A RAND NOTE

A Review of European Arms Collaboration and Prospects for Its Expansion under the Independent European Program Group

Terrell G. Covington, Keith W. Brendley,
Mary E. Chenoweth

July 1987

RAND

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PREFACE

This Note reviews the initial research and findings of a multiyear study that is examining the potential for limited arms cooperation between the United States and its European NATO allies on projects of the Independent European Program Group (IEPG). The RAND "Two-Way Defense Trade" Project is conducting the research, which is sponsored by the Office of the Under Secretary of Defense for Acquisition (International Programs and Technology), under the auspices of the National Defense Research Institute, the OSD-supported federally funded research and development center. The work is being carried out in the Applied Science and Technology Program.

The Note concentrates on the organization and activities of the IEPG, the history of U.S.-European arms cooperation, and current intra-European collaboration. Subsequent research will examine why the United States should collaborate on IEPG projects that are of specific interest to this country and have a high probability of full-scale engineering development, how the United States might achieve such collaboration, and which projects show greatest promise for collaboration.

The research and conclusions are intended for policymakers interested in European defense policies, arms collaboration, and the two-way defense-trade issue.

SUMMARY

The United States and NATO Europe have long collaborated on procuring arms, using ad hoc collaborative programs and methods. At the same time, NATO, the United States, and Europe (i.e., the 13 European NATO nations, including France) have sought ways to bring greater order to the collaborative process. As a set of divergent and comparatively small nations, Europe has been more concerned with collaboration issues than has the United States. To organize and coordinate intra-European arms collaboration, the European nations have formed the Independent European Program Group (IEPG).

This Note examines the purpose and structure of the IEPG. It then reviews past transatlantic and intra-European arms collaboration programs and policies. Finally, it examines some of the forces driving collaboration.

ROLE OF THE IEPG IN EUROPEAN ARMS COLLABORATION

The IEPG was founded in 1976 at the suggestion of the NATO Eurogroup defense ministers, who wanted a forum for increased arms collaboration that would include France. Although France has been a major participant in intra-European arms collaboration and has sought to improve the European collaborative process, the French have preferred to operate outside NATO. The IEPG is affiliated neither with NATO nor the Eurogroup.

Using the IEPG as a forum for annual discussions, the defense ministers of the 13 member nations issue communiques defining goals and targets. To carry out these communiques, the IEPG is organized into three panels. Panel I reviews military requirements and conducts preliminary weapons systems analyses. Panel II refines the system concepts defined by Panel I. Panel III examines the broad issues raised by collaboration.

The issues that concern the IEPG may be defined in terms of the goals of both the IEPG and European arms collaboration in general. The IEPG seeks to foster a more efficient use of defense resources through cooperation within the European community so as to

- Strengthen the contribution of the European allies to the common defense of the NATO alliance

- Improve the European technology base
- Balance U.S.-European defense trade.

To achieve these goals, the IEPG begins to study potential procurement projects at the requirements level so as to ensure general agreement on tactical and operational concepts associated with new systems. The requirements studies are expanded into systems studies when deemed appropriate by the ministers. At the same time, each nation works toward improving cooperative industrial policy within the European defense community.

Thus, the IEPG shares with NATO the primary goal of unifying European procurement policies and practices. Europe's success in achieving this arms collaboration goal will affect U.S. policies regarding U.S.-European arms collaboration. To estimate this effect, this Note examines past policies and accomplishments in U.S.-European arms collaboration.

RELATIONSHIP BETWEEN U.S. AND EUROPEAN ARMS COLLABORATION POLICIES

Experience seems to have tempered NATO's expectations in fostering arms collaboration. Rather than developing policies for rationalizing arms throughout the NATO community, it now concentrates on bilateral and multilateral collaboration as opportunities arise.

On the civilian side of NATO, the NATO basic military requirement (NBMR) procedure has given way to policies and organizations fostered by the Conference of National Armaments Directors (CNAD). NATO had created the NBMRs with the aim of unifying national military requirements so that NATO-wide arms collaboration agreements could be reached. The CNAD, through such bodies as the NATO Industrial Advisory Group (NIAG), focuses on cooperation between ad hoc groups of countries.

The NATO Military Agency for Standardization (MAS) handles the military issues relating to standardization and interoperability. Although the MAS had earlier attempted to set standardization goals for the entire alliance through the standardization agreements (STANAGs), it now seeks to increase standardization among a more limited number of countries.

Similarly, U.S. arms collaboration policies, while acknowledging the importance of NATO-wide arms standardization, concentrate on ad hoc bilateral collaboration. Bilateral is used here to describe cooperation between the United States and any group of countries. In

most cases of bilateral cooperation, the European participants have first organized into an ad hoc group which then collaborated with the United States on terms approaching equality—hence, bilateral cooperation.

The family-of-weapons concept offers a good example of a bilateral U.S. collaboration policy. The concept is based on grouping similar weapon systems for purposes of development and eventual production, with, say, the United States developing one weapon in the group, France another, missile, the UK a third, and so on.

The difficulty of finding even two weapon systems that might be grouped into a family and meet each country's military and time requirements limits the utility of the family-of-weapons concept. So far, only missiles have been suggested for grouping, and only the advanced medium-range and short-range air-to-air missile (AMRAAM-ASRAAM) family has progressed beyond the talk stage. In the AMRAAM-ASRAAM collaboration, the United States is developing the medium-range missile and an ad hoc group of Europeans is codeveloping the short-range system. A second limitation on the concept derives from the European preference for a more structured form of collaboration at the development stage than the family-of-weapons concept provides.

A more recent U.S. policy, the Nunn amendment, including the NATO comparative test program, holds greater promise for generating widespread arms collaboration within NATO. The amendment fosters cooperation by offering U.S. technology and the possibility of eventual U.S. procurements to nations that participate in cooperative programs with the United States.

The examples of U.S.-European arms collaboration included in this study (as well as others not included) indicate that greater European cohesion increases the prospects of success of U.S. policies and programs relating to arms collaboration with NATO. Greater European cooperation in arms development and production, as noted, is the goal of the IEPG. Thus, the basic agreement between the goals of the U.S. and European collaboration policies should foster the success of both.

EUROPEAN COLLABORATIVE PROJECTS

To illustrate the intricacies of collaboration, this Note focuses on codevelopment. Strictly speaking, codevelopment refers to the joint design and development of a weapon system. In practice, however, the collaboration extends into the production and export phases as well. To date, most European codevelopments have involved aircraft and missiles because these systems are often too complicated and costly for individual countries to develop and produce by themselves.

The management of collaborative projects has tended to shift over time from organizations controlled largely by one nation, often France, to a more equitable form of decisionmaking in which the collaborating countries share in the responsibilities of management.

The French government and French industry, for example, dominated the management hierarchy of the Alpha Jet trainer and close-support aircraft project. Breguet, a French aircraft manufacturer, assumed the position of prime contractor and received its instructions from the French government. After conferring with the German government, Breguet subcontracted 50 percent of the work to Dornier, a German aircraft firm and Breguet's collaborative partner.

The French also dominated the NATO Atlantic maritime patrol aircraft program. Most of the work for the Atlantic program was conducted in France and Germany, although other European countries also participated. The French controlled SECBAT, the management organization for the Atlantic. During certain periods, the French government provided the entire financial support for the project. This arrangement gave France enormous influence over the direction of the Atlantic project.

The management of the Transall transport aircraft codevelopment between France and Germany exemplifies bilateral control. The management organization that oversaw the development and production of the Transall provided few mechanisms for working out disagreements, and bilateralism throughout the decisionmaking process left little room for compromise. As a result, the Transall ended up as a great disappointment in terms of (1) the gap between the desired and resulting product, (2) scheduling, and (3) recurrent problems.

More recently, European collaborative programs have been managed by international corporations created for that purpose. These corporations are often formed before the development phase begins, as in the cases of Panavia and Eurofighter. Panavia oversaw the development and production of the Tornado multiple-role combat aircraft, a collaborative venture involving the UK, Germany, and later Italy. Eurofighter is managing the development and will eventually oversee the production of the Eurofighter aircraft for the same three countries and Spain.

Panavia and Eurofighter function as multinational corporations with full-time staff and integrated personnel. German and British personnel at Panavia predict that equal decisionmaking will become the norm in future collaboration involving these nations. In fact, most European nations will probably adopt this method of operation.

The shift from strong project control by a single government to joint project control has contributed to the increased stature of the IEPG. An international coordinating body, such as the IEPG, obviously can help a group of governments seeking an equal partnership.

FACTORS INFLUENCING ARMS COLLABORATION

In pursuing its goal of increasing European arms collaboration, the IEPG also fosters European unity. Greater European cohesion, in turn, portends a change in the relationship between the United States and its NATO allies with regard to transatlantic collaboration on defense procurement and arms trade.

The IEPG is not alone in its pursuit of greater European unity. Other institutions have the same goal in other areas, for example, the European Economic Community and the Western European Union. These institutions have been created in part because Europe views itself as a complex marketplace, with each nation being too small to generate significant new industry.

The Europeans consider high-technology industries particularly important to the health and vigor of their economies, and they are concerned about falling behind the United States and Japan in technology. Increased cooperation, they believe, would give their high-technology industries a large enough market for growth. Although European planners recognize the benefits of cooperation, they are often thwarted in their pursuit of it by the insistence of the individual countries on maintaining a large degree of political and cultural independence.

The success of the IEPG in fostering a more unified defense procurement policy may directly affect U.S. relations with its European NATO allies, particularly with regard to U.S.-European bilateral arms trade. The arms-trade balance, which has favored the United States since the creation of NATO, concerns both Americans and Europeans. If the IEPG changes the way that Europeans procure their armaments, the change will affect the two-way arms trade between the United States and Europe which will, in turn, affect overall trade balances.

The United States trade deficit in all but two years since 1968 has made it the largest debtor nation in the world. In 1986 alone, the trade deficit reached $160 billion. The United States has also had a negative bilateral trade balance with some of its NATO partners. Sales of military goods to the other NATO countries, however, provide one bright spot on the U.S. trade balance, if one excludes the transfer of funds to pay for basing a large number of U.S. military personnel in Europe. Despite U.S. domination of bilateral arms trade with NATO

Europe, in multilateral trade the Europeans export far more arms than they import, registering a surplus of over $5 billion in 1983.

The European defense industry relies on its exports to maintain its size. A smaller export market would increase the cost of weapon systems and decrease European high-technology competitiveness. However, traditional markets for European arms outside Europe are disappearing. Some customary arms importers are developing their own production capabilities. The drop in oil prices and the tightening of international credit has decreased the demand for arms from the Middle East and other third world areas. After a decade of growth, imports by the developing countries in 1983 decreased by 11 percent from the high in 1982.

The Europeans may thus have to look for new markets, and the largest defense market in the free world is the United States. The United States certainly wants a healthy European defense industry, for such a production capability serves NATO and the individual members, including the United States. The United States spends tens of millions of dollars per year testing foreign weapons, especially those from the NATO countries, in seeking weapons for U.S. procurement.

Increased transatlantic arms collaboration offers a possible solution to the bilateral arms-trade imbalance. Collaboration undoubtedly would strengthen the bonds between the allies and perhaps enable them to resolve, or at least mitigate, their differences. It would also increase U.S. influence on European arms policy and European influence on U.S. arms policy.

The United States would achieve a twofold political effect with increased arms collaboration: a greater dependence on Europe for the development of weapons systems and a higher volume of arms trade across the Atlantic. Critics, however, see a collaborative venture as sending jobs and technology overseas rather than as enhancing arms cooperation within NATO. Proponents argue that increased collaboration will improve the U.S.-European trade balance by providing Europe and the United States greater access to the entire NATO arms market.

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I. INTRODUCTION

The NATO allies have long recognized the inefficiencies—attributed largely to inadequate rationalization, standardization, and interoperability (RSI)—that seem to arise naturally in the military association of free nations with independent arms policies. General Andrew J. Goodpaster, formerly Supreme Allied Commander Europe, noted that "NATO...was losing at least 30 percent and in some areas 50 percent of capability due to the lack of standardization."[1] Over the years, both the United States and its NATO allies have adopted policies aimed at reducing costs and increasing RSI through arms collaboration within the alliance.

The Independent European Program Group (IEPG) was established in 1976 to promote arms cooperation in Europe (but not to manage collaborative arms programs). Although all of its members belong to NATO, the IEPG is not itself a part of NATO.

As the nations of Europe pursue a more unified arms procurement policy, the United States must face the prospect that their efforts may succeed, whether under the IEPG or under some other organization. The United States should therefore develop a policy for dealing with the collaborative projects of such organizations.

Although in seeking to expand cooperative arms procurement with its European allies, the United States might deal directly with NATO, the individual countries, the participating companies, or the cooperative programs themselves, the IEPG offers the following advantages as a contact organization:

- The IEPG is Europe's designated repository for information on European collaborative programs, and NATO relies on it for such information.
- The IEPG has the resources to study the complex issues that would arise in connection with U.S.-European arms cooperation. It could provide the United States with an authoratitive European viewpoint on how the United States might approach such collaborative programs.

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[1]*NATO Standardization: Political, Economic, and Military Issues for Congress,* Foreign Affairs and National Defense Division, Congressional Research Service, Library of Congress, March 1977, p. 28.

- The IEPG identifies suitable projects for collaboration early enough in their conceptualization and/or development to allow the agreement of all participants on requirements.

To provide insight into the organizational issues of U.S.-European collaboration on programs sponsored or monitored by the IEPG, Sec. II of this Note examines the goals, structure, and current and proposed projects of the IEPG. Section III describes NATO organizations and procedures designed to encourage arms collaboration, summarizes U.S. policies regarding collaboration, and offers several examples of U.S.-European cooperative programs. A final background section reviews seven successful and unsuccessful European projects and their management organizations.

Finally, the Note addresses issues that may be suggested by the successful operation of the IEPG. These include (1) the benefits and pitfalls for the United States of collaborating with a more unified Europe if the IEPG is able to carry out the provisions of its charter and (2) the effect that the efforts of European countries to increase their ability to produce the complex weapons that they need will have on two-way trade with the United States. The Note ends with an outline of future RAND research on the IEPG as a possible forum for U.S.-European arms collaboration.

II. GOALS, STRUCTURE, AND OPERATION OF THE INDEPENDENT EUROPEAN PROGRAM GROUP

The Independent European Program Group, founded in 1976 to expand the NATO European Program Group (EPG), consists of 13 European NATO nations: Belgium, Denmark, France, Federal Republic of Germany, Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Turkey, and United Kingdom. Unlike the European Economic Community and the Western European Union, the IEPG was not established by treaty.

The NATO Eurogroup defense ministers suggested the creation of the IEPG as a forum for increased European equipment cooperation that would include France, which was a member of neither the Eurogroup nor the EPG.[1] Although the IEPG and EPG have similar charters and goals, the French found the IEPG more acceptable because it operates outside the NATO structure.

GOALS

The IEPG seeks to foster a more efficient use of defense resources through cooperation within the European community so as to

- Strengthen the contribution of the European allies to the common defense of the NATO alliance
- Improve the European technology base
- Balance U.S.-European defense trade.

To achieve these goals, the IEPG begins to study potential procurement projects at the requirements level so as to ensure general agreement on tactical and operational concepts associated with new systems. At the same time, each nation works toward improving cooperative industrial policy within the European defense community.

The IEPG annual ministerial meetings provide the major direction of the organization through ministerial communiques. Working groups associated with potential projects act on these communiques.

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[1]The Eurogroup is an informal association of defense ministers of European member governments within the framework of NATO. See *Western Defense: The European Role in NATO*, NATO Information Service, 1982, p. 20.

After a slow beginning, the IEPG held its first ministerial meeting in November 1984 in The Hague.[2] The participants noted the potential for future collaboration in three major areas:

- Main battle tanks
- Medium-range surface-to-air missiles
- Large transport aircraft.

Emphasizing their intention to develop cooperative technology projects that would enhance the technology base of the European community, the ministers sought greater discipline in not launching national development projects where a multinational program already existed, greater readiness to adopt equipment already in production or otherwise acceptable, and greater willingness to allow competition in European cooperative projects.[3]

Meeting again in June 1985 in London, the ministers noted the progress that had been made: Some 30 research and technology areas had been examined as possible cooperative ventures; military requirements for mortars and short-range antiarmor weapon systems were being harmonized; and in the area of actual codevelopment, the project for the third-generation antitank guided weapon was progressing. They also saw good prospects for the standardization of components in main battle tanks and for the redevelopment of joint requirements for medium-range surface-to-air missiles.[4]

The most recent ministerial meeting, held in April 1986 in Madrid, recognized continuing advances toward the IEPG's goals. Several technology projects were being developed, and joint requirements had been established for medium-range surface-to-air missiles. In addition, progress had been made in defining main battle tank components

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[2]In its early years, the IEPG served mainly as a clearinghouse to provide NATO with information on the military requirements and procurement plans of the European members. This largely technical role was expanded in 1984, when the European defense ministers chose the IEPG as their forum for annual discussions. Jan van Houwelingen, the Norwegian minister of defense, is credited with suggesting this role for the IEPG.

[3]Independent European Program Group, "Decisions by the Ministers, The Hague," IEPG/MIN/D-1/Corrected Version, January 1985, and interviews with IEPG representatives in France, FRG, Spain, and UK, May 19-30, 1986.

[4]Independent European Program Group, "Communique, Ministerial Meeting," IEPG/MIN/D-5, June 1985, and interviews with IEPG representatives in France, FRG, Spain, and UK, May 19-30, 1986.

and the requirements for a future large aircraft, which had previously been called the tactical air transport.[5]

The 1986 meeting initiated a major study on European aeronautical cooperation.[6] The ministers agreed to examine all types of aircraft, helicopters, drones, and associated weaponry and equipment. They also pledged to identify opportunities for cooperation over the next two decades and beyond in coordinating military programs, defining requirements, and codeveloping equipment. Finally, they planned to harmonize standards, methods, and means for designing and manufacturing equipment. This would include defining technical standards, identifying key advance technologies, and developing test facilities.

STRUCTURE

Three IEPG panels, consisting of members from the interested countries, carry out the ministerial communiques. Two panels have the responsibility for defining specific projects, while the third looks at the broad issues associated with European collaboration. Panel I reviews requirements and conducts the initial studies leading to Panel II projects. Panel II concentrates on refining system concepts defined by Panel I. Panel III examines the broad issues raised by collaboration, including defense economics and trade; rationalization, standardization, and interoperability; and burden sharing in NATO. Figure 1 shows the projects under each panel.

Current Panel I projects include the future large aircraft, the medium-range surface-to-air missile, and the main battle tank components. The future large aircraft project will probably evolve into several aircraft projects, including both a tactical transport and a long-range maritime patrol aircraft. However, these Panel I projects have yet to proceed to Panel II, where they would be formalized into cooperative monitor programs, which Panel II would continue to monitor.

