RAND

The Independent European Force

Costs of Independence

M. B. Berman, G. M. Carter

Project AIR FORCE
Arroyo Center
National Defense Research Institute

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Project AIR FORCE
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Foreword

In recent years, West Europeans have once again begun discussing the idea of an independent European military force, an idea that for the most part has been dormant since the failure of the European Defense Community in 1954. While West Europeans generally agree on the need to develop the capability to act in a more timely, militarily effective, and coordinated manner, they disagree on the appropriate role and scope of any new European arrangement, as well as on its relationship to the United States and NATO.

Within Europe, there are two broad schools of thought on this question. The first, championed by the United Kingdom and the Netherlands, sees a strengthened European pillar within NATO and greater coordination of European efforts for non-NATO contingencies, most likely through the Western European Union (WEU). Advocates of this approach see the European effort as complementary to NATO and oriented toward coalitional activities rather than independent European action. The second viewpoint, most forcefully supported by France, focuses on developing a truly independent European capability as a component of European political integration through the European Community (EC). This second approach stresses the need for Western Europe to have the capability to act on its own, without necessarily relying on U.S. military support.

While the U.S. government has broadly supported strengthening West European military capabilities through greater coordination of European efforts for both NATO and non-NATO contingencies, U.S. officials have stressed that any independent European force should not undermine the role of NATO in European security. In particular, General John Galvin, the former Supreme Allied Commander in Europe, expressed concern that European efforts not divert resources from NATO-identified needs and requirements.

The outcome of the European debate on an independent European force will have a significant impact on global and regional military strategies. A stronger, more integrated European military capability can provide a complement for meeting future NATO requirements. It could also provide the United States with a more effective partner for non-NATO contingencies, such as future crises in the Gulf, and offer an option for military response in circumstances where the United States chooses not to engage directly. At the same time, an enhanced and more independent European capability could alter global and regional power relationships.

Many of the issues involved in defining the potential role and scope of an independent European force involve political questions concerning both intra-European political arrangements and the future transatlantic relationship. In this report, we make no effort to assess the political or strategic arguments for or against an independent European force. Instead, the document focuses on the costs of acquiring and operating force projection and satellite surveillance systems. Paying these costs would require either finding new resources or shifting away from other planned activities within the projected European defense budgets.

Preface

Based on its work for the United States Department of Defense and the U.S. military services, RAND has developed considerable expertise in analyzing the costs associated with developing and operating the types of key systems that would be necessary in creating an independent European military force. This report, which leverages off that expertise, is intended to help inform the debate over the choices open to Western Europe by focusing on the costs associated with acquiring and operating two key components of independent military operations: force projection and surveillance (C^2I) systems—two areas where West Europeans currently possess rather limited capabilities.

This work was supported by RAND's Resource Management department, which used funds for exploratory research from Project AIR FORCE, the Arroyo Center, and the National Defense Research Institute (NDRI), RAND's three federally funded research and development centers for national security studies. The three centers are sponsored, respectively, by the U.S. Air Force, the U.S. Army, and the Office of the Secretary of Defense and the Joint Staff.

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Background and Objectives

NATO's announcement that it would form a rapid reaction corps (RRC) has reignited in several European Community (EC) nations the desire for a similar capability that would allow employment out-of-area under pure West European control. Given current European capabilities and what would be needed to deploy and support such an independent force, the Europeans would have to augment their force projection capabilities, enhance their intelligence capabilities (especially space-based), and create new command and control mechanisms.

This study examines the costs that the Europeans would incur to generate these incremental capabilities and the feasibility of these costs. The most important issue here is how "independent" such a force should be, and the study examines varying levels of capabilities and generates "back of the envelope" cost analyses, providing a gross estimate of the trade-offs available between capability and cost.

Force Projection for the European Independent Force

Determining Force Projection Requirements

In considering their force projection needs, Europeans must confront the reality that they cannot know the "right amount" of force projection capability, because force projection requirements are driven by such uncertainties as size and composition of the necessary deploying force, speed of response required, duration of combat, reception facilities, and distances. These uncertainties, along with such others as ship and aircraft reliability, the percentage of planned payload that is actually attained, and constraints on sortie rates due to maintenance, drive home the need to develop a robust projection capability—one that works well in a large variety of situations. The need for affordability requires looking at a balance of airlift and sealift and at trade-offs among available airlift resources, sealift purchases, tankers, and capabilities available through mobilizing a European Civil Reserve Air Fleet (CRAF).

To understand deployment needs, we first determined the characteristics of an independent European force, using descriptions of the RRC as a basis for defining a corps with two Light Infantry Divisions, one Air Assault Division, one Light Armored Division, and one Heavy Armored Division. These units comprise 50,000 combat soldiers, with an equivalent amount for combat support (CS) and combat service support (CSS). The force was rounded out by fighter squadrons and 20 Patriot Fire Units for air defense.

Light, medium, and heavy force packages were then determined and tied into a series of four scenarios (and three variations on those scenarios) keyed to a series of threats and defined in terms of distance required for force projection, infrastructure constraints, and the nature of air- and seaports available at the destination.

Using cargo characteristics for each unit in the corps, we derived the cargo needs for each force package. Broken down by airlift and sealift force projection components, the numbers we arrived at for the four scenarios are shown in Table S.1.

Finally, we presumed that all forces deployed must arrive within 30 days.

Matching Force Projection Assets with Force Projection Requirements

Given the cargo needs (i.e., the force projection requirement), we matched force projection assets—airlift, sealift, and tankers—to those needs. Table S.2 summarizes the results of the force requirements analysis, grouping the scenarios into three investment groups (driven by the number of outsize airlift aircraft needed).

The airlift assets shown in Table S.2 consist of existing European military and civilian transport aircraft and options for improving capabilities. Existing assets for the analysis include 153 (out of 200) C-130s and 25 B-747 equivalents; options

Table S.1

Cargo Needs for Scenario (Total/Outsize)
(M tons x 1000)

	Light	Medium	Heavy (w CS/CSS)	Heavy (w/o CS/CSS)
Total	52/4	104/28	252/84	139/44
Airlift	52/4	104/28	110/29	68/17
Sealift	0	0	142/55	71/27
Scenario	1	4	2	3

Table S.2

Force Projection Required Resources by Investment Level and Scenario

Assets/Scenarios	Small Investment 1, 2A, 3A (easier)	Med. Investment 2B, 3B, 4A (harder)	Large Investment 4B, 4C (arduous)
C-130	153	153[a]	153[a]
Civilian B-747 equivalent	25	25[b]	25[b]
EC-17	32	63	116
Current military tankers	30	30	30
A-300 F/T (active)	16	30	30
Civilian A-300 F/T (CRAF)	5	15	30
FSS	9	9	9
Commercial leased ships	29	29	29

[a]Not usable in longest scenarios.
[b]Not usable where airport ramp space is constrained.

include the purchase of EC-17[1] and A-300 freighters. As Table S.2 shows, the utility of the baseline capacity (the C-130s and B-747s) declines and the requirement for flexible military aircraft increases as the scenarios move from easier to arduous. Specifically, the C-130s are inefficient at longer ranges, and the B-747s are not usable because of airport ground constraints; the result is a dramatic increase in needed EC-17s.

In terms of sealift assets, we considered government-owned and -operated ships (in this case, the fast sealift ships [FSS] employed by the United States) and commercial ships for charter. Table S.2 reveals the results of the sealift analysis, showing that given the cargo needs in Table S.1 and the desire to deploy within 30 days, a fleet of 9 FSS is needed for the unit equipment of a Heavy Armored Division. At worst, the fleet can deliver the division in 26 days, with an average of 22 days. If the CS/CSS materiel is shipped by 29 commercial leased ships, it will start arriving by day 30. Thus, while commercial shipping is not sufficiently responsive for deploying unit equipment, it is suitable for transporting support materiel, especially since no costs are incurred before deployment.

For tanker assets, we considered modified A-300 freighter-tankers (using them as both tankers and airlifters and thus further increasing robustness), modified civilian A-300s, and the current European base fleet of 30 tankers. We created best- and worst-case scenarios for each of the three investment levels shown in Table S.2, where the worst case required air refueling of all cargo aircraft during force deployment and had a greater distance between basing and operations for

[1]EC-17 is a European C-17 surrogate.

fighter aircraft. In the small- and medium-investment cases, the best refueling subcase requires 30 tankers, and in the large investment case, the best refueling subcase requires 50 tankers; in the small-, medium-, and large-investment cases, the worst refueling subcase required 50, 80, and 100 tankers, respectively. As Table S.2 shows, enough tankers are kept in the active force (46, 60, and 60) to cover the best refueling subcases, with the CRAF as a backup to cover over 90 percent of the worst refueling subcases (51/50, 75/80, and 90/100).

Force Projection Cost Analysis Results

Table S.3 repeats the information in Table S.2, adding plus signs (+) to represent resources needed to augment the force projection capability (unmarked assets are currently available) and a cost piece corresponding to the three investment levels.

As the table shows, total cost (both investment and operating) to cover the incremental assets ranges from $18 billion to $49 billion. While the most expensive investment provides a very robust capability, it is not anywhere near as robust as the U.S. capability. On the other hand, the least expensive system gives an effective capability for light deployments or for deployments where good infrastructure exists. This system lacks robustness, however—that is, it lacks the ability to handle many potential scenarios. When costs are broken

Table S.3

Force Projection Requirements and Costs by Investment Level

Assets/Scenarios	Small Investment 1, 2A, 3A (easier)	Med. Investment 2B, 3B, 4A (harder)	Large Investment 4B, 4C (arduous)
C-130	153	153[a]	153[a]
Civilian B-747 equivalent	25	25[b]	25[b]
+EC-17	32	63	116
Current military tankers	30	30	30
+A-300 F/T (active)	16	30	30
Civilian A-300 F/T (CRAF)	5	15	30
+FSS	9	9	9
Commercial leased ships	29	29	29
Initial investment (total/per year for 5 years)	9/1.8	16/3.2	23/4.6
Operating costs (total/per year for 25 years)	9/0.36	16/0.64	26/1.04
Total 25-year life cycle cost	$18 billion	$32 billion	$49 billion

[a]Not usable in longest scenarios.

[b]Not usable where airport ramp space is constrained.

down by costs per system, the EC-17 clearly dominates in cost, from 60 percent of total costs in the first grouping of scenarios ($11 billion out of $18 billion) to 80 percent in the third grouping ($39 billion out of $49 billion).

A Satellite System for an Independent European Force

We focused on satellite systems rather than on the intelligence needs of an independent European force for three reasons: (1) satellites have definite advantages over other ways of gathering military intelligence data, (2) satellites can serve other national purposes (e.g., treaty verification), and (3) there has been substantial talk about a European intelligence satellite system. Because a satellite system has various nonmilitary purposes, we did not attempt to find the least-cost method of obtaining the intelligence that a new military force might need. In particular, we have not considered all the nonsatellite ways of gathering additional intelligence for an independent European force. Instead, we have assembled the costs of obtaining various intelligence and communications capabilities via satellites and added the costs of theater tactical control systems.

Determining Capabilities

Before estimating the costs of a European satellite system for communications and intelligence, we determined what capabilities the system will provide. As was the case in estimating force projection requirements, a range of capabilities might be purchased. At the low end of the range are the European military systems now operational or in an advanced stage of development. At the high end is a system that contains all the capabilities that have been considered feasible in the reasonably near future. An almost infinite variety of capability levels are possible in between these two extremes. Rather than try to enumerate a large number of capability levels, we chose three levels that illustrate points on the spectrum and that together provide a notion of the possible cost/capability trade-offs. We also provided the underlying data so the cost of different configurations could be estimated or the sensitivity of the findings to particular cost parameters could be checked.

The satellite systems in the three scenarios are defined as follows. The limited-capability case included only continuing capabilities that European governments have already deployed or that are in advanced development with a plan for deployment.

The medium-capability case included a unified, large-scale satellite communication system dedicated to European military communications and several of the capabilities mentioned in a statement by French Defense Minister Pierre Joxe: imaging in the optical, infrared, and radar ranges, and a system to eavesdrop on electronic signals. We also added two dedicated military data relay satellites so that information from the other satellites could be relayed to a ground station in Europe.

The high-capability case provided more robustness by increasing the number of radar imaging satellites from one to two and by adding several capabilities, including a set of three polar meteorological satellites dedicated to support the independent European force, a system to eavesdrop on communications from geosynchronous orbit, a system to detect ballistic missile launches, and a duplicate of the United States' Global Positioning System (GPS).

In addition to satellite intelligence and communication systems, an independent European force will need tactical control systems that can move with the force. We included both an airborne command and control system and a battlefield intelligence system in our medium- and high-capability cases, but neither in the limited-capability case.

Satellite System Cost Analysis Results

Most of the satellite capabilities that are required for our scenarios are found in systems for which an architecture has been proposed, and cost estimates can be found in the literature or developed by analogy. In one case, we developed a cost estimate from a satellite with a different purpose but with a similar size and level of sophistication. In two other cases, we used U.S. system costs.

We considered a 25-year period, which consists of a 5-year period during which new systems are developed and deployed followed by a 20-year period in which roughly similar capabilities are operated. This is the same time frame used in conducting the force projection analysis. Costs incurred during the development period included all ground facilities, software development, and research and development (R&D).

Table S.4 shows the estimates for the total life cycle cost of each of the three systems, including development, acquisition, and operation for a 20-year period. The limited case, which includes only current or nearly operational European military systems, has a total 25-year system cost of just under $9 billion. The medium case would roughly triple this cost to $26.9 billion, and the high-capability case would increase the cost to $46.3 billion, or five times the resources of the limited case. The remaining lines of the table allocate the life cycle costs

Table S.4

Estimated Costs of Satellite System ($ billion)

	Limited	Medium	High
Total cost	8.8	26.9	46.3
Average annual cost			
Development period (5 yrs.)	0.7	1.8	2.4
Operating period (20 yrs.)	0.3	0.9	1.7

NOTE: The total does not add because of rounding in annual costs.

between a 5-year development period and a subsequent 20-year operational period.

