

Preserving America's Strength in Satellite Technology

A Report of the CSIS Satellite Commission

Executive Director
James A. Lewis

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Executive Summary

America dominates military activities in space, but American preeminence cannot be taken for granted. Activity in space is now predominantly commercial, and the strategic environment is shaped by foreign competitors in satellites and space, the global spread of satellite technologies, the availability on the international market of militarily useful commercial satellite services, and the increasing importance of this global commercial market to the health of the U.S. satellite industry.

The dominance of global and commercial factors in shaping today's satellite industry poses a very different set of challenges for national security. The communications, navigation, and imagery services that were once available only to a few governments are now sold commercially in a global market. Other nations have crossed the threshold into space and operate satellites that provide commercial and militarily useful services. By 1999, revenues from the commercial satellite and satellite services market were roughly double those from the government and military market.¹ The rise of commercial services and of new competitors in the satellite industry increases the challenge to U.S. space policies.

This report looks at the new challenge faced by the United States in space. It assesses the nature and quality of commercial satellite services available on the global market in the militarily important areas of communication, navigation, and remote sensing. Second, it assesses the failure and costs of U.S. efforts to prevent potential opponents from gaining access to satellite service by restricting the participation of U.S. firms in the international market. Finally, it considers possible alternative approaches, while recognizing that the United States faces some hard choices concerning the satellite industry and its long-term viability.

Satellites and the Global Market

The goal of national space policy is to ensure that the United States continues to have capabilities in space that are superior to any potential opponent. Although U.S. spending on space and satellites dwarfs that of other nations, the domestic satellite industry needed for space power is being hollowed out. The reasons for this challenge lie in profound changes over the last decade. The United States no longer has a peer-competitor in space. One effect of this has been to focus Russian and U.S. space industries onto the commercial market. Second, the global spread of technological capabilities means that more nations are capable of building and using satellites for imagery, communications, and navigation without U.S. technology or support. Governments in Europe, Japan, China, and India have decided to make

1. Satellite Industry Association, 1999 survey.

the growth of national satellite capabilities a priority. These governments, and others, will continue to invest in space programs to enhance national pride and avoid a U.S. monopoly in space and satellites. The result is subsidized indigenous satellite industries that compete with U.S. firms. In the face of these new competitors, U.S. satellite manufacturers and service providers must rely more on a global market for customers and suppliers if they are to remain financially and technologically viable.

This global market reflects the increased demand for satellite services. As information and services have grown more economically important in the international economy, demand has increased for information technologies, including satellites. This demand was reinforced by the “lessons” of the war in the Persian Gulf, which showed militaries around the world that space capabilities are an essential component of military effectiveness and that military power is not measured by size or mass but mobility and swiftness. These two factors have increased global demand for satellites, and if the United States does not meet this demand, the global diffusion of technology means that others can and will.

The popular view that the United States and Russia, the two countries with manned space capabilities, are the only two nations with space programs markedly underestimates global space and satellite capabilities. More than a dozen countries have robust space programs, many of which have been in existence for decades. These countries have built and orbited satellites, often using their own launch facilities. They can produce imagery, communications, and experimental satellites that, while not always equivalent to top-of-the-line U.S. products, are capable of meeting many military needs.

Other nations have gained enough experience in building and operating satellites, communications equipment, and sensors. Russia and other parts of the former Soviet Union have commercialized their space technologies. The result is that many countries now have the technical skills to manufacture satellites and their components and to have independent national programs. These programs are often quasicommercial—owned or operated by governments and providing services to them, but also offering services on the commercial market. This is an attractive way to let foreign spending help subsidize government programs and is the model for remote sensing outside of the United States.

In 1998, congressional concerns over alleged leaks of space technology to China led to legislation that transferred the export-licensing jurisdiction for communications satellites to the Department of State. A review of changes in U.S. satellite revenues and share of the commercial communications satellite market shows that there has been significant damage. Budget cuts in the early 1990s gravely harmed the industrial base for military space programs; the export control changes of the 1990s are completing the damage by eroding the commercial industrial base through loss of sales.

Four years after these legislative changes, one leading space analyst told reporters: “The biggest problem we're facing is that of export controls. It has become increasingly difficult for American companies to export satellites and satellite-related components, software and technology over the past couple years. As it has become more difficult for American companies, our foreign competitors have gotten better and better at this stuff.”²

When Congress weighed new satellite restrictions in 1998, it underestimated their cost to the U.S. industrial base. It did so because the 1998 debate overstated the “uniqueness” (and thus the risk to national security) of U.S. satellite and launch technology. The impetus the 1998 changes gave to foreign satellite manufacturers may result in a permanently larger share of the satellite market for these firms, much in the way that Airbus has permanently established itself as a leading manufacturer. In an era of fierce competition and overcapacity in satellite manufacturing, supportive government policies and a positive regulatory environment will be a key determinant for a healthy space industry.

Data on imports and exports show the change in startling detail. In 1998, the year before the new regulations went into effect, the United States imported only 19 percent of spacecraft, satellites, and satellite parts used in this country. In every year after the new regulations, U.S. imports rose to more than 40 percent, with imports in 2001 reaching more than 46 percent. This suggests that the United States could find itself being a net importer of satellite technology in the near future if this trend is not reversed.³

The 1998 restrictions on commercial communications satellites were not the only factor responsible for a decline in U.S. satellite market share (exchange rates, new suppliers, and European industrial policy also played a role), but they were the only factor that resulted from U.S. government intervention. The new rules came at a time when U.S. manufacturers were already under substantial pressure, and they reinforced trends outside the United States that worked against the health of U.S. satellite industry.

Technology restriction was effective when the United States had a near monopoly on advanced satellite technology (and when the Cold War limited technology exports). The United States still has some unique satellite technologies where restriction remains appropriate, but as technological capabilities have spread around the world, this has become a very small set of items. The United States, which controls all satellite technology as a munition, has not been able to distinguish between those technologies where there is still a U.S. advantage and that should be protected and those satellite technologies that are routine, commercial, and available from foreign sources.

For example, delays in securing a State Department license to bid to sell electronic modules worth \$50 million for European commercial satellites led the European builder to purchase instead from European and Japanese suppliers. Another U.S. company waited for almost a year before a ground station was licensed so it could be shipped to a NATO ally. More recently, a major Canadian satellite operator has told U.S. satellite manufacturers that it will no longer purchase satellites from them because of onerous export requirements.

2. Elliot Pulham, president and CEO of the Colorado Springs–based Space Foundation, in Lyn Berry-Helmlinger, “Why Has Colorado Taken the Lead in the Space Industry?” *Denver Business Journal*, January 18, 2001.

3. The figures for 1999 and 2000 are 49 percent and 71.4 percent respectively; see series 31, “Exports of U.S. Aerospace Products,” and series 32, “U.S. Imports of Aerospace Products,” http://aia-aerospace.org/stats/aero_stats/aero_stats.cfm, accessed March 24, 2002.

These broad U.S. technology transfer restrictions are counterproductive, as they reduce the commercial sales that are the key to sustaining the U.S. satellite industrial base. Military and government demand will not be enough in the coming decade, when the United States will need fewer satellites for national requirements and longer gaps will occur between government satellite acquisitions. The effect of denying U.S. satellites, components, and technology to the global market has been to encourage other nations to develop non-U.S. sources of supply. For some key space technologies, such as traveling wave tubes, European firms have taken the lead since 1998.

Commercial Satellite Services

The best measure of the changed satellite environment is the expanding number of foreign satellite programs (private and governmental) that provide communications, navigation, and imagery services. These have increased dramatically in number and capability over the last 10 years and continue to expand. A review of the services available show that most are sufficient for military needs and some are equivalent to what is available to the United States.

Foreign communications satellites and services provide services equivalent to much of what is available to U.S. forces. Mobile satellite communications services and VSAT (very small aperture terminals) provide a level of service that lets companies or government build high volume, geographically dispersed communications networks for commercial or governmental purposes. The same is true of navigation services. Although GPS (global positioning services) and GLONASS (global navigation satellite system) satellites remain the only sources of navigation signals (Europe and Japan are developing their own navigational satellite systems), the receivers for these signals are easily built and widely available on the commercial market. The commercial market offers equipment equal to what is available to the military and dwarfs the military market in value. Degrading GPS signals in a conflict would damage the ability of opponents from using satellite navigation, but the risk that the United States could block or degrade GPS signals helps motivate others to build and launch their own systems.

Commercial satellite imagery serves a smaller market than do communications or navigation, and governments remain a major source of demand. However, the promise of the commercial market has led several nations to cross the threshold of having access to high-quality (one-meter) imagery for military and intelligence use. Many other nations have considered purchasing or developing their own satellite reconnaissance systems, but only a few (France, Japan, Israel, India, Russia, and China) have the resources to pursue these programs.

Technological capabilities for building remote sensing satellites are unevenly spread among spacefaring nations. The United States retains unique technical capabilities that even Russia cannot match. The technologies that provide these capabilities should remain restricted. However, the United States, despite its efforts, cannot prevent other nations from obtaining satellite imagery. Commercially available imagery has limitations—it is not as detailed or as timely as the imagery

provided by U.S. reconnaissance satellites. This reduces its value for military and intelligence purposes such as early warning. However, for other military purposes, such as planning and targeting, it is more than sufficient.

Surviving the Global Market

The U.S. satellite manufacturing industry has been engaged in contracting since 1990, when luxurious defense budgets for space and satellite acquisitions came to an end. Overcapacity, intensifying foreign competition, and damaging export regulations, when combined with low returns on equity compared with other tech industries, have led many firms to quit the business. Changes in export regulations since 1998 accelerated this demise by increasing uncertainty and reducing profitability. At the same time, the United States has not been able to prevent other nations from acquiring space capabilities, and it must look for other ways to manage the risks posed by the growth of commercial satellite services.

A study by Booz-Allen & Hamilton sponsored by the National Reconnaissance Office and the Office of the Secretary of Defense found that the “deteriorating financial health” of satellite companies poses a threat to the defense industrial base. It summarized the satellite industry as one with overcapacity in production, increased business risk without adequate returns and increased debt, making the sector “unattractive” for the investment community.

The United States can manage the risks of commercial space activity by taking steps to help the U.S. satellite manufacturing base remain strong and to maximize the role of U.S. companies as the suppliers of services and goods in commercial space.

For example, space remote sensing poses the greatest risk to U.S. forces, as imagery provides potential opponents with potentially great strategic advantages. If U.S. firms have a larger share of the global market for imagery, commercial incentives for foreign governments and firms to build imagery satellites will decline (since many hope to use commercial imagery sales to subsidize their programs). A larger U.S. market share would also reduce the supply of services from non-U.S. sources and increase the effectiveness of shutter control in time of crisis. U.S. companies can be influenced in ways that foreign companies cannot.

Numerous studies and commissions have urged the United States to gain advantage by using commercial satellite services for military and intelligence purposes. Purchasing services from commercial imagery providers would be like the early programs when the United States paid commercial airlines to deliver the mail—thus obtaining a service it needed at lower cost and promoting the growth of an important domestic industry.

Both policy and legislation have encouraged government purchases of commercial imagery from U.S. suppliers, but these have not been sufficient to sustain a robust domestic industry. Although the United States should continue to rely principally on organic satellite capabilities to supply core services to its military and national security communities, it should extend purchases of commercial services to include imagery and an expanded array and quantity of communications ser-

vices. Using commercial services provides an economical alternative (and potentially reduces vulnerabilities) to the current U.S. approach, which uses small numbers of large, expensive systems to provide service to the military and national security community.

Policies that shift market share away from the United States weaken national security. A policy that emphasized participation and leadership of the global space market would put the United States in the best position to capture the benefits of satellite innovation and advances in satellite research and development. If U.S. firms supply the satellite and component market, it will increase their financial health and allow them to benefit from technological developments. Greater U.S. participation in the global satellite market also enhances transparency, as the United States will be more knowledgeable about foreign satellite programs and their capabilities.

For the United States, removing regulatory obstacles may be a key determinant for keeping America strong in space, but other measures are needed as well. A new national strategy must recognize both the realities of the marketplace and the attendant risks to national security. Like it or not, America's armed forces now live in an era of commercially available satellite communications and reconnaissance products. Managing the risks involved requires an emphasis on keeping intact U.S. leadership in satellites and space.

Recommendations

U.S. national security strategy emphasizes information dominance as the basis of future military superiority. Satellites for remote sensing, intelligence, and communication satellites and navigation are key to information dominance. To exercise information dominance, the United States continues to have capabilities in space that are superior to any potential opponent.

However, in seeking superior space capability, the United States has not paid enough attention to its commercial industrial base or to the commercial satellite market, which is where most of the nations of the world concentrate their satellite activities. The unexplored aspect of "space control" is how it applies to the world commercial market for satellite services. Commercial satellites will play a larger role in sustaining the U.S. satellite industrial base in the coming decade as national requirements are met with fewer satellites that have longer lives and as there are longer gaps between defense and intelligence satellite programs.

There is no simple remedy for preserving the health of the U.S. satellite industry in a competitive, global commercial space environment. A 1960s-style defense-industrial policy would be costly and inefficient. Direct subsidies would be politically difficult to defend and difficult to manage. The best option will be to ensure that U.S. firms benefit from the larger forces shaping the global market. These forces are the increasing international demand for satellite services in communication, navigation, and remote sensing, the emerging global market for commercial satellite services. A successful policy will take advantage of these trends.

