircraft functions of Daimler-Benz, MAN-Turbo, and other significant aircraft engine capabilities. (See Figure 6). The MTU Munich group is also allied with MTU in Friedrichshafen, which concentrates on diesel and industrial engines. The present discussion focuses primarily on MTU Munich, as the aircraft engine entity. This organization is jointly owned by Daimler-Benz and MAN. In turn, MTU Munich owns about 84% of the shares of MTU Friedrichshafen. MTU also has about 6,000 employees in

Figure 6

MTU Ownership Structure



Source: MTU

Friedrichshafen, which produces diesel engines for ships, heavy trucks, industrial units, and also the engine for the Leopard Tank.

The company currently has annual sales on the order of about $120 million. Consequently, the principal point to keep in mind is that this is rather a small firm by American standards, in spite of the wide variety of programs in which it is engaged. Although the metal-working capabilities are new and well-advanced - including electro-chemical milling, electro-stream drilling, electron beam welding, and friction welding - the facilities are nevertheless rather small and total production capabilities are limited. Among the current principal programs are the following:

> Collaboration with Rolls-Royce in the Turbo-Union consortium for the RB-199 engine (also with Fiat).
>
> Continuing production of the General Electric J-79 engine under license.
>
> Licensed production of the GE T-64 turboshaft engine to power the Sikorsky CH-53 helicopters being built in Germany.
>
> Participation with GE and SNECMA in component production for the CF-6-50 engine to power some versions of the European Airbus.
>
> Probable participation with Pratt & Whitney and Rolls-Royce on the JT-10D ten-ton engine.

Participation with SNECMA and Turbomeca on Larzac engine production for the Alphajet trainer.

In spite of rather extravagant claims in German industry brochures, MTU is faced with a substantial job of catching up in product and manufacturing technology. The level of engine manufacturing experience in Germany is very low. In spite of a capability of delivering high-quality finished parts such as small forgings, blades, shafts, and discs, the capability to turn out complete engines, supported by adequate testing, has not yet been fully demonstrated. However, the industry has gained a great deal of experience in J-79 subcontracting and subsequent manufacture, initially for the F-104 and later for the German F-4. MTU has also gained a great deal of useful information as a full-scale participant with Rolls-Royce in the RB-199 program which is of great help in building development capabilities in Germany.

MTU has a long history of collaboration with General Electric, especially for the J-79 engine, of which 1,000 out of a total 13,000 production run were built in West Germany. For the J-79 for the Phantom, the arrangement called for 40% of the engine parts to be manufactured in Germany and 60% sold direct from General Electric.

One area of particular concern is the fact that no new programs are currently anticipated following the development and production projects of the RB-199 and Alphajet engines. Much depends, therefore, on the outcome of the JT-10D turbofan program with Pratt & Whitney and Rolls-Royce.

II. The European Tactical Missile Industry

A. An Industry Overview

B. The National Industries

A. An Industry Overview

A. An Industry Overview

The remarkable proliferation and duplication of tactical missile programs in Western Europe in the last 15 years can be attributed to a number of causes. First of all, the requirements for capital investment, compared with the much higher levels of investment required for efficient production of aircraft, are well matched to Europe's resources, and rapid market growth has made that investment secure. Secondly, the level of R&D manpower allocation is well matched in a quantitative sense to European resources, while the high qualitative abilities of the European defense engineering base are sufficiently challenged by tactical missile development. Third, many European air, naval, and ground force requirements are extremely well served by tactical missile technology, particularly in view of technological advances that have taken place, under the general heading of precision guidance, in recent years. Next, there is the manufacturing element. The relatively long and high-volume production runs that characterize the tactical missile industry provide a virtually unique opportunity for European industry to gain the full benefits of large-scale and highly repetitive manufacture. Further, the enormous export potential of the various families of tactical missiles renders them important in Western Europe. Finally, the lower costs of tactical missiles enhance their attractiveness to hard-pressed defense ministries.

Another point which is often emphasized in Western Europe is that, while the United States and Soviet Union were virtually pre-occupied, in the 1960s, with competitive advances in strategic weapons, the principal European countries - at least in Britain, Germany, and France - saw the importance of tactical missiles and gained a considerable head start in the development of the next generation of such weapons. Consequently, in spite of a recent re-orientation of American efforts in this category, Europe still maintains parity in most categories of tactical missiles and is prepared to compete head-to-head in a number of categories. In contrast with some other types of military systems, the European tactical missile industry generally feels itself to be the technological equal of the United States, capable of collaborating as a co-equal in any future programs or, if necessary, of competing in world markets.

Furthermore, there appears to be a more immediate French readiness for collaboration with Britain and Germany in tactical missile programs than in other fields. Two possibilities are evident. First, the existing consortium of interests between MBB and Aerospatiale, in Euromissile, could be joined by one of the British groups - for example the BAC Guided Missiles Division; or, merely as another example, there could be a German linkage with the coalition that has formed between MATRA and HSD. In practice, following the nationalization of the British aerospace industry, which will probably lead gradually to a merger of the missile activities at BAC and HSD, the collaboration of this merged British organization with Euromissile would appear to be the most likely development. In such a case, it will be important for France to preserve the capabilities of MATRA in air-launched weapons development in this new international context.

The head of Euromissile (which will be mentioned frequently in the following sections) has been quoted as saying that "equality is the golden rule": in the division of development and production work between France and Germany. He has also added to this another "golden rule", to the effect that "there should be no duplication of production activities." As a result of the second rule, Euromissile has taken a somewhat different approach from other European collaborations. There is, for example, only a single final assembly line for the missile itself - at the Bourges facility of Aerospatiale. The launch units are assembled only at the Ottobrunn plant of MBB; and mounting of the units on the respective vehicles is carried out separately in the two countries. Initial production rates are about four launch units and 200 missiles per month. The goal of Euromissile is to produce up to 40,000 missiles and 2,000 firing posts by 1985, representing sales on the order of $2 billion, not including the U.S. market which is expected to be worth another $2 billion.

There appears to be a strong interest in Europe in further collaboration on missile systems, not only among a broadened group of European partners, but also with the United States. Discussions with European industry analysts in the course of the present study have been helpful in identifying some European views about possible future projects, all of which stress co-development rather than licensing. With regard to areas in which European industry perceives a European lead, the short-range SAM for battlefield use against fast, low-flying targets is certainly one category - a viewpoint substantiated by the Roland, Rapier, and Crotale developments in the first generation. However, there is interest in a collaborative approach, both intra-European and trans-Atlantic, in a second generation short-range SAM.

The same is true of anti-tank missiles, an area in which Europe feels itself to be the equal of the United States based on systems that are already fully developed but in which U.S. technology is important in the next generation. The British government, for example, has encouraged future collaboration on a third-generation anti-tank missile to meet standardized alliance requirements.

A medium-range SAM, with greater systems integration than preceding systems, with a very low-altitude capability and considerable ability to operate in the presence of ECM, is certainly of interest for collaboration; and the European industries consider themselves in a good position to collaborate on such a project.* There are already two to three proposals underway which would be based on various combinations of the electronics and aerospace industries in Europe, using new types of radars. A lead might be expected, for example, from such firms as Marconi and AEG-Telefunken.

There is also a feeling of technological equality in the area of AAMs, as exemplified by the R-550 Magic missile. The European state of the art is considered to be well advanced both in terms of high-altitude interceptors and close-in dog-fight weapons. In addition to the French capabilities represented by MATRA, the new seeker developed by Marconi for the UK Sparrow is considered to be a superior unit. Observers in the French industry believe that there could be a collaborative requirement for the next generation of high-altitude, high-Mach-number AAM interceptor missile as a follow-on to the Super 530 and Phoenix. Such a missile would have long range and would depend on a two-phase guidance system, one for cruise and one for homing. A follow-on to the present generation of dog-fight missiles could also be considered, using a U.S. target seeker with a European missile (or at least assigning design leads along these lines).

Another domain of considerable future interest for Europe is the SSM. The view is that Lance and Pluton fulfill virtually the same requirement for a 100-kilometer ballistic weapon. A new generation based on improved navigation and propulsion technology could be of interest. In Europe, Aerospatiale would be one obvious participant in such an effort.

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* A U.S.-German collaboration is possible, but French-U.K. collaboration seems very unlikely.

As for anti-ship missiles, the European position is considered to be fairly strong. As discussed later, there is some resentment that the United States did not give greater attention to Exocet, which was already well into development at the time that Harpoon was started. The attitude in Europe is that the technologies and performance parameters of Exocet, Harpoon, and Otomat are generally equivalent and that Europe had, prior to the start of the Harpoon project, at least some design lead in this area. All three missiles operate at about the same cruise speed regime. A potential need for a follow-on to these three systems is recognized. The principal specification would be supersonic speed, compared with the typical 300 meters per second of the present generation.

A similar list of potential trans-Atlantic collaborative missile ventures has been provided privately by a French aerospace company. The list is as follows:

Low-weight air-to-air radar missile

Long-range supersonic anti-ship missile

Next generation SSM to replace Lance and Pluton

New AAM for interception of high-altitude high Mach targets

Ship defense against anti-ship missiles

New generation of low-altitude SAM to replace Rapier Roland and Crotale

RPV

NIAG has also reportedly completed several early feasibility studies concerning a second-generation supersonic anti-ship missile which could be standardized for the NATO countries. This has the strong support of the leading NATO

Table 16

Characteristics of Selected Anti-Shipping Missiles

Country and designation	Length (m)	Weight (kg)	Max. range (km)	Propulsion	Guidance	Countries deploying	
France EXOCET	5.2	730	40	S	ARS	France Britain West Germany Malaysia Greece Peru	Argentina* Brazil* Belgium* Ecuador* Pakistan*
W. Germany KORMORAN	4.4	600	35	S	IR/ARS	West Germany	
Italy/France OTOMAT	4.4	730	80	S/TB	ARS	Italy Peru*	Venezuela*
Italy/France SEA KILLER Mk 2	4.7	300	25	S	RC	Italy	Iran
Norway PENGUIN	3	340	30	S	IRS	Norway Turkey	Sweden
U.S.A. HARPOON	4.6	660	110	S/TB	ARS	USA Holland* Denmark* Norway*	Britain* W. Germany* Iran*

* Countries that have not yet deployed system, but are known to have placed an order.

Key: Propulsion:
- S solid-fuel rocket
- TB turbojet
- R ramjet
- L liquid-fuel rocket

Guidance:
- ARS active radar seeker
- SARS semi-active radar seeker
- TV television command
- IRS infra-red seeker
- RC radio command

Source: IISS 1975

countries and could possibly be a project for Euromissile.

There is general recognition in Europe of a U.S. technological advantage in a number of areas such as electro-optical systems for terminal guidance; various forms of precision guidance to the target; in large SAMs; in large ASMs, and in cruise missiles. A U.S. lead is also recognized in various types of miniaturized target seekers. Another domain in which the United States is recognized to have a strong lead is that of remotely piloted vehicles (RPVs). In this category, Europe would undoubtedly accept pure licensing arrangements from the United States; and it seems likely that air-to-ground missions would be of greatest interest.

In examining European interests and motivations, it is vitally important to recognize, that for Europe as a whole, 50% to 60% of missile production is normally exported. The prospect of an embargo on supplied parts would essentially rule out the prospect of any licensing agreement. (Obviously, however, if export potential to the third world were replaced by some assured share of the American military market, this could become a negotiable issue.)

One problem that is recognized in the European missile industry, as in the United States, is the difficulty that arises from different standards and regulations of manufacture and operation from country to country. (This problem is discussed in more detail in Part VI.) Due to problems that have arisen within Europe, interest has developed in the establishment of supranational authorities to standardize regulations and standards of all kinds governing contractor performance. It is recognized as essential, in future trans-Atlantic collaboration, to establish an international body on standards.

There have been heavy administrative and psychological burdens created by the lack of standardized procurement regulations and specifications, and performance standards within Europe, and the differences are likely to be even greater where the United States is concerned (as the Roland II experience may suggest).

Another problem of general importance for standardization but of special criticality for missiles is the "two-way street." The trans-Atlantic balance of missile purchases still strongly favors the United States as shown in Table 17 . Although the United States will undoubtedly be able to establish several significant licensing or subcontracting arrangements without a two-way street, any real progress toward standardization will require either co-development, along lines already suggested, or additional Europe-to-U.S. licensing agreements that are freer of difficulties than the Roland II arrangement.

As the following sections will indicate, the firms involved in tactical missile development and production in Western Europe are, with few exceptions, the same as those involved in aircraft production (MATRA is the most important exception). In Britain, Hawker Siddeley Dynamics (a division of the Hawker Siddeley Group), British Aircraft Corporation, and Short Bros. and Harland have all developed tactical missiles of different types. In West Germany, MBB is the principal developer and manufacturer of tactical missiles. In France, Aerospatiale and MATRA are the important factors in missile development and production.

The tactical missile industry, both in Europe and the United States, is closely linked and dependent upon the major electronics firms. In fact, the electronics

Table 17

Trans-Atlantic Missile Trade Through Mid-1975

	European Purchases/Licenses	U.S. Purchases/Licenses	
Country	Missile	Missile	Supplier
Norway	Bullpup, Sea Sparrow, Nike Hercules, Sidewinder, Tow	SS.10 SS.11 Entac	France France France
Sweden	Hawk, Redeye, Falcon, Sidewinder	Roland II	France/Germany
Finland	Falcon		
Denmark	Honest John, Bullpup, Harpoon?, Sea Sparrow, Nike Hercules, Hawk, Redeye, Sidewinder, Tow		
Germany	Honest John, Sergeant, Pershing, Lance, Asroc, Nike Hercules, Hawk, Tartar, Redeye, Sparrow, Sidewinder, Tow.		
Holland	Honest John, Lance, Harpoon, Terrier, Sea Sparrow, Hawk, Tartar, Sidewinder, Tow		
Belgium	Honest John, Lance, Sea Sparrow, Nike Hercules, Hawk, Sidewinder		
Luxembourg	Tow		
France	Honest John, Hawk, Tartar, Sidewinder		
Spain	Asroc, Sea Sparrow, Hawk, Standard, Sparrow, Sidewinder		
Switzerland	Falcon, Sidewinder		
Italy	Honest John, Asroc, Terrier, Nike Hercules Hawk, Sea Sparrow, Tartar, Sparrow, Sidewinder, Tow		

Trans-Atlantic Missile Trade Through Mid-1975
(continued)

	European Purchases/Licenses	
Country	Missile	
Greece	Honest John, Asroc, Nike Hercules, Hawk, Sparrow, Sidewinder, Tow	
Turkey	Honest John, Bullpup, Harpoon, Asroc, Sparrow, Sidewinder, Tow	
UK	Honest John, Lance, Bullpup, Sparrow, Sidewinder, Harpoon	

Source: Flight International, 29 May 1975 firms often act as prime contractors for tactical missile systems (e.g. Raytheon's role in the United States and that of Thomson CSF in France as prime contractors). These firms are identified in Part V of the report.

B. The National Industries

1. The British Missile Industry

2. The French Tactical Missile Industry

3. The German Missile Industry

1. The British Missile Industry

To summarize briefly, there are three British firms engaged in missile production: Hawker Siddeley Dynamics; British Aircraft Corporation; and Shorts. Hawker Siddeley Dynamics, Ltd. is a subsidiary of Hawker Siddeley Group. This division has about 7,000 employees engaged in design, development and production of guided weapons as well as a small amount of work on space programs. Because there have been so many program cancellations in Britain in the last several years, the emphasis here will be on projects which are still active or on capabilities that provide a basis for further activity. In general, British industry appears to be stronger in surface-to-air than other types of missile systems.

HSD maintains a strong R&D capability, as exemplified in its short-range air-to-air missile research program (designated SRAAM) calling for high accelerations and high maneuverability for dog-fight conditions at high closing speeds. The SRAAM program, as currently conducted, is guided by a passive IR homing system and uses thrust vector control for high maneuverability. Experienced observers in other countries are doubtful about the use of thrust vector control but recognize its theoretical advantages for maneuverability. SRAAM has been reduced to a technology acquisition project but may result in several test firings. There is also a concept study for a ship-launched version designated Shield.

HSD is Raytheon's licensee for production of the British version of the Sparrow AAM (designated XJ-521), a medium-range all-weather air-to-air weapon using a new semi-active radar guidance system developed by Marconi

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Space and Defense Systems. This project is now reportedly in the production phase. The Marconi system has attracted a fair amount of attention in U.S. industry, and there is a strong feeling that the British version of Sparrow, with the Marconi semi-active radar homing head and EMI fuse, makes it one of the best medium-range AAMs available. The XJ-521 will arm all RAF interceptors. It will incorporate an inverse monopulse seeker to operate beyond visual range and give an all-weather capability. This seeker, combined with an active fuse, is being tested in the United States for possible use on U.S. fighter aircraft. At the same time, Raytheon and General Dynamics are now developing an inverse monopulse seeker for the AIM 7F and have already developed and tested an active fuse. According to press reports, the U.S. forces may proceed with the purchase of the XJ-521 monopulse seeker while development of a second-generation seeker in the U.S. continues.

In the surface-to-air category, one important program is the naval SAM designated Sea Dart, which is in production both for the Royal Navy and the Argentine Navy. This is a third-generation area defense weapon capable of interception at both high and low altitudes, both of aircraft and missiles. It is intended for the Royal Navy's Type 42 destroyers and ASW cruisers. The missile uses ramjet propulsion and radar guidance, combining an illumination radar with semi-active homing in the missile. Range is in excess of 30 kilometers. The tracking and illumination radar is built by Marconi Radar Systems. The missile is boosted to speed by a solid fuel booster, followed by a ramjet engine for sustained cruising flight. Production began in 1967. A land-based version of this system is also under development.

In the air-to-surface category, HSD has collaborated with MATRA in the development of the Martel ASM, which employs either TV or anti-radiation guidance systems, depending on national requirements. Both versions are designed to operate in an ECM environment. The AS-37 anti-radar version homes on electromagnetic radiation. In the AJ-168 version, a nose-mounted TV camera and data link for video and command signals is employed. Range is probably on the order of 60 kilometers. Electronique Marcel Dassault provides the homing head for the anti-radiation missile. Marconi Elliott Avionics Systems Ltd. produces the TV homing system. A proposed anti-ship version was abandoned when the McDonnell Douglas Harpoon was selected by the Royal Navy in 1975.

Finally, HSD is the developer and manufacturer of the IKARA anti-submarine missile, which in its principal mode of operation is dropped by parachute from an aircraft operating in conjunction with anti-submarine surface vessels. This is a collaboration with the Australian Navy.

The second major missile firm in Britain is the Guided Weapons Division of British Aircraft Corporation, which also has about 7,000 employees. The main current activities at BAC are the following:

> The Sea Skua anti-ship missile, using semi-active radar homing, which is a development primarily to arm the Lynx helicopters in the Royal Navy. Its role is to provide long-range self defense for frigates against missile-carrying fast patrol boats. The target will be illuminated by a Ferranti radar on board the Lynx helicopter. This system has not yet entered service, but full development has been authorized. Up to four missiles will be carried on a single helicopter. It seems likely, according

to recent reports, that the French Navy will also purchase Sea Skua for use on its own Lynx aircraft, but this is far from certain.

The Sea Wolf naval point-defense SAM is now in final stages of development for the Royal Navy. This is a short-range radar-guided weapon which appears to be regarded, both in and outside Britain, as a promising system technologically. The system is designed for use on frigates, to provide rapid reaction against both aircraft and anti-shipping missiles. Marconi Space and Defense Systems is developing the surveillance radar, target tracking radar, TV and data handling equipment. The development program is largely completed, and production orders may have already been placed. Sea Wolf is viewed primarily as an anti-missile missile capable of intercepting missiles with speeds of up to Mach 2. The first role of Sea Wolf will be to arm the Royal Navy's Type 22 frigates and subsequently to be fitted in existing vessels, both in Britain and for export.

Rapier is a low-level SAM with both optically guided and blind-fire versions. It is currently in operational service with the British Army and RAF as well as the armed services of Iran, Zambia, Oman, Abu Dhabi, and Australia. Rapier was designed as a light-weight, highly mobile SAM for battlefield troop protection against fast low-flying aircraft. Rapier was one of the finalists in the U.S. Army competition for a battlefield SAM, along with Crotale and Roland II. The loss to Roland II was apparently a reflection of the operational mode desired by the U.S. Army rather than any inferiority of operation. Roland is self-propelled rather than towed and offers some armored protection to the crew. Furthermore, the Roland carrier holds more missiles and would be marginally more effective against successive waves of attack down a single narrow corridor - whereas Rapier is considered more effective in dispersed operations against individual aircraft. However, Rapier is a much cheaper system than Roland II and probably has a strong export potential, as orders to date confirm. Export orders for Rapier already total about $1 billion. Currently, development of a tracked Rapier is underway, capable of carrying eight missiles.

The further developments of the BAC Swingfire anti-tank missile, the Hawkswing helicopter-mounted version and Beeswing infantry-operated version have all been cancelled as a result of the British MOD decision to adopt the Franco-German MILAN for manufacture under licensing in Britain. The stated reason for the choice was that MILAN is semi-automatic compared with the manually operated Swingfire system. Of interest to the British Army of the Rhine is a helicopter-launched MILAN. The British MOD has based negotiations on the need for worksharing as well as British technical involvement in improvements of the missile, and also the prospect of a Europe-wide missile for the next anti-tank generation so that France, Germany, and the UK will all be involved in a standardized system.

The SAM III. This is a BAC proposal for a joint development with Thomson CSF and MATRA. In addition, BAC has held discussions with AEG-Telefunken on this proposal, which would in effect be a successor to the Bloodhound, Thunderbird, Hawk and NIKE Hercules - presumably for an extended range interceptor missile.

Short Bros. and Harland Ltd., with facilities in Belfast, has remained active in the missile business, but there is some indication that the government's protection of this activity has been strongly associated with its geographic location. The firm has about 6,000 employees, not all of whom are engaged in missile production. The ownership is largely in the hands of the British Government (69½%) with shares of slightly over 15% each by Rolls-Royce and Harland and Wolf. The main current programs, not including older programs, are the following:

Blowpipe, a shoulder-launched infantry missile for surface-to-air use, of which 285 units are on order for the British Army and Royal Marines as well as 100 for the Canadian Armed Forces.

The Seacat ship-based SAM which has been sold to numerous navies; and its land-based version, Tigercat, a low-level SAM which is in production for the RAF and the export market. This system utilizes a command link with optical or radar tracking.

The SLAM system (submarine launched air flight missile), a close-range surface-to-air missile based on the Blowpipe. This system was actually developed by Vickers to meet the need of submarines and light surface craft for effective short-range defense both against helicopters and other surface craft. Shorts supplies the Blowpipe missile for the system.

Currently, two major trends in the British tactical missile industry are apparent: first, the likelihood of an eventual merger of the missile divisions of the BAC and HSD in the course of the industry's nationalization into the new "British Aero Space". Second, a number of recent decisions - especially the choice of Milan over Hawkswing - indicates that the British government will favor multi-national collaborative ventures to purely national guided weapons programs. A third point, already apparent, is that the major British electronics firms such as Marconi are likely to take the prime role in many future programs, rather than the missile manufacturers, given the necessary emphasis on electronics as the basis of any tactical missile system.

2. The French Tactical Missile Industry

In France, there are two major centers for the development and production of tactical missiles. The largest is Aerospatiale, a diversified aerospace company, in which one of four divisions is devoted to both tactical and strategic missiles. Aerospatiale is responsible not only for the tactical missiles which are of interest in this study, but also for the land-based and sea-based strategic missile programs, which will not be considered here. As already mentioned, Aerospatiale is a nationalized company and has acted as France's collaborator with Germany on the Roland, HOT and MILAN programs under the Euromissile rubric. Aerospatiale's tactical missile programs tend, in general, to be concentrated more on Army requirements than those of Engins MATRA, the privately owned company which has specialized in air-launched missiles of considerable sophistication.

Not including older programs such as the AS-20 and AS-30 which have a long production history, the current and early future programs of Aerospatiale which appear to be of most importance, for purposes of this study, are Exocet, Roland II, MILAN, and HOT.

Exocet is one of Aerospatiale's most important projects. This is a solid propellant anti-shipping missile which has been developed both in surface-launched and air-launched versions and is now in its second generation of development. Orders have already exceeded over 1,000 rounds for 14 customers, including both the British and German navies. Over 90% of Exocet production is exported, which gives it special importance to French government and industry. For the British orders, there is one offset agreement under which many components are produced in Britain.

