Commercial Space and United States National Security

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I. Introduction

Commercial satellite services are important to United States (U.S.) national security in several ways. Commercial satellites provide services and products to the U.S Government for defense and intelligence missions.[1] Commercial satellites are part of the nation's critical telecommunications infrastructure and support many other U.S. critical infrastructures, including banking, finance and transportation.[2] In addition, commercial satellites are integral to daily life and commerce.

Commercial satellites enable U.S. companies to participate in the market, teachers to educate the nation and farmers to grow America's crops. From residents at the base of the Grand Canyon[3] to explorers at the South Pole,[4] satellites deliver communications, information, navigation, Internet, rescue,[5] disaster relief, emergency[6] and other services to people,

[1] *See*, *e.g.*, "Iridium Rebounds to Win," *The Washington Post*, 11 December 2000, E1.
[2] For example, companies are using satellite systems to provide network and cyberspace protection services. Peter J. Brown, "Satellite Telephony A Vital Link," *Via Satellite* (January 2001), 48. (Brown, *Satellite Telephony*)
[3] Peter S. Goodman, "Dishing Up a New Link to the Internet," *The Washington Post*, 6 November 2000, A01. Virginia-based StarBand Communications, Inc. is providing two-way satellite Internet service to the Havasupai Indian reservation at the bottom of the Grand Canyon. Ibid.
[4] Gary Sheftick, "Women Ski Across Antarctica Using Army Phone Links," Army LINKS News, 19 December 2000. http://www.dtic.mil/armylink/news/Dec2000/a2001219antarctica.html. A team of two explorers, Ms. Ann Bancroft of the United States and Ms. Liv Arnesen of Norway, are attempting a 2,300 mile,100-day expedition across Antarctica. The explorers are using an Iridium satellite telephone (that the U.S. Army provided) to maintain contact with expedition headquarters in Minneapolis, Minnesota, to conduct live interviews and to communicate with their families, schoolchildren and others. The satellite phone also enables three-way conference calling and text messaging. In addition, the explorers are using the Global Positioning Satellite System, a navigation and location satellite system, to chart their daily courses. The website for the expedition is: http://www.yourexpedition.com.
[5] For example, on December 17, 2000, U.S. Coast Guard helicopters rescued 34 crewmembers from a passenger ship, *Sea Breeze I*, which was sinking about 200 miles east of Cape Charles, Virginia. "Coast Guard Rescues 34 People Update 1," *Coast Guard News*, 17 December 2000. Retrieved December 19, 2000, from the World Wide Web: http://www.uscg.mil/d5/news/2000/rl62_00.html. Satellite systems enabled the timely and successful rescue.
[6] Brown, "*Satellite Telephony*, 42-53 (describes various U.S. and foreign commercial and civil satellite systems and programs that provide emergency and disaster relief, including U.K.-based Surrey Satellite Technology Ltd.'s Disaster Monitoring Constellation, Volunteers in Technical Assistance, UNICEF, U.K.-based Inmarsat, U.S.-based Globalstar and West Virginia-based Chesapeake Satellite) *supra*, n.2.

businesses and organizations.[7] In these regards, the U.S. commercial space sector contributes to the strength of the U.S. economy and to the position of the United States as the world leader in space.

As described below, the United States relies heavily on commercial space services and technologies. That reliance likely will magnify as information and communications become more integral to U.S. defense and intelligence missions and more imbedded in American commerce and activity.[8] With reliance comes vulnerability. At the same time, commercial satellite services provide means for adversaries to act against the interests of the United States, posing national security risks. Commercial space, however, also presents opportunities. It offers faster, innovative technologies and services, increasing efficiency and broadening the types of applications. Commercial satellites provide the means for the United States to advance and protect—at home and abroad—the principles upon which this country was formed and stands today.

This paper provides background research for the Report of the Commission to Assess U.S. National Security Space Management and Organization (Commission).[9] In 1999, Congress chartered the Commission, directing it to assess U.S. national security space, including management and organization changes that could strengthen U.S. national security.[10] In its assessment, the Commission identified four space sectors: defense, intelligence, commercial and civil. The Commission considered the role of the commercial space sector in the United States and the world, including the growing interdependence of the four sectors and the rise in international space programs. The Commission studied the extent to which the United States relies on space, and the ensuing vulnerabilities, risks,

[7] "Information and Knowledge … form the building bricks of the new economy." "A Survey of the New Economy, Untangling e-conomics," *The Economist*," 23 September 2000 (*The Economist* Survey), 27. "The rapid growth and critical importance of the telecommunications and information industries will continue for at least the next decade." "NTIA Information," Retrieved Department of Commerce, National Telecommunications and Information Administration (NTIA): http://www.ntia.doc.gov/ntiahome/aboutntia.htm. NTIA is the Executive Branch agency principally responsible for domestic and international telecommunications and information policy issues. Ibid.
[8] "The rapid growth and critical importance of the telecommunications and information industries will continue for at least the next decade, domestically and internationally." NTIA website: http://www.ntia.doc.gov/ntiahome/aboutntia.htm. *See also The Economist Survey*, 7 ("America has been the first to embrace the IT [information technology] revolution and the new economy [and] this could prove to be the biggest technological revolution ever for the world as a whole"); Merrill Lynch, *Satellite Communications: Launching a New Era* (August 1, 2000), 64 (Merrill Lynch, *Satellite Communications*).
[9] *Report of the Commission to Assess United States National Security Space Management and Organization*, Commission to Assess United States National Security Space Management and Organization (January 11, 2001).
[10] Public Law 106-65 (Oct. 5, 1999), Section 1622, 10 U.S.C. 111 note.

threats and opportunities arising from that reliance. The Commission assessed opportunities for the U.S. Government to use the commercial space sector for national security space functions. Finally, the Commission studied ways to leverage the commercial space sector to strengthen U.S. national security.

This paper describes four types of satellite services: (1) remote sensing satellite services; (2) location, navigation and timing satellite services; (3) communications satellite services; and (4) weather satellite services.[11] The paper discusses the principal commercial applications of each service, its technological characteristics, financial value and expected growth, as well as national security implications. The paper also discusses global business trends, U.S. and international legal and regulatory issues and interagency coordination. In addition, the paper addresses U.S. use of commercial satellite services and products for defense and intelligence missions.