To repair this situation, we offer the following conclusions and recommendations.

- 1. Adjust U.S policies and plans to recognize the progress other countries have made in the commercial satellite market, both as satellite builders and as satellite service consumers.**

America now confronts a very different environment in space for national security. The growth of commercial space activities, where private entities or governments operate satellites and sell satellite services on a global commercial market, has changed the nature of the challenge to national security. From a national security perspective, foreign commercial satellite services are the most significant activity in space. However, forecasts of foreign space activities that alternate between alarmist and dismissive do a disservice to serious policymakers and operators. A growing number of countries can build and operate satellites, and all countries have access to satellite services. This is not an arms race, and competitors will be commercial more than military.

Managing any risk posed by commercial satellite services requires a dedicated effort to track what is available on the global commercial market. This should not be industrial policy or a new regulatory system for commercial satellites, but the assignment of responsibility within an agency (perhaps the Department of Defense or in the intelligence community) to work with U.S. companies and to use budgets and information to help the United States shape the global market in ways that are conducive to national security. This should be an integral part of any reorganization of U.S. government space functions.

- 2. Streamline irrelevant technology transfer restrictions. Most restrictions now applied to commercial satellites fall into this category.**

Restrictions on satellite technology transfers have backfired in the new global economic and security environment. These restrictions now do more damage to the U.S. satellite industry than to foreign space programs. State, the current regulator, has overbroad restrictions that damage U.S. national security. The efforts of the Defense export control agency are disconnected from program requirements and the reality of international space activity. Although State could reduce licensing times, it will take hard work and courage to undo the damage. The State process has been streamlined in the last year, but fundamental requirements of its regulations for technology and reexports make them harmful to the satellite manufacturing base.

If there were time, a “fix” to the satellite problem would be part of a broader reform of U.S. export controls, but continuing to treat communications satellites as munitions while we wait for some distant reform will lead to further shrinkage in America's satellite industry and expand the satellite industries of other nations. Legislation currently pending in Congress to return jurisdiction to Commerce for communications satellites, which includes extensive technology safeguards, would go far to repair damage. Passage of this or similar legislation is an important first step toward ensuring U.S. leadership in space.

To address concerns that have been raised about Commerce controls, any return to Commerce should include requirements for continued Defense Department monitoring, technology control plans, State Department licenses for launch failure investigations, and intelligence community review to verify end users. Commerce should also continue its former practice of referring all export license applications for communications satellites and related items to Defense and State for review.

This does not mean that the United States should simply end all restriction on satellite technology. In remote sensing, the United States retains unique capabilities that no other country can match, but the governmental process for identifying these unique technologies is broken. The regulatory bureaucracy at Commerce, State, and Defense lacks the expertise to determine which technologies require continued control. The solution is to use external expertise in satellites. Involving actual operators and builders will give any restrictions a sound footing. A neutral and technically proficient external body, like the National Research Council, supported by recognized outside experts and NRO, NASA, or other agencies with space expertise, should carry out this review to design effective regulations and lists by Commerce. This external effort would allow a clearer sense of where the world market for satellites and satellite technology stands to inform policymakers.

3. Develop measures that will prepare U.S. forces for conflict with opponents who take advantage of commercial satellite services, but recognize that the denial of satellite services is potentially a double-edged sword and may pose knotty problems for military planners.

America now confronts a very different environment in space for national security. The growth of commercial space activities, where private entities or governments operate satellites and sell satellite services on a global commercial market, has changed the nature of the challenge to national security. Maximizing the national advantage in this different environment requires a different strategy, which emphasizes active participation in the global market and finding ways to make U.S. firms into strong competitors. The more of the market space U.S. companies occupy, the less space there will be for foreign governments to use commercial programs to subsidize their military and intelligence use of satellites. For satellite services, the United States has a better idea of capabilities and more leverage in crisis over U.S.-made or U.S.-operated satellites than it does over foreign-made or foreign-operated satellites.

The military conflict in Afghanistan showed some of the measures that can protect U.S. forces, including the exclusionary purchase of imagery from commercial sources and the leasing of all available communications satellites transponders. In addition, cooperation with friendly remote sensing service providers can ensure temporary blackouts of areas of tension or conflict.

However, in a more extensive conflict or against a country with access to its own commercial communications and remote sensing assets (India, China, and Russia are such states), this may not be sufficient. The question of whether to actively deny such assets is a difficult one, as it could legitimize attacks on U.S. space assets, where we have more at risk. There is also the dilemma of an opponent using neutral third-

party assets, such as (hypothetically) China using a privately owned Russian communications satellite. It could be very difficult to neutralize such space assets.

4. Develop new ways to reinforce the commercial space sector, including supportive regulatory structures and the further “outsourcing” of communications and remote sensing requirements to U.S. companies.

Countries that are best able to exploit commercial development for military purposes will be stronger than opponents who are less adept at this. Policies that emphasize participation and leadership of the global commercial space market will put the United States in the best position to capture the benefits of economies of scale in satellite production and advances in satellite research and development. Commercial remote sensing is the area of greatest challenge for the United States. PDD-23 has outlived its usefulness. Its ambivalence about U.S. participation in the commercial remote sensing market has worked against U.S. interests. It has not stemmed the “proliferation” of remote sensing satellites outside the United States, it has not seen any turnkey systems exported (chiefly because they are too costly for most countries to operate), and the state of U.S. commercial imaging companies remains parlous. The regulation of U.S. satellite service providers, remote sensing technology, and remote sensing satellites remain essential ingredients for policy. The key issues for renewing PDD-23 are to move away from “remote sensing satellite proliferation” and to emphasize sales of U.S. systems and services as the best way to reduce risks to national security.

Having U.S. firms in the market and able to supply better-quality imagery than foreign competitors will provide the most effective means of shaping the international commercial imagery market. The United States needs to allow American imagery providers to take advantage of the qualitative superiority of U.S. imaging satellite technologies by offering higher quality imagery than is available from non-U.S. sources. Holding U.S. companies to a level of imagery quality equal to what is available on the world market gives the initiative in imagery to foreign firm and reduces both sales by U.S. firms and leverage for the U.S. government.

For the long term, the United States will need to consider if the national interest is best served by the sort of consolidation among satellite manufacturers as has already occurred among defense firms. There is global overcapacity in satellite production, and a real possibility that the United States will not be able to sustain (especially if current technology restrictions continue) the number of prime contractors and subcontractors it has now. Pruning a few, although painful, may be better than starving all. The key policy objective should be to ensure that a downsized global industry rests on an American base.

5. Create a coherent organization for government involvement in space activities.

Managing risk in an era of commercial space services will not be easy, and the United States will see other nations’ capabilities in space increase relative to its own. This does not mean, however, that the United States needs to surrender preeminence. New policies can help the United States reduce the potential risks of commercial satellite services, but the current, fragmented approach to space in the

United States may prevent us from developing and implementing effective new approaches. Program managers, research agencies, and export control bureaucracies have little overlap and less coordination, with a resulting loss of impetus. Whether this new, guiding organization is the Presidential Space Advisory Group called for by the Commission to Assess United States National Security Space Management and Organization or a recreation of the White House Space Council that existed until 1993, the current civil, commercial, military, and regulatory “stovepipes” must be replaced with a coherent structure that can integrate commercial, military, and intelligence requirements.

Introduction

This report examines the new space environment—where most activity is commercial and where commercial satellite operators in many countries provide increasingly sophisticated remote sensing, communications, and navigation services with real military utility. It reviews U.S. efforts to manage the risks of this commercial space environment and how one of these efforts—restrictions on satellite technology transfers—has damaged U.S. national security. Finally, it looks at various policy options for better managing the risk that commercial satellite services could pose to U.S. forces and interests.

The growth of a global market in commercial satellite services and the appearance of new competitors in the satellite industry have changed the strategic and technological environment for satellites. This growth is fueled by the global spread of satellite technologies. Commercial entities now provide services in communication, remote sensing, and navigation that were once available only to the U.S. and Soviet militaries. Strong commercial demand for satellite services and political decisions by governments to subsidize their national space industries (for reasons of national prestige, to spur technological development, and after seeing how the United States used space in Afghanistan and the Persian Gulf War) means that the United States will face increasing competition in satellites and their use.

Our underlying assumption is that “space power” is unattainable without a strong satellite manufacturing base. “Space power” means satellites that provide force-enhancing support to the ground. The elements of this strong base are competition, profitable companies, a wide range of subcontractors, and innovative research and development. The United States, which depends on the commercial industry to build the satellites it needs, must ask itself whether its policies work for or against strength.

The net effect of U.S. policy is to work against a strong satellite manufacturing base. In the mid-1990s, America seemed poised to dominate the satellite market. Following legislative changes in 1998, however, U.S. satellite firms lost ground to foreign competitors. Although there has been some recovery in system sales in 2001 (but not to the peaks of the pre-1998 period), a pronounced downward shift has occurred in revenues and in satellite component sales. In 1996, the United States dominated the market for high-end satellite components. As a result of tight export controls, which have cut sales for the small- and medium-sized component makers who form the core of the space industry, we have seen the U.S. share fall, while the European share has grown. More telling is the growth of satellite component manufacturers outside of Europe and the United States—they now account for 10 to 15 percent of the market.

Satellite manufacturing revenues show a similar trend. The U.S. share of world satellite manufacturing revenues peaked in 1997 at 65 percent of the total revenue. By 2001, the U.S. share was only 50 percent. Although world satellite manufacturing revenues are increasing at 9 to 10 percent a year, the U.S. share is declining by 10 to 11 percent.

Satellite manufacturing became a subject of intense debate in the second half of the 1990s. In 1998, concerns over satellite exports to China led to legislation that transferred the export-licensing jurisdiction for communications satellites to the Department of State. Since then, there has been significant damage to the satellite industry. One result is that foreign satellite manufacturers may gain a permanently larger share of the satellite market, much in the way that Airbus has permanently established itself as a leading aircraft manufacturer. In an era of fierce competition and overcapacity in satellite manufacturing, supportive government policies and a positive regulatory environment will be a key determinant for a healthy space industry.

To rethink the satellite question, CSIS assembled a group of key space and defense experts. This commission looked at the implications of a commercial space environment for national security and the health of the U.S. satellite industry. It assessed the nature and quality of commercial satellite services available on the global market in the militarily important areas of communication, navigation, and remote sensing. It also assessed the costs of U.S. efforts to prevent potential opponents from gaining access to satellite service by restricting the participation of U.S. firms in the international market. Finally, it considered possible approaches using technology restrictions, market dominance, and accelerated R&D to strengthen the satellite industry, while recognizing that the United States faces some hard choices concerning the satellite industry and its long-term viability.

First, restriction still has benefits in those areas where the United States maintains a technological advantage. Unfortunately, the current State Department controls regard all satellite technology as sensitive and subject to regulation. The effect is to strangle the U.S. domestic satellite industry. Restrictions continue to make sense in a few areas, such as in remote sensing and some satellite manufacturing techniques.

Second, the United States could try to dominate the international market for satellites and satellite services, thus enhancing U.S. control and knowledge. However, this strategy also has limits. Our major competitors in space have made a decision to subsidize their industries precisely to avoid U.S. dominance. Despite these limitations, seeking a larger U.S. share of the commercial market may be the best tool for managing risk.

Third, and perhaps most important, the United States could accelerate its efforts in satellite research and development. The only way the United States can maintain leadership in space is through technological innovation, and an expanded R&D program for satellites will have the greatest long-term benefits.

As a corollary, the United States must think about what sort of satellite industry it hopes to have a decade from now. It may be too early for a satellite "Last Supper" similar to that held for defense firms in the early 1990s, but some sort of review of

whether market forces are taking our space industry where we want it to go is necessary.

None of these approaches is exclusionary. All can be used together. Finding a new balance that emphasizes competitiveness and innovation over restriction and reorganizing the U.S. approach to space into a more coordinated system that breaks the agency stovepipes will do the most to let the United States manage the risks of the new commercial space environment.

Space and satellites have played a central role in national security since 1958, when the United States began the Corona reconnaissance satellite program. Satellites provide essential services to the U.S. and global economies in communications, navigation, and, increasingly, remote sensing. Although U.S. spending on space and satellites dwarfs that of other nations, the domestic satellite industry needed for space power is being hollowed out. U.S. spending on space and satellites is by itself no longer enough to support a robust domestic satellite industry as U.S. national requirements are met with fewer satellites that have longer lives and as longer gaps occur between defense and intelligence satellite programs. The global market is increasingly central to the health of America's satellite industry, and U.S. policy will determine how well America performs in this complex new commercial space environment.

There is no simple remedy for preserving the health of the U.S. satellite industry in a competitive, global commercial space environment. A 1960s-style defense-industrial policy would be costly and inefficient. The best option will be to ensure that U.S. firms benefit from the larger forces shaping the global market. In this new and more complex environment, the United States faces new risks and, if it is bold enough, new opportunities. The United States can no longer afford to advocate strength in space while pursuing policies and regulations that weaken the industrial and research base that space power depends upon. To repair this situation, we offer the following conclusions and recommendations.

Commercial Satellite Services and National Security

We Are Not Alone

The popular view that the United States and Russia, the two countries with manned space capabilities, are the only nations with space programs does not recognize the extent of global space and satellite capabilities. More than a dozen countries have robust space programs. France, Russia, China, Israel, India and Japan have built and orbited satellites using their own launch facilities. They can produce imagery, communications, and experimental satellites that, while not equivalent in many instances to the best U.S. products, are capable of meeting most commercial and many military needs.