Panel II coordinates the projects that are expected to enter production in the participating countries. To date, efforts have focused on the TRIGAT third-generation antitank guided weapons, the follow-on to the Milan and the HOT missile systems.[7]

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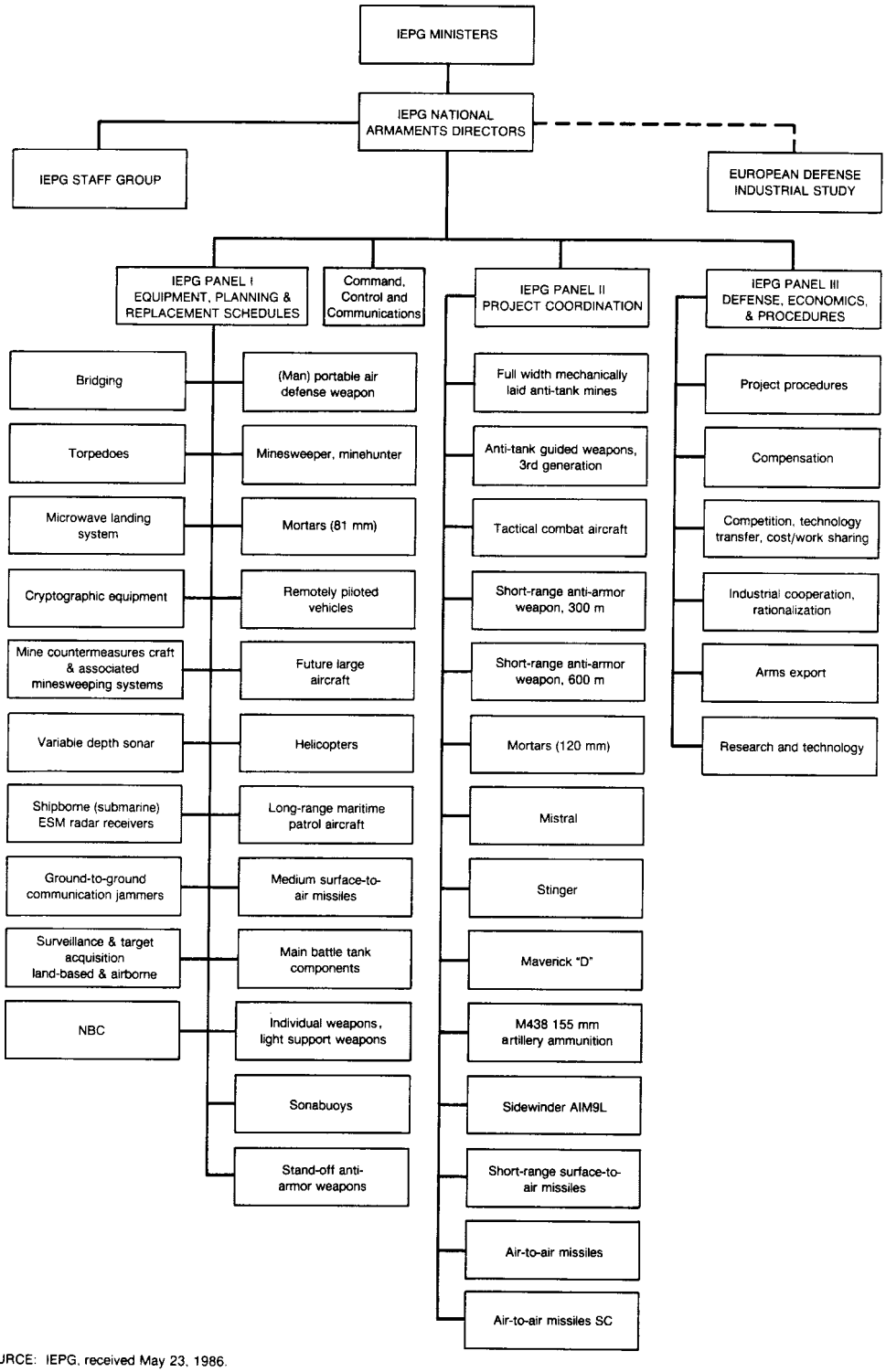
[5]Independent European Program Group, "Ministerial Communique," IEPG/MIN/D-9, April 1986, and interviews with IEPG representatives in France, FRG, Spain, and UK, May 19-30, 1986.

[6]Independent European Program Group, "Aeronautical Cooperation Within the IEPG," IEPG/MIN/D-6, April 1986.

[7]These projects are discussed in Sec. IV, below.



SOURCE: IEPG, received May 23, 1986.

Fig. 1—Organization of Independent European Program Group (IEPG)

The three largest member countries—France, Germany, and the UK—have formed a multinational corporation, the Euromissile Dynamics Group (EMDG), to manage the TRIGAT development. Five other IEPG members are also involved in the TRIGAT program, although the exact form of their participation is still being negotiated. Panel II also has responsibility for the currently dormant tactical combat aircraft project, which monitors the cooperative Eurofighter program.[8]

Panel III supports policy studies and administrative functions. It also fosters technology projects, including injection molding of explosives; microelectronic components, particularly those based on gallium arsenide technology; explosively formed projectiles; torpedo warhead design; and advanced processing techniques to improve the hardware and software available for future computer systems.

OPERATION

The IEPG emphasizes codevelopment as the way to achieve its goals, but it recognizes the usefulness of other forms of collaboration, including coproduction, licensed production, arms trade, and technology transfer. These forms of collaboration often overlap.

Codevelopment involves the joint design and development of a weapon system. If codevelopment is to work, the cooperating nations often must compromise on requirements to achieve a common program. The European arms industry has begun to rely to an appreciable extent on codevelopment agreements for complex, high-cost replacement systems. The IEPG seeks to increase the number of successful codevelopment projects.

The relatively small size of the individual European national economies often prevents these nations from producing certain complex, high-cost weapons efficiently. The *coproduction* of such weapons offers one possibility for alleviating the problems of small production runs. With coproduction, one or more nations produces a weapon or equipment that another nation or group of nations has developed. The IEPG may foster coproduction when a national development program already exists. Coproduction has also been used as a method for offsetting costs associated with the importation of U.S. technology.

When neither codevelopment nor coproduction seems feasible, *licensed production* offers another avenue of collaboration. Under this system, a producer in one country sells the data package of a given product, along with the right to produce that product, to either another country or to a producer in that country. For allies, licensed production has the

[8]The Eurofighter program is discussed in Sec. IV, below.

advantage of reducing development costs while avoiding some of the inefficiencies normally associated with joint programs. It is sometimes considered a practical alternative to purchasing arms.

Arms trade is the importation and exportation of weapons and military goods. Unless otherwise noted, it does not include other costs, such as the cost to the United States of stationing troops in Germany.

All of the above forms of arms cooperation involve *technology transfer*. In addition, established diplomatic channels foster technology transfer between allies, usually on a bilateral basis. Because the quantity and quality of technology transfer depend directly on the closeness of cooperation, codevelopment obviously results in greater and more advanced technology transfer than arms trade. Technology transfer becomes a sensitive issue to the extent that a country perceives its economic health to depend on its remaining technologically competitive with its trading partners.

In sum, the establishment of the IEPG represents the European community's continuing pursuit of greater cooperation to achieve both common and national goals at an affordable price. The discussions and communiques of the IEPG ministerial meetings affirm the high-level encouragement of the approach and the expectation of real results, and IEPG members have already signed memorandums of understanding (MOUs) involving several specific projects. Given these developments, the United States should consider appropriate responses to the possibility of an increasing number of European cooperative arms projects, including major defense systems, under the IEPG (or some similar institution).

III. EUROPEAN AND U.S. COOPERATIVE POLICIES AND PROGRAMS

NATO ORGANIZATIONS INVOLVED IN ARMS COLLABORATION

The members of NATO, including the United States, have long supported policies and programs aimed at increasing cooperation on weapon development and production. Cooperation, by reducing the number of weapon systems, enhances rationalization, standardization, and interoperability.[1]

The Eurogroup considers the IEPG the principal institution in which the European members of NATO can cooperate on armaments procurement. The brief summary of NATO collaborative efforts that follows may help to suggest a suitable relationship between the United States and the IEPG as the clearinghouse for European arms collaboration.

Mutual agreement on basic military requirements constitutes one of more contentious issues in joint development. At the suggestion of the NATO Defense Production Committee, established in 1954, NATO created the NATO basic military requirement (NBMR) procedure in 1959 in an attempt to solve the requirement problem. Of the more than fifty NBMRs agreed on, seven were procured from existing national stocks, but the NBMR program never achieved its goal of spurring a joint development program.[2] The primary difficulty stemmed from the NBMR requirement for a consensus of all the NATO countries.

NATO members, however, considering limited cooperation preferable to none, established the Conference of National Armaments Directors (CNAD) in the late 1960s. The CNAD, the civilian defense organization of NATO, is directly below the Defense Planning Committee and on the same level as the Military Council (MC), as shown in Fig. 2. Today, the CNAD and the MC are the primary organizations concerned with the problems of RSI and weapon collaboration.[3]

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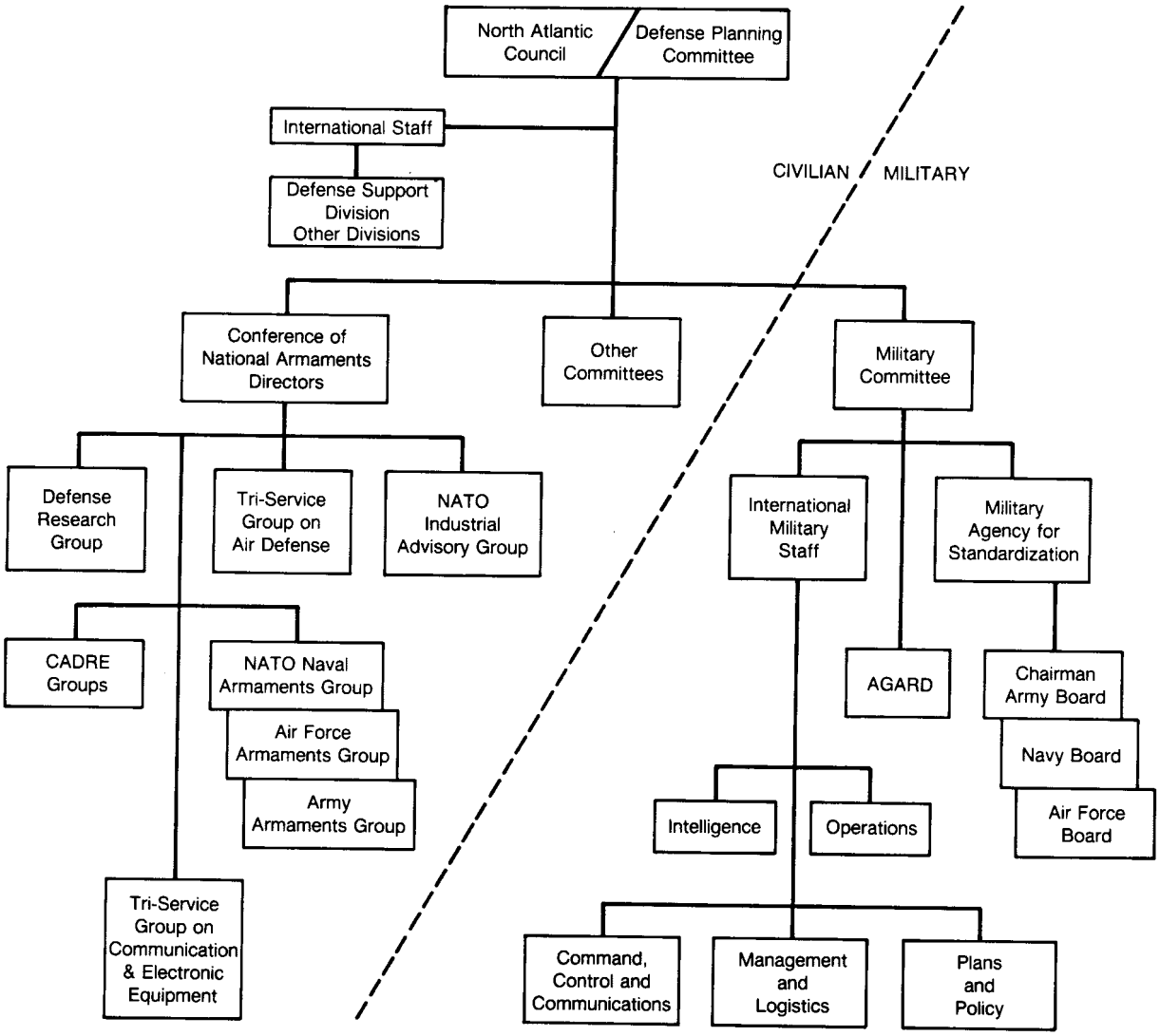
[1]For U.S. statements supporting NATO goals and efforts to encourage RSI, see *Reference Book on NATO Rationalization, Standardization, and Interoperability,* vols. 1 and 2, American Defense Preparedness Association, Arlington, Virginia, November 1979.

[2]*NATO Facts and Figures,* NATO Information Service, Brussels, 1971, pp. 124-126.

[3]For a description of the CNAD and MC, see Alexander A. Cornell, *International Collaboration in Weapons and Equipment Development and Production by the NATO Allies: Ten Years Later—and Beyond,* Martinus Nijhoff Publishers, Boston, 1981, pp. 48-58.



SOURCE: Alexander A. Cornell, *International Collaboration in Weapons and Equipment Development and Production by the NATO Allies: Ten Years Later—and Beyond*, Martinus Nijhoff Publishers, Boston, 1981, p. 49.

Fig. 2—NATO Organizations Concerned With Arms Collaboration

Conference of National Armaments Directors

The CNAD seeks to encourage joint research and development within NATO and to make NATO requirements known to the member nations. It also addresses the logistic and technological problems that stem from dissimilar equipment.[4]

The CNAD has fostered several important NATO organizations. For example, the NATO Multi-Role Combat Aircraft Development and Production Management Organization (NAMMO) provides a forum in which countries participating in the production of the multirole combat aircraft (MRCA) may debate major issues at the governmental level. In addition, the CNAD has promoted the NATO Industrial Advisory Group (NIAG), created in 1968 as a forum at the industrial level for discussions pertaining to weapon research and development.[5]

The phased armaments planning system (PAPS), which the CNAD also oversees, was organized in 1980 and became a NATO committee in 1984.[6] PAPS reviews NATO weapon acquisition programs from requirement specifications to phaseout; it has often been compared to the U.S. Defense Systems Acquisition Review (DSARC). Pursuant to its goal of imbuing national and joint weapon development processes with NATO requirements at an early stage in their conceptualization and development, PAPS obtains the European input from the IEPG.[7]

Military Council

The Military Council also handles collaborative issues, but it does so from the military perspective. Its subordinate organizations include the Military Agency for Standardization (MAS), the Armaments and Interoperability Division, the Advisory Group for Aerospace Research and Development (AGARD), and the NATO Defense College. The MAS has been working since 1951 to increase RSI, using the standardization agreement (STANAG) as a major tool. Although a number of STANAGs were ratified, only a few items of minor equipment survived through procurement.[8]

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[4]*NATO Facts and Figures, Second Impression,* NATO Information Service, Brussels, 1978, pp. 140-142.

[5]See Cornell (1981), pp. 54-56.

[6]*Standardization of Equipment Within NATO,* Twelfth Report to the United States Congress, Caspar W. Weinberger, Department of Defense, March 1986, p. 14.

[7]See "Progress Report," CNAD Ad Hoc Study Group for a Possible Periodic Armaments Planning System, November 1, 1979.

[8]*NATO Facts and Figures* (1971), p. 19.

The Military Council controls the NATO Long-Term Defense Program (LTDP), which the May 1978 summit meeting in Washington approved.[9] The Military Council considers the LTDP central to the objective of increasing RSI. The LTDP has defined a large number of areas that would benefit from collaboration in both the long and medium terms.

U.S. ARMS COLLABORATION POLICIES

The current policies of the United States with regard to arms collaboration with its European allies send mixed signals: The policies range from the "Buy American" laws that hinder collaboration to the "family-of-weapons" concept that encourages it. In addition, the United States is offering advanced research programs to its allies, but the U.S. Congress would first require proof that the programs could not readily be conducted in this country.

Moreover, U.S. policies fail to address all significant collaboration issues. In particular, the United States still lacks a policy regarding the IEPG. Current U.S. policies on international arms collaboration are examined immediately below.

Buy American Act

The U.S. Congress has enacted several laws that require the U.S. military to show that any foreign goods that it proposes to buy are neither available nor readily producible in the United States. Supporters and critics alike refer to these laws as the "Buy American" act.[10] Obviously, such laws hamper arms collaboration with our allies.

Fortunately, the DoD can, under certain circumstances, waive the "Buy American" laws. In fact, most general memorandums of understanding (GMOUs) contain specific exemptions from such laws.[11] For example, the 1978 GMOU with the Netherlands contains the following statement by then Secretary of Defense Harold Brown:

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[9]*Rationalization/Standardization Within NATO*, report to the United States Congress by Harold Brown, Secretary of Defense, January 31, 1981, p. 16.

[10]The original "Buy American" law was enacted over 50 years ago; see Section 2 of Title III of the act of March 3, 1933, 47 Stat. 1520, 41 USC 10a. It has been amended and expanded several times since then.

[11]General memorandums of understanding are discussed under "Triad of Initiatives," below, in this section.

> I hereby determine that it is inconsistent with the public interest to apply the restrictions of the Buy American Act to the acquisition of those items of Netherlands produced or manufactured defense equipment that are covered by this Determination and Findings.[12]

Even with explicit waivers, however, the "Buy American" act offends U.S. allies, and some members of Congress have introduced measures to encourage collaboration despite it.

Culver-Nunn Amendment

The Culver-Nunn amendment to the Department of Defense Appropriation Authorization Act of 1977 addressed the issue of increasing weapon commonality within NATO as follows:

> It is the policy of the United States that equipment procured for the use of personnel of the Armed Forces of the United States stationed in Europe...should be standardized or at least interoperable with equipment of the members of the North Atlantic Treaty Organization.[13]

At the time that this amendment passed, some NATO commanders estimated that achieving the goals of RSI would save approximately $15 billion;[14] T. A. Callaghan estimated a $10 billion saving.[15] Moreover, NATO officials believed that the Soviet Union and the Warsaw Pact were getting more output for each dollar of input than the NATO allies were getting; they attributed this disparity at least in part to the multiplicity of weapon types in NATO.

The Culver-Nunn amendment received some criticism, however. One congressional study focused on the cost overruns that a few codevelopment programs had experienced. It also questioned the potential saving that RSI would achieve and concluded that $3 billion was the upper limit.[16]

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[12]*Memorandum of Understanding Between the Governments of the United States of America and the Kingdom of the Netherlands,* enclosure no. 5, August 24, 1978.

[13]Public Law 94-361, Sec. 802(a)(1).

[14]U.S. Congress, Senate, Committee on Armed Services, *Report on Authorizing Appropriations for Fiscal Year 1977 for Military Procurement, Research and Development,* 94th Cong, 2d sess, 1976, S Rept 69-019, p. 109.

[15]Thomas A. Callaghan, *U.S./European Economic Cooperation in Military and Civil Technology,* rev., Center for Strategic and International Studies, Washington, D.C., September 1975.

[16]U.S. Congress, House, Committee on Armed Services, *NATO Standardization, Interoperability and Readiness,* 95th Cong, 2d sess, 1978, H.A.S.C. No. 95-101, p. 14.