This paper is a survey of commercial satellite applications and developments. It intends to provide an overview of the four satellite services rather than a comprehensive treatment of the commercial space sector. References to particular companies and countries are to illustrate satellite applications and trends; omission of others is unintentional. This paper is based on multiple sources. In addition to the research that the paper cites, resources include: briefings before the Commission to Assess National Security Space Management and Organization, interviews with more than 50 U.S. Government and industry members, including representatives of the National Security Council (within the Defense Policy and Arms Control Directorate), Office of Science and Technology Policy (within the Division of Technology), Department of Defense,[12] Department of State,[13] Department of Commerce,[14] Department of Transportation (Coast Guard), Department of Justice (Criminal Division), Federal Bureau of Investigation (Office of General Counsel), Federal Communications Commission,[15] Wall Street financial firms, satellite companies and private

[11] The paper does not cover the satellite manufacturing segment, launch segment or the civil space sector.
[12] Specific offices included: Office of the Assistant Secretary for Command, Control, Communications and Information, Office of Net Assessment, National Security Space Architect, Defense Information System Administration, U.S. Air Force, U.S. Army and U.S. Navy.
[13] Specific offices included: the Bureau of Oceans and International Environmental and Scientific Affairs, Office of Space and Advanced Technology.
[14] Specific offices included: the National Telecommunications and Information Administration and the National Oceanic and Atmospheric Administration.
[15] Specific offices included: Office of Commissioner Michael K. Powell, the International Bureau and the Office of Engineering and Technology.

entities. The factual information below attempts to be as current and accurate as possible as of the time of publication. Given the dynamic nature of the commercial satellite industry, however, it is possible that information may have changed since that time.

II. Background

A. U.S. Leadership in Space through Government and Commercial Enterprise

1. Origins of the U.S. Commercial Space Sector

The U.S. space industry has evolved into four sectors. These are: the defense, intelligence, commercial and civil space sectors. Since the start of U.S. space activities decades ago, the vision and efforts of scientists, entrepreneurs, private companies and government officials have made the U.S. space sectors what they are today. The world lead of the United States in space is the result of U.S. Government and commercial enterprise.

In 1919, an American scientist, Robert H. Goddard, published a landmark paper that established the foundation for the development of U.S. rockets.[16] On October 13, 1936, an Army Air Corps Lieutenant met with Dr. Goddard to assess military applications of Goddard's study. In 1945, Arthur C. Clarke first wrote of geosynchronous satellites. A 1946 RAND Corporation study predicted that earth satellites would "inflame the imagination of mankind, and would probably produce repercussions in the world comparable to the explosion of the atomic bomb."[17] On October 1947, a U.S. Navy V-2 rocket took the first photograph of the Earth from an altitude of 100 miles.

In 1958, Congress formally established a civilian space agency in the "National Aeronautics and Space Act of 1958." The Act established the National Aeronautics and Space Administration (NASA) as a civilian agency to develop a comprehensive program for research and development in aeronautical and space services.[18] In addition, the Act provided for

[16] "Space Almanac," *Air Force Magazine* (August 2000), 34.
[17] Douglas Aircraft Company, Inc., "Preliminary Design of an Experimental World-Circling Space-ship," Abstract, *Report No. SM-11827,* (May 1946), 8, 9, 17, 23, quoted in Walter A. McDougall, … *the Heavens and the Earth* (New York: Basic Books , Inc., 1985), 102.

development of space technology for civilian applications such as communications satellites and sought "the preservation of the role of the United States as a leader in aeronautical and space science and technology."[19]

Four years later, in the Communications Satellite Act of 1962 (Satellite Act), Congress laid the foundation for the world's first global communications satellite system.[20] Congress declared that "it is the policy of the United States to establish, in conjunction and cooperation with other countries, as expeditiously as practicable, a commercial communications network, which will be responsive to the needs and national objectives, which will serve the communications needs of the United States and other countries, and which will contribute to world peace and understanding."[21] Eventually, that global satellite system became the International Telecommunications Satellite Organization (INTELSAT) system.[22]

INTELSAT began as an intergovernmental, treaty-based satellite organization of thirteen members and one geosynchronous satellite. INTELSAT, which now has 144 members and approximately 20 satellites, will become a private company in July 2001.[23] In the Satellite Act, Congress established COMSAT as the first private U.S. satellite corporation to operate for profit.[24] Congress created COMSAT to facilitate development of the global INTELSAT system and to provide for the widest possible participation by private enterprise in that system.[25] INTELSAT launched its first satellite, Early Bird, in 1965. As an initial commercial satellite provider, INTELSAT benefited from U.S. taxpayer-funded research and development conducted in the pioneering days of space communications. [26] INTELSAT also benefited from government policies designed to assure its early commercial success so as to achieve the broader public policy goals intended by its creation.[27]

[18] National Aeronautics and Space Act of 1958, 42 U.S.C. 2451.
[19] 42 U.S.C. sec. 2451(c)(5).
[20] Public Law No. 624, 87th Congress, 2d Sess., 76 Stat 419, approved Aug. 31, 1962.
[21] 47 U.S.C. sec. 701(a).
[22] Alexandra M. Field, "INTELSAT at Crossroads," *Law and Policy in International Business*, Vol. 25,
No. 4 (Summer 1994): 1335-66.
[23] The INTELSAT website is: http://www.intelsat.int.
[24] 47 U.S.C. sections 701-757. *See Comsat Study—Implementation of Section 505 of the International Maritime Telecommunications Act,* C.C. Docket No. 79-266, FCC 80-218 (1980).
[25] 47 U.S.C. sec. 701(c).
[26] *INTELSAT LLC,* Memorandum Opinion Order and Authorization, FCC 00-287 (August 8, 2000).
[27] Ibid.,1, n.10 citing *Policy for the Distribution of United States International Carrier Circuits Among Available Facilities During the Post-1988 Period,* 3 FCC Rcd 2156 (1988).