We believe the limited-capability case is just that—limited. It provides neither the integrated capability required for the unified European military force found in the medium case nor the robustness of the high-capability case.

Conclusions

Table S.5 combines the cost estimates from the force projection and satellite systems analyses. It reveals that force projection dominates the low-capability case, but at greater capability levels, the two components contribute roughly equally to the costs for an independent European force.

While these costs could feasibly be accommodated by the combined annual $160 billion (1989) defense budgets of the NATO European nations, the issue is how much of their defense budgets the European nations will be willing to devote to reach different levels of independence or robustness. The modest systems of the low case provide some independent capability, but for many contingencies, the European force would require the aid of robust U.S. systems to minimize risk. The high case will provide more robustness, but even this will not match U.S. capabilities in force projection. In an era of declining budgets, the costs of high

Table S.5

Combined Cost Estimate for Independent European Force ($ billion)

	Low	Medium	High
Force projection	18	32	49
Satellite system	9	27	46
Total costs (25-year life cycle)	27	59	95

capability can be absorbed, but are these costs worth the displacement of other national and regional needs?

Beyond the cost considerations are the inevitable command and control problems of trying to set up and operate an independent European force. Who will control all the force projection and intelligence analysis capability? All these additional cost and command problems have to be addressed when developing an independent European force.

Acknowledgments

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Abbreviations and Acronyms

AAST	Air Assault Division
ACCS	Airborne Command and Control System
C&C	Command and control
CAP	Combat Air Patrol
CBO	Congressional Budget Office
CRAF	Civil Reserve Air Fleet
CS	Combat support
CSS	Combat service support
DMSP	Defense Meteorological Satellite System
DSP	Defense Support Program
EC	European Community
EDRS	European Data Relay System
ERS	European Remote Sensing Satellite
ESA	European Space Agency
ET	En route time
FSS	Fast Sealift Ship
FT	Flying time
F/T	Freighter/tanker
GEO	Geosynchronous orbit
GPS	Global Positioning System
IEF	Independent European Force
IFOV	Instantaneous field of view
IR	Infrared
J-STARS	Joint Surveillance and Target Attack Radar System
LANDSAT	Land-based Satellite
LID	Light Infantry Division
LT	Loading time
MAC	Military Airlift Command
MEDRS	Military European Data Relay System
MTMCTEA	Military Transportation Management Command Transportation Engineering Agency
NATO	North Atlantic Treaty Organization
NDRI	National Defense Research Institute
O&S	Operation and support
ODS	Operation Desert Shield
ODSS	Operation Desert Shield/Storm

PAA	Primary Authorized Aircraft
POEM	Polar Orbit Earth Observation Mission
RAF	Royal Air Force
R&D	Research and Development
ROM	Rough order of magnitude
Ro/Ro	Roll-on/Roll-off
RRC	Rapid Reaction Corps
SACEUR	Supreme Allied Commander in Europe
SAR	Synthetic Aperture Radar
SCIB	Ship Characteristics Improvement Board
SPOD	Seaport of debarkation
USAF	United States Air Force
WEU	Western European Union

1. Introduction

Background

The announcement in May 1991 that NATO would undergo a sweeping reorganization—a reorganization that includes the creation of a rapid reaction corps (RRC) designed for use anywhere in Europe—has sparked criticism within Europe. Speaking at a meeting of the Western European Union (WEU), French Foreign Minister Roland Dumas argued that NATO's decision to form the RRC "had created the force without defining the role it would play" and that it would thus "cost the alliance a whole lot of money, a lot of time, [and] a lot of problems."[1]

What is behind this criticism on the part of several European Community (EC) nations, spearheaded by France, is that they would like a similar capability under West European control for possible out-of-area employment. Such an independent European force has been envisaged as being "completely independent of NATO and equipped with its own intelligence-gathering facilities, including satellites and its own airlift."[2] More specifically, French Defense Minister Pierre Joxe has argued that "the European military, after working together during the Gulf crisis, should continue to cooperate by building joint capability for military or humanitarian airlifts."[3] Joxe focused his attention on "satellite intelligence-gathering—an increasingly key factor of military superiority—as a field for cooperation between sophisticated European technologies."[4]

As Europeans discuss organizing, planning, equipping, and funding an independent European force to send to out-of-area conflicts, it is important to understand the capabilities needed to deploy such a force and to support it once deployed. Given the equipment that currently exists, the Europeans would need to augment their force projection capabilities, enhance their intelligence

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1 "France: France Attacks NATO's Rapid Force, Pushes for WEU Role," Reuters News Service, June 4, 1991, p. 26.

2 "NATO: A New Start," *The Economist*, June 1, 1991, p. 46.

3 "France: France Soldiers on for 'Pure' Euro-Defence," Reuters News Service, June 4, 1991, p. 34.

4 Ibid.

capabilities (especially space-based), and create new command-and-control mechanisms to supplement those of NATO.

Study Objectives and General Approach

This study's focus is to consider the feasibility of generating these incremental capabilities for an independent European force in terms of their cost.

The key consideration here, of course, is how "independent" such a force should be or needs to be. How such a force would be used seems uncertain. Dealing with this uncertainty and reducing the risk it entails require that the force be "robust" (i.e., that it works well in a large variety of situations); the amount of robustness, in turn, affects the needed capabilities and the cost. To use the example of enhancing intelligence capabilities, Joxe has argued that the "French government should attach as much importance to building spy satellites in the 1990s as it did to securing France's independent nuclear capability in the 1960s."[5] Developing such robust capabilities, however, promises to exact a heavy financial toll, since the maintenance of France's nuclear force now amounts to almost 30 percent of its 1991 defense budget.[6]

Our intent here, then, is to examine the issue of cost feasibility by considering "levels of robustness" for the needed capabilities. In terms of intelligence capabilities, for example, the robustness argued for in Joxe's proclamation forms the basis for a high-cost case. That case can then be evaluated in terms of low-cost and middle-cost cases, which are based on lower levels of capabilities and, thus, lower levels of robustness. A similar evaluation is used for determining force projection capabilities and costs, with low-, medium-, and high-cost cases created to match scenarios envisioned for the use of such a force.

Our approach to structuring projected forces and developing costs relies heavily on the data and procedures that the United States would use in approaching this challenge. This approach provides the ability to develop a consistent set of forces and costs. It is quite likely that European force planners would have some different views gained from their experiences in the Falklands and Africa. We have included some of those experiences within the text.

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[5] "Joxe: Spy Satellites Essential for France," *Space News*, May 13–19, 1991, p. 1.

[6] Jean-Luc Vannier, "France's Defense Reassessment: More Bang for the Franc," *Armed Forces Journal International*, June 1991, p. 59.

Scope

The analysis here is not intended to provide a definitive answer about the costs of developing the capabilities for an independent force. Rather, the focus is on determining the feasibility of such a force by performing some "back of the envelope" cost analyses that provide a gross estimate of the magnitude of the range of costs.

Recognizing that these estimates will contain errors, we adopted the conservative approach of resolving key assumptions by giving the benefit of the doubt to the independent force. For example, we used a combat force that is somewhat lighter in weight—easier to deploy—than the NATO RRC.

In addition, this analysis does not consider the political problems entailed in implementing such a force. While those arguing for the creation of the independent European force do not necessarily see it as being directly in conflict with NATO's RRC, and while France views the WEU as the logical choice to oversee such a force, there is no consensus here. As one article notes:

> The main contenders [to oversee the force] are the European Community, the NATO Eurogroup and the Western European Union. None is wholly satisfactory. The EC contains neutral Ireland, the Eurogroup excludes France, the WEU leaves out some NATO members. The betting is on the WEU, as the least unsuitable. The Euro-force, once (if?) created, will probably include many of the units assigned to the newly created rapid-reaction corps—minus the Americans but with a French force (and maybe a French commander) added on.[7]

Nor does the analysis deal with the politically thorny problems surrounding ownership of the data interpretation capabilities for the satellites. Will there be a single center for reception and processing, or will each country have its own center for reception and processing? Although intelligence interpretation is traditionally a national prerogative, we have assumed in our cost estimates a single center, consistent with our policy of resolving key assumptions by giving the benefit of the doubt to the independent European force. If a single center is not chosen, the costs presented here could be underestimated.

Organization of This Document

In Section 2, we examine the force projection capabilities needed for some given scenarios and then examine low-, medium-, and high-cost cases. Section 3 deals with the needs for satellite intelligence and command and control, again

[7] "NATO: A New Start," *The Economist*, June 1, 1991, p. 46.

generating three cases for the cost analysis. The final section connects the cost estimates from the two previous sections and then offers some general conclusions.

2. Force Projection for European Independent Force

In this section, we first examine the uncertainties that drive projection needs and then discuss how we determined scenarios and force packages for the force projection analysis. Next, we present our analyses of airlift, sealift, and air-refueling tanker assets to meet the projected needs for the devised scenarios. Finally, we present the results of the cost analysis for the force projection needs of the independent European force.

Uncertainties Driving Force Projection Needs

In considering their force projection needs, European planners must confront the reality that they cannot know what the "right amount" of force projection augmentation is, because deployment considerations are plagued by uncertainties. The key issues causing these uncertainties are discussed below.

Size and Composition of Deploying Force

One of the key determinants of the amount and type of transportation is the size and composition of the units to be deployed. For example, large armored forces require considerably more transportation than do light infantry units. And the bulky equipment of armored and missile forces can require costly specialized aircraft. In addition, supplies and supporting logistics units can double transport requirements.

The choice of which units to send in developing contingencies also depends on many unpredictable factors—the threat, the geography, local force capabilities, military objectives, etc. Because threats can be large or small, local forces powerful or nonexistent, objectives finite or grand, the force must contain a variety of capabilities—even though a particular contingency is not likely to demand all of them. For example, some contingencies may require only light force—a single paratroop division. But large contingencies, such as the Gulf War, will demand substantial deployment capabilities for multiple divisions, including some heavy forces.

Speed of Response

Speed of response—the immediacy of the need—will also determine deployment capabilities. But this, too, ultimately depends on unpredictable details of future contingencies. Responding in days will require more airlift than would be the case if three or four weeks can be tolerated. Though Europeans are talking about a 30-day goal for deploying the force in a contingency, some contingencies may well require faster response, others a slower pace. Clearly, an independent European force will require some fast-response airlift, but the question of how much airlift is a major determinant of total costs. Some contingencies may allow deployments over a month or two, allowing sealift to carry most of the burden.

Duration of Combat

The uncertain duration of future contingencies also affects required deployment capabilities. If planners can confidently judge that a contingency will last just a few days, they need only deploy combat forces, since such forces can usually sustain themselves for a short time. But if the contingency is extended and a lasting European presence is needed, support forces and resupply capabilities would have to be deployed along with the combat forces. In some cases, the whole panoply of military logistics capabilities—transportation, maintenance, medical, supply, etc.—may have to be deployed. Such deployment requirements depend on the presence or absence of local logistics support in the contingency area.

Reception Facilities

As the last point drives home, the speed and efficiency of deployments depend on the availability and quality of facilities in the contingency area. The deployments to Saudi Arabia during the Gulf War had the advantage of large and modern seaports and airports. But in other contingencies, such facilities may be far less developed. In those cases, the process of deployment may well be constrained by the quality of reception facilities. Moreover, the airports and seaports in an area may be somewhat distant from the force's ultimate destination. Not only does this delay the speed with which the force can close on its objective, it also affects the required mix of combat and supporting forces.

Distance

How far the deploying forces have to go will, of course, also affect force projection requirements. Obviously, deployments to trouble spots in the Arabian Gulf will require far more transportation than would sending the same force across the Mediterranean or into Eastern Europe. Some contingencies may occur just a few hundred kilometers from the continent. But given the diverse interests of NATO nations and the great uncertainty about future contingencies, deployments of several thousand kilometers are also plausible.

The Bottom Line—The Need for Robustness

All these uncertainties—in addition to others, such as ship and aircraft reliability, whether payloads will be as high as planning factors assume, whether airlifters will achieve high sortie rates or be constrained by maintenance requirements—argue that the best approach is to strive for a robust deployment capability, one that performs well regardless of scenario details and is affordable.

The issue of affordability or cost drives the issue of robustness. A robust capability should certainly include both ships and aircraft. Ships are clearly cheaper than aircraft, but they cannot provide the prompt response demanded in some conditions, they require even more time if port facilities are poor, and they may require substantial local transportation to move their cargo forward for inland operations. Airlift allows for fast reaction. Aircraft can deliver inland (by air drop if necessary), can (if they are like the C-17) carry most types of cargo, and can operate in small, poorly developed airfields. But the costs of an all-airlift deployment capability are extremely high. Thus, striving to find robust mixes of deployment systems at an affordable price requires looking at a balance of airlift and sealift and making trade-offs among available airlift resources, sealift purchases, tankers, and European Civil Reserve Air Fleet (CRAF).

Determining Scenarios and Force Packages

A deployable independent European force can have many missions. Displaying European interest, power, and support could be one. Protecting European nationals or rescuing hostages is a second. Restoring order when European interests are threatened is a third. Sending combat power to support the United Nations, as in the crisis and war in the Gulf, is clearly a fourth.

To understand the deployment needs for any of these missions, we first determined the characteristics of an independent European Force; then, we packaged that force into light, medium, and heavy units and connected them to four separate scenarios, which form the basis for the force projection analysis in the subsequent sections.