Political, commercial, and military motives lie behind these foreign programs; they are a source of pride and of revenue, act as vehicle for development, and can offer military advantage. This blend of motives means that although operating in space is costly, the majority of these programs are unlikely to go away. The chief constraint on their progress is funding—all of these space agencies could do more if they had the financial resources, and none come close to matching U.S. government spending. Although the less-industrialized countries depend on foreign-made components, France (and the European Union), Japan, Russia, and, to a lesser extent, China have the capability to operate in space without outside assistance.

The European Space Agency's catalogue illustrates the growing availability of satellite components from non-U.S. sources. The "European Space Technologies Catalogue" offers an overview of the products available from the European and Canadian space industries. The catalogue lists hundreds of parts, components, fully integrated systems and services from dozens of European and Canadian firms.¹ The debate over whether these components are as good as U.S.-made components is irrelevant; foreign nations can build capable and competitive communicants, remote sensing, and navigating satellites without U.S. technology. Unlike the United States, the Europeans do not regard these items as military goods and do not restrict access to them as tightly as does the United States.

Although many countries have space and satellite capabilities, with or without U.S. cooperation, few countries have military space programs. They lack the budget, strategic vision, and military need for such programs. The Soviets had an extensive military space program, operated fleets of satellites for military purposes, experimented with space-based weaponry, and had an advanced missile and rock-

1. See http://www.esa.int/est/f_home.htm/, accessed December 2001.

etry program. No country today (other than the United States) has military space programs of this scope or operates fleets of military and intelligence satellites.

That said, the satellite industry is another example of the global dispersion of technology. Lower transportation and communications costs make cooperation and delivery across borders easier than a decade ago. While the internationalization of manufacturing is not as advanced for satellites as for aircraft, the trend is the same. In 1999 and 2000, for example, U.S. firms imported one third of the components used to build satellites.²

U.S.-made satellite components are often superior to foreign components, but foreign alternatives are sufficient to build effective satellites. Russia, Europe, and Japan are the leading sources of satellite technology outside the United States. Russia built and deployed an extensive fleet of satellites for military and intelligence purposes without U.S. components. European firms manufacture communications satellites that are essentially equal to U.S.-made satellites and can build electro-optic imagery systems capable of 1-meter imagery, but are unable to match U.S. producers in building systems with sub-meter capabilities. European companies have built a number of capable meteorological satellites, and Europe plans to deploy its own fleet of navigational satellites.

With the gradual demise of the Russian military space fleet, no other nation is likely to operate galaxies of military satellites for reconnaissance, navigation, and communication. A few countries will operate dedicated military communications satellites, and several countries will attempt to develop remote-sensing capabilities for reconnaissance, warning, and targeting capabilities. Military space, with a few exceptions, has essentially become a U.S. activity. U.S. military space spending is many times larger than all foreign military space programs combined. The satellites that challenge U.S. national security in space are commercial, not military.

The number of foreign satellite programs (private and governmental) that provide communications, navigation, and imagery services have increased dramatically over the last 10 years and continue to expand. Demand for satellite services has created a new space environment where most activity is commercial. Commercial satellite services fall into three categories—communications, imagery and navigation. Access to these commercial services allows potential opponents to narrow the U.S. advantage in information dominance. An array of foreign communications, remote sensing, and navigation satellites have been built and launched in response to strong commercial and government demand. These services are sufficient for military needs, and some are equivalent to what is available to U.S. forces.

Commercial Satellite Services

The United States and the Soviet Union spent billions of dollars to orbit fleets of satellites that provided intelligence, communication, and navigation to their military forces. Today, only Japan or the European Union could match this military

2. European Aerospace Industry, 1999 Statistical Survey; Aerospace Industry Association, Harmonized Customs Schedule Data.

expenditure (although China and India may eventually develop such capabilities). However, future threats to U.S. national security will not involve global deployments of massive conventional forces, probably will not entail formal declarations of war, and may not even involve states.

In this murky legal and political environment, potential opponents can take advantage of commercially available services to assemble a package of satellite information services that reduce the U.S. advantage in space. For far less cost, a potential opponent could assemble an "economy-class" package to obtain of imagery, communications, and navigation services. We can determine areas of risk for the United States by reviewing what level of service is available on the commercial space market in navigation, communications, and intelligence (both imagery and signals).

Demand for satellites and other information technologies reflect the increasing importance of services and information in the international economy. Services have been the fastest growing sector of international trade for the past 20 years and are now worth perhaps a quarter of all international trade.³ Services depend on the flow of information, so demand for information technologies including satellites has increased. The number of commercial satellites and the number of companies supplying these satellites and satellite services will continue to grow in response.

The services sector continues to be the fastest-growing sector of the satellite industry. The value of satellite services increased from \$25 billion in 1996 to \$40 billion in 2000, dwarfing the shares of satellite manufacturing (\$16 billion in 2000) and launch services (\$8 billion).⁴ Spending on satellite services is expected to continue to increase, reflecting demand for Internet access, direct broadcast, and imagery services. The commercial satellite industry generated \$81.1 billion in revenue in 2000, a 17 percent increase compared with 1999 revenues.

Increased demand for satellite services also reflects the realization by many governments that the information and coordination provided by satellite services are an essential component of modern military power. The single most important event for understanding the source of this demand was the war against Iraq in Persian Gulf. During the 1980s, the United States assembled, in competition with the Soviet Union, an impressive array of military satellites to support the U.S. ability to fight a global war. This Cold War constellation, which included communications, intelligence-gathering, and navigational satellites, proved invaluable in the wars against Iraq and the Taliban and will become increasingly central to U.S. military operations.⁵

The war in the Persian Gulf was a pivotal moment in the military use of satellites. It was the first war where space-based resources played a central role in shaping both strategy and tactics. The United States demonstrated to its coalition partners and to outside observers the benefits of combining space-based communi-

3. World Trade Organization, http://www.wto.org/english/tratop_e/serv_e/gats_factfiction2_e.htm, accessed December 2001.

4. Satellite Industry Association, 1999 survey.

5. Space Imaging Corp., the U.S. commercial remote sensing satellite operator, provided more than 470,000 square kilometers of imagery to the National Imagery and Mapping Agency during its three-months exclusive contract. Source: communication from Space Imaging Corp.

cations, navigation, and imagery for military operations. The satellite network designed for use against the Soviet Union in a global war gave the United States a measurable advantage in a war against a heavily armed regional competitor.

The United States used a combination of air- and space-borne sensors, an extensive satellite-based communications network, and precision targeting (with either smart weapons or through ordinary munitions using satellite imagery and targeted with GPS) against their Iraqi opponents. This was not a digital battlefield, but it had many digital elements connected by human interfaces for tactical and strategic sensors. Iraqi forces found it difficult to compete with an opponent well supplied with space services for navigation, communication, and remote sensing and with a superior communications network and a range of interfaces.

Remote sensing satellites provided data on the disposition and strength of Iraqi forces as well as targeting information and allowed coalition forces to assess battle damage. Although there were no commercial high-resolution imaging systems in orbit during the Gulf War, the United States did purchase several million dollars of imagery from France's French SPOT, which operated a quasi-commercial system with a ground resolution of 10 meters.

The specialized Defense Service Satellites were able to provide warning (albeit very short warning) of Iraqi Scud launches. The use of military communications satellites and rented transponders on commercial communications satellites allowed unparalleled coordination between deployed U.S. forces and Washington. Although GPS receivers were in short supply for the campaign, GPS satellites allowed coalition forces to navigate precisely in the desert and in the air.

From a military point of view, the most important aspect of the use of satellites in the Persian Gulf was the possibilities it suggested for future warfare.⁶ First, the use of long-range precision-guided weapons using GPS and remote sensing data to identify and strike Iraqi targets made possible a new and more lethal method of attack. Second, and perhaps more important, the integration of satellite services for communication and data collection suggested that the United States could develop a force multiplying advantage in information in future conflicts. The integration of satellite services (communications, remote sensing, and navigation) with precision guided munitions and command structures underlies much of the U.S. vision for the future of warfare.

U.S. operations in the Persian Gulf with their emphasis on precision, satellite services, and information superiority changed the face of conventional warfare. Satellites are a force multiplier, allowing smaller forces to operate more effectively. They are a key element in the new style of warfare envisioned by the United States, where information dominance plays a central role in tactical military operations.

In reviewing the results of the conflict with Iraq, potential U.S. competitors knew that they operated at a disadvantage, and many militaries, although they did not intend to match the array of satellites operated by the United States, saw the benefit of integrating precise navigation and remote sensing into their operations. The immediate result was a burst of initiatives by more than a dozen governments

6. Department of Defense, *Conduct of the Persian Gulf War*, Final Report to Congress, April 1992.

to acquire remote sensing satellites. Potential opponents around the globe learned that they needed to modernize their forces to remain credible, and, more important, they had to look for new vulnerabilities in U.S. forces created by this new high-tech style of combat. The success of the United States in the war in the Persian Gulf and the ongoing revolution in military affairs persuaded a number of other nations to increase their use of satellites and satellite services.⁷

Commercial satellite services for communications, navigation, and remote sensing are now widely available. This does not mean, however, that these commercial services allow potential opponents to match U.S. forces across the board. There is an immediate large payoff for any military force when it incorporates satellite services into its operations, and access to commercial services can reduce the asymmetric advantage the United States now has in space. Once this threshold has been crossed, however, further investments yield only a marginal improvement in military capability. The following sections on communications, navigating, and remote sensing services assess how the satellite environment has changed because of commercial activity.

Satellite Communications Services

Satellite communications services are the largest sector of satellite services. Communications satellites were originally developed for civil and commercial purposes, and the United States has encouraged the commercialization and privatization of communications satellite services since the early 1960s. Satellites have been a part of the public telecommunications network for decades, and commercial operators will lease transponder time for dedicated communications to both civil and military users. In every year for the past five years, 30 commercial communications satellites have been launched; 425 are now in operation, and 227 geostationary communications satellites offer commercial services.

Many more communications satellites are in low earth or elliptical orbits.⁸ These geostationary earth orbit satellites provide transmission of voice, broadcast, and data traffic to fixed terrestrial receivers over broad areas. Numerous private service providers in Europe, the United States, Asia, and other regions own and operate these satellites. In addition, several private firms attempted to build constellations of large numbers of low earth orbit (LEO) communications satellites to provide mobile telephony. Although many of these efforts proved to be commercially unviable, 180 LEO satellites have been placed in orbit over the last five years.

7. According to the Ballistic Missile Commission, "A number of nations are incorporating technical features of the RMA into their forces. These include space-based surveillance, reconnaissance and communications by way of both space and land-based fiber-optic networks (perhaps using civilian assets), guidance from the space-based global positioning system/global navigation satellite system (GPS/GLONASS) to increase the accuracy of missiles and the computational capabilities needed to plan, organize, and conduct operations." *Report of the Commission to Assess the Ballistic Missile Threat to the United States*, Donald Rumsfeld, chairman (July 15, 1998).

8. Department of Commerce, Office of Space Commercialization, *Trends in Space Commerce*, 2001.

Fixed commercial communications satellite systems such as Intelsat (based on geostationary communications satellites) have been used since the 1960s and are now complemented by mobile satellite systems and by direct broadcast systems (DBS). Mobile satellite systems (like Iridium) may no longer be economically viable in the face of greatly expanded terrestrial cellular telephony services, but direct broadcast satellites have been commercially successful. Fourteen direct broadcast systems are in operation around the world, and demand for DBS is expected to increase as satellites that are more capable offer Internet access, video conferencing, and other services.

Satellite broadcasting has become more important as television service providers use satellites to provide content to terrestrial systems. A single satellite can provide content for an entire region—the Spanish language network Univision, for example, operates a GEO satellite that feeds programming to television networks in six Latin American countries. Demand for broadband satellite Internet services and data relay are also expected to grow, assuming spectrum allocation and technical problems can be resolved. Internet access from aircraft for the tens of thousands of business travelers who are airborne every day and access for remote areas are the most likely markets for broadband services.

The introduction of VSAT (very small aperture terminals) and mobile communications services (including Internet access) in the last decade has considerably increased the military utility of communications satellites. These services offer new communications and control capabilities to the military forces of potential opponents—we know, for example, that terrorist groups have used mobile satellite telephones for their communications network.

VSATs allow a satellite to serve as a relay point between a command center and hundreds of widely dispersed ground stations. VSAT technology allows organizations to overcome the limitation of the landline public switch networks. Walmart, for example, uses VSAT to link its stores to company headquarters, allowing the rapid and automatic relay of sales and reorder information. Potential opponents, using this technology, could compensate for U.S. military satellite communications with commercial services at relatively little cost. Integration of satellite communications also poses less of a challenge for foreign forces, both because there is ample experience in the private sector with using these technologies (which are designed to be easy to use for the commercial market) and because they are to some extent an enhancement and expansion of existing capabilities rather than the introduction of a new capability.

Although U.S. forces retain greater access to communications services than what is available on the commercial market, the operational style and global deployments of U.S. forces generate a greater need for communications than that required by many potential opponents. Potential opponents could meet many of their requirements for communications from commercial services. VSAT technology in particular could allow foreign commanders to access an extensive military communications system covering a wide geographic area and many units.