Although the critics could not stop the passage of the Culver-Nunn amendment, they killed the Taft-Nunn-Culver amendment, which took a much stronger stand on defense collaboration. The latter amendment would have required the secretary of defense to seek cooperative arrangements, such as codevelopment or coproduction, with U.S. allies.[17] The Taft-Nunn-Culver amendment would have had greater applicability to possible U.S.-IEPG collaborations than does the Culver-Nunn amendment.

The passage of the Culver-Nunn amendment in some ways only reiterated existing U.S. policy. For example, the amendment gave the secretary of defense explicit authority to waive provisions of the "Buy American" act, even though he already possessed such authority. It explicitly listed increased RSI as a U.S. policy goal, although this had long been both a NATO and a U.S. goal.

Perhaps Congress intended the Culver-Nunn amendment to be a strong message to U.S. allies that the United States was more concerned with increasing the effectiveness of the alliance than fostering its own defense industry. In any case, shortly after the amendment passed, the Department of Defense (DoD) adopted a weapon-collaboration policy known as the triad of initiatives.

Triad of Initiatives

The triad of initiatives consists of the family-of-weapons concept, general memorandums of understanding, and dual production. These initiatives are directed toward five ambitious defense goals:

- Increasing force effectiveness
- Fostering controlled competition
- Promoting technology sharing
- Expanding the industrial base
- Resolving the two-way defense trade imbalance.[18]

Family-of-Weapons Concept. The family-of-weapons concept, based on grouping similar weapon systems, is designed to reduce the number of competing weapons within the

[17]See "Senator Culver on NATO Standardization," *Congressional Record,* July 1, 1976, p. S 21983.

[18]Cornell (1981), p. 69.

NATO alliance.[19] According to this concept, the United States would develop one set of weapons and a European consortium another set from the same family. The participating nations could then purchase or coproduce each other's developed products.

The family-of-weapons concept thus postpones the organizational and requirement decisions that usually plague collaborative programs: The methodology for coproducing or trading those systems would be worked out only after the systems had been developed. As a result, issues of coordination would surface only if further agreements were struck for some type of coproduction. Moreover, because the programs are so loosely linked, the participants would have to agree only generally on requirements.

As a further advantage, little if any money would actually cross the ocean during the development stage. Thus, even the most protective U.S. legislator might have difficulty applying the "Buy American" laws.

By delaying many controversial decisions until the production phase, the family-of-weapons policy makes the cancellation of a program more difficult. How the policy will fare in the coproduction or trade stage has yet to be tested.

A problem with the family-of-weapons concept is that few military needs are suited to grouping into families. So far, only missile systems have been suggested for development, and only the development of the advanced air-to-air missile family has actually gone beyond talks. The systems split between the United States and Europe in the advanced air-to-air missile program typifies the family-of-weapons concept: The United States is developing the medium-range version (AMRAAM) and a European consortium the short-range missile (ASRAAM).[20]

The U.S. press and defense-related trade journals hardly noted the joint nature of the AMRAAM-ASRAAM program, and none has defended the embattled AMRAAM program as a U.S.-European codevelopment project. In Europe, however, even a troubled collaborative development project—the SP-70, for example—is almost routinely defended simply because it is a collaborative program. One wonders if this difference reflects the unpopularity of collaboration in the United States, or whether the United States and Europe remain undecided on whether to carry the AMRAAM-ASRAAM project through to the coproduction phase.

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[19]*Achieving Improved NATO Effectiveness Through Armaments Collaboration,* Defense Science Board 1978 Summer Study, December 1978. Interestingly, the DSB recommended that the DoD choose potential programs from among PAPS pilot programs; PAPS received its European input from the IEPG.

[20]The AMRAAM-ASRAAM program is also discussed under "U.S.-European Collaboration," below, in this section.

General Memorandums of Understanding. In connection with the triad of initiatives, a memorandum of understanding (MOU) is defined as an agreement between the U.S. Department of Defense and one or more foreign governments regarding a particular defense-related area. Such memorandums, which often cover technical issues relating to military equipment, do not require congressional approval.

A general memorandum of understanding is usually a bilateral agreement covering a broad area of cooperation between the United States and another country on research, development, procurement, and production. The GMOU has the advantage of applying to a broad range of issues that otherwise would require separate MOUs.

A typical GMOU would encourage U.S. departments and agencies to utilize the resources of the signatory country. It would also set forth such goals as strengthening the military and economic positions of each country through improved RSI. Finally, it would contain a section on exemptions from both the "Buy American" act and U.S. restrictions on certain types of trade.[21] The preamble of the GMOU would state that the United States and the other signatory agreed to reopen discussion of the GMOU if the United States should enter into an agreement with the IEPG that might conflict with that GMOU.

The United States has GMOUs with the following NATO countries: Belgium, Canada, France, FRG, Italy, Netherlands, Norway, Portugal, and the UK. It also has GMOUs with non-NATO countries, including Australia and Switzerland.

Dual Production. The United States has offered a list of weapon systems for coproduction by its NATO allies. The list contains some of the most advanced weapons either already in the U.S. inventory or under development, including the HARM missile, the JTIDS communication system, the advanced attack helicopter, and the Copperhead munition.[22] However, the dual-production policy leaves such issues as proprietary restrictions and sales to third countries to be negotiated later.

In sum, although the triad of initiatives provides the framework for such forms of collaboration as coproduction and licensed production, it offers little guidance. Nor has it produced the hoped-for results, and one may argue that it was never fully implemented as U.S. policy.

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[21]Cornell (1981), p. 63.
[22]Cornell (1981), p. 60.

Carter Speech at NATO Ministerial Meeting

At the first session of the May 1977 NATO ministerial meeting, President Carter presented a strong affirmation of the U.S. policy of two-way trade and arms collaboration among the allies. Acknowledging the potential for increased effectiveness in military procurement that increased collaboration could achieve, Carter outlined the U.S. policy for addressing this problem as follows:

> As we strengthen our forces, we should also improve cooperation in development, production, and procurement of Alliance defense equipment. The Alliance should not be weakened militarily by waste and overlapping, nor should it be weakened politically by disputes over where to buy defense equipment.
>
> We must make a major effort—to eliminate waste and duplication between national programs; to provide each of our countries an opportunity to develop, produce, and sell competitive defense equipment; and to maintain technological excellence in all Allied combat forces. To reach these goals our countries will need to do three things: First, the United States must be willing to promote a genuinely two-way transatlantic trade in defense equipment.... Second, I hope the European allies will continue to increase cooperation among themselves in defense production. I welcome the initiative taken by several of your countries in the European Program Group. A common European defense production effort would help to achieve economies of scale beyond the reach of national programs.... Third, I hope that European and the North American members of the Alliance will join in exploring ways to improve cooperation in the development, production, and procurement of defense equipment. This joint examination could involve the European Program Group as it gathers strength and cohesion.

One may note the important role of the European Program Group, the predecessor of the IEPG, in this statement. However, the proposed link between the United States and the EPG—or the IEPG—to date has not materialized.

Nunn Amendment

As a long-standing member of the Senate Armed Services Committee and now its chairman, Senator Nunn on several occasions has sponsored legislation that affects NATO collaboration. The most recent, the Nunn amendment to the National Defense Authorization for Fiscal Year 1986, set aside $125 million for the American share of joint NATO research projects: $25 million to each of the three services, $25 million to the Office of the Secretary of Defense (OSD), and $25 million for side-by-side testing.[23] For Fiscal Year 1987,

[23]Public Law 99-145, Sec. 1102, Laws of the 99th Congress—1st Session, pp. 712-715.

Congress approved an additional $190 million to continue the Nunn amendment initiatives.[24]

The Nunn amendment was enacted at about the same time that NATO ministers concluded memorandums of understanding on joint research in seven areas: 155-mm precision-guided munitions, modular standoff weapons, identification friend-or-foe (IFF) components for NATO aircraft, a standoff airborne radar demonstrator system for target acquisition and surveillance, the Link II naval communications improvement, and the Ada computer language.[25] The MOUs and the Nunn amendment are not necessarily linked, but Nunn amendment monies will probably be used in the MOU projects. If completed, these projects will contribute to RSI in some critical areas, particularly communications and IFF.

The Nunn amendment was designed to increase prospects for collaboration between the United States and Europe by beginning the collaborative process in the research phase. Thanks to the amendment, allied cooperation now carries the incentive of additional monies—an incentive that may attract program managers who might otherwise never have considered collaborative research.

The Nunn amendment does not, however, present a detailed U.S. policy for collaboration. If the amendment eventually leads to collaborative weapon programs, the United States will have a greater impetus for developing such a policy.

Redressing the Arms-Trade Imbalance

In recent years, for every dollar that Europe has spent to purchase weapons in the United States, this country has spent 35 cents to buy weapons in Europe. In 1984, the 14 European members of NATO agreed to purchase $3.81 billion in U.S. weapons, while the United States agreed to $1.19 billion in European purchases. The bilateral trade ratio favored the United States even more in the late 1950s, when European nations spent 12 times as much on American weapons as the United States spent in Europe. Throughout most of the 1970s, the ratio favored the United States nine to one. (Since 1982, a different

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[24]*Annual Report to the United States Congress, Fiscal Year 1988,* Caspar W. Weinberger, Secretary of Defense, January 12, 1987, p. 278.

[25]Telephone interview with a member of Nunn's staff, September 1986. Also, "NATO Ministers Pledge Funds for Joint Research," *Jane's Defence Weekly,* May 17, 1986, p. 874; "NATO Weapon Collaboration to Cut Waste, *Jane's Defence Weekly,* March 15, 1986, p. 462; "Europeans Wary of U.S. Offer on Military R&D," *Science,* April 18, 1986, p. 314.

formula has been used to calculate the data.) Some analysts predict, however, that European trade barriers may swing the ratios in favor of Europe.[26]

This trade imbalance obviously concerns the Europeans, and the United States has initiated several programs to develop a two-way street in trade. Most notable among these are the foreign weapons evaluation (FWE) program, established in 1981, and the more recent NATO comparative test (NCT) program. The Office of the Undersecretary of Defense, Research and Engineering (Development, Testing and Evaluation) administers both programs, which test foreign weapon systems that seem to meet U.S. service requirements. The FWE and NCT programs also seek ways to avoid duplicative R&D, increase RSI, and encourage the exchange of technology with our allies.

Since 1981, the FWE program has parlayed $60 million worth of evaluation into over $2 billion worth of procurements. Thus, the testing cost 3 percent of the procurement, whereas the R&D associated with most major equipment purchases runs to 25 percent to 30 percent. To date, the FWE program has resulted in the purchase of several systems, including the Squad automatic weapon, the Beretta 9-mm pistol, the MAN 10-ton truck, and the improved 81-mm mortar.[27]

The NCT program was a part of the 1985 Nunn amendment involving weapon collaboration with NATO. Table 1 lists the 19 programs under which 22 systems are currently being tested. Their sophistication indicates the advanced status of European technological capability.[28]

U.S. Industries as Defense-Procurement Policymakers

Private industries have eagerly sought arms sales and contacts with foreign industry to further their sales. As a consequence, a large portion of U.S. involvement in arms collaborations evolves from industrial agreements. For example, Honeywell (U.S.) and FFV (Sweden) had already decided to coproduce the AT-4 antitank weapon even before Honeywell sold it to the U.S. Army. In fact, some U.S. policymakers consider the involvement of U.S. industry in collaborative agreements with foreign industry to be the preferred U.S. policy.[29] Many European governments, however, value government-to-government agreements far more than industrial agreements.

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[26]"Choice of Weapons: Arms-Trade Balance With NATO Nations Turns Against U.S.," *Wall Street Journal,* November 8, 1985, p. 1.

[27]Interview with Captain Michael Sullivan, USDRE(DT&E), August 1986.

[28]Interview with Captain Sullivan, USDRE(DT&E), August 1986.

[29]See U.S. Congress, House, Committee on Armed Services, *NATO Standardization, Interoperability and Readiness,* 95th Cong, 2d sess, 1978, H.A.S.C. No. 95-101, p. 5.

Table 1

NATO COMPARATIVE TEST PROGRAMS BY THE U.S. ARMY, U.S. NAVY, AND U.S. AIR FORCE

Program	Country	FY1986 ($K)	FY1987 ($K)
U.S. Army			
NBC reconnaissance vehicle	FRG	1,300	
Mine reconnaissance & detection system	FRG	1,000	
Mistral air-defense system	France	7,000	
U.S. Navy			
Advanced integrated MAD	France, Canada	736	637
90-mm gun for LAV	Belgium	800	2,000
Air-defense system displays	UK	400	100
NATO ID system RM interrogator	UK	1,820	970
2.75-in. penetrating warhead	Norway, Canada	600	1,200
Naval depth sounder	FRG	250	260
Submarine periscope	FRG, France	450	465
Insensitive 2.75-in. rocket motor	France	1,100	
Osborne minehunter	UK	2,100	250
Cryogenic cooling system	Netherlands	580	560
U.S. Air Force			
Penguin missile	Norway	1,600	1,600
Cratering munition fuze	France	40	445
Flail system	UK	480	
Hades munition dispenser	UK	115	50
Millimeter-wave seeker	UK	2,000	4,000
Flare/chaff dispenser switch	Denmark	200	
Total for 8 NATO countries, 19 programs, and 22 systems		22,671	12,537

Because the Europeans have designated the IEPG as the central repository for European collaboration, the United States should consider a policy of directing U.S. industries toward the IEPG. The laissez-faire approach may adequately identify industrial opportunities, but the U.S. government should accept the responsibility for taking advantage of such opportunities if collaboration is to proceed.

U.S.-EUROPEAN COLLABORATIVE PROJECTS

The United States has sold considerably more arms and technology to Europe than it has bought from the Europeans. Some authors refer to this trade as collaboration. If it is indeed collaboration, it is collaboration in which the United States has made few compromises.

The U.S.-European programs that have required a fair amount of compromise, such as those involving codevelopment, have tended to fail. Even where a program succeeded—the 120-mm gun—success came out of the failure of another program—the MBT-70 tank. One exception to these disappointments is the multiple-launch rocket system (MLRS), discussed below.

In the area of coproduction, the United States for a long time exported more manufacturing licenses than it imported. Such exported programs include the highly successful F-16 aircraft coproduction with the Benelux countries and Norway. More recently, however, the U.S. purchase of foreign systems has increased. The U.S. Army, for example, is buying the AT-4 antitank weapon from Sweden and the RITA battlefield communication system from France.

A representative group of U.S.-European collaborative programs is described immediately below. The programs were chosen to illustrate successes and failures; the list is representative rather than exhaustive.

MBT-70 Tank and 120-mm Gun Programs

Under Secretary of Defense McNamara, the United States attempted to collaborate with Germany on the design and production of a main battle tank (MBT). The two countries had agreed in 1962 to cooperatively develop tank components; on August 1, 1963, they agreed to develop the new MBT-70. The first prototype appeared in 1967, but cost overruns and technical hurdles led to the cancellation of the program in 1970. The Germans developed the Leopard II three years later; the United States did not field the M1 until 1979 and the M1A1 until 1984.[30]

The Germans had produced the Leopard I shortly before McNamara approached them with the collaboration proposal. Since they had only just begun to rearm, the prospect of U.S. technology enticed them, and they welcomed the opportunity to collaborate.

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[30]Thomas L. McNaugher, unpublished RAND research, 1979.

The management structure for the U.S.-FRG collaboration proved difficult at best. A committee of U.S. and German military, government, and industry representatives drew up and voted on technical and military requirements; tied votes were often resolved by developing or incorporating both options. Two main armament systems and three engines were developed in this manner.

The Germans usually developed their own version of any component for which the U.S. had responsibility. Thus, they were able to field the Leopard II in a relatively short time, while the U.S. XM-801 program eventually failed.

The MBT-70 program failed because of the basic dissonance in both the military requirements and the time requirement for each force needing a new tank. The Germans wanted a vehicle with high mobility, conventional gun armament, and high nuclear protection but low protection against conventional attack. The United States sought a vehicle with more modest mobility, missile-type armament, low nuclear protection, and high protection against attack by conventional projectiles. They jointly approved a vehicle that would provide high mobility, both gun and missile firepower, high nuclear protection, and high protection against conventional attack.[31]

The resulting tank proved enormously costly and heavy and required a much longer than estimated development time. Table 2 shows the discrepancy between planned cost limits and final cost estimates for the MBT-70 in 1970. The development cost and weight increase caused the greatest problems. Weight seemed to be the trade-off of first choice, and the technical challenges posed by requirements ensured an expensive development.

After the MBT-70 program failed in 1970, a few German components, including the Rheinmetall 120-mm smoothbore gun, were evaluated for use by the U.S. Army. Between 1973 and 1978, Congress, the Office of the Secretary of Defense (OSD), and the Army fought over collaboration on the 120-mm gun: The OSD wanted it as the main armament of the XM1, while parts of Congress and the Army strongly resisted.

Although the Germans were eager for the United States to adopt their 120-mm gun, they set hard conditions. For example, in the 1976 collaboration talks, the United States agreed to the German provision prohibiting the export of M1s carrying the 120-mm gun. This provision, which would also have kept the United States out of the European market, further angered critics of the gun. Germany finally conceded on this point,[32] and the United States procured the 120-mm gun for the M1A1 tank.

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[31]The authors thank David C. Hardison, a RAND consultant, for this discussion.
[32]McNaugher (1979).

Table 2

PLANNED AND ACTUAL TRADE-OFF LIMITATIONS
FOR MBT-70 IN 1970

	Beginning Estimate	Ending Estimate
U.S. development cost	$80 million	$305.4 million
Unit production cost	$532,000	$850,000
U.S. requirement	5400 tanks	2400 tanks
Production target date	1970	1975
Weight of MBT-70	35 tons	50 tons

SOURCE: Homer Johnstone, "Technology Transfer from NATO to the United States Army: An Assessment," Ph.D. dissertation, The George Washington University, December 30, 1975, p. 135.

Multiple-Launch Rocket System Program

The United States, UK, Germany, and France signed the basic MOU for cooperation on the multiple-launch rocket system (MLRS) in July 1979. Italy joined the program in 1982, and it was adopted as a NATO program in 1983. In Phase I of the MLRS program, the United States developed the rocket system and an improved warhead, which it began to produce in 1983.[33] In Phase II, the Germans began to develop the ATII scatterable antitank mine. Phase III envisions the codevelopment of the terminally guided warhead (TGW), a smart antitank warhead for the MLRS.

The combined team of Martin Marietta (U.S.), Thomson-CSF (France), Thorn EMI(UK), and Diehl (FRG) won the initial 28-month development contract for the TGW in October 1984. The TGW is designed to attack armored vehicles from the top, where they are generally considered to be the most vulnerable. If, as seems likely, the MLRS-TGW program survives to deployment in the 1990s, it will be one of the most successful NATO codevelopments that included U.S. participation.[34]

[33]*Standardization of Equipment Within NATO* (1986), p. 54.

[34]See "Four Nations to Build NATO Warhead," *Jane's Defence Weekly*, December 8, 1984, p. 1003; "European MLRS Due in 1987," ibid., May 25, 1985, p. 926.

AMRAAM-ASRAAM Program

The only example to date of the family-of-weapons approach to cooperation involves the agreement between the United States and a European consortium to develop two advanced air-to-air missile systems in the same family. The United States is developing the medium-range air-to-air missile (AMRAAM) and the Europeans the short-range (ASRAAM). According to current plans, AMRAAM will be ready for production by 1988 and ASRAAM by the early 1990s. AMRAAM will replace the Sparrow long-range missile and ASRAAM the Sidewinder.[35]

The European participants in the AMRAAM coproduction program include the UK and Germany; France has also signed the MOU; and Norway wants to participate. Canada and Italy are observer governments.