In addition to British and French orders, the missile has also sold very well in Latin America and the Middle East. Exocet is regarded in France as the technological equal of Harpoon; and some cynicism about American intentions on standardization is attributed to the fact that Exocet development preceded that of Harpoon by about two years. Exocet has a surface-to-surface range of about 20 miles, flying at very low altitude. Although it is a national program, it does use several elements in common with the joint MBB-Aerospatiale Kormoran air-to-sea missile - for example a twin-gyro inertial guidance system for the initial trajectory. In addition to Aerospatiale, which acts as system manufacturer and integrator, EMD provides the electromagnetic homing head, TRT the radio altimeter, and BAC provides radomes. The initial production rate was about ten a month, and this may have grown to about 25 per month currently. However, precise figures are not available.

For the future, it is not possible to assess Aerospatiale's tactical missile activities in a purely national context. For Aerospatiale, the collaboration with MBB, through Euromissile, is becoming increasingly important. Obviously, Roland II, MILAN, and HOT provide the basis of this collaboration, but there are other design projects underway, such as the Jason study for a development of Roland capable of intercepting anti-ship missiles. For France, as for Germany, the sustained production runs that have resulted from these programs are especially welcome. For the long run, some 10,000 to 12,000 rounds will probably be purchased by each country. In addition, the selection by the U.S. Army, resulting in the license to Boeing and Hughes, has increased world interest in the missile - even though it has created complications in sourcing for the export market. All three countries have agreed to seek an optimum level of standardization for their Roland systems, but obviously any redevelopment of the system in the United States, which at the present moment seems to be considerable, destandardizes the system. Furthermore, Norway has announced its intention to purchase Roland, but the announcement that a version would be manufactured in the United States has led to complications in the Norwegian order.

The MILAN medium-range man-portable anti-tank missile is now being turned out at the rate of 1,300 per month, with an increase to 1,600 a month anticipated in the early future. Total French and German procurements are estimated at 100,000 - and this does not include the many export prospects. To date, over 20,000 rounds have been manufactured, and orders reached 35,000 in 1975.

Turning now to MATRA, this smaller and privately-owned company has established advanced technology capabilities, especially in the development and manufacture of air-launched missiles. In future, it will probably extend its activities into other families of tactical missiles. MATRA has formed an international alignment through its collaboration with HSD, which offers an interesting alternative to Euromissile as a locus for American collaboration. MATRA has a total workforce of about 4,000 employees and current sales of about $190 to $200 million annually. Although the company engages in a number of civil markets, especially automotive, by far its largest and most successful operation is in the missile field. The programs of principal current interest at MATRA are the following:

The R-530 air-to-air missile, which is the standard Mirage armament, with IR homing provided by SAT. Some 4,000 of these have already been sold; and it is now being superceded by the MATRA Super 530.

The Super 530 is scheduled to enter operational service in 1978. It is a longer-range AAM which will arm the Mirage F-1. There will probably be an initial French order of about 1,000 rounds, and other Mirage F-1 customers are very likely purchasers. The Super 530 is an interception missile which essentially doubles the range and target acquisition distance of the R-530. It is intended for use against high-altitude, high-Mach-number targets - e.g. altitudes in excess of 70,000 feet. Following the completion of tests against supersonic high-altitude targets, this Mach 3 missile will probably enter production sometime in 1977.

The R-550 Magic, with IR homing, is a close-in dog-fight missile. There have already been orders for about 6,000 rounds by the French Air Force and Navy as well as a Sidewinder replacement in the French military services. Deliveries of the first series-produced missiles began in 1974. It reached operational status in 1975.

The Martel ASM program, carried out in collaboration with HSD, has already been described. It is being used by the French Air Force on Mirage 3 and Jaguar; by the French Navy on the Atlantique; and also on RAF aircraft as already discussed. MATRA has prime responsibility for the AS-37 anti-radiation version, for which EMD provides the electromagnetic homing head.

In collaboration with the electronics firm Thomson CSF, MATRA is producing the Crotale battlefield SAM, which has been developed jointly with French and South African defense ministry funds. It has been ordered by the French Air Force and Navy and also for export by South Africa and Saudi Arabia. In addition, other European and Middle Eastern countries have ordered the system. As noted elsewhere, Crotale was a finalist in the competition with Rapier and Roland II for ground force defenses against low-flying aircraft. The complete system is mounted on several separate vehicles, carrying the missiles in containers as well as a pulse Doppler S-band surveillance radar and acquisition radar. The system uses command guidance by data-link. Series production has been underway since the end of 1968.

Finally, the Otomat anti-shipping missile, developed jointly by MATRA and Oto-Melara of Italy, is worth mentioning. This missile is essentially a competitor to Exocet and Harpoon. It is intended for launching from naval platforms of any size, but it also has a capability for fixed or mobile land deployment or aircraft deployment. The latest version has a range of about 100 kilometers in all modes. The missile has a Thomson CSF guidance which permits a late pull-up and dive trajectory to the target. After launch, the Otomat follows a cruise phase using radio altimeter control and inertial buidance. First launch was in 1974, and the missile is now in production following an initial order of 120 rounds, most of which were for the Italian Navy. In addition Venezuela has ordered 40 missiles and other export orders have reportedly been added.

Among European aerospace companies, MATRA has developed one of the more impressive capabilities for systems analysis, systems integration, and simulation. They have, for example, developed computer simulation techniques for linking the sometimes conflicting technologies of missile aerodynamics, propulsion, and guidance. In the early 1970s, about 65% of MATRA's sales were military (50% missiles and 15% rocket-launchers and parachute bombs), 25% were in space activities, and the remaining 10% in civilian work - primarily for the MATRA sportscar. However, although the goal was to reach a higher civilian proportion, it seems entirely likely that the balance has shifted even more to the military by the mid-1970s.

MATRA has recently expressed its disappointment that "after perfect cooperation" on MARTEL, the British MOD appears to have reverted to trans-Atlantic collaboration rather than further European missile development - especially in rejecting the sub-MARTEL anti-submarine version of the weapon for Harpoon, and also in collaborating on the Sparrow program instead of joining with MATRA on the R-530. MATRA's earlier expectation had been that British cancellation of the SRAAM and Taildog programs would have been a first step to Anglo-French collaboration on a dog-fight missile. MATRA has also argued that German purchase of AIM-9L has resulted in a second-rate system compared with what they regard as the superior R-550 Magic.

3. The German Missile Industry

The leading missile manufacturer in Germany is, of course, MBB. The firm's missile activities began in 1956 in the development of the Cobra anti-tank missile for the German Ministry of Defense, a program that was performed in collaboration with another German firm and the Swiss firm Contraves-Oerlikon. This missile is still in production, and through 1975 more than 150,000 units had been built.

As noted in the aircraft section, the German government strongly supports collaboration, and this attitude is thoroughly evidenced in MBB's missile programs. In addition to Cobra, which is now well into its production life, the following are some of the major programs and planning projects at MBB:

> The Kormoran air-to-surface anti-ship missile, a collaboration of MBB and Aerospatiale, has been ordered by the German Navy and may possibly also be used on MRCA. It is a long-range low-level system with three different guidance systems: anti-radiation, active radar, and IR homing. The missile is launched when the aircraft is flying at a low level, and there is on-board computation equipment to relate the position of the aircraft at launch with that of the target in order to allow the on-board inertial navigation system to guide the missile toward the target at low altitude. The radar homing head is a development of Thomson CSF, capable of active or passive modes of operation.
>
> The FK-80 (Hydra) is the designation for a project for the next generation of supersonic anti=ship missile, which will

probably be developed as a collaboration between MBB and Aerospatiale. Presumably, this will replace Kormoran in the long-term future. Development of this missile is proposed to begin in about 1981, with service entry planned for about 1986. This long-range weapon will probably be ramjet-powered and will arm ships, fixed-wing aircraft, and helicopters. It would probably supercede all three of the present anti-ship missiles including Kormoran, Harpoon, and Exocet.

The Mamba is a portable wire-guided infantry anti-tank missile, based closely on Cobra technology, that is now in production at MBB. The motor for this missile utilizes programmed thrust, which provides a comparatively slow start and a fast cruise mode. No orders have yet been placed, and the project is still in the development phase.

Jumbo is a long-range ASM utilizing a combined autopilot and inertial guidance system in the cruise mode and TV homing and data-link in the terminal phase. It is now cancelled but was scheduled to enter service in 1981, primarily for use on MRCA and to supplement the Kormoran missile on other naval aircraft. The weapon was intended for use against large or high-value surface targets. Project definition began in 1972, and full-scale development started briefly in 1976. According to previous planning, two of these missiles can be carried on MRCA, and the system can be launched at high or low level. Clearly, MBB would prefer to have a collaborator in this program, and there was some hope that the United States would be an appropriate partner.

The Armbrust, a ballistic anti-tank missile which is now in final stages of development. This is a close combat weapon which has attracted attention in the United States, as demonstrated by its inclusion in an Army contract with Boeing for the study of close-in combat weapons. Armbrust is a man-portable shoulder-fired weapon for use against armor and protected targets at ranges up to 300 meters.

Most important, however, within the MBB missile activities are the collaborations with France on MILAN and HOT, which are being manufactured under the general guidance of the collaborative firm Euromissile. It is interesting to note here that MBB has expressed its hope, occasionally, that the British missile industry would also join Euromissile at some future time. MILAN began replacing Cobra in 1975 and is expected to serve until 1990 in the German forces. HOT will begin to replace the SS-11 in about 1978 and remain operational until the mid-1990s. As noted previously, MILAN will probably be built under license in Britain. MILAN is a wire-guided, spin-stabilized anti-tank system incorporating semi-automatic guidance. Although it is somewhat heavier than first-generation anti-tank missiles, it is nevertheless portable.

HOT is also an anti-tank missile using wire guidance. It differs from MILAN in terms of weight and application. Typically, HOT is mounted on a tank or other armored vehicle. The weapon has been accepted for use in the German and French ground forces and will undoubtedly have a long production run in both countries, under the general direction of Euromissile. A helicopter-mounted version is under study which may also be accepted by the British Armed Forces. The key points to make about HOT and MILAN are: first, that by combining the military markets of France and Germany, long production runs are ensured which provide efficiencies of scale; and second, that standardization is a very real output of this effort.

Finally, it is also worth pointing out that Euromissile represents the possible beginning of a fairly large consortium of European countries for the development and production of tactical missiles, since it is also responsible for the Roland missile which has been licensed to the United States. The next logical step, one which is very much desired by the Germans, will be for Britain to take part more actively in the Euromissile consortium. It may be that, in the missile field, as contrasted with aircraft, there will be more French willingness to collaborate with British industry - as already evidenced by the apparently harmonious relationships that have been developed between HSD and MATRA.

For the future, it seems most likely that MBB will be the focal point for additional development in tactical missiles. However, Dornier is apparently still engaged in a short-range naval SAM study, in collaboration with AEG-Telefunken, VFW Fokker, and MATRA. This project is designated KUMAR, related to the development of a SAM for use against close-in targets.

III. The European Naval Shipbuilding Industry

A. Overview

B. Great Britain

C. France

D. Germany

E. Other NATO Navies

1. Italy

2. The Netherlands

3. Belgium

4. Denmark

5. Norway

F. Conclusions

A. Overview

In 1973, the report of the Commission on American Shipbuilding made the following comment: "By and large, Japanese shipbuilding has been dedicated to perfecting production of the known, whereas the largest part of the shipbuilding industry of the United States, through dominance of Navy requirements, has been primarily dedicated to exploring the technologically unknown." While the experience of European shipyards, including government-owned installations, has been closer to that of the United States since World War II, cost inflation and competition within Ministries of Defense for development funds, plus the much larger competitive R&D program of the U. S. Navy, have made the development of advanced naval technological systems in Europe very difficult to achieve. There have, of course, been exceptions to this (the hovercraft and the Harrier Carrier in the U. K.). New designs and technology in subsystems of naval construction since World War II have tended to originate in the United States.

Among the Western European countries, only the U. K. and France have relatively large, continuous naval construction programs. Both countries have maintained a naval nuclear deterrent force. France has three nuclear-powered ballistic-missile submarines, and the U. K. four. Both have maintained helicopter carriers or amphibious assault ships, of which France has one and Britain two. France has two 22,000-ton aircraft carriers, and Britain has one, the Ark Royal at 33,000 tons. Each country has a varying number of cruisers, destroyers, frigates and fast patrol boats, plus diesel-electric submarines. Both naval services have accepted the mission of deep-water ocean patrol and participate regularly in ocean-going training exercises. Britain participates in NATO exercises, while France's participation has been limited to the planning level.

To keep a fleet of 50 to 75 surface vessels at sea requires an annual construction program for naval vessels. There are essentially three reasons for this, the most important of which is the replacement factor. It is generally accepted that warships, as adequate launch platforms, should be scrapped after approximately 20 years. The proportion of ships in the British and French Navies, however, which are more than 10 years old, is two to one over the portion that is less than 10 years old, which argues for either a stepped-up construction program by each country in the period 1976 through 1985, or the decision to keep a smaller fleet afloat by each country during that same period. A second demand determinant for naval construction is technological developments which continue to occur during a 20-year period and generally require changes in ship, i.e. platform, size and configuration, to accommodate the technological changes that have occurred in the launching systems. Finally, the frequently less obvious desire on the part of national governments to keep a naval shipbuilding capacity in being adds to the argument for a regular program for naval ship construction.

While Britain and France, together, normally account for 67% of naval ship procurement expenditures among the six Western European NATO countries that maintain significant naval forces (the others are the Federal Republic of Germany, Italy, the Netherlands, and Belgium), there has been a strong tendency on the part of all six countries to direct all shipbuilding contracts to yards in their own country. In addition to keeping some naval shipbuilding capacity available for future needs, and (with the exception of France) to assisting the commercial shipbuilding of each country to survive, there has been a conscious effort in each country to support national employment policies as much as possible, keeping in mind that while total shipyard production is frequently not a significant factor in a national economy, shipyard employment can be highly significant in a few concentrated areas where it is located.

As in the United States, the British government made a decision in the early 1970s to direct all new naval construction to commercial shipyards on the grounds that it is cheaper to build there than in naval dockyards. Four naval dockyards in Britain, plus a fifth in Gibraltar, have been kept for maintenance and refit of existing vessels. In France, all naval ship construction is done in four government dockyards, with the exception of some small diesel-electric submarines and patrol craft, which have been allocated to private yards. In addition, the French government dockyards compete with private dockyards for export orders of warships.

Even in Britain and France, a relatively low level of naval construction has forced specialization to occur in two different ways. First, in each country there is specialization between yards. As in the case of Electric Boat Company in Groton, Connecticut, each country has one shipyard that specializes, to the exclusion of others, in nuclear submarines. (Cherbourg Dockyard in France and Vickers at Barrow-in-Furness in England). Different types of surface ships are allocated among lead shipyards, and it would be very difficult and costly for transfers to take place between them. In a second dimension, specialization has occurred in a limited way between countries. Partially in response to the practical needs of the construction program, and partly due to the nature of assigned missions, Britain and France have tended to concentrate in recent years on fewer, heavier ocean-going surface ships in the frigate and guided-missile destroyer categories. Informal discussions between Britain and the Continental NATO powers have led West Germany, the Netherlands, and Belgium to concentrate on lighter frigates and a larger number of fast patrol boats and mine vessels for the inshore missions they have to assume.

Since World War II, there has been a spiraling decline (with some significant exceptions) in the physical capacities of a majority of Western European shipyards. By 1975, Japan was up to 48.2% of total world ship output, followed by Sweden, Germany and the United Kingdom. Sweden's increasingly high labor rates and the history of poor management policies and low productivity in Germany and the United Kingdom led inevitably to lower investments in shipyards. (The reverse sequence can also be argued effectively.) Thus all of these countries found themselves progressively less able to compete on the world market. As noted above, the British government, as part of its attempt to offset this situation, has transferred naval production from Royal dockyards to private shipyards. The result throughout Western Europe has been consolidation of large shipyards and the specialization already referred to. There remain many small and medium-sized shipyards serving local needs for specialized vessels and ships to engage in cabotage (coast-wise shipping).

The net result of these trends, however, has been to make it very difficult for European shipyards to find the funds for R&D and design work, much less the capital improvements that are necessary to keep up with the rapidly developing and changing technology in naval warfare.

A paradox growing out of the changing requirements of naval warfare in the future (i.e., a larger number of smaller and more varied ship platforms, which will bear launching systems capable of sustaining anti-ship and anti-submarine warfare) may permit European NATO countries to resume affordable shipbuilding programs to replace their aging fleets of larger-sized frigates, destroyers, and cruisers at the very time they need to. In the absence of advance R&D and design work, however, it will continue to be more probable that the technology behind the development of these ships will come from the United States.

B. Great Britain.

At the end of 1975, the Royal Navy comprised 75 surface ships of frigate size or larger, including one aircraft carrier and two helicopter carriers, 32 submarines, including four nuclear ballistic-missile vessels, and eight other nuclear-powered submarines, and 464 smaller craft, including two assault ships. The construction program included three nuclear submarines, five guided missile destroyers, five frigates, four fast patrol boats, one helicopter, or so-called through-deck cruiser, and smaller craft. Future construction plans call for concentration on nuclear-powered submarines, guided-missile destroyers, guided-missile frigates, and smaller ship platforms, including Hovercraft and a flat-decked frigate capable of carrying VSTOL, such as the Sea Harrier and/or anti-submarine helicopters such as Sea Kings.

As noted previously, British Navy has accepted the NATO mission of deep-sea patrol in the North Atlantic, complementing that of the United States and, to a lesser extent, France. As the forward construction program, therefore, indicates, there will be a continued need for new naval ship construction for replacement and addition to the fleet.

In 1964, thirteen shipyards, including the Royal Dockyards, were capable of producing naval vessels. By 1976, this number is down essentially to three lead commercial yards, plus three additional commercial yards capable of building primarily on license for export.

Five Royal Dockyards remain in commission, four in the U. K. and one in Gibraltar. They are now confined entirely to repair, maintenance, and re-fit work. The following Table outlines the task of each Royal Dockyard from

1974 through 1977:

Ships in Refit 1974-75, 1975-76 and 1976-77

Class	Portsmouth						Devonport						Chatham					
Year ...	74–75		75–76		76–77		74–75		75–76		76–77		74–75		75–76		76–77	
Refit ...	M	N	M	N	M	N	M	N	M	N	M	N	M	N	M	N	M	N
Amphibious Forces ...	—	1	—	—	—	—	—	1	—	1	—	1	—	—	—	—	—	—
Aircraft Carrier	—	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—
Cruisers	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—
Nuclear Submarines ...	—	—	—	—	—	—	—	—	—	—	—	—	—	2	1	2	2	—
Conventional Submarines	1	3	1	2	—	2	1	2	1	2	1	1	1	—	—	—	—	—
Destroyers	1	4	1	2	—	3	—	—	—	—	—	—	—	—	—	—	—	—
Frigates	1	4	1	6	2	4	5	4	6	5	5	2	1	2	2	2	1	3
Mine Warfare Force ...	—	5	—	6	—	4	4	3	—	3	—	4	1	1	1	1	1	1
Other Ships and Vessels ...	—	4	1	5	3	2	1	4	1	5	—	4	—	2	—	4	—	4

Class	Rosyth						Gibraltar					
Year ...	74–75		75–76		76–77		74–75		75–76		76–77	
Refit ...	M	N	M	N	M	N	M	N	M	N	M	N
Amphibious Forces ...	—	—	—	—	—	—	—	—	—	—	—	—
Aircraft Carrier	—	—	—	—	—	—	—	—	—	—	—	—
Cruisers	—	—	—	—	—	—	—	—	—	—	—	—
Nuclear Submarines ...	—	1	1	—	2	—	—	—	—	—	—	—
Conventional Submarines	1	—	1	1	—	1	—	—	—	—	—	—
Destroyers	—	—	—	—	—	—	—	—	—	—	—	—
Frigates	1	2	1	2	1	2	—	3	—	3	—	2
Mine Warfare Force ...	1	6	1	6	—	7	2	1	2	—	3	—
Other Ships and Vessels ...	—	4	—	6	1	5	—	—	—	—	—	—

Notes:
(1) " M " denotes Major Refit. " N " Normal Refit.
(2) Where a refit spans 2 years or more it is shown in each of them if the period in a particular year is more than about 1 month.

Source: British Ministry of Defense

As in the United States, the decision to shift all new naval ship construction out of government-owned shipyards into commercial yards was based on studies that demonstrated that the cost of building in the latter was significantly lower than in the government facilities. Total employment in the five dockyards in 1975-76 approximated 33,600, of whom just under 26,000 were industrial workers. It is estimated that by 1979-80 there will be 34,750, with the number of industrial workers remaining fairly constant. Capital expenditures at the five dockyards are estimated to be about $52 million in the current year and to be $41 million annually by 1980. There have been repeated attempts by the government to reduce this expenditure, either by closing dockyards or reducing the workloads, but the attempts have generally failed, due in part to concern about increased unemployment and, in part, to concern for the disbandment of essential skills now concentrated in the dockyards. There is a fairly high degree of standardization between the British Royal Dockyards and the repair and refit dockyards of the other NATO navies in areas of fuel transfer, couplings, pipe sizes, etc.

Defense shipbuilding accounted for approximately 31% of all shipbuilding in the U. K. in 1974. The British shipbuilding industry has, under the impact of price competition from abroad (particularly the Japanese) and cost inflation at home, been reduced to some severe rationalization, usually under government supervision. As a result, the government has found itself in the position of owning varying amounts of different shipyard companies. For example, the government has had to take over Sunderland Shipbuilders, Ltd., Appledore Shipbuilders, Ltd. in North Devon, Govan Shipbuilders, Ltd. in Glasgow, and currently owns 50% of Cammel Laird at Birkenhead, Scot Lithgow, Ltd. in Glasgow, and Harland & Wolff in Belfast. The orderbook for most yards (with some notable exceptions) runs out in 1976 and 1977. In 1975, only 11% of orders from U. K. owners were placed in U. K. yards, instead of the 37% which have historically filled approximately 75% of total U. K. shipyards. The orders went instead to Japanese and South Korean shipyards, and shipyard owners and workers in the U. K. have turned increasingly to the government for assistance. An industry nationalization bill is due to receive royal assent in October 1976, following which major reorganizations of the shipyard industry may be expected. Chairman of the organizing committee, and Chairman designate of the British Shipbuilders Corporation, is Vice Admiral Sir Anthony Griffin, GCB, who recently retired as Controller of the Royal Navy and Third Sea Lord.

The exceptions to the gloomy outlook described above fall into two classes. One shipyard, Austin & Pickersgill, has concentrated on production in series of a standard type cargo ship, SD-14. They currently have 18 of these 15,000 dwt. ton ships on order, with additional orders stretching well into 1978. Part of their success has been due to concentration on a single line, part on the willingness of the company to invest sufficient capital in both the yard and management talent to successfully market their product.

The other class of exceptions, the three main shipyards involved in naval construction - Vickers at Barrow-in-Furness, Vosper Thornycroft at Portsmouth and Southampton, and Yarrow on the Clyde - each have, and will continue to have, a significant naval construction program under way. At mid-year 1976, current orderbook for all three is composed exclusively of naval vessels for the Royal Navy and foreign non-NATO navies.

The Royal Corps of Naval Constructors have historically done most of the ship design for the Royal Navy. In recent years they have begun to work very closely with the Design Departments of the three lead shipyards. The combined skills of the two groups, plus government-ordered specialization among the three yards, has proven to be a very successful formula. Vickers concentrates on nuclear submarines, the new through-deck cruiser, and the Type 42 guided missile destroyers; Vosper Thornycroft works on the Type 21 frigate, fast patrol boats, and mine-countermeasure vessels made of glass-reinforced plastic. Yarrow has specialized in the Type 22 frigate, but has also built Type 21s as well.

Table 18

British Shipyard Information

Yard	Production Capacity	Facilities	Personnel	Current Order Book	Sales	Subsidiaries	Licensed By
Vickers, Ltd. Barrow-in-Furness	Naval ships of all types: Submarines - Nuclear and Diesel Surface vessels up to 160,000 DWT Tankers Cargo Ships Bulk Carriers Design and Engineering	4 Dry Docks 5 Building Berths 1 Fitting-Out Pier 8 Cranes	8,300	3 Nuclear Submarines 2 OBERON Class Submarines-Brazil 2 Type 42 Destroyers-Argentina 1 Type 42 Destroyer at Swan Hunter 1 ASW Cruiser (Invincible)	$86MM Profit (1969) $9,720M Capital (1971) $93.8MM	Part of Vickers Group	Sulzer, Switzerland M.A.N., Augsberg, W. Germany
Swan Hunter Shipbuilders, Ltd. Wallsend	Naval surface vessels from frigate to aircraft carrier size Tankers Cargo vessels Small ships Engine work	Wallsend: 8 Building Berths 2 Cross-over Berths 12 Cranes	15,000 (3,000 on warship production)	2 Type 42 Destroyers 1 Tanker 4 Product Tankers 3 Tankers (Cayman Is.) 1 Fleet Tanker (Iran)	(1970) $153.2MM shipbuilding only Profit ($14.9MM) shipbuilding only Capital $28.1MM	Part of Swan Hunter Group	N.A.