The United States would face unusual problems if it were confronted by an opponent using commercial satellite services. Interfering with commercial communications used for military purposes could create problems for the United States if,

in the event of a dispute, a potential opponent had purchased communications service from a third party not involved in the conflict. Disrupting access to these commercial services could be difficult, especially if an opponent leased transponders on a satellite also used by neutral parties or even allies. The United States would have no legal recourse for shutting down the service, and an attack on a third party communications satellite (aside from setting a precedent for attacks on U.S. satellites) would be politically very difficult.

Foreign intelligence collection is not among the areas improved by allowing other nations to purchase U.S.-made commercial communications satellites. Despite concerns expressed during the 1998 debate over satellite jurisdiction, there is little or no risk that communications satellite technology will be diverted to signals intelligence collection. No other nation operates signals intelligence collection satellites (Russia has some heritage collection capabilities that continue to degrade). Commercial communications satellites have specialized payloads that cannot collect signals or to transmit these collections without significant modification that would degrade the commercial utility of the satellite and require modifications that could be made only with the consent of the manufacturer. This means the communications satellites built in the United States are the most secure because the United States can have a high degree of confidence that foreign intelligence services have not had access to or modified a satellite.

Satellite Navigation Services

There are no commercial navigation satellites, but the commercial market for satellite navigation services is now four or five times as large as the military market. The civil global positioning services market today dwarfs the military market, with sales of more than \$2 billion (as compared to a few hundred million for the military market). This commercial market depends on two groups of navigational satellites. The most famous system is the U.S. GPS system. Russia's GLONASS system offers similar (but less precise) navigational services. When the United States and the Soviet Union deployed global satellite positioning systems, their use was primarily military.

Navigation services equal to those enjoyed by U.S. forces are readily available using commercial GPS and GLONASS receivers. For navigation, a potential opponent could obtain a level of service equal to the United States for lower cost, as it can piggyback on the investment made by others to orbit positioning satellites. Access to satellite navigation will increase in the next decade as other nations orbit their own positioning satellites.

Many nations have successfully adopted satellite navigation for military purposes. This is primarily the result of the explosive growth of the commercial GPS market. In 1990, most GPS sales were to the military. Now, sales to the military make up a fraction of a \$7 billion a year market where GPS has become a low-cost consumer electronic device. The United States initially sought to restrict access to GPS by classifying the receivers as a munition and by "degrading" the signal avail-

able to commercial receivers. The export restrictions were unsuccessful, as many nations could build receivers capable of providing GPS data.

The contribution of the GPS capabilities to increased military effectiveness is a function, however, of the underlying effectiveness of the military force. Ground, naval, and air forces that lack the necessary equipment, training, and organization to take advantage of better navigational capabilities will not benefit fully from commercial services. For example, ground forces that lack the necessary logistical support and that have not trained for rapid maneuver warfare will not benefit markedly from better navigation.

Efforts to use GPS to improve weapons guidance will be technically challenging for many nations, a challenge compounded by uncertainty as to the U.S. ability to “turn off” GPS signals. The greatest benefit to guidance is likely to come from improved navigational accuracy for delivery platforms, such as aircraft. Increasing the likelihood that an aircraft gets to the point best suited for bomb release will increase accuracy and effectiveness, although not as much as smart munitions.

Although there is some risk that proliferators may use GPS to improve ballistic missile accuracy, they may come be as reluctant as the United States, which does not use GPS to guide its strategic missiles, to rely on a potentially disruptible guidance system. U.S. retention of the “selective availability” feature of GPS,⁹ which allows it to degrade the accuracy of GPS signal in a crisis, may deter. Selective availability may have long-term disadvantages, as it encourages other nations to develop alternative navigation satellite systems or new techniques to make the commercial signal more accurate.

The military benefits of satellite navigation aids also prompted several nations to seek alternatives to the U.S.-controlled GPS system. The Russians inherited the Soviet GLONASS system, and a few countries have developed “dual-mode” satellite navigation receivers that used both GPS and GLONASS signals. Although GLONASS is less accurate than GPS, using the two signals would reduce the risk to the United States from “spoofing” or blacking out satellite navigation. A few other countries have also begun their own global satellite navigation programs. The most important of these foreign programs is the European Space Agency’s “Galileo,” which has received funding and will deploy satellites in the next few years. Japan and India also are considering whether to develop satellite navigation programs (although the Japanese program may end up being complementary to GPS).¹⁰

The basic technology is (with few exceptions) not complicated. A number of satellites in equidistant positions around the globe (the orbit is relatively far from earth in an uncrowded plane) transmit radio signals. A terrestrial receiver, which now can be the size of a cell phone, uses two or more of the signals to determine its position. The most sensitive technology is the “clock” used on the satellite to make sure that the signals sent by different satellites match precisely. Timing problems introduce inaccuracies into the positions. The United States has an advantage in building very precise “atomic” clocks for use in space, but over the last decade,

9. Selective availability allows the United States to degrade the accuracy of GPS signals available to civilian users, from 25-meter accuracy to 100-meter accuracy.

10. Interview with Japanese officials, November 20, 2001.

other nations have developed similar capabilities chiefly for sale to the communications satellite market. Satellite positioning and navigation data must now be regarded as a freely available service for both military and commercial users around the world.

Remote Sensing

The United States developed the first imagery satellites in the late 1950s for intelligence gathering, to replace vulnerable aircraft in photo-reconnaissance missions. Commercial remote sensing from space is an outgrowth of these military programs. In contrast to communications satellites, where demand is overwhelmingly commercial, space imagery remains more valuable to governments. This could change if Internet bandwidth, computer memory capability, and the availability and cost of interpretive software expand over the next few years. These changes would make commercial space imagery more useful and easier to obtain and could increase commercial demand. Now, however, the commercial space imagery is the smallest of the satellite services market, with annual revenues for all companies at less than \$500 million per year.

Many countries are interested in acquiring space remote sensing capabilities. Eight countries and the European Union operate remote sensing satellites. France, the United States, and Israel have the most active commercial imaging satellite service providers, but Russia, Japan, India, Canada, and China have built imaging satellites and offer imagery to the commercial market. Many other nations have expressed interest in acquiring imagery satellites at various times, including Germany, Spain, Turkey, the United Arab Emirates, Taiwan, Korea, and Brazil, but for most the cost of operating an imagery system has been a deterrent. Absent further technological progress,¹¹ we are unlikely to see many more nations acquire this capability.

Although few countries operate remote sensing satellites, many have ground stations that can obtain data from foreign-owned remote sensing platforms. Most remote sensing satellites now also record and transmit data digitally, which avoid the short life and cumbersome recovery procedures associated with the use of film. The use of sophisticated imagery software to process digital imagery can provide additional information and can speed analysis. China's Remote-Sensing Satellite Ground Station (a branch of the Chinese Academy of Science), for example, receives and processes data from Landsat-5, ERS-2 (European Space Agency), JERS-1 (Japan), SPOT-1/2 (France), and Radarsat (Canada). The station also plans to use data from CBERS-1 (China/Brazil earth remote sensing satellite, a joint project). The station provides this data to Chinese government ministries and offers it for sale to commercial users.¹² The SPOT remote sensing system operated by France has ground stations in 21 countries, including India, Pakistan, Indonesia,

11. Developments in microsatellites, in which China has a considerable interest, and lighter, cheaper sensors could change.

12. Chinese Academy of Sciences (RSGS), China Remote Sensing Satellite Ground Station, <http://www.rsgs.ac.cn/>, accessed December 2001.

Israel, Saudi Arabia, and Taiwan. These stations can issue commands to the satellite and receive data, allowing countries to download militarily useful imagery directly from the satellite.

The United States has the premier remote sensing technology, but several nations can build satellites similar to those operated by the United States in the 1960s and 1970s. Russia and France, Japan, and Canada can build relatively sophisticated remote sensing systems, and China, Israel, and India have built imaging satellites (India's best satellite has 5 meter resolution). Resolution is only one factor for assessing the value of this imagery for military and intelligence purposes. Coverage and revisit times, control and slant capabilities, and the analytical capabilities for processing imagery also determine the utility of a satellite for military and intelligence purposes.

Resolution refers to the level of detail in the imagery collected by the satellite. All foreign and commercial remote sensing satellites provide imagery at a lower resolution than is available from U.S. intelligence satellites. This resolution difference is important for intelligence analysis—details of weapons systems cannot be easily determined from 1-meter imagery—but it is less important for reconnaissance purposes. One-meter imagery is sufficient to identify ships, aircraft, and armored vehicles. Although most commercially available imagery today is electro-optical imagery akin to digital photographs, multispectral imagery able to see through clouds and unmask decoys will be increasingly available. Sub-meter imagery would provide improved military and intelligence capabilities: one estimate is that perhaps half of the intelligence requirements for imagery could be met with half-meter resolution imagery. Several U.S. companies have licenses to build and launch half-meter systems, but none are in orbit today. The highest resolution commercial camera in operation today is owned and operated by Digital Globe (previously known as Worldview Corporation) on its “Quickbird” satellite (built by Eastman Kodak and Fokker Space B.V.), with a 0.61-meter resolution.

Resolution is determined not only by the quality of the sensor aboard the spacecraft, but also by the pointing accuracy of the satellite and by the stability of the craft. Pointing accuracy is the ability to command the satellite to look at a specific spot on earth. Just as a camera must be held steady when taking a picture, even tiny vibrations in a satellite can degrade resolution significantly, given the distance of the satellite from its target. Foreign remote sensing satellites are not comparable to U.S. satellites in pointing accuracy and stability.

The type of sensor used to collect the imagery is another determinant of the military utility of the satellites. The sensors on most of the commercial satellites use light from the visible spectrum. Multispectral satellites, which can use infrared radiation for imaging, are more useful and provide more information, but usually do not have as good a resolution as visible light imagery. Russia, France, Japan, and Canada can build multispectral satellites. Japan, the European Space Agency, and Canada operate radar satellites and sell the imagery commercially. The U.S. lead in sensors has been shrinking in recent years, but the United States retains unique technologies and capabilities for remote sensing satellites.

Obtaining adequate coverage and revisit times pose greater problems for potential opponents to gain military advantage from commercial remote sensing. These

are important factors for the military use of imagery. Coverage refers to the size of the area imaged by a satellite, and revisit time refers to the time interval between a satellite's passes over a particular area. Both depend to some extent on the degree of control exercised over the satellite. If the satellite can only be tasked or download data when it is within line-of-sight, the potential for real-time intelligence collection is limited. If the satellite can only be tasked or data obtained from a third party (a commercial vendor), the military utility is further reduced.

A remote sensing satellite that has the ability to "take pictures" at a slant (i.e., of items not directly beneath the satellite's path of travel) can cover greater area and provide greater military capability because the satellite can cover a greater area in a single pass. Slant capabilities may also make it harder for those on the ground to predict a satellite's target, reducing their ability to conceal or mask activities.

Access to imagery is not in itself a guarantee of military advantage. Nations considering the purchase of a turnkey system are often surprised to find that the satellite is not a flying camera, easily pointed at the object you wish to image, but requires an infrastructure of highly trained interpreters and analysts capable of fitting imagery into a larger intelligence context. Imagery itself is easily misinterpreted—for example, recent newspaper accounts of military activity in Kabul, accompanied by satellite photo, managed to print the images upside down. This sort of mistake limits the military utility of commercial imagery.

Commercially available remote sensing satellite services have disadvantages that limit their military utility. For some purposes—mission planning or simulation, observation or targeting of fixed facilities, monitoring of selected geographic areas—commercial imagery services provide an adequate (although not equivalent) substitute for U.S. intelligence satellites. For other purposes that require greater coverage, revisit time, and an ability to task the satellite to look at specific areas, commercial services are not as useful. It would be very difficult to match the coverage and revisit time available to U.S. forces using commercial imagery. Overall, U.S. forces retain an advantage over potential opponents who depend on commercial imagery, but against an opponent who took the necessary steps to integrate commercial imagery into their planning and operations, this advantage is less than it was when the United States had a near-monopoly.

We can no longer prevent nations that are willing to spend the money from obtaining imagery that is sufficiently accurate for many military purposes. This commercial imagery will not provide the same advantages, however, as those obtained from dedicated military reconnaissance satellites. Envy of U.S. capabilities will impel other nations to develop more sophisticated imagery satellites. Unlike the Soviet Union, today's potential opponents do not need to match U.S. capabilities in remote sensing to gain a military advantage. The high-resolution imagery collected by the United States is not necessary for many reconnaissance purposes. Access to remote sensing data can be of great military value, providing reconnaissance and early warning functions not available from other sources. To gain this advantage, the potential opponent does not need state-of-the-art remote sensing satellites: 10-meter imagery is sufficient to identify ships, 3-meter imagery can identify armored vehicles and aircraft. Revisit time is as important as resolution. For those nations concerned with U.S. power projection capabilities, remote sens-

ing gives them the ability to find and target U.S. forces outside of their borders that they would not otherwise have.

Remote sensing satellites pose a greater risk to U.S. security than other satellite services, but we need to be careful in differentiating this risk. Access to remote sensing capabilities provides extensive military advantage to those who did not have this access before. Once countries obtain this basic level of access, however, it requires substantial improvements in revisit time and resolution to gain further military advantage. The United States no longer has the ability to prevent the spread of basic remote sensing capabilities, and it needs a new approach to managing the risks created by commercial remote sensing services. The challenge is how the United States can best interact with the commercial space imagery market to maximize benefits to national security. As countries seek to improve their remote sensing capabilities, however, the United States still has unique technologies that provide resolution and targeting capabilities beyond what is available from foreign sources or in the commercial market. Foreign sources are unlikely to develop similar technologies in the near future. The United States should not share these technologies with foreign imagery satellite programs.