Hughes, which is developing the AMRAAM for the United States, has promised to keep costs within the original $556 million ceiling despite recent schedule slippages. The secondary producer is Raytheon. The European consortium for the coproduction of AMRAAM includes British Aerospace (UK), Messerschmitt-Boelkow-Blohm (MBB) (FRG), Marconi Defense Systems (UK), and AEG-Telefunken (FRG).[36]

British Aerospace and Bodenseewerk Geraetetechnik form the core of the BBG consortium to oversee the ASRAAM development and production. They plan to distribute the subcontracts as follows: Bayern Chemie (FRG) for the propulsion motor, Thorn EMI (UK) for the proximity fuze, MBB (FRG) for the warhead, Junghaus (FRG) for the safety arming and contact fuze, Dowty for the cooling system, Garrett Manufacturing (Canada) for the actuation gear, and Raufoss (Netherlands) for other components.[37]

F-16 Aircraft Program

The joint F-16 program involves the coproduction with four European countries—Belgium, Denmark, Netherlands, and Norway—of a U.S.-developed aircraft system. Components, such as the airframe, engine, and avionics, are produced in five countries and assembled in three. The aircraft developer, General Dynamics, is the U.S. producer; the European producers are Fokker (Netherlands) and SABCA/SONACA (Belgium).

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[35]See "Contractors for ASRAAM," *Jane's Defence Weekly*, September 28, 1985, p. 662.

[36]See "AMRAAM Slippage," *International Defense Review*, No. 3, 1986.

[37]See "Contractors for ASRAAM," *Jane's Defence Weekly*, p. 662; "ASRAAM Development Slips," ibid., April 14, 1986, p. 13.

The four European governments formed a consortium, referred to as the European Participating Governments (EPG). The United States was originally slated to purchase 650 aircraft and the EPG 348 aircraft.[38]

In June 1975, the United States and EPG signed an MOU covering offtakes, exchange rates, schedules, and production shares. The United States agreed to a European offset amounting to 58 percent of the dollar value of the 348 aircraft that the EPG expected to buy. The offset took the form of a guaranteed production percentage for the EPG contractors as follows: 10 percent of the procurement value of the initial U.S. F-16s, 40 percent of all EPG purchases, and 15 percent of the procurement value of sales outside the consortium.

The five participating countries also decided to keep the F-16 as standard as possible throughout its operational lifetime. Since the program is now being upgraded for the third time, the decision to standardize has resulted in a high level of continued cooperation among consortium members. All except the Netherlands are participating in the third, or operational, capabilities upgrade (OCU); the Netherlands is expected to join later. On the completion of the program, probably in the early 1990s, the United States and the EPG will have approximately 1100 standardized F-16s in inventory.[39]

Roland Missile Program

The Roland ground-to-air missile system is a product of the Euromissile multinational corporation. The Roland was compared with other air-defense systems in 1974, including the British Rapier, the French Crotale, and the U.S. Chaparral; it was considered the superior system for U.S. Army needs.[40] The United States agreed to license-produce Roland in 1975 and chose Hughes Aircraft as the U.S. producer. The U.S. Army cancelled the program after Hughes had built only 31 firing units and 700 missiles. The Army has since sold the balance of its inventory to the New Mexico National Guard.

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[38]For a thorough history of the F-16 program and its economic and other implications, see Michael Rich, William Stanley, et al., *Multinational Coproduction of Military Aerospace Systems*, R-2861-AF, The RAND Corporation, October 1981, pp. 79-120.

[39]See "Five Air Forces to Modernize F-16s," *Jane's Defence Weekly*, April 5, 1986, p. 608.

[40]*Rationalization/Standardization Within NATO*, Department of Defense Report to the United States Congress by Donald Rumsfeld, Secretary of Defense, January 1976, p. 61.

A phenomenal cost growth accompanied the production transfer to Hughes. While the cost growth of most U.S. systems developed during the 1970s averaged 120 percent, Hughes encountered over a 200 percent rise.

Cost-estimation errors were blamed for the growth. The differences between U.S. and European record keeping and manufacturing methods were cited as the primary reason for difficulties in cost estimation. For example, Hughes expected to receive 25,000 supporting documents during the transfer; they eventually received 145,000, 80 percent of which dealt with changes to the original documentation.

Moreover, European manufacturing methods tend to be more labor-intensive than American methods, and the Europeans often use commercial rather than military standard components. Finally, to these complexities were added the abnormal amount of congressional and OSD oversight of the Roland program.[41]

RITA Battlefield Communication System

RITA, a battlefield communications system, somewhat resembles a cellular telephone. Strictly speaking, the United States government is purchasing RITA from a French manufacturer, Thomson-CSF; the U.S. and French governments did not directly negotiate a coproduction framework. However, Thomson-CSF has teamed with the U.S. firm of GTE, and approximately 70 percent of the system will be manufactured in the United States. One may therefore consider RITA a de facto bilateral collaboration.

The total system is estimated to cost $4.3 billion, making it one of the more costly systems purchased by the U.S. Army. The deliverable includes over 8000 mobile radios, 1400 switching centers, and 25,000 telephones over the next eight years. The Army claimed that purchasing RITA will save it $500 million in R&D. Using RITA rather than another communication system will save the Army $8 billion over the 20-year life of the system.[42]

One interesting aspect of the RITA decision is that the only two bidding teams on the project were led by Europeans: Thomson-CSF and Plessey (UK). Earlier, the United States had collaborated in the codevelopment of a system called Mallard, which was similar to RITA, in which the UK, Australia, and Canada also participated. The program progressed well from 1967 to 1969, when the United States unilaterally withdrew. The British went on

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[41]Rich et al., (1981), pp. 56-60.

[42]See "U.S. Tri-Tac System Set to Get Back on Course," *Jane's Defence Weekly*, November 16, 1985, p. 1066; "Ptarmigan, $3.1 Billion More, Loses to RITA," ibid.

to develop and field the Ptarmigan system; the United States started to develop a new system—Tri-Tac—but then decided instead to buy RITA.

AT-4 Antitank Guided Weapon

The AT-4 is a man-portable antitank guided weapon (ATGW) developed by FFV of Sweden, which is not a member of NATO. The U.S. Army plans to purchase some 500,000 of these systems between 1986 and the early 1990s as a replacement for the LAW. FFV is teaming with Honeywell to manufacture them, making this a purely industrial relationship.

Between 1986 and 1989, the Army will purchase 267,000 AT-4s from FFV for $200 million. Thereafter, the DoD will buy all AT-4s from Honeywell. FFV accepted this arrangement primarily because it wants to capture the European market (as it did with the Carl Gustav), but it does not want to expand; therefore, it must restrict its involvement with the United States. FFV views Europe as more likely than the United States to provide a sustained market over a long period.[43]

U.S.-EUROPEAN COLLABORATION IN PERSPECTIVE

The IEPG was established primarily to unify the procurement policies and practices of the Western European nations, a goal it shares with NATO. Europe's success in achieving the NATO-IEPG arms collaboration goal will affect U.S. policies regarding U.S.-European arms collaboration. To estimate this effect, this Note examined past policies and accomplishments in U.S.-European arms collaboration.

Experience seems to have tempered NATO's expectations in fostering arms collaboration. Rather than developing policies for rationalizing arms throughout the NATO community, it has concentrated on bilateral and multilateral collaboration as opportunities arise.

On the civilian side of NATO, the NATO basic military requirement procedure has given way to policies and organizations fostered by the Conference of National Armaments Directors. NATO had created the NBMRs with the aim of unifying national military requirements so that NATO-wide arms collaboration agreements could be reached. The CNAD, through such bodies as the NATO Industrial Advisory Group, focuses on cooperation between ad hoc groups of countries.

The NATO Military Agency for Standardization handles the military issues relating to standardization and interoperability. Although the MAS had earlier attempted to set

[43]Interviews with Honeywell personnel, July 1986.

standardization goals for the entire alliance through STANAGs, it now seeks to increase standardization among a limited number of countries.

Similarly, U.S. arms collaboration policies, while acknowledging the importance of NATO-wide arms standardization, concentrate on ad hoc bilateral or multilateral cooperation. We use the term bilateral here to describe cooperation between the United States and any group of countries. In most cases of bilateral cooperation, the European participants have first organized into an ad hoc group, which then collaborated with the United States on terms approaching equality—hence, bilateral cooperation.

The triad of initiatives, in particular, frames collaboration issues in bilateral terms. Ideally, according to the family-of-weapons concept, the United States would develop missile A, France missile B, the UK missile C, and so on. Practical considerations, however, limit the ideal.

The limitations on the family-of-weapons ideal stem, first, from the difficulty of finding even two weapon systems that might be grouped into a family and meet each country's requirements. So far, only missiles have been suggested for grouping, and only the AMRAAM-ASRAAM family has progressed beyond the talk stage. Second, Europeans often prefer a more structured form of collaboration at the development stage than the family-of-weapons concept provides. Most families of weapons suggested to date define two weapon systems as a family, with the United States slated to develop one system and an ad hoc group of Europeans slated to codevelop the second system.

A more recent U.S. policy, the Nunn amendment, including the NATO comparative test program, holds greater promise for generating widespread arms collaboration within NATO. The amendment fosters cooperation by offering U.S. technology and the possibility of eventual U.S. procurements to nations that participate in cooperative programs with the United States.

Although Europe often relies on the United States for advanced defense technologies, the collaborative programs discussed in this section indicate a large input of European technology. In the ASRAAM and MLRS-TGW programs, for example, the United States is showing a willingness to rely on the R&D abilities of a European consortium. The "big three" European NATO nations—France, Germany, and the UK—are involved in the MLRS-TGW program, and the latter two are participating in the ASRAAM development.

The United States also relies on European technology in procuring weapon systems off the shelf, either through direct purchases or, more likely, through licensed production agreements. The United States has procured systems from European consortiums, such as the Roland missile from the Euromissile group, and from individual nations, such as the

120-mm gun from Germany, the RITA communication system from France, and the AT-4 antitank missile from Sweden.

These examples of U.S.-European arms collaboration, as well as others not included in this study, indicate that greater European cohesion increases the prospects of success of U.S. policies and programs relating to arms collaboration within NATO. Greater European cooperation in arms development and production, as noted, is the goal of the IEPG. Thus, the basic agreement between the goals of U.S. and European collaboration policies should foster the success of both.

IV. MANAGEMENT OF EUROPEAN COLLABORATIVE PROJECTS

The development and production of complex weapons systems require national budgets and indigenous industrial capabilities that many individual European nations cannot afford or believe that they cannot afford. This perception of insufficiency often encourages such nations to seek collaborative development of advanced defense technologies.

The NATO European nations have worked together fairly successfully on several armaments projects ranging from licensed production to codevelopment. Although the problems and issues that it raises make codevelopment the most complex of all types of arms cooperation, European nations have increasingly favored this form because of the perceived benefits to their indigenous defense industries.

Past attempts at collaboration between the United States and European nations have yielded mixed results. Currently, several U.S. initiatives call for increased cooperation between U.S. and European industry for the joint development of selected advanced technologies. A review of European codevelopment projects offers the opportunity to better understand the European experience and, in so doing, to determine whether it offers any lessons for future U.S.-European cooperation.

Many factors—some more controllable than others—contribute to the success or failure of codevelopment projects. National defense policy and economic circumstances, for example, which fall outside the domain of the project, are among the hardest to control. Effective management stands out as one important factor that can be controlled and can contribute to the success or failure of a project. Clear direction and available mechanisms to resolve differences effectively and quickly can make a project function smoothly; their absence can add to its problems.

This section describes six European codevelopment projects involving military aircraft and one involving missile systems, focusing in particular on the management organizations used in each (see Table 3).[1] Because projects under the IEPG's purview are still in the early stages of development and management, only collaborations outside the IEPG are included. However, as noted in Sec. II, above, the IEPG is coordinating the

[1]The discussion and conclusions regarding the Transall and the Atlantic aircraft (immediately following) are based largely on Mark A. Lorell, *Multinational Development of Large Aircraft: The European Experience,* R-2596-DR&E, The RAND Corporation, July 1980. Other data throughout the section were drawn from unpublished RAND research by Geraldine Walter, 1979.

development of the TRIGAT third-generation antitank guided weapon and monitoring the development of the Eurofighter, both discussed in this section.

Table 3

SUMMARY OF EUROPEAN CODEVELOPMENT PROJECTS DESCRIBED IN THIS STUDY

Project	Active Participants	Management Organizations	Year[a] Begun
Transall military transport aircraft	France, FRG	Transall Working Group	1959
Atlantic maritime patrol aircraft	France, FRG	SECBAT	1959
Milan, HOT, Roland antitank missiles	France, FRG	Euromissile	1963[b]
Jaguar fighter & trainer aircraft	France, UK	SEPECAT	1965
Alpha Jet strike/ trainer aircraft	France, FRG	French, German industry & govt	1969
Tornado multirole combat aircraft	FRG, Italy, UK	Panavia	1969
Eurofighter aircraft	FRG, Italy, Spain, UK	Eurofighter GmbH	1976[c]
Third-generation guided missiles	France, FRG, UK (Italy, Belgium, Netherlands, Greece, Spain)	Euromissile Dynamics Group	1979

[a]Unless otherwise noted, dates refer to first formal agreement.
[b]Discussed at the end of this section together with third-generation guided missiles.
[c]Beginning of discussions; serious negotiations continue.

TRANSALL MILITARY TRANSPORT AIRCRAFT

France and the Federal Republic of Germany jointly developed and produced the NATO-sponsored Transport Alliance (Transall) aircraft. Because for the first time the participants addressed such difficult issues as joint accounting procedures and politically acceptable work allocation, some observers have concluded that the Transall marks the true

beginning of NATO aircraft codevelopment. Other NATO-sponsored collaborative projects developed before the Transall, such as the NATO G.91 lightweight strike fighter and the Atlantic maritime patrol aircraft, were conducted for the most part on a national basis and thus avoided some of the thornier issues of collaboration.

In 1959, France and West Germany signed an agreement to cooperatively develop and produce a transport aircraft. From the beginning, disagreements over requirements and specifications plagued the project. These and other problems, including competing U.S. and European political agenda, contributed to serious disruptions in the project in 1959, 1963, and 1967, bringing it close to cancellation several times.[2]

The Transall was inextricably linked to Franco-German relations, U.S.-German relations, and German domestic politics, the last often at variance with the spirit of cooperation. During this time, both France and the United States made strong attempts to influence German armaments policy through treaties, agreements, offset arguments, and offers of off-the-shelf, less costly hardware. Despite Germany's lack of enthusiasm for the project during periods of its participation, it nevertheless remained in the program for political and other reasons.

The Transall began with a design based largely on French technology, specifically, the Noratlas, a transport aircraft built by the French aircraft firm Nord-Aviation, now part of Aerospatiale. As early as August 1954, the French had begun to generate requirements for the replacement of the Noratlas. The Germans also wanted to replace their Noratlas inventory. At the same time, Nord-Aviation, concerned about the prospective shutdown of three of its aircraft assembly lines as Noratlas production wound down, sought to begin the development of a next-generation transport aircraft.

Defense budget problems eventually caused the French to abandon their plan to procure the proposed transport aircraft unilaterally. The French government initiated discussions with defense representatives of Germany and Italy to explore the possibility of collaboration. Although Italy participated in the early joint development negotiations, it did not become a collaborative partner.

Despite the common need for a new transport aircraft and interest in pursuing joint design and production, French and German requirements for the Transall differed considerably. The French wanted a long-range, large-capacity transport designed for maximum performance in a desert environment to support their military commitments in North Africa. The Germans needed a short-to-medium-range, medium-capacity transport

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[2]See Lorell (1980), p. 46.

with short takeoff and landing (STOL) capability, designed for central European climatic conditions.

Germany almost withdrew from the Transall project in the early 1960s. In 1963, attempts to strengthen the transatlantic bonds between Germany and the United States contributed to the deterioration of Franco-German relations. At the same time, cost growth and schedule delays made the Transall program extremely vulnerable to attack in Germany. Franco-German relations were further exacerbated when the Germans unilaterally withdrew from a joint tank-procurement venture with France and instead signed an agreement with the United States to develop a main battle tank.

During negotiations on requirements, the German government and industry were concerned with the differences between French and German requirements and with the possibility of a production gap in Germany between the Noratlas and the Transall programs. As a result, the Germans gave serious consideration to coproducing American C-130 transport aircraft rather than participating in the Transall project.

Several factors contributed to Germany's willingness to make significant concessions to the French. First, in 1963 Germany had signed the Franco-German treaty calling for bilateral weapons collaboration with France. Because other prospective joint programs with France had failed to materialize, the Transall offered an important opportunity to keep Franco-German weapons collaboration alive.

Second, an agreement with France to codevelop the aircraft would enable Germany to develop and expand the capability of its national aerospace industry. The industry had started up again in 1955 and was trying to recover from its setback of the previous decade. Unlike the U.S. proposal of licensed U.S. technology for the production of C-130s, the French offer gave the Germans a large role in the actual development of the Transall aircraft, and thus a boost to its manufacturing lines, as well as its design and technical capabilities.

As the political climate between Germany and the United States cooled, the Germans sought to reaffirm their European ties in the face of feared U.S. withdrawal of military support in Europe. This reversal gave the Transall program the support that it needed for continued survival.

The French allegedly yielded the project leadership to Germany because the FRG had just compromised extensively on joint requirements and had a stronger budget than France. Furthermore, the French wanted to block the proposed deal between the United States and Germany for the coproduction of C-130s and were willing to compromise significantly to encourage the FRG to remain in the Transall program.

By January 1959, the French and German governments had agreed on joint requirements that satisfied neither side's needs completely, Germany's even less than France's. Nevertheless, the two signed an agreement later that year to design and develop the transport and to divide development work and cost equally. In July, the German firm Weser was designated the Transall project leader.