Table 18 (continued)

Yard	Production Capacity	Facilities	Per-sonnel (1972)	Current Order Book	Sales (1971)	Subsidiaries	Licensed By
Yarrow & Co., Ltd. Scotstown, Glasgow	Naval ships up to 630' Destroyers Frigates Patrol Boats Boilermaking	6 Drydocks 6 Berths 6 Quays 14 Cranes Annual steel use: 14,000 tons	4,300	4 Type 21 Frigates 2 Type 22 Frigates	$46MM	Yarrow Engineers, Glasgow Yarrow Africa (Pty) Ltd. South Africa	-
Vosper Thorneycroft Ltd. Portsmouth and Southampton	Naval ships; primarily Frigates Corvettes Fast patrol boats Hovercraft up to 5,000 tons	Camber Yard 2 berths Portchester Works 8 berths Woolston Works 3 berths	5,100	Portsmouth: 6 - 110' Fast Patrol Boats, Foreign 2 - 75' Fast Patrol Boats, Foreign Southampton: 1 Type 21 Frigate 1 Type 42 Destroyer 4 Frigates-Brazil	$75MM	N. A.	N. A.

Table 18 (continued)

Yard	Production Capacity	Facilities	Personnel	Current Order Book	Sales (1971)	Subsidiaries	Licensed By
Scotts Ship-building Co., Ltd. Greenock	Naval ships: Submarines Surface vessels up to 520' LNG Carriers Container Ships Reefers Bulk Carriers Tankers	7 Building Ways 1 Dry Dock 1 Garnel Dry Dock	8,500	1 OBERON class submarine-Chile 2 OBERON class submarines-Australia 2 Fleet Replenishment vessels 1 Exper. Research vessel 3 D/P Drillships Foreign	$50MM Capital $6,111M	Part of Scott Lithgow Group, Ltd.	N. A.
Cammell Laird & Co., Ltd. Birkenhead	Naval surface ships up to 1050 tons Tankers Bulk Carriers Submarines	4 Ship Berths 8 Cranes	5,800 (1,500 available for warship production	2 Type 42 Destroyers 11 Products Tankers	N. A.	N. A.	N. A.

Table 18 provides detailed information on each of these three yards, plus three additional, Swan Hunter, Cammell Laird, and Scot Lithgow, Ltd., which, working with the lead yards, have built some naval ships, primarily for export.

The economies of scale inherent in concentrating all ship types on three yards have led to a considerable volume of export orders for all three. The following Table lists the surface warships of corvette size and larger built, or building, by the three lead shipyards to their own design since 1945.

Numbers	*Type*	*Country*	*Designers*
Three	Destroyers	Venezuela	Vickers
Two	Destroyers	Chile	Vickers
One	Frigate	Malaysia	Yarrow
One	Frigate	Thailand	Yarrow
Two	Corvettes	Ghana	Vosper Thornycroft
One	Corvette	Libya	Vosper Thornycroft
Two	Corvettes	Nigeria	Vosper Thornycroft
Four	Frigates	Iran	Vosper Thornycroft[1]
One	Frigate	Libya	Vosper Thornycroft
Six[2]	Frigates	Brazil	Vosper Thornycroft

Source: British Ministry of Defense

In addition, Vickers have built submarines for Brazil and Argentina, Vosper has built fast patrol boats for Venezuela, and Yarrow has built frigates for Chile. This type of warship export business, combined with relatively advanced technologies and the continued worldwide demand for warships - particularly among newly emerging nations, is given credit by the managements of all three shipyards for a significant part of the continued profitability of their companies.

The home market for naval ships has prospered during the past two years with the introduction of all-gas turbine engines combined in submarines with diesel-electric engines for cruising. The original intention was to have a class of Type 82 large guided missile destroyer/cruisers. The cost, however, became prohibitive, and only one, HMS Bristol, was launched.

Type 42 guided-missile destroyers began with the launching of H.M.S. Sheffield in 1971. Six more of these ships have been ordered, of which four have been launched. Two additional ships have been constructed for Argentina. Displacing 3,500 tons, the destroyer is designed to carry the SEADART missile. Of the five that have been launched, two were produced by Vickers, two by Cammell Laird, and one by Newcastle, all under the supervision of the design team from Vickers.

The following Table provides the main particulars about the Type 42 destroyer:

Length, o.a.	125 m
Length, b.p.	119.5 m
Beam	14.6 m
Draught	5.18 m
Displacement, standard ..	3150 t
Displacement, full-load ..	3500 t
Speed	30 knots
Maximum power	56 000 bhp
Cruise power	8500 bhp
Endurance	4200 nm at 18 knots
Complement	300

Source: British Ministry of Defense

Type 21 frigates are general purpose vessels, displacing 2,500 tons. Each will carry a Lynx helicopter armed with homing anti-submarine torpedoes and will have a quadruple short-range surface-to-air missile Seacat, one 4.5" MK8 Vickers gun, and six torpedoes tubes. Later ships will be armed with the Sea Wolf surface-to-air missile and the EXOCET ship-to-ship missile. All will have gas turbine propulsion. Eight ships have been ordered and four are in commission. The first two ships were constructed by Vosper Thornycroft as was the fourth, and the third by Yarrow.

Type 22 missile frigates are designed at 3,800 tons. The first two are being built by Yarrow.

Three "through-deck" helicopter cruisers have been planned. The design work has been done by Vickers and the naval constructors working together. The prototype ship - Invincible - will have an angled flight deck, very similar to a small aircraft carrier, and will carry about nine helicopters and five Sea Harriers (VSTOL) craft. The ship is designed to be about 20,000 tons, and the prototype should come into service in 1979.

One of the problems brought out in the defense expenditure review undertaken in 1975 in Britain was that progress on construction of the Invincible had been seriously delayed by labor problems at the Vickers Yard at Barrow-in-Furness. In July 1975, the ship was as far from entering service as she had been in January 1975, although no major technical problems had arisen. While it had been hoped that all three cruisers could be built by Vickers, allowing experience gained in construction of the lead ship to reduce overall program costs, it is now planned to build the second at Swan Hunter on the Tyne because of the difficulties at Barrow. The labor problems have not been work stoppages or union difficulties, but, rather, the large number of workmen who have left the yard to go to work on the Continent or in the North Sea oil rigs, particularly in the steelwork trades. When Invincible was first laid down, it was with the understanding that Vickers would be able to recruit additional workforce. Contrary to being able to recruit, there has been a net loss of skilled trades and, as a result, the Navy will have to convert one or both of the existing helicopter or commando carriers to Harriers to fill the gap, thereby sacrificing the ability to transport two battalion landing teams of Marines ashore in emergency areas.

A new design proposed by Vosper Thornycroft, in conjunction with the Hawker Siddeley Aviation Company, is for a completely new type of warship: a vessel of frigate size (6,000 tons) with a carrier deck capable of launching either eight Sea Harrier VSTOL (vertical short take-off and landing) aircraft, or eight Sea King antisubmarine helicopters, or any mix totaling eight aircraft. The ship is, in essence, a small version of the Invincible, and for that reason may bring the cost within reach of many navies that could not otherwise afford the larger vessel.

The following Table gives the principal data about the proposed vessel, which is called a Harrier Carrier:

Full load	7200 t
Length oa	135 m
Length on WL	122 m
Beam—flight deck	28 m
Beam—waterline	21.2 m
Draught	6.5 m
Ship's fuel (nom)	740 t
Aircraft fuel (nom)	570 t
Range at 16 knots	4500 nm
Maximum speed	25 knots
Maximum shp	32 000
Fresh water	70 t
Provisions for	60 days
Naval/aviation stores for	45 days
Maximum complement ..	385

Source: British Ministry of Defense

The entire ship design is built around characteristics of the Sea Harrier aircraft which can land vertically without restriction on the ship's heading. The Sea Harrier, as an interceptor, carries 30 mm. guns and a Sidewinder air-to-air missile complement. One aircraft can be kept in instant readiness on the VTO grid to intercept a threat from any direction without interfering with flying activities on the short takeoff (STO) deck. A typical mission profile permits over 20 minutes of combat air patrol loiter time at 100 nautical miles from the ship. There is space on deck to park all aircraft. In addition to antisubmarine functions and air defense, these ships could carry out fleet support, civil disaster relief, and troop transport functions. The Harrier Carrier's great versatility and its low cost have led Vosper Thornycroft to hope that not only the Royal Navy but foreign navies will include it in their ordering in future years.

Britain was the pioneer and is today the world leader in the production of Hovercraft. British Hovercraft Corporation, on the Isle of Wight, is a subsidiary of Westland Aircraft Corporation. The three main hovercraft models that are used for military purposes are the SRN6 (Winchester) which weighs 10 tons and has a maximum speed of 57 knots, propelled by a Rolls-Royce gas turbine engine driving an air propeller. This craft can carry 20 fully-equipped troops, perform coastal defense missions, search and rescue, and casualty evacuation. A second model is the BH7 (Wellington) which, at 55 tons, is much larger and has a maximum speed of 55 knots. This craft can carry 152 fully-equipped troops, or various combinations of troops, vehicles and stores. As a logistic vehicle, it can carry military loads up to 14 tons, or can be equipped with guided missiles for offshore defense work. The third model, the SRN4, (Mountbatten) is 190 tons and cruises at speeds of 60 knots on 8-foot deep cushion of air. It carries 254 passengers and 30 vehicles. The main engines are four Rolls-Royce gas turbines driving four 19'-diameter Hawker Siddeley variable-pitch propellors. More than 50 of the Winchesters have been sold in nine countries. Iran has bought eight, as well as six of the BH7 category.

Other Hovercraft manufacturers have designed new versions to compete with BHC. Vosper Thornycroft have developed the VT2, a 66-ton 60-knot craft capable of carrying up to four ship-to-ship missiles and a 57 or 76 mm. gun.

The combination of design and production skills concentrated in the three lead yards, which has led to the development of the above six new ship types, represents a technological asset in naval ship construction second only to that of the United States, and perhaps the Soviet Union. The new materials, such as fiberglass in mine countermeasures vessels, the development of high-speed patrol Hovercraft, which are also capable of transporting men, equipment and vehicles onto a beach, and the concept of the Harrier Carrier, which provides a relatively small and low-cost platform from which to launch a novel mixture of aircraft types for antisubmarine or other purposes, all attest to these skills. New technological developments are going to occur among the NATO Navies in Western Europe which can be the basis for licensing agreements with U. S. naval ship constructors, and there is a high probability they will occur in Britain.

On the question of buying foreign equipment for the British services, the Ministry of Defense stated that 75% of the equipment for the forces was British, 15% was collaborative, and 10% was foreign. In order to justify foreign purchases, the Ministry had to be able to point to substantial cost savings as well as military necessity, and industrial and political considerations also had to be taken into account. The Ministry also stated that while it was government policy that the Royal Navy should cooperate to the utmost with other NATO navies, the problem of standardization and cooperation fell into two parts - i.e., standardization, where the goal was interoperability, and collaboration, which involved a great many inter-dependent projects. Some measures of standardization had been achieved on equipment. There are a number of areas of standardized interoperability between NATO navies. Some weapons systems are common to more than one service - for example, EXOCET on French, British, and German frigates, or SEACAT, which is common both to the Royal Navy and the Dutch Van Speijk class of frigates. There is a standard NATO agreement on the interchange-ability of fuels, lubricants, and associated products. The majority of NATO navies, including the United States, have now adopted a common fuel (RN Dieso) as the standard main propulsion fuel for all modern warships, and, as a result, fuel interchangeability is becoming a lessening problem. On the negative side, after 25 years of cooperative activity, there has been a failure to achieve an interoperable naval communications system. A NATO project group was set up in 1973 to study the development of a light frigate (less than 2,500 tons) for all services. An agreement was reached on the characteristics of a future light frigate which could meet the requirements of the participants, but it is now agreed that it is unlikely that final decisions in this area would be reached for some time.

In the effort to rationalize tasks among the NATO navies leading to standardization, the Royal Navy decided to give a high priority to the nuclear submarine program since none of the other European NATO navies (with the possible exception of France) seemed likely to be able to afford to construct more than conventional submarines. On a different subject, a decision was reached to phase out aircraft carriers at the end of the Ark Royal's service and depend entirely on the United States to provide strike carrier capability. In a third area, both Britain and France are placing less emphasis on coastal forces, or fast patrol boats, and rely on the Danish, German, Dutch and Belgian Navies to be more active in those ship classes in relation to their missions, while the French and the British concentrate on heavier ocean-going vessels of the frigate and destroyer variety. While there have not yet been any significant industrial contracts for the production of standardized equipment for mutual use between allies, an effort is being made for the Royal Navy to standardize on English marine gas-turbine equipment. Both countries are attempting to maintain a balance between the transaction on both sides to ensure that it does not affect the balance of payments.

In an interview with Vice Admiral Sir Anthony Griffin, he maintained that, for weapon and shipbuilding standardization programs to be really effective, they should start from the bottom up - that is, with the commercial firms who are doing the building. If they are brought together, they should be able to work out areas where cooperation can be most effective and efficient and identify the problems that are involved. In his view, political and high-level statements and assurances are rarely realistic or satisfactory, and very little progress is made by starting at the top. As examples, he quoted the Harrier Carrier project inside the U. K. where Hawker Siddeley Aviation Company, Rolls-Royce, Pratt & Whitney, and other companies all worked directly with Vosper Thornycroft to get a good end result. The helicopter arrangement between Westland Aircraft Company and SNIAS in France was another example. A sensible dialogue was established which leads to further proposals for commercial development.

In summary, while standardization and specialization have yet to make great progress in Britain, the need for export orders, the technological skills concentrated in the three lead yards, and the generally weakened condition of the remainder of the British shipbuilding industry, may lead to greater cooperative efforts with other NATO navies in Western Europe and provide some critical mass to serve as the base for licensing interchange with U. S. naval shipbuilders.

C. France

In 1969, defense shipbuilding performed in private shipyards amounted to approximately 4% of total shipbuilding, or approximately $18 million. Beginning in 1973, government expenditures for warships, other than nuclear submarines, began to be reduced in favor of other branches of service. As noted previously, all naval vessels produced for the French Navy, with the exception of small diesel submarines, escort vessels, and patrol craft, are constructed in naval dockyards owned by the French government.

In 1975, the French fleet consisted of 54 surface ships larger than frigate size (1,000 tons); 23 submarines, including three nuclear-powered ballistic missile vessels; and 265 smaller ships. Eight additional surface ships, including four guided-missile frigates and four escorts, were under construction in naval dockyards. Also under construction were six submarines, including two nuclear-powered ballistic missile submarines. Eight additional surface vessels, including one helicopter carrier and one additional nuclear-powered hunter/killer submarine are projected for the future.

Direction Technique des Construction Navales (DTCN), which is part of the French Ministry of Defense, is the French government agency responsible for supervising construction in naval dockyards. In 1974, DTCN had 35,000 employees, of which 12,000 were engaged in naval construction. Total turnover amounted to approximately $630 million. Of the four major dockyards comprising DTCN, Cherbourg concentrates mainly on submarines, both diesel and nuclear. Toulon works primarily on repair, maintenance and refit. Brest and Lorient construct all of the surface ships for the French Navy over approximately 1,000 tons. As noted above, the rate of construction has declined somewhat for surface ships since 1973, but it plans to construct an additional helicopter carrier, and, as a continued program of frigates and escort vessels is maintained, these yards should be kept busy, though not up to capacity.

Despite the fact that France is a major shipping nation (60% of France's import-export trade is seaborne), only 18% of the seaborne cargo is carried in French ships. In 1975, only 1.5% of the world's cargo ships were French and only 3% of the gross tonnage. Repeated plans to stimulate the French commercial shipping industry (and thereby the shipbuilding industry) have been cancelled due to lack of available capital and drain on the nation's foreign exchange resources.

The French shipbuilding industry, as a result of lack of demand for commercial ships for the French fleet and the government policy of maintaining almost all naval construction in government dockyards, has had to turn more and more toward high technology competency and production of specialty ships, such as LNG carriers, and to the export market, in which to sell the output. There are remarkable similarities in the development of the French commercial shipbuilding industry during the past 10 years with that of the United States. Although the U. S. government does contract naval construction to private shipyards exclusively, more than 90% of Federal funding of naval vessels normally goes to only three shipyards.

Thus the major French commercial shipyards had to concentrate heavily on container ships, tankers, Roll-On Roll-Off vessels, and liquid natural gas and liquid petroleum carriers; and while each retains some potential capacity for naval ship construction, any large-scale transfer of such construction to private yards would now mean major capital investment and re-tooling on the part of all of the yards. The accompanying Table 19 outlines the capacities of five of the principal commercial shipyards. Each has some residual capacity for naval construction. Dubigeon Normandie in Nantes has produced diesel submarines of the Daphne Class for both the French Navy and that of South Africa, but none are in construction at the present time. An additional yard, Constructions Mèchaniques de Normandie (CMN) specializes in small boats, such as fast patrol craft and mine hunters. They currently have a contract to build 20 new fast patrol missile boats armed with the EXOCET missile for the West German government. CNIM on the Mediterranean Coast near Toulon produces torpedo tubes and rocket launchers for the naval dockyard program, in addition to possible export sales.

An important factor in both capital investment decisions and yard capacities has been the interlocking directorships and overlapping ownership of a number of principal French shipyards. Penhoët, CIE Industrielle et Financière de Participations, is a holding company with major interests in shipbuilding, which is, in turn, owned 18.3% by Compagnie Financière de Suez. Penhoët owns 62% of Chantier de l'Atlantique, 82% of CMN, 16% of Dubigeon Normandie, and 12.17% of an additional French shipyard, Chantier de la Loire.

As in the case of the United States and Britain, the French shipyard industry is small in relative terms. Total personnel employed will amount to somewhere between 50,000 and 100,000, and, with the exception of technology developed for liquid natural gas carriers, there has been very little research and development work done since World War II on hull

Table 19

French Shipyard Information

Yard	Production Capacity	Facilities	Personnel	Current Order Book	Sales	Subsidiaries	Licensed By
Chantiers de l'Atlantique St. Nazaire	Tankers LNG Carriers Bulk Carriers Container Ships Large Naval Surface Ships	1 Building Dock 1 Graving Dock 1 Shipway 2 Gantry Cranes 750 & 250 tons Ann. steel use: 130,000 tons	8,300	1 Tanker Panama 2 Tankers Shell 2 Tankers France 2 Tankers Arab Mar. 1 LNG Bermuda 1 LNG Neth. 2 LNG France 1 Container SA 7 Container Fr.	(1969) $143MM Profit ($3,850M) Capital $15,500M	S.E.M.T.-Pielstich Diesel engines G.A.A.A. Babcock Atlantique G.E.X.A. Desulfurization coop. with Dubigeon Normandie	Diesel Engines: Pielstich, B&W, Sulzer Nuclear Propulsion: B&W Turbines: Stal-Laval Compressors: Nuovo Bignone Italy
Chantiers Navals de la Ciotat La Ciotat	Tankers (VLCC) LNG Carriers LPG Carriers Container Ships Large Naval Surface Ships	1 Building Dock 1 Graving Dock 2 Berths Ann. steel use: 100,000 tons	3,500 (2,500 in prod'n)	1 Tanker Kuwait 1 Tanker Germany 2 Tankers Foreign 1 LNG Algeria 1 LPG Esso 1 LPG Iran 4 LPGs Kuwait 1 LPG Norway 1 LPG France 2 Container Ships 3 Cargo Ships	$144MM $N.A. $6,125M	Le Prait Rouen	Foster Wheeler Boilers Nordberg Diesel Engines Reavell Air Compressors Brown Bros. Steering Gears

Table 19 (continued)

Yard	Production Capacity	Facilities	Personnel	Current Order Book	Sales	Subsidiaries	Licensed By
Chantiers de France Dunkerque Dunkerque	Tankers Ore/Bulk Carriers LNG Carriers LPG Carriers RO/ROs Reefers Cargo Ships Naval Surface Ships	2 Berths 2 Drydocks Annual steel use: 50,000 tons	3,200	2 LNG El Paso 1 LNG France 3 LNG Malaysia 1 LPG Bibby 5 RO/RO France 2 Containers France	$98,800M $14,785M $8,800M	Corp. de la Constr. Navale Gas-Transport C.I.N.B. France Gironde	N. A.
Dubigeon Normandie Nantes	Diesel Submarines (Daphne Class) Reefers Container Ships Drilling Rigs	4 berths	3,800	5 Product Carriers 1 RO/RO 2 Car Ferries	$66,000M	N. A.	N. A.

Table 19 (continued)

Yard	Production Capacity	Facilities	Personnel	Current Order Book	Sales	Subsid-iaries	Licensed By
Construction Navales et Industrielles de La Mediterranee (CNIM) La Seyne (in Toulon)	LPG Carriers LNG Carriers Container Ships Tankers Reefers RO/ROs Naval surface ships incl. Torpedo Tubes and rocket launchers	1 Dry Dock 2 Berths Annual steel use: 100,000 tons	4,500	2 Logistic Support (Foreign Navy) 3 Container (Tung) 4 Container (France) 2 LNG Algeria 2 LNG Malaysia 2 LPG France	N. A.	N. A.	EVT: Boilers Blohm & Voss: Turbines G.E.: Turbines Foster Wheeler: Boilers

design, propulsion systems, or other subsystems which would play a decisive role in naval construction. Development of missiles, such as the EXOCET, has forced French naval construction, as it has with other countries, into a pattern of smaller, lighter platforms such as frigates, escort vessels, and fast patrol boats, which, of necessity, are of fairly standard design throughout western navies, and the numbers of which, in any case, have not been sufficient to support advanced technological R&D or investment. Thus, while France may continue to be a logical customer for certain advanced U. S. weapons systems, there is little likelihood of the development of naval ship construction techniques in France that could be licensed to U. S. manufacturers.

D. Germany. Since the founding of the Federal Republic in 1949, a relatively small proportion of the defense budget has been allocated to naval construction. Germany has historically spent far more on army troops and military aircraft, and the result has been that the Navy has been confined to small ships designed primarily for inshore patrolling. Furthermore, Germany has been the only NATO European country to order naval vessels to be constructed outside the country. Orders were placed for three guided-missile destroyers from the Bath Iron Works at Bath, Maine, and for 20 fast patrol boats from CNM in France, armed with EXOCET missiles. Approximately 30% of procurement funds have been spent abroad, and defense shipbuilding in 1969 constituted between 5% and 10% of total shipbuilding in Germany, or approximately $72 million.

In 1975, the West German Navy consisted of 29 diesel submarines, 43 surface ships (all ranging from fast patrol boats to guided missile destroyer types), and 247 small craft. The new construction program includes one submarine and 10 more fast patrol boats armed with the EXOCET missile to be constructed in France. Previous plans to replace aging destroyer and frigate types have been postponed indefinitely.

As a seagoing nation, Germany has had a long history of shipbuilding, although not of naval types. One per cent of the total work force in West Germany is employed in the shipbuilding industry. In certain coastal localities, this is naturally a much higher concentration - 12% in Schleswig Holstein and 27% in East Friesland

Despite this industrial base, German shipyards have found it more and more difficult to compete, particularly with Japanese serial production of large vessels such as tankers, and have consequently turned to other activities to earn revenue. There are five major shipbuilding companies summarized in Table 20 which accompanies this section. Blohm & Voss has built frigates in the past, but naval work now represents less than 12% of Blohm & Voss's annual volume. Howaldtswerke-Deutsche Werft and Rheinstahl Nordseewerke have both built submarines for West German navy as well as for export to non-NATO countries. No such construction is currently under way, however. A. G. Weser, which in 1971 accounted for 28.4% of the nation's total output of $1.9 million gross registered tons, produces no naval construction at all.

West German shipyards, like those in the United Kingdom, have been plagued with labor shortages. As in the United States, there are over 60 separate crafts required to construct higher-technology ships such as Liquid Natural Gas Carriers and Container Ships. The difficulty of retaining skilled workers in each of these crafts, the competition from other industries (now including North Sea oil drilling) has made labor shortages one of the main cause for delays in scheduled launchings.

As in the case of French shipbuilding industry, there is a fairly high degree of ownership concentration, although not as many overlapping directorships. Table 21 outlines the ownership of the principal West German shipyards.