Implications of Commercial Satellite Services

The result of the increased demand for satellites is that space has gone from being a preserve of the superpowers to a crowded commercial arena. New governmental actors—Europe, China, and India—have entered the market. Space services, in communications, remote sensing, and navigation, are now commercially available in sufficient quantity and quality to change the national security equation for the United States.

Access to satellites and satellite services is not sufficient in itself to provide military advantage. Effective use of satellite services requires the development of a support infrastructure of analysts and operators and the integration of satellite data and services into military plans and operation. Countries seeking to use satellites for military purposes often overlook this terrestrial and expensive element of space power. Few nations have such establishments, and few are likely to try to match the extensive U.S. military space establishment.

Foreign military space programs remain dwarfed by U.S. spending on space and, given the high cost of space programs (greater than the budget for many countries' entire defense establishment), this is unlikely to change. Despite this advantage, the United States can no longer expect to be able to deny satellite communications and navigation services to potential opponents. The United States, for now, can still deny a potential opponent the ability to match U.S. capabilities through purchases of commercial satellite services, but these potential opponents are now able to cross a critical threshold for reconnaissance. From a strategic perspective, commercial services, rather than specially built military satellite fleets, offer the greatest avenues for skilled potential opponents to match U.S. capabilities in space.

The debate over satellite policy has tended to focus narrowly on denying specific technologies to foreign countries. This has helped obscure the larger problem of

other nations' ability to acquire satellites and satellite services in remote sensing, communications, and navigation without U.S. assistance. It also misses the question of what sort of capabilities other nations are trying to acquire. In this context, the value of much of the debate of the past three years is open to question. Restricting U.S. firms from selling satellites or satellite components has not kept foreign countries from acquiring satellites or access to satellite services.

Actions that the United States can take to respond to the use of commercial satellites and the sale of satellite services in a peacetime environment are significantly limited. A country cannot go blowing satellites out of the sky when they displease it, and in any case the United States, which is more dependent on space than other nations, could regret a course of action that legitimized attacks on satellites. The problem of commercial satellites' providing military services becomes even more complicated if a third party who is not a participant in a conflict or crisis is providing communications or remote sensing services to a U.S. opponent. Absent cooperation or some other leverage, the United States will find it difficult to prevent those satellites from operating.

Commercial satellite services unevenly duplicate U.S. military capabilities. More than commercial satellites are needed to match the United States in space. However, there is undeniable risk to U.S. forces that was not present a decade ago. Countries that are best able to exploit commercial development for military purposes will be stronger than opponents who are less adept at this. A new national strategy must recognize market realities and the attendant risks to national security. Like it or not, America's armed forces now live in an era of commercially available satellite services. The United States has not been able to prevent other nations from acquiring space capabilities through indigenous production and from a global market for satellites and satellite services. It must look for other ways to manage the risks posed by the growth of commercial satellite services.

Regulating Satellite Exports

The United States regulates satellite exports in order to preserve its military advantage. This policy, like the policies that once applied to encryption or computers, grows from the days when the United States faced a “mirror-image” superpower competitor and the primary purpose of satellites was military or intelligence. This is no longer the case. The U.S. regulatory structure now faces a situation where commercial activity has become more important and where a single competitor has been replaced by many.

Exports are of central importance to satellite manufacturing, particularly for U.S. firms, as they do not have the same direct government support received by their foreign competitors and must depend on private markets for financing and revenue. The increased importance of exports has put significant pressure on the traditional national security policy for satellites, which has been to impede foreign space capabilities by limiting access to U.S. satellite technology and services. This policy was successful in an era when the United States had a near-monopoly on advanced satellite technology and when government programs dominated space. It has been increasingly ineffective since 1991 in the face of market and political forces.

The United States recognized at the end of the Cold War that military and government ventures would no longer dominate space, and it took hesitant and incomplete steps to adjust its policies to the emerging commercial satellite market. These steps have not kept pace with global developments. Hesitation has real consequences for the United States. When satellites and satellite services are available from foreign sources, a restrictive policy can actually damage national security by limiting U.S. influence in shaping the global satellite services market without denying other nations access to satellite capabilities.

This argument—restriction hurts security—is counterintuitive, but its validity can be measured by looking at foreign

Multilateral Satellite Controls

The Wassenaar Arrangement is the only multilateral regime that controls satellites. Wassenaar is not like other nonproliferation regimes and is generally considered ineffective. Although major satellite-producing countries (the United States, Russia, France, Italy, Japan, and Canada) are Wassenaar members, new producers (China, Israel, India) are not. Other Wassenaar members do not share U.S. views on the risk of exporting commercial satellite systems or technology. The chief difference between the United States and its Wassenaar partners is that they control satellites as “dual-use” goods while the United States controls them as munitions.

industries. Foreign sources for communications, remote sensing, and navigation satellites and services continue to multiply, while the U.S. industry faces contraction. Restrictions have not prevented other nations from acquiring threshold satellite capabilities, and five countries—France and the European Union, Russia, Israel, China, and India are developing increasingly sophisticated satellite capabilities. An effort to restrict access to satellites may cost the United States its opportunity to lead the global market.

Since that time the United States has grappled unsuccessfully with how to characterize and regulate satellites, their components, and satellite technology. The issue is whether to continue to treat commercial satellites as a military technology requiring tight restrictions. After decisions by the Republican and Democratic presidents in 1992 and 1996 to increase the role of the Commerce Department in satellite regulation, Congress passed legislation redefining commercial satellites as a military technology.

From 1988 until 1998, the United States adjusted its policies on satellite exports to recognize the growing internationalization of the satellite market. The first step was the Reagan administration's decision in 1988 allowing China to launch U.S. commercial satellites. In the context of the Cold War strategic equation, the United States obtained pricing, launch quota, and technology safeguard agreements with China to reduce commercial and military risk. In the early 1990s, the Bush administration negotiated similar agreements with the Russians and allowed U.S. companies to enter into joint ventures with Russian space firms in the provision of launch services. Commercial satellites were a valuable bargaining chip for security in nonproliferation negotiations with the Russians and the Chinese, and this security incentive helped move the United States toward greater trade liberalization and economic competitiveness.

The first Bush administration decided, in 1992, to split the jurisdiction of commercial communications satellites and allow less advanced models to be exported as civil goods under more predictable Commerce Department regulations. The United States, unlike its European allies and Japan, controlled satellites as a munition or military good until 1992. The first Bush administration decided that, given the changed international security environment, communications satellites and the equipment needed to launch them could be exported under Commerce Department licenses, but it also decided that satellite technology and manufacturing techniques remain a munition. This split jurisdiction would create serious implementation problems that persist a decade later.

The first Bush administration established nine technical parameters for determining whether a commercial communications satellite should be treated as a munition or a commercial good. These included antenna size, cross-linking (the ability of one satellite to talk to another), and encryption. The nine criteria had become unworkable by 1995. For example, the large LEO telecom constellations planned for launch (such as Iridium) would require both larger antennas and cross-link capability, which had previously been used only by military satellites.

U.S. manufacturers argue that they are put at a disadvantage when satellites are treated as munitions. The basis for this lies not only in the more complicated license

processing and long delays associated with munitions, but also in the differing requirements of U.S. law and regulation for munitions and for commercial goods. If a foreign product incorporates a U.S. component classified as a munition, the entire foreign item becomes subject to U.S. licensing. If a \$100 million European satellite incorporates a \$15 U.S.-controlled component, a State Department license is required for that satellite's export. Under Commerce rules, reexport requirements apply only when the U.S. content reaches 25 percent of the value of the foreign item. In light of this licensing requirement, foreign manufacturers have chosen to "design out" U.S. components when foreign substitutes are available and have begun production of those components that are now available only from the United States.¹³ The result is that a European satellite's use of U.S. components requires a U.S. State Department license for export. An increasing number of European firms have chosen to design out U.S. components or to avoid partnerships with U.S. firms rather than face the license process.

Commerce regulations are less restrictive than the State Department's regulations because multilateral agreements determine the Commerce Control List's scope. If a multilateral regime does not control an item or technology, Commerce does not control it (except to sanctioned countries). Satellites are controlled by the Wassenaar arrangement (which grew out of CoCom, the Cold War export regime), but Wassenaar (and CoCom) did not control satellite technology or "know-how." Commerce officials also chose in 1992 to interpret the new satellite controls in the most liberal fashion allowed by their regulations.

The United States is also significantly more restrictive in its control of satellite technology. The Wassenaar Arrangement, the only multilateral regime that covers satellites, does not control any commercial satellite technology because commercial satellite technology has no strategic or military relevance. This means that companies in Europe, Japan, Canada, and Russia do not face the same level of restriction and oversight faced by U.S. companies, an issue that becomes more important in the context of U.S. monitoring requirements (discussed below). Despite the intense domestic debate over the implications for national security of satellite technology, the United States has never proposed that Wassenaar or the Missile Technology Control Regime (MTCR), the international missile nonproliferation regime, apply controls to it.

The MTCR does control some components that can be used in satellites, such as radiation-hardened chips and various guidance technologies. These components are available from foreign sources, but almost all MTCR members have been scrupulous in not allowing exports of these items to missile programs. However, the MTCR allows the export of these items for manned aircraft and satellites. This is another area of discrepancy between the United States and its nonproliferation partners, as the United States has taken a more restrictive approach, not only in regard to countries like China but also for space programs in allied countries.¹⁴

13. See John J. Hamre et al., *Technology and Security in the Twenty-First Century: U.S. Military Export Control Reform* (Washington, D.C.: CSIS, 2001).

14. See the provisions of the 1998 National Defense Authorization Act.

This difference reflects an element of confusion that has entered into the debate over satellites regarding their relation to missile programs. Satellites themselves make little or no contribution to missiles, which is why the MTCR chose not to control them. Satellite launches pose a more difficult problem because launches involve technologies of very serious concern for ballistic missile proliferation. However, there has been a blurring of the distinction between missile and satellites that exaggerates the potential proliferation risk of satellite exports. The inability to accurately measure risk is one of the most serious problems for the U.S. system of export controls.

U.S. Policy, 1993–2000

The Clinton administration continued the review of jurisdiction for satellite exports begun under President Bush. Faced with the erosion of the technical parameters useful in determining whether a commercial satellite was a “munition” or a “dual-use good,” the Clinton administration transferred jurisdiction of communications satellites not previously transferred in 1992 to Commerce. The decision reflected the evolution of satellites from a military to a civil technology (as had been the case with jet aircraft and jeeps) and reflected the administration’s confidence in its new Executive Order 12981, which gave Defense and State new, broad-ranging authorities to participate in Commerce licensing. The move was bitterly resisted by the State Department, which saw it as a significant loss of turf, and State officials lobbied Congress to have the decision reversed.

The Clinton administration also decided to retain the Bush administration decisions on splitting jurisdiction between State and Commerce for satellites and satellite technology. Although communications satellites went to Commerce, the related technology remained a munition. Technology for space-launch vehicles, which was never considered for transfer, also remained a munition.

The difficulties of the split jurisdiction in the U.S. satellite manufacturing industry were brought into sharp focus by the 1998 debate over whether satellite exports to China, either for use by Chinese telecommunications firms or for launch by China’s commercial launch service provider, had resulted in the transfer of technology that would improve China’s ballistic missiles. Foes of the Clinton administration and its China policies were able to exploit these technology transfer concerns.¹⁵ Acting with a speed that reflected both unhappiness with the administration (the satellite debate was intertwined with impeachment proceedings) and concern over China, the Congress passed legislation that returned jurisdiction of communications satellites to the State Department, made communications satellites a munition by law, and imposed new restrictions on the transfer of missile related technology to China.

15. See, for example, Michael May, editor, “The Cox Committee Report: An Assessment” (Stanford University: Center for International Security and Cooperation, December 1999); Gerald Seib, “Another Threat Looms: China as a New Demon,” *Wall Street Journal*, May 26, 1999; Walter Pincus, “China Spy Gains Overvalued, Two Former Lab Directors Say,” *Washington Post*, May 30, 1999, p. A10; Steven Fidler, “Secrets Thefts May Be Overblown,” *Financial Times*, May 27, 1999.

The State Department complemented these legislative changes by expanding the reach of its own regulations. State declared that not only were communications satellites now munitions, but their components were now munitions as well; that all satellite technology, even fundamental research that had been excluded from control by the Reagan administration, now requires a munitions license for export; and that foreign operators of commercial communications satellites must apply for a technology safeguards agreement even if they had been operating the U.S.-made satellite for years before the transfer.