The Transall collaborative agreement did not provide for an international management organization. Instead, the bilateral Transall Working Group was created to organize the work of the participating firms and to manage the development and production of the Transall. The participating German aerospace firms—Weser, Blume, and Hamburger (now part of Messerschmitt-Boelkow-Blohm [MBB])—worked jointly with the French firm Nord-Aviation. The governmental Steering Committee, in charge of overseeing the program, relied on the Direction Technique et Industrielle de l'Aeronautique (DTIA), the aviation procurement directorate of the French Ministry of Defense (MOD), to implement its decisions (see Fig. 3).[3]

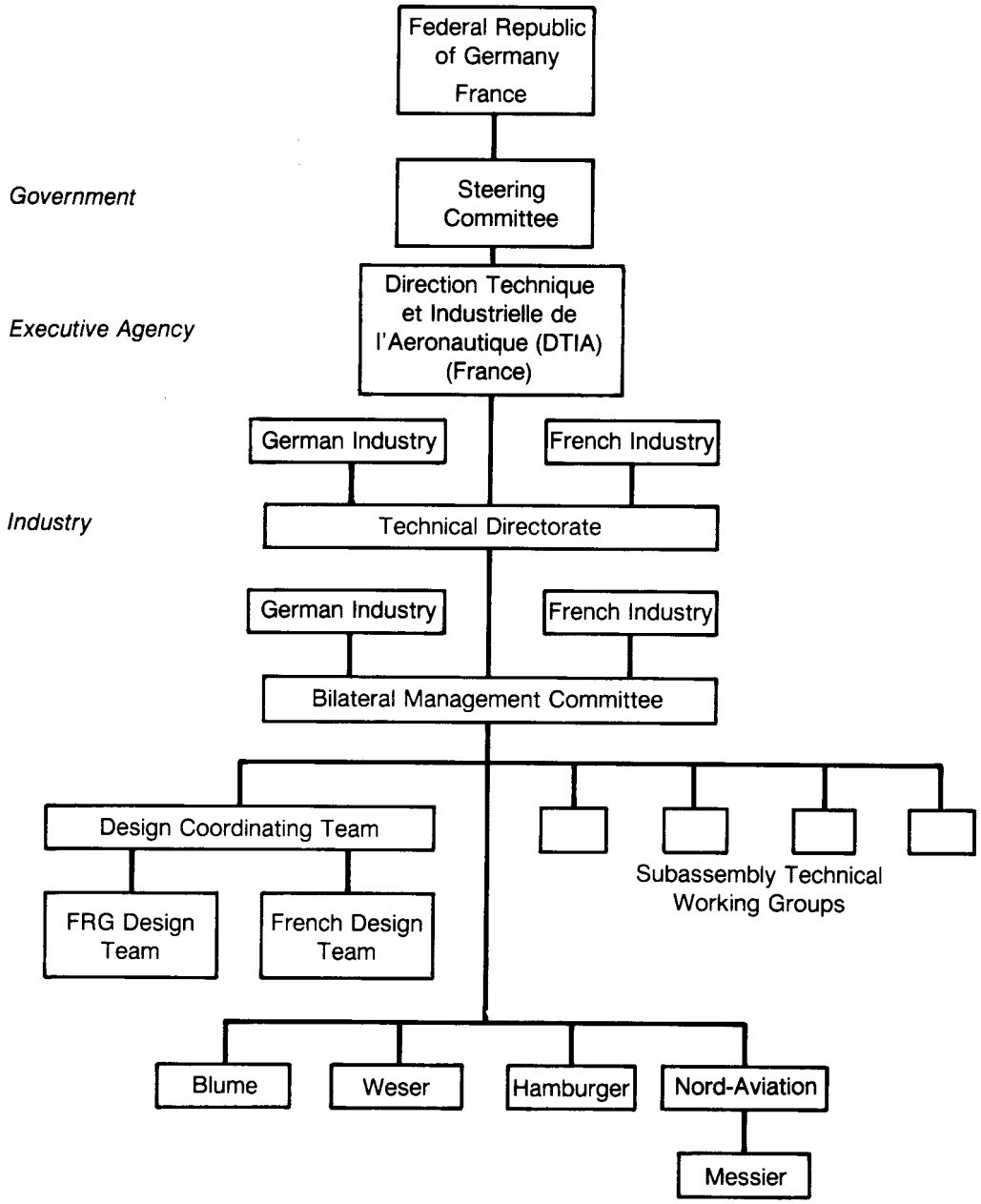
At the industrial level, a bilateral technical directorate with eight members (two from each company) met once a month to coordinate technical activities. Below the directorate, a bilateral management committee of four industrial representatives met twice weekly in Lemwerder, Germany. At the working level, the three German firms together formed a design team, and Nord-Aviation set up its own French design group. A joint coordination team at Weser, in Bremen, pulled together the two efforts. Finally, technical working committees were created for each major subassembly.

The Transall Working Group operated on the principle of equality, with no central authority functioning at any level. This practice led to stalemates and schedule delays whenever the partners disagreed. Moreover, a proliferation of bilateral committees seriously complicated program coordination; the problem was exacerbated by the lack of any clear authority.[4]

The absence of an effective mechanism for handling disagreements over work-sharing agreements meant that the resolution of impasses required meetings and negotiations that were costly and often caused delays. Differences in French and German industrial and governmental procedures, working methods, and financial practices also proved difficult to

[3]The DTIA was renamed the Direction Technique des Constructions Aeronautiques (DTCA) in 1965 and the Direction des Constructions Aeronautiques (DCAe) in 1984.

[4]Lorell (1980), p. 36.



SOURCE: Mark A. Lorell, *Multinational Development of Large Aircraft: The European Experience*, R-2596-DR&E, The RAND Corporation, July 1980, p. 37

Fig. 3—Transall Working Group

arbitrate.[5] Moreover, although France had agreed to German project leadership, the French allegedly tried to thwart any substantial exercise of that leadership. Under the resulting bilateral management structure, authority was diffused and veto power was widespread. French advocates of collaboration blamed this situation for the project's difficulties.[6]

The last aircraft of the original order were delivered to the French and German air forces in 1973. Production lines were reopened in 1977, when the French reordered and the Indonesians decided to purchase Transalls. Although the second production run ended in 1985, the production tooling remains in place against the possibility of future orders.

ATLANTIC MARITIME PATROL AIRCRAFT

Had the Atlantic antisubmarine warfare (ASW) aircraft been procured on a NATO-wide basis as was originally planned, this effort would have gone a long way toward achieving RSI goals. In the late 1950s, NATO nations decided to replace the Neptune P-2, a maritime patrol aircraft. In March 1957, the NATO Armaments Committee established a panel to advise NATO on how to proceed.

The committee drew up and issued NATO-wide requirements for a new naval reconnaissance aircraft in January 1958. Six months later, member nations were invited to submit competitive design studies; 25 were received. In October, NATO unanimously recommended the proposal of the French firm Breguet for the Atlantic aircraft.

Originally six nations—Belgium, Britain, Canada, France, the Netherlands, and the United States—showed interest in buying the selected aircraft. When the French design won, however, Britain, Canada, and the United States withdrew from the list of prospective buyers.

In the end, France and West Germany developed and primarily produced the Atlantic, with financial support in the R&D phases from the United States, Belgium, and Netherlands. Although it did not add the Atlantic to its own inventory, the United States financed nearly one-third of the project's R&D costs; France was the other main contributor.

The participants in the Atlantic's R&D made the joint financing arrangements and signed the governmental oversight and industrial management agreements on December 4, 1959, giving France the design leadership. However, Breguet had begun the R&D of the Atlantic the previous February—before agreements were signed—under the auspices of the French government. Thus, in granting France design leadership, the other participants in

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[5]For example, the project had to cope with differences in accounting methods, currencies, sales taxes, and custom duties.

[6]See Lorell (1980), p. 46.

effect gave the French the authority and influence over the project that they had assumed from the beginning.

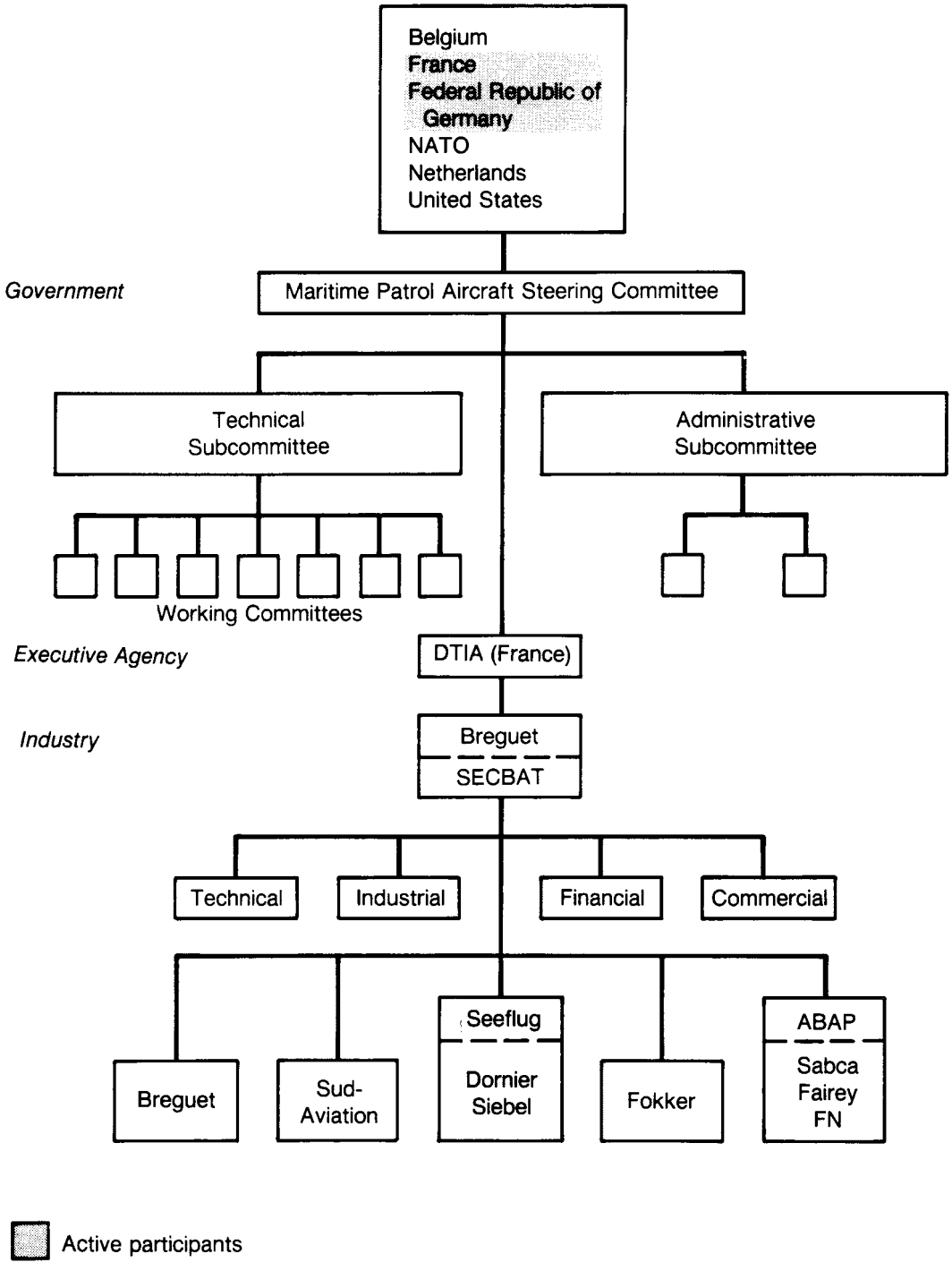
Also on December 4, 1959, the project participants established the Maritime Patrol Aircraft Steering Committee to interface between NATO and project management (see Fig. 4). A representative of each of the five sponsoring countries, plus a NATO observer and secretary, made up the main committee, which had a technical and an administrative subcommittee.

Three days after the creation of the governmental steering committee, a joint industrial company, the Societe Europeenne pour la Construction du Breguet Atlantique (SECBAT), was established to coordinate the development of the Atlantic aircraft. SECBAT was allegedly created to distribute the legal and financial responsibility and risk among all industrial participants in the program. Breguet, however, retained the overall management authority.

As was the case with the Transall Working Group, the French DTIA, which became the executive authority for SECBAT, carried out the steering committee decisions. The DTIA managed the Atlantic program in the same way it did French programs. It awarded the Atlantic contracts to Breguet, which, acting as the prime contractor, subcontracted to other participating firms, in particular Dornier (FRG). It also supervised the work of SECBAT.

In 1968, after placing an order for Atlantic aircraft, the Italian government joined the project; a year later, four Italian manufacturers joined SECBAT. The industrial members of SECBAT then included Breguet and Sud-Aviation (France); Seeflug, an association consisting of Dornier and Siebel (FRG); Association Belge pour l'Avion Patrouilleur (ABAP), a Belgian group including Fairey, SABCA, and Fabrique Nationale; Fokker (Netherlands); and Aerfer plus three other Italian firms. The Societe Nationale d'Etude et de Construction de Moteurs d'Aviation (SNECMA) built the engine for the Atlantic under license from Rolls-Royce.

The French effectively assumed authority over SECBAT. Representatives of each major industrial participant chaired the SECBAT administrative committee on a rotating basis. However, the administrative committee delegated all final authority to a permanent, nonrotating French managing director, who appointed technical, industrial, financial, and commercial directors. His naming of many compatriots to key posts in SECBAT ensured French domination of the project management.



SOURCE: Mark A. Loreli, *Multinational Development of Large Aircraft: The European Experience*, R-2596-DR&E, The RAND Corporation, July 1980, p. 20.

Fig. 4—Atlantic Management Organization

The French took several bold unilateral steps during the Atlantic R&D. As noted above, they began Phase I of the R&D ten months before the collaborating nations had reached final agreements. Phase I called for the design, construction, flight testing, and development of two prototypes. In mid-1960, the other sponsors failed to approve a French attempt to expand the initial R&D program. The French, however, proceeded unilaterally with Phase II in January 1961, financing it alone for 18 months. Finally, on June 29, 1962, the United States, Belgium, Netherlands, and Germany agreed to help finance Phase II.[7]

The Atlantic project did not duplicate component manufacture. Except for the A-300B Airbus, the Atlantic project was the only European codevelopment venture to have a single final assembly line. The fact that France dominated the project partially explains this lack of duplication. In later projects, when members considered themselves equal, duplicative efforts occurred more frequently.

The Atlantic may be the only example of an aircraft codevelopment program that NATO initiated and completed. Compatible requirements, similar specifications, coinciding replacement schedules, and strong program leadership contributed to the Atlantic's technical success.

The original production was completed in 1974. In 1979, the French government told Dassault-Breguet to begin the development of the Atlantic new-generation aircraft, the ATL-2. Although France sought collaborators, the ATL-2, which is now in production, remains a French national program.

JAGUAR FIGHTER AND TRAINER AIRCRAFT

The Jaguar evolved from separate strike/trainer aircraft programs in France and the UK. Collaborative efforts were begun after the British and French defense ministers learned of the simultaneous efforts in the two countries.[8]

In October 1964, the Royal Air Force (RAF) issued requirements for a supersonic training and ground attack aircraft. Although the British Aircraft Corporation (BAC) conducted extensive research on the development of a variable geometry fighter aircraft to be used for training, the project was finally cancelled in the initial stage of development.[9] The possibility of cost overruns and technological inadequacies in the program posed unacceptably high risks for the British government.

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[7]See Lorell (1980), p. 21.

[8]Arthur Reed, *Modern Combat Aircraft 14: SEPECAT Jaguar,* Ian Allan Ltd., 1982, pp. 6-7.

[9]The British Aircraft Corporation later became the British Aerospace Corporation.

Meanwhile, the French air force had developed specifications for a small subsonic trainer with an optional role as a light attack aircraft. During the same year, French aerospace companies, including Breguet, Nord-Aviation, Dassault, and Sud-Aviation, submitted design studies for a French national combat training and tactical support (*ecole de combat et d' appui tactique* [ECAT]) aircraft. The Breguet 121 design won the competition.

Government representatives of France and the UK signed an MOU in May 1965 in which the two countries agreed to collaborate on several aerospace systems, including helicopters, jet engines, the Martel missile, and two fighter-attack aircraft: the Jaguar and a proposed Anglo-French variable geometry (AFVG) penetrator aircraft.

The agreement included the joint development and production of (1) an aircraft based largely on the Breguet 121 design that became the Jaguar and (2) a variable geometry aircraft similar to the British P-45. The French took over the design phase of the Jaguar airframe with the understanding that the British would undertake the airframe design of the proposed AFVG. The French later withdrew from the variable geometry project, effectively forcing its cancellation in 1967.

British and French specifications and schedules were among the first topics for negotiations concerning the Jaguar project. The British wanted only a supersonic trainer; the French sought both a tactical and a training subsonic aircraft. With regard to schedules, the French wanted their aircraft in service by 1970, three years before the British required theirs. The British also wanted more sophisticated avionics than did the French, an important difference in terms of cost.

By October 1965, the two sides had agreed on the major aspects of the project: The Jaguar was to be a twin-engine tactical support and supersonic training aircraft projected to enter service by 1971. Five versions of the aircraft were to be developed, reflecting the different purposes it was expected to serve. Each country was to develop its own avionics.

The Jaguar engine was based on French and British designs. In 1965, Rolls-Royce (UK) and Turbomeca (France) had conducted research independently on engines suitable for military and commercial applications. The Rolls-Royce and the Turbomeca engine technologies eventually were combined in the Adour engine. After competing against Bristol-Siddeley/SNECMA to develop the Jaguar engine, Rolls-Royce and Turbomeca won the contract with the Adour in May 1966. The two firms formed a joint company, Rolls-Royce Turbomeca Ltd., to develop and produce the Jaguar engine.

The French and British sought to split the management of the Jaguar project evenly. France received the design leadership of the airframe. Breguet and the British Aircraft Corporation, the principal airframe firms for the Jaguar, on May 10, 1966, set up a joint company, the Societe Europeenne de Production de l'Avion Ecole de Combat et d'Appui Tactique (SEPECAT), in Paris, under French law. The British won the design leadership of the Jaguar engine. They formed a joint company, Rolls-Royce Turbomeca Ltd., in the UK, subject to British law.

Work was shared evenly between Breguet and BAC for the airframe and between Turbomeca and Rolls-Royce for the engine. Later, France and the UK each had an assembly line for the airframe and engine.

The Anglo-French Jaguar Management Committee supervised SEPECAT. This committee consisted of one representative each of the British Ministry of Technology, the British Ministry of Defense, the Direction Technique des Constructions Aeronautiques (DTCA) under the Delegation Ministerielle pour l'Armement (DMA), and the French Air Staff (see Fig. 5). Three subcommittees—airframe, engine, and administration—reported to the management committee. Other representatives of the DMA, Ministry of Technology, and industrial companies involved handled sales.

Contracts were distributed symmetrically between British and French firms. The DTCA, acting as the executive authority for both the British and French governments, let the contracts for the Jaguar airframe and provided technical direction. The British Ministry of Technology, also acting as the executive authority for both governments, let the contracts for the Adour and gave the program technical direction. Under this management system, when the DTCA received aircraft purchase orders from the British and French governments, it forwarded airframe contracts to SEPECAT; SEPECAT then issued instructions to the participating companies to fill the orders.

The management committees of SEPECAT and Rolls-Royce Ltd. were similarly organized. SEPECAT was a ghost company with no permanent employees or separate physical facilities. This arrangement ensured low overhead costs and no personnel layoffs when the project ended. SEPECAT's management structure (see Fig. 6) included a board of directors at the top, a management committee (different from the Jaguar Management Committee), and representatives of BAC and Breguet. Three representatives each from BAC and Breguet sat on the board of directors; the chairmanship alternated annually between the two companies.

