

Historically, the predominance of U.S. investment in and experience with space systems has minimized the consideration of space as an area with real or potential interoperability problems. Whether with select allies or within a broader Alliance framework, the United States has provided the bulk of products or services derived from space assets, especially satellite reconnaissance data to support military coalition operations. The development of the Global Positioning System (GPS) has also allowed the United States to dominate space-based positioning, navigation, and timing.

Yet while U.S. sharing of space-based data has increased over time, some European allies are dissatisfied with the nature of the information shared (in terms of volume and levels of analysis) as well as with the lack of European input into tasking mechanisms. Moreover, the Europeans have ever greater expectations about the value of space, whether for civil resource management or defense purposes.

These factors and the proliferation of space and space-related technologies have created new incentives for the development of new space capabilities, especially within Europe. While the United States will continue to dominate space for some years to come, European space developments may provide important opportunities to improve the security advantage of the United States and/or its allies.

Space may be a new area in which to consider interoperability, either as a source of progress or as a source of potential conflict. For example, if different sources of space-derived data are used by the United States and its European allies, very different viewpoints can arise when each independently performs critical military functions

such as indications and warning, target development, and battle damage assessment.

The United States needs to seriously consider the existing and planned slate of European space capabilities—and their associated ground segments—for their potential contribution to coalition operations, taking into account interoperability considerations. This involves consideration not only of the interests and capabilities of individual nations but also of developments within European space cooperation. And space, as it increasingly becomes valuable as a source of diverse kinds of information, must be considered in the broader context of information sharing, not only among U.S. government agencies but also with allies in a range of military operations.

Thus, the case study described in this chapter highlights areas of potential cooperation or competition that might arise between U.S. space programs that have proved vital in past coalition operations, and Europe's growing desire to increase its nascent space capabilities as a means of lessening its dependence on U.S. assets in future military operations.

THE BROADER CONTEXT FOR SPACE COOPERATION

Space cooperation should be considered in the context of overall U.S. national objectives as well as the increasing information value that space provides and the forces that accompany the larger set of information-sharing issues and options.

U.S.-European military space activities suffer a plight equal to if not worse than the slate of more traditional interoperability issues that arise among the NATO allies. As we will see in our discussion of the various European space programs, the United States and Europe are divergent in overall strategy and perspective as well as in the nature of public-private interactions with regard to technologies and markets. Both are important as they relate to the use of space in military affairs, to the scope and speed of innovation in space

technologies, and to the information value derived from such technologies on the ground.¹

Because the value of space is so closely wedded to its provision of information, we must also consider space cooperation within the broader context of U.S. information sharing. One aspect of U.S. strategy that has not been sufficiently explored is the extent of U.S. information sharing that exists in both classified and unclassified domains, as well as the overall cost-benefit analysis that is derived from that sharing or any inconsistencies in those sharing arrangements.²

Information-sharing policy assessments need to be informed by an objective appreciation of what kinds of space-based or other data military organizations process and how. This is often a function more of organization, information culture, and experience with specific data sets than with information policy per se. For example, one can compare the substantial U.S. experience in all-source integration of information sources, including imagery data, in the U.S. defense program with Europe's fledgling efforts to fold information derived from satellite images into European military planning and operations.

The rapid emergence of commercial space and information markets also promises to advance lagging countries and entities to the extent that they are willing to rely on commercial sources within their military programs.

MOTIVES AND METHODS FOR SPACE COOPERATION

U.S.-European space cooperation is not without precedent. European countries—especially France and the United Kingdom—rank prominently on the list of countries with which the United States has international agreements in remote sensing for civil and scientific purposes.³ Meteorology, wildlife tracking, climate change,

¹See Gompert et al. (1999), p. 9.

²Such an analysis is beyond the scope of this effort.

³See Wagner (1998).

atmospheric science, ocean science, land use, and mapping are among the themes covered in these agreements.

There are a number of additional motives for the United States to consider cooperation with its European allies in space:

- U.S. National Space Policy (PDD-49) encourages cooperation in space-related activities for achievement of scientific, foreign policy, economic, or national security benefits for the nation.
- The U.S. Policy on Foreign Access to Remote Sensing Space Systems (PDD-23) and its related Commerce Department regulations recognize increased foreign interest in space systems as well as the opportunity to enhance U.S. industrial competitiveness and security through foreign access to remote sensing data and technology.
- U.S. Space Command, in support of the warfighter, envisions growth in partnerships with foreign militaries.
- The interests of DoD and the intelligence community dictate cooperation in space and space-related areas, such as (1) promotion of bilateral ties and Alliance cohesion, (2) promotion of doctrine, operations, and equipment interoperability, and (3) information and intelligence sharing.