Characteristics of the Independent European Force

To determine these characteristics, we started with descriptions of NATO's RRC that were reported in the European press from May through July of 1991, increased the mobility of those forces, and then matched that to data on similar U.S. forces. This led us to define a corps with two Light Infantry Divisions, one Air Assault Division, one Light Armored Division, and one Heavy Armored Division. These divisions comprise 50,000 soldiers as the combatants, with the need for roughly 50,000 more troops in corps combat support (CS, e.g., corps artillery, corps aviation, combat engineers, etc.) and combat service support (CSS, e.g., corps and theater supply, transportation, maintenance, etc.). To round out the force, we assigned squadrons of fighter/attack aircraft and 20 Patriot Fire Units for protection against air threats that include primarily tactical ballistic missiles.

Comprising Force Packages

To determine force packages, we again relied on descriptions of the NATO RRC presented in a series of articles in the European press between May 20 and July 1, 1991.[1] These descriptions were interpreted in light of the need for rapidly mobile forces and then translated into analogous U.S. forces. Doing this enabled us to determine deployment personnel, tonnage, and shipping area characteristics.[2]

The analogous forces are described in Table 2.1, along with the fighter aircraft and missile defense assets we judged would be required. (The force tonnage and personnel are shown later in Table 2.3.)

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[1]See, for example, "NATO: A New Start," *The Economist*, June 1, 1991, p. 46.

[2]Military Traffic Management Command Transportation Engineering Agency (MTMCTEA) Report OA 88-4f-25, Military Traffic Management Command, *Deployment Planning Guide*, September 1989.

Table 2.1

Table of Force Packages

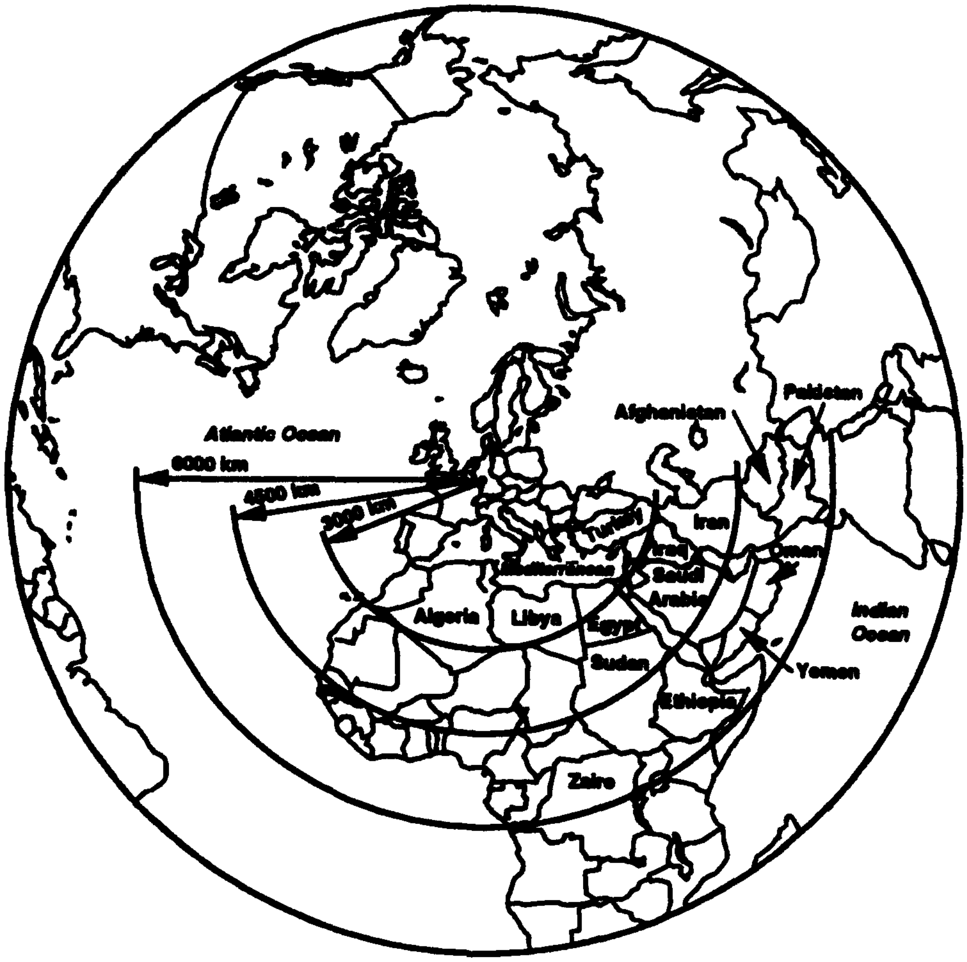
Light	Medium	Heavy
Air Assault Division	Air Assault Division (or 2 Light Infantry Divisions)	Air Assault Division (or 2 Light Infantry Divisions) (or add 1 Light Infantry Division)
CSS & CS package	1 Light Armored Division	1 Light Armored Division
3 Fighter Squadrons	CS + CSS packages	1 Heavy Armored Division
	6 Fighter Squadrons	CS + CSS packages
		6 Fighter Squadrons
		20 Patriot Fire Units

Devising Scenarios

In devising scenarios, we first determined the potential distances for the contingencies (shown on the azimuthal equal-distance projection map in Figure 2.1). Assuming that air deployments are centered in Frankfurt (a logical choice given the central location of Germany and the extensive air base complex at the Rhein-Main Air Base), we created some bands to correspond to potential mission areas.

At the shortest distances (3,000 kilometers), primary European contingencies can be handled, but covering much of the Middle East and parts of Southwest Asia requires 4,500 kilometers of force projection; the remainder of Southwest Asia and most of Africa require 6,000 kilometers.

Given the distances, we then created four scenarios to provide the basis for determining force projection needs. The scenarios are keyed to a series of threats and defined in terms of the distance required for force projection, the infrastructure constraints (condition of the airports and seaports), and the nature of the transport challenge (ranging from easy to arduous). Three variations on the scenarios were created that varied the distance and, thus, the transport challenge. The selected scenarios are among the most arduous in each class—defining the upper bounds of the required resources—but also cover a wide range of transport challenges. Table 2.2 summarizes the four scenarios and the variations.



(Scale – 1 cm = 1100 km)

Figure 2.1—Azimuthal Equal Distance Projection, Centered on Frankfurt

Table 2.2

Scenarios for Force Projection in 30 Days

Scenario	Threat	Infrastructure Constraints	Distance	Transport Challenge
1	Light but early resistance			
	Employ light force (w/ CS + CSS increment)	Poor airports; no seaports	6000 km	easier
2A	Secure base & ports against early enemy use of force			
	Employ heavy force (w/ CS + CSS increment)	Good airports; good seaports	4500 km	easier
2B	Same	Same	6000 km	harder
3A	Potential heavy enemy force in 30+ days			
	Show of heavy force (no CS + CSS increment)	Poor airports; ok seaports	4500 km	easier
3B	Same	Same	6000 km	harder
4A	Medium enemy force on the move			
	Employ medium force (w/ CS + CSS increment)	Poor airports; good seaports	3000 km	harder
4B	Same	Same	4500 km	arduous
4C	Same	Same	6000 km	arduous

Mating Scenarios to the Force Packages

Table 2.3 provides the cargo characteristics for each unit type within the independent European force described in Table 2.1 and employed in Table 2.2. Using the numbers in Table 2.3 and the light, medium, and heavy force packages summarized in Table 2.1, we can determine the total cargo needs for each force package. Table 2.4 illustrates the process for the medium force package. There are two medium forces—one with the Air Assault Division (AAST) and one using two Light Infantry Divisions (LID). Using the data from Table 2.3, we develop the cargoes of each force and then average them to get a medium force cargo requirement (104 metric tons, of which 28 metric tons are outsize). Similar computations were done for the light and heavy force cargo requirements. (Appendix A shows the tables for all the force packages.)

Table 2.3

Table of Forces: Cargo Characteristics
(M tons x 1000)

	Combat Personnel (x 1000)	Bulk & Oversize	Outsize	Total Unit	CS/CSS
Light Infantry Division	11	10.7	.4	12.6	12.6
Light Armored Division	7	9.3	11.9	22.1	22.1
Air Assault Division	16	19.3	1.4	23.0	23.0
Heavy Armored Division	17	41.3	27.3	71.1	71.1
Fighter Squadron		1.5	.4	2.0	
Patriot Brigade (18 Fire Units)		4.2	1.0	5.2	

NOTE: When available, combat personnel are converted to a tonnage number and added to the bulk & oversize and outsize requirements to get total unit tonnage.

Table 2.4

Cargo Needs for Medium Force Package
(M tons x 1000)

Units	Cargo	Amount Outsize	Units	Cargo	Amount Outsize
1 Air Assault Division	23.0	1.4	2 Lt. Inf. Divisions	25.2	.8
+CS/CSS	23.0	1.4	+CS/CSS	25.2	.8
1 Light Armored Division	22.1	11.9	1 Light Armored Division	22.1	11.9
+ CS/CSS	22.1	11.9	+CS/CSS	22.1	11.9
6 Fighter Squadrons	12.0	2.4	6 Fighter Squadrons	12.0	2.4
	102.2	29.0		106.6	27.8
Avg: medium force pkg.	104	28			

If we then marry the light, medium, and heavy force packages with the scenarios, we get the cargo requirements per scenario broken up by airlift and sealift (as shown in Table 2.5).[3] We decided to sealift the Heavy Division because of its

[3]The United States delivered about 100,000 metric tons per month by airlift during Operation Desert Shield/Storm (ODSS). Even with its robust system, carrying the heavy division by air was ruled out. See "They Deliver," *Air Force Magazine*, August 1991, p. 52.

Table 2.5

Cargo Needs for Scenario (Total/Outsize)
(M tons x 1000)

	Light	Medium	Heavy (w/CS + CSS)	Heavy (w/o CS + CSS)
Total	52/4	104/28	252/84	139/44
Airlift	52/4	104/28	110/29	68/17
Sealift	0	0	142/55	71/27
Scenario	1	4	2	3

great weight, because of its need for large quantities of outsize cargo capability, and because of observations based on U.S. experience. We selected air for the light and medium force because of the need for quick reaction and because ship deliveries take two to four weeks. The numbers in Table 2.5 are the numbers used to determine the airlift and sealift assets required.

Finally, we presumed that all forces are required within 30 days. For the medium and heavy forces, that means the combat divisions can be deployed as shown in Table 2.6.

Table 2.6

Unit Arrival Patterns

Air Assault Division (or 2 Light Infantry Divisions)[a]	Arrive day 7
3 Fighter Squadrons	Arrive day 8
Fighter Squadrons CSS	Arrive day 9
3 Fighter Squadrons	Arrive day 10
Fighter Squadrons CSS	Arrive day 11
Light Armored Division[a]	Arrives day 17
CS and CSS increment for above divisions	Arrives days 24 & 30
Heavy Armored Division[a]	Arrives day 22
Heavy Armored Division CS and CSS	Arrives day 30

[a]These target delivery dates become the driving requirements for the force projection resources.

Matching Airlift Assets to Force Projection Requirements

Airlift Options

In analyzing airlift options, we considered existing European military and civilian transport aircraft and options for improving capabilities. In terms of current capacity, we assumed that "baseline" airlift capacity would include 153 (out of 200) C-130s and 25 B-747 equivalents. We eliminated the 130 C-160 Transalls because their range/payload limitations make them an inefficient cargo aircraft for operations in excess of 3,000 kilometers. The few converted civil aircraft in military service were excluded because their condition is unknown and because there are too few to have more than a marginal impact. The number of C-130s was reduced to reflect competing missions, training, and aircraft overhaul requirements.

In terms of options for improving capability, we examined the EC-17 (a European C-17 surrogate) and the A-300 Airbus. The EC-17 will (1) carry a 53-metric-ton payload approximately 4,500 kilometers without refueling; (2) refuel in-flight to extend its range; (3) land and take off on runways of 1 kilometer; (4) be faster and more autonomous in loading and unloading cargo; (5) consume a smaller area of ramp space while on the ground; and (6) be able to carry most outsize military equipment, including a main battle tank. These characteristics are expensive, but they provide military planners with flexibility.[4]

Alternatively, the A-300 freighter is a civil design that operates as cost efficiently as possible. Thus, it (1) requires a ground-based infrastructure for loading and unloading; (2) requires 1.5- to 2.2-kilometer runways for landing and taking off; (3) cannot refuel in-flight, but has a longer design range than that of the EC-17; and (4) cannot carry the full range of outsize military equipment. Thus, these two aircraft complement one another.

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[4]The experience of the Netherlands Army during the 1991 Gulf War illustrates the need for the flexibility provided by outsize cargo airlift capability. NATO headquarters asked the Netherlands Army to move two Dutch Patriot Fire Units to Turkey within 48 hours. They had no outsize cargo capability and no U.S. aircraft could be diverted from the deployment of U.S. forces. Without any European capability, their only recourse was to lease Russian Antonov An-124 aircraft. (See *Jane's Defence Weekly*, International Edition, March 23, 1991, p. 427.)

During Operation Granby in support of the 1991 Gulf War, the British provided most of their own airlift for their 46,000-person force. The major exception was the need for 28 C-5 sorties for outsize cargo provided by the U.S. Military Airlift Command.

Several European military organizations have argued for purchasing some outsize airlift capability, often suggesting C-5 or C-17 purchase. See, for example, *Jane's Defence Weekly*, June 22, 1991, p. 1093, and *Aviation Week*, September 21, 1992, p. 27.