The combination of low emphasis on naval expenditures in the defense budget, plus the propensity to buy what few ships are required in foreign yards, has led to the point where there is almost no naval construction in German shipyards. Major West German shipyards have concentrated on commercial

Table 20

West German Shipyard Information

Yard	Production Capacity	Facilities	Personnel	Current Order Book	Sales	Subsidiaries	Licensed By
Blohm und Voss Hamburg	Container Ships Tankers Bulk Carriers Reefers Diesel Engines	2 Building Ways 1 Building Basin 10 Floating Docks	7,325 (5,500 prodn.)	4 Container Ships 2 Bulk Carriers Self-propelled derrick Floating dock Submersible Drilling Platform	(1970) $139MM Profit ($8,400) Capital ($17,600)	Hamburg: Ottensener Eisenwerk Barthels & Lueders. Marine-Schiffstechnik Planungs H. Schiffbau-Versuchungsanstalt Elbe Wohnungsgesellschaft B & V Unterstuetzungskasse Oslo: B & V Norden A/S S. Africa: B & V (Pty) Johannesburg	Stal-Laval, Gotenberg, Sweden M.A.N., Nürumberg diesel engines Pielstick, SEMT Paris diesel engines

Table 20 (continued)

Yard	Production Capacity	Facilities	Per-sonnel	Current Order Book	Sales	Subsidiaries	Licensed By
Bremer Vulkan Schiffbau und Maschinen-fabrik Bremen	Container Ships Tankers Car Carriers Reefers Bulk Carriers Ships' boilers Foundry products Compressors	5 Building ways 1 Building Basin 2 Floating Docks Fitting-out piers with cranes	5,400	3 Turbine Tankers 4 Container Ships 2 OBO Carriers 3 Cargo Motor Ships	(1971) $106.5MM $892,000 N. A.	Cooper Vulkan (50%) Compressors Living Room Con-struction Co. (55%)	M.A.N. Diesel Engines Stal Laval Turbines
Howaldts-werke-Deutsche Werft A.G. Kiel and Hamburg	Cargo ships Container Ships Bulk Car-riers Tankers OBOs Naval Sur-face Ships Submarines	17 Floating Docks 4 Graving Docks 1 Floating Tank 13 Berths	19,800 (9,000 Hamburg) (8,800 Kiel)	2 LNG Carriers 4 Tankers 4 Container Ships 3 Bulk Carriers 1 Product Carrier 1 Drilling Rig	$190.5MM N. A. $21,576M	Kieler Verkswohung-gen - Kiel Simplex Turbulo Marine Co., Ltd. London	M.A.N. Diesel Engines A.E.G. Stal-Laval Turbines G. V. Boilers

Table 20 (continued)

Yard	Production Capacity	Facilities	Personnel	Current Order Book	Sales	Subsidiaries	Licensed By
Rheinstahl-Nordseewerke' Emden	Cargo Liners Container Ships Bulk Carriers Tankers Medium-sized ships	3 Shipbuilding Ways 1 Drydock 2 Floating Docks Outfitting Piers	5,754	1 Bulk Carrier 2 OBOs 4 LPG Carriers	$48.2MM N. A. (consolidated with Rheinstahl)	N. A.	Sulzer M.A.N. Diesel Engines
A. G. Weser Bremen Bremerhaven	Bremen: Tankers Container Ships Bulk Carriers LNG Carriers OBOs Up to 500,000 DWT Bremerhaven: Cargo Ships Ferries Ice Breakers, etc. Up to 25,000 DWT	Bremen: 2 Shipways Bremenhaven: 2 Docks 1 Slipway Annual steel used: 150,000 tons	7,950	Bremen: 3 Tankers 6 Cargo Ships 2 Container Ships Bremerhaven: 13 Cargo Ships 3 Tankers 3 Container Ships	$159.7MM $4.2MM $109.2MM	N. A.	G. E. Foster Wheeler Westinghouse Babcock & Wilcox Mitsui

Table 21

Ownership of the Principal West German Shipyards

Blohm und Voss	August Thyssen-Huette	64.7%
	Ver. Elbe (Blohm Group)	17.9%
	Siemens von Dietlein family	4.9%
Bremer Vulkan	Thyssen-Bornemisza Group	92.0%
Howaldtswerke-Deutsche Werft	Salzgitter (Government)	100.0%
Rheinstahl/Nordseewerke	Rheinstahl Group	100.0%
A. G. Weser	Fried. Krupp GmbH	86.34%

Source: Hoagland, MacLachlan & Co., Inc.

production of large capacity bulk carriers, both tanker and dry bulk, but only in recent years have been forced by Japanese competition to return to higher technology vessels such as Liquid Natural Gas Carriers, Roll-On/Roll-Off Vessels, etc. A capacity for naval construction exists in a number of yards, principally those of A. G. Weser and Howaldtswerke-Deutsche Werft, but would require large-scale capital investment and re-tooling in order to make such construction feasible. In addition, a domestic German design effort would have to be mounted, or rigorous efforts made to obtain licensing rights from foreign countries, presumably the United States, for major ship construction.

Thus while it is not inconceivable that non-NATO countries might in the future place contracts with the larger German shipyards for small diesel submarines, or surface ships of the size of frigates or smaller (3,000 tons or lower), no such contracts currently exist and there is no current impetus for German shipyards to be doing R&D or design work. In these circumstances, it is unlikely there will be any licensing opportunities for German technology in the naval shipbuilding category in the near future.

E. Other NATO Navies.

1. Italy. The Italian Navy consists of 11 diesel-powered submarines and 41 surface vessels larger than fast torpedo boats. Included are three guided-missile cruisers, four guided-missile destroyers, four other destroyers, and 11 frigates. In addition, there are 243 smaller craft. While the defense budget share of total government expenditure has been declining since 1971, an additional five-year appropriation for new naval construction between 1975 and 1980 has been approved. This program calls for one helicopter carrier, eight frigates, two diesel submarines, and 19 smaller craft, including one amphibious assault ship. Considerable emphasis is being placed on small patrol craft, such as hydrofoils for inshore work, as well as helicopters.

The Italian shipbuilding industry is 90% controlled by Instituto Per La Ricostruzione Industriale (IRI), the leading financial and industrial group in Italy, which, in turn, controls six holding companies. One of them is Fincantieri, which controls most of the firms involved in shipbuilding, ship repair, marine engineering and propeller manufacture. Another of IRI's holding companies is Finanziaria Marittima (FINMARE) which controls the state interest in Italian shipping companies.

Fincantieri is divided into two main operating groups, the first of which, Italcantiere, controls shipbuilding at three yards, Genoa-Sestri. Monfalcone. north of Trieste, and Castellamare di Stabia, south of Naples. The second major operating group under Fincantieri is Cantieri Navali Riuniti (CNR) which controls shipbuilding facilities at Palermo, Ancona, and the Riva Trigoso, which is between Genoa and LaSpezia.

Finmare is developing a national fleet development plan which will define Italian shipping needs and, in turn, translate these into requirements for new ship construction for Italian shipyards. Government assumption of responsibility for 90% of the country's shipyard capacity, plus repair and marine engineering industries and the resulting capital investment program, are being followed with great interest in the United Kingdom, which is on the verge of nationalization and needs some similar planning to retain its competitive position in world markets.

CNR facility at Riva Trigoso is the main Italian shipyard for naval construction. Twelve frigates of 2,400-ton displacement (of CNR design) are currently on order - four for the Italian Navy, four for the Peruvian Navy, and four for the Venezuelan Navy. It is likely that this orderbook will be extended to 18 ships in the near future.

The Riva Trigoso Yard is currently the subject of a high degree of CNR investment. Now under way is the construction of a large assembled unit shop and continued development of the building berth area. By the autumn of this year, it is expected that its sectional building method will be in full swing. There is a new CMIG 200-ton 72-meter-high traveling gantry crane. The capacity of the yard should be in the area of 2 to 2.5 ships per year of the 2,400-ton frigate class.

Despite the design capabilities of the Riva Trigosa Yard and the extensive tanker, bulk carrier, and container ship capacity in other major Italian yards, it is unlikely that much new development will be contributed to naval ship construction in the near-term future.

2. The Netherlands. The Netherlands Navy currently consists of six diesel-powered submarines, one old cruiser with Terrier SAM Missiles, 10 destroyers, six frigates, six corvettes, and 99 small craft. Additional ships under construction or on order are two large (3,500 ton) guided missile frigates, four missile frigates, eight general purpose frigates, and two other vessels.

Between 1968 and 1972, a variety of designs were produced in negotiation with the Royal Navy to evolve an Anglo-Dutch frigate which would replace 12 destroyers in the Dutch Navy built during the 1950s. This effort did not succeed, and a thorough study of the U. S. Patrol Frigate design was also discarded. The Dutch Navy, therefore, designed its own Standard Frigate in close cooperation with the builders, Royal de Scheldt Yard at Flushing. Eight of these anti-submarine warfare Standard Frigates will be ordered between 1974 and 1977.

The main propulsion machinery consists of two Rolls-Royce gas turbine engines, similar to those used by the Royal Navy. They drive two lips cp propellors. Armament includes anti-submarine warfare torpedo tubes, two quadruple Harpoon SSM launchers, and a NATO Sea Sparrow PDMS missile system. Each ship will be equipped with a Lynx reconnaissance helicopter.

The following Table provides the significant statistics for the Netherlands Standard Frigate:

RNN frigate - principal particulars

Length o.a.	128 m
Length b.p.	121.8 m
Beam	14.4 m
Displacement	±3,500 t
Speed, maximum	30 knots
Cruising range	4,000 nm
Complement	189

While there are many medium-sized shipyards in the Netherlands, the largest and most significant is Rijn-Schelde-Verolme. This group holds most of the shipbuilding capacity in the Netherlands. Only two other Netherlands yards show capacities above 20,000 tons. RSV has four domestic yards and two overseas yards, with 26 building docks and 35 repair docks in Holland. One shipyard in the group, Royal Schelde, Koninklijke Mij de Schelde, B.V. at Vlissingen, concentrates on naval ships, including guided missile frigates and submarines. The shipyard employs 3,500 workers and has a current orderbook of one guided missile frigate, and eight standard frigates for the Royal Dutch Navy.

While the Dutch take considerable pride in the design of the Standard Frigate to Dutch specifications, it is nevertheless evident from the ship's specifications that much of the design technology was derived from the Type 42 Frigate developed in the U.K. It is unlikely that Dutch naval design or construction capacity will be significant in the development of new technology in the near future.

3. Belgium. Prior to 1973, the Royal Belgian Navy concentrated on mine counter-measure operations in the NATO Channel Command. Naval forces consisted entirely of mine vessels and smaller craft. It was decided, however, at that time to acquire four anti-submarine warfare frigates suitable for operation in restricted waters adjacent to Belgium. With the cooperation of the two main shipyards, designs were begun with the help of the Netherlands. Four ships were ordered beginning in 1973, and will begin to be delivered to the Navy in December 1976. The following Table provides vital statistics for the new frigate type:

RBN frigate - principal particulars

Length o. a.	128 m
Length b.p.	103 m
Beam	12.3 m
Draught	5.6 m
Displacement, standard ...	1,940 t
Displacement, Full-load ..	2,340 t
Speed, maximum	28 knots
Cruising range	4,500 nm
Complement	155

The two principal shipyards in Belgium, Boelwerf NV at Tamise, near Antwerp, and Cockerill Yards at Hoboken, can each produce major ship types. 75,000-dwt. bulk carriers and 131,000 cubic meter LNG carriers are currently being constructed. Like the other commercial yards in Western European NATO countries, with the exception of the three lead yards in the U.K., they have little or no capacity for the production of naval vessels.

4. Denmark. The Royal Danish Navy comprises six diesel-powered patrol submarines, seven frigates, four corvettes, 16 fast patrol boats and 74 smaller craft. With the exception of the four corvettes, all of these have been built in Denmark, either in private shipyards or the Royal dockyard in Copenhagen.

In November, 1973, the Danish Navy started discussions with U. K. private shipyards to consider the construction of corvettes or frigates, either in the U. K. or under license in Denmark. The firm of Y-Ard, Ltd., consultants of Scotstoun, near Glasgow, were given a contract in 1974 to design a new warship. It was to range in size between fast patrol boats and frigates. As a result, at the end of 1975, the Royal Danish Navy placed an order with Aalborg Shipyard, Ltd. for the building of three corvettes to the Y-Ard design. Each vessel will have a displacement of 1,300 tons and will include the Sea Sparrow surface-to-surface and the Harpoon surface-to-air missiles.

While design for this new class of ships was done in the U. K., the Aalborg Yard has had long experience of constructing small vessels to design for the Royal Danish Navy. There are at least two other yards in Denmark, Burmeister and Wains in Copenhagen, and Odense, which have the capacity to build large tonnage ships but which do not have either experience or equipment for naval vessels.

5. Norway. The Norwegian Navy consists of 15 coastal submarines, five frigates, two corvettes, 26 fast missile boats, 20 fast torpedo boats, and 39 other vessels. No additional construction is currently under way.

Norway, like the other NATO sea-coast countries, has a significant shipbuilding industry. A. Aker group and the Moss Rosenberg Verft are both world-famous. Moss Rosenberg is one of the principal producers of LPG and LNG carriers in the world. While these yards may be able to accommodate naval construction in the future, it will require re-tooling and conversion.

F. Conclusions.

As can be seen from the following Table 22, Britain and France strongly dominate Western European NATO navies and therefore their requirements for naval ship construction. Britain has 38% of total surface ships larger than frigate size among the eight nations studied, followed by France with 27%. The two nations possess 37% of diesel-powered submarines and 100% of nuclear-powered. West Germany and Italy form a second rank with medium-sized patrol ships and frigates, as well as diesel-powered patrol submarines. The four smaller countries concentrate heavily on fast patrol craft for inshore coverage.

It is not surprising, therefore, that naval ship construction, and especially naval ship design, has tended to be strongly concentrated in Britain and France. Since French naval ship construction is carried on in government-owned dockyards, much of the information related to it is classified. The influence of the British drive for export orders, however, from the three lead shipyards, Vickers, Vosper Thornycroft and Yarrow, has been apparent in design configuration and armaments of the remaining six countries.

While the outlook for standardization of naval components, ammunition, and fuel and for collaboration in naval ship construction is, at best, unclear, certain conclusions about the future direction of naval ship technology seem reasonable at this time.

Table 22

<u>Ships in Service (and on Order)</u>
(1975)

	Total	Britain	France	West Germany	Italy	Nether-lands	Belgium	Denmark	Norway
Surface Ships (Larger than Frigates)	197 (42)	75 (11)	54 (4)	17	22 (9)	17 (14)	-(4)	7	5
SSBN	7 (2)	4	3 (2)	-	-	-	-	-	-
SSN	8 (3)	8 (3)	-	-	-	-	-	-	-
SS Diesel	107 (7)	20 -	20 (4)	29 (1)	11 (2)	6	-	6	15
Smaller Ships	1,603 (39)	464 (4)	265 (4)	273 (10)	262 (19)	105 (2)	53	94	87

(On Order)

Source: Hoagland, MacLachlan & Co., Inc.

There will undoubtedly be continued pressure from cost inflation and the desire to reduce defense expenditures to hold down total ship construction in each country. This will be offset in part by the desire to maintain an employment policy and total shipyard capacity above certain minimum levels.

The types of ship platforms considered for construction in the next decade by each of the NATO navies will be influenced by three factors. First, the recognized inability of all but the British, and possibly the French, to keep up with technological developments at the same rate as the Superpowers. Second, the decline, due to the lower level of naval ship employment in recent years, in over-age or excess vessels available for sale on the export market. Third, the changing nature of the naval missions assigned to the Continental naval powers and the rapidly-changing configuration requirements for ship platforms to perform these tasks.

An interesting paradox is emerging from the confluence of the trends toward limited defense expenditures for naval ship construction and the changing requirements for types of ships. The enormously increased fire power now available to smaller navies in the form of, particularly, antiship missiles may require a number of much smaller ship platforms to perform the task of coastal and inshore patrol work, as well as deep-water ocean patrol of medium endurance. Thus, new designs like the Harrier Carrier, or smaller-sized frigates, may be both affordable in appropriate numbers and sufficient for assigned missions for all or most of the smaller navies, as well as Britain and France. This possibility argues for increased export orders for the British lead yards as well as, possibly, for DTCN in France. There will undoubtedly continue to be a drive on the part of both countries to dominate the export market through continued design development, as well as maintenance of ship construction capacity. Notwithstanding this, the desire of each country to maintain its own naval shipbuilding capacity will remain strong and thus the need for collaboration between the design team, which may be British or French, and the various national shipyards will perhaps give rise to collaborative efforts.

The contrasting missions of the French and British offshore fleets (deep-water ASW and patrol) and the Continental navies (inshore, coastal defense, and mine work) will continue to cause a disparity in the emphasis on naval construction and the amount of each national defense budget devoted to the navy. The cost factors, however, will continue to argue for greater interchangeability between particularly adjacent countries and standardization, wherever possible, of equipment. The use of the French EXOCET missile by Britain, France, and Germany on patrol craft is an indication of how this can work, straddling both general mission areas.

On the question of technological development which can be exported (and excepting whatever may emerge from the design work done in the French government dockyards), it seems most likely that such developments will be confined to the three main British yards and the associated design firms. It is indeed possible that another NATO country may develop a new weapons system for mounting on a frigate type, for example, or that the government design bureaus in, for example, Holland or Denmark might work out one new technological system applicable to a multinational class of ships. On a longer-range basis, however, the combination of design and construction skills and the volume of continuous naval production in Britain argue that this team will be the only one likely to compete with the United States on the technology front. The development of the Hovercraft and the Harrier Carrier have already been quoted as examples of this, and it is not inconceivable that developments such as these could be the subject of licensing negotiations with three main shipyards doing the bulk of U. S. Naval production, namely Electric Boat, Newport News, and Ingalls Shipyard at Pascagoula, Mississippi. Joint projects such as the Harpoon-equipped patrol hydrofoil, now under joint development by Italy, Germany and the United States, will benefit greatly from the pioneer work done in Britain. Similar projects can be expected from the British work on small platform types capable of supporting various types of aircraft for anti-submarine and anti-ship warfare.

IV. The European Tank Industry

A. Introduction

B. Organization of Development and Manufacture

1. United Kingdom
2. Federal Republic of Germany
3. France
4. Other Countries

C. Current and Future Programs

1. United Kingdom
2. Federal Republic of Germany
3. France
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D. Comparisons with the United States

1. General Situation
2. Design of Battle Tanks
3. Other Vehicles
4. Major Components

E. Licensing Opportunities

A. Introduction

A. Introduction

Part IV examines the capabilities of European NATO countries and France to develope and to manufacture tanks and other armored vehicles, including their major components. It starts with a description of how these activities are carried out in the different countries concerned, which includes an outline of the organization of government and industrial establishments involved in them and a list of principal facilities. The paper then deals with the principal current and future programs and the characteristics of the vehicles produced in the different countries. Finally, the paper compares the activities and products of the countries concerned with those of the United States and ends with an attempt to assess opportunities for trans-Atlantic licensing, especially for European licenses in the United States.

This Section was completed, as the text will indicate, prior to the latest agreement between Bonn and Washington, signed in late July, 1976, regarding commonality of components for the main battle tanks of the two countries. However, few of the conclusions presented here would require change because of the latest agreement.

B. Organization of Development and Manufacture

1. United Kingdom

2. Federal Republic of Germany

3. France

4. Other Countries

1. United Kingdom

Of all the European countries, Britain has the longest record of tank development and continues to be one of their most important manufacturing centers. Development and design of armored vehicles in the UK is very largely carried out in government establishments. The principal one is the Military Vehicles and Engineering Establishment (MVEE), located in Chertsey, Surrey, which has an overall responsibility under the British Ministry of Defense Procurement Executive for research and development in the field of armored combat vehicles, ranging from heavy battle tanks to light armored reconnaissance vehicles. However, tank guns as well as other weapons are the responsibility of another government establishment, the Royal Armament Research and Development Establishment (RARDE), at Fort Halstead, Kent, which also shares with MVEE the responsibility for the development of armor.

MVEE employs about 2,000 professional engineers, technicians and workers, and its capabilities compare in general with those of the U.S. Army Tank-Automotive Research and Development Command (TARADCOM, formerly TACOM) in Warren, Michigan.

Detailed design of armored vehicles for production is generally carried out elsewhere, at the manufacturing centers. The principal of these is the Royal Ordnance Factory (ROF) at Barnbow, Leeds. ROF Leeds is a modern, well-equipped manufacturing plant built primarily to machine heavy components of battle tanks and to assemble them, but at present it manufactures not only the Chieftain battle tank but also the Fox wheeled armored reconnaissance vehicle. The only other battle tank manufacturing facility in the UK is the plant of the Armament Division of Vickers Ltd., in Newcastle-upon-Tyne.

Light armored vehicles are for most part manufactured by Alvis Ltd., of Coventry, a division of British Leyland Ltd., Britain's largest automotive group is at present heavily dependent for its continued operation on government financial support. However, in contrast to its parent company, Alvis' financial position has been sound.

At present Alvis is manufacturing light tracked armored vehicles of the Scorpion family. Until recently they also produced six-wheeled armored vehicles of the Saracen-Saladin series. Alvis employs 2,000 people and has what is probably the world's most modern equipment for automatic machining and welding of the aluminum armor plates, of which the turrets and hulls of the Scorpion family are made.

Some light wheeled armored vehicles based on truck chassis are also being made by Short Brothers and Harland Ltd., of Belfast, in Northern Ireland, and by GKN Sankey Ltd., of Telford, Salop, a division of GKN, Britain's largest engineering group, which was responsible for the manufacture of the FV 432 armored personnel carrier (APC), the British equivalent of the US M113 APC.

All British tank guns are made at the ROF in Nottingham, which together with RARDE is responsible for the leading position occupied by the UK in the tank field. In particular, it manufactures the 105mm high-velocity gun which is used in German Leopard 1 and several other types of tanks, as well as being made under license in the United States. ROF Nottingham also manufactures, of course, the 120mm gun of the Chieftain battle tank and a medium-velocity 76mm gun for lighter armored vehicles, such as the Scorpion.

Smaller weapons, and in particular the highly effective 30mm RARDEN light armored vehicle gun, are the responsibility of ROF Enfield. Altogether there are eleven ROFs employing 20,000 people, of whom about 1,500 work at ROF Leeds.

Automotive components of armored vehicles are designed and manufactured by industrial companies. Thus, the L-60 diesel of the Chieftain has been developed and produced by the Leyland division of British Leyland. The Diesel Division of Rolls-Royce Motors Ltd., located in Shrewsbury, is now developing a new range of tank diesels, while the Jaguar division of British Leyland, in Coventry, is manufacturing a militarized version of one of its gasoline engines for light armored vehicles, such as the Scorpion and Fox.

Self-changing Gears division of British Leyland and David Brown, Ltd., Huddersfield, have manufactured tracked vehicle transmissions, while GEC Ltd., and Marconi Radar Systems Ltd., have been responsible for the development and production of tank fire control systems.

Between them, the government and industrial facilities provide the UK with the ability to develop and produce, virtually without any help from abroad, the most advanced combat vehicles and to manufacture them not only for British forces but also for large-scale export. Thus, the UK has sold more than 2,000 of the highly successful Centurion battle tank and is now engaged in producing a similar number of Chieftains for export. Until recently it has also been a major producer and exporter of wheeled armored vehicles and is now beginning to export light tracked armored vehicles of the Scorpion family, whose total production is going to amount to more than 3,000 vehicles.

2. Federal Republic of Germany

Although the development of armored vehicles was not resumed in Germany until the mid-fifties, Germany has since become the largest producer of battle tanks in Western Europe. It has, in fact, produced about 3,000 of them, not only for its own army but also for the armies of Belgium, Netherlands, Norway, Italy and Denmark; and more tanks have been ordered from FRG by Australia, Canada, Greece and Turkey.

In contrast to the UK, Germany has no government design and development establishment comparable to USATARADCOM, although it has a well-equipped government establishment for the testing of armored vehicles, which might be compared, so far as automotive components are concerned, to the US Army's Aberdeen Proving Ground in Maryland, or some of the test facilities at Warren, Michigan. Thus, design and development of armored vehicles is done largely by industry.

In the case of tanks, development and production are carried out primarily by the armored vehicle division of Krauss-Maffei AG, a heavy engineering company located in Munich, which acts as the parent organization for the manufacture of battle tanks in FRG. Krauss-Maffei have a total workforce of 6,000, of whom about 10 per cent are concerned with tanks, and they have Europe's most highly organized tank assembly line.

However, turrets of German tanks are designed and made by Wegmann & Co. in Kassel, a heavy engineering company which has a workforce of about 1,800, approximately one half of whom are concerned with defense projects. Tank design studies are also carried out by the Porsche Company in Stuttgart and by MAK Maschinenbau GmbH in Kiel.

MAK also manufactures the armored recovery version of the standard FRG Leopard I battle tank and shares in the production of the Marder Mechanized Infantry Combat Vehicle (MICV), whose principal manufacturer is Rheinstahl AG-Transporttechnik of Kassel. MAK has a workforce of about 3,700, of whom 40% are engaged in defense contracts while Rheinstahl-Transporttechnik has about 4,000 of whom 1,000 are in defense.