Space cooperation, according to the new DoD Space Policy, is to be undertaken when mutual, tangible benefits are available in support of the strategic enabling function of space.⁴ Given its own investments, its expertise in space operations, and its use of space-derived information, the U.S. Air Force—in collaboration with other DoD and U.S. government agencies—should help shape space cooperation with the U.S. European allies.

There are other dimensions, such as foreign motives, to consider if cooperation is to be successful:

- Foreign governments have a variety of interests in space, including foreign policy and national security, international prestige, autonomy in national decisionmaking, creation or maintenance

⁴See DoD (1999b).

of their industrial base, land use and resource management, and political motives.

- While foreign governments want access to U.S. information and space technology, they are also trying to create indigenous capabilities.
- Governments are looking increasingly to strong growth in commercial space capabilities (in areas like communications, remote sensing, and navigation) as an important component of their use of space.⁵
- The development of foreign space capabilities is seen as offsetting possible U.S. and other international political agendas, as they provide an independent view of world events. Of course, unless they choose to take advantage of the commercial space market, foreign interests in space generally remain bounded by the high expense of developing, launching, and operating space systems.

Figure 6.1 depicts a conceptual spectrum of the different ways that governments might choose to cooperate in space programs. Cooperation can range from the sharing of data at the lower end of the spectrum to coproduction and codevelopment of space systems and their associated ground infrastructure at the higher end of the spectrum. Each of these methods carries political, technical, and security benefits and risks.

There are limits to space cooperation. Shifting U.S. views on technology transfer, in particular satellite technology transfer, will limit cooperation in this area. Space cooperation also requires some agreement on the operational decisionmaking structures for satellite systems, especially as they relate to access and control of data (e.g., prioritization of imagery tasking). Data policy and intellectual property-rights issues are at stake, yet such issues either are unresolved in international forums or are a potential source of

⁵For specific details on the state of global commercial space activities, see Space Publications (1999).

Space System Activities	Examples	General Features
Products	<ul style="list-style-type: none"> • Data sharing—governments trade or share intelligence products <ul style="list-style-type: none"> – Imagery for analysis trades, etc. 	Coupling Trend 
Operations	<ul style="list-style-type: none"> • Joint operations—governments jointly operate intelligence assets <ul style="list-style-type: none"> – Bilateral/multilateral system use – Technical support 	
Acquisition	<ul style="list-style-type: none"> • Procurement—governments purchase systems developed and produced by aerospace contractors in partner countries <ul style="list-style-type: none"> – Systems sales – Systems leases – Contingent sales • Production—aerospace contractors from partner countries produce systems developed in one of the partner countries <ul style="list-style-type: none"> – Coproduction – Licensed production • Development—aerospace contractors from partner countries jointly develop and produce space systems <ul style="list-style-type: none"> – Codevelopment – Technical support 	

Figure 6.1—Space Cooperation Methods

conflict between the United States and its partners.⁶ Finally, there are no clear valuation metrics for cooperation.

European space policies and programs have some unique challenges. Space issues in Europe are dominated by industrial considerations, although some of this has abated as European aerospace consolidation has taken place. Fidelity to European policies of *juste retour*—an expectation that Europeans would receive industrial work shares consistent with their governments' investment in European cooperative programs—is difficult to satisfy. Individual countries will have their own preferences and capabilities for cooperation, which must be considered against the slate of overall U.S.-European cooperation in this area. As is the case with the United States, government-to-government cooperation will have an impact on the emerging market for commercial space products and services, which

⁶See Pace et al. (1999).

may affect the market in disadvantageous ways for U.S. or European industry. Finally, European governments may be looking increasingly to space systems as a source of cost-offsetting revenue—this is part of the current rationale for Galileo—that will conflict with U.S. data policies and may disadvantage U.S. interests.