After the INTELSAT global system was operating, the United States began to explore the possibility of authorizing "domestic" satellite systems to serve the United States. On January 23, 1970, the Executive Office of the President submitted a memorandum to the Federal Communications Commission (the independent U.S. agency responsible for licensing communications systems) setting forth several satellite policy objectives, many of which still apply:

- Assuring full and timely benefit to the public of the economic and service potential of satellite technology.
- Fostering widespread awareness about the possibilities for satellite services.
- Minimizing regulatory and administrative impediments to technological and market development by the private sector.
- Encouraging more vigorous innovation and flexibility within the communications industry to meet a constantly changing range of public and private communications requirements at reasonable rates.
- Discouraging anticompetitive practices that inhibit growth of healthy communications and related industries.
- Ensuring that national security and emergency preparedness needs are met.[28]

The Executive Office of the President recommended:

> It is most important that the establishment and operation of domestic facilities be consistent with our obligations and commitments to Intelsat and the International Telecommunication Union, with other foreign policy considerations, and with national security communications requirements…. It also is important that provision be made for use of domestic satellite services by national security and emergency preparedness agencies when appropriate.[29]

[28] Memorandum for: Hon. Dean Burch, Chairman, Federal Communications Commission from Mr. Peter Flanigan, Assistant to the President (The White House, Washington, D.C., January 23, 1970) as reproduced in *Establishment of Domestic Communication-Satellite Facilities by Nongovernmental Entities*, 22 FCC 2d 86, 125 (1970) (*Domsat I*).

Two months later, the Federal Communications Commission issued its landmark Domsat I decision. That decision and its sequel, Domsat II,[30] gave birth to the U.S. satellite industry. In those orders, the Federal Communications Commission established its "Open Skies" policy—the hallmark of U.S. satellite policy today. The Federal Communications Commission found that satellite technology has the potential of making significant contributions to the nation's domestic communications structure by providing a better means of serving existing markets and developing new markets not now being served. The Open Skies policy was based on the agency's conclusion that the public interest would best be served at this initial stage by affording a reasonable opportunity for entry by qualified applicants. The agency established a framework of maximum flexibility and minimal regulation. Recognizing as well the uncertainties regarding the potential success of commercial communications satellites and the availability of other terrestrial alternatives, the Federal Communications Commission let market forces and competition drive the satellite industry. It opened the U.S. satellite market to any number of satellite operators to provide any type of domestic satellite services in the United States. A competitive U.S. satellite industry subsequently developed, contributing substantially to the strength of the United States in the global satellite market.

The U.S. Government has continued to play a substantial role in facilitating a competitive global satellite market and influencing the direction of INTELSAT. After recognizing the benefits of a global satellite telecommunications system and the benefits of U.S. participation in such a system by creating the framework for INTELSAT, in the 1980s-90s, the United States and other governments authorized other communications satellite systems to introduce competition in the international satellite market.[31] After those systems became operational and eventually more competitive, in the mid-1990s, the U.S. Government undertook efforts to encourage INTELSAT to become more competitive as well, recognizing the strong public interest benefits that would result. "The privatization of INTELSAT is a policy goal of the United States."[32]

[29] *Domsat I*, 22 FCC 2d at 128.
[30] *Domsat II*, 35 FCC 2d 844 (1981).
[31] *See, e.g., Separate Satellite Systems*, 101 FCC 2d 1046 (1985).
[32] *INTELSAT LLC*, Memorandum Opinion Order and Authorization, FCC 00-287 (August 8, 2000), 11, citing *Direct Access to the INTELSAT System,* Report and Order, 14 FCC Rcd 15703, 15759 (1999) (stating support for privatization and citing the Statement of Administration Position by Ambassador Vonya B. McCann, United States Coordinator, International Communications and Information Policy, Department of State, before the Senate Committee on Commerce, Science and Transportation, Subcommittee on Commerce (March 25, 1999)) .

As discussed in Section V. below, in response to competition and the interests of governments for a more competitive satellite market, INTELSAT inaugurated a multi-year effort to restructure. In 1998, INTELSAT spun-off five satellites to a separate entity, New Skies Satellites, N.V., which is based in the Netherlands and now competes with INTELSAT.

In March 2000, Congress passed the "Open Market reorganization for the Betterment of International Telecommunications Act" (ORBIT), establishing competitive criteria for the full privatization of INTELSAT in order to serve the U.S. market.[33] Thereafter, in August 2000, the Federal Communications Commission authorized INTELSAT to operate in the United States effective upon its privatization, and conditioned upon compliance with ORBIT.[34] The agency took this forward-looking action to "promote competition in the provision of satellite communications services through the privatization of INTELSAT in a manner consistent with U.S. law."[35]

This history shows that the development of U.S. space assets is the result of a strong connection between government and industry. That connection has benefited both, as well as the public overall. U.S. industry has profited from U.S. Government research and technology. At the same time, the U.S. Government has relied on commercial satellite services and products for numerous defense and intelligence purposes over many years. For example, the U.S. Government used commercially developed direct broadcast television technology in conceptualizing its Global Broadcast Satellite system and used commercial remote sensing data in Desert Storm. Since the inauguration of U.S. space efforts decades ago, the four space sectors have been linked. As delineated below, today, they are becoming increasingly interdependent.

2. Commercial Space Sector

The space industry is transforming and growing. In the past, the manufacturing and launch components of the industry were strong segments. That strength, however, is shifting to satellite services. For example, over the last decade, the U.S. defense industry generally has been

[33] Public Law 106-180, 114 Stat. 48 (2000). ORBIT also includes privatization and entry criteria for Inmarsat and spin-offs of the two organizations.
[34] *INTELSAT LLC*, Memorandum Opinion Order and Authorization, FCC 00-287 (August 8, 2000).
[35] Ibid., 3.

operating at flat levels.[36] The growth rate for manufacturers of launch vehicles and satellites "has been relatively flat" while ground segment industry "has been a source of tremendous growth."[37] For example, in its S*atellite Communications 2001 Outlook and Investment Guide*, C.E. Unterberg, Towbin ranks manufacturing and launch services segments lower than most other segments of the commercial communications satellite industry.[38] One prediction is that infrastructure and manufacturing, which represent about half of space industry revenues, will grow minimally in the next five years.[39]