In addition to the Marder MICV, Rheinstahl also produces the eight-wheeled Lynx armored reconnaissance vehicle and has produced several hundred gun-and-missile-armed tank destroyers based on the Marder chassis. Other wheeled armored vehicles of the Transportpanzer type which are based on truck components are being made by Daimler-Benz.

Engines for German tanks and MICVs, which are water-cooled four-stroke diesels, are developed and built by Motoren and Turbinen Union GmbH of Friedrichshafen AG and by Renk AG in Nuremberg.

Leopard tanks currently in production are still armed with the 105mm gun imported from the UK, but Rheinmetall GmbH of Dusseldorf has now developed new 105 and 120mm guns for Leopard II as well as manufacturing 20mm automatic cannons for the Marder and for other light armored vehicles. Rheinmetall employs about 8,000 people, of whom approximately 3,500 are employed on defense business.

Except for the participation of some U.S. companies, such as Cadillac Gage in stabilized gun controls and Hughes Aircraft Co. in laser rangefinders, FRG is fully capable of producing by itself a full range of armored combat vehicles and has established a lead in some areas, such as tank transmissions and stabilized optics.

3. France

Like the British, French armored vehicle development is government centered. Tanks as well as other types of armored vehicles are developed and designed at the Atelier d'Issy-les-Moulineaux (AMXO, a government establishment located at Satory near Versailles. Battle tanks and other tracked armored vehicles are also manufactured at a government establishment, the Atelier de Construction de Roanne (ARE) at Roanne in central France; but earlier AMX 13 light tanks are still manufactured by a private company, Creusot-Loire.

AMX and ARE are both part of the Groupement Industrielle des Armaments Terrestres (GIAT), which comes under the Direction Technique des Armements Terrestres (DTAT) of the French Ministry of Defense. In addition to AMX and ARE, GIAT incorporates eight other establishments and employs a total of 17,000, of whom 1,050 are employed at AMX and 2,900 at ARE.

Tank guns as well as other guns of more than 30mm caliber are developed and produced at the Etablissement d'Etudes et Fabrication d'Armament de Bourges (EFAB), at Bourges, which employes 2,500 people. Turrets and other heavy components are made at another GIAT establishment, the Atelier de Construction de Tarbes (ATS), which is located in the foothills of the Pyrenees and which employs 2,900 people.

As in the UK, automotive components are produced by industrial companies. In particular, tank engines are made by SAVIEM, the truck division of the government-owned Regie Nationale des Usines Renault.

Wheeled armored vehicles are generally designed and made by industrial organizations, under contract from DTAT or on their own initiative. The companies concerned consist of S.C.M., Panhard, and Levassor, the world's oldest manufacturers of combat vehicles, who are located in a suburb of Paris and who are now part of the Citroen car group. Panhard have sold their light four-wheeled armored cars to about 30 countries. Two other companies are SAVIEM, mentioned earlier, who are beginning to manufacture the VAB wheeled armored transporter, somewhat similar in principle to the German Transportpanzer, and Berliet (now a SAVIEM subsidiary), a heavy truck manufacturer which builds the four-wheeled general-purpose VXB armored carrier (which resembles the U.S. Cadillac Gage Commando.)

Like the British, the French are virtually self-sufficient in the field of armored combat vehicles and have shown themselves capable of developing and manufacturing all types. In fact, they have a wider range of armored vehicles than either the British or the West Germans.

4. Other Countries

Apart from the UK and FRG, the only European NATO country to have a major armored vehicle manufacturing facility is Italy. Its facility consists of the OTO-Melara SpA plant outside La Spezia, which has a workforce of about 1,500, employed on naval ordnance as well as ground equipment. The plant has assembled 200 U.S.-designed M60A1 battle tanks and is now manufacturing 600 Leopard I tanks, using a number of components supplied from Germany. For several years OTO-Melara has also manufactured M113 armored personnel carriers under a co-production agreement with the United States; and they have now produced an improved version of the M113 which has been developed by the Italian Army and is designated the Infantry Armored Fighting Vehicle (IAFV).

The Special Vehicles Division of Fiat, the large Italian automotive company, has also participated in OTO-Melara's production of the M60A1 and more recently of the Leopard I. It has also developed two-wheeled armored vehicles of its own, the Type 6614 armored carrier and the Type 6616 armored car, but neither has yet gone into quantity production.

Italy has considerable further potential for armored vehicle development based on companies such as: Ottico Meccanico Italiana (OMI), which has manufactured tank optical rangefinders; Breda Meccanica Bresciana SpA (BMB), which has been working closely with the Swedish Bofors Company on naval and ground gun mountings; and Contraves Italiana, an affiliate of the Swiss Oerlikon-Buhrle company - well known for its light anti-aircraft guns and fire control systems.

The Netherlands has limited armored vehicle design and development facilities vested in the DAF truck company of Eindhoven. However, apart from one or two light to medium vehicle prototypes, DAF has only produced, some years ago, the YP-408 eight-wheeled armored carrier based on one of their truck chassis.

More significant are the Dutch capabilities in the area of electronics related to gun systems, vested in the Philips company which has played a major role in the development of the twin 35mm anti-aircraft tank gun based on the FRG Leopard chassis to be produced for German, Dutch and Belgian armies, by supplying radar equipment for its fire control system.

Apart from the rifle-caliber machine guns produced by its famous FN company, Belgium has only produced medium-pressure 90mm smooth bore guns and integrated fire control systems for battle tanks. The former are suitable for light armored vehicles; and one of the 90mm guns is offered on a model of the Cadillac Gage armored car series, while another has been mounted in the FN police armored car, the only armored vehicle of Belgian design. The fire control system for the Leopard tanks of the Belgian Army, and also those ordered by Australia, has been produced by SABCA working under license from the Hughes Aircraft Company. The only other significant Belgian activity in the field of armored vehicles is participation in the production of the British-developed

Scorpion family of light tracked vehicles, some of which have been assembled in Belgium.

Norway's activities in the armored vehicle field have been confined to modernization of its U.S.-built M24 light tanks by the Thune-Eureka Company. It has, however, made a significant contribution to some British and other tank fire control systems by supplying laser range-finders developed by Simrad AS of Oslo.

The remaining five countries - Denmark, Luxembourg, Portugal, Greece and Turkey - have at present no capability to develop or to manufacture armored vehicles, although Portugal built some copies of the U.S. developed Cadillac Gage Commando armored cars, and Greece may start to build some armored vehicles in the near future.

C. Current and Future Programs

1. United Kingdom

2. Federal Republic of Germany

3. France

4. Other Countries

1. United Kingdom

By far the most important British armored vehicle program is the manufacture of Chieftain battle tanks. Approximately 600 have been produced for the British Army and another 600 for Iran. A further 1,200 of an improved type are to be produced for Iran, and 100 have also been ordered by Kuwait.

With the possible exception of the latest Soviet tank, the Chieftain is the most powerful battle tank in service anywhere in the world. It weighs 55 metric tons, which means that it carries heavy armor; and it is armed with a 120mm gun which fires highly effective armor-piercing discarding sabot (APDS) projectiles. The British have held a world lead in the development of this type of ammunition, and their earlier APDS-firing 105mm gun has won wide acclaim. Thus, it was adopted for production in the United States for the M60 series of tanks and has been retained for the latest U.S. XM-1 battle tank prototypes. It has also been adopted for the German Leopard, Swiss Px.61 and 68, Swedish S-tank, Indian Vijayanta and the Japanese Type 74 battle tanks.

The general layout of the Chieftain is much the same as that of almost all other contemporary battle tanks, and its design has been evolved directly from the earlier, well-proven Centurion tank. However, it is unique in having a supine position for the driver, which lowers the height of its hull and reduces its silhouette.

The original fire control system of the Chieftain has been unusual, being of a simple and robust kind based on a ranging machine-gun, instead of the optical rangefinders favored in contemporary U.S. and other tanks. However, this system is now being replaced by a fire control system incorporating a laser rangefinder and an electronic computer which is as advanced as that being retrofitted in U.S. M60A1 Product-Improved tanks. On the other hand, unlike contemporary U.S., German, and French tanks, the Chieftain has been fitted from the start with stabilized gun controls for firing on the move, in keeping with the lead which Britain established in the use of stabilized gun controls after World War II.

The least satisfactory feature of the Chieftain has been its L-60 engine, developed and produced by British Leyland. This 720 hp engine is of the six-cylinder, opposed-piston two-stroke type based on an earlier German Junkers aircraft diesel. It has proved to be troublesome mechanically, suffers from high oil consumption, and requires frequent overhaul. Because of troubles with its pistons and other components, its power could not be increased as much as had been hoped. Consequently, the Chieftain has a relatively low power-to-weight ratio and has a bad name from the automotive viewpoint.

The engine shortcomings of the original Chieftains are to be rectified, in the new models to be produced for Iran, by replacing the Leyland L-60 diesel by a new V-12 four-stroke diesel of 1,200 hp which is being developed by Rolls-Royce Motors. The new version of the Chieftain will also have "Chobham" armor which will greatly increase its survivability. This type of armor, invented in the UK, has also been adopted for the latest U.S. XM-1 tanks and is one of their major features.

In addition to the basic gun tanks, which are now all being built by ROF Leeds, there is also an armored recovery version of the Chieftain which is being built by Vickers and a bridgelayer version built by ROF Leeds.

Wow!

Vickers is now marketing an improved, Mach 3 version of their tank - a 38-ton vehicle with a 105mm gun - which was originally developed under contract from the Indian government and which is now being manufactured in India as the Vijayanta battle tank. The Vickers/Vijayanta battle tank is a cross between the earlier Centurion and the Chieftain. (It has the same gun as the former and the same engine and transmission as the latter.) Being lighter, it is inevitably less well armored than the Chieftain but it is more mobile; and because its L-60 engine does not have to work so hard, it has been much more successful than in the Chieftain. Apart from those produced originally for India, 50 Vickers battle tanks were produced for Kuwait, and additional ones may be ordered by one or two of the smaller countries.

The second most important British program is represented by the production, since 1970, of the Scorpion family of light, aluminum-armored tracked vehicles. The basic Scorpion is an eight-metric ton, three-man light tank with a turret-mounted 76mm medium-velocity gun as well as the usual rifle-caliber coaxial machine gun. It is powered by a 195 hp six-cylinder militarized Jaguar gasoline engine, which gives it a maximum road speed of 50 m.p.h., faster than almost all other tracked armored vehicles currently in service.

The other members of the Scorpion family include the Scimitar, which is almost identical except for mounting a high-velocity 30mm RARDEN gun instead of the 76mm gun, the turretless Striker launcher vehicle for Swingfire anti-tank guided missiles, and the seven-man Spartan armored personnel carrier. There are also three other turretless models basically similar to the Spartan: the Sultan command vehicle, the Samaritan armored ambulance and the Samson recovery vehicle.

Except for being cramped, because their design was over-constrained by the cargo compartment dimensions of the aircraft in which they were originally to be carried, the Scorpion and its derivatives represent a very successful example of a coherent family of light armored vehicles suitable for reconnaissance, security and airborne operations. About 2,000 were originally ordered for the British Army and another 600 for the Belgian Army. Since then, further vehicles of the Scorpion family have been ordered by Iran and a number of smaller countries. The vehicles have been manufactured by Alvis in collaboration with a factory operated by British Leyland at Malines in Belgium.

As the British Army decided to switch to tracked armored vehicles of the Scorpion series, the UK lost the position it held as a leading developer and exporter of wheeled armored vehicles, represented by the six-wheeled Saracen and Saldin which were produced by Alvis and the light four-wheeled Ferret scout car which was produced by the Daimler division of British Leyland. ROF Leeds is, however, manufacturing a development of the Ferret called the Fox. This is a four-wheeled armored car which weighs six tons and is powered by the same Jaguar engine as the Scorpion; it has a crew of three and is armed with a 30mm RARDEN gun, which is its best feature.

ROF Leeds is also beginning to produce a Combat Engineer Tractor. This is a unique aluminum=armored vehicle which can act as an earth-mover or bulldozer but is at the same time more mobile than corresponding commercial vehicles. Only the British Army has so far developed such a vehicle, and it greatly increases the effectiveness of its combat engineer units.

The first of the new programs to come to fruition is likely to be the SP-70, a 155mm self-propelled gun which has been developed by the UK in collaboration with Germany and Italy. SP-70 is intended eventually to replace U.S.-built M109 155mm s.p. howitzers with which British, German and Italian armies are at present equipped. It uses the same ammunition as the towed FH-70 155mm gun already jointly developed by UK, FRG and Italy, and it will have a considerably longer range than the current M109.

Since 1972-73, Britain and Germany have also been carrying forward joint studies of a new battle tank which, it has been hoped, would be produced by the two countries in the 1980s. A number of different configurations have been considered for their MBT-80, but details are still classified.

In anticipation of new tank designs, RARDE has been developing a new 110mm gun and an improved 120mm gun, one of which would eventually succeed the 120mm gun at present made for the Chieftain.

The UK has also been studying, on its own, the design of a future MICV which might succeed its current FV 432 armored personnel carrier.

In addition, British companies have developed, on their own, various systems to upgrade earlier British, U.S. and Soviet-built tanks in the inventory of second or third rank powers. Thus, Vickers Ltd., and Airscrew Howden Ltd., offer new engine and transmission assemblies suitable for retrofitting in Centurions and, in the latter case, M47 and M48 tanks. Marconi Radar Systems Ltd., and Lucas Defence Systems Ltd., offer fire control systems incorporating laser rangefinders and electronic computers for retrofitting not only in Centurions and M47 or M48 tanks but also in Soviet-built T-54 or R-55 tanks used by various Arab countries.

2. Federal Republic of Germany

The principal armored vehicle programs continue to be the production of the Leopard I and the development of the Leopard II battle tanks.

Leopard I is a 40-metric-ton vehicle manned by a crew of four and armed with a British-made 105mm gun. It is powered by a 830 hp V-10 water-cooled diesel which has given it a power-to-weight ratio of almost 21 hp per ton. This high power-to-weight ratio has been equalled only by the French AMX 30 among the tanks introduced into service so far. The design of Leopard I stems from a specification for a "European" tank, drawn up jointly by German and French General Staffs in the mid-fifties, which emphasized mobility at the expense of armor protection. As a result, Leopard I is less heavily armored than its U.S. contemporary, the M60A1, and even less than the British Chieftain. On the other hand, its automotive performance has been considered superior to that of other tanks.

The first production models of Leopard I were delivered in 1965. Since then it has become NATO's most numerous tank in Europe. Thus, in addition to 2,400 produced for the German Army, another 1,800 have been ordered by the NATO countries indicated earlier, and further tanks are on order. The international success of Leopard I must be ascribed to a combination of its excellent automotive characteristics, the good performance of its gun and the attractive offset trade arrangements offered to purchasing countries by the FRG.

In addition to the basic gun-armed battle tanks, a total of about 600 Leopard armored recovery vehicles have also been produced, as well as 200 Leopard combat engineer and bridgelaying vehicles.

A major extension of the Leopard I program is the development of the twin 35mm gun anti-aircraft tank with an advanced, all-weather radar fire control system. This vehicle, called the Gepard, is well in advance of any other mobile anti-aircraft system - capable of giving close protection to armored units against low-level attack by aircraft. About 600 vehicles are to be produced for the German, Dutch and Belgian armies, and the twin 35mm gun turret and radar system might also be adopted by the U.S. Army, in which case it would be mounted on the hull of the M60 tank.

A follow-on to the Leopard I is the Leopard II program. Leopard II is a new vehicle developed from the basis of Leopard I and of the ill-fated U.S.-German MBT-70. It has heavier armor than Leopard I and a more powerful gun. The gun, developed by Rheinmetall, is a smooth-bore which fires armor-piercing fin-stabilized discarding sabot (APFSDS) projectiles which are inherently more effective than the spin-stabilized APDS projectiles used at present.

The heavier armor of Leopard II indicates a change of heart about the value of armor protection b y the German Army and brings Leopard II up in weight almost to the level of the British Chieftain. However, in contrast to the latter, Leopard II still has a very high power-to-weight ratio of almost 30 hp per (metric) ton, thanks to the automotive components inherited from the MBT-70 program which was jointly pursued by Germany and the United States from 1963 to 1970. In fact, it has a 1,500 hp engine, a robust V-12 water-cooled diesel produced by MTU, and a Renk hydrokinetic transmission which is more advanced than any other of its kind in the world.

In its latest, Leopard II AV configuration, it weighs 54.5 tons, fully laden, and incorporates advanced composite armor equivalent to the "Chobham" armor developed in the UK and adopted for the U.S. XM-1 prototypes as well as the new versions of the British Chieftain. The first Leopard II AV was built in the spring of 1976. In September 1976, it is to be flown to the United States for competitive trials with U.S. XM-1 prototypes. Its main advantage over the latter is its 120mm gun.

So far as Germany is concerned, Leopard II is intended not to replace Leopard I but to replace the earlier, U.S.-built M48A2C tanks, of which about 1,000 are still in service with the German Army. Phasing out of Leopard I is not likely to start until the studies of MBT-80, which have been carried out by FRG and UK, result in the production of a new and much more advanced battle tank.

Next in importance to the Leopard program has been the Marder MICV program. More than 2,000 of these vehicles have been produced by Rheinstahl and MAK, all for the German Army. The first production model of the Marder was delivered in 1971, and it became the first MICV, developed and built as such, to come into service outside the Soviet Union. In other words, it is the first vehicle in service which can fight on the move and not serve merely as a transporter of infantrymen for dismounted action, like the U.S. M113 and its equivalents elsewhere. The Marder was also designed to closely accompany tanks and, as a result, its automotive performance is comparable to that of Leopard I. It weighs 25.5 metric tons, which makes it heavier than all other armored infantry vehicles, be they APCs or MICVs. Moreover, it is considerably more expensive than any of them, and it has not therefore replaced all earlier APCs used by the Bundeswehr, including U.S.-built M113s.

The chassis of the Marder has also been used, however, for the Jagdpanzer (kanone), a 90mm gun turretless tank destroyer of which 770 were produced for the German Army and 80 have been ordered by Belgium. It has also been used for the Jagdpanzer (rakete), an anti-tank missile tank destroyer. Originally 365 were produced for mounting the French SS-11 anti-tank guided missile system, but a new version has been in production since 1975 to mount the second-generation Franco-German HOT guided missile system. The Jagdpanzer (rakete) is the most sophisticated of the anti-tank guided missile armed vehicles to appear anywhere so far and is much in advance of the efforts now being made in the United States to mount the TOW anti-tank guided missile under armor.

The chassis of the Marder has also been adopted for mounting the Franco-German Roland surface-to-air missile system. The production of this mobile anti-aircraft system for the German Army is planned for 1977 and the U.S. Army is also to adopt the Roland system, mounted on a U.S. armored vehicle, with the Hughes Aircraft Company acting as the prime contractor.

In the field of self-propelled artillery, Germany is pursuing the SP-70 in collaboration with the UK and Italy, as already mentioned.

Since 1975, Rheinstahl has been producing the eight-wheeled Lynx armored reconnaissance vehicle, of which approximately 400 are eventually to be made. This 20-ton amphibious vehicle with a crew of four is interesting technically, but its large size, weak 20mm gun main armament, and high cost make it a questionable military investment.

A much better investment is represented by the Transportpanzer, a six-wheeled amphibious armored cargo and personnel carrier which is under development by Daimler-Benz. Procurement of this general-purpose vehicle for the German Army might eventually amount to 1,200. It might also attract orders from other NATO armies, particularly as there is no competitor to it in Western Europe, except for the French SAVIEM VAB.

3. France

The principal French armored vehicle programs are the production and further development of the AMX 30 and AMX 10 families of vehicles.

The AMX 30 family is based on a battle tank which emanates from the same Franco-German specification as Leopard I. It weighs 36 metric tons, which makes it as light as any battle tank currently in service anywhere in the world; but it also indicates that it was designed at a time when the French as well as German armies did not place much value on heavy armor. Like almost all other contemporary battle tanks, the AMX 30 is manned by a crew of four and is powered by a compact, flat-12 water-cooled diesel designed by Hispano-Suiza and produced by SAVIEM. It develops 720 hp, which gives AMX 30 a power-to-weight ratio virtually as high as that of Leopard I and higher than that of other tanks currently in service.

The main armament of the AMX 30 is an EFAB-developed 105mm gun which, in contrast to the 105mm guns of British origin used in the United States, Germany, and elsewhere, does not fire APDS or any other kind of kinetic energy armor-piercing ammunition. The only armor-piercing projectile it fires is of the chemical-energy type (HEAT) with the shaped charge mounted in ball bearings within the body of the shell to prevent its performance being degraded by the spin imparted to the body by the rifling of the gun. The reason for the adoption of this ingenious projectile and the unique concentration on HEAT ammunition for defeating armor lies in the exaggerated belief which was once held in France, and also in the United States, in the efficacy of HEAT projectiles.

The gun-ammunition system of the AMX 30 and its light armor have since been regarded as its major weaknesses, but they have not prevented about 1,000 being produced for the French Army. In addition, 120 have been built for Venezuela, 60 for Greece, 150 for Saudi Arabia and 20 for Spain, which is likely to produce more under license.

Like the U.S. M60A2 and the ill-fated MBT-70, a second-generation version of the AMX 30 was to have been armed with a gun/missile launcher. This was the 142mm ACRA which, in some respects, was even more advanced than the U.S. 152mm gun/Shillelagh missile launcher. However, just as the U.S. Army decided not to proceed with the 152mm gun/missile launcher beyond the M60A2 and the MBT-70, the French have shelved the development of their 142mm gun/launcher.

Instead, AMX is now developing a new version of the AMX 30 which is armed with a smooth-bore high-velocity 110mm gun firing APFSDS projectiles. This should result in a tank comparable in fire power to Leopard II but probably much lighter. One of the other features of the new, second/third generation version of the AMX 30 might be a high-output turbo-supercharged diesel employing the Hyperbar system of enhancing the performance of supercharged diesel engines by using a gas turbine type combustion chamber to supply additional energy to the supercharger turbine when required. The Hyperbar system is also being considered for high output diesels outside France.

In addition to the basic gun-armed version of the AMX 30, the French have also developed and produced the usual armored recovery and bridgelayer versions. They have also produced an anti-aircraft version with twin 30mm Hispano Suiza guns which is comparable to the German Gepard anti-aircraft tank but whose clear-weather radar fire control system is less advanced. There is also an AMX 30 armored launcher for the Pluton tactical nuclear missile and an AMX 30 155 GCT, a 155mm self-propelled gun with all-round traverse and an automatic loading system which provides a high rate of fire of eight rounds per minute. Neither vehicle has at present a counterpart in any NATO army; and the 155 CGT represents a significant advance in self-propelled artillery equipment. In addition to the version based on the AMX 30 chassis, the turret and gun of the 155 CGT have been mounted experimentally on a Leopard I chassis. Still another derivative of the AMX 30 is a launcher vehicle for the Roland surface-to-air missile.

The second major French program is based on the AMX 10, a 14-ton tracked armored infantry combat vehicle capable of carrying 11 men. The AMX 10 is outwardly similar to the U.S. M113 and is also aluminum-armored and amphibious but it is better armed (with a 20mm cannon.) Like other vehicles of this kind, it has been adapted to a variety of roles, including that of a command post vehicle and heavy mortar prime mover. There is also a version for launching HOT anti-tank guided missiles, which has anticipated U.S. development of TOW under armor, and AMX 10 has also been used as the basis of the AMX 10 C, a four-man reconnaissance vehicle with a turret-mounted 105mm gun firing fin-stabilized HEAT projectiles. There is also a six-wheeled alternative of the reconnaissance version, the AMX 10 RC, with a unique skid-steering system. A similar system had been tried before in Britain, but without success.

No major foreign orders appear to have been placed yet for any of the models of the AMX 10 series but this is still relatively new and has not been offered for as long a time as the AMX 30.

In the meantime, small-scale production continues for export of the basic light tank of the earlier AMX 13 light armored vehicle family which the AMX 10 family is replacing. The AMX 13 family has included 20 different models and has been widely used outside France as well as by the French Army.

In addition to the tracked vehicle programs, France has at least three-wheeled armored vehicle programs. The most significant technically is that of Panhard who are continuing to produce their light five-ton AML turreted armored car and its derivative, the VTT light armored carrier. About 4,000 of these vehicles have already been made not only for the French Army but also for about 30 different countries. Moreover, several hundreds have been produced under license in South Africa. For some time Panhard have been working on new designs and have produced several experimental models. They are now about to launch a new series but details of it are still classified.

The second wheeled armored vehicle program is based on the VAB 4 and six-wheeled general-purpose armored carriers which were developed under

French Army contract by SAVIEM and which are now entering production. They include vehicles mounting various alternative forms of armament, from machine guns to light mortars for internal security operations and HOT anti-tank guided missiles. The quantity of vehicles ordered by the French Army is not known but appears considerable. Figures as high as 4,000 have been mentioned.