EUROPEAN SPACE PROGRAMS

We identified five European space programs that highlight the choices for the United States on whether to cooperate or compete with Europe in space technologies and operations. These programs also highlight the diverse opportunities and challenges involved in maintaining the interoperability of U.S. and NATO allies' space-derived services and products. Our research endeavors to answer the following questions concerning each program:

- **French space program.** How should the United States respond to continuing French interest in greater military space cooperation, particularly given France's unwillingness to appear dependent on the United States in key military technology areas?
- **Italian space program.** Italy is pursuing a highly ambitious dual-use remote sensing satellite program in a bid to increase its importance among Europe's advanced technology leaders. Should the United States encourage this development even though SKYMED/COSMO (Constellation of [Small] Satellites for Mediterranean [Basin] Observation) program, while offering the opportunity for burden sharing in military operations, creates added competition for American commercial remote sensing firms?
- **WEU Satellite Centre.** The WEU Satellite Centre provides a nascent image processing capability to support European civil and security-related activities. Can the United States and its NATO allies leverage WEU Satellite Centre capabilities in coalition operations?
- **Galileo program.** The European Union has strongly endorsed plans for the Galileo satellite navigation system as an independent source of global positioning data. What might be the interoperability implications of this alternative European architecture for the United States and its NATO allies in coalition operations?

- **European space-based radar programs.** There is a strong European interest in new imaging phenomenology, particularly those associated with radar and hyperspectral imagery. This interest is reinforced by the Allied Force experience. Would interoperability in coalitions be enhanced by more U.S. cooperation with Europe on radar and hyperspectral technologies and applications?

We discuss each of these programs in more detail.

French Space Program

France and the French Space Agency (Centre National d'Études Spatiales, or CNES) dominate European space programs. France has the largest and broadest space program in Europe, largely in areas of earth observation, communications, microgravity, and satellite navigation.⁷ France also serves as the greatest proponent of European cooperation in space, in part as a response to U.S. space activities and consolidation of the U.S. space industrial base. The French have supported European cooperation both in the civil arena—in the European Space Agency (ESA)—and in the defense arena, as in satellite communications and remote sensing.

Unlike the U.S. model for organizing space activities—general separation of civil space and military space—France and most other European nations manage their space programs under one organization such as CNES.⁸ In recent years CNES has managed programs related to both civil and defense missions and has undertaken a consolidation of its own programs. One of these, the Helios program, is representative of the challenges of space cooperation as well as the possibility of conflict and cooperation as they relate to U.S.-European strategic purpose and interoperability.

Helios is the first in a family of military observation satellites to provide a limited daytime surveillance capability.⁹ It was launched

⁷See CNES (1999).

⁸The comparatively smaller size and scope of European space programs facilitates this.

⁹See McLean and Swankie (1998).

from French Guiana in July of 1995 with a life expectancy of four or five years. Helios was designed to fulfill a long-standing desire on the part of the French government for space-based imagery and was also intended to quell that government's historic frustration over Europe's reliance on the United States for such data in the face of unsuccessful attempts at space cooperation dating back to the 1970s.¹⁰ French interest in space-based military remote sensing was further stimulated by their experiences in the Gulf War.

In addition to satisfying its own needs from Helios, Paris has attempted to make the Helios program representative of the opportunities for further European space cooperation, with mixed results. Political and financial considerations prompted the French to solicit broader European support for the program in the late 1980s, resulting in Italian and Spanish commitments to finance approximately one-fifth of total system cost.¹¹ However, both Italy and Spain are considering alternatives to France's follow-on program, Helios 2, because they have doubts about whether that program is the best way to meet their future defense requirements.¹²

A subsequent initiative captured German involvement in the Helios program and responsibility for the development of a related radar program known as Horus, which ultimately failed as a cooperative program largely because of German fiscal constraints.¹³ Yet France and other Europeans cite Helios' primary value as a capability that is independent of the United States. And, as the Europeans focus anew on their common foreign and defense policy needs, remote sensing capabilities are seen as vital to European intelligence needs and overall strategy. One strategy may be to continue to build remote

¹⁰Ibid.

¹¹Italy's contribution is 14 percent, and Spain's contribution is 7 percent (de Selding, 1995a, and de Selding, 1999).

¹²See de Selding (1999).