For example, the “thermistor bolometer” is a resistor that senses infrared radiation from heat. First developed for use by railroads in the 1950s, the thermistor bolometer was attached to station platforms; when a car with overheated bearings went by, the heat set off a signal used to alert the train crew. The same thermistor bolometer technology was used, beginning in the 1970s, to orient satellites toward the horizon (known as “attitude determination”): the thermistor distinguished between the dark side of the planet (cold) and the light side (hot). Although originally designed for use with steam locomotives, after the 1998 legislative change, the Departments of State and Defense decided that the thermistor was a munition and required arms export licenses. Two years later, agencies were still debating how this piece of equipment should be treated. Thermistor producers experienced a sudden and damaging jolt in their revenue stream as their export status changed and as the debate dragged on.¹⁶

Foreign operators of U.S. commercial communications satellites were surprised in 1999 when the Department of State went to them and required that they retroactively obtain Technical Assistance Agreements (TAAs) governing technology transfers for satellites that had been licensed by Commerce and exported and launched years before. These Technical Assistance Agreements are usually required for the manufacture and launch of satellites. One Nordic embassy official told CSIS that it was puzzled as to how a technology transfer could occur for a satellite already in space and to which the Nordic operator had no access.¹⁷

When satellite licensing moved back to the State Department, new regulations governing satellite technology removed the fundamental research distinction, and State issued “deemed export” directives to NASA and universities requiring licenses

Satellite Licensing at State

Average time for approval: 4 months
Average number of licenses required: 9

- 1 Marketing license
- 1 Program TAA* (notified to Congress)
- 1 DSP-5 export license for hardware
- 1 DSP-5 for fuel
- 1 DSP-61 import license for fit-check
- 1 TAA for data to insurance companies
- 1 Launch services TAA
- 1 Customer service and operation license
- 1 DSP-5 for post-launch anomalies

* Technical Assistant Agreement

16. Interviews with BXA and company officials. See <http://www.servo.com/elecpl1.htm> (March 24, 2002) for more information about thermistors.

17. See *Aeronautics and Space Report of the President* for a general account of this problem.

for collaboration with foreign researchers on fundamental research. This had a chilling effect on the space research community. Scientists and researchers from the national labs, universities, and companies tell us that they find it increasingly difficult to carry out their research as a result of these restrictions.¹⁸

These measures were accompanied by an expansion of the satellite-monitoring regime implemented by the Defense Department under State's authorities. Defense monitoring had been a part of the 1988 Reagan administration decision to allow China to launch U.S. satellites. When the first Bush administration decided to transfer some communications satellites, Commerce agreed to continued Defense monitoring when it received jurisdiction in 1992, but did not support DOD charging the satellite firms for travel costs. Although it reversed its position in 1996 to support monitoring, this opposition was held against it in the jurisdictional debates.

The Defense Department's satellite export monitoring programs also came in for criticism in 1998 for being overly lax. In at least one instance, Defense had the authority to send a monitor to a China launch but chose not to do so. In response to congressional criticism, Defense greatly expanded its monitoring program. The new program covered not only Chinese and Russian launches of U.S.-made satellites (Defense even planned to monitor French launches of U.S. satellites), but also extended to domestic U.S. launches and activities not previously monitored. In the new program, U.S. government monitors have access to satellite-related activities by U.S. manufacturers during the construction of the satellite, including the participation of monitors in telephone conferences, prior review of data to be exchanged, and access to the manufacturers' databases. These measures entail remarkable access to unclassified company information, but the manufacturers, fearful of a congressional reaction, dependent in many cases on Defense for other contracts, and wary of potential delays in license approvals, did not object.

This expanded monitoring program reflects a larger debate in the United States over the treatment of unclassified information. The Economic Espionage Act and the Commerce Department's "deemed export" rule exemplify the increased concern to protect information. The trend in the 1990s was to apply export control restrictions to privately held information that was not sufficiently sensitive to require classification. For satellites, the Department of State went even further in its 1998 regulations and required licenses for basic research information that the Reagan administration had released from control.

The single most significant difference between Commerce and State licensing is the treatment of technology. State regards all satellite technology as sensitive and controlled, irrespective of its use, its intended recipient, or its availability from non-U.S. sources.¹⁹ State regards anything having to do with Space as militarily sensitive. The effect of the 1998 legislation was to reinstitute satellite technology controls from the 1970s. The treatment of technical data will be an especially difficult issue.

18. State was preparing regulations to overturn its earlier decision restricting research as this study goes to press.

19. The allegations of satellite information being transferred to China were the result of State's broad interpretation making these technical violations of the rules rather than actual transfers of sensitive military technology.

The high end of technology is particularly sensitive, and the most sensitive military technologies are classified. The State Department, however, applies its technology controls in a blanket fashion, catching both the high end and the low, defining satellite technology as

information, in any form, which is directly related to the design, engineering, development, production, processing, manufacture, use, operation, overhaul, repair, maintenance, modification, or reconstruction of defense articles. This includes, for example, information in the form of blueprints, drawings, photographs, plans, instructions, computer software and documentation. This also includes information that advances the state of the art of articles on the U.S. Munitions List.²⁰

This broad reach covers too much and sometimes defies common sense. One European satellite manufacturer, Alenia, reported that when it sends technical data to a U.S. partner, the U.S. partner needs a license to send the same data back, even though it originated with the European company.

To put this problem in perspective, compare it to speed limits. When cars were first introduced, many cities imposed a speed limit of 5 to 10 miles an hour on the new and potentially dangerous technology. They did this for reasons of public security. This low threshold essentially caught all cars. If cities had not raised speed limits to reflect technical change and a new environment, most people today would violate the speed limits and “threaten” security. State’s low threshold for technology controls, like the 5-mile-an-hour speed limit, are appropriate for an earlier age, but results in many technical violations that have nothing to do with security and unnecessarily impede the flow of legitimate traffic.

The marked increase in the number of Technical Assistance Agreements required by State for technical data over the last few years is evidence of this overreach. TAAs are long, contract-style documents, often comprising dozens or even hundreds of pages that list explicitly what can be exported. Obtaining a TAA is a lengthy process, often involving complex, lengthy negotiations that result in inflexible agreements that are difficult to interpret. This difficulty creates a high degree of risk for anyone planning to partner with a U.S. company, and satellite manufacturers in NATO countries have told us that it deters them from buying from or cooperating with U.S. firms.

State, recognizing that its slow performance in license processing was a liability, sought to implement a number of reforms for satellites. U.S. allies were displeased in 1998 to discover that new U.S. satellite export restrictions applied to their requests as equally as to those from other nations, and Congress encouraged State to relax restrictions on exports to NATO allies. However, the reforms did not address the question of overbroad controls on technology. State also froze license approval to China for a period of months as part of secret negotiations on missile proliferation, although when State announced that it was lifting the freeze, there was no noticeable improvement in license processing—major U.S. manufacturers

20. Department of State, International Traffic in Arms Regulations (ITAR).

reports that the mean time for licensing went from 104 days in 2000 to 169 days in 2001 and 150 days in 2002.²¹

U.S. Share of the Communications Satellite Market

In 1998, congressional concerns over alleged leaks of space technology to China led to the passage of legislation that transferred the export-licensing jurisdiction for communications satellites from the Department of Commerce to the Department of State. The effect of this transfer on U.S. market share for commercial satellites has become an important element of the satellite debate. U.S. revenues and share of the commercial communications satellite market show that a significant decline has occurred. Our review suggests that the export controls administered by the State Department are one of the factors responsible for the decline.

If foreign firms did not have a larger share of the satellite market since the transfer, we could dismiss claims that the 1998 legislation damaged U.S. satellite manufacturers' market share. However, showing that a decrease occurred after the change in jurisdiction does not establish why it occurred. The temporal correlation—the decline began after the legislative change—suggests that they are connected, but a decline in U.S. market share could reflect several other factors. Having a “strong” dollar makes European satellites cheaper. New entrants into the commercial market, such as China, India, Israel, and Russia, take market share (this also suggests that some 1998 technology restrictions are futile). A determined effort by European governments to become more competitive in the space market through mergers and collaboration has reduced U.S. market share.²²

Foreign exchange difference are the most compelling alternative to export controls for explaining a diminished market share, but a stronger dollar does not explain the decline in U.S. satellite sales. The dollar rose by 7–8 percent against foreign currencies in 2000, but U.S. exports of goods and services continued to increase until the last quarter of 2000.²³ Other large U.S. multinational firms estimate that a strong dollar has lowered their sales by 2 to 4 percent in the last year.²⁴ The continued rise in the value of the dollar may help explain future losses, but it does not account for losses in satellite manufacturers' revenues in the period after export jurisdiction was changed.

21. Statement of Brian Daley, Lockheed Martin, at CSIS conference, “Space and National Security in the Twenty-First Century,” March 12, 2002.

22. See page 18 in “Towards a Space Agency for the European Union, Annex II, Joint ESA/EC Document on a European Strategy for Space,” and John M. Logsdon, “‘Constructing Europe’ and the Future of European Space Activities for the United States,” May 2000.

23. Federal Reserve Board, Monetary Policy Report submitted to Congress on July 18, 2001, pursuant to section 2B of the Federal Reserve Act, Section 2, Economic and Financial Developments in 2001.

24. Danny Hakim and Greg Winter, “G.M. Official Says Dollar Is Too Strong,” *New York Times*, August 9, 2001; David Huether, “NAM Says Strong Dollar and Weak Growth Abroad Continue to Hamper U.S. Exports,” April 2001; Federal Reserve Statistical Release, Foreign Exchange Rates (Monthly), August 1, 2001.

If an overvalued dollar caused the decline in satellite sales, we should see a similar decline in sales from other industries. Using orders for large commercial jet aircraft, we can assess whether the decline in market share reflects factors unique to satellites or is part of larger aerospace industry trends. The U.S. share of orders for large commercial jet aircraft does not track satellite market share.²⁵ Both went down in 1999, but the U.S. share of large aircraft orders went back up in 2000. Although U.S. sales of satellite systems recovered somewhat in 2001, this was offset by a dramatic fall in the U.S. share of the satellite component market and a marked increase of imports from Europe and elsewhere of the hardware needed to build satellites.²⁶

How would legislative changes shape the market for satellites? Export controls that apply only to the United States affect market share because they change the price differential between United States and foreign satellite manufacturers. The new regulations created delays and uncertainties and increased the risk and expense of acquiring a satellite from the United States. Purchasers must commit funds to the satellite manufacturer; they must pay interest on these funds and lose the opportunity to invest them elsewhere while the satellite is being built. On a \$100 million satellite, these finance charges could be substantial. Every day the satellite is not in orbit is a day of lost revenue and greater finance charges.

Both U.S. and European companies have told us that State's extensive technology rules and Defense's monitoring requirements slow down discussion between U.S. companies and foreign satellite purchasers and component suppliers. These are usually Western firms, so there is little security risk to justify the added government oversight. European companies have told us that making the design changes and modifications that are often part of the manufacturing process is slowed considerably when U.S. companies must get approval for conversations, faxes, or e-mails, making them unattractive partners. The requirement for congressional notification can add several months' delay, primarily owing to unpredictable delays in submitting notifications.

U.S. manufacturers must commit to a specific delivery date or face financial penalties. Since they know that State licensing adds delays of unpredictable length, they build in extra time into their delivery dates. This would make U.S. satellites more costly to purchase. Changes in manufacturing—the use of standardized parts and assembly-line techniques—have reduced satellite production times, but the ultimate uncertainty of when State will issue a license for a satellite—measured in months—increases the risks for foreign purchasers. The chief source of this uncertainty, according to U.S. companies, is the delay in State's submission of congressional notifications, which are unpredictable and can add up to three months in processing times.

The extraterritorial aspects of State's regulations also affect demand for U.S. satellites. State-controlled items fall under sanctions that restrict sales to India and

25. Aerospace Industries Association, "Net New Orders, Shipments, and Backlog for Large Civil Jet Transport Aircraft," see http://aia-aerospace.org/stats/aero_stats/aero_stats.cfm/, accessed December 2001.

26. Bureau of the Census, *Statistical Abstract of the United States*, 2000; statement of Brian Daley, Lockheed Martin, at CSIS conference, "Space and National Security in the Twenty-First Century," March 12, 2002.

China. U.S.-made satellites, or foreign-made satellites that use State-controlled components, have additional retransfer and licensing restrictions. U.S.-made satellites, or foreign-made satellites that use State-controlled components, have additional retransfer and licensing restrictions. State is currently reviewing an in-orbit transfer of a communications satellite to a European operator, but it has delayed making a decision for several months on whether to approve the transfer, what licenses are required, and whether to notify Congress. Foreign firms have stated that these factors make U.S. satellites less attractive.²⁷

Implications of Declining Market Share

Using conservative measures, the United States suffered at least a 16 percent decline in its share of the GEO satellite market since the transfer of jurisdiction. Perhaps more important, we have seen a shift in components and subcontractors that has long-term implications for the health of the U.S. satellite industry. In 1995, U.S. satellite component suppliers had 90 percent of the market whereas by 2000 they retained only 56 percent. In contrast, European suppliers' share had increased from less than 10 percent in 1995 to 34 percent in 2000.²⁸ The shift of component manufacturing to non-U.S. sources is very damaging, and the United States already finds many of its commercial and military satellite programs dependent on foreign suppliers as a result. U.S. export control changes bear considerable responsibility for this because of their effect on prices and demand for U.S. satellites and satellite components.

The 1998 restrictions on commercial communications satellites were not the only factor responsible for a decline in U.S. market share (exchange rates, new suppliers, and European industrial policy also played a role), but they came at a time when U.S. manufacturers were already under substantial pressure and reinforced trends that worked against the health of U.S. satellite industry. Foreign competitors do not face the more extensive technology restraints, the extraterritorial requirements, and the higher degree of uncertainty in licensing faced by U.S. satellite manufacturers. These differences put U.S. firms at a disadvantage by increasing uncertainty and risk for potential foreign purchasers of U.S. satellites.