At the same time, the satellite industry is growing in both the United States and worldwide. The Satellite Industry Association estimates that 2000 worldwide revenues for the commercial satellite industry will be $82.6 billion.[40] This figure, which includes commercial communications satellite services, launch services, manufacturing of satellites and of ground equipment, as well as sale of remote sensing imagery and value-added services, represents nearly a 100% increase since 1996 when global satellite industry revenues were $44.8 billion.[41] According to the Satellite Industry Association, U.S. satellite industry revenues represent nearly half of worldwide revenues: an estimated $37.5 billion.[42] That amount is nearly twice U.S. satellite revenues in 1996: $19.6 billion.[43] One prediction is that satellite services and applications will more than double by 2005, representing more than two-thirds of space industry revenues.[44] ING Barings estimates that global commercial satellite service revenues will more than triple by 2009.[45]

[36] *See, e.g.*, John R. Harbison, General Thomas S. Moorman, Jr. (USAF Retired), Michael W. Jones, Jikun Kim, Booz, Allen & Hamilton, *Viewpoint*, "U.S. Defense Industry Under Siege—An Agenda for Change," (2000), 3 (stating that top line revenues for the U.S. defense are projected to be stable, and even growing slightly, after a twelve-year period of declines linked to the fall of the Berlin Wall, outbreak of peace, changes in priorities under the Clinton Administration and government procurement policies) (Booz, Allen & Hamilton, *2000 Defense Industry Viewpoint*).
[37] International Space Business Council, *State of the Space Industry 2000* (2000), 10 & 24 (ISBC, *Space Industry 2000*).
[38] C.E. Unterberg, Towbin, *Satellite Communications 2001 Outlook and Investment Guide* (January 21, 2001), 5 (C.E. Unterberg, Towbin, *Satellite Communications 2001Outlook*). C.E. Unterberg, Towbin assessed and ranked twelve segments of the satellite industry: satellite television, international satellite television, satellite radio, capacity leasing, Very Small Aperture Terminals (VSATs), satellite imaging, manufacturing, earth stations, satellite Internet Service Providers, launch services, telephony and satellite messaging.
[39] ISBC, *Space Industry 2000*, 17.
[40] Satellite Industry Association and Futron, with cooperation from World Teleport Association, The Space Transportation Association, Global VSAT Forum and Society of Satellite Professional International, *Satellite Industry Indicators Fact Sheet* (June 5, 2000), 3 (*Satellite Industry Fact Sheet*).
[41] Ibid.
[42] Ibid., 4.
[43] Ibid.
[44] ISBC, *Space Industry 2000*, 17, *supra* n.37.

Several factors influence the viability and growth potential of particular commercial satellite services. These are for example: technology, cost, competing services, regulatory policies and the economy.[46] The technical ability of satellites to cover large geographic areas and to provide views from space, make satellites advantageous for several applications. For example, and as elaborated in Section V. below, communications satellites offer these technological advantages and economic efficiencies:

- Instant infrastructure: Once a satellite is launched, it can serve millions via a few ground stations.

- Cost efficiency: Satellites avoid the cost and difficulty of laying fiber especially in geographic areas with rough terrain or small populations.

- Simultaneous access: Satellites can allow satellite companies to reach many customers at once, regardless of distance or geography.

- Point-to-multipoint: Through satellite networks such as VSATs (Very Small Aperture Systems), which use a "hub" design, information can be distributed from one central source to many distant locations. For example, a U.S. corporation can set up offices in foreign countries, including those with inadequate telecommunications infrastructure, and communicate with a home office in the United States.

Availability of competition from other services and technologies has a substantial impact on the satellite industry. For example, at this time, imagery from airplanes represents the largest part of the imagery market. Remote sensing satellites, however, can see much larger areas of the earth than that visible from airplanes and are equipped to produce images of higher resolution. Another example of the varying viability of satellite technology is the U.S. Global Positioning Satellite (GPS) System. The timing feature of the GPS system has wide commercial, government and societal applicability. To date, however, there is no comparable timing capability available in the world.

[45] ING Barings, *The Satellite Communications Industry: Efficient Infrastructure 2000* (March 2000), 7 (ING Barings, *Satellite Communications*). This estimate includes communications satellite services, manufacturing and launch. It excludes government systems and services.
[46] *See, e.g.*, Merrill Lynch, *Satellite Communication*, 64, *supra* n.8.

By contrast, there are numerous telecommunications services available and many provide strong competition to commercial satellite communications services. As described in more detail in Section V. below, competition is stronger against certain types of communications satellite services than others, based largely on technology, demographics and cost. For example, the satellite telephony market, particularly the global mobile market, has had difficulty competing with terrestrial wireless services. Generally cheaper and quicker to build and install than satellite systems, cellular telephone systems have been deployed rapidly and widely around the globe.

B. U.S. National Security Space Policies

Space is becoming increasingly important in U.S. national security strategy. U.S. forces must have information superiority in every mission area and assured access to and use of space.[47] The *1999 National Security Strategy* states that:

> We are committed to maintaining U.S. leadership in space. Unimpeded access to and use of space is a vital national interest—essential for protecting U.S. national security, promoting our prosperity and ensuring our well-being…. We will maintain our technological superiority in space systems, and sustain a robust U.S. space industry and a strong, forward-looking research base. We also … will continue to pursue global partnerships addressing space-related scientific, economic, environmental and security issues.[48]

The *1999 U.S. National Security Strategy* provides that “vital interests” of the United States include: “the economic well-being of our society, and the protection of our critical infrastructures—including energy, banking and finance, telecommunications, transportation, water and systems and emergency services.”[49]

[47] Prepared Statement by Dr. John J. Hamre, Deputy Secretary of Defense, Hearing before the U.S. Senate, Subcommittee on Strategic, Committee on Armed Forces regarding the Department of Defense Authorization for Appropriations for Fiscal Year 2000 and the Future Defense Program (Colorado Springs, March 22, 1999), 287-289 (*1999 Prepared Statement by Dr. Hamre*).
[48] *A National Security Strategy of Engagement and Enlargement*, the White House (December 1999), Part II, p. 12 (*1999 National Security Strategy*).
[49] Ibid. Part I, p. 1.