The third program involves the four-wheeled VXB armored carrier developed on their own initiative by Berliet on the basis of their truck automotive components. It has been adopted by the French gendarmerie for internal security duties, and a military version has been offered for export.

4. Other Countries

The only other country to have programs of any significance is Italy, whose OTO-Melara company is producing Leopard I tanks in collaboration with Krauss-Maffei, the German parent company. OTO-Melara has also been producing M113 armored carriers under a co-production agreement with the U.S. and has also built an unknown number of an improved version, the IAFV. It has also experimentally mounted the new FH-70 gun in the U.S.-built M109s.p. gun chassis to produce a vehicle which offers the improved performance of the new gun and the low cost of the existing chassis. OTO-Melara has also studied and offered for export a 20-ton MICV, the OF-24 Tifone, which incorporates the 76mm gun turret of the British Scorpion and the chassis of a Swiss Mowag MICV.

Fiat's independent entry into the field with the four-wheeled 6614 and 6616 armored vehicles has not, so far, borne fruit beyond the order for a few vehicles from the Italian carabinieri for internal security duties.

D. Comparisons with United States

1. General Situation

2. Design of Battle Tanks

3. Other Vehicles

4. Major Components

1. <u>General Situation</u>

In general, the European view is that Britain, Germany, and France have been more successful in developing armored vehicles in recent years than the United States, especially in relation to the resources available or deployed. The principal reasons for this appear to be three. First, their development efforts are not as fragmented and wasteful as in the United States, which is clearly illustrated by the large number of agencies involved in U.S. development of armored vehicles. Second, their military authorities appear to have had a clearer idea of what is needed and practicable, which has saved them from fiascos like the development of the U.S. Armored Reconnaissance Scout Vehicle (ARSV), the T95 medium tank program in the 1950s, and the MBT-70 program in the 1960s. Third, their armored vehicle programs have been less vulnerable and have suffered less from changes of policy and in senior military personnel. They have also been more cautious and evolutionary and less liable to prematurely embracing technological novelties before their value could be fully assessed.

Given better management, there is no major armored vehicle program that the U.S. could not have done at least as well as the three European countries. However, better management would have involved radical changes in organization and attitudes, including a drastic concentration of effort at present dispersed among far too many agencies and the abolition of the present system of project management, except in its proper sphere of getting new models into production. It would also have required greater continuity in the tenure of senior military posts concerned with armored vehicle development, in order to ensure greater involvement and personal responsibility, and less frequent changes in the structure of the agencies involved.

On the whole, the quality of the R&D facilities directly related to armored vehicles is about the same on both sides of the Atlantic. Because they are more recent, static engine and vehicle test facilities are at present superior in Britain and Germany, but the United States has superior proving ground facilities. The United States is also ahead in computer modelling of armored vehicle performance and should, therefore, be in a better position to assess new models (but in the European view this has not, so far, given the U.S. any practical advantage.)

Manufacturing facilities directly related to armored vehicles and in particular to tanks are also comparable, each of the three European countries concerned being capable of producing battle tanks at roughly the same rate under peacetime conditions. However, labor and management problems of the British industry and lack of competitive pressures, or incentives, in British society have made British production slow and its delivery schedules long. On the other hand, the lower level of wages in British industry has made armored vehicles cost less in UK than they would have done in Germany or France.

Germany has generally managed its production of armored vehicles more efficiently, but their cost reflects the high level of German wages and the high exchange level of German currency. The cost of French armored vehicles has also been relatively high, partly because of relatively high wages and partly because of high overheads, but deliveries have been quicker than from Britain.

Generally speaking, the French have shown an earlier and better appreciation of the importance of selling armored vehicles abroad, both on account of the contribution they can make to the balance of payments and because of the help this provides to the development of vehicles for the French Army. They have also adopted a vigorous attitude toward arms sales.

In contract, the British have shown much greater concern, for instance, over sales in southern Africa.

2. Design of Battle Tanks

Until recently the view of the UK General Staff on tank design have differed significantly from those of the FRG and France. All three have regarded firepower as the most important characteristic, but the UK has consistently championed kinetic energy APDS projectiles, while the French opted for shaped-charge HEAT projectiles. The FRG and United States have had less definite views and used both. However, the biggest difference concerned armor protection, which the UK has rated second to firepower while FRG and France put mobility before armor. Once again, the United States adopted a less positive attitude, demanding more armor for its tanks than Germany and France but prepared to accept less than the UK; at the same time, the United States has demanded greater mobility than the UK but less than the FRG.

At first sight, British tank development has appeared very conservative, but the UK has, in fact, produced several major design innovations. British tanks have incorporated several new features in advance of others. For instance, the new type of "Chobham" armor which has dramatically increased the protection of tanks, including the U.S. XM-1, is a British invention; as are triple differential tank steering systems and collapsible flotation screens. Other equipment pioneered in the UK and adopted ahead of other countries includes APDS ammunition, two-axis electrical stabilized gun controls, supine driving position, and non-reflective periscopes.

France has pioneered in such things as oscillating (trunion-mounted) turrets and, coupled with them, automatic loading systems. France was also the only country which, during the 1960s, competed with the United States in the development of gun/missile launchers. In fact, its 142mm ACRA system was in some respects even more advanced than the contemporary U.S. 152mm gun/Shillelagh system. However, the French were wiser in not over-committing themselves to it; and when the shortcomings of the gun/missile launchers became obvious, they could shelve their ACRA program quietly without any of the repercussions which attended the dramatic termination of the U.S. MBT-70/XM803 program by the U.S. Congress.

One of the notable features of French tank development, first demonstrated with the AMX 13 family, has been the ingenuity displayed in the development of a number of different vehicles on the basis of one chassis. Thus, seven different vehicles have already been built on the AMX 30 chassis, which is more than the number of models derived from any other battle tank and which results in considerable economic and logistical advantages.

The FRG has not, until recently, demonstrated any great originality in tank design. German tanks have, however, generally proved superior to others from the point of view of automotive performance and reliability, due to the thorough detail design of their components and equally thorough testing, including extensive troop trials prior to production. In detail, German tanks have certainly been better engineered than British and French tanks, and at present the FRG is the only country which can match the latest U.S. tank designs from the point of view of power-to-weight ratio and agility.

In recent years, the FRG has also started a program of research into highly mobile tanks with power-to-weight ratios much higher than in all other tanks. Details of this program are still classified but it may be expected to produce some new and original designs.

3. Other Vehicles

Self-propelled guns have had far less effort devoted to them than battle tanks, and the need for them has been met to a large extent by procurement from the United States. As a result, both British and German armies are equipped with U.S.-built S.P. guns, except for the British 105mm Abbot s.p. gun. The 155mm SP-70 is the first major piece of s.p. artillery to be developed in either country for some time, and its range and fire control should make it a serious challenger to s.p. equipment produced in the United States. In the s.p. gun as in other fields the French have shown greater independence, and their army is equipped with French-built s.p. guns; but the only one which might be considered superior to comparable U.S. guns is the new 155mm AMX 30 GCT.

In contrast to the limited progress with s.p. guns, European countries have made more progress than the United States with anti-aircraft tanks. In particular the French, and more recently the Germans, have shown much greater awareness of the need for them than the U.S. Army. The French Army has had a number in service for some time while the U.S. Army still has none.

Neither the UK nor France have, so far, shown much originality in the development of tracked armored infantry vehicles, except for the ingenuity displayed by the French in deriving several different models from the basis of their AMX 10 infantry vehicle.

On the other hand, Germany has developed the Marder MICV whose characteristics are certainly different and in some respects superior to those of all earlier armored infantry vehicles. However, in recent years the concept of infantry fighting from its MICVs which is embodied in the Marder has been seriously questioned and may well be recognised as unrealistic. The Marder might, therefore, prove to be a doubtful investment, particularly in view of its high cost, and this may also be the case with the new U.S. XM723 MICV.

The UK, FRG and France have all three developed wheeled armored vehicles (which the United States has not), although the military value of the German eight-wheeled Lynx is debatable. The UK has recently contented itself with producing an improved version of one of its earlier vehicles which, when first introduced, were in advance of others from the automotive viewpoint. Novel designs were studied in the 1960s but were abandoned when the British Army decided to adopt tracked vehicles for reconnaissance.

The widest and most original range of wheeled armored vehicles has been developed in France, by Panhard, SAVIEM-Berliet and AMX. A measure of French leadership in this field is provided by the eight-wheeled Panhard EBR developed thirty years ago, whose sophistication has still to be surpassed in several respects by other vehicles. Moreover, unlike the British, the French are continuing to develop more advanced wheeled armored vehicles. This is particularly true of the development programs of Panhard and AMX.

The UK is alone at present in having developed and produced a family of light-weight tracked armored vehicles consisting of the Scorpion and its derivatives. Their design is not particularly original but is nevertheless skillful from the point of view of compactness and light weight. Armed as they are with medium-velocity 76mm and high-velocity 30mm guns respectively, the Scorpion and Scimitar carry considerable firepower in relation to their weight, which is only surpassed by the five-ton Panhard AML armored car armed with a 90mm smooth-bore gun. The Scorpion and Scimitar are, in fact, unique at present as effective tracked reconnaissance vehicles and an Americanized version of the Scorpion was included in 1972 in the U.S. Army competition for ARSV. It was not accepted, but nothing has come of the winner of the competition either.

4. Major Components

Success in the development of major components for armored vehicles reflects to a considerable extent the position of the different countries in particular fields of technology or their economic strength. Thus, the United States has been strong in electronics-based systems because of its preeminent position in electronics technology. However, Britain, the FRG and France have not been slow in taking up U.S. developments such as laser rangefinders and developing them further on their own.

On a much smaller scale, Britain had derived from the lessons of World War II a strong base for tank gun development and has used it successfully to develop a series of guns and related munitions, including the highly successful APDS and the less well known high explosive squash head or HESH rounds. It has avoided dissipating its gun development talents, as the United States has done by undertaking dubious projects, such as the gun of the T95 medium tank, or abandoning them prematurely, as it did with smooth-bore gun projects around 1960. But Britain became too strongly wedded to APDS. Now that APFSDS has been shown superior not only in theory but also in practice, the UK is no better off than the United States, which has lagged behind in APDS development but is as advanced as any country with APFSDS.

France has led in the development of medium-pressure smooth-bore guns of 90 and 105mm caliber which fire fin-stabilized HEAT projectiles and which are particularly suitable for light armored vehicles. France has also led in the development of anti-tank guided missiles. Its original SS-10 and SS-11 missiles were procured in quantity by the U.S. Army as well as others and were the first guided missiles to be carried by armored vehicles. From the basis of its early experience, France developed the ACRA, which might have proved superior to the U.S. Shillelagh and, in collaboration with the FRG, the second-generation HOT anti-tank guided missile which is similar but superior with regard to range to the U.S. TOW. France has also developed with FRG the Roland mobile surface-to-air missile system which is now being adopted by the U.S. Army as well as being adopted by the French and German armies.

France backed the wrong choice in its 105mm tank gun but is now restoring its position by developing a high velocity 120mm smooth-bore gun firing APFSDS.

Development of tank guns in Germany has suffered from the restrictions imposed on it after World War II, but Rheinmetall is now restoring them and their country's position with 105 and 120mm smooth-bore guns which fire APFSDS.

Both France and the FRG have successfully exploited Swiss light automatic cannon technology, represented by 30mm Hispano Suiza and 35mm Oerlikon automatic guns, to develop anti-aircraft tanks with radar fire control systems which have no equal anywhere, with the possible exception of the Soviet Union.

On the other hand, there appears no equivalent yet in any of the three countries of the cannon-launched laser guided projectiles developed recently in the United States.

Britain has had a long tradition of engine development and has originated the variable compression ratio pistons which are the basis of the latest U.S. tank diesels. It has also originated the two-stage rotary or Wankel diesel, although it abandoned further development of it three years ago as unprofitable, even though the original spark ignition version of the Wankel invented in Germany continues to be developed by Curtiss-Wright. Britain made a mistake in adopting the L-60 Leyland engine for the Chieftain and is now trying to restore the situation with more conventional Rolls-Royce diesels.

France has shown originality in developing the Hypebar system mentioned earlier. Otherwise its engine development has been sound but generally undistinguished. This is true even more of FRG engine development.

In relation to the United States, all three countries face the problem of manufacturing scale, which makes commercial engines produced on a large scale in the U.S. much cheaper than engines produced in Europe. This is particularly true of the two-stroke diesels produced by the Detroit Diesel Allison Division of General Motors, several of which are suitable for armored vehicles and have been adopted for them in Europe as well as America for cost reasons, in preference to European engines.

The three countries have lacked the financial resources which made it possible in the United States to develop successfully a gas turbine for tanks - the Avco Lycoming AGT-1500 which powers the Chrysler version of the XM-1. The first gas-turbine-powered tank was, in fact, built in Britain 20 years ago but, apart from anything else, the UK has not had the money to continue the development of tank gas turbines.

As in the case of engines, Detroit Diesel Allison transmissions are difficult to compete with for European manufacturers so far as smaller armored vehicles are concerned, because of their cost advantages based on large-scale production. So far as battle tanks are concerned, their smaller numbers make European transmissions more competitive, even though they may be less sophisticated than their Allison counterparts. This is certainly true of the transmissions of the AMX 30 and the Chieftain. On the other hand the Allison CD-850 transmission produced for the U.S. M60 and other tanks incorporates features copied from earlier British transmissions. At present, the most highly developed hydro-kinetic tank transmissions are those built for the Leopard II by the Renk company in Germany.

The UK and FRG are about level with the United States in the development of hydro-pneumatic and other suspension systems, and the FRG is level with the United States in the development of tracks. France, on the other hand, is ahead in the development of Michelin tires for cross-country wheeled vehicles.

The UK lead in the development of special armor has been mentioned already, and the UK is now leading in the construction of light vehicles from second-generation, 7039-type aluminum armor, even though America originated and still leads in the application of the original 5083-type aluminum armor. The company responsible for the UK lead is Alcan Booth Ltd. The UK has also established a lead, through RARDE and ROF Nottingham, in the application of very high strength ESR steels to gun construction.

The FRG has exploited the strength of its optical industry to develop superior optical devices, such as the stabilized panoramic commanders' sights developed by Zeiss and novel types of rangefinders. The UK on the other hand has produced the Helio periscopes with inclined, nonreflective heads.

The UK and France have independently taken a lead in the development of tank-driving simulators which can result in considerable savings in training costs and which have no equivalent in the United States.

E. Licensing Opportunities

The ultimate objective of activities concerned with licensing must be to arrange for one country to license one, or more, others to manufacture in its entirety an armored vehicle which it has developed. Such an arrangement can be advocated on the grounds of economies in development costs, of greater operational efficiency through standardization of equipment in the field, and of the reduction in the logistical burden.

However, the country or countries which have acquired the license and produce vehicles to another country's design might thereby lose the capability to develop similar vehicles themselves. This might lead to a general contraction of its technological activities and a reduction of its independence, including its ability to export armored vehicles without the consent of the licensing country, whose views on sales to third parties might be very different. Production under license is also likely to lead to a reduction of employment opportunities in the country which acquires the license, particularly for highly skilled specialists.

The above does not apply, of course, to countries which do not already have their own tank development facilities and for whom manufacture under license is an attractive proposition. In fact, for them it may be the only way to manufacture armored vehicles within a reasonably short time scale. At the same time, it is much more advantageous economically than the alternative of purchasing complete vehicles, even though many components might still have to be imported. As a result, such manufacture under license may not amount to much more than assembly of imported components but it is still an attractive proposition for the less highly developed countries.

A good example of this is provided by the manufacture in Italy first of the U.S.-designed M60 and now of the German-designed Leopard I tanks. Further opportunities now exist for similar arrangements to manufacture under license of U.S. as well as UK, FRG or French designs in the smaller NATO countries, such as Greece, Turkey as well as Netherlands and Belgium.

On the other hand, manufacture under license of complete vehicles is not an attractive proposition for the larger countries, i.e., UK, FRG and France, capable of developing their own vehicles, for the reasons stated earlier. In fact, manufacture under license under such circumstances has only been considered twice so far and in both cases by the United States.

The first instance was the possible adoption by the U.S. Army of the British-designed Scorpion in 1972 as the ARSV, but the Scorpion was eventually rejected, ostensibly for technical reasons. The second example is the recent candidature of the German-designed Leopard II AV for U.S. manufacture. However, there was no strong technical reason why Leopard II AV should be adopted for manufacture in the United States in preference to the U.S.-designed XM-1.

Manufacture under license of components is an entirely different matter. It has, in fact, become accepted practice and its extension appears a far more reasonable and profitable line to pursue than hankering after the production of a single battle tank, for instance, for all NATO armies and France.

Good examples of manufacture under license are provided by the U.S. adoption of the British-designed 105mm tank gun and the licenses granted by Hughes Aircraft Co. for the development of laser rangefinders in the UK and FRG.

In the gun field, there are some further opportunities for licensing arrangements but they are not as clear cut as before. Thus, UK no longer holds the lead it did over others with its gun-APDS ammunition systems, and none of the four countries concerned has yet shown that its gun-APFSDS system is clearly superior to all the others. Yet the case for standardization and therefore for licensing arrangements is far stronger where tank gun ammunition is concerned than elsewhere. The most immediate opportunity related to this is the licensing to the United States of the German or possibly the French 120mm smooth-bore guns, although not necessarily of their APFSDS ammunition.

Should the U.S. Army decide to develop a new light armored vehicle, there might be an opportunity to license the British 76mm medium velocity gun and, even more, the 30mm RARDEN gun. Alternatively, there might be an opportunity to license the French medium-pressure 90 or 105mm smooth-bore guns, or a Belgian 90mm gun of the same type. None of these weapons have counterparts in the U. S. armory.

The U.S. Army is already contemplating the procurement from the FRG of the twin 35mm anti-aircraft gun turret mentioned earlier and there may be further opportunities for licensing to the U.S. of British or German smoke dischargers.

So far as fire control systems are concerned, there appear to be no opportunities for licensing any European equipment to America, except possibly for novel optical rangefinders from the FRG and the anti-aircraft radar gun control systems mentioned previously. However, there are further if somewhat limited opportunities for licensing U.S. fire control systems to Europe, as indicated by the adoption of the Hughes system for the Leopard II AV. Similar comments apply to stabilized gun control systems, and Cadillac Gage and Honeywell have been active in this field in Europe.

The opportunities for licensing to the United States are greater for optical equipment, such as the Zeiss and Helio periscopes mentioned earlier, which have no U.S. equivalents.

Although U.S. production of the German MTU diesel used in Leopard II has been mentioned, it is difficult to foresee a real justification for it or for licensing any other European piston (diesel or gasoline) engine. There is a far better case for U.S. licensing to Europe of the Avco-Lycoming AGT-1500, since no similar gas turbine has been developed in Europe. However, if that engine were adopted by the U.S. Army, it would probably cost less for European countries to procure directly than to produce it themselves.

On the other hand, there is scope for licensing components from Europe for incorporating in U.S. engines, just as the British variable-compression ratio pistons have been incorporated in the Teledyne Continental AVCR-110 and AVCR-1360 tank diesels. Potential candidates are the French Hyperbar system for supercharging, advanced supercharging systems developed in the UK under contract to MVEE, and engine cooling systems developed by Airscrew Howden Ltd., who have already worked under contract on U.S. armored vehicle development programs.

Purely on technical merit there is a case for licensing to U.S. the latest Renk transmissions; but their U.S. counterparts, the Allison X-series, including the X-1100 used in XM-1 prototypes, are adequate, and there are no obvious licensing opportunities in either direction in the field of transmissions.

If they make further satisfactory progress, there might be a case for licensing the interconnected hydro-pneumatic suspension systems which are being developed in the UK by Dunlop Ltd. and by Automotive Products Ltd.

There appears nothing at present of consequence which any European country could offer the United States in the field of tracked APCs or MICVs. On the other hand, if the United States were to develop a new, low-cost APCs to succeed the M113, this could be adopted in Britain and possibly also in the FRG.

In contrast, the United States has nothing to offer in wheeled armored vehicles, and if the U.S. Army finally recognized their virtues there would be licensing opportunities for French companies, in particular Panhard, with all their experience in wheeled armored vehicle development. There would also be further opportunities for the French Michelin tire company, whose excellent cross-country tires are already being considered for new U.S. Army trucks.

There are also opportunities for licensing to the United States of tank driving training simulators developed in Britain by the Link-Miles Division of Singer (UK) Ltd. and in France by Le Materiel Telephonique (LMT) and laser tank weapon simulators developed in the UK by The Solartron Electronic Group Ltd.

V. Other European Defense Industries

A. Defense Electronics

B. Some Notes on Guns and Artillery

A. Defense Electronics

1. The British Electronics Industry

2. The German Electronics Industry

3. The French Electronics Industry

A. Defense Electronics

This part of the report is supplementary. It provides some added notes on two industries that are important but subordinated to other categories discussed in the report, such as missiles and tanks. The discussions which follow cannot be regarded as comprehensive. They merely cover a few basic points that are important to the conclusions presented in Part VII. Consequently, for anyone interested primarily in the electronics or arms industry, these two sections will be unsatisfactory, even though they serve the purposes of the present report sufficiently.

As shown in Table 23, the electronics industries of Britain and France are second only to the aerospace industries in terms of total dollar output. They represent, consequently, the second largest source of jobs and industrial activity under the general defense heading. Furthermore, they are industries which are less dependent, in total, on defense than other defense-associated sectors. The defense share of total British electronics output historically was less than 10%. This same ratio is true of Germany, where the electronics industry is larger than the aircraft industry. In France, the defense share of total electronics industry output has been much higher but still less than half the total industry turnover.

The electronics share of almost any type of modern weapons system is increasing rapidly. In combat aircraft systems, the electronic share of total cost has risen from about 10% in the 1950s up to about 30% at the present time. In the tactical missile industry, the importance of electronics is illustrated by the simple fact that the electronic firms are increasingly acting as prime contractors. One highly qualified British civil servant has argued that "the capacity of the country's industry to meet its own defense needs rests more

Table 23

Defense-related Industries - Defense Output[a]

and Defense Share of Total Output

Industry	Britain (1968)[b] Defence output	Britain (1968)[b] % of total output	France (1969)[c] Defence output	France (1969)[c] % of total output	Germany (1969)[d] Defence output	Germany (1969)[d] % of total output
Airframes and missiles }	815	52·9	540	46	175 }	70–80
Aero-engine }					100 }	
Shipbuilding	396	34·3	18	4	72	5–10
Motor vehicles	104	2·1	72	1·2	140	5–10
Ammunition and explosives }	246	2·9	45	40	100	'depends heavily'
Engineering and ordnance }			117	7	222	5–10
Electronics	600	9·1	396	45	317	5–10

[a] In $ million; taking $1 = £0.417, 5·55 fr, DM4.
[b] Proportion of gross output generated by defence demand, as calculated by Roy Morris in 'The Industrial Impact of Defence Expenditure, 1963 and 1968 – An Input-Output Study' (unpublished paper). The shipbuilding figures include ship repairing and the Royal Dockyards.
[c] Source: Jean Blancard, 'Conception et Réalisation des Armements', in *Revue de Défense Nationale*, February 1971. The shipbuilding and ammunition and explosives figures exclude the activities of the relevant 'Directions Techniques'.
[d] Source: *White Paper 1970 on the Security of the Federal Republic of Germany and on the State of the Federal German Armed Forces* (Bonn, 1970), pp. 147–9. The figures in the right-hand column are not intended to be more precise than the general statements in the text of this source.

Source: IISS, 1975

on the capability of its electronic industry than that of any other sector."

Shown in Table 24 is a fairly complete list of major European electronics companies, together with their total turnover and work force. The main difficulty with such a table is, of course, the need to recognize that only some fraction (presumably ranging from about 10% in England and Germany up to about 40% in France) is actually involved in defense projects.

Possibly because of their predominantly commercial nature - combined with the types of commercial markets that are served by advanced electronics and data processing industries - there has been far more multinational activity in the electronics than in the aerospace industry. American investment is more predominant in the European electronics industries than in other European defense industrial sectors. According to one estimate, some 56% of the British electronics industry is foreign-owned - most of it American. American ownership is strong in a number of the firms listed in Table 24 .

Within the limits of the present project, and given its precisely defined purposes, it seems most useful here merely to outline and characterize the main national electronics industries of Europe.