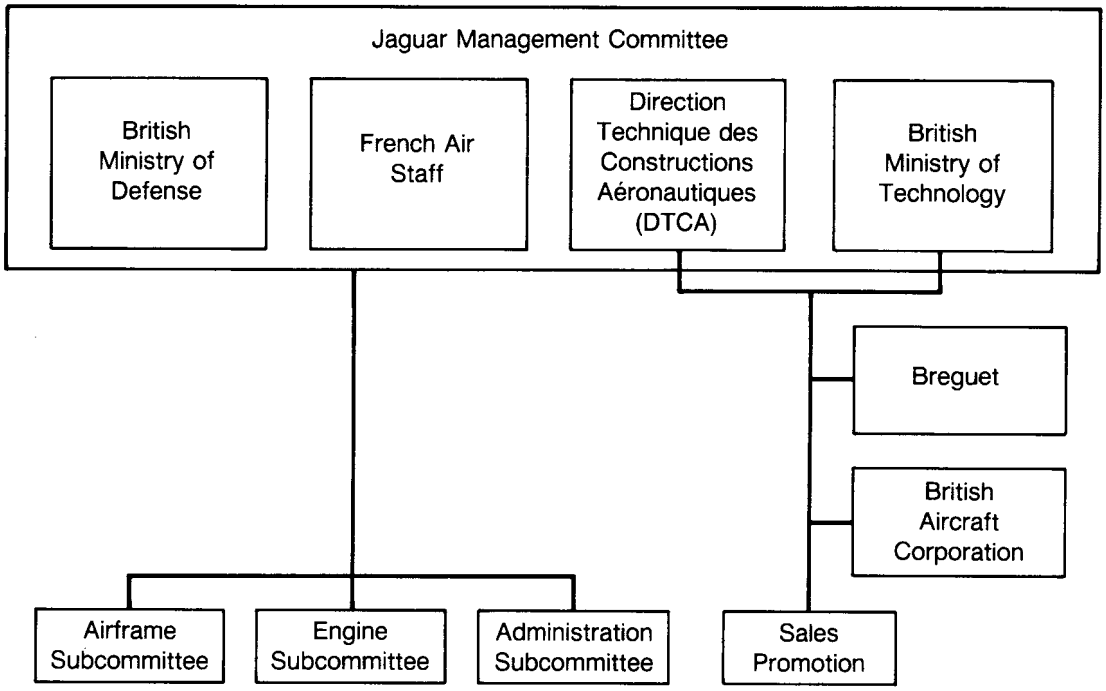

Fig. 5—Jaguar Management Committee, the SEPECAT Supervisory Board

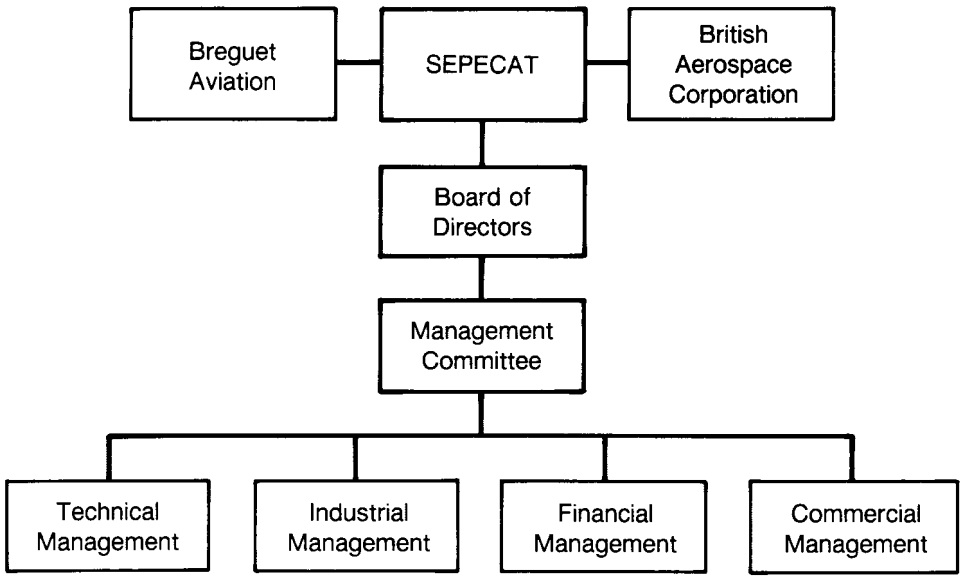

Fig. 6—SEPECAT: Industrial Management Structure of Jaguar

On the next level down, the SEPECAT management committee supervised the engineering, production, commercial, financial, and sales activities of the Jaguar project. The primary responsibility for each of these functions rested with a member of the management committee from one company whose deputy came from the other company. Breguet oversaw design and production management; BAC, finance and sales. Members of the management committee answered to the boards of both SEPECAT and Rolls-Royce Turbomeca Ltd., as well as to their own company.

Although SEPECAT had been designated the main contractor for export sales, it lacked the necessary mechanisms. Consequently, both BAC and Dassault-Breguet marketed the Jaguar.[10] If BAC signed the contract, then it became the prime contractor, with Dassault-Breguet assuming the subcontractor role, and vice versa. The last Jaguars of the original order were delivered to the French and British air forces in 1981.

Overall, the French dominated the program, as evidenced by the fact that Breguet built all of the prototypes, albeit using mixed teams of employees from each company. The French also took the lead in the flight test program of the development models: Breguet, using French pilots, tested six of the eight models; RAF pilots tested two.

The Jaguar project failed to meet some of its original goals. The aircraft was unsuited as the trainer for which it had been intended and cost more than planned—by some reports, four times the original ceiling set by the French. Moreover, in both countries, other aircraft eventually took over part of the Jaguar's role. The French later collaborated with Germany to develop the Alpha Jet, and the British, on their own, developed the Hawk trainer.

ALPHA JET TRAINER AND CLOSE SUPPORT AIRCRAFT

In the late 1960s, Germany and France issued similar requirements for a trainer aircraft. In response to its own country's requirements, Dassault, a French aircraft manufacturer, and Dornier, a German one, concurrently but independently conducted design studies for a next-generation trainer. The eventual recognition of these redundant efforts led to preliminary talks concerning the joint development of a common aircraft.

Following an agreement between the two firms, the French and German governments agreed in May 1969 to organize a design competition for a trainer aircraft. Two transnational efforts to develop a winning design evolved: Dassault and Breguet of France

[10]Dassault and Breguet began to merge in 1967; the merger was completed in 1971.

and Dornier of Germany developed the Alpha 501 Jet design, and Messerschmitt-Boelkow-Blohm (MBB) of the FRG and Sud-Aviation and Nord-Aviation of France cooperated on the Eurotrainer design.[11] This pairing of industrial teams contributed to the competition's success by enabling both countries to win with either choice of consortium.

The Alpha Jet design won the competition. In July 1970, France and Germany agreed to prepare the project definition jointly and to split production equally. The agreement named Dassault-Breguet the prime contractor for the airframe and Dornier the associated contractor. Another consortium composed of two French companies, SNECMA and Turbomeca, was named prime contractor to coordinate the development of the Alpha Jet engine, the Larzac 04. Each nation agreed initially to procure 200 Alpha Jet aircraft.

Germany's changing requirements for a trainer and export policy differences with France delayed the final agreements. Germany had originally wanted a trainer that would also have close air support capabilities. It planned to have German pilots train with the French air force in the Alpha Jet, rather than with the U.S. Air Force in U.S. aircraft as they had been doing. However, the United States wanted German pilots to continue to train in the United States so as to partially offset the cost of stationing U.S. troops in Western Europe, and the Germans acceded.

Germany's decision to continue U.S. training for Luftwaffe pilots substantially undercut its rationale for remaining in the Alpha Jet program. Forced to modify its requirements if it was to continue in the program, it finally decided on the Alpha Jet solely as a strike/reconnaissance or close air support aircraft to replace the Fiat G.91.[12] The French requirement continued to call for a trainer.

Once the Luftwaffe had formally issued requirements for the close support aircraft (rather than the trainer), serious negotiations with France began. In February 1972, several years after concluding the original agreement to collaborate, the two countries signed an MOU to develop the Alpha Jet. They agreed to develop two versions—a trainer/light-attack aircraft for the French air force and for export and a close-support aircraft for the Luftwaffe.

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[11]Sud and Nord later merged with Aerospatiale (Societe Nationale Industrielle Aerospatiale [SNIAS]).

[12]The trilaterally developed MRCA aircraft (see the subsection immediately following), originally destined to assume the close support role required by the German air force, had become too heavy. At this time, the Germans had not yet decided on a strike/reconnaissance aircraft.

Differing policies concerning sales to third countries later precipitated a new round of discussions. The Germans wanted to restrict sales to NATO allies, whereas the French sought a much wider market. In the end, a development agreement signed in 1975 permitted the French unrestricted export of only the Alpha Jet trainer.

The French dominated the Alpha Jet project. In the development phases both the French and German assembly lines followed the Dassault prototyping approach. The fact that the Alpha Jet program helped to expand Dornier's industrial capability may explain why Germany continued to participate in a project that did not fully meet its requirements.

The July 1970 agreement had designated the DTCA as the executive agency for the project definition phase. It later became the bilateral government management committee, responsible to a steering committee composed of an equal number of French and German members (see Fig. 7). The management committee, which represented governmental oversight of the project, was advised by a French and a German air force representative and an engineer from each nation. A report produced at the end of the definition phase made recommendations for project development.

In the development phase, another member from each side joined the management committee to handle finance and contract responsibilities. The committee had 16 members and convened semiannually. In addition, an integrated team of Breguet and Dornier representatives was created and located just outside Paris. This produced a three-tiered

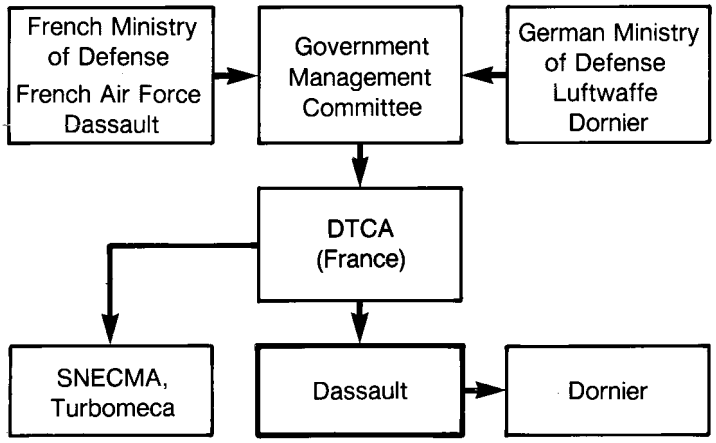

Fig. 7—Alpha Jet Management Structure

management structure: the bilateral government management committee on top; the executive agency (DTCA) in the middle; and an industrial consortium, with Dassault as the prime contractor, at the bottom.

The DTCA placed contracts with Dassault, which subcontracted to Dornier and German equipment manufacturers. Contract prices were fixed in both currencies according to a formula that took into account the respective inflation rates. All invoices were channeled through Dassault, which then submitted them to the DTCA. The DTCA paid Dornier and other German firms with funds that the German government posted with the DTCA. This method of operation aimed in part at minimizing problems associated with currency fluctuations between the mark and franc, a problem that the Jaguar project had also encountered.

Although each country believed that the aircraft could serve its own requirements, differing needs and practices delayed the start-up of production. The German tactical aircraft, for example, called for more detailed requirements than the French trainer. Moreover, the Germans sought frozen requirements and more testing before entering the production phase. The French, in contrast, had greater confidence in the aircraft and took risks more willingly. Production finally began in 1976.

In 1983, Dornier assembled the final aircraft of the original order for the German air force. A new-generation, modernized attack/advanced trainer, the NGEA, is being developed for export.

TORNADO MULTIROLE COMBAT AIRCRAFT

Germany, Italy, and the UK began to develop the Tornado MRCA in 1970. The two agreed-on versions of the aircraft—the interdiction and strike (IDS) aircraft and the air defense variant (ADV), the latter only for the British—entered service in 1982 and 1983; the original production run of slightly over 800 is expected to be completed in 1987 or 1988. Panavia, a multinational corporation representing MBB (FRG), British Aerospace Corporation (UK), and Aeritalia (Italy), coordinated the development and production of the Tornado.

In 1967, Germany sought to develop and produce a fighter/strike aircraft to replace its F-104G Starfighters and G-91s by the late 1970s; the German air force began to determine the requirements for the proposed aircraft. Several concerns eventually led Germany to abandon its unilateral effort, including the high cost estimates for developing and producing the aircraft, German industrial uncertainty regarding its own technical capability, the

military's reservations concerning sustained and adequate German government funding, and political sensitivity to an ambitious German weapons system program.[13]

Having made the decision to drop their national program for the next-generation fighter aircraft, in late 1967 Germany convened a group of interested NATO members to discuss the feasibility of jointly developing a strike aircraft. This working group included Belgium, Canada, Germany, Italy, and the Netherlands; the UK joined in 1968, shortly after the group's first meeting. All signed an MOU declaring their interest in the joint development of a multirole, variable-geometry aircraft. Belgium and Canada withdrew in late 1968.

The British, Dutch, Germans, and Italians continued to discuss the codevelopment of the MRCA. Final agreements concerning the aircraft that was to become the Tornado were reached only when these negotiations were tied to other projects of keen interest to Britain and Germany. In exchange for the design leadership of the MRCA program, the UK agreed to participate in the Airbus program, a project in which Germany, already a committed partner, sought British participation. When the French offered Germany equal partnership in the development of the Dassault Mirage G1 strike aircraft, Germany relinquished to Great Britain its claim on the design leadership of the Tornado. The UK was also chosen as the site for the main Flight Test Management Group.

The British wanted a swing-wing design, two-seat, long-range aircraft. The Germans, Italians, and Dutch sought a single-seat, shorter-range aircraft. They finally agreed to develop two versions: an interdiction and strike aircraft and an air defense variant. The two have almost identical airframes, engines, and aircraft systems; swing-wing STOL and fly-by-wire capability; and two-man crews. Their radar systems, avionic software, and submunitions differ.

To organize all design and development work for the codevelopment and coproduction of the aircraft, the Germans preferred the creation of an international company with an integrated staff rather than the less-centralized management arrangement favored by the British. Germany offered office space in Munich for the proposed company headquarters, while the UK advocated a British site. Eventually the German plan prevailed. In late 1968, the participants agreed to form Panavia, an international company that would manage the development of the aircraft and would be located in Munich.

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[13]Germany also explored with the United States the possibility of jointly developing a vertical/short takeoff and landing (VSTOL) fighter/ground attack aircraft, but nothing substantive came of these talks.

In June 1969, the Netherlands withdrew from the proposed collaboration, leaving Britain and Germany firmly committed to the project and Italy undecided. Panavia settled on basic mission requirements even before the participants signed formal financial commitment agreements. Once financial agreements were reached, the trilateral company proceeded to develop system design requirements and to designate the three major national aircraft industries for airframe development and production.

As had been the case with the design leadership, requirements and work allocations for the MRCA resulted from a mixture of military and industrial preferences and political compromises. The UK had just entered the European Economic Community (EEC), and both Britain and the other members wanted to appear accommodating. For instance, the Rolls-Royce engine chosen for the aircraft may not have been technically optimal. Moreover, work was allocated on other than technical grounds. The development work for wing joints, for example, a critical piece of the aircraft, went to Dornier (FRG), which had less background in this area, less designing capability, and less technological capacity than British Aerospace. These examples of compromise typify European collaborative efforts.

The NATO MRCA Management Organization (NAMMO), which draws its personnel from NATO and the member governments, represents Germany, Italy, and the UK in the Tornado project. NAMMO, created in 1969 as the primary policymaking body for the MRCA program, is located in Brussels. The NATO MRCA Management Agency (NAMMA), the executive body of NAMMO, occupies the same building as Panavia in Munich.[14]

The companies participating in the Tornado formed consortia to organize work on specialized technology required for the aircraft, such as the engine and avionics. In fall 1969, a Rolls-Royce engine was selected for the Tornado. A second international company, Turbo Union, was established in the UK to coordinate the development and production of the engine. Like Panavia, Turbo Union reports to NAMMA.

NAMMA assigned the MRCA avionics prototype development to the British consortium Elliott-Automation Space and Advanced Military Systems (EASAMS), which reports to Panavia, thus acting as a Panavia subcontractor. EASAMS contains two national consortia: the German Elektronik System Gesellschaft (ESG) and the Italian Societa Italiana Avionica (SIA). MBB took over responsibilities from EASAMS when a Tornado prototype, the Panavia 200, began flight testing.

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[14]Interview with Panavia personnel, May 26, 1986.

Despite higher cost estimates than anticipated, in July 1970 the German and British government formally approved the initiation of the prototype development phase. In September, the Italians also agreed to participate.

The FRG, Italy, and the UK signed the Tornado production agreement in July 1976, and the aircraft entered service in 1982 and 1983. The total projected national commitment as of January 1986 was 220 IDS aircraft for the UK, 324 for Germany, and 100 for Italy, plus an additional 165 of the ADV for Britain. The last of the more than 800 Tornados are expected to roll off the three national assembly lines in 1987 or 1988.

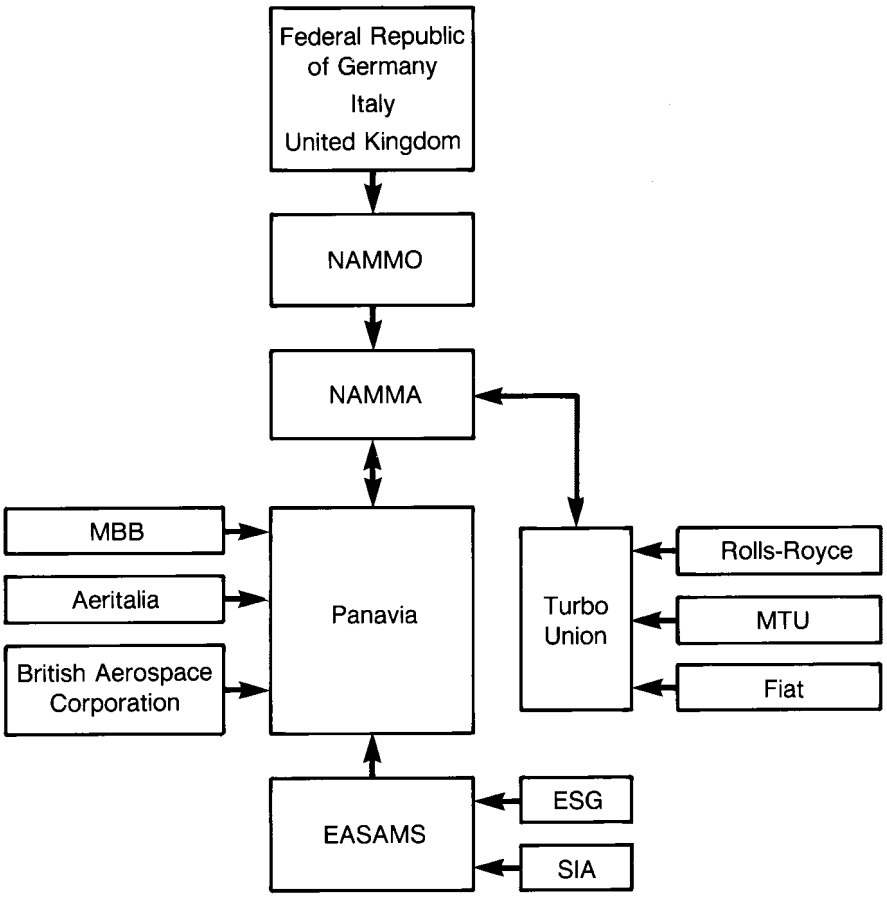

Fig. 8—Tornado MRCA Management Structure

[15]Interview with Panavia personnel, May 26, 1986.