¹³The fiscal constraints are discussed, for example, in de Selding (1995b) and de Briganti (1995). After this research was completed, France and Germany decided to resurrect plans for a joint military reconnaissance satellite program based on the French Helios and a new, lower-cost (approximately \$340 million) German radar imaging program known as SAR-Lupe (CNES, 2000; de Selding, 2000). Italy may also join this new pact, which could provide Europe with a robust and independent space-based reconnaissance capability (Lewis, 2000).

sensing capability as a means to stimulate U.S. interest in greater cooperation.

With regard to the United States, the French are interested in reestablishing and reenergizing an early 1990s space cooperation agreement, with an emphasis on satellite communications, navigation, and remote sensing. French discussions have centered on the need for greater synergy among U.S. and coalition space assets, given the increasing role of coalition operations. French officials have also indicated a desire to remain linked to U.S. plans, given the relatively large scale of those programs and the long time lines associated with the development and production of French space systems.

French views on space cooperation with the United States include the concept of balance between sovereign and cooperative needs—a classic French concern—as well as focus on cooperation in areas throughout the space infrastructure (in other words, space and ground segments). French officials see little room for cooperation in areas that have been commercialized, such as launch. They also envision themselves as a potential intermediary between the United States and a broader set of European space partners and activities.¹⁴

The French desire for cooperation with both the United States and the Europeans is consistent with other defense activities: as much as 30 percent of the French defense budget is devoted to cooperative programs.¹⁵ Yet French pursuit of space cooperation with the United States has strong political motives as well: France looks to space cooperation with the United States not only as a measure of its prominence but also as a means of offsetting the challenges the Helios program faces and as a way to remain linked to U.S. space plans and technologies. At the same time, France will continue to pursue pan-European space initiatives.

With regard to future interoperability, one implication of U.S.-French space cooperation is that it will increase the number of sources of data and information—including not only Helios imagery

¹⁴This discussion is based on a number of direct interactions that one of the authors has had with French Embassy officials in Washington, as well as representatives of the Délégation Général pour l'Armement (DGA) in France and the United States.

¹⁵See International Institute for Strategic Studies (1998).

but also commercial assets such as Satellite pour l'observation de la Terre (SPOT). The U.S. military's experience with access to and use of SPOT data has been positive and is expanding. Unless data sharing is properly synchronized, however, it can lead to conflicts in indications and warning; target nomination, approval, and development; and battle damage assessment.

France has occasionally cited Helios data as a source of information that differed from the stated public U.S. view of some situation.¹⁶ France has also suggested that U.S. sharing of information is largely tailored to U.S. political aims rather than to a comprehensive view of a particular situation. This issue was raised during the Kosovo conflict, in which the French expressed concern with the substance and volume of U.S. assessments. Competing data sources require some venue for discussion of alternate interpretation, perhaps below the political level. Besides reducing the probability of conflicts, properly synchronized collection may also reduce the burden on U.S. collection in future Alliance or coalition operations.

At a minimum, in collaboration with DoD and other government agencies, the U.S. Air Force should closely monitor French space developments, as well as the progress of the U.S.-French space cooperation initiative, and then clearly define information-sharing protocols for those space assets that support future coalition operations.

Italian Space Program

Italy has initiated the development of an ambitious remote sensing satellite program known as SKYMED/COSMO. Although one of the partners behind the French-led Helios military reconnaissance satellite program, Italy has nevertheless decided to pursue its own remote sensing program in an effort to become a leader in European remote sensing capabilities.¹⁷ Italy sees an important strategic role for itself

¹⁶France argued in December 1996 that the U.S. interpretation of developments in Iraq were different from French interpretations of Helios imagery, thereby diminishing a U.S. rationale for military strikes at that time.

¹⁷See Taverna (1999).

and within NATO in maintaining awareness of developments in the Mediterranean and North Africa.

The SKYMED/COSMO plan calls for a constellation of seven smaller imaging satellites (600 kg each), with three optical satellites and four radar imaging satellites. The radar satellites would feature a synthetic aperture radar (SAR)-2000 sensor capable of about 1-meter resolution, while the optical sensor would have a 2.5-meter resolution.

During the past two years, Italy has been exploring options for industry-to-industry cooperation, including cooperation with U.S. aerospace partners. If a government-to-government agreement can be reached, this approach will enable Italy to acquire more advanced satellite remote sensing capabilities than might otherwise be available to it on the commercial market. Like France, Italy is seeking European partners for the SKYMED/COSMO program to help spread the estimated \$550–\$600 million acquisition costs and reduce the program's technology risks.