Several other options were considered and set aside. The C-5 was judged to be too costly, since further production would require reopening the production line. The A-340 was also judged to be too expensive, since its maximum payload at moderate distances is not significantly greater than that of the A-300 but its advertised price is more than $24 million higher. The C-130H was considered redundant and limited in range, and the Euroflag aircraft was viewed as too expensive given research and development (R&D) costs.[5]

Effect of Scenario Variables on Airlift Requirements

The important variables for determining airlift requirements are distance, force requirements, and capabilities of the airlift route network.[6]

Distance. As distance increases, with constant tonnage requirements, the number of aircraft required to deliver cargo within a fixed period increases. Distance affects cycle times—the amount of time required to load, take off, fly, land, unload, refuel, return, and perform maintenance.[7]

For the independent European force, the impact of distance on fleet requirements is not linear; instead, the number of new aircraft required tends to accelerate as distance increases, because most of the existing European fleet are short-range C-130 aircraft. These aircraft are replaced in longer-range, 4,500-kilometer or greater scenarios.[8]

Force Requirements. Force requirements also have a nonlinear effect on airlift fleet requirements. Generally, given a constant distance, the more cargo that is required, the more aircraft that will be required. However, the specific composition of the forces can dramatically affect the airlift fleet composition. For example, an Airborne Brigade may have a fairly small percentage of outsize

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[5]The C-5 option should be reconsidered if the C-17 fails to demonstrate its advertised performance or if the costs to reopen the line are borne by other nations. The A-340 option should be reconsidered if one of the principal goals of Europe's policymakers is to deploy significant military forces to regions in excess of 6,500 kilometers without the aid of en route transit points. And the Euroflag aircraft should be reconsidered if R&D costs are borne by industrial development funds rather than military budgets.

[6]This approximate analysis has simplified what is a complex set of variable interrelationships. The methodology we employ is summarized in Appendix B, as are further notes on our simplified approach.

[7]In this analysis, each of these activities is considered an independent event (e.g., loading is not occurring while maintenance is being conducted). Also, this analysis varies maintenance expectations for the EC-17, which is an unproven aircraft. Advertised flying hours are 15.65 hours per day. Alternatively, peacetime rates for other aircraft are closer to 10 hours per day. We provide results based on each parameter.

[8]The C-130 can be flown farther than 4,500 kilometers, just as it was in the Falklands War. However, the number of required refuelings becomes prohibitive considering the relatively small cargo (12 metric tons) carried.

materiel (about 5 percent), while a helicopter Air Cavalry Brigade has 15 percent, and an Armored Cavalry Regiment has 50 percent. Since only specialized military aircraft (such as C-17, C-5, and the proposed Euroflag aircraft) can carry this cargo, the planned force composition dramatically affects expected fleet requirements.

Aside from the outsize cargo issues, increasing force requirements may also have an accelerating impact on aircraft requirements if the quantity of cargo and the number of requisite missions begin to interact with airport constraints, such as the amount of available ramp space or the number and size of runways.

Airlift Route Network. We approximated the airlift route network constraints by focusing on the airport constraints. Airport constraints can affect requirements in three ways. First, runway length may be too short for typical civil designs to land. Second, the number of landing and takeoff events may be constrained by air traffic management limits. Third, the number of aircraft that can land and unload may be constrained by physical space and materiel handling limits.

We imposed two separate circumstances to test how fleet requirements would vary with increasing ground constraints. In the less constrained case, we assumed conditions much like those of the well-developed portions of the Persian Gulf—about 500,000 square meters of available ramp space and three main runways. The more constrained case assumes 100,000 square meters and one runway. In all cases, the physical space is assumed to be shared equally with tactical fighters. Finally, the number of aircraft landings and takeoffs is limited so that these operations are separated by a minimum of eight minutes.

As these constraints become more binding, they tend to push the fleet composition toward aircraft that load and unload quickly and toward larger aircraft (to reduce the number of aircraft required to deliver a given quantity of cargo). The variable that controls the extent to which these constraints become binding is the force requirement. The more tonnage required, the more the ground constraints will have an impact on airlift fleet composition. And as the analysis shows, if the tonnage requirements are substantial and the constraints restrictive, the fleet may shift from a mix of civil and military airlift aircraft to all military aircraft to meet the requirement.

Results of Airlift Analysis

Table 2.7 summarizes the requirements in each of the scenarios shown in Table 2.2. The scenarios vary distance, force requirements, and airport constraints, using the

Table 2.7

Cargo Aircraft Needs for Force Packages

Scenario	1	2A	2B	3A	3B	4A	4B	4C
Distance (km)	6000	4500	6000	4500	6000	3000	4500	6000
Force reqts. (M tons × 1000)	52	110	110	68	68	104	104	104
Ground constraints	more	less	less	more	more	more	more	more
C-130	0	153	0	153	0	60	80	0
Civilian B-747 equiv.	21	25	25	13	13	1	2	0
EC-17	29–40	27–40	35–48	23–31	61–86	73–75	77–108	118–161
A-300	0	16	89	0	0	0	0	0

NOTE: The two numbers for the EC-17 reflect aircraft utilization rates of 15.6 and 10 hours/day. This depends on the maintenance ability of the ground operations.

force requirements numbers for airlift shown in Table 2.5. In the first scenario, a light force is deployed a long distance to an area with significant ground constraints. The distance limits the utility of the C-130s, and the ground constraints limit the utility of the civil aircraft. (See Appendix B, Fleet Composition.) The result is a requirement for between 29 and 40 EC-17s (depending on maintenance assumptions). Scenarios 2A and 2B deploy a heavier load over two separate distances to areas with few ground constraints. In the shorter case, all the existing capacity is brought to bear and EC-17s are required only for the outsize component of the force.[9] In the longer scenario, more aircraft are required because of the distance and the C-130 fleet must be replaced. Scenarios 3A and 3B deploy a mid-weight force over two separate distances into an area with more ground constraints. The result is an increase in the number of military aircraft required because of limits on the utility of the baseline fleet and of the A-300. Finally, scenarios 4A, 4B, and 4C deploy a heavy cargo over three separate distances into an area with more ground constraints. The result is that the utility of the European baseline is very small and the requirement for flexible military airlift aircraft is very high.

The scenarios described in Table 2.7 may be grouped based on the number of outsize airlift aircraft required (see Table 2.8). Grouping the scenarios this way

[9] A question that is worth addressing is the force deployment ability of current European airlift (without any outsize cargo aircraft). They could airlift 95 percent of two combat-equipped light divisions or an Air Assault Division a distance of 4,000 kilometers in a week. However, some outsize equipment (2,000 to 4,000 metric tons) could not be accommodated. (Notable shortfall would include divisional helicopters, command and control vans, 10k rough terrain forklifts, and aviation repair shelters.)

Table 2.8

Grouped Airlift Fleets

	Small Investment	Medium Investment	Large Investment
Scenarios	1, 2A, 3A	2B, 3B, 4A	4B, 4C
C-130	153	153	153
Civilian B-747 equivalent	25	25	25
EC-17	32	63	116
A-300	16	30	0

keeps the variance low and allows us to classify scenarios into small, medium, and large investment scenarios. The groupings reflect those scenarios that require similar numbers of flexible, outsize-capable military airlift.

Matching Sealift Assets to Force Projection Requirements

Sealift Options

As indicated earlier, we developed sealift options for deploying the Heavy Armored Division. In some scenarios that do not need Heavy Armored Divisions, the ships could be used for moving some of the other forces, thus adding to the robustness of the projection forces.

Sealift capability can be built using one or more combinations of three ship categories: (1) ships that are government-owned and maintained in reserve status by commercial firms under government charters; (2) commercial ships chartered by the government in time of need; (3) government-built ships leased to the commercial sector that are requisitioned in time of need.[10] For this analysis, we focused on the first two categories.

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[10]Europeans, particularly the British, have considerable experience in deploying modern forces by sea. We have tried to incorporate elements of those experiences into our analysis of sealift requirements for a future European Force.

Typically, European nations have not maintained fleets of government-owned cargo ships held in reserve for contingency operations and have instead relied on acquiring civilian ships operating in the market when the need arises. For example, during the Falklands War, the British government requisitioned some 50 British-owned ships, rapidly modified them to support the operations envisioned (helicopter pads, repair workshops, hospital facilities, troop accommodations, and more), and employed them throughout "Operation Corporate."

Government-owned ships in high-readiness reserve status typically are maintained in 4- to 5-day readiness and can respond quickly to force deployment requirements. However, maintaining this capability requires substantial investment in ship procurement and an annual payment of support cost. Relying on charter commercial ships can negate these costs, but there is a penalty in response time. Ship availability will vary substantially from days to weeks, depending on economic conditions and operating cycles, which are outside government control.

Category 1: Government-Owned and -Operated. In this analysis, we used the fast sealift ship(s) (FSS) employed by the United States. It is a proven design, provides as good a response as several other designs, and is easily built in European shipyards.

The FSS is a 30-knot ship with a maximum cargo capacity of 21,000 square meters, with hullform and dimensions identical to those of the eight FSS currently in the U.S. Department of Defense (DoD) inventory. The Heavy Armored Division of 71,000 metric tons and 123,000 square meters requires nine FSS.[11]

Category 2: Commercial Ships. During ODS, the United States chartered over 50 foreign-flag commercial ships to carry military equipment, many of these from NATO countries; in planning mobility capabilities for a rapid response force, these assets should be considered. Cost is the principal advantage of this option—there is no procurement cost and the commercial sector pays operating and maintenance costs. However, there are three principal drawbacks in using commercial assets for rapid deployment: (1) availability, (2) small relative size compared to the government-controlled ships, and (3) slow speed.

The availability of commercial ships to carry military cargo will vary as a function of ship employment cycles and economic conditions. Since they may be employed in the Atlantic or Indian Ocean or Far East trade routes, they may not be as readily available as government-controlled ships in reduced operating status. Thus, for this analysis, we postulated a seven-day activation time for commercial shipping.

In terms of size, the commercial roll-on/roll-off (Ro/Ro) ships used in ODS on average carried 5,000 square meters of cargo, which is only 18 to 40 percent of the cargo capacity of the government-owned sealift candidates (taking into account

[11] Ship availability is assumed to be 90 percent, and we employed a cargo stowage factor of 75 percent.

cargo stowage). Thus, a fleet of about 29 comparable commercial ships would be required to carry the unit equipment or the CS/CSS of an armored division. This number needs to be obtained out of nearly 1,000 European flagged ships.

Commercial Ro/Ros used in ODS were also slower than their government-owned counterparts—15 knots versus 30 knots for the FSS. Taking into account longer activation time and slower speed, comparable commercial ships would complete cargo deliveries within 30 days to all representative locations if seaports of debarkation (SPODs) are unconstrained. In constrained berthing and access cases, they would begin deliveries only within 30 days. This suggests that commercial shipping is not a robust option for the rapid deployment of unit equipment. However, because commercial ships are essentially a no-cost option, they are suitable for transporting support materiel that does not have to arrive at the same rate as unit equipment.

Effect of Scenario Variables on Sealift Performance

For this analysis, we postulated that the sealift ships are based and pick up cargo at a central Mediterranean port (i.e., Genoa, Italy). The ships carry cargo to three notional locations: (1) the eastern Mediterranean (1,500 nautical miles [nmi]); (2) central Africa (3,500 nmi); and (3) the Persian Gulf (4,500 nmi). (These correspond to our air scenario alternatives.) Taking into consideration ship activation, loading and unloading, and transit times, we calculated the cycle time of the candidates to the three locations, under varying reception conditions.

Two key variables affect sealift performance: constrained berthing and limited access.

Constrained Berthing. In the constrained cases, we postulated that only three FSS can be accommodated in the port berthing facilities, thus slowing cargo deliveries compared to cases with no constraints.

Limited SPOD Access. In the limited-access case, the FSS cannot enter port and must unload cargo at anchorages to lighters. Consequently, they complete cargo deliveries later than they would with no constraint. Specifically, unloading time is increased by 50 percent.

Results of Sealift Analysis

Table 2.9 gives the delivery time of the unit equipment of a Heavy Armored Division for a fleet of nine FSS. At worst, the fleet can deliver it in 26 days, with

Table 2.9

Sealift Performance of FSS

Scenarios	Days to Cargo Arrival
Eastern Mediterranean (1500 nmi)	
Unconstrained SPOD	10
Constrained berthing	16
Limited SPOD access	20
Central Africa (3500 nmi)	
Unconstrained SPOD	13
Constrained berthing	19
Limited SPOD access	23
Persian Gulf (4500 nmi)	
Unconstrained SPOD	16
Constrained berthing	22
Limited SPOD access	26

an average of 22 days. If the CS/CSS materiel is shipped by 29 commercial leased ships, it will arrive by day 30 in the unconstrained case, or at least begin off-loading by day 30 in the constrained cases.

Matching Tanker Assets to Force Projection Requirements

Tanker Options

There are three basic options for tankers: (1) active A-300 freighter-tankers, (2) civilian A-300 freighter-tankers/CRAF, and (3) the current European fleet of approximately 30 military tankers (e.g., KC-135R, VC-10, KC-707, and L-1011s).

In the first option, conventional A-300 freighters would be modified on the production line so that they have an in-flight capability to off-load fuel. The basic concept is that the A-300 would be fitted with additional internal piping, fuel pumps, a control panel in the cockpit, and necessary hardpoints for the mounting of drogue pods (on the wingtips). The drogue pods would then be stockpiled at mobilization points.

The second option would involve the same modification as described above but would involve a different operational concept: The planes would be owned by an airline or air freight company and, with the exception of a brief training period each year, would be required only in times of crisis. More specifically, with respect to crew training, the aircraft would be called up for a five-day period each year (the airline would be paid for the period it was out of regular service), the drogue pods would be attached, and the crews would then practice refueling sorties.

The third option is the base fleet.

Effect of Scenario Variables on Tanker Requirements

The degree to which air refueling is required depends on the specific situation in which a particular scenario unfolds. There are two basic considerations for tanker support: (1) en route refueling, and (2) support of the fighter air operations. In both cases, the tanker requirements can be highly variable, and worse, their probabilities of occurrence can vary greatly depending on specific scenarios. Thus, our attempt here is to attain some "reasonable" estimate of tanker support without buying the maximum possible.