Project management was more clearly defined in the Tornado project than in earlier codevelopment projects, such as the Transall and the Atlantic. Panavia personnel attribute the Tornado project's relatively efficient decisionmaking to (1) the single interface between the three industries, represented by Panavia, and the three governments, represented by NAMMA, and (2) the colocation of the management organizations in Munich (see Fig. 8).[15]

On the industrial side of program management, Panavia, representing corporations from the three participating countries, is incorporated under German law. The trilateral company's board of directors consists of six members drawn from the three member industries, Aeritalia, British Aerospace, and MBB. Panavia has a managing director and seven functional managers, including two directors of system engineering and a director each of program management, finance and contracts, production, procurement, and marketing. Panavia personnel, drawn largely from the three constituent corporations, rotate positions of responsibility, thus sharing equally in decisionmaking.

Unlike SEPECAT and SECBAT, the ad hoc development organizations of the Jaguar and Atlantic projects, Panavia has maintained control of the Tornado program from the beginning of development into the production stage. Moreover, Panavia would like to take on the responsibility for developing and implementing a common logistic and product support arrangement to bring the customer and manufacturer together more cost-effectively.

The three principal companies in Panavia serve as the prime contractors. They are authorized to subcontract to other companies. Design leadership was allocated to British Aerospace for reasons noted above. The airframe development and production were apportioned as follows: Germany, 42.5 percent; the UK, 42.5 percent; and Italy, 15 percent.

Like Panavia, Turbo Union is composed of one company from each of the participating nations: Rolls-Royce, MTU, and Fiat. The engine development work was allocated proportionally to the major participants based on their procurement intentions and investment. As noted, Turbo Union reports directly to NAMMA.

The three participating countries shared the flight testing and prototype assembly. They avoided wasted time and redundancy by not duplicating testing responsibilities. They similarly divided construction of the prototypes.

By May 1986, Panavia controlled an estimated 500 subcontractors for the Tornado project, in addition to the three prime contractors. Airframe design and production were divided among the principal industries in terms of subunits. The responsible company fully assembled and tested the various components and then shipped them to a factory in each country, which assembled that country's aircraft. Although less cost-effective than a single assembly line, European nations use this method because they are unwilling to give up the new industrial capabilities involved.

EUROPEAN FIGHTER AIRCRAFT (EUROFIGHTER)

The European fighter aircraft (EFA) or Eurofighter program proposes a European solution to the problem of replacing European fighter aircraft for the mid-1990s and beyond. Discussions of the Eurofighter began in the late 1970s. On October 22, 1986, the defense ministers of Britain, Germany, Italy, and Spain signed a memorandum of understanding committing their governments to continue work on the EFA. They will make future commitments to the EFA program phase by phase.

The EFA project came about because Britain, Germany, Italy, and Spain faced similar replacement schedules for an advanced fighter aircraft by the mid-1990s; they considered national programs insufficient or too risky to meet the need; and they preferred to create a European aircraft rather than to buy an American one.

The UK must replace the Jaguar and Phantom aircraft during the next decade. It wanted its future-generation combat aircraft to be a battlefield air-support aircraft capable of short-range interdiction and reconnaissance, one that would combine the Harrier's vertical/short takeoff and landing (VSTOL) capability with the Jaguar's range.

Unacceptably high technical risks associated with the aircraft that they originally sought prompted the British to begin discussions for the joint design, development, and production of a European aircraft. However, protracted negotiations over requirements delayed agreement. One problem stemmed from the potential collaborative partners' lack of interest in the VSTOL capability, a requirement that the RAF was unwilling to give up.

After much negotiation, with particular emphasis on bringing France into the partnership, the UK, Germany, Italy, and Spain agreed on an outline European staff requirement called the Turin Agreement. The French, however, decided not to join the program because their requirements proved incompatible with the proposed Eurofighter design: They wanted an aircraft that was lighter in weight and smaller in volume.[16]

During the discussions, the UK government discontinued funding national efforts to replace the Jaguar. Nonetheless, to help establish a better technological base for the development of future combat aircraft, the British MOD supported British Aerospace in the design of the experimental aircraft program (EAP); this support was augmented by R&D backing from British Aerospace, MBB, and Aeritalia. The resulting demonstrator aircraft made its first flight in mid-1986. The British do not yet know how to integrate this aircraft design into the Eurofighter program, although they, and many others, regard it as the basis for the Eurofighter prototype.

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[16]Despite the French withdrawal from the program, SNECMA appears interested in a share of the engine development (industrial collaboration).

In December 1985, the four participating nations signed a European staff requirement (ESR) and provided for a project definition study (PDS) that was due to be completed in late 1986. An industrial evaluation of the requirements led to refinement of the ESR, to be conducted under the current (October 1986) MOU.[17]

The current MOU does not specify exact requirements for the aircraft or work-sharing arrangements for the project. Nor does it commit the participants to proceeding with full-scale development. They have agreed, however, to an interim definition-refinement and risk-reduction phase, with commitments to the EFA to be made at the conclusion of each phase. Full-scale development was projected to begin in mid-1987.

The participants have established two joint companies to manage the development and production of the Eurofighter: Eurofighter Jagdflugzeug GmbH and Eurojet Engines GmbH. Eurofighter GmbH, formed in Munich in June 1986, is owned by the partner companies: British Aerospace; Messerschmitt-Boelkow-Blohm and Dornier; and Aeritalia and CASA. The company will occupy the same building as Panavia, the industrial company that manages the Tornado MRCA project (discussed above). Moreover, the management organization of Eurofighter GmbH is expected to be based on that of Panavia. Some Europeans speculate that Eurofighter GmbH will merge with Panavia.

Eurojet Engines GmbH will control and coordinate the design, development, and manufacture of a new engine for the Eurofighter. This joint company consists of Fiat Aviazione (Italy), Motoren- und Turbinen-Union (West Germany), Rolls-Royce (UK), and Sener (Spain); it will also be based in Munich. Companies bidding for equipment contracts on the Eurofighter will work through these two joint companies.

The 1986 MOU calls for the formation, under NATO auspices, of a multinational governmental management organization that will integrate with NAMMA, the body that oversees the Panavia Tornado.[18] The new agency will be located in Munich.

The United States has expressed interest in supporting the Eurofighter to help further NATO standardization. The Europeans, while conditionally welcoming U.S. participation, have demanded that any such cooperation (1) benefit their own ventures and (2) not change the basic Eurofighter concept. The exact terms for the participation of U.S. aerospace companies has yet to be settled.

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[17]See "Four Nations Agree to Continue Work on European Fighter," *Aviation Week & Space Technology*, October 27, 1986, p. 17.

[18]The West German MOD had initially opposed combining the EFA program office with NAMMA, but later agreed to the merger.

Concerning further collaboration on the Eurofighter, the UK government has continued to study the possibility of industrial cooperation between the four EFA participants and France on standardizing aspects of the Eurofighter and the French Rafale fighter, as well as perhaps using components in common with U.S. aircraft. The participants plan to design the Eurofighter with an eye toward its export potential, making American participation even more difficult because of the constraints of U.S. export controls.

The four collaborating countries have yet to agree on the number of development aircraft or where they will be assembled. They plan to begin production in 1995 on four assembly lines. Under the current work-sharing arrangements, they will contribute to the program and split manufacturing contracts according to the following formula: Germany and the UK, 33 percent each; Italy, 21 percent; and Spain, 13 percent.

MILAN, HOT, AND ROLAND MISSILES; TRIGAT FOLLOW-ON PROGRAM

Euromissile

In the early 1960s, both France and Germany were developing antitank and antiaircraft missiles. The complexity and cost of developing advanced missile systems, however, led the two countries to agree to codevelop and coproduce the Milan 2-kilometer-range, HOT 4-kilometer-range, and Roland surface-to-air missiles.

Aerospatiale (France) and MBB (FRG) began in 1963 to collaborate on the development of the advanced missile systems. For a brief period in the mid-1960s, the British considered but rejected joining the program.

Initially, project management relied on French leadership. Under the terms of the original MOU, DTIA, the French MOD procurement directorate, awarded development contracts on behalf of both participating countries to Aerospatiale, which then subcontracted half of the work to MBB (see Fig. 9). The Committee of Directors, organized by Aerospatiale, made the joint industrial decisions. The committee, whose members came from the two principal companies, met only when the need arose.

The parent companies controlled the industrial work and management of the subcontractors. Aerospatiale and MBB representatives assumed the role of program managers on behalf of both the Committee of Directors and their own companies. This decentralized organization of collaborative efforts worked reasonably well during the development phase; however, as the demands on management grew, so did the need for a more organized structure. One problem stemmed from the restrictive German export laws that forced Germany to work through the French government for third-country sales.

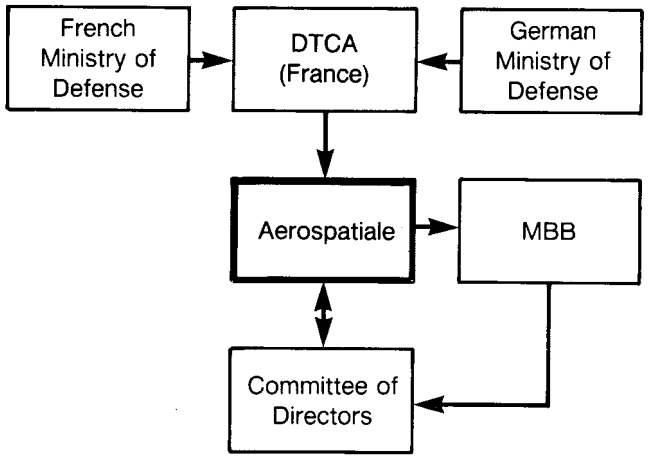

Fig. 9—Early Management Structure of Milan, HOT, and Roland

Euromissile was created in 1972—just as the Milan, HOT, and Roland missiles were going into production—to better coordinate development, sales, and production. It has the authority, with government approval, to sign sales contracts and offer after-sales product support.

Euromissile was formed under a *groupement d'interet economique* (GIE), which provides for its legal status in France until 1989.[19] Unlike the earlier arrangement, under which France dominated and management convened only when necessary, Euromissile was established on the premise that the two companies were equal partners and operated as a company rather than a committee.

Complementing the industrial management structure of Euromissile are standing governmental program offices: BPFA, representing France, and BLBM, representing Germany. These offices, staffed by the MODs of each country, assumed program control at the government level and act as the contract bureau for the industry.

Once established, BPFA let contracts to Euromissile, which then subcontracted to the parent companies. The parent companies are allowed to subcontract further, as needed, and they oversee the activities of the subcontractors. Although all industrial capabilities remain with the parent companies, Euromissile coordinates missile production and sales.

[19]Interview with Euromissile personnel, May 22, 1986.

Euromissile management has features characteristic of a corporate organization, including a board of directors, chief executive officers (CEOs), an administration, and full-time employees. The Assembly of Members, Management Board, and Administration constitute the three main levels of organization. They control the three missile programs and sales as illustrated in Fig. 10.

The Assembly of Members, which functions as a corporate board of directors, determines long-term policy strategies for Euromissile. The six members of the assembly, three from each company, include the chief executive officers of MBB and Aerospatiale. Thanks to their positions in their parent companies, they have the authority to implement

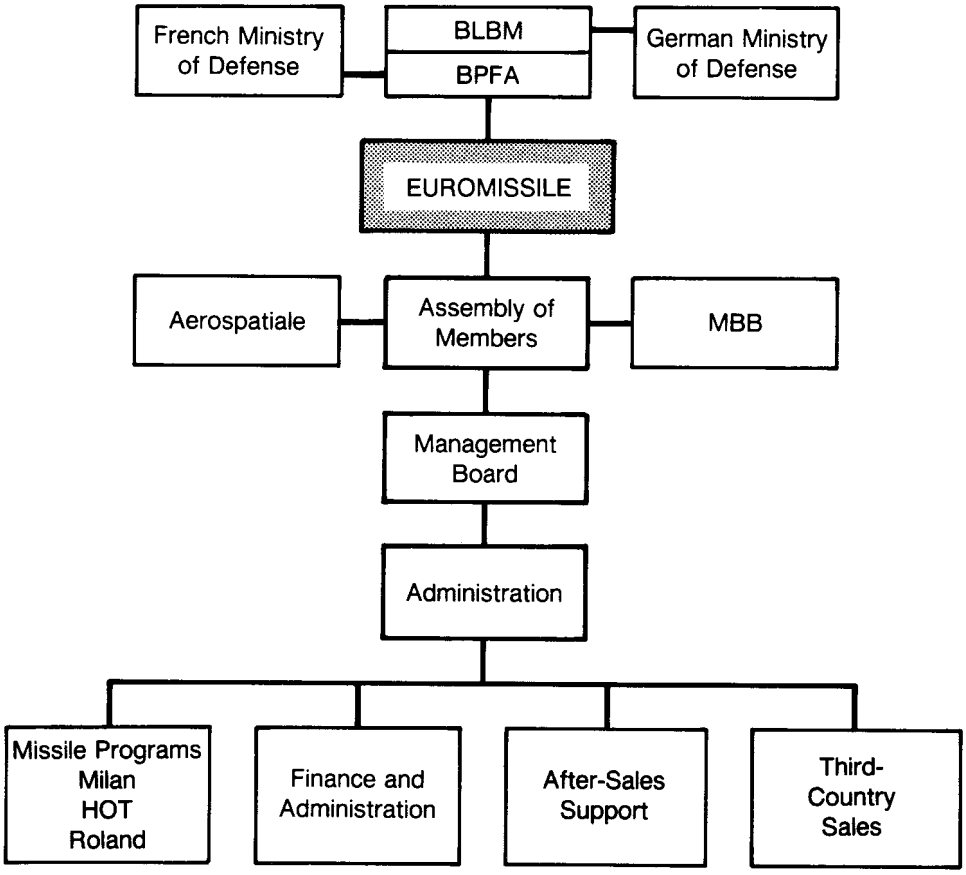

Fig. 10—Euromissile Management Structure

Euromissile policies in these companies. Their Euromissile duties require only short absences from their companies.

The Management Board, directly below the Assembly of Members, sets the Euromissile agenda, plans and budgets for the organization, and coordinates the staff. Its four members, like the six assembly members, make decisions for both Euromissile and their own companies.

The Management Board consists of two members from each company, including the president and vice-president of Euromissile. The positions of president and vice-president alternate between representatives of the two companies; thus, the companies share equally but alternately the top executive position. The board also renegotiates work-sharing agreements and resolves disagreements that cannot be satisfactorily worked out at lower levels.

Unlike the two higher levels of management, the Administration is staffed by full-time personnel. They are also employees of MBB and Aerospatiale. The Administration controls four major efforts: management of the three missile programs, finance and administration of sales to Germany and France, after-sales or product support, and third-country sales. Two program managers, one from each company, head each missile program. Impasses at these levels may be brought before the Management Board; as of May 1986, this had not been necessary.[20]

In the late 1970s, Euromissile licensed to the UK the technology to coproduce the Milan missile. The UK later signed an MOU with Germany and France to collaborate on all future ATGW programs, starting with improvements on the Milan.

Euromissile Dynamics Group

To coordinate the development of TRIGAT, the third-generation antitank guided weapons that will eventually replace the Milan and HOT missiles, France, Germany, and the UK formed the Euromissile Dynamics Group (EMDG) in 1976. Euromissile and EMDG, although colocated near Paris, are legally distinct and separate organizations. Each organization for the most part has its own employees. EMDG will no doubt draw on the Euromissile experience, but three rather than two countries will share the top management positions.

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[20]Interview with Euromissile personnel, May 22, 1986.

The Bureau Trilateral Programs (BTP), the governmental authority for the three major participants in TRIGAT, will be established near Paris and colocated with the BPFA and BLBM, the project offices for Euromissile. Thus, organizations located in Paris will manage all TRIGAT activities, with EMDG representing industry and BTP representing government. The companies currently collaborating on the development of the TRIGAT include British Aerospace Corporation (UK), Aerospatiale (France), and MBB (Germany).

Belgium, Greece, Italy, the Netherlands, and Spain will also participate in the TRIGAT program. In integrating smaller nations, such as these, into the project, France, Germany, and the UK face much the same problems as the United States faces in undertaking codevelopment projects with the rest of NATO. The European negotiations for developing EMDG may provide lessons for future transatlantic collaborative programs.

EUROPEAN COLLABORATIVE PROJECTS IN PERSPECTIVE

France and Germany collaborated with each other on the majority of projects described above, sometimes in combination with other nations (see Table 3, above). One may reasonably assume that they and other countries will continue to participate in the joint development and production of weapons systems.

The management of collaborative projects has tended to shift over time from organizations controlled largely by one nation, often France, to a more equitable form of decisionmaking, such as Euromissile, Panavia, and from current indications also Eurofighter. With the Alpha Jet project, the French government and French industry dominated the management hierarchy. Indeed, Breguet, a French aircraft manufacturer, assumed the position of prime contractor and received its instructions from the French government. After conferring with the German government, Breguet subcontracted 50 percent of the work to Dornier, a German aircraft firm and Breguet's collaborative partner.

The French also dominated the Alantic program, although more indirectly, through the SECBAT organization. During certain periods, the French government provided the entire financial support for the Atlantic. This arrangement gave France enormous influence over the direction of the project. The Atlantic, as well as the Tornado and the antitank guided missiles that were developed later, were in many ways considered collaborative successes by the Europeans.

The Alpha Jet and the Atlantic both represent cases of one nation dominating the decisionmaking process. The Transall project, with little or no directive management, exemplifies the other extreme. In fact, of the collaborative programs studied, the Transall

ended up as perhaps the greatest disappointment in terms of (1) the gap between the desired and resulting product, (2) scheduling, and (3) recurrent problems. The management organization that oversaw the development and production of this transport aircraft provided few mechanisms to work out disagreements. As a result, bilateralism throughout the decisionmaking process left little room for compromises.

In the case of the Jaguar, decisionmaking was evenly divided and areas of leadership clearly demarcated. The French dominated the airframe development and production; the British led the engine project. Like the Atlantic SECBAT, but unlike later projects, SEPECAT, the Jaguar management organization, evolved as a corporation only after the project had begun.

More recently, international corporations have come into being sometimes even before the official development phase of the project begins, as in the case of EMDG, Panavia, and Eurofighter. Although like these corporations in the way it conducts business, Euromissile was formed when the Milan, HOT, and Roland missiles were ready to go into production. Eurofighter, formally established in late 1986, is expected to assume many characteristics of Panavia, the industrial organization managing the Tornado project.

Panavia, Eurofighter, and EMDG function as multinational corporations with full-time staff and integrated personnel. German and British personnel at Panavia predict that equal decisionmaking will become the norm in future collaboration involving these nations.[21] Most European nations will probably adopt this method of operation.

European nations interested in future collaboration with the United States for the joint development and production of advanced weapons systems may seek a management structure modeled on Panavia, Eurofighter, and Euromissile. The Europeans now favor equal decisionmaking, even when one partner makes a disproportionately large or small contribution to a given project, as in the case of the Tornado, to which Italy is contributing much less than Great Britain or the FRG.

The EMDG, in organizing the industrial activities of the Milan and HOT follow-on missiles, may provide an interesting indication of the organizational structures associated with potential transatlantic cooperative projects. EMDG now faces the prospect of coordinating the undertakings of up to eight nations of unequal size in one management structure. The representation of large and small nations in a single organization, such as EMDG, may establish an important precedent for the management of future U.S.-European cooperative projects.