Italy appears determined to enhance its standing in the space field, both within Europe and on an international scale. Its estimated government spending on space for 1999 is over \$700 million, which ranks Italy as fifth in the world in nonmilitary spending on space. Its space budget is comparable to Germany's and is substantially more than Russian spending on nonmilitary space. Italy is also raising its international prominence by directly contributing to the International Space Station program with national resources beyond those committed through ESA.

Italy's ambitious plans for developing its own space capabilities create several opportunities for cooperation with the United States that could yield significant benefits for both sides, particularly in terms of providing imagery data of mutual interest on locations within the politically volatile Mediterranean region.

One potential area for U.S.-Italian cooperation is the Discoverer II satellite program. Italy could contribute additional resources and technical expertise in developing smaller radar imaging satellites. As various aspects of Discoverer II are under consideration, more thought needs to be given to how international collaboration might affect cost, technical, and data aspects of the system.

NATO combat operations against Yugoslavia highlighted many of Italy's major security concerns. These operations indicated the broader trade space within which space cooperation must be considered. Space access, in essence, may be valuable to a potential partner in return for other kinds of access (landing and basing rights, other kinds of intelligence data). In addition, Operation Allied Force and continued surveillance of the Balkans provide opportunities for greater U.S.-Italian cooperation. Hence, the U.S. Air Force should take advantage of existing coalition information-collection operations in the Balkans to gain a more focused appreciation of the leeway of Italian government agencies and aerospace firms for cooperating with the United States regarding military space.

WEU Satellite Centre

The WEU Satellite Centre was created by the WEU Council of Ministers in 1991 and declared a "permanent WEU body" in 1995. Located in Torrejón, Spain, the Centre was declared fully operational in May 1997. The satellite center is an indigenous image-processing center that relies on commercial and European military sources of data to support the civil and military information needs of WEU and associated members. The Centre's self-described mission is "to exploit imagery derived from space observation satellites for security and defense purposes."¹⁸

Among the data sources exploited by the Centre are the following: (1) primarily commercial imagery sources (e.g., SPOT, Earth Resources Satellite [ERS-1]), (2) Helios imagery contributed by France, and (3) occasionally, airborne imagery provided by member nations. Imagery is acquired in response to questions posed by WEU member nations and any others approved by the WEU Council. Figure 6.2 portrays the work process for imagery collection, interpretation, and dissemination for the Centre.

The products developed in response to these WEU taskings are provided in the form of a hardcopy "dossier" that contains the imagery

¹⁸See WEU Satellite Centre (1998).

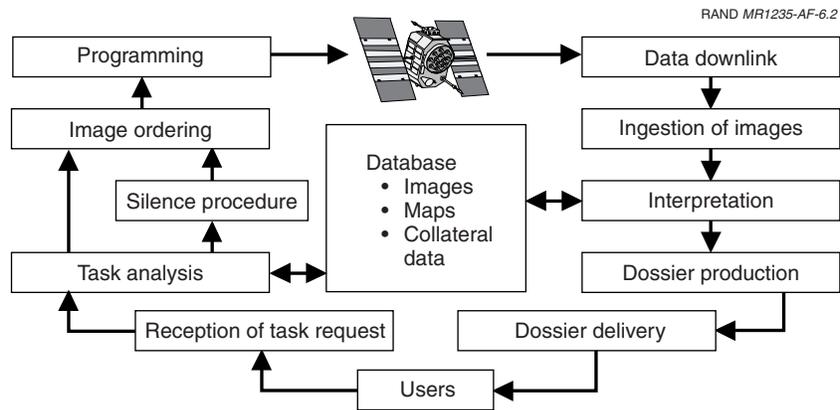


Figure 6.2—WEU Satellite Centre Imagery Cycle

and maps used in the interpretation as well as the analytical markings and interpretation performed at the Centre.¹⁹

The Centre's processes are interesting from a number of perspectives. First, the level of image interpretation done at the Centre is fairly rudimentary (similar to U.S. phase one exploitation: identification of specific structures and activities); more advanced phases of exploitation are considered political judgments and are done largely in the national capitals. Second, because of the multinational character of the Centre, analysts are drawn from different WEU countries and are therefore somewhat representative of the views of those countries. In essence, the Centre is an interesting laboratory in which analytical interpretation and political judgment intersect. Third, the dissemination policy of the Centre is that its products are available to all WEU and associate members, so there are no problems with compartmentalization and selective sharing under this construct.