En Route Refueling. For airlift or fighter aircraft, there may be no requirement for air refueling if adequate refueling locations exist along the route of the deployment. Deployments under 3,000 kilometers will require minimum refueling, while deployments of 6,000 kilometers and 4,500 kilometers both require refueling. If air refueling would be required because no en route refueling is possible, we need to estimate refuelers. We used the 4,500-kilometer range to estimate the number required and assumed the use of an A-300 modified for tanking (see Appendix C).

The en route tanker requirements (if needed at all) are:

- 20 for the easiest cases (Scenarios 1, 2A, 3A);
- 25 for the harder cases (Scenarios 2B, 3B, 4A);
- 44 for the arduous cases (Scenarios 4B, 4C).

In-Theater Operational Support. This fighter air refueling requirement depends on many variables: the fleet size, the daily sortie rate, distances from air bases to targets, aircraft type, and external stores carried. If conditions are right, and include a lower demand for sorties, some or most refueling could take place on the ground. Any realistic estimation of tankers for a future unknown scenario will be difficult. We estimated 30 to 50 tankers for in-theater fighter operations (see Appendix C).

Results of Tanker Analysis

Table 2.10 presents the results of the analysis.

For scenarios 1, 2A, and 3A, we assumed in a best case (see top of table) that tankers are needed only for support of the fighter air operations and that the operations are less than 750 kilometers from the air bases. In the worst case, en route refueling is necessary, but fighter operations are within 750 kilometers. For scenarios 2B, 3B, and 4A, we assumed the same best case, but the worst case requires simultaneous air refueling with fighter operations at 1,000 kilometers. Given poor fields, scenarios 4B and 4C will require remote fighter (1,000 kilometers) operations even in a best case, although enough en route refueling locations can be found for the airlift. The worst case adds en route air refueling. The bottom part of the table shows that enough tankers are kept in the active force to cover the best case (30 + 16 = 46 vs. 30 needed for the best case), with CRAF as a backup to cover 90 to 100 percent of the worst cases (presuming the very worst cases have low probability and can be managed by alternative actions). All the A-300s used are fitted out as tanker-freighters, as indicated in the cost section. We presumed that even when refueling they can carry useful freight payloads, thus increasing flexibility.

Summary of Force Requirement Results

The first half of Table 2.11 builds up airlift, sealift, and tanker requirements from Tables 2.8, 2.9, and 2.10, respectively. Those assets marked with a plus (+) represent resources needed to augment the force projection capability; unmarked assets represent resources currently available to the European Community (EC).

Table 2.10

Grouped Tanker Assets

	Small Investment	Medium Investment	Large Investment
Tanker best case	30	30	50
Tanker worst case	50	80	100
Scenarios	1, 2A, 3A	2B, 3B, 4A	4B, 4C
Current military tankers (active)	30	30	30
A-300 tanker-freighter/active	16	30	30
Civilian A-300 tanker-freighter/CRAF	5	15	30

Table 2.11

Force Projection Required Resources by Investment Level and Scenario

	Small Investment	Medium Investment	Large Investment
		Scenarios	
	1, 2A, 3A	2B, 3B, 4A	4B, 4C
Assets	(Easier)	(Harder)	(Arduous)
C-130	153	153[a]	153[a]
Civilian B-747 equivalent	25	25[b]	25[b]
+EC-17	32	63	116
Current military tankers	30	30	30
+A-300 F/T (active)	16	30	30
Civilian A-300 F/T (CRAF)	5	15	30
+FSS	9	9	9
Commercial leased ships	29	29	29
Initial investment ($ billion) (total/per year for 5 years)	9/1.8	16/3.2	23/4.6
Operating costs (total/per year for 25 years)	9/.36	16/.64	26/1.04
Total 25-year life cycle cost	$18 billion	$32 billion	$49 billion

[a]Not usable in the longest scenarios.
[b]Not usable where the airport ramp space is constrained.

The augmentation is shown across the three scenario groupings, which represent varying levels of robustness. Each increasing investment level includes the cases at the lower investment levels.

The A-300 Airbuses serve as both tankers and airlifters, thus further increasing robustness. Obviously, these systems can be employed in different ways than when we computed them. When a known situation arises, specific resource allocations can be made. For example, if only a light force is needed early and/or a great deal of time is available to deliver further forces, then very few airlifters are required and everything can be done by ships (both active and leased). The systems are all very balanced, providing active forces in airlift, tanker, and FSS, with backup in the CRAF and in the leasing of ships.

These systems are designed to provide combat forces and their combat support and combat service support within 30 days and to provide about a month of sustainability. If operations beyond four to six weeks are anticipated, a theater support increment and resupply are needed. Experience says these additional elements will be equal in weight to the combat force initially delivered.

Cost Analysis Results

The total costs, both investment and operating (see Appendix D), to cover the augmentation needed for the + assets are shown at the bottom of Table 2.11, ranging from $18 billion to $49 billion. As indicated, initial investment (R&D plus procurement) accounts for roughly half of the total 25-year life cycle costs. If the initial investment is spread over a five-year period, then initial investment costs will run from $2 billion a year on the low end to $5 billion on the high end. Once the initial hurdle has been passed, annual operating costs will run anywhere from $400 million to $1 billion per year.

While the most expensive investment provides a very robust capability, it is not anywhere near as robust as the U.S. capability. On the other hand, the least expensive system gives quite a capability for light deployments or for deployments where good infrastructure exists. It just lacks robustness.

When costs are broken down by costs per system (Table 2.12), we see that the EC-17 clearly dominates cost, from 60 percent of total costs in the first grouping of scenarios to 80 percent in the third grouping.

Alternatives clearly exist with respect to aircraft and ship types, procurement strategy, and operational concept. For example, the C-5B is an alternative to the C-17, and it may be that the costs of reopening the line are more than offset by its lower flyaway cost. With respect to procurement strategy, it may be that the Europeans would prefer to build the EC-17 themselves under a directed licensing

Table 2.12

25-Year Life Cycle Costs by System (U.S. $ billions)

Scenario	EC-17/ Active	A-300 F-T/Active	A-300 F-T/CRAF	B747-400F/ CRAF	FSS/Ro/Ro	Total
1, 2A, 3A	11	4	negligible	0	3	18
2B, 3B, & 4A	22	7	negligible	0	3	32
4B & 4C	39	7	negligible	0	3	49

agreement[12] than to buy the aircraft directly from McDonnell Douglas. Or it may be that a more cost-effective procurement strategy with respect to the A-300 freighter-tankers would be to procure used wide-body aircraft and refurbish and modify them as necessary (e.g., the Royal Air Force's [RAF's] Tri-star tankers). And finally, with respect to operational concepts, we considered active-duty status and civilian reserve status. It may be that the Europeans feel that military reserve status offers the best balance between cost and response time.

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[12]In this type of situation, the licensor provides a data package, technical assistance, and occasionally some equipment. The exact amount and type of assistance needed varies with the skill and experience of the licensee. Historically, transfer costs (license fees, royalties, and liaison costs) have varied from 3 to 16 percent of the total airframe procurement cost with an average of roughly 10 percent. (See G. A. Carter, *Directed Licensing: An Evaluation of a Proposal Technique for Reducing the Procurement Cost of Aircraft*, R-1604-PR, RAND, Santa Monica, Calif., December 1974, pp. 53–55.)

3. A Satellite-Based System for an Independent European Force

In this section, we will provide rough estimates of the cost of building several alternative satellite-based systems that provide communication and intelligence functions.

Why Focus on Satellite Systems?

We focused on satellite systems rather than on the intelligence needs of an independent European force for three reasons. First, satellites have some definite advantages over other ways of gathering military intelligence data. For example, satellites are relatively safe against enemy threats. In the Outer Space Treaty of 1967, the United Nations agreed that satellites can freely travel in space over every country's territory.[1] Another advantage of satellites is that they offer access to anywhere in the world without the need for a nearby infrastructure—satellites need neither airport nor harbor and, with a suitable communications infrastructure, can beam their data to a receiving station anywhere in the world.

While commercial systems like the American LANDSAT satellite and the French SPOT are useful for some military and intelligence-gathering purposes, several European leaders have decided that these commercial satellites are not adequate for the intelligence needs of a modern army. Greater resolution would improve the military usefulness of pictures taken from space.[2] Also, satellites can serve in a large variety of ways in addition to imaging. France's Defense Minister Joxe[3] has said that electronic intelligence could allow one to listen in on communications and other signals or provide early warning of missile attack. In addition, satellites could continually monitor known nuclear test sites to detect explosions.[4] Moreover, satellites can be used to improve weather forecasts, and the military can position a satellite to obtain such information in an area of the

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[1] See, e.g., Lucy Stojak, "Comparison of the legal aspects of space-based remote sensing and aerial remote sensing for verification," in Michael Slack and Heather Chestnutt (eds.), *Open Skies: Technical, Organizational, Operational, Legal and Political Aspects*, Center for International and Strategic Studies, York University, Toronto, Canada, 1990.

[2] Ann M. Florini, "The Opening Skies," *International Security*, Vol. 13, No. 2, 1988, pp. 91–123, provides information about the resolution needed for various targets.

[3] *Defense Nationale*, May 1991.

[4] See Krepon et al., *Commercial Observation Satellite*, St. Martin's Press, New York, N.Y., 1990.

world that would not otherwise have such coverage. Further, the precision of military operations can be greatly enhanced by providing the precise location of military units through a system such as the United States' Global Positioning System (GPS). Finally, many European nations already use satellite systems for military communications.

A second reason we are focusing on satellite systems is that such systems can serve various other national purposes beyond the purely military uses discussed above. For example, satellites can be used to verify compliance with disarmament treaties, can allow monitoring of military activities to prevent benign activities from being misunderstood as hostile activities, thereby increasing the public's confidence in its security, and can allow monitoring of resource utilization and environmental problems. In addition, some nations look on developing space capabilities as a way of encouraging economic growth, particularly in their high-technology sector. Some countries even view satellite systems as a source of prestige.

The third reason for focusing on satellite systems is that there has been a substantial amount of talk about a European satellite intelligence system. French Defense Minister Joxe said that surveillance from satellites should receive the same financial and political priority that nuclear forces received in the 1960s.

Because of this public discussion, we decided it might be helpful to describe the costs of various satellite capabilities. We have not considered all the nonsatellite ways of gathering the additional intelligence that an independent European force would need. In particular, we have not done a cost-benefit analysis of satellites vs. alternatives.[5] In addition, because of all the nonmilitary purposes of a satellite system, we did not attempt to find the least-cost method of obtaining the intelligence that a new military force might need. Rather, we assembled the costs of obtaining various capabilities via satellites.

Determining Capabilities of a Satellite-Based System

To estimate the costs of a European satellite system for communications and intelligence, we first determined the capabilities the system will provide. As was the case in estimating force projection requirements, a range of capabilities might be purchased. At the low end of the range are the European military systems that are now operational. At the high end is a system that contains all the

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[5] See, e.g., Peter Stübrany, "Airborne and space-based sensors: A comparison," in Michael Slack and Heather Chestnutt (eds.), *Open Skies: Technical, Organizational, Operational, Legal and Political Aspects*, Center for International and Strategic Studies, York University, Toronto, Canada, 1990.

capabilities that have been considered feasible in the reasonably near future. An almost infinite variety of capability levels are possible in between these two extremes. Rather than try to enumerate a large number of capability levels, we chose three levels that illustrate points on the spectrum and that together provide a notion of the possible cost/capability trade-offs. We also provided the underlying data so the cost of different configurations could be estimated or the sensitivity of the findings to particular cost parameters could be checked.

Three Scenarios for Satellite Systems

The satellite systems in the three scenarios are defined as follows. The limited-capability case only includes continuing capabilities that European governments have already deployed or that are in advanced development with a plan for deployment. We view this as a minimum-capability level to which improvements may be added.

The medium-capability case includes a unified, large-scale satellite communication system dedicated to European military communications and several of the capabilities mentioned in the statement made by French Defense Minister Joxe: imaging in the optical, infrared (IR), and radar ranges and a system to monitor electronic signals. We also added two data relay satellites so that information from the other satellites could be relayed to a ground station in Europe.

The high-capability case provides increased robustness by increasing the number of radar-imaging satellites from one to two and by adding several capabilities. The first additional capability is a set of three meteorological satellites dedicated to supporting the independent European force. Although meteorological information is available from civilian satellites, having polar satellites run by the military can provide improved forecasts in targeted sections of the world. Other capabilities added in the high-capability case are a system to eavesdrop on communications from geosynchronous orbit and a system to detect ballistic missile launches.

The final capability added in the high-capability case is a duplicate of the United States' GPS. At any point on the earth, beams from four satellites in this system can be received and the precise location of the observer calculated. This capability can be of substantial military value. Although initial plans had been for the United States to encode the signals so there would be some (roughly 100-meter) uncertainty in the estimated position of users who were not privy to the code, the system currently provides roughly 15-meter accuracy to all users. The scientific community is putting substantial pressure on the U.S. Department of

Defense to maintain this level of accuracy in the future; thus, Europeans are likely to have continued access to this capability without further investment. However, some Europeans might argue that the independent European force should be completely independent of the United States. Therefore, duplicating this system could be part of an investment in a large satellite capability. The 24 satellites included duplicate the completed GPS rather than the GPS that existed during this study.

Theater Tactical Control Systems

In addition to satellite intelligence and communication systems, an independent European force will need tactical control systems that can move with the force. We included both an airborne command and control system and a battlefield intelligence system in our medium- and high-capability cases, but neither in the limited-capability case.

An airborne command and control system would integrate information from air defense radars, airborne surveillance, and other sources to support decisionmaking in times of tension and to allow combined and joint operations to be conducted efficiently during wartime. The system would provide timely information exchange and a central data base for air traffic control, integrated tasking, and combined air operations. The radars and other detectors being used for national forces do not need to be duplicated, but an independent force would require an independent command and control system.

Other costs that we have not counted are also likely to be incurred in setting up a duplicate command and control center. For example, substantial nondollar costs may be incurred because the best officers will be required to learn two systems. Other costs include training costs to learn to operate under a duplicate system.