Table 24

European Electronics Companies Important for Defense

Company	Country	Turnover (1971) $m (1971)	Employees (1972)	Ownership
Philips	Holland	5,006	367,000	
Siemens	Germany	3,613	234,000	8·9% Aérospatiale 8·9% Boeing
GEC	Britain	2,420	181,000	
AEG-Telefunken	Germany	2,466	169,000	10% General Electric
STET group	Italy	1,224	97,000	52·46% IRI
Thomson-Brandt	France	1,413	93,000	
Plessey	Britain	692[a]	62,000	
EMI	Britain	554	40,800	
SEL	Germany	528	36,700	95·44% ITT
Standard Telephones and Cables	Britain	387	34,000	subsid. of ITT
Smiths Industries	Britain	211	23,000	
ACEC	Belgium	260	17,000	67·8% Westinghouse
Ferranti	Britain	159	17,000	mainly Ferranti family
G3S group	France	245	16,000	
Lucas Aerospace	Britain	150	15,000	
Decca	Britain	166	9,100	
LMT	France	106[b]	6,500	
Sperry Rand	Britain	90	n.a.	subsid. of Sperry Rand (US)
MBLE	Belgium	n.a.	5,500	subsid. of Philips
FIAR	Italy	25	3,500	80% General Electric (through CGE)
Racal	Britain	63[a]	4,000	
Selenia	Italy	50	2,900	49% STET 10% Raytheon
Electronique Marcel Dassault	France	41	1,800	

[a] 1970. [b] 1972.

NOTE Source: IISS 1975

1. The British Electronics Industry

As indicated in Table 23 , the British industry is the largest of any of the European countries.

In Britain, the various Marconi subsidiaries of GEC comprise one of the most important defense electronic groups. This portion of the GEC group has about 27,000 employees and an annual turnover on the order of $400 million. Within this division, Marconi Radar Systems supplies air defense systems and is prime electronics contractor for Sea Wolf. Marconi-Elliott covers a fairly wide range of defense electronics products, primarily associated with tactical aircraft and missiles. The firm is probably the world leader in the design of head-up displays. Marconi has also provided the inertial navigation system for Jaguar; has won contracts for an auto-throttle system for the Boeing 747; and a fly-by-wire system for the YC 14. Other companies in the Marconi group are involved in the development of ground-based fire control radars as well as air traffic control radars for the civil market. Of particular recent interest has been a new homing head developed for the UK Sparrow version by Marconi Space and Defense Systems. This is a semi-active radar seeker incorporating an EMI fuse. To fit European operating conditions, the system uses a CW radar rather than pulse Doppler. The head has been designed specifically to operate in heavy jamming. In addition to the inertial platform, Marconi also makes a digital computer for the Jaguar system. The firm has also been the supplier of height-finding radars along the entire 3,000-mile radar chain operated by NADGE.

All of the Marconi operations are subsidiaries of GEC, the giant of the British electrical companies, with total sales on the order of $3 billion and total employees in Britain of about 170,000.

Plessey markets a fairly wide range of advanced technology radar and high frequency devices both for civil markets and military. On the civil side, for example, ILS equipment is important to the company. Plessey also has a fairly wide range of air traffic control radars on the world market. Military programs include ground proximity warning systems, dunking sonars and sonar beacons, and weapon control systems for Jaguar and Harrier. Plessey's world-wide employment has reached 69,000 in several countries. In the United States, it has established subsidiaries and sales operations of considerable importance to the company. Total sales are in excess of $600 million.

For Smiths Industries, the main areas of concentration appear to be head-up displays (for Jaguar and MRCA) and various types of flight monitoring and control systems based on digital techniques. The company has pioneered an advanced electronic control system for gas turbine engines, including the engine controls on the T-41 Spey engine used in the LTD A-7 aircraft. Smiths also provides engine control systems for the Pegasus and Viper engines.

Total consolidated turnover of Smiths is probably on the order of $310 million, of which about $50 million is in aerospace. The company has about 20,000 employees, of whom about 5,000 are involved in aerospace projects.

Decca has found an important world market in Doppler radars for civil and military use. Currently, Decca radars are specified for Jaguar, MRCA, and other military aircraft. Other Decca military programs include a passive ECM system, and a variety of airfield traffic control systems. The company is rather small, with consolidated sales on the order of $300 million, of which electronics and radar equipment account for about $50 million. There are about 12,000 employees.

Ferranti is a widely based avionics company with capabilities in two key areas: first, in airborne radars; and second, in airborne laser applications. (This refers to target illumination radars). Ferranti will supply the Blue Fox airborne radar for Sea Harrier and also radars for many other combat aircraft. In addition, it has a development contract for the heading and altitude reference system for Sea Harrier and supplies the Sea Spray radar for the Lynx helicopter. In addition, Ferranti is active in inertial navigation systems and has supplied the system used in Harrier, as well as being selected for MRCA. It also provides the moving map display for Jaguar. Ferranti is also responsible for development of navigation and attack systems that combine inertial navigation with a weapon-aiming computer. Both the Ferranti inertial navigation system and a laser device will be used on MRCA.

Among Ferranti's current projects are the following:

- Moving map display for MRCA
- Stabilized helicopter sights
- Sea Spray helicopter radar
- Inertial navigation system for MRCA and Japanese military aircraft
- Laser rangefinders and marked target seekers

2. The German Electronic Industry

German defense electronics are dominated by four major companies: AEG-Telefunken, Siemens, Standard Electric Lorenz (SEL) which is a subsidiary of ITT, and finally, Rohde & Schwarz. In Germany particularly, the trend toward American ownership is pronounced. In general, German companies appear to be strong in ground-based systems but lag somewhat in airborne avionics. In military aircraft, they tend to make use of license-built equipment. In addition, there is an important joint subsidiary of these four companies, known as Electronik System Gesellschaft (ESG), specializing in system engineering for Panavia.

AEG-Telefunken employs about 140,000 in West Germany. Probably only about two to three percent of their business is involved in electronics for civil and military aircraft and space equipment. At the present time, the company is particularly active in space electronics and telecommunication systems. In military systems, AEG-Telefunken has acquired licenses both from Bendix and GE for airborne power supply equipment for military aircraft. It is now working with Ferranti on the transformer rectifier unit and power takeoff shaft for MRCA.

The Telefunken Radio and Radar Systems Division is engaged in a number of advanced military electronic and radar systems programs. Of particular interest to American visitors has been the Telefunken mobile search radar (TRMS) being developed for the German Navy. This is a mobile phased-array three-dimensional air surveillance radar with digital processing. The Radio and Radar Systems division of AEG is committed about 80% to military work. Programs include the fire control radar for Luftwaffe aircraft, and equipment for NADGE. Telefunken has built up to 60% of the basic Hawk missile under Raytheon license. It also is contractor for the command transmitter and receiver in the on-ground equipment of Roland and antenna and transmitter on the missile itself. Telefunken has also teamed with Raytheon on development of an advanced point defense system.

Currently, the firm is also subcontracting to Marconi-Elliott Avionics Systems for components of the head-up display and map display unit on MRCA. In missile equipment, the company has been active in radio command systems and other missile related electronics both for the Roland and Hawk programs.

Siemens has about 300,000 employees, of which perhaps 2% are in the aerospace field, both civil and military. Siemens is the principal supplier to the Luftwaffe of IFF systems and transponders. Siemens has also collaborated with Thomson CSF in surveillance equipment associated with the Roland missile as well as similar equipment for tank armaments.

SEL, a subsidiary of ITT, has about 37,000 employees. Aerospace represents less than 5% of the company's business. (The principal line is telephone switchgear.) On the military side, TACAN represents the main product line. Over 4,000 airborne TACAN sets have been delivered with 200 or more ground stations. Practically all French and German military aircraft are equipped with sets produced in collaboration by LCT and SEL. The two firms also collaborate on an artillery radar and battlefield surveillance system. Rohde & Schwarz is a much smaller firm with some 4,000 employees. The principal military lines are in communications equipment for airborne and shipborne use. As of 1972, perhaps 12% of Rohde & Schwarz's sales were military; and this can probably be taken as a reasonable factor for the industry as a whole. Although the sales level is often on the order of 12%, the total number of employees involved in military work fluctuates from 5% to 10%. Within the electronics industry, it is a relatively simple matter to shift workers from military to civil projects. Finally, ESG is a system engineering company owned equally by AEG-Telefunken, Siemens, SEL, and Rohde & Schwarz. It also has a sister company which collaborates with Honeywell, Litton, Teldix (the Bendix German subsidiary) and Eltro (which is also the subsidiary of a U.S. optical firm). The major share of the ESG work load is related to the MRCA avionics firm, Avionica System, in which it collaborates with EASAMS of England.

3. The French Electronics Industry

Although there are a number of lesser companies involved in defense electronics in France, the principal firm is Thomson CSF, a part of the Thomson-Brandt group. The company is grouped in four main divisions of which the electronic equipment division is the most important for defense purposes. This division covers defense systems related to telecommunications, aeronautical systems, ground detector equipment, weapon systems, shipboard equipment, and underwater acoustics. The company as a whole employs about 28,000 people.

Thomson CSF has produced the Cyrano series of airborne radars for all of the Mirage fighter aircraft. For the forthcoming Mirage 2000, Thomson CSF will develop the pulse Doppler interception radar. The Thomson CSF radar for the Mirage F-1 has a range of 35 nautical miles against a fighter-sized target.

Electronique Marcel Dassault, a subsidiary of Dassault-Breguet, has also developed a series of radars and is collaborating with Thomson CSF on the airborne radar for the Super-Etendard carrier-launched aircraft.

Also important in a very specialized field is SAGEM, the French developer and manufacturer of inertial navigation systems. SAGEM has worked closely with Singer-Kearfott in various programs, for example in the digital inertial system for the Super-Etendard.

In general, it seems likely that there is a fair amount of lag both technologically and in manufacturing development, between the French electronics industry and that of the United States. Furthermore, it seems likely that the French industry runs a poor third to those of Britain and Germany. The heavy proportion of military work also suggests the problem that commercial product development is very modest.

B. Some Notes on Guns and Artillery

B. Some Notes on Guns and Artillery

In this section, the purpose is only to touch on a few highlights of gun and artillery manufacture in Western Europe to amplify some of the points raised in the section on tanks, to which this section is ancillary. First, it is important to take note of some collaborative trends within the NATO countries. Perhaps the most important of these is the FH-70 155mm towed gun and its associated ammunition; and the SP-70, self-propelled version. Under a 1968 memorandum of understanding Britain and the Federal Republic agreed to collaborate in the development of these two systems. The FH-70 is intended to replace the British 5.5-inch gun and German 155mm howitzer. Subsequently, Italy also joined the project, both to contribute funds to development and to share in the manufacture. Plans for the SP-70 were reached much later, when a decision was made within Eurogroup for Britain, Germany, and Italy to jointly develop this unit, designed to replace the U.S.-built M-109 155mm howitzer. Industrial responsibility for the program, at least as far as development is concerned, lies with Vickers in Britain and two companies - Rheinmetall and Faunwerke - in Germany. During the development phase, the gun carriage of the FH-70 is a Vickers responsibility. Rheinmetall is developing the barrel and breech. When the gun goes into production, Oto-Melara of Italy will be responsible for the recoil system. According to present plans, the gun will go into service in the late 1970s.

The FH-70 incorporates a Leitz sighting system and data display unit and can launch a 95-pound shell nearly twenty miles. A 1700cc four-cylinder gasoline engine is incorporated into the gun carriage to enable the gun to move a limited distance under its own power.

The gun will have a range of 24 kilometers with a full caliber shell, and the goal is to increase this to over 30 kilometers with rocket-assisted shells. The rate of fire will be over six rounds per minute, with a sustained rate of two rounds per minute over a one-hour period. All types of 155mm shells now in NATO service will be usable, including nuclear, but special ammunition is also being developed for the gun. This will include a new type of HE shell with a goal of higher lethality than the 175mm M-107 U.S. projectile. Also to be designed will be a smoke shell, an illuminating shell, and an extended range shell which will have a longer, fin-stabilized sub-calibre shell. The gun will also use U.S. M-549 rocket-assisted projectiles. Mobility is one of the main goals in the program, as evidenced by the detachable auxiliary propulsion unit which will give it a limited cross-country performance over a distance of up to 20 kilometers. The gun and ammunition will also be air portable.

Shown in Table 25 are the principal ordnance and ammunition producers in Western Europe. Many of these firms have diversified their activities as broadly as possible to counteract the decline in orders for conventional armaments. This list, it will be noted, also includes the various state-controlled ordnance factories such as the Royal Ordnance Factories in Britain and DTAT in France. Even following severe cut-backs in the state-owned factories, European industry as a whole is faced with overcapacity for conventional arms.

In Britain, the most important private firm is Vickers. In France, aside from state-owned operations, Creusot-Loire is important as a manufacturer of naval gun mounts and armor-plate. Also important is the armaments division of Thomson-Brandt. In Germany, Rheinmetall is principal manufacturer of artillery, and other armaments firms are Krauss Maffei and

Table 25

Principal West European Ordnance and Ammunition Producers

Company	Country	Turnover (1971) $ million	Employees (1972)	Ownership
Creusot-Loire	France	463[a]	33,800	50% Marine-Firminy; 50% Schneider
Vickers	Britain	364[b]	27,400[b]	
Royal Ordnance Factories	Britain	225	18,900	Government
DTAT	France	212[a]	17,000	Government
Rheinmetall	Germany	150[a]	n.a.	80% Roechling family
FN	Belgium	74	8,400	
Krauss-Maffei	Germany	205	6,300	94·2% Buderus'sche Eisenwerke
SNPE	France	70[c]	5,300	Government
PRB	Belgium	n.a.	3,000	
Eurometaal	Holland	n.a.	660[f]	70% Government, 30% Dynamit Nobel AG
Contraves	Italy	60[d]	2,500	Contraves AG, Zurich
Thomson-Brandt (armaments div.)	France	40[e]	2,000[e]	part of Thomson-Brandt group
Oto Melara	Italy	26	1,400[a]	IRI-Finmeccanica

[a] 1970.
[b] Group total (less shipbuilding): the engineering division's turnover was $102 million.
[c] 1972.
[d] Group total.
[e] Armament division only.
[f] Military production only.

Source: IISS 1975

Dynamit Nobel. In Italy, Oto-Melara of La Spezia makes a wide variety of armaments and artillery, Breda makes gun mounts, and there are also explosive and ammunition firms. FN in Belgium is obviously one of the most important designers and manufacturers of rifles and small arms for NATO. Shown in Table 26 are some of the principal artillery guns and rockets now in production or development within the NATO countries.

Table 26

Principal Guns in European Country Forces

COUNTRY OF ORIGIN	GUN	RANGE	RATE OF FIRE	REMARKS
U.K.	120 mm Tank Gun L11A3	APDS 3 km HESH 8 km	7 r.p.m.	In service with British Army Main armament of Chieftain tank.
	105 mm Tank Guns L7A1 L7A2 & L7A3	APDS 1.8 km HESH 5.5 km	9-10 r.p.m.	A1 und A2 fitted in Centurion tanks. A3 in Vickers Mk3 tank and Leopard. In service.
	105 mm Towed SP gun Abbot	17 km	—	Highly mobile. Mounted on FV 433. In service with British Army.
	105 mm Towed Light Gun	17.5 km	—	Close support mobile. Will replace the Italian 105 mm Pack Howitzer. Uses same ammo as the Abbot.
	81 mm Mortar	4.5 to 5.4 km	15	Man portable in 3 loads. In service with British and other armies.
France	155 mm Howitzer Mk F 3	20 km	1 r.p.m.	General fire support for mechanised divisions. Fires U.S. or French ammunition. In service with French army.
	155 mm GCT SP Gun	23.5 km	8 r.p.m.	Direct and indirect fire support. Under development.
	105 mm Tank Gun CN-105-F1	—	—	Main armament of the AMX 30 tank. In service with the French Army.
	105 mm Tank Gun D1504	—	—	Main armament of the AMX 13 tank. In service with French and several other armies.
	105 mm Light Gun	15 km	—	Demonstration prototype only. General purpose, air droppable gun.
	105 mm SP Howitzer AMX 105A	11.5 km with US ammo 15 km with French ammo	—	Basic weapon for close fire support. Fires US or French ammo. In service with French and Dutch armies.
	105 mm SP Howitzer AMX 150B		—	improved AMX 105A. All round traversing and lower silhouette.
	90 mm AFV Gun CN-90-F1	—	—	Fitted in the smaller AFVs and in the M24 Chaffee tank. In service in French and one other army.
	120 mm Heavy Mortar MO 120 AM50	—	8 r.p.m.	Can be fired from its own road wheels or bipod. In service in French Army.
	120 mm Mortar MO 120 M65	8.3 km	12 r.p.m.	Normally transported on wheels but can be hand carried. Lighter than the AM50. In service with French Army.
	120 mm Rifled Mortar 120-RT 61	—	11 r.p.m.	Maximum range a. with normal shell "PR-14" is 8.300 m. b. with shell with additional propulsion "PRPA" is 13.000 m. in service in the Netherlands, on order by the French Army.
	120 mm Light Mortar MO 120 M60	—	15 r.p.m.	Lightweight. Divided into 3 loads for man transport. In service with French Army.
	81 mm Light Mortar MO 81 61C	4.1 km	15 r.p.m.	For use by parachute infantry. Various lengths of barrel available. In service with French Army.

Table 26 continued

COUNTRY OF ORIGIN	GUN	RANGE	RATE OF FIRE	REMARKS
France (contd)	60 mm Light Mortar MO 60 63	—	—	For mobile operations. In production.
	60 mm Commando Mortar	1 km	—	Short range. Highly portable. In production.
	60 mm Vehicle Mortar 60 MC A1	2.6 km	—	Can be used from an APC either as a mortar or for direct fire. Breech or muzzle loading. In service in several countries.
	60 mm CS Mortar Type 1969	1.6 km	—	Breech loading for mounting in the turrets of armoured vehicles. Under development.
W. Germany	155 mm SP Howitzer M109G	18.1 km	—	Modified U.S. M109. In service with German Army.
	155 mm Towed Light Field Howitzer	14.1 km	—	Modified U.S. M101. Longer barrel. Muzzle brake. In service with German Army.
	90 mm Anti-Tank Gun	—	—	High precision gun with auxiliary propulsion
International	155 mm Towed Howitzer FH70	24 km Over 30 km with special shell	6 r.p.m.	Being developed jointly by Britain, Italy and Germany.
	155 mm SP Howitzer SP70			MBT80 tank chassis.
	110 Tank Gun L10	—	—	Under development for the Leopard II by Britain and Germany.
	RS80 Rocket	30-40 km	—	Multiple launcher. Under development by Britain, Italy & Germany.
Italy	155 mm SP Howitzer	24 km	—	Modified U.S. M109. In service with Italian Army.
	105 mm Pack Howitzer Model 56	10.6 km	—	Lightweight, highly portable. Can be manpacked. In service with 17 countries, including U.K.

Source: NATO's Fifteen Nations, Dec. 1974-Jan. 1975

VI. Some Industrial Issues

A. Standardization and Some Current Projects

B. Lessons from Civil Aircraft Collaboration

C. Some Published French Views of Standardization

D. Some Notes on Licensing and Co-Development

A. Standardization and Some Current Projects

1. The F-16 and trans-Atlantic Industrial Collaboration

2. The Roland II License

1. <u>The F-16 and trans-Atlantic Industrial Collaboration</u>

In spite of its probable success as a cost-effective solution to meeting the requirements of several air forces, one inevitable economic effect of the F-16 program on the European aircraft industry as a whole is to lower its productivity. This effect is created in two ways: First, by requiring capital investment in countries where there is little long-term prospect for sustained aviation production, resulting eventually in under-utilization of capital resources; and second, by depriving the major, well-capitalized industries in Britain, France, and Germany of work which would lead to fuller utilization of their own capital resources. As a result, European-wide aerospace industry productivity will continue to compare poorly with the United States - a situation of which European industry planners are well aware.

It could be argued that the success of any Alliance standardization based on industrial cooperation will ultimately depend on successful U.S. relationships with the major defense industries of Western Europe rather than with smaller or non-defense companies that may serve as job shops to American firms. The tooling-up of aerospace vendors in smaller countries, simply to participate in one or two programs, may tend, directly or indirectly, to reduce the effectiveness of European industry as a whole and make major trans-Atlantic collaborations more difficult.

Under terms of the F-16 agreement, the European participants will build 40% of the European version (350 aircraft), 10% of the USAF version (650), and 15% of those ordered by other countries. Sharing will extend into final stages of production. There will be three assembly lines - one each in Fort Worth, in Belgium, and in the Netherlands. In July 1976, General Dynamics and Fokker-VFW of the Netherlands reached agreement on the F-16-coproduction program. Under the contract, Fokker will produce major fuselage and wing components for more than 500 aircraft and will assemble and deliver up to 102 complete aircraft for the RAF and 72 for the Royal Norwegian Air Force. Fuselage and wing components also will be furnished to production lines in the United States. Work is to start immediately at six Fokker plants, and the first delivery of components is scheduled for May 1979.

Among the major European aerospace companies, the view has been expressed that the F-16 program has weakened European efforts to integrate national industries and achieve higher productivity rates through greater concentration of resources in principal facilities. The F-16 consortium has necessitated capital investment for plant and equipment in small, scattered facilities with no conceivable hope for long-term roles in aerospace. For this reason, the project is resented in Britain and especially France. The latest American initiative for standardization comes hard on the heels of an American sales effort which actually served to delay prospects for industrial unity within Europe.

It is interesting to note that, among European missile manufacturers, the F-16 program has created renewed fears that large U.S. missile companies will try to by-pass the European missile industry, which has already made heavy investments of R&D and plant, and associate themselves with non-missile companies in the smaller countries, thus undermining the existing European missile manufacturers.

In summary of this point, the credibility of the U.S. standardization initiative will probably be enhanced if specific proposals are addressed to the major factors in the European defense industries.

In the present paper, given the stated goal of the U.S. policymakers in strengthening European industry so that it can collaborate more effectively with the United States, the primary emphasis is necessarily placed on the major aircraft industries of Western Europe. However skillfully the F-16 collaboration is being organized, and however cost-effective the aircraft will prove to be in the purchasing air forces, this overall negative effect on European industry as a whole must be noted. On the other hand, numerous features of the F-16 collaboration could be of considerable interest in future collaborations with the major producing countries. Notable among these are:

> The use of USAF System Program Office at Wright Field, as well as subsidiary SPO in Brussels, to which the European partners have direct and frequent access;
>
> The participation of the European partners in both the U.S. and third-country markets;

A clear formula for work-sharing and offset for the aircraft to be used in Europe versus those in the United States and third countries;

The acceptance of a price differential for the European aircraft and parts.

The positive intermediary role that a technically competent and experienced government office can play has long been apparent. The history of the U.S.-German advanced VSTOL fighter (AVS), in the mid-1960s, no matter how poorly conceived the aircraft itself may have been, provides an interesting case of how a SPO can improve communications and facilitate the work of industrial firms in a collaborative development project. In the case of AVS, which had a brief life in the mid-1960s, the SPO at WPAFB supervised the work of EWR in Germany and Fairchild in the U.S. and incorporated about 20 German engineers into the Dayton office. One of the bright spots of this ill-fated program was the smooth functioning of government and industry people at the technical level.

As reports in the aviation trade press have indicated, the open-door policy of the F-16 SPO and the free access to technical information regarding the aircraft, have played a significant role not only since the decision to participate in the program, but in fact served as a strong sales feature for the European participants in making their initial decision. Currently, there are about 14 European government program officers from the participating governments who are actually based at Wright Field.

2. The Roland II License

The preparatory work for this report has not included any direct research or analysis on the Roland II license to Boeing and Hughes. The program has received so much attention in Europe that it may be worthwhile to record here some of the secondary observations and impressions that have been gained during this research, especially in order to identify any practical points that may add to policy guidance concerning future licenses from Europe to the US.

Clearly, there have been problems of adaptation - in terms of standards, manufacturing technology, and technical and performance specifications for the different military services. When the resolution of such differences is pressed down to the contractor level, particularly at a time when defense contractors are very hard pressed themselves on questions of workforce stability, overhead and G&A burdens resulting from underutilization, and generally critical government customers, the problems of adaptation are likely to be magnified.

Furthermore, there are certainly instances in which development or manufacturing technology in Europe is behind that of the United States, due to lower European capital investment. In such instances, it would be inefficient to set up a retrograde manufacturing capability in the U.S. company, based on earlier and abandoned practices; but the alternative is product redevelopment so that the system conforms with current U.S. manufacturing technology. This class of problem is amplified by any tendency of the procuring military service to specify additional modifications in the system.

As discussions in Part I have already noted, many irritations that development at the industrial level are the results of historical differences in customer requirements - e.g., hours of service life. They do not always reflect relative backwardness in a particular industry.

Differences in RDT&E practices occur for many reasons but are most often simply manifestations of differences in scale. In a private interview in September 1972, Herman Bondi, the Chief Scientist of the British Ministry of Defense, made substantially the following statements to a visiting American:

> If there are 10 obvious ways of doing a job, the United States will typically try them all, and one will emerge as superior. In contrast, in the United Kingdom several years will be spent, using the best brains, to decide which option has a probability of more than 10% of being a winner. If they are lucky, they will get one in the 35% range of success, and then will put all of their resources into it and have one chance out of three to be successful. Much of the difference in approach is due to simple scale differences in the size of the two countries.