Recent events in Kosovo have catalyzed WEU interest in expanding activities related to space-based reconnaissance, and the Satellite Centre is firmly engaged in those activities. While earlier studies by

¹⁹Ibid.

the WEU on the feasibility of acquiring a shared European space reconnaissance system concluded that the costs were too high,²⁰ Operation Allied Force has reenergized political interest in such capabilities.

Various studies are under way within the WEU to look at options for increasing access to space observation, improving the number and quality of European image analysts, and creating electronic access to the Centre's product.²¹ These studies indicate a desire to leverage existing and planned European national programs such as Helios and the civil programs sponsored by ESA. Independent of these activities, remote sensing commercialization—including the successful operations of Space Imaging's Ikonos satellite—means that the Centre will have access to increasing amounts of quality imagery data.

The WEU Satellite Centre offers the potential for burden sharing in military operations. Whether as a source of additional imagery data or analysis,²² the Centre could support some U.S. and especially European military operations. But while the Centre is gaining expertise in exploiting commercial imagery, the scope and depth of its knowledge are limited, and it has only a limited capability to support coalition military operations. The direct downlink and digital dissemination are among the current upgrade initiatives that would enhance the Centre's ability to support U.S. and allied military operations.

Image processing remains a challenge because of a lack of indigenous sources and varying national data processes and policies. Cooperation and commercialization will drive countries to common standards (e.g., Earth Resources Data Analysis System [ERDAS] image processing systems); some dedicated military will remain (OCAPI and PEPITE image processing systems). Meanwhile, the United States clearly has an overwhelming advantage in imagery exploitation and data use. The United States needs to know more

²⁰See de Selding (1995c).

²¹Dissemination of product heretofore has been accomplished via courier or traditional postal means. See WEU Technological and Aerospace Committee (1999).

²²A parallel to "imagery for analysis trades" could be envisioned and has an interesting precedent in the signals intelligence arena.

about current WEU procedures and future enhancements to determine the best approach for burden sharing and to develop an acceptable level of interoperability. U.S. Air Force experts on imagery analysis and targeting could help synchronize procedures and establish acceptable quality control procedures.

Galileo Program

Space-based positioning and navigation are issues of growing importance to Europe for a variety of reasons related to civil requirements, industrial competitiveness, and security and sovereignty concerns about having to depend on the United States and other countries for this critical information source.

In a major step toward acquiring an independent satellite navigation capability, the European Union (EU) approved a study plan in May 1999 to begin the definition phase of the Galileo program in coordination with ESA.²³ This unprecedented display of EU support for a European space program was also a case of unprecedented coordination on a space program from Brussels as opposed to the national capitals. The strength of political support for Galileo was reflected in its oversubscription by voluntary contributions from ESA members.

The Galileo program, a major technology and infrastructure program, involves extensive cooperation between ESA, which is responsible for the space segment, and the European Commissioners for Industry, Research, and Transport, which will manage the extensive ground infrastructure. At an estimated total cost of \$2.5–\$3 billion, the Galileo program is expected to involve some 21 to 36 satellites in medium earth orbit (MEO) and an additional 3 to 9 satellites in geostationary orbit (GEO). Although envisioned as a full positioning system that is independent of GPS and Russia's GLONASS, Galileo still emphasizes the need for interoperability with existing systems.

The Galileo navigation satellite system, also known as Global Navigation Satellite System 2 (GNSS 2), builds on the European Geostationary Overlay Service (EGNOS). EGNOS groups together the first generation of European positioning satellites as the European

²³See Barensky (1999) for an overview of European motives for Galileo.

regional contribution to GNSS 1 provided by the U.S. GPS and the Russian GLONASS system. The EGNOS system, which consists of additional satellites and ground-based systems to become fully operational by 2002, is designed to improve navigational accuracy to 5–10 meters,²⁴ to monitor the integrity of GPS signals, and to ensure the line-of-sight availability of at least six satellites at all times.