Since one of the external trends affecting market share is the entrance of new supplier nations like China and India into satellite and launch vehicle production, it is possible that the new restrictions placed new costs on U.S. industry with little or no compensating effect on foreign space capabilities. More important, of the factors that account for a decline in market share, the United States only has effective leverage over export controls. It has little or no influence on exchange rates for the euro, decisions by other nations to enter into satellite production, or European industrial policy. If the United States wants a healthy satellite industry in the face of intense competition, exchange rate difficulties, and the declining effectiveness of

27. The latest example appears in the June 25, 2001, edition of *Space News*, where Asiasat says it will no longer buy U.S. satellites because of the restrictions.

28. Statement of Brian Daley at CSIS conference, March 12, 2002.

technology restrictions, it will have to reconsider legislation widely perceived as making its satellite companies less competitive.

This question is complicated because many in the United States see communications satellite exports as proliferation and security problems. The national security aspect that has been emphasized is the effect of the transfer on potential leakage of space and launch technology. However, an equally important aspect of satellite exports for national security has not received equal attention. This is the need to maintain a robust and technologically advanced manufacturing base to build military and intelligence satellites.

Restrictions work against the health of U.S. companies in global markets when foreign competitors do not face similar controls. However, national restrictions could be justified if they applied to unique U.S. satellite and launch technologies from which others could use for military advantage. If these technologies were not unique to the United States, restrictions would damage industry without compensating security benefits. Since U.S. leadership in space depends on a robust commercial satellite-manufacturing sector, we may have done more harm than good for national security by restricting exports of replaceable technologies in an effort to lower the risk of technology leakage.

For example, current State regulations require that the reexport to a third country of any U.S. munitions items or technology, no matter how small, requires a State Department license. This raises serious problems when a U.S. munitions item is incorporated into a foreign satellite. No other country has this requirement. Foreign companies had to accept this restriction when the United States was the only source for satellite technology. Now that the United States no longer has a monopoly on many satellite technologies, they have “designed out” U.S. components and replaced them with foreign equivalents.

The impetus the 1998 changes gave to foreign satellite manufacturers has resulted in a larger share of the satellite market for these firms, much in the way that Airbus has established itself as a leading manufacturer of passenger aircraft. In an era of fierce competition and overcapacity in satellite manufacturing, supportive government policies and a positive regulatory environment will be a key determinant for a healthy space industry. For the United States, removing regulatory obstacles may be a key determinant for keeping America strong in space.

Decline in market share is just one element of the satellite jurisdiction debate. Other elements include the effect of the change of jurisdiction on space research, on smaller component suppliers (“subcontractors”), and on the composition of the satellite services market. The climate of regulatory uncertainty created by the transfer also affects crucial related activities, such as insurance and financing of satellite construction and launch. Measuring changes in market share does not fully reflect these other issues, but there is also considerable evidence that just as the transfer of jurisdiction damaged U.S. market share, it damaged U.S. activities in these other sectors.

A study by Booz-Allen & Hamilton sponsored by the National Reconnaissance Office and the Office of the Secretary of Defense found that although there are “more than adequate capacity and competition” in the U.S. satellite industry today, the “deteriorating financial health” of companies poses a threat to future U.S. suffi-

ciency in this sector. It summarized the satellite industry as one with overcapacity in production, increased business risk without adequate returns, and increased debt, making the sector “unattractive” for the investment community.²⁹

The study found excess production capacity for satellites and a “growing reluctance for companies to invest in restructuring” and innovation. The return on assets (ROA) for satellite manufacturers fluctuates between the return on a BBB corporate bond and U.S. Treasury bonds—assets with much lower risk.

Technological improvements have also put pressure on the industry. Existing satellite fleets (both commercial and military) will be replaced in the next 5 to 10 years with satellites of greater capabilities and longer lifespan (approaching 15 years, according to some sources). The result will be fewer satellite purchases and longer gaps between government satellite programs, but additional financial strain on primary producers and component manufacturers.

29. Thomas Moorman, “U.S. Space Industrial Base Study,” Booz-Allen & Hamilton, February 2000.

Remote Sensing Satellites and Presidential Decision Directive-23

The policy for remote sensing satellites exhibited a similar trajectory during the Clinton administration. The contribution of remote sensing to the effectiveness of U.S. forces in the Persian Gulf created global interest in acquiring such satellites. The Bush administration had begun a review of the question, prompted by legislative changes and by concerns over the effect of declining Defense acquisitions on U.S. satellite manufacturers. The review would not be completed, however, until 1994 by the Clinton administration, which announced the new policy in Presidential Decision Directive-23.

Presidential Decision Directive-23 (PDD-23) governs the export of remote sensing equipment, satellites, and services. It was an effort by the intelligence community, the Defense Department, and the Department of State in 1991 to come to grips with the effect of the Persian Gulf War on demand for remote sensing and the end of Cold War expenditures for government satellite systems. The Gulf War excited foreign demand for space remote sensing capabilities at the same time that U.S. government demand for remote sensing satellites was declining drastically. Congressional pressure to better manage imagery requirements and to support industry also shaped PDD-23 (the Land Remote Sensing Policy Act of 1992, for example, supported the development of private systems and authorized the Commerce Department to license private sector parties to operate private remote sensing space systems).

PDD-23 attempted to manage the imaging satellite market to align foreign use of remote sensing satellites with U.S. national interests and to use foreign demand to maintain a robust U.S. satellite industrial capability. PDD-23 had three objectives: to help maintain the U.S. remote sensing satellite industrial base through foreign sales; to obtain a dominant presence in foreign remote sensing satellite programs and the global remote sensing market; and to provide the United States with a measure of shutter control (i.e., deciding what could and could not be imaged) for domestically operated commercial remote sensing satellites.

Although the review of remote sensing policies began in the Bush administration, it concluded in the Clinton administration, and the change in administrations led to an important change in emphasis in administering the policy. PDD-23 called for the United States to explore creating a new regime (similar to the MTCR) to prevent or slow the “proliferation” of remote sensing capabilities. The nonprolifer-

ation element was originally seen as a minor part of the policy, put in at State's insistence despite intelligence community concerns. Under the Clinton administration, however, it became a central focus, with the Department of State dutifully going from capital to capital to urge other nations to resist the temptation of remote sensing and to join with the United States in governing the spread of this dangerous technology. Although the United States learned early in the process that creating a new multilateral regime was unlikely, State did undertake a series of bilateral discussions, negotiations, and agreements with other countries on remote sensing.

State made some progress in securing bilateral agreements, but these tactical advances do not add up to strategic success. Foreign access to remote sensing continues to "proliferate." Further, the bilateral agreements did not advance a key element of PDD-23, the displacement of foreign space imagery service providers. Emphasizing "nonproliferation" at the expense of participation may have actually reduced U.S. control of the global imagery market.

U.S. entreaties for agreements were often accompanied by offers of access to U.S. space remote sensing imagery or equipment. PDD-23 had originally envisioned the provision of U.S. imagery, components, and even "turnkey" satellite systems as a way for the United States to control the spread of remote sensing, by ensuring U.S. involvement in foreign programs (which means that the United States would understand foreign capabilities and operations), and access to foreign-collected data. At the extreme, provision of high-quality U.S. remote sensing satellites would, the United States hoped, deter other nations from building an independent industrial capability to make their own remote sensing satellites.

This policy was not without risk, but in 1992 the United States saw it as the best way to manage an irreversible trend. A fundamental assumption of PDD-23 was that remote sensing capabilities were going to spread, whether the United States liked it or not, and that U.S. participation in this spread, though it could increase its pace, would give the United States a measure of control it would otherwise lack.

PDD-23 was a major departure for U.S. policy in that it allowed the Departments of State and Defense to approve applications to export sensitive components, subsystems, and information concerning remote sensing space capabilities. Previously, the policy had been to automatically reject any request. However, in practice the elements of State and the intelligence community responsible for implementing the policy were exceptionally risk-averse. Many members of the permanent staff had not been convinced of the inevitability of the spread of remote sensing and clung to the previous policy of denying all requests for satellites and sensitive equipment. This innate resistance flourished in the attitude of caution and reluctance that often permeated the early days of the Clinton administration's dealing in military force and intelligence matters.

PDD-23 also permitted the transfer of jurisdiction of low-resolution remote sensing satellites—20 or 30 meters or more—from State's munitions list to the Commerce Department.³⁰ These satellites, which are used for weather prediction, have little intelligence utility. U.S. intelligence satellites have a resolution size of less than 1 meter. However, State resisted the transfer for four years until the 1998 China satellite imbroglio made the matter moot. It is unlikely that there would have been much of a commercial market for such satellites even if they had been trans-

ferred to Commerce as many other countries can either build imaging satellites of this quality or have access to 30-meter imagery from non-U.S. sources.

Nor has the United States actually transferred any turnkey systems to another country. For some more sophisticated potential recipients such as Germany, the conditions that the United States would have attached to the transfer made it unpalatable. Other nations, such as France or Japan, clearly intended to build their own systems despite U.S. offers of turnkey systems better than what they could build themselves. However, for most potential customers, systems cost was also a major factor in their decision not to acquire satellites. At the most basic level, senior defense and intelligence officials of customer nations hoped to be able to independently obtain the quality of classified imagery and analysis they were occasionally shown by their U.S. embassy briefers. Learning that this required not only an expensive satellite, but also an expensive and permanent operations and analytical establishment to process the satellite's product discourages many potential remote sensing satellite buyers.

PDD-23 also had to contend with competitions from France's SPOT and HELIOS programs. The French offered access to imagery, partial ownership, and even tasking authority as a competitor to U.S. systems. These options were cheaper than purchasing and operating a turnkey system and could be perceived or portrayed as having less political baggage (PDD-23 gave the United States the authority to limit imaging of certain allies as part of an approval). Foreign competitors were inadvertently aided by PDD-23's requirement that only turnkey systems with performance and imagery quality equal to what was available on the world marketplace could be exported. The effect was to limit U.S. firms to offering turnkey systems no better than SPOT or HELIOS. The combination of reticence, cost, and foreign competition meant that PDD-23 did not do much to preserve U.S. remote sensing satellites industrial capabilities.

Although the export provisions of PDD-23 were ineffective, the policy applying to the operation of privately owned U.S. remote sensing systems was more successful. PDD-23 allowed the licensing of U.S. firms, using the authority given the Secretary of Commerce, in the Land Remote Sensing Policy Act of 1992, to operate private remote sensing space systems. Licenses include restrictions allowing U.S. government oversight of private remote sensing, reflecting a fear that potential opponents of the United States or its friends would use the new service for hostile purposes. These restrictions included keeping records of customer requests, using encryption for data transmissions, allowing the U.S. access to imagery, and "shutter control," where, if requested by the secretaries of state or defense, the collection of imagery could be limited or "turned off."

The Commerce Department strenuously opposed shutter control at first. Commerce shared the commercial service providers' concerns that U.S. companies would be handicapped in competing in the commercial remote sensing market if

30. Resolution refers to the sharpness of the image taken by the satellite. For digital pictures, resolution refers to the size of an object represented by one "pixel" in the photo; 20-meter resolution, for example, means that a 20-meter object would appear as a one-pixel dot in the satellite photo.

their customers knew that the U.S. government had the ability to prevent companies from imaging certain areas. In practice, however, this does not seem to have occurred. Economic factors such as the price and the availability of imagery from aircraft have been more important in shaping (and limiting) the commercial remote sensing market, so that potential shutter restrictions appear not to have affected sales of imagery services. That said, as least some of the appeal of foreign commercial imagery products for purchasers outside of the United States is that it is free of U.S. political control.

In retrospect, shutter controls may be the policy's most important aspect. PDD-23 has guided the licensing of the remote sensing services by U.S. companies. Although the legal authority³¹ to regulate the sale of commercial remote sensing products and services lies with the Commerce Department (which gave the secretary of commerce the authority to license private sector providers of space remote sensing services), PDD-23 extended the legislation's requirement that any approval be consistent with national security.

Increasing the role of State and Defense in overseeing and licensing remote sensing operators was very beneficial. However, agencies inadvertently did real damage to U.S. competitiveness in attempting to develop rules for licensing. The most harmful of these rules restricted U.S. firms to offering remote sensing imagery that was no better than what was available from foreign sources. At a single stroke, U.S. service providers lost their technological advantages over foreign competitors. The result was to transfer a larger share of the remote sensing market to foreign operators.

Israel is a good illustration of the limits of shutter control. Israeli concerns over PDD-23 was one of the factors that led State and Defense to seek greater oversight over the Commerce licensing process (other nations also expressed concern, and one of the reasons for Commerce resistance was an initial fear that U.S. firms would be bound by a series of restrictive covenants covering larger portions of the globe). The National Defense Authorization Act of 1997 specifically limited the ability of U.S. firms to provide imagery of Israel at any better resolution than what was available from commercial sources in other countries. However, Israeli troops discovered that Palestinian forces had obtained overhead imagery of Israel, ironically from Israeli commercial sources.³²

PDD-23 has had mixed success. Although it has allowed the United States to manage the provision of commercial remote sensing by U.S. companies, it has not stemmed the "proliferation" of remote sensing satellites outside the United States, it has not seen any turnkey systems exported, and the state of U.S. commercial imaging companies remains parlous. The key issues for any review of PDD-23 are to end the emphasis on nonproliferation and to emphasize sales of U.S. turnkey systems and services as the best way to reduce the risk to U.S. national security.