In practice, this difference means that prototype testing of the single developed system is very intensive in Europe. Figures on bench test and flight test hours compare favorably with similar U.S. systems. Furthermore, for major systems, operational life standards tend to be the same. With regard to military combat aircraft, the current design criterion, both in the United States and Western Europe, is 4,000 hours. The standards are the same and presumably can be met satisfactorily, even though the manufacturing technology required to reach those standards is likely to be different in Western Europe based on lower production runs, resulting usually in a greater tendency to build up parts rather than fabricate them out of single work-pieces, and a tendency to use a higher increment of labor.

Although many attempts have been made to generalize about comparable standards of quality across a spectrum of systems, these generalizations usually collapse into a sort of military-industrial folklore. The best solution is to establish a governmental authority, in advance of any specific program, to resolve all the important differences before assigning the work to industry.

In the European view, the main solution to all of these problems is prior planning and the establishment of a centralized controlling authority in advance of the project. It is essential, in the European view, to have common discussions among military and government authorities before the project is started and not to leave to the industrial contractors a great many unresolved problems. It is also regarded as essential to have the common procurement authority demand a clear identification of the various military services of their operational requirements and then to prevent divergence of requirements and technical specifications during the life of the program. One approach worthy of consideration would be a greater intermediary role not only for the SPO but for the DOD development centers or commands.

B. Lessons from Civil Aircraft Collaboration

In August 1976, the French government announced its financial support of a collaborative development by McDonnell Douglas and the French aircraft industry of a 160-180 passenger derivative of the Dassault-Breguet Mercure transport. The aircraft, to be powered by the GE-SNECMA CFM-56, will enter production in 1980. It is worth examining briefly, in the present study, why this program has been accepted so readily in France, in comparison with various past U.S.-French discussions in other fields. The key and closely related issues are: jobs, access to the American market, and collaboration on a full-partnership basis.

Recent studies under WEU auspices have resulted in the following forecasts of European air transport requirements in the year 1990: 300 short-to-medium range aircraft of 160 seats each; 350 short-medium range aircraft of 200 to 260 seats; 100 to 150 long-range aircraft with 200 seats; and 300 long-range, high-capacity aircraft like the Boeing 747. However, to break even on the production of a civil transport aircraft typically requires minimum sales of about 400 units, which indicates that European manufacturers probably cannot break even on sales to the European market alone, even if they were able to protect this market completely. What is really needed, in the eyes of European industry leaders, is some form of collaboration in development and production, and some rational division of world markets, with the United States. What is also badly needed, in the European view, is some logical structuring of the European share in the American home market of the 1980s.

European industry has already given a great deal of consideration to what types of transport aircraft could be brought to market collaboratively with the United States before the anticipated surge in transport aircraft sales of the early 1980s. One result is that some of the national industries, especially that of France, have been making direct overtures to American companies, with the guidance and encouragement of their respective ministries, to form bilateral agreements, often to the exclusion of their European partners. In response, the major American companies have sent their senior executives, in the last six to twelve months, for frequent and detailed discussions with European ministries and companies. The main job of corporate managers is, quite properly, to be responsive to the needs of their own corporations. There is also, however, a vital need for a U.S. policy voice in these discussions - especially with regard to the alternative of broader multinational collaboration and the potential impact of civil projects on the future trans-Atlantic military opportunities.

The difficulties being encountered in the civil sector of the European aerospace industry are matched in the United States. In this country, industry employment has been dropping rapidly, and industry sales, in constant dollars, have been in steady decline. In the late 1960s, the U.S. aerospace workforce numbered about 1.4 million. By the end of 1975, it stood at 925,000, and the projection for the end of 1976 is 893,000. In the late 1960s, industry sales ran at about $30 billion annually and declined to a low point, in current dollars, of $23 billion in 1971. They have since recovered to about a $28 billion level annually. In constant 1968 dollars, however, industry sales now stand at about $18 billion per year. The major part of this decline has been absorbed by the civil sector of the industry. The industry's principal strength, at the moment, is in combat aircraft production for the U.S. and export market. As for commercial transport aircraft, in which the United States has always dominated the world market, world-wide deliveries of U.S. built transport aircraft fell from 332 units in 1974 to 282 in 1975; and the Aerospace Industries Association is now predicting that commercial transport sales in 1976 will not exceed 215 aircraft. Currently, according to some estimates, the major airlines of the world could handle a 10% increase in passenger traffic without buying any new aircraft.

Although the American industry, in its own difficulties, is thoroughly amenable to the idea of international collaboration as a means of locating new development funds, there are obvious risks in joining together two troubled industrial sectors in the hopes that new strength will evolve. One potential solution would be to restore, to some degree, the role that military support aircraft development played in previous decades, in utilizing underemployed transport aircraft capacities and opening the way for follow-on commercial aircraft development. If one were to search for potential candidates, AWACS would emerge immediately because of the requirement for a large airframe with large, long-endurance engines. Washington, however, has proposed only minimal work-sharing on an existing American design rather than to suggest a co-development that could utilize more fully the badly underemployed capacities of BAC, Aerospatiale, and others.

In Britain and France, there is a desperate need to use the capacities left vacant by the Concorde and Airbus programs. This represents a high priority to which the AWACS proposals have not, apparently, been sensitive.

Furthermore, there is a deep concern in Britain that purchase of the Boeing AWACS may mean the end of the Nimrod production line and the resultant jobs at Hawker Siddeley factories as well as at the supporting avionics firms such as Marconi. British officials are known to doubt that Parliament would ever approve purchase of an American aircraft if the price were British jobs. At the moment, the U.S., Britain, and Germany are funding the NATO AWACS Program Office (NAPO). The British remain concerned, of course, about a British production share of up to 350 McDonnell Douglas AV-8B Harriers. In the meantime, British MOD is funding development work on advanced Nimrod avionics and has funded a feasibility study for the use of Nimrod to carry a limited early warning system.

AWACS is merely one case in point. The entire range of military support aircraft and their engines for the 1980s and 1990s should be examined for their collaborative potential, since - as civil trends indicate - this is an area in which European industry needs work and would welcome U.S. collaborative proposals. It is also, however, an area in which U.S. industry is presently under-utilized.

The issue of domestic employment is virtually fundamental among the major manufacturing companies of Western Europe. Although it may not be part of the rhetoric of defense ministers, it is of prime consideration in the voting patterns of parliaments. The issue of stable employment permeates both the civil and defense industries of Western Europe and must not be underestimated. For the United States, in attempting to identify potential licensing opportunities, the level of employment can to some extent be traded off against technological design and development lead.

C. Some Published French Views of Standardization

Particular attention should be given, in this closing section, to French policies and needs - since it has been generally recognized that French participation in future Alliance standardization efforts is both essential and difficult.

One of the most useful recent statements of the current French defense industrial view towards trans-Atlantic collaboration was provided in a speech by Marcel Chassagny, President of MATRA and, for the last 10 years, French representative to NIAG. In a speech in the spring of 1976 to representatives of the French aerospace industry, Chassagny made the following statements:

> We must strengthen the bonds between France, Great Britain and the Federal Republic of Germany, all of whom must lead Europe in aeronautics since these countries possess the technical, industrial, financial and human resources necessary . . . We cannot admit American hegemony which allows them to provide 83% of the market and which is further marked by a lack of fair play to such an extent that they have forbidden the landing in the U.S. of the Franco-British supersonic aircraft . . . In the NATO Industrial Advisory Group, we have started some 20 studies on new weapon systems. As soon as one of their projects is in conflict with these, the United States withdraws from the study group, and it is obviously not their intention to furnish to Europe the slightest technological support. Furthermore, they do not share what they are doing with their Allies. . . . Because of the differences in industrial potential between the member countries, Eurogroup is comparable to the UN, where laws are made by Yemen, in concert with Zaire and Zambia. Our industrial survival must not be linked to a Danish or Portuguese decision. France has been extremely inept in its dealings in Europe. We have had a policy of grandeur which has shocked our European neighbors, who do not have the means to defend themselves and have a need for the American nuclear umbrella. The fragmentation of European industries and the absence of any common force are likewise difficulties in attempting to cooperate with the Americans.

For reasons that are clearly enunciated in the Chassagny statement, French industry and government are likely to greet new American initiatives on standardization with considerable skepticism, based on past experience. At the same time, there is a gradual renunciation of the "grandeur" of Gaullism and a new recognition of the need for intra-European defense collaboration. It is this latter element that is probably the principal factor in France's participation in the new European Program Group.

Clearly, in any large-scale U.S. initiative for standardization, special attention must be given to France, whose policies are so irritating in Washington because they often mirror so closely the attitudes of the United States itself. As Callaghan has pointed out:

> France and the United States, more than any other NATO countries, see the issue of dependence as the major obstacle. It is perhaps all the more intractable an obstacle because its origin is more visceral than intellectual.

In an article of May 1976 in Defense Nationale, Jean-Laurens Delpech, the Délégué Ministeriel pour l'Armament and French member of CNAD, enunciated an official policy view of standardization which is regarded as a definitive view within French industry. In his view, standardization should be defined, in the strictest terms, as the body of rules and procedures which permit the production of unified and interchangeable elements.

He criticizes the NATO definition which refers to standardization as the process by which member countries realize the most intense possible cooperation in the use of resources for R&D and production, and undertake to adopt on the widest possible basis the utilization of common or compatible logistic and administrative procedures in an operational plan.

It is interesting that Delpech ridicules the Callaghan report as unrealistic, especially in its underlying assumption of the value to be derived from homogeneity of arms and equipment within the trans-Atlantic Alliance. The French argument is that, while the Warsaw Pact forces have a geographic unity and a single projected conflict, it is only Germany on the Western side that is essentially continental, purely European and organized strictly for conventional war in the central European theater. The French line of argument is that the other NATO countries are situated along coastal littorals and thus have concerns that are not nearly as continental in nature as that of Germany or the Warsaw Pact. In the French policy view, the requirements of France, Italy, Greece, or others are entirely different from one another. In specific terms, Delpech argues that the linear front of the Elbe lends itself to very heavy and powerful tanks. In France, on the other hand, mobility inside its many different frontiers demands the use of lighter tanks whose dimensions are dictated by rail transportability and whose weight tolerances cannot exceed the historic roadways and buildings of the countryside. According to this French declaratory view, naval vessels differ even more widely in their required characteristics in different regions. Consequently, there is a basic rejection, at the outset, of any notion that total unification of materials is practical or desirable.

In identifying obstacles to standardization, Delpech points first to non-concurrency in new requirements. He argues that it would take virtually a quarter of a century of very cooperative policy for the Alliance countries to achieve concurrency in their calendar of requirements.

Delpech also ridicules the idea that a "two-way street" could ever actually be established with the United States in defense equipment, comparing the flood of American equipment into Europe with the single instance of the Roland into the United States. He argues that, however high-minded the American goal of achieving the acceptance of the fewest number of standardized systems in the largest number of Alliance countries, and of furthering the interoperability of systems, the reality is that these goals must be limited by the national interests of the Americans, which are not confined to the Atlantic Alliance in general or the Central European theater in particular. Furthermore, in the French view, Washington is bounded in its freedom of action by the technical and industrial interests of its industry. Consequently, in this view, U.S. policy consists in achieving the most compatible degree of standardization without creating a threat to the U.S. role in world competition - in other words, standardization without a two-way street.

He then makes the argument for European collaboration and points out that France, no matter how incurably individualistic it may be, has brought to production with West Germany two aircraft, (Transall and Alphajet), the Roland surface-to-air missile, the Milan and HOT anti-tank missiles, two marine missiles (Kormoran and Exocet), and the RATAC radar. With Britain, France has brought to realization the Jaguar, the SA-30, SA-41, and WG-13 helicopters, and the air-to-surface missile Martel. With Belgium and Netherlands, France has entered development of a modern minesweeper. He argues that France has a much better record than Britain in collaboration for standardization. Finally, Delpech leaves the door open for determination by specialists, on a case-by-case basis, of programs which would permit reduction in costs and interoperability of systems. He even holds out a challenge to the United States to bring forward realistic proposals that genuinely involve a two-way street.

Consequently, both in public statements and in action, French government and industry have not closed the door on the American standardization initiative, in spite of their obvious skepticism based on past experience. The need for collaboration in civil aircraft and engines, as the only apparent way to avoid heavy cutbacks in the workforce, is certainly one factor. Another is the Roland II license and memories of the SS-10 and SS-11 sales to the United States. A third is the F-16 experience which, however unpleasant, provided a reminder of the difficulties of competing for business in countries to whom the U.S. security shield is highly valued.

However, the ultimate test, for France, will be the two-way street, and a secondary test will be full collaboration in new projects, in the new European collaborative sense, in contrast with simple licensing. The French view, like that of Europe in general, is that the $50 billion American civil and military government market is the most protected market in the world. Total foreign penetration has recently been estimated at less than 0.5%. Any initiative that offers a larger share of that market will obviously be of interest.

France has in fact been moderately forthcoming in its attitude toward purchases of U.S. equipment, provided there were offsets. Even in the Gaullist period, France often showed a strong preference for American technology. As Callaghan points out, the British often found themselves confronted with French insistence upon the selection of U.S. rather than British subsystems and components for Concorde. Examples can be found not only in civil programs but among the most nationalistic of defense programs such as SSBS and MSBS, the strategic missile.

As mentioned above, collaborative arrangements involving co-development appear to be of much greater interest than licensing. One analyst in the French missile industry pointed out, in the course of this study, the potentially useful collaborative models provided by three industrial consortia - MESH, STAR, and COSMOS - that have been formed to carry out joint European space programs. Each of these involves several major aerospace manufacturers from different countries to carry out space projects. There are two particularly interesting features about these consortia:

> first, the prime contractor alternates among the main companies in the group - e.g., a rotation of HDS, MATRA, and ERNO in the MESH consortium;

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> second, each of the consortia will have a primal association with an American firm - e.g., TRW's established role in MESH.

Another stumbling-block, based on French perceptions of past experience, is the issue of complete freedom in third-country exports. The aerospace industry in particular is regarded as indispensable to the country in two ways: first, at the political level, to give France an independent decision-making capacity on strategic issues; and second, as a critical factor in the national balance of payments. French industrialists point out that exports per aerospace worker in France compare with the other major aerospace countries as follows (based on 1974 figures):

France	-	50,000 francs
U.S.	-	45,000
U.K.	-	36,000
Germany	-	25,000

Furthermore, particularly in France, the aerospace industry is regarded as a non-costly one based on the ratio of export sales to R&D and tooling costs for most existing systems. French industry claims, for example, a ratio of 50:1 for the Mirage aircraft and 13:1 for Exocet. Any arrangement which threatens to reduce these highly favorable ratios would be rejected.

A further difficulty, in the French view, is presented by U.S. industrial security and disclosure policy. For a number of reasons - e.g., the occasional role of the principal labor union, the CGT, in corporate decision-making bodies in France - industrial security is apparently a difficult issue to resolve. This difficulty is heightened by concerns in the United States about dual-purpose technology transfers that have application in the competitive commercial marketplace as well as defense - e.g., aircraft engine technology, integrated circuits, aircraft and helicopters, avionics, etc. It is precisely in the area of dual-purpose technology that transfers are most desired in Europe, since the economic priority is to build the civil sector.

A two-year study by a task force of the Defense Science Board on the export of U.S. technology was released in February 1976. This task force studied technology transfer in four industries: airframes, aircraft engines, instrumentation, and solid-state devices. The four subcommittees for these topics concluded that "control of design and manufacturing know-how is absolutely vital to the maintenance of U.S. technological superiority. Compared to this, all other considerations are secondary." French industry would tend to agree with this conclusion and would, therefore, be doubtful about the freedom of collaboration in any major defense industrial project.

Finally, it is probably useful, under this heading, to discuss briefly the potential role of the newly formed European Program Group (EPG) in providing France with a medium for discussing trans-Atlantic collaboration.

There are widely differing interpretations of the purpose of EPG. Certainly, it is far more than a simple response to American initiatives for greater standardization. For both France and Britain, the issue of the "two-way street" is undoubtedly more important a goal of EPG than it is for the United States. For France more than other European countries, EPG is perceived as a means for protecting the long-term technical independence of Europe and preserving a European armaments industry through far greater collaboration on military projects within Europe. The perception is widespread in Europe that the European countries are purchasing about 10 times the value in arms from the United States that this country purchases from Europe. Certainly, for all European countries, the correction of this imbalance is a principal goal of EPG.

With regard to the four sectors on which EPG will work, the specific tasks appear to be the following:

Definition of a program for a tactical support fighter for service introduction in the 1985-1995 period. (For France, this would presumably be a Jaguar replacement for low-altitude attack).

Extension of the Franco-Belgium-Netherlands co-operation for minehunters into a Europe-wide program.

Exploration of a possible ammunition program for 105mm guns of battle tanks.

Definition of a program for the next generation of short-range anti-tank weapons.

In addition, there will be EPG committees working on principles and procedures and also on the harmonizing of timetables for major defense procurements. Although the U.S. view (and possibly that of other NATO countries) appears to be that EPG is primarily a European attempt to get organized in order to begin discussions with the United States on co-production for standardization, the French emphasis is placed only on intra-European harmonization of programs and resulting collaboration.

D. Some Notes on Licensing and Co-Development

To support some of the conclusions presented elsewhere in this report, it may be useful to assemble here some of the observations about licensing and co-development arrangements that were provided by industry sources in the course of the study.

First, with regard to direct licensing from the United States to Europe, some random observations may be useful. License income can take three basic forms: an initial license fee and royalty on sales; specified sales of parts and components; and fees for supporting sources.

For major U.S. defense and aerospace companies, the royalty income to be derived from licenses is often regarded as a by-product of an action which was taken for other reasons entirely. Obviously the sale of parts and components is one potentially important motivation, since many contracts specify a phased program, beginning with licensee assembly of knock-down kits and leading gradually to a higher level of fabrication. In addition, the license can create a long-term market for spares.

In many major instances of licensing, the American firm really does not have an option of providing the required systems through direct export of U.S.-manufactured units. Typically, for economic and political reasons, the recipient government has control over the situation and can insist on a license and specify its general conditions. Another consideration that is noted among major U.S. licensors, is a desire to maintain and strengthen connections, and therefore future market position, with European corporate affiliates and European governments. In essence, however, corporate managements are likely to view licenses as defensive actions designed to generate as much revenue as possible for markets which, for reasons beyond U.S. government or industry control, could not be served by direct exports.

Another element in the income potential from licensing agreements is the required technical support in adapting the licensed product to the European user needs. Typically, such technical support is charged to the licensee or the purchasing government on a straight time and materials basis.

In the case of the CH-53G co-production program with West Germany, manufacturing and other operations were divided between Sikorsky and its German partners (mainly VFW Fokker), with the German firms responsible for about 60% of the value added and Sikorsky 40%. As in other cases, Sikorsky supplied an initial batch of U.S.-manufactured prototypes, followed by the shipment of complete parts sets for assembly in Germany. Subsequently, some of the simpler parts were fabricated by the German licensees, with Sikorsky supplying only some of the more sophisticated and complex components for the balance of the total run of 110 aircraft. As is typical in U.S. military procurement practice, the engines for these aircraft were procured under separate contract by the German Ministry of Defense from a German manufacturer, under license to GE in the United States.

It is also of interest in this arrangement that United Technologies, Sikorsky's parent firm, owns 13% of the German prime contractor, VFW Fokker. The terms of the license provided a lump sum fee for aircraft manufactured and assembled in Germany, and an additional amount for each spare main rotor blade and each spare tail rotor blade manufactured in Germany. Subsequent to the license agreement, a number of contracts were negotiated including one between Sikorsky and VFW Fokker to provide the basis for the Sikorsky portion of the co-production program. Other contracts were signed by Sikorsky to provide for tooling, personnel, hardware, software, and training. There were also contracts with the German government for technical advisers, instructors, pilot and personnel training, handbooks, support equipment, and spares.

Licensing experience by major American corporations to Europe suggests a strong preference to acquire working control over licensees. Given the difficulties of receiving what is regarded as an adequate return on investment through simple license agreements, licensing to affiliates is strongly preferred. In the defense industries, it is of course a matter of national policy whether or not an American corporation can acquire a controlling share of the equity in a European corporation. Normally, for this reason, American corporations have found it necessary to license to non-affiliates, since European governments are naturally concerned about overseas control of chosen instruments in the defense field. In such cases, there is a natural effort on the part of the U.S. licensor to establish fees which, in themselves, can provide a sufficient return to the licensing company. In these cases, the selection of a licensee is quite different than in mass commercial markets. The American licensor often has little or no choice of licensees, since there is typically a single chosen national interest instrument in a given field of defense technology. Consequently, negotiations may be more difficult than in a purely commercial endeavor.

In one U.S. company which manufactures high-technology instrumentation, typical royalty fees on gross sales in aerospace lines might range from 5 to 7.5% in relatively high-volume applications (for example, navigation equipment for the general aviation market) and up to 10% in very specialized situations. These fees compare with 2 to 5% in, for example, automotive product lines. If the royalty is higher, the initial fee or front-end load might be lower, intended only to cover routine costs of negotiation, and early coordination.

The issue of technology transfer, already discussed in a previous section, influences industry's consideration of licensing just as strongly as it does that of the U.S. government's disclosure policy community. It may be helpful to take the example of helicopter technology, where Europe considers itself the technical equal of the

United States. Discussions with American helicopter manufacturers reveal a view that the U.S. helicopter industry has spent large amounts on R&D to advance the state of the art of helicopter design that are not matched by Western European industry. The major objectives in U.S. industry have been to improve the parameters of performance, especially speed, and to achieve significantly greater reliability and maintainability. The most important and fundamental R&D carried out by U.S. industry has been on the aerodynamic and structural design of rotors, resulting in a series of significant contributions to helicopter flight performance. There has also been a great deal of structural innovation aimed at weight reduction, reduced vulnerability to fatigue, and greater freedom for the aerodynamic designers who optimize rotor configurations. In these areas, the U.S. industry feels that it has moved well ahead of Western Europe. Because of this, a strong position is taken in licensing arrangements, affecting either the initial fee, or the amount of technology transferred, or both. The view voiced by the head of one U.S. firm is that, in view of the technological imbalance, his company will let someone else do the sheet metal work, so long as the American licensor can retain the production share that requires maximum productivity and investment in R&D and heavy machine tools.

There may also be a variation in fee or royalty schedules depending on the ultimate destination of the equipment. On the European side, for example, Euromissile has made it clear that, in future questions of third country export rights, Euromissile can be expected to demand higher license fees and royalty payments for units exported to third countries than for those in the U.S. home market of the licensee.

Turning now to the issue of collaborative development and production as it has evolved in Europe, it may be helpful to summarize some of the points made throughout the report:

> The sunken costs that have already been absorbed by European governments in establishing chosen industrial instruments in each of the principal fields of defense technology create a need of the major countries to ensure that the R&D and manufacturing capacities of these industries are adequately utilized. Collaboratively funded programs, based on careful division of work in the R&D and manufacturing phases (and balanced by funding contributions and purchases) have evolved as a complex but satisfactory solution.

> The establishment of intra-European consortia has already resulted in greater standardization in the defense field and will lead to more. For this reason, the consortia represent a useful focal point for new U.S. initiatives. It seems useless, in the view of the present study, to attack or ignore this approach, since in fact it already exists and

has the unique advantage of having already overcome some of the inherent European and political economic impediments to standardization.

In any form of collaboration between the United States and Europe for defense systems, it may in future be more comfortable for the United States to collaborate with a multilateral entity, representing two or more European governments, than a single national industry. This has the advantage of gaining a wider political consensus and a broader European constituency, both industrial and political, to avoid the perceived imbalances that usually result from a bilateral arrangement between the United States and a single European country. Perhaps the most interesting organization, in this regard, would be the British-German-Italian Panavia consortium, which has a well-established management structure, an intimate connection with NATO, and well-established major programs which can serve as the basis for future programs.

With regard to collaborative ventures, the view at Rolls-Royce is that R&D costs are about 20% higher in a collaborative program but that appreciable gains eventually result in the reduction of production costs. The Rolls-

Royce view is that the 20% cost differential cannot be reduced, since it is not necessarily the result of wasteful practices but of necessary coordinations. However, it is also the Rolls-Royce line of argument that this overlapping of activity reduces the chance of major mistakes. Furthermore, intentional under-bidding is virtually impossible in the consortium context.

One goal of standardization is to bring about a re-structuring of the European defense industries to permit longer production runs and lower unit costs due to economies of scale. This is to some extent already being achieved through European collaborative projects. This goal suggests a U.S. interest in in-vading collaborative programs of major defense firms, compared with purely national efforts.

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