In September 1996, President Clinton issued the *National Space Policy*.[50] It establishes five U.S. goals:

(1) Enhance knowledge of the Earth, the solar system and the universe through human capital and robotic exploration;

(2) Strengthen and maintain the national security of the United States;

(3) Enhance the economic competitiveness, and scientific and technical capabilities of the United States;

(4) Encourage State, local and private sector investment in, and use of, space technologies;

(5) Promote international cooperation to further U.S. domestic, national security, and foreign policies.[51]

The *National Space Policy* declares that the United States "will conduct those space activities necessary for national security"[52] and that "[c]ritical capabilities for executing national security missions must be assured."[53] It provides that the "fundamental goal of U.S. commercial space policy is to support and enhance U.S. economic competitiveness in space activities while protecting U.S. national security and foreign policy interests. Expanding U.S. commercial space activities will generate economic benefits for the Nation and provide the U.S. Government with an increasing range of space goods and services."[54] The *National Space Policy* also states: "U.S. Government agencies shall purchase commercially available space goods and services to the fullest extent feasible and shall not conduct activities with commercial applications that preclude or deter commercial space activities except for reasons of national security or public safety."[55]

[50] "National Space Policy," Fact Sheet, Presidential Policy Directive (PDD) 49, (The White House, National Science and Technology Council) (September 19, 1996) (*National Space Policy Fact Sheet*), 1.
[51] *National Space Policy Fact Sheet*, 1.
[52] Ibid., 4.
[53] Ibid., 5.
[54] Ibid., 8.
[55] Ibid. "`Feasible' means that such goods or services meet mission requirements in a cost-effective manner." Ibid.

C. National Security Implications of Satellite Infrastructure

1. U.S. Critical Infrastructure

Commercial satellites are part of the U.S. critical infrastructure. The 1998 *Critical Infrastructure Protection Policy* (Presidential Policy Directive 63) defines "critical infrastructures" as "those physical and cyber-based systems essential to the minimum operations of the economy and government."[56] "They include, but are not limited to, telecommunications, energy, banking and finance, transportation, water systems and emergency services, both governmental and private." [57] The "telecommunications" infrastructure, also called the "information and communications" infrastructure, includes "satellite service."[58]

According to the 1997 President's Commission on Critical Infrastructure Protection, the U.S. communications and information infrastructure sector:

> generates more revenue than most nations produce… . We have led the world into the information age, and in so doing have become uniquely dependent on its technologies to keep our economy competitive, our government efficient, and our people safe. [59]

[56] The White House, "White Paper, The Clinton Administration's Policy on Critical Infrastructure Protection: Presidential Decision Directive 63," (May 1998) (*Critical Infrastructure Protection Policy White Paper*). Retrieved October 21, 2000, from the World Wide Web: http://www.whitehouse.gov/WH/EOP/NSC/html/documents/NSCDoc3.html.

[57] Ibid., 8. The *Critical Infrastructure Protection Policy* designates U.S. lead agencies for responsibility for the specified critical infrastructures, including, for example: Department of Defense—national defense; Central Intelligence Agency—foreign intelligence; Department of State—foreign affairs; Department of Commerce—information and communications; Department of Transportation—aviation and highways (including trucking and intelligent transportation systems); Department of Justice and Federal Bureau of Investigation—law enforcement services; Federal Emergency Management Administration—emergency fire service and continuity of government services. The National Telecommunications and Information Administration (within the Department of Commerce) is the lead agency for protecting the U.S. information and communications infrastructure from purposeful cyber or physical attack. *Critical Infrastructure Protection Policy White Paper*, 8-9.

[58] President's Commission on Critical Infrastructure Protection, "Critical Foundations Protecting America's Infrastructures, The Report of the President's Commission on Critical Infrastructure Protection," 13 October 1997, A-2 (stating that the U.S. information and communications infrastructure sector includes the Public Telecommunications Network (PTN), the Internet, and computers and that the "PTN includes the landline networks, of the local and long distance carriers, the cellular networks, and satellite service") (*1997 Critical Infrastructure Report*).

[59] Ibid., A-2.

As a result, the sector "has swiftly become essential to every aspect of the nation's business, including national and international commerce, civil government, and military operations."[60] Thus, like highways and airways, water lines and electric grids, services supplied from space already are an important part of the U.S. and global infrastructures. As such, they raise national security considerations.

The *Critical Infrastructure Protection Policy* established a program to assure the continuity and viability of U.S. critical infrastructures. This policy set a national goal that by 2000, the United States shall have achieved an "initial operating capability" and no later than by 2003, the United States shall have achieved and shall thereafter maintain the ability to protect our nation's critical infrastructures from intentional acts that would significantly diminish the abilities of:

- the federal government to perform essential national security missions and ensure public health and safety;
- state and local governments to maintain order and deliver minimum essential public services;
- the private sector to ensure the orderly functioning of the economy and the delivery of essential telecommunications, energy, financial and transportation services.[61]

As the 1997 President's Commission on Critical Infrastructure Protection found, the nation's critical infrastructures have become more interconnected and vulnerable. While in the past, many of these systems were physically separate, as a result of advances in information technology and greater efficiency, today, many of the systems are more automated and interdependent. For example, the nation's electrical energy infrastructure is linked to the communications infrastructure: the distribution portion of the bulk power grid involves telecommunications networks, including satellite systems.[62] The country's air transportation infrastructure is linked to satellites: modernization of the National Airspace System will depend on GPS and GPS augmentation as its sole navigation and landing systems.[63]

[60] Ibid., A-3.
[61] *Critical Infrastructure Protection Policy White Paper*, 2, *supra* n.56.
[62] *1997 Critical Infrastructure Report*, A-27, A-34, *supra* n.58.
[63] Ibid., A-19.

The interdependence of U.S. critical infrastructures has "created new vulnerabilities to equipment failures, human error, weather and other natural causes, and physical and cyber attacks."[64] For example, "Possible exclusive reliance on GPS and its augmentations, combined with other complex interdependencies, raises the potential for 'single point failure' and 'cascading effects.'"[65] As the *Critical Infrastructure Protection Policy White Paper* states:

> Because of our military strength, future enemies, whether nations, groups or individuals, may seek to harm us in non-traditional ways including attacks within the United States. Our economy is increasingly reliant upon interdependent and cyber-supported infrastructures and non-traditional attacks on our infrastructure and information systems may be capable of significantly harming both our military power and our economy.[66]

Addressing those vulnerabilities "will necessarily require flexible, evolutionary approaches that span both the public and private sectors, and protect both domestic and international security."[67]

2. Satellite Infrastructure

Security and Reliability

Like most U.S. infrastructure, satellites and their supporting systems are susceptible to a variety of security and reliability risks. These include, but are not limited to:

- Physical attacks of facilities and ground stations.