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[21]Interview with Panavia personnel, May 26, 1986.

V. PROSPECTS FOR COLLABORATION UNDER THE IEPG

In pursuing its goal of increasing European arms collaboration, the IEPG also fosters European unity. To the extent that greater European cohesion is actually achieved, it portends a change in the relationship between the United States and its NATO allies with regard to transatlantic collaboration on defense procurement, arms trade, and NATO burden sharing.

TREND TOWARD GREATER EUROPEAN UNITY

The IEPG is not alone in its pursuit of greater European unity. Other institutions have the same goal in other areas, for example, the European Economic Community and the Western European Union. These institutions have been created in part because Europe views itself as a complex marketplace, with each nation being too small to generate significant new industry on its own.

Concerned Europeans see cooperation in starting up new industries as the way to open financial and trade markets, to decrease protectionism, and thereby to improve individual national economies. They are striving for greater economic unity and a better competitive position in the world marketplace.

European Technological Independence

The Europeans consider high-technology industries particularly important to the health and vigor of their economies, and they are concerned about falling behind the United States and Japan in technology. Each country wants to maintain national capabilities for defense technology development and production. They have consequently refused to permit market or other forces to determine the location and concentration of defense industrial capabilities. At the same time, individual national programs are too small to permit efficient operation. Cooperation, they believe, would give their high-technology industries a large enough market for growth.

The push for high technology led to the Eureka program, a $2 billion nonmilitary research program that may lead to marketable high-technology products. The program was established in part as a response to the U.S. SDI program, because Europeans expected the trickle-down technology from SDI to increase the U.S. lead in high-technology commercial products. The United States recognized the Europeans' eagerness to acquire high-

technology skills when U.S. spokesmen highlighted the benefits of technology transfer in presenting the case for SDI collaboration. Several European countries agreed to participate in the U.S. Strategic Defense Initiative (SDI) program, in part to enhance their own technology base.

Given the Europeans' eagerness to compete in the high-technology market, one can understand their willingness to undertake seemingly inefficient military development projects with immature technologies. The British attempt to develop a variable geometry aircraft is a case in point; France finally withdrew from the collaboration because it believed that the UK lacked sufficient technological experience for success at a reasonable cost and because the two sides could not establish common requirements.

Ideally, the Europeans would like to collaborate with the United States, but they would have the United States place fewer restrictions on the use of its technology, including in foreign sales. In this regard, the U.S.-European collaboration to enhance the Ada computer language represents a successful collaborative military project.

European Economic Cohesion

Europeans see greater economic cohesion as an important step in increasing their competitiveness in high technology. One would be hard pressed to imagine a region with greater economic interdependence than Western Europe. Although European planners recognize the benefits of cooperation, they are often thwarted in their pursuit of it by the insistence of the individual countries on maintaining a large degree of political and cultural independence.

The effects of European nationalism manifest themselves particularly in the communications and electronics industries. Each country's communications and electronics industries set their own standards in an obvious attempt at protectionism. Nearly every country in Europe has its own telephone exchange system and, significantly, manufactures its own switches. Europe has one of the largest communications markets in the world, but it has yet to produce an electronics industry that can compete effectively with those of the United States and Japan.

Because the Western European nations are military allies and cooperate at the national level, military projects lend themselves more readily to collaborative efforts than, say, communications and electronics. Indeed, these countries have cooperated on the development and production of several weapon systems.[1] A review of current European

[1]Some of these cooperative ventures were discussed in Sec. IV, above.

programs would seem to indicate that international development is now about as likely as national development of major systems.

Collaborative R&D programs can benefit national defense budgets as well as defense industries. During peak production of the Jaguar,[2] the UK experienced one of its largest peacetime increases in equipment expenditures. Between 1972-1973 and 1973-1974, the UK procurement budget grew by 29.5 percent, with 33 percent of that in air systems.[3]

Furthermore, collaboration on weapon R&D helps national leaders to defend military budgets. Rather than arguing for a particular weapon, ministers may argue for European cooperation, which often carries independent value. Government officials and others who oppose an ongoing collaborative program may be accused of rejecting economic cooperation as well as defense. The collaboration argument has been used, for example, to defend the troubled SP-70 program for the joint development of a self-propelled 155-mm howitzer by Germany, the UK, and Italy.

POTENTIAL EFFECT ON U.S.-EUROPEAN COLLABORATION

The IEPG was created to coordinate European arms procurement and development policies and activities. Its success in fostering a more unified defense procurement policy may directly affect U.S. relations with its European NATO allies, particularly with regard to three major defense issues:

- Balance of trade
- Rationalization, standardization, and interoperability
- Transatlantic arms collaboration.

U.S.-European Arms-Trade Balance

The arms-trade balance, which has favored the United States since the creation of NATO, concerns both Americans and Europeans. If the IEPG changes the way that Europeans procure their armaments, the change will affect the two-way arms trade between the United States and Europe. Before addressing that issue, however, let us examine briefly the overall trade balance and the arms-trade balance between the United States and its European allies.

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[2]Discussed in Sec. IV, above.

[3]Roger Facer, *The Alliance and Europe: Part III. Weapons Procurement in Europe—Capabilities and Choices,* International Institute for Strategic Studies, Adelphi Paper No. 108, 1975, p. 6.

The United States has the world's largest overall trade deficit: $100 billion in 1984, $125 billion in 1985, and over $160 billion in 1986.[4] The United States has also had a negative overall trade balance with many of its NATO partners for the past several years. Sales of military goods to the other NATO countries, however, provide one bright spot on the U.S. trade balance, if one excludes the transfer of funds to pay for basing a large number of U.S. military personnel in Europe.

U.S. military sales to NATO members reached a peak of almost $10 billion in 1984.[5] Turkey was the largest single buyer that year by virtue of an F-16 coproduction contract worth over $4 billion. In addition, the United States sold a total of over $2 billion worth of military goods to Italy, Spain, and the United Kingdom and between $1 and $2 billion worth to Canada, the Netherlands, and West Germany. France never bought more than several hundred thousand dollars worth of goods in any single year.

On average, between 1982 and 1985 the United States sold most military goods to Turkey, the United Kingdom, Denmark, West Germany, Spain, and the Netherlands, in that order. These sales accounted for more than three-fourths of all U.S. arms sales during the period. At the same time, discounting peak-year sales to Turkey and Spain, U.S. arms sales remained constant at approximately $6 billion.

Thanks to the increase in NATO-country arms sales to the United States from $1.5 billion in 1982 to $2.7 billion in 1985, the U.S. trade advantage fell from a ratio of 4 to 2.2. The United States made major purchases from Canada, ranging from $0.8 billion in 1982 to $1.2 billion in 1985.[6] In fact, Canada supplied nearly one-half of all U.S. military imports. The same year, Britain, the second major supplier, sold the United States goods worth $0.6 billion.

Despite U.S. domination of bilateral arms trade with NATO Europe, in multilateral trade the Europeans export far more arms than they import (see Fig. 11) and have a positive total trade balance with the United States. Why, then, do they feel threatened by the negative bilateral arms-trade balance?

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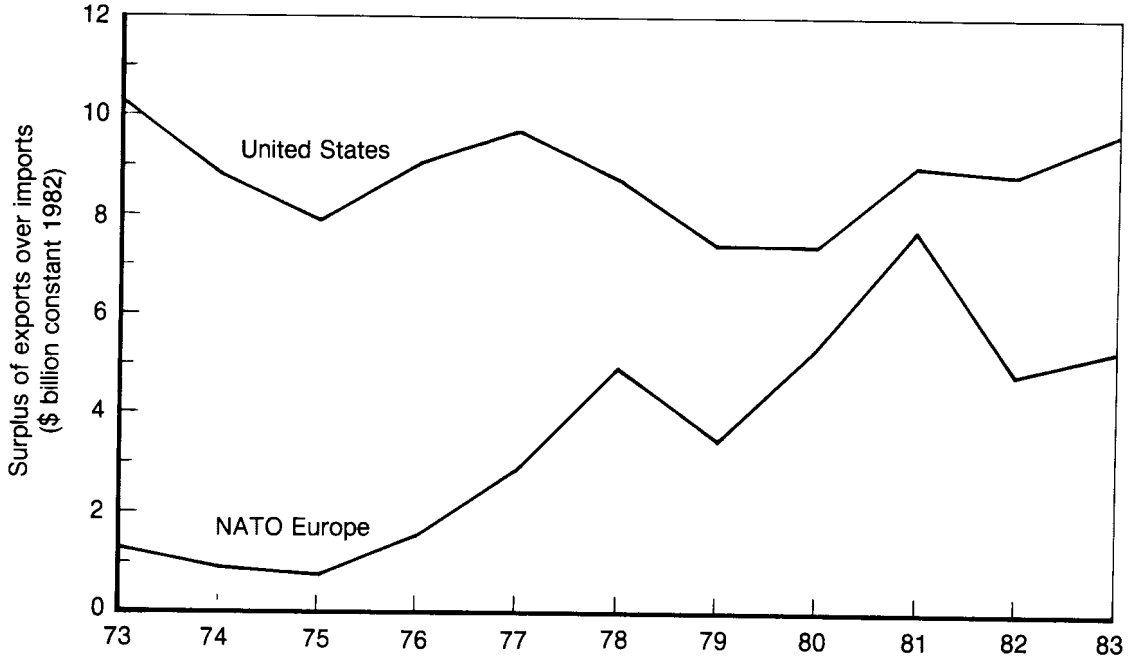
[4]"There's More to Trade Than Textiles and Oranges," *The Economist*, August 2, 1986, p. 17; "Better, but Hold the Cheers," *The Economist*, November 8, 1986, p. 31; and "When Politics Gets the Better of Economics," *The Economist*, April 4, 1987, p. 21.

[5]Based on MOU Defense Trade Balance Summary, 1982-1985, from interview with Marilyn Barnett, Office of International Acquisition, OSD, June 9, 1986.

[6]Interview with Marilyn Barnett, Office of International Acquisition, OSD, June 9, 1986.



SOURCE: Based on *World Military Expenditures and Arms Transfers, 1985*, U.S. Arms Control and Disarmament Agency, Washington, D.C., August 1985, pp. 90, 127.

Fig. 11—United States and NATO Europe: Surplus Arms-Trade Balances, 1973-1983

The larger European NATO nations, which devote a relatively high percentage of their defense budgets to research and development, believe that they need to maintain a sizable defense market so as to justify their position in the technology race.[7] They cannot count on the European markets alone to sustain the kind of demand that European nations believe that they need to keep abreast of technology and to maintain independent indigenous industries.

Moreover, traditional markets for European arms outside Europe are disappearing. Some customary arms importers are developing their own production capabilities. The drop

[7]Between 1981 and 1984, the UK devoted nearly 13 percent and France about 11.5 percent of its military budget to R&D. During the same period, the United States committed a slightly larger share than France to R&D. Sweden and Federal Germany were next, with about 6.5 percent and a little over 3 percent. In contrast, less than 1 percent of the military expenditures of the Netherlands, Spain, Greece, Belgium, Denmark, and Turkey (in that order) went to military R&D. See *World Armaments and Disarmament. SIPRI Yearbook 1985*, Stockholm International Peace Research Institute, Taylor & Francis, Philadelphia, 1985, p. 289.

in oil prices and the tightening of international credit has decreased the demand for arms from the Middle East and other third world areas. After a decade of growth, imports by the developing countries in 1983 decreased by 11 percent from the high of 1982.[8]

The Europeans may thus have to look for new markets, and the largest defense market in the free world is the United States. They argue, however, that the U.S. defense market is protected by Congressional mandates, such as the "Buy American" act, and by DoD restrictions relating to technology security. However, some DoD officials, members of the U.S. Congress, and industrial leaders oppose U.S. technology transfer, arguing that it aids European high-technology industries to the detriment of U.S. industry.

The United States certainly wants a healthy European defense industry, for such a production capability serves NATO and the individual members, including the United States. The U.S. Congress long ago authorized the secretary of defense to waive the "Buy American" laws for arms purchases from the NATO allies. The United States also spends tens of millions of dollars per year testing foreign weapons, especially those from the NATO countries, in seeking weapons for U.S. procurement. Many European codevelopment projects, however, represent efforts to produce weapons that are already available off the shelf in the United States.

Superior technology does not always flow from the United States to Europe. For example, the U.S. purchase from France of the RITA communication system, considered superior to any American competitor, saved the United States large development costs. A meaningful technology transfer—one based in large measure on shared R&D programs—would undoubtedly benefit the United States.

In sum, the Europeans seek balanced arms trade with the United States and a means to ensure their competitive position in high-technology industries. The United States wants to protect its arms industry and its technological superiority. Increased collaboration in arms development and manufacture between the United States and Europe could provide the link between a higher level of trade and technology transfer in both directions.

Rationalization, Standardization, and Interoperability

Rationalization, standardization, and interoperability (RSI) may be considered a highly desirable, although not necessarily central, goal of collaborative programs. Most

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[8]*World Military Expenditures and Arms Transfers, 1985*, U.S. Arms Control and Disarmament Agency (ACDA), Washington, D.C., August 1985, p. 89.

European collaborative programs produce complex equipment that is expensive or difficult to produce unilaterally. For example, the Germans, British, and French together developed and produced the HOT missile; thus, these countries rely on one, rather than three, missiles.

The expansion of collaboration, especially between the United States and Europe, would further narrow the variety of available systems. The IEPG is chartered to encourage joint development where no system currently exists, coproduction where a system has already been developed, and licensed production or trade where an existing system meets a given nation's needs. While this charter primarily represents an effort to husband European resources, it also fosters RSI. Thus, the success of IEPG efforts NATO-wide could further RSI.

U.S.-European Arms Collaboration

Increased transatlantic arms collaboration has been suggested as a possible solution to a major problem confronting the United States and its European allies: making U.S.-European arms trade a two-way street. Collaboration undoubtedly would strengthen the bonds between the allies and perhaps enable them to resolve, or at least mitigate, their differences. It would also increase U.S. influence on European arms policy *and* European influence on U.S. arms policy.

The United States would achieve a twofold political effect with increased arms collaboration: a greater dependence on Europe for the development of arms and weapons systems and more European arms in the U.S. defense budget. In recent years, however, Congress has focused on the disadvantages of arms imports, despite healthy U.S. arms exports. Concerns regarding U.S.-European collaboration may prove similar to those regarding arms trade.

In sum, critics may see a collaborative venture as a method of sending jobs and technology overseas rather than as a method of enhancing the U.S. position in NATO. Proponents will argue that increased collaboration will improve the U.S.-European trade balance by providing the European allies greater access to the U.S. defense market and U.S. technology.

VI. FUTURE RESEARCH

Future RAND research will attempt to answer the following three policy-relevant questions:

- What are the likely directions of European arms industries and policies, and what are the major forces influencing those directions?
- What are the implications of the above for U.S. interests and policy, especially in the area of collaboration?
- Which specific programs would benefit the United States most?

The answers will be based on the analysis of (1) ongoing European collaborative efforts, especially within the IEPG, (2) European and U.S. arms trade, and (3) specific U.S. military requirements.

In considering specific programs, the research will concentrate on European codevelopment projects that are expected to mature into the production phase. The points of interest in these projects include the relationship of the project to U.S. interests and requirements, the compatibility of U.S. and European schedules, the European community's approach to organization, and the possibilities of an interface between the activities of those organizations and U.S. activities. Based on this research, we will assess the opportunities for U.S.-European cooperation.

We will continue to review IEPG technology projects, as they portend future European codevelopment activities. We will also monitor the evolving IEPG philosophy and structure. The IEPG is currently conducting two studies of interest to the United States: the European Aeronautical Cooperation Study and the European Defense Industry Study. The latter assesses European industrial capabilities, examines the ways to improve the European technology base, and suggests methods for increasing the competitiveness of European industry.

GLOSSARY

ABAP	Association Belge pour l'Avion Patrouilleur
ACDA	U.S. Arms Control and Disarmament Agency
AFVG	Anglo-French variable geometry (penetrator aircraft)
AGARD	Advisory Group for Aerospace Research and Development [NATO]
AMRAAM	advanced medium-range air-to-air missile
ASRAAM	advanced short-range air-to-air missile
ATGW	antitank guided weapon
BAC	British Aircraft Corporation (later British Aerospace Corporation)
BTP	Bureau Trilateral Program (TRIGAT) [France, FRG, UK]
CNAD	Conference of National Armaments Directors [NATO]
DCAe	Direction des Constructions Aeronautiques [France]
DoD	Department of Defense [U.S.]
DSARC	defense systems acquisition review [U.S. DoD]
DTCA	Direction Technique des Constructions Aeronautiques [France]
DTIA	Direction Technique et Industrielle de l'Aeronautique [France]
EAP	Experimental Aircraft Program [UK]
EASAMS	Elliott Automation Space and Advanced Military Systems [UK]
ECAT	[avion] ecole de combat et d'appui tactique (training and tactical ground support aircraft) [France]
EEC	European Economic Community
EFA	European Fighter Aircraft (Eurofighter)
EMDG	Euromissile Dynamics Group
EPG	European Program Group [NATO]
EPG	European Participating Governments
ESR	European staff requirement [Eurofighter]
FWE	foreign weapons evaluation (program) [U.S.]
GDP	gross domestic product
GMOU	general memorandum of understanding
GNP	gross national product
HOT	4-km antitank missile
IEPG	Independent European Program Group
IFF	identification friend-or-foe
LTDP	Long-Term Defense Program [NATO]
MAS	Military Agency for Standardization [NATO]
MBB	Messerschmitt-Boelkow-Blohm [Germany]
MC	Military Council [NATO]
Milan	2-km man-portable antitank missile
MLRS	multiple-launch rocket system
MOD	ministry of defense
MOU	memorandum of understanding
MRCA	multirole combat aircraft [NATO]
NAMMA	NATO Multi-Role Combat Aircraft Management Agency [executive body of NAMMO]
NAMMO	NATO Multi-Role Combat Aircraft Development and Production Management Organization
NATO	North Atlantic Treaty Organization
NBMR	NATO basic military requirement

NCT	NATO comparative test (program) [U.S.]
NIAG	NATO Industrial Advisory Group
OCU	operational capabilities upgrade
OSD	Office of the Secretary of Defense
PAPS	phased armaments planning system [NATO]
PDS	project definition study [Eurofighter Project]
RAF	Royal Air Force [UK]
RSI	rationalization, standardization, and interoperability
SDI	strategic defense initiative
SECBAT	Societe Europeenne pour la Construction du Breguet Atlantique
SEPECAT	Societe Europeenne de Production de l'Avion Ecole de Combat et d'Appui Tactique [France, UK]
SIPRI	Stockholm International Peace Research Institute
SNECMA	Societe Nationale d'Etude et de Construction de Moteurs d'Aviation [France]
SNIAS	Societe Nationale Industrielle Aerospatiale [France]
STANAG	standardization agreement [NATO]
STOL	Short takeoff and landing [aircraft]
TGW	terminally guided warhead
TRIGAT	third-generation antitank guided weapon [France, FRG, UK]
VFW	Vereinigte Flugtechnische Werke
VSTOL	vertical/short takeoff and landing [aircraft]