The strong political endorsement for proceeding with the Galileo plan indicates the EU's determination to avoid depending on other countries, such as the United States and Russia, for critical data to meet its positioning, navigation, and timing (PNT) requirements. These PNT services are currently free, but European planners view the Galileo program as important to ensuring that Europe is not vulnerable to future changes in the availability of service or the imposition of fees. These planners also see their own PNT capability as critical to economic development and to improving European industry competitiveness on the international market. Satellite navigation is viewed as important in safe and efficient navigation, particularly for air traffic control, and in many economic enterprises. Without something like the Galileo program, Europeans fear they will fall behind the United States—and to some degree Japan—in taking full advantage of this important information technology.

Whether or not the Galileo program is ever fully realized, this effort will likely stimulate major disputes with the United States and others in the trade and military realms in spite of European pledges to seek compatibility with GPS and GLONASS. A major source of conflict arises from the competition for spectrum that is caused by European interest in developing an independent satellite navigation and positioning system. Competition between GPS and the new mobile satellite systems (MSSs) for high-quality spectrum could result in degrading the quality and reliability of the GPS signal. This could lead to market fragmentation for civil frequencies.

²⁴As of 2 May 2000, the United States no longer degrades the GPS signals available to the public (White House, 2000). With Selective Availability turned off, the geopositioning accuracy for the Standard Positioning Service is now less than 5 meters (GPS Support Center, 2000). This decision occurred during the final preparation of this report, and thus we have not assessed its impact on European space-based positioning and navigation programs such as Galileo.

Resolving liability and other legal issues is complicated by the disparate public-private philosophies that both sides bring to this question. The U.S. approach views GPS signals as a public good that is made available without fees. By contrast, the European approach will impose charges for restricted access to higher-accuracy service and will emphasize private enterprise participation to reduce program costs.²⁵ There is also an important difference in how both sides view liability and what types of public warnings are necessary.

Europe's decisions on Galileo also have important implications for sustaining Russia's GLONASS system, which is steadily degrading over time without the needed replacement satellites and ground modernization. Despite its growing operational problems, however, the GLONASS system makes use of valuable spectrum allocation that has a strong appeal to Europe.

Given the U.S. Air Force's substantial ongoing investment in the GPS system and in GPS-guided weapons and delivery platforms, the issue of GPS integrity and availability is critical to future Air Force planning and operations, particularly in the European region. Although European leaders see Galileo as a potential revenue source or cost offset, it is not clear that full thought has been given either to European military implications or to those for U.S. and allied operations.

Ongoing U.S. negotiations with the Europeans over Galileo highlight the need for compatibility among the navigation systems as well as for longer-term discussion about how military systems may be affected by the existence of Galileo. The U.S. Air Force must maintain an active role in these discussions in order to help U.S. authorities understand, identify, and protect U.S. equities.

European Space-Based Radar Programs

Europe is strongly committed to pursuing space-based imaging radar technologies for a broad range of applications. This emphasis on radar imaging satellites is reflected both in national programs and in the Earth observation programs that are supported by ESA. The chief

²⁵See de Selding (1995c).

ESA remote sensing program focuses on the European Remote Sensing (ERS-1 and -2) satellites launched in 1991 and 1995. These satellites have microwave instruments, including a SAR, that are used for environmental monitoring, ocean research, and disaster monitoring. A much larger Earth observation satellite, Envisat-1, is scheduled for launch in 2000. It will have an advanced SAR and other sensors.

Several countries are also pursuing national programs on radar technologies. Among the most notable is Italy's SKYMED/COSMO program, described earlier. Germany has extensive experience with radar imaging technologies. Deutsche Aerospace was the prime contractor for the ERS satellites. Following its decision not to proceed with joint development of the Horus radar imaging satellite with France—mainly because of budgetary constraints—Germany initiated new radar imaging satellite efforts, including studies on a smaller series of radar satellites known as SAR Lupe and TerraSAR, a joint U.K.-German development to develop a radar satellite with a 1.5-meter resolution that could be launched in 2004.

German interest in radar imagery is driven by diverse requirements. Scientific research has included sophisticated experiments to derive SAR interferometric data from tandem flights of the ERS-1 and ERS-2 spacecraft. Given frequent cloud cover and adverse weather, radar imaging is also needed for various civil missions, such as disaster monitoring for flooding. Furthermore, SAR data are particularly useful for creating digital elevation models (DEMs) that can be used to create three-dimensional terrain visualization. Finally, German military involvement in military and peacekeeping operations, such as Kosovo and Bosnia, has created another imagery need.