- Cyber attacks on ground networks.

  — Mechanisms to remotely access, change or destroy information in vulnerable systems and to damage, control or shut down systems have become more available, sophisticated and easier to use.

[64] *Critical Infrastructure Protection Policy White Paper*, 1, *supra* n.56.
[65] *1997 Critical Infrastructure Report*, A-19, *supra* n.58.
[66] *Critical Infrastructure Protection Policy White Paper*, 1-2, *supra* n.56.
[67] Ibid., 2. The Directive also establishes a "public-private partnership" to reduce vulnerability and establishes an interagency coordination process.

- Large numbers of computer-based attacks are not detected.
- New entrants and multinational alliances.
  - Technical details of systems are widely available.
  - Introduction of numerous third parties, including foreign companies operating in partnership with U.S. companies.[68]

Satellites may malfunction. For example, in May 1998, the Galaxy IV satellite suddenly malfunctioned, shutting down 80% of the nation's 40-45 million pagers, as well as video feeds for cable and broadcast transmissions.[69] At that time, paging companies, which have operated on lower margins than networks and thus, had less back-up capability, took weeks in some cases to fully restore paging service because thousands of ground antennae had to be repointed to other satellites. With greater redundancy measures available, the networks were able to switch relatively quickly to other satellites.

There are mechanisms to address system failures. Satellite systems generally include replacement satellites that can be launched or moved into the orbit of an inoperable satellite. In addition, innovative backup options are emerging. For example, a new U.S. company, AssureSat will offer on-orbit back-up capacity for lease to companies in need of substitute or additional capacity.[70] Hughes Global Services is reconfiguring satellites for new owners that do not need the same level of capability as a satellite's original owner.[71] This type of service will provide important safeguards and minimize the effects of service outages and delays. It also will provide financial benefits to the satellite industry because most satellite insurance covers only the book value of the hardware and does not cover losses due to lack of service.

[68] *1997 Critical Infrastructure Report*, A-2 to A-6, *supra* n.58.
[69] Michael J. Martinez, "The Satellite Fix is In," ABCNEWS.com, (May 22, 1998). Retrieved December 19, 2000, from the World Wide Web: http://abcnews.go.com/sections/tech/DailyNews/satellite980519.html.
[70] The AssureSat website is: http://www.assuresat.com.
[71] Peter B. De Selding, "Rescuing Satellites Turns Into Growing Business at Hughes," *Space News* 11 December 2000, 1.

III. Remote Sensing Satellite Services

A. Background

Remote sensing satellites operate by detecting various forms of electromagnetic radiation reflected from objects near the surface of the earth. The satellite sensors receive visible light (optical), thermal (infrared), or radio waves (radar). Optical sensors provide images that are similar to eyesight and therefore are more easily interpreted by humans. Optical sensors require that a satellite pass over an area during sunlight and in cloud-free atmospheric conditions. Infrared sensors are capable of detecting thermal radiation in darkness but are hampered by cloud cover. Radar sensors require neither sunlight nor cloud-free conditions and are not affected by water vapor in the atmosphere.[72]

The resolution of the images produced by remote sensing satellites depends on the quality and type of sensors. The latest generation of commercial remote sensing satellites is capable of producing panchromatic images of less than one-meter resolution. Through such high-resolution images, one can identify objects on the ground that are the size of vehicles. By comparison, the best available imagery from older remote sensing satellites was slightly more than five-meter resolution. Through those images one could detect only larger objects the size of bridges and roads.

Satellite imagery has been available publicly through the U.S. Landsat program since 1972. Since then, the United States has made available for civil purposes remote sensing imagery and data from its Landsat satellites, first operated by NASA and later transferred to the National Oceanographic and Atmospheric Administration (NOAA).[73] After passage of the Landsat Commercialization Act of 1984, the U.S. government privatized the Landsat program, which eventually failed.[74] In the 1992 Land Remote Sensing Policy Act, the Landsat program was transferred back to the U.S. government.[75] In 1994, Presidential Decision Directive 23 gave NASA, NOAA, and the U.S. Geological Survey joint responsibility

[72] The photographic equipment onboard remote sensing satellites can be either film-based or electro-optical, which converts the reflected radiation into electrical signals that can be transmitted digitally.
[73] Control of the Landsat program passed to NOAA at the end of 1979.
[74] General Thomas S. Moorman, Jr., USAF, Retired, "The Explosion of Commercial Space and the Implications for National Security," *Air Power Journal* (Spring 1999). Retrieved October 17, 2000, from the World Wide Web: http://www.airpower.maxwell.af.mil. The article is based on the author's lecture presented to the National Convention of the American Institute of Aeronautics in Reno, Nevada, January 13, 1998.

over the Landsat program.[76] Until the mid-1990s, Landsat, Spot Image and the Indian Space Research Organization (ISRO) were the only sources of commercial satellite imagery.

At present, aerial imagery, rather than satellite imagery, has the largest share of remote sensing revenues.[77] The satellite remote sensing segment, however, is expected to grow at a faster rate than the aerial segment. [78] Industry analysts expect that over 40 remote sensing satellites will be launched in the next decade.[79] Frost & Sullivan estimated that the remote sensing sector generated about $2.3 billion in revenues in 1998 and expects revenues to reach $5.1 billion by 2004.[80] Governments are the main customers of remote sensing products and this trend is likely to continue as commercial high-resolution satellite imagery becomes available at lower costs.[81]

There have been two key technological advances in satellite remote sensing in the last decade: higher resolution and smaller satellites. For example, prior to the launch of Space Imaging's Ikonos satellite, the best commercially available imagery was six-meter panchromatic resolution imagery produced by the Indian IRS series of satellites. Higher resolution improves the image and broadens its possible uses. Reduction in the size of satellites is significant because it lowers launch costs. For example, earlier remote sensing satellites weighed between 1,000- 2,000 kg and typically cost between $300 million and $350 million per satellite to manufacture and launch. Newer satellites weigh between 68-720 kg and can be launched on less powerful rockets for under $150 million, including manufacturing costs.[82]