A battlefield intelligence system would consist of aircraft that fly over or near the area being surveyed and relay information to battlefield commanders. We included 5 airplanes and 24 ground support modules.

Intelligence Data Processing

As mentioned earlier, an important system-design decision concerns whether there will be a single centralized facility that performs the function of reception and interpretation of intelligence information or whether separate national facilities will serve this purpose. Reception and interpretation of intelligence data have traditionally been reserved by national governments. In a satellite intelligence system, this would allow each government to separately evaluate the information contained in the raw data and to reach its own conclusion about the desirability of committing to military action. The price of this independence is duplication of facilities and unnecessary effort.

In each of our cases, we chose to assume a single central facility for data fusion and interpretation.[6] From a technical standpoint, this is clearly the more efficient arrangement. However, it implies a substantial degree of interdependence among the nations in the military consortium and may not be politically appropriate. If it is not appropriate, costs would be somewhat higher.

Other Infrastructure

To operate the new intelligence system provided by any of these cases, it will be necessary to build certain items of infrastructure. We assumed existing or planned launch vehicles and facilities could be used for launches, and, thus, we included only expendable launch vehicle purchase in the costs for each satellite. We included the costs of ground stations for tracking, telemetry, and control of each satellite system. In the high-capability case, we also included a space surveillance radar system that will monitor the location of satellites and other debris.

Civilian Systems

Military and civilian space systems are intertwined in several ways. For example, civilian systems provide data directly to the military and some satellites carry both military and civilian payloads. In addition, many European military systems use exactly the same technology as civilian systems. Helios, the French military remote sensing satellite, will use the same bus as the European Remote Sensing (ERS) satellite and the commercial remote sensing satellite (SPOT), and Ariane rockets are used to launch military and civilian satellites; there are other examples covering data relay and remote sensing systems.

The European civilian space sector contributes substantially to European military capabilities by providing research and development efforts to technologies that can be used by the military, either directly or as a precursor to further development in the military sector. We assumed that substantial civilian space

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[6]Each satellite system has its own ground station to actually receive the data from the satellite and transmit it to the central facility. This is necessary for technical reasons of matching the antenna and other equipment to the needs of the satellite being served.

effort will continue in all our scenarios. Our calculations assumed that the level of civilian effort is constant in all three scenarios. Thus, the civilian programs contributed the same amounts of both costs and capabilities to the military in all three scenarios. Consequently, the civilian programs were not explicitly costed in any of the scenarios.

Cost Data for a Satellite-Based System

System Costs

Most of the generic capabilities required for our scenarios are found in systems for which an architecture has been proposed; thus, cost estimates can be found in the literature or can be developed from simple rules of thumb. Table 3.1 shows the military space systems we have used to develop the cost of our alternative systems, their costs, and the sources of the cost data. For all but three of the capabilities in our scenarios, European systems exist for which costs can be estimated either directly from a published estimate or by analogy with a similar system. The costs covered in the table include the purchase of one generation of satellites; launch costs; all costs associated with telemetry, tracking, and control of the satellite; and, in some cases, R&D directly related to system development. For example, we believe that the R&D included in the Helios I cost estimate includes R&D related to sensor development. But it does not include the R&D related to the spacecraft bus that is used on several other systems and that was developed in a different project. No R&D is included in the costs of the communication systems of Syracuse, Hispasat, or Skynet, because these are existing systems.

No comparable European system could be found for three space capabilities. First, there was no system for listening to communication signals from geosynchronous orbit. This capability would require a reasonably large, sophisticated communications satellite. Thus, we estimated that its costs would roughly approximate those involved in developing and building the civilian European Data Relay System (EDRS), except with three satellites rather than two. (We used EDRS to derive our cost estimate because of the system's size and sophistication; we do not suggest the equipment would be similar.)

Second, there is no system for navigation and location. We priced the system used in the scenarios based on the contract that the U.S. government has for the next block of satellites in the GPS system. We included no R&D costs here because we assumed that existing technology would be used.

Table 3.1

Cost Data for Military Space Systems

Satellite System	Purpose	Design Lifetime (years)	Number of Satellites	System Cost Estimate ($ millions)	Estimate Source
Skynet4	Communication	7	3	554	Interavia
Syracuse	Communication	10	3	120	Our estimate from Hispasat
Hispasat	Communication	7	2	85	Interavia
Eumilsat	Communication	10	6	1350	Defence News '91
Helios I	Imaging	5	2	1200	Defense Daily, 7/15/91
MEDRS	Data relay	7	2	973	Dornier, Deutsche Aerospace
Cerise	Intelligence, LEO	n/a	1	25	Space News
Zenon	Intelligence, LEO	3	6	629	Our estimate based on satellite weight
	Intelligence, GEO	10	3	1660	Our estimate from EDRS
Helios II	Imaging & IR	5	2	1360	Dornier, Deutsche Aerospace
Osiris	Imaging-radar	5	2	1500	Dornier, Deutsche Aerospace
Poseidon II	Ocean surveillance	5	3	350	Defense Nationale with estimate
GPS	Navigation	5	24	2426	Interavia
DSP	Early warning	5	2	2500	Nicholas and Rossi
POEM Ops	Weather	3	3	431	Defense, 6/91, and Air and Cosmos, 11/18/91

SOURCES: *Interavia Space Directory 1991–92* (A. Wilson, ed.), Jane's Information Group, Alexandria, VA, 1991. Ted Nicholas and Rita Rossi, *U.S. Weapon Systems Costs*, Tenth Edition, Data Search Associates, 1990. J.C. Husson, "State of technology required for satellite dedicated to arms control," Conferences of Western European Union, Rome, March 1990. *Dornier Deutsche Aerospace*, "Industrial View on European Space Based Verification," Feb. 18, 1992.

NOTES: When sources listed a range, we took the median. Costs of Hispasat include only those paid by military. The costs of GPS and Cerise were increased to add launch and ground costs. Zenon was described in Husson, 1990. The following are brief descriptions of the space systems that we have named. Eumilsat is an integrated, dedicated European military satellite system being discussed that would reduce the redundancy of the currently separate national systems. MEDRS (Military European Data Relay Satellite) is a dedicated military copy of the civilian European Data Relay System (EDRS). Helios II is the second-generation Helios satellite, which is being planned to include extensive infrared capability. Poseidon II is a dedicated ocean reconnaissance system based on the sensor developed for the civilian Topex/Poseidon mission. POEM (Polar Orbit Earth Observation Mission) Ops is a military polar meteorological program based on the experience gained in the experimental civilian POEM program. n/a = not available.

Third, there is no system to detect and provide early warning of missile launches. We priced the system in the scenarios from a scaled-down version of the U.S. system, Defense Support Program (DSP).

Nonspace System Component Costs

The systems costs shown in Table 3.1 cover only ground systems related to the health of the spacecraft, not to the processing of its data. Table 3.2 shows our estimates of the other nonspace system components of our alternative intelligence systems and their source. The estimate for Syracuse includes the cost of 100 receiving and transmitting stations. We estimated that creating an integrated European system of six satellites would call for roughly an equivalent additional investment beyond the existing and planned networks.

In the medium-capability case, we provided a single data center to integrate reconnaissance and estimated its costs from an existing system to integrate tactical reconnaissance data. In the high-capability case, we doubled both the capacity and the cost shown in Table 3.2.

The cost of the airborne command and control system will depend heavily on the detailed requirements that are decided upon. For example, the original proposal

Table 3.2

Ground and Air System Components

Component	Component Cost ($ millions)	Estimate Source
Ground network for Syracuse	1200	Defence Weekly, 7/9/88
Ground network for Skynet	1200	Estimated from Syracuse costs
Ground network for Hispasat	600	Estimated from Syracuse costs
Additional stations for Eumilsat	1200	Estimated from Syracuse costs
Processing stations for Helios	250	Cost of 3 stations
Intelligence data center	1250	Cost of tactical reconnaissance integrated ground station near Hahn, as reported in C4I Report, 4/15/91
Battlefield intelligence	1156	Scaled down from official estimates of J-STARS
Airborne command and control	4000	Estimated (see text)
Space surveillance center	470	Cost of 5 Cobra class radars from *Jane's Radar Systems*, plus estimated data center and operations cost

NOTE: Costs include investment costs and 10 years of operations costs except for the last three systems, which include 20 years of operations costs. J-STARS is the Joint Surveillance and Target Attack Radar System.

to build NATO a new Airborne Command and Control System (ACCS) would have required spending between $25 billion and $30 billion over a 20-year period. Subsequent options examined included four that ranged from $7 billion to $10.5 billion. Sensors accounted for only 25 to 30 percent of the costs of these options. Thus, we believe that the $4 billion we estimated for building an ACCS (excluding sensors) for an independent European force is reasonable.

The space surveillance system is designed to survey from earth the positions of satellites and debris. Knowing this information increases satellite mobility and decreases the danger of accidental loss of satellites. This system, estimated at $470 million, is included only in the high-capability case.

We did not include ground receivers for the navigation system, reasoning that the alternative to building a European navigation system is to use GPS for European military needs rather than not to have a system. Consequently, the European navigation system would not require the purchase of additional ground equipment.

Our sources were predominantly secondary sources, which are well known for difficulties related to reliability and interpretation. Thus, we cannot be certain of individual numbers. Our goal was to provide rough estimates of the magnitude of the costs and capabilities involved rather than definitive answers.

Civilian European System Costs

Table 3.3 presents a selected set of civilian European systems that have substantial joint costs with military systems, their costs, and the source of the cost estimates. We selected these systems because they provide either data of apparent military value or technology to a military system, either directly or as a precursor system. The $7 billion total cost greatly exceeds the cost of current dedicated military systems. We did not add these items in any of our cases. Our estimates of R&D costs came mostly from European sources and assumed a continued healthy civilian sector.

Estimating the Costs of Alternative Capability Levels

The data presented in Tables 3.1 and 3.2 are the sources of our estimates of the costs of adding the various capabilities. However, the system costs are not directly comparable because they provide services that last for different periods

Table 3.3

Cost Data for Selected Civilian Space Systems

Satellite System	Purpose	Design Lifetime (years)	Number of Satellites	System Cost Estimate ($ millions)	Source
Civil Hispasat	Communication	10	3	867	Interavia
Telecom (Syracuse)	Communication	10	3	764	Defence News, 6/3/91
SPOT	Imaging	5	1	444	Interavia
Artemis	Data relay	10	1	560	Air & Cosmos, 11/18/91
EDRS	Data relay	10	2	1186	Air & Cosmos, 11/18/91
Topex/ Poseidon	Ocean surveillance (SAR, altimeter)		1	142	Interavia
ERS	Ocean surveillance (SAR, altimeter)	3	2	1002	Pryk
POEM	Polar/climate	4.5	1	1095	Air & Cosmos, 11/18/91
Meteosat	Weather	5	3	551	Interavia
Locstar	Navigation	12	2	392	Interavia

SOURCES: *Interavia Space Directory 1991–92* (A. Wilson, ed.), Jane's Information Group, Alexandria, VA, 1991. Also, Ian Pryk of the Washington Office of the European Space Agency, private communication, dated Feb. 10, 1992.

NOTE: Topex/Poseidon includes only European costs.

of time and because costs are incurred over different time periods. For example, the communications satellites are typically designed to last 10 years, while satellites in low earth orbit typically last only 3 to 5 years. To keep a system whose satellites will last for only 5 years operating for a 10-year period requires buying twice as many satellites as are required for a system whose satellites will last for 10 years.

Our solution to comparing alternative systems with different time frames is to consider a 25-year period that consists of a 5-year period during which new systems are developed and deployed, followed by a 20-year period in which roughly similar capabilities are operated.[7] The 20-year operational period was chosen as a reasonable period in which to amortize the costs of many of the facilities described in Table 3.2. It also provides the same time frame as the analysis of force projection costs used in Section 2.

[7]Technology will probably change substantially over a 25-year period, with costs decreasing and capabilities increasing. The calculations can also be rationalized by assuming that the same amount of money is spent to buy a product that improves over time.

This analysis plan required partitioning the costs in Tables 3.1 and 3.2 into costs incurred during system development and into recurring costs. The system development costs include ground facilitity construction, software development, and R&D, as well as differences in costs between the first satellite in a series and subsequent satellites. When detailed information was not available, we used rules of thumb. For example, the European Space Agency (ESA) finds that 10 to 15 percent of a system's costs are for ground stations and mission operations. The 10 percent figure is typical of scientific and low earth orbit observation, while the 15 percent figure is for platform missions. We decided on a simple rule where mission operation costs equal 1 percent annually of the cost of one generation of the system, and up-front costs for ground operations are typically 5 to 10 percent. A second rule of thumb, also from the ESA, is that the first satellite in a set costs 50 percent more than later satellites. The extra 50 percent covers the cost of ground stations and the R&D to develop the satellite. Rather than picking any particular scenario for the time of launches, we provided average annual costs. Thus, the expected number of satellites purchased during a year of the operation period is n/l, where n is the number of satellites in orbit at any one time and l is the expected lifetime of a satellite in years.

Table 3.4 shows the estimates for each system. The up-front costs include construction of ground facilities, development of software, and R&D. The costs of the first integrated reconnaissance data center are included with the Zenon system and the second with the communications intelligence system. We show the partition of the costs incurred while the system is operational into the costs of purchasing satellites and all other costs.

For example, the ground network for Skynet is estimated to cost $1.2 billion (from Table 3.2), or $240 million per year for 5 years. Because Skynet uses existing communication technology, there are no R&D costs, so the total costs for the development period are $240 million per year. In the Skynet system, there are three satellites in orbit, each with a design lifetime of 7 years, so that on average one must purchase 3/7 of a satellite each year. Each satellite costs approximately $184 million, including launch costs (from 554/3 in Table 3.1); thus, the satellites cost an average of 184 × 3/7 = $78.86 million per year. Finally, we used our 1 percent rule of thumb to estimate operating costs of $5.54 million per year.