31. The Land Remote Sensing Policy Act of 1992, Section 5621.

32. Reuven Shapira, "We Are on the Palestinians' Map," *Maariv* (Tel Aviv), Musaf le'Shabat, May 18, 2001.

Conclusion

The commercial aerospace industry remains a premier component of America's economic strength and national security. One component, aviation, has seen tremendous shrinkage in the number of firms, a growing use of international partnerships in production, and an increased dependence on foreign sources of supply. These changes were essential in order to remain competitive, but they have not yet occurred to the same degree in the space sector.

Space is not a profitable activity for the most part. Launching objects into space is expensive and risky. The only profitable activities to date have been to build satellites that provide enhanced terrestrial services for governments and commercial firms or to operate the satellites that provide these services. However, the combination of the collapse of the commercial low-earth orbit telecommunications satellite programs and a high degree of regulatory uncertainty has left capital markets uninterested in the satellite sector.

These straitened economic circumstances, when combined with increasing space activity outside of the United States, have real implications for national security. America has sought to ensure that its military technology remains superior to those of potential opponents. For many years, the United States implemented this policy for satellites through a combination of heavy defense spending and technology export restrictions. The first section of this report has shown, however, that the rapid growth in commercial satellite services has completely changed the environment for the United States. Maintaining long-term superiority in space now requires a different combination of policies.

First, restriction still has benefits in those areas where the United States maintains a technological advantage. Unfortunately, the current legislatively mandated controls executed by the State Department regard all satellite technology as sensitive and therefore worthy of restriction. The effect is to strangle the U.S. domestic satellite industry. Restrictions continue to make sense in only a few areas, such as in remote sensing and in some satellite manufacturing techniques.

Second, the United States could try to dominate the international market for both goods and services. If U.S. companies dominate the remote sensing market, for example, it reduces the risk that opponents will have access to commercial imagery during a crisis. If U.S. manufacturers sell the majority of satellites, the United States will have far more insight into foreign capabilities than if they are supplied from non-U.S. sources. However, this strategy also has limits. First, our major competitors in space have made a decision to subsidize their industries precisely to avoid U.S. dominance. Although a policy that allowed U.S. companies to dominate the world market would weaken other nations' military-related space programs, it would not eliminate them. Second, the last four years of export restric-

tion have done immense damage to the U.S. satellite industrial base, resulting in a permanent shift of manufacturing capabilities. Despite these limitations, seeking a more expansive U.S. role in the global market may be the best tool for managing risk.

Third, and perhaps most important, the United States could accelerate its efforts in satellite research and development. Other studies of the role of technology in military success have noted “the importance of such timely and innovative cooperation among scientists, the research and development community, and military commanders in bringing technological knowledge to bear for operational and strategic advantage cannot be overstated.”³³ Mature industries are not usually known for innovation, but the U.S. satellite industry faces obstacles in competing for new talent. The dot-com era drew engineering talent away from satellites. Security restrictions put in place after 1998, through onerous obstacles in the way of research and publication, encourage researchers to move to other areas not as bound by red tape. Finally, a few large projects eat up much of the budget, leaving little for developing new technologies. The only way that the United States can maintain leadership in space is through technological innovation, and an expanded R&D program for satellites will have the greatest long-term benefits.

As a corollary, the United States must think about what sort of satellite industry it hopes to have a decade from now. Unlike arms production, where demand is small and almost entirely from governments, the highly competitive commercial satellite market means that a hothouse industry will not be strong and may not survive. It may be too early for the satellite “Last Supper” that Secretary of Defense William Perry had with defense firms in the early 1990s, but some sort of review of whether market forces are taking the U.S. space industry where we want it to go is necessary.

None of these approaches is exclusionary. All can be used together, which is probably the best approach for maintaining advantage in satellites. In fact, the United States currently pursues all of these approaches, albeit in a stovepiped and uncoordinated fashion. Finding a new balance that emphasizes competitiveness and innovation over restriction and reorganizing the U.S. approach to space into a more coordinated system that breaks the stovepipes will best allow the United States to manage the risks of the new commercial space environment.

Technological change creates policy challenges for governments as markets and societies recombine in ways that do not necessarily fit the model of national states and vertically organized agencies now used for governing. In many ways, we are watching agencies grounded in an era of government-led, national programs deal with a world where sources of technology and innovation are more diffuse and where the line between commercial and government has blurred.

The common theme of this report is the growing importance of global and commercial forces in shaping today's satellite industry and activity in space. The risk posed by these forces to the United States is not immediate, but it is real. Foreign satellite capabilities will continue to improve, both for manufacturing satellites

33. Vice Admiral J.A. Baldwin, National Defense University president, in Montgomery Meigs, *Slide Rules and Submarines* (Washington, D.C.: National Defense University Press, 1990), p. xv.

and for exploiting satellite services. The commercial satellite market will continue to grow, offering improved communications and imagery services. U.S. national security policies that ignore these commercial trends will damage America's satellite industrial base and reduce the U.S. advantage in space.

A new policy for satellites must find ways to extract national security advantages from the global commercial satellite services market. The keys to this are participation in the global market, a streamlined regulatory system, and a strong base for innovation in satellites. Effective action to allow this and to preserve the U.S. advantage in satellites will require both legislative and regulatory changes. It will be a complicated and difficult task, as it requires a significantly different understanding of satellites and space, but a failure to adapt to new circumstances will only damage the national security of the United States.

Three separate commissions with deep experience in space and national security have all emphasized the importance of space power and leadership in space for future U.S. national security (the Commission to Assess U.S. National Security Space Management and Organization, the National Reconnaissance Office, and the National Imagery and Mapping Agency). Yet, the United States finds itself advocating strength in space while pursuing policies and regulations that weaken the industrial and research base that space power depends upon. The reason for this growing discrepancy between goals and means is a slowness or even unwillingness to recognize the changes that the growth of commercial satellite services have made in the global equation for satellites and space. To repair this situation, we offer the following conclusions and recommendations.

1. Adjust U.S policies and plans to recognize the progress other countries have made in the commercial satellite market, both as satellite builders and as satellite service consumers.

America now confronts a very different environment in space for national security. The growth of commercial space activities, where private entities or governments operate satellites and sell satellite services on a global commercial market, has changed the nature of the challenge to national security. From a national security perspective, foreign commercial satellite services are the most significant activity in space. However, forecasts of foreign space activities that alternate between alarmist and dismissive do a disservice to serious policymakers and operators. A growing number of countries can build and operate satellites, and all countries have access to satellite services. This is not an arms race, and competitors will be commercial more than military.

Managing any risk posed by commercial satellite services requires a dedicated effort to track what is available on the global commercial market. This should not be industrial policy or a new regulatory system for commercial satellites, but the assignment of responsibility within an agency (perhaps in the Department of Defense or the intelligence community) to work with U.S. companies and use budgets and information to help the United States shape the global market in ways conducive to national security. This should be an integral part of any reorganization of U.S. government space functions.

2. Streamline irrelevant technology transfer restrictions. Most restrictions now applied to commercial satellites fall into this category.

Restrictions on satellite technology transfers have backfired in the new global economic and security environment. These restrictions now do more damage to the U.S. satellite industry than to foreign space programs. State, the current regulator, has overbroad restrictions that damage U.S. national security. The efforts of the Defense export control agency are disconnected from program requirements and the reality of international space activity. Although State could reduce licensing times, it will take hard work and courage to undo the damage. The State process has been streamlined in the last year, but fundamental requirements of its regulations for technology and reexports make them harmful to the satellite manufacturing base.

If there were time, a “fix” to the satellite problem would be part of a broader reform of U.S. export controls, but continuing to treat communications satellites as munitions while we wait for some distant reform will lead to further shrinkage in America's satellite industry and expand the satellite industries of other nations. Legislation currently pending in Congress to return jurisdiction to Commerce for communications satellites, which includes extensive technology safeguards, would go far to repair damage. Passage of this or similar legislation is an important first step toward ensuring U.S. leadership in space.

To address concerns that have been raised about Commerce controls, any return to Commerce should include requirements for continued Defense Department monitoring, technology control plans, State Department licenses for launch failure investigations, and intelligence community review to verify end users. Commerce should also continue its former practice of referring all export license applications for communications satellites and related items to Defense and State for review.

This does not mean that the United States should simply end all restriction on satellite technology. In remote sensing, the United States retains unique capabilities that no other country can match, but the governmental process for identifying these unique technologies is broken. The regulatory bureaucracy at Commerce, State, and Defense lacks the expertise to determine which technologies require continued control. The solution is to use external expertise in satellites. Involving actual operators and builders will give any restrictions a sound footing. A neutral and technically proficient external body, like the National Research Council, supported by recognized outside experts and NRO, NASA, or other agencies with space expertise, should carry out this review to design effective regulations and lists by Commerce. This external effort would allow a clearer sense of where the world market for satellites and satellite technology stands to inform policymakers.

A second area for relief is in the regulation of imagery. The United States needs to allow American imagery providers to take advantage of the qualitative superiority of U.S. imaging satellite technologies by offering higher quality imagery than is available from non-U.S. sources. Holding U.S. companies to a level of imagery quality equal to what is available on the world market gives the initiative in imagery to foreign firms and reduces both sales by U.S. firms and leverage for the U.S. government. Having U.S. firms in the market and able to supply better-quality imagery

than foreign competitors will provide the most effective means of shaping the international commercial imagery market.

3. **Develop measures that will prepare U.S. forces for conflict with opponents who take advantage of commercial satellite services, but recognize that the denial of satellite services is potentially a double-edged sword and may pose knotty problems for military planners.**

America now confronts a very different environment in space for national security. The growth of commercial space activities, where private entities or governments operate satellites and sell satellite services on a global commercial market, has changed the nature of the challenge to national security. Maximizing the national advantage in this different environment requires a different strategy, which emphasizes active participation in the global market and finding ways to make U.S. firms into strong competitors. The more of the market space U.S. companies occupy, the less space there will be for foreign governments to use commercial programs to subsidize their military and intelligence use of satellites. For satellite services, the United States has a better idea of capabilities and more leverage in crisis over U.S.-made or U.S.-operated satellites than it does over foreign-made or foreign-operated satellites.

The military conflict in Afghanistan showed some of the measures that can protect U.S. forces, including the exclusionary purchase of imagery from commercial sources and the leasing of all available communications satellites transponders. In addition, cooperation with friendly remote sensing service providers can ensure temporary blackouts of areas of tension or conflict.

However, in a more extensive conflict or against a country with access to its own commercial communications and remote sensing assets (India, China, and Russia are such states), this may not be sufficient. The question of whether to actively deny such assets is a difficult one, as it could legitimize attacks on U.S. space assets, where we have more at risk. There is also the dilemma of an opponent's using neutral third-party assets, such as (hypothetically) China's using a privately owned Russian communications satellite. It could be very difficult to neutralize such space assets.

4. **Develop new ways to reinforce the commercial space sector, including supportive regulatory structures and the further "outsourcing" of communications and remote sensing requirements to U.S. companies.**

Countries that are best able to exploit commercial development for military purposes will be stronger than opponents who are less adept at this. Policies that emphasize participation and leadership of the global commercial space market will put the United States in the best position to capture the benefits of economies of scale in satellite production and advances in satellite research and development.

Commercial remote sensing is the area of greatest challenge for the United States. PDD-23 has outlived its usefulness. Its ambivalence about U.S. participation in the commercial remote sensing market has worked against U.S. interests. It has not stemmed the "proliferation" of remote sensing satellites outside the United States, it has not seen any turnkey systems exported (chiefly because they are too

costly for most countries to operate), and the state of U.S. commercial imaging companies remains parlous. The regulation of U.S. satellite service providers, remote sensing technology, and remote sensing satellites remain essential ingredients for policy. The key issues for renewing PDD-23 are to move away from “remote sensing satellite proliferation” and to emphasize sales of U.S. systems and services as the best way to reduce risks to national security.

Having U.S. firms in the market and able to supply better-quality imagery than foreign competitors will provide the most effective means of shaping the international commercial imagery market. The United States needs to allow American imagery providers to take advantage of the qualitative superiority of U.S. imaging satellite technologies by offering higher quality imagery than is available from non-U.S. sources. Holding U.S. companies to a level of imagery quality equal to what is available on the world market gives the initiative in imagery to foreign firm and reduces both sales by U.S. firms and leverage for the U.S. government.

For the long term, the United States will need to consider if the national interest is best served by the sort of consolidation among satellite manufacturers as has already occurred among defense firms. There is global overcapacity in satellite production and a real possibility that the United States will not be able to sustain (especially if current technology restrictions continue) the number of prime contractors and subcontractors it has now. Pruning a few, although painful, may be better than starving all. The key policy objective should be to ensure that a downsized global industry rests on an American base.

5. Create a coherent organization for government involvement in space activities.

Managing risk in an era of commercial space services will not be easy, and the United States will see other nations' capabilities in space increase relative to its own. This does not mean, however, that the United States needs to surrender preeminence. New policies can help the United States reduce the potential risks of commercial satellite services, but the current, fragmented approach to space in the United States may prevent us from developing and implementing effective new approaches. Program managers, research agencies, and export control bureaucracies have little overlap and less coordination, with a resulting loss of impetus. Whether this new, guiding organization is the Presidential Space Advisory Group called for by the Commission to Assess United States National Security Space Management and Organization or a recreation of the White House Space Council that existed until 1993, the current civil, commercial, military, and regulatory “stovepipes” must be replaced with a coherent structure that can integrate commercial, military, and intelligence requirements.

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