[75] Lawrence W. Fritz, "Commercial Aspects of Space Remote Sensing Including Spin-Off Benefits," Background Paper in *Space Benefits for Humanity in the Twenty-First Century* (United Nations, 1999), 173.
[76] Ibid.
[77] In 1998, Frost & Sullivan estimated space-based revenues to be $140 million, compared to about $2.2 billion for the aerial remote sensing segment. Space Imaging Corporate Overview, 2000, http://www.spaceimaging.com.
[78] Ibid.
[79] The Teal Group forecasts that 43 commercial imaging satellites will be launched during 2001-2010. "Teal Forecasts 43 New Commercial Imaging Satellites Valued at $3.62 Billion to be Built and Launched During 2001-2010," *PR Newswire*, 23 August 2000.
[80] Robert K. Ackerman, "Geospatial Information Market Poised for Geometric Growth," *Signal Magazine*, (August 1998). Retrieved October 17, 2000, from the World Wide Web: http://www.us.net/signal/Archive/Aug98/geospatial-aug.html.
[81] John R. Copple, Letter to Senator Bill Frist, Senate Commerce Subcommittee on Science, 27 February 1998.
[82] Ibid.

B. Commercial Applications

There are a number of commercial applications for satellite remote sensing. These include for example, agriculture, civil and urban planning, environmental and pollution monitoring, geological exploration, forestry, insurance and terrestrial mapping. In agriculture, remote sensing satellites enable identification of insects, disease and irrigation problems. Remote imagery can assist local governments with urban planning, property appraisal, emergency planning and response, and infrastructure management. Color and near-infrared images have been used to identify vegetation species and land cover and to measure environmental factors that could affect ecosystems. The insurance industry is another market for satellite remote sensing. Property loss evaluation and risk assessment problems also lend themselves well to satellite imaging solutions.[83]

Exploration of oil, gas, and mineral deposits is a major market opportunity for the commercial remote sensing industry. As the current sources of supply of natural energy deposits decreases, governments and corporations will continue to seek new methods to identify and locate large supplies of natural energy resources. Oil and gas deposits can be identified by combining imaging products with other types of geological data such as seismic assessments and geological interpretations. Mapping also may improve from remote sensing applications: one meter spatial resolution satellite data would close the gap between satellite imaging products and the aerial photographs currently being used for smaller scale mapping.[84]

Some companies are exploring the commercial market for satellite-based radar remote sensing. Unlike visual imagery, which requires sensors to detect light reflected off objects on the earth's surface, radar signals are unaffected by cloud cover and darkness. Radar signals thus enable the satellite to obtain images 24 hours a day in atmospheric conditions that otherwise would render most other types of imaging satellites useless.

Spot Image has estimated that commercial radar imagery generated about 15% percent of the global market revenues in the satellite imagery segment in 1999.[85] The prospects for a large commercial market, however,

[83] The National Imagery and Mapping Agency (NIMA), for example, notes that OrbView-2 and the Indian IRS-1C satellites are used for disaster assessment for hurricanes and tornadoes. Laura Robinson, *NIMA Commercial Imagery Program*, Slide Presentation to the 3rd National Space Forum, 2 June 1999.
[84] Joanneum Research Institute, *Overview of High Resolution Optical Satellite Systems*, http://www.dib.joanneum.ac.at.

are uncertain at this time. The current generation of radar remote sensing satellites in orbit is more applicable for scientific and geologic purposes than for commercial purposes. For example, radar imagery may be used to monitor glacial movements[86] to map regions such as rain forests where cloud cover is a problem and to conduct environmental monitoring.[87]

A number of governments and companies in the United States, Canada and Germany have plans to launch commercial satellites with high-resolution radar sensors within the next few years. In June 1998, the Department of Commerce issued the first-ever license to build and operate a commercial radar imaging satellite to RDL Space Corporation.[88] In November 2000, however, RDL surrendered its license after NOAA alleged that the company committed government-contract fraud.[89] NASA is attempting to finance and build a radar imaging satellite.

Canada's Radarsat 1 satellite contains synthetic aperture radar sensors with ground resolution capabilities of about 10 meters. A second Radarsat satellite with ground resolution capabilities of its SAR sensors to three meters is scheduled for launch in 2002. European companies, with assistance from European governments, are designing a radar imaging satellite predominantly for commercial applications.[90] One such program consists of a two-satellite system, called TerraSAR, being designed by the German Aerospace Center (DLR industry, DASA) (now part of the Franco-German-Spanish industrial consolidation in EADS), the British National Space Center and Matra Marconi Space U.K. The satellites, tentatively scheduled for first launch in 2004, reportedly will carry X-band and L-band radars capable of producing images with a resolution of one meter.[91]

[85] Compiled by Stephanie G. Rosenfeld, "Marketplace," *Space News*, 21 February 2000. Retrieved October 31, 2000, from the World Wide Web: http://www.search.mconetwork.com/smembers/sarch/sarch00/SN0221V.HTM.

[86] Hall, Dorothy K., "Satellite Remote Sensing (Imaging)." Retrieved October 31, 2000, from the World Wide Web: http://chht-ntsev.er.usgs.gov/Glacier_wkshp/srs.htm.

[87] Canadian Space Agency, *RADARSAT Background*, http://www/space.gc.ca.

[88] Jason Bates, "RDL Nabs First License for U.S. Radar Satellite," *Space News Online: This Week*, 22-28 June 1998. Retrieved October 31, 2000, from the World Wide Web: http://www.space.edu/mailing-lists/forum/msg00599.html.

[89] "RDL Cedes Satellite License in Response to Fraud Allegations," *Space News*, 14 November 2000. Retrieved November 14, 2000, from the World Wide Web: http://www.spacenews.com/smembers/sweek/index.html.

[90] The German Ministry of Defense is developing a four-six satellite constellation of SAR-Lupe satellites for military applications through OHB-System of Bremen and Astrium GmbH of Munich. Peter B. de Selding, "German Satellite Plan Could Reignite French Partnership," *Space News*, 26 June 2000. Retrieved from the World Wide Web: http://www.search.mconetwork.com.