As an example of where rules of thumb are used more frequently, consider the radar surveillance system Osiris. Our source for Table 3.1 estimated that a two-satellite system would cost approximately $1.5 billion, including launch and

Table 3.4

25-Year Costs for Each Military System ($ millions)

System	Purpose	Annual Costs of Development	Annual Costs of Satellite Purchase	Other Operating Costs	Total 25-Yr. Period Costs	Capability Level
Skynet	Communication	240	79	6	2888	Low
Syracuse	Communication	240	12	1	1464	Low
Hispasat	Communication	120	8	1	777	Low
Helios I	Imaging	88	152	8	3631	Low
Eumilsat	Communication	260	121	12	3954	Medium & High
MEDRS	Data relay	17	124	9	2747	Medium & High
Zenon	Intelligence, LEO	215	164	30	4956	Medium & High
Helios II	Imaging & IR	54	218	11	4842	Medium & High
Poseidon II	Ocean surveillance	20	49	2	1133	Medium & High
Osiris A	Imaging & IR	60	120	6	2820	Medium & High
Osiris B	Imaging & IR	6	120	6	2550	High only
Intelligence from GEO	Intelligence from GEO	284	132	38	4824	High only
Navigation	Navigation	23	360	0	7313	High only
Early warning	Early warning	197	80	24	3064	High only
Polar weather	Polar weather	12	49	2	1095	High only
Space surveillance	Space surveillance	78	0	4	468	High only
J-STARS	Battlefield intelligence	193	0	10	1166	Medium & High
Airborne C&C	Airborne C&C	720	0	20	4000	Medium & High

ground costs (for the health of the satellite only), but the source provided no other details. Using the rule of thumb that the first satellite costs 50 percent more than later satellites, we calculated that the first satellite would cost $900 million and the second satellite $600 million. We used the $600 million as the cost of each satellite purchased and used $300 million as the total of R&D and ground station acquisition. Thus (as shown in Table 3.4), the first satellite incurs development costs of $60 million per year ($300/5) during the 5-year development period and annual purchase costs of $120 million ($600/5, because of the 5-year lifetime). To maintain a second satellite, one needs to add an additional ground station but no R&D. Since ground stations are typically 5 percent of a satellite's cost, the second satellite requires only $30 million for development, or $6 million annually. The purchase cost of the second satellite is similar to that of the first. In both cases, 1 percent of satellite purchase costs are spent for annual operating costs.

The final calculation in Table 3.4 gives the 25-year system costs. This is the sum of 5 times the annual development costs plus 20 times the sum of annual purchase costs and annual development costs. For example, for Skynet the costs are: $5 \times 240 + 20 \times (78.86 + 5.54) = 2{,}888$.

What remains is only to summarize our costs across the capability levels. The last column notes the capability levels to which each system is assigned. In the low-capability case, we can merely sum the systems in the development and operating periods. However, for the medium- and high-capability cases, we expect that the European nations would continue to operate the existing systems during the 5-year development period. For example, although Great Britain has expressed extreme interest in the development of a system similar to the one we call Eumilsat, it also recently contracted for the purchase of additional Skynet4 satellites that will not be launched until the existing Skynets become unusable in the late 1990s.

The first line in Table 3.5 shows the total life cycle cost of each of the three systems, including development, acquisition, and operation for a 20-year period. The total 25-year system cost for the limited-case current European military systems is just under $9 billion. The medium case would roughly triple it to $26.9 billion, and the high-capability case would increase the cost to $46.3 billion, or five times the resources of the limited case. The remaining lines of the table allocate the life cycle costs between a 5-year development period and a subsequent 20-year operational period.

Table 3.5

Estimated Costs of Satellite System ($ billions)

	Limited	Medium	High
Total cost	8.8	26.9	45.4
Average annual cost			
Development period (5 yrs.)	0.7	1.8	2.4
Operating period (20 yrs.)	0.3	0.9	1.7

NOTE: Total costs do not add because of rounding in annual costs.

4. Conclusions

Table 4.1 combines the cost estimates from the force projection and satellite systems analyses. It reveals that force projection dominates the low-capability case; however, at greater levels, the two capabilities contribute roughly equally to the costs for an independent European force.

While these costs could feasibly be accommodated by the annual $160 billion (1989) defense budgets of the NATO European nations,[1] the issue is how much of their defense budgets are the European nations willing to devote to gain different amounts of "independence" or robustness. The modest systems of the low case ($27 billion over 25 years) provide some independent capability, but for many uses, they will require the aid of robust U.S. systems to minimize risk. The high case ($95 billion over 25 years) will provide more robustness, but even this will not match the level of U.S. robustness. For example, for comparison purposes, Table 4.2 shows approximate numbers of U.S. aircraft in the year 2000 versus what the Independent European Force (IEF) would buy in the high investment case.

Thus, the question becomes whether the greater capability afforded by the high case is worth the 150 percent cost increase over the low case. How might the European nations judge these expenditures? A natural way would be to compare them with currently planned military expenditures. In 1989, the 12 European nations of NATO spent $160 billion on defense. They plan to reduce that by 20 percent or more in the next few years. For comparison, in the high

Table 4.1

Combined Cost Estimate for Independent European Force ($ billions)

	Low	Medium	High
Force projection	18	32	49
Satellite intelligence system	9	27	46
Total costs (25-year life cycle)	27	59	95

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[1]*The Military Balance 1990–1991*, The International Institute for Strategic Studies, London, 1990.

Table 4.2

Projected U.S. Aircraft in the Year 2000

Aircraft	Numbers of U.S. Aircraft in 2000 A.D.	IEF High Investment
C-141	180	0
C-17	120	116
KC-10	60	60
C-5B	50	0
CRAF (747 cargo equivalents)	74	25
KC-135 tankers	515	30
C-130	332	153

SOURCE: *U.S. Strategic Airlift Choices*, Institute for Foreign Policy Analysis, Washington, D.C., 1986, and other sources.

case, we computed costs for the first five years to be roughly $7 billion per year for new force projection and intelligence equipment. To fit these costs in the budget would mean a 4.4 percent greater reduction of other kinds of defense on top of the 20 percent planned reduction. Alternatively, in the limited-capability case, we computed that the first five years would cost roughly $2.5 billion annually, which is equivalent to a 1.5 percent greater reduction.[2] In an era of declining budgets, the costs of a robust capability could be absorbed, but are they worth the inevitable displacement of other national or regional needs?

Other questions arise for an independent European force. Who provides the command and control? The U.S. Transportation Command has central control over U.S. force projection resources, and we have assumed central control in our calculations. Is such central control possible in the Western European Union? If so, how long will it take to develop sufficient experience? Where would the technical officers come from to run such a system? If the force projection or intelligence analysis capability is parceled out across several countries, how would it be controlled? Would it be sufficiently responsive? All these cost and command problems have to be addressed when developing an independent European force.

[2]The cost contention might be even greater if the new systems are considered to compete against the current weapon systems in the R&D and procurement portions of the budget. These portions of the budget tend to stay a constant share of the total budget. (In the United States, they have remained 40 percent of the budget in recent up and down budget years.) Using 40 percent as a reasonable slice of the European nations' budget would mean that a high-cost system would have to displace 10 percent of R&D and procurement for current systems.

Appendix A
Computations on Deploying Force Cargo Needs

The force package and the tonnage information in Section 2 are combined to arrive at the cargo needs of the light, medium, and heavy force, which are shown below in Tables A.1–A.4.

Table A.1

Cargo Needs for Light Force Package (M tons x 1000)

Units	Cargo	Amount Outsized
1 AAST Division	23.0	1.4
+ CS/CSS	23.0	1.4
3 Fighter Squadrons	6.0	1.2
Total	52.0	4.0

Table A.2

Cargo Needs for Medium Force Package (M tons x 1000)

Units	Cargo	Amount Outsize	Units	Cargo	Amount Outsize
1 AAST Division	23.0	1.4	2 Light Infantry Divisions	25.2	.8
+CS/CSS	23.0	1.4	+CS/CSS	25.2	.8
1 Light Armored Division	22.1	11.9	1 Light Armored Division	22.1	11.9
+CS/CSS	22.1	11.9	+CS/CSS	22.1	11.9
6 Fighter Squadrons	12.0	2.4	6 Fighter Squadrons	12.0	2.4
Total	102.2	29.0	Total	106.6	27.8
Average medium force package	104	28			

Table A.3

Cargo Needs for Heavy Force Package (w/o CSS)
(M tons x 1000)

Units	Cargo	Amount Outsize	Units	Cargo	Amount Outsize	Units	Cargo	Amount Outsize
2 Light Infantry Divisions	25.2	.8	1 AAST Division	23.0	1.4	1 Light Infantry Division	12	1.4
1 Light Armored Division	22.1	11.9	1 Light Armored Division	22.1	11.9	1 AAST Division	23	11.9
1 Heavy Armored Division	71.1	27.3	1 Heavy Armored Division	71.1	27.3	1 Heavy Armored Division	22	27.3
6 Fighter Squadrons	12.0	2.4	6 Fighter Squadrons	12.0	2.4	6 Fighter Squadrons	71	2.4
20 Patriot Fire Units	5.8	1.1	20 Patriot Fire Units	5.8	1.1	20 Patriot Fire Units	125.0	1.1
Total	136.2	43.5	Total	134.0	44.1	Total	146.6	44.5
Average heavy force package	139	44						

Table A.4

Cargo Needs for Heavy Force Package (with CSS)
(M tons x 1000)

Units	Cargo	Amount Outsize	Units	Cargo	Amount Outsize
2 Light Infantry Divisions	25.2	.8	1 AASLT Division	23.0	1.4
+ CS/CSS	25.2	.8	+CS/CSS	23.0	1.4
1 Light Armored Division	22.1	11.9	1 Light Armored Division	22.1	11.9
+CS/CSS	22.1	11.9	+CS/CSS	22.1	11.9
1 Heavy Armored Division	71.1	27.3	1 Heavy Armored Division	71.1	27.3
+CS/CSS	71.1	27.3	+CS/CSS	71.1	27.3
6 Fighter Squadrons	12.0	2.4	6 Fighter Squadrons	12.0	2.4
20 Patriot Fire Units	5.8	1.1	20 Patriot Fire Units	5.8	1.1
Total	254.6	83.5	Total	250.2	84.7
Average heavy force package	252	84			

Appendix B
Airlift Parameters

Methodology for Assessing Transport Performance

The performance of air transports is a function of vehicle technical characteristics and scenario variables. The technical characteristics that determine aircraft performance are speed, range/payload, utilization rate,[1] and loading and unloading efficiency. The scenario variables that affect cargo deliveries are travel distances, airfield accessibility, airfield capacity, and airfield infrastructure, including fuel availability.[2] The relationship between transport characteristics and scenario variables can be expressed in general terms as follows:

The required number of aircraft by aircraft type = Tonnage Required / (P × C)

where

P = the payload per cycle by aircraft type
C = the number of cycles per period by aircraft type, and

the number of aircraft is the unknown. Tonnage required is exogenously set. Payload is a function of aircraft capabilities, cargo type, and unrefueled distance. Cargo type is assumed to be a generic mix with 20 percent outsize. (See Table B.1.)

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[1]Utilization rate is the percentage of a day that an aircraft type can fly.

[2]The capacity of an airlift route system is a function of many interrelated variables, including: (1) the capabilities of en route airports for servicing aircraft; (2) the number of available pilots and other crew to operate aircraft and maintenance facilities; (3) the availability of materiel handling and fueling equipment; (4) the availability of fuel and other consumables; (5) the capability of the air traffic control systems; (6) the quantity and geometry of airport ramp space; and (7) the allocation of available resources to the airlift mission by political and military authorities at en route and reception airports. This analysis has necessarily simplified these complex variables by focusing solely on the ramp space and air traffic limitations of reception airports. This simplification is necessary because across the spectrum of potential trouble spots in which European nations might choose to intervene, there is a large variation in available services at en route and destination facilities. Furthermore, where en route airports are concerned, there is both considerable choice and the capability of substituting aerial refueling. Finally, some airport limitations may be imposed by factors not normally available in standard references. These include the fuel capacity of pipes entering the airfield, the availability of bed space for crew rest, the distance between fuel stands, and the number of aircraft jacks and other key maintenance tools. As a result, this analysis focuses on macrolevel constraints, and thus, the resulting numbers should be thought of as theoretical upper limits on the performance of the airlift aircraft.

Table B.1

Payloads (metric tons)

Range (km)	C-130	B-747 Equivalent	C-17	A-300
2000	12	80	54	45
3500	11	80	54	45
4500	7	80	51	45
5500	n/a	80	48	45
6500	n/a	75	37	40

n/a = not applicable.