The key point here is that Europeans have increasing stakes in radar and other advanced forms of remote sensing. The U.S. common experience in Kosovo reaffirms the need for radar capabilities. This, of course, is at a time when the United States is also pursuing enhanced space-based radar capabilities. The Discoverer II program and other radar programs are part of an overall improvement of ISR capabilities. Although the United States retains an overall advantage in advanced space capabilities of this sort, it must also interact increas-

ingly²⁶ with new foreign-government and commercial initiatives that may be of value to U.S. or allied operations. Effective cooperation between the United States and Europeans is one way to offset the costs of the Discoverer II program, for example, and as well as potentially minimize interoperability issues in future military operations. Leveraging its expertise in radar imagery assets and as a partner in Discoverer II, the U.S. Air Force should be an active participant in U.S.-European space-based radar cooperation efforts.

OBSERVATIONS AND SUGGESTED ACTIONS

The U.S. trade space with regard to space cooperation with Europe is multidimensional. U.S. options and strategies for space cooperation include bilateral and multilateral agreements, commercial and government activities, and cooperation along a spectrum from the sharing of space-derived data to joint development of space systems. The costs and benefits of any one of these arrangements should be weighed in light of its overall impact on U.S. objectives. This means that space cooperation dominated by U.S. contributions may provide the leverage to gain other non-space-related contributions from its NATO allies in coalition operations, i.e., access to airspace and infrastructure. NATO—a logical venue for some of these discussions—appears to be absent from most major discussions about space issues, especially within the broader context of interoperability.

Within this case study, we have attempted to discuss the broad dimensions of U.S.-European space cooperation with a view toward enhancing interoperability (or at least identifying areas of potential progress or conflict related to interoperability) in coalition operations. Aspirations of European space actors like France (the dominant player) or Italy and Germany (emerging players) could provide opportunities to improve interoperability, especially to the extent that U.S. and European decisionmakers develop standards and methods for cooperation in space-related capabilities to support

²⁶Recent U.S. discussions with the Italians and Canadians reflect the kinds of challenges that the United States faces in this area. For example, the United States and Canada have been engaged in an occasionally contentious set of discussions over RADARSAT 2 (see Pearlstein, 1999, or Ferster, 1999).

military coalition operations. A good first step, especially in the case of France, would be to improve data-sharing protocols; this would precede any greater collaboration in space system development.

The WEU Satellite Centre represents a potentially important opportunity for information burden sharing. In exchange for increased access to WEU capabilities, the U.S. Air Force, in collaboration with other DoD and U.S. government organizations, could help the Centre train its imagery analysts and help the WEU develop quality control procedures that would optimize its products for military coalition operations. This collaboration would be an important step in developing a policy for NATO allies to use information developed at the Centre for coalition operations.

Although still in its definition phase, the Galileo program could negatively affect U.S. defense interests, given the possible need for additional technical capabilities to use the signal aboard U.S. military platforms as well as Brussels' interest in pursuing a fee-based service for using precision navigation signals. Galileo could also enter into direct competition with U.S. capabilities, although current negotiations reveal an understanding of the value of compatibility between the systems. Nonetheless, significant military policy and operational disputes could arise from competing political or commercial interests, as well as from the added costs of equipping or refitting military platforms with new navigation signal receivers capable of using signals from both the U.S. and European systems.

Finally, European political (especially post-Kosovo) and technical experience with radar means that there are potential opportunities for technology and other exchanges with the European space-based radar programs.

The United States will continue to derive comparative advantages from space, based on its strategic requirements and its decades-long investment and experience in using space for military and national security purposes. However, the five programs examined here clearly reflect increased European appreciation for the security and economic value of space as well as Europe's willingness to take independent action. Thus, U.S.-European space relations appear to be at a crossroads—with important ramifications for future cooperation

or competition, and any attendant benefits or damages to interoperability and security relations.

Because the United States retains advantages of architecture in space, not to mention unparalleled investment and experience, the United States should be able to shape European partnerships (whether within or outside of NATO) in a way that benefits both U.S. and NATO allies' security interests. But because of the size of the trade space, this will require considerable thought about a strategy that invariably involves cooperation, competition, and some continued U.S. dominance. The U.S. Air Force needs to play an active role in such activities. In particular, it can contribute to the broader realm of policy and operations that relates to information-sharing practices—both products and services derived from space assets—for use in U.S. and NATO allies' coalition operations.