The number of cycles completed within a period is a function of cycle time. Cycle time is a function of aircraft speed, scenario distance, total on-ground time, and allowable daily aircraft utilization. These parameters can be expressed as follows:

$$\text{Cycle Time} = \Sigma FT_n \times (1 + [(24 - \text{Ute}) / 24]) + LT + ET$$

where

ΣFT_n	=	the sum of all route flying times,
FT_n	=	route distance divided by route speed,
$(1 + [(24 - \text{Ute}) / 24])$	=	maintenance hours per flight hour plus 1,
LT	=	loading and/or unloading time,[3]
ET	=	en route services time for refueling and crew change.[3]

In addition to the above, a parallel set of calculations must be performed. These calculations impose constraints that must be met. For example, the operation cannot overload the runways; so with only one runway, a mix of aircraft that

[3]An alternative method would not add LT or ET but would assume these activities are captured within the objective utilization rate. The U.S. Military Airlift Command (MAC) uses this alternative. By treating LT and ET as exogenous, this analysis slows expected cycle times by the amount LT plus ET. This is done because loading and en route service times may be influenced by the time taken for tasks performed by non-airlift personnel, such as the owners of cargo and operators of airports. These tasks include providing cargo and fuel to load aboard the aircraft, providing maintenance and fuel stands for servicing the aircraft, and providing properly loaded pallets for the specific aircraft type used. Taking LT and ET outside the main equation should ideally be accompanied by a small change in the objective utilization rate. This has not been done because of the complexity of developing objective utilization rates. We believe this controversy is important only at the margin and does not substantively affect this simplified analysis. See *Military Airlift Planning Factors*, U.S. Air Force Pamphlet 76-2, 1987.

emphasizes a large number of small aircraft may exceed the runway capacity. However, if three runways are available, then this constraint may not be an issue:

- Runway consumption = number of aircraft cycles per period x 2 x 8
  - the multiplier 2 is for one landing and one takeoff per cycle.
  - the multiplier 8 is for 8 minutes per landing/takeoff event.
- Runway capacity = 24 x 1 x 30
  - the multiplier 24 is operations hours per day (could be less).
  - the multiplier 1 is the number of runways (could be more).
  - the multiplier 30 is the period, in days, we are examining.
- Runway consumption ≤ runway capacity.

An additional constraint is that the consumption of ramp space at the airport cannot exceed the quantity:

- Ramp space consumption = sum over all aircraft types.

  (space required by aircraft type x time required to conduct ground operations by aircraft type x number of cycles by aircraft type over the period)
- Ramp space capacity = physical square feet x percentage allocated airlift (50 percent) x operational hours per day (24) x period width (30).
- Ramp consumption ≤ Runway capacity.

The equation above requires aircraft space requirements data and ground-time planning assumptions. These assumptions, and the data for the parameters of the earlier equation, are shown in Tables B.2 and B.3.

Table B.2

Aircraft Parking

	C-130	B-747 Equivalent	C-17	A-300
Parking requirements for aircraft (square feet)	13,020	45,383	28,908	45,383
Multiple	3.45	3.45	2.14	3.45
Space per aircraft	44,919	156,571	61,863	156,571
Aircraft per 50,000 square feet	11	3	8	3

Table B.3

Aircraft Loading/Unloading Times and Utilization Factors

Planning Factors	C-17	B-747 Equiv.	C-130H	A-300
On-load time (hours)	2.25	3.5	0.5–1	3.5
En route service time (hours)	2.25	1.5	1.5	1.5
Off-load time (hours)	2.25	3–5	1.5	3–5
Utilizations (hours/day)	15.65	10–12.5	8	10–12.5

A series of similar constraints could be applied for support equipment and supplies such as fuel, fuel pumps, fuel trucks, materiel-handling equipment, and the total number of aircraft crew available. However, these require a more far-reaching analysis than we are attempting here, and these variables are themselves policy variables (i.e., having more or less of this equipment, either on-site or ready for deployment, is itself a policy decision).

Fleet Composition

The rules for designing airlift fleet composition were as follows. Whenever existing baseline capacity could perform a task without hindering delivery of the total requirement, it was preferred as the least-cost option. When the baseline was incapable or insufficient, new civil aircraft capacity was the next preference because of its lower cost relative to military airlift aircraft. When some portion of the requirement was still unmet, military aircraft were used. The factors used to control the utility of the various aircraft were range, payload (quantity and outsize capability), aircraft ground requirements, airport ramp space, and air traffic control limitations.

Appendix C
Tanker Requirements

Tankers Required for En Route Refueling

We assumed the use of the Airbus 300 modified for tanking[1] with 100,000 pounds of off-load fuel available and capable of flying 1.5 sorties per day. We used the grouped airlift fleets shown in Table 2.8.

Airlift refueling requires 50,000 pounds on a 4,500-kilometer mission (out and return); then:

- for 48 airlifters (EC-17/Airbus), 48 x 50,000/100,000/1.5 = 16 tankers/day.
- for 63 C-17s, 63 x 50,000/100,000/1.5 = 21 tankers/day.
- for 116 C-17s, 116 x 50,000/100,000/1.5 = 39 tankers/day.

For fighter aircraft (6 squadrons @ 24PAA = 144 fighters), we assume 6 days to deploy or 24 aircraft per day, each requiring 24,750 pounds of refueling.

- 24 aircraft x 24,750 pounds = 594,000 pounds.
- Tankers = 594,000/100,000/1.5 = 4 per day.

Tankers Required for In-Theater Operational Support

We assume 6 squadrons (144) of F-16 class aircraft based either 750 or 1,000 kilometers from the target (or combat air patrol) area. Two-thirds are in the attack mode and one-third in the defense mode (less 10 percent for reserves). (See Table C.1.)

If maximum airlift operations are completed prior to hostilities, then only 32 to 51 tankers are required. If both operations are conducted simultaneously, then we get the results shown in Table C.2.

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[1] *All the World's Aircraft*, Jane's Information Group, Alexandria, Virginia, 1990–1991.

Table C.1

Tankers Required for In-Theater Operational Support

	Distance from Target (out and back)	
	750 km	1000 km
Fuel required in 1000 lbs.		
Attack/sortie	12.8	28
CAP/sortie	20	20
Attack sorties/day	173	173
Defense sorties/day	130	130
Fuel/day attack	2214	5017
Defense	2600	2600
Total	4814	7617
Tankers required (Total/100/1.5)	32	51

Table C.2

Tankers Required for Simultaneous Operations

Scenario	Maximum Possible Fighter Operations: 750 km	Tankers 1000 km
1, 2A, 3A	52	71
2B, 3B, 4A	57	76
4B, 4C	75	94

Appendix D
Costs of Force Projection Alternatives

This appendix documents the derivation of 25-year life cycle costs for the following airlift/sealift/tanker scenario groupings shown in Table D.1.

These groupings do not reflect unique range/lift combinations, but rather they represent range/lift requirement combinations that require similar numbers of outsize-capable military airlift aircraft (i.e., C-17s). Consequently, since it is the outsize capability that tends to be the dominant cost driver, these groupings will provide distinct breaks in terms of the required investment. Thus, by grouping in this manner, assessments can be made about the "amount" of capability that can be purchased at specified funding levels.

Assumptions

General Assumptions

- Twenty-five-year life cycle costs encompass all relevant R&D and procurement expenditures, as well as 25 years of operations and support.
- All costs are given in constant FY 1991 U.S. dollars. All costs not originally in FY 1991 dollars were adjusted using the inflation rates provided in Air Force Regulation (AFR) 173-13, *USAF Cost and Planning Factors*, as of 28 January 1991.
- The total number of each military aircraft type procured equals 125 percent of the operational requirement. (The additional aircraft are for attrition, the maintenance pipeline, and crew training.)

Table D.1

Airlift/Sealift/Tanker Groupings

Scenario	C-130 Active	EC-17 Active	A-300 Freighter/Tanker Active	A-300 Freighter/Tanker CRAF	B-747 Equivalent CRAF	FSS/RoRos
1, 2A, 3A	153	32	16	5	25	9
2B, 3B, 4A	153	63	30	15	25	9
4B & 4C	153	116	30	30	25	9

- Military aircraft procurement costs include basic flyaway costs plus a 16 percent allowance for initial spares, support equipment, training, and data.
- It is assumed that aircraft are operated in one of two modes: as part of the active-duty force (Active), or as part of what we term the Civilian Reserve Air Fleet (CRAF). In this latter concept, aircraft would be procured by airlines or air freight companies under agreements with European ministries of defense. These agreements would specify what military features were to be added to the aircraft and what compensation would be paid. These aircraft, along with crew and maintenance personnel, would then be turned over to the military in time of need. The advantage of this concept is that it costs less. However, responsiveness will also be lower, since it will take longer to assemble the aircraft and the airlines will resist providing the aircraft in any but the most pressing crises.[1]
- All aircraft operation and support (O&S) costs are peacetime operating costs; no costs associated with potential mobilizations are included.
- All military aircraft O&S costs reflect current USAF transport aircraft maintenance policy and are based on a flying program of 620 hours per year. O&S costs for aircraft that typically fly either more or less than 620 hours per year were normalized to 620 hours per year under the assumption that 40 percent of annual aircraft O&S costs are fixed and 60 percent are flying-hour related.
- The total number of ships procured equals 110 percent of the operational requirement. (The additional ships offset the maintenance pipeline.)
- It is assumed that ships are government-owned but maintained in reduced operating status (4- to 5-day readiness) by commercial firms under government charter.

System-Specific Assumptions

This section discusses the system-specific assumptions. The tables provide R&D, unit procurement, and O&S costs for the aircraft used in the study so that the reader can do additional analysis if desired.

C-130/Active. Current European military aircraft capacity includes approximately 200 C-130E&H aircraft, a number that comfortably exceeds the

[1] For additional background on the CRAF concept, see Mary E. Chenoweth, *The Civil Reserve Air Fleet: An Example of the Use of Commercial Assets to Expand Military Capabilities During Contingencies*, N-2838-AF, RAND, Santa Monica, Calif., June 1990.

"baseline" European C-130 capacity assumed in this analysis. Thus, no R&D or procurement funds are required. Moreover, since the C-130s are used to satisfy existing peacetime requirements (e.g., base supply, personnel transportation), no annual O&S costs are chargeable to this mission. (See Table D.2.)

C-17/Active. IEF C-17 procurement is assumed to tag on to the back end of the currently planned 120-aircraft USAF buy. An R&D recoupment charge of $20 million per aircraft has been included in the unit procurement cost.

A-300 Freighter-Tanker/Active. Conventional A-300 freighters are assumed to be modified on the production line so they have an in-flight capability to off-load fuel. The basic concept is that the A-300 would be fitted with additional internal piping, fuel pumps, a control panel in the cockpit, and necessary hardpoints for the mounting of drogue pods (on the wingtips). The drogue pods would then be stockpiled at mobilization points. A basic A-300 freighter is estimated to cost $75 million; the in-line conversion, roughly $800,000; and two drogue pods, about $900,000 ($450,000 each). Thus, overall flyaway cost is estimated to be roughly $77 million. (See Table D.3.)

Civilian A-300 Freighter-Tankers/CRAF. Here, the same modification as described above is done, but there is a different operational concept—the planes would be owned by an airline or air freight company and, with the exception of a brief training period each year, would be required only in times of crisis. Consequently, the military would not have to pay the basic aircraft cost of $75 million. Instead, it would pay the $1.7 million conversion cost plus a reimbursement to the airline for carrying the extra weight of the fuel transfer equipment (about 300 pounds). Based on USAF experience, a lump sum payment for the additional fuel costs for the life of the aircraft would be on the

Table D.2

C-130 Life Cycle Element

Life Cycle Element	$ x Million
R&D	0
Unit procurement	125–135
Annual O&S cost per operational aircraft	7.3

SOURCE: Source of basic flyaway cost: Dec. 1990 selected acquisition report (SAR). Source of R&D recoupment charge: Frank Norman, Lockheed. Source of annual O&S cost: Dec. 1990, SAR. The actual range provided by Frank Norman was $15 million to $20 million per aircraft and was based on a proposed Lockheed foreign sale of the C-5B several years ago. Another source indicated that current U.S. surcharges can be as high as 24 to 70 percent. (See "Industry Pressure Forces DoD to Review Recoupment Policy," *Defense News*, April 22, 1991, p. 4.)

Table D.3

A-300 Freighter-Tanker/Active Life Cycle Element

Life Cycle Element	$ x Million
R&D	20
Unit procurement	89
Annual O&S cost per operational aircraft	4.2

SOURCES: Basic flyaway cost: market intelligence (firm wishes to remain anonymous). R&D cost: KC-10 program office. Annual O&S cost: assumed to be the same as KC-10 (obtained from AFR 173-13). Conversion cost: KC-10 program office.

order of $300,000. Thus, flyaway cost (including the lump sum reimbursement) is estimated to be about $2 million. With respect to crew training, it is assumed that the aircraft would be called up for a five-day period each year (the airline paid for the period it was out of regular service) and that the drogue pods would be attached, and with that the crews would then practice refueling sorties. The annual O&S costs associated with this concept are estimated at $200,000 ($90,000 for charter costs, $90,000 for fuel costs, and $20,000 for aircrew compensation at full airline wage). (See Table D.4.)

Civilian B-747 Equivalents/CRAF. Since these aircraft are not enhanced in any way, no conversion costs or lump sum reimbursements are required. Additionally, no special peacetime training is required, so no annual peacetime O&S costs are incurred. Thus, no costs are incurred for this alternative.

Fast Supply Ships/Reduced Operating Status. The fast supply ship is a 30-knot ship with a cargo capacity of 220,000 square feet. Its hullform and dimensions are identical to the 8 FSS currently in the U.S. Navy inventory (i.e., it is a proven design). (See Table D.5.)

Table D.4

A-300 Freighter-Tanker/CRAF Life Cycle Element

Life Cycle Element	$ x Million
R&D	20
Unit procurement	2.3
Annual O&S cost per operational aircraft	0.3

SOURCE: Annual O&S cost estimates are taken from information provided by the KC-10 program office and other RAND work.

Table D.5

Fast Supply Ships/Reduced Operating Status

Life Cycle Element	$ x Million
R&D	0
Unit procurement	204
Annual O&S cost per operational aircraft	6.0

SOURCES: Sailaway cost: "Strategic Sealift Ship Program," briefing at SCIB Working Group Meeting, May 23, 1991 (given by Eugene E. Shoults, Amphibious Warfare and Strategic Sealift Program, Naval Sea Systems Command). This briefing provided an ROM (rough order of magnitude) estimate for the FSS of $255M. It was based on the assumption that the ships would be built in a U.S. shipyard. However, the Europeans would undoubtedly buy their ships from European shipyards, which we have assumed to be 25 percent more productive than U.S. shipyards. Thus, the FSS sailaway cost is $204M ($255M x 1/1.25).

Annual O&S cost: Working group briefing, as related by RAND colleague Myron Hura.