C. Remote Sensing Satellite Programs and Companies

1. United States

U.S.-based companies began to enter the commercial satellite imaging market in the mid-1990s. It has taken longer than anticipated to deploy remote sensing satellite systems because of regulatory issues, funding considerations and technical problems. Today, EarthWatch Inc. and Space Imaging offer one-meter resolution imagery.[92] In 2001, Orbimage plans to launch a one-meter resolution satellite and the world's first hyperspectral imaging satellite.[93]

In December 2000, the Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), which licenses the operation of remote sensing satellites in the United States, authorized Space Imaging and Earth Watch to provide half-meter imagery—the highest resolution imagery ever authorized in the United States.[94] Space Imaging plans to provide half-meter imagery in 2004, when it launches a second satellite. Under U.S. regulation, however, commercial providers cannot release half-meter imagery until 24-hours after it is obtained. The purpose of the restriction is "to mitigate concerns that foreign governments could use the photographs to conduct military operations against U.S. forces."[95]

2. Foreign Programs and Satellite Systems

Several foreign countries currently have or are developing remote sensing capabilities. Among these, France, Japan, India, Israel, Russia and China/Brazil have the most substantial capabilities. More than 20 nations plan to launch their own remote sensing satellites by 2005.[96]

[91] Peter B. de Selding, "Germany Plans to Use X-Band Technology for Commercial Imaging," Space News, 6 March 2000. Retrieved October 31, 2000, from the World Wide Web: http://www.search.mconetwork.com/smembers/sarch/sarch00/sn0306j.htm.

[92] Space Imaging Corporate Overview, http://www.spaceimaging.com. The main investors in Space Imaging are the U.S. companies Lockheed Martin and Raytheon. Additional investors include these foreign entities: Mitsubishi Corporation of Japan, the Swedish Space Corporation, Europe's remote sensing affiliates, Hyundai of South Korea, Van Der Horst Ltd. of Singapore and Thailand's Loxley Public Company Ltd.

[93] Orbimage, http://www.orbimage.com.

[94] Jason Bates, "U.S. Approves Licenses for Two Imaging Satellites with Half-Meter Resolution," Spacenews.com, 18 December 2000, http://www.space.com/businesstechnology/business/satellite_licenses_001218.html.

[95] Andrew Koch, "Space Imaging Gets .5m Go Ahead," *Jane's Defence Weekly*, 10 January 2001.

France is a strong foreign player. With cooperation from Belgium and Sweden, beginning in 1982, the French space agency *Centre National d'Etudes Spatiales* (CNES) developed the Spot Image remote sensing satellite system.[97] The Spot program now includes commercial satellites capable of providing panchromatic images at 10-meter resolution,[98] sensors for vegetation and biosphere applications and a Pastel optical terminal that can provide intersatellite laser connectivity.[99] Spot Image's customers include military users.[100]

U.K.-based Surrey Satellite Technology Ltd. is building a "Disaster Monitoring Constellation" (DMC). The system consists of five satellites that will provide satellite coverage of participating countries affected by disaster once every 24 hours. The Surrey system will offer 36-meter resolution images from satellites at 425-mile polar orbits. The British government and Algeria have announced that they will acquire the first two DMC satellites.[101]

The Japanese government has supported the development of indigenous satellite technologies, even while it has continued purchasing images from companies in the United States and elsewhere.[102] The Japanese government continues to fund satellite development by Japanese companies despite the fact that those satellites cost about 50% more than similar U.S. satellites.[103]

The Indian Space Research Organization, which was established in 1972, monitors India's remote sensing satellite programs. Following its first launch in 1987, India now has four Indian Remote Sensing (IRS) satellites in orbit. Its most advanced in orbit IRS satellite is capable of producing panchromatic images at about six-meter resolution.[104] India

[96] Lawrence W. Fritz, "Commercial Aspects of Space Remote Sensing Including Spin-Off Benefits," 172.
[97] Spot Image's main shareholders are CNES (35%), Matra Marconi Space (23%), the French National Geographic Institute (10%), and entities in Belgium, Sweden and Italy (combined share of 11%). The Spot Image website is: http://www.spotimage.fr.
[98] Spot 5, which is scheduled to be launched on an Ariane booster in 2002, will provide five-meter resolution for panchromatic images and 10 meters for multispectral images. CNES-supplied information on the Spot program (1999), http://www.cnes.fr.
[99] "World Survey of Remote Sensing Satellites," *Air and Cosmos/Aviation International*, 4 April 1997. FBIS translation FTS19970801001299.
[100] Spot Image mission statement, http://www.spotimage.fr.
[101] Brown, *Satellite Telephony*, 42-44, *supra* n.2.
[102] "Progress of Japanese Satellite," Asian Office of Aerospace Research and Development (AOARD), http://www.nmjc.org/aoard/jsatellite.html.
[103] A 1969 Japanese Diet resolution allows NASDA to cooperate with Japanese companies on commercial programs that are not expressly military in nature. Kyle T. Umezu, "EarlyBird Tweaks the Law," *Japan Space Net*, 1997, http://www.spacedaily.com.

plans to launch a series of remote sensing satellites through 2003, which include the IRS-P6 with a reported 2.5-meter resolution capability.[105] India's commercial activities for its remote sensing satellites include distribution relationships with EOSAT in Norman, Oklahoma and Euromap, a subsidiary of GAF located in Munich, Germany.[106]

Although many of the Israeli remote sensing programs are military in nature, the Israel Space Agency, founded in 1983, has conducted a significant amount of research and other such activities with American and European partners in the area of civil space. The Eros satellite program is being developed through West Indian Space, a joint venture between IAI and Core Software Technology of Pasadena, California.[107] The Eros satellites will have resolution capabilities of about one meter in the panchromatic range, making them competitive with those offered by U.S.-based companies.[108] Russian remote sensing satellites purportedly are capable of mapping the earth's surface at one-meter resolution.[109] According to the Russians, the electro-optic cameras aboard its satellites can cover 60,000 square kilometers of the earth's surface with one picture, a capability, they claim, that U.S. cameras do not possess.[110]

In 1988, China and Brazil established a joint program to cooperate on the development of an earth resources satellite. In October 1999, China and Brazil launched the ZY-1 satellite with 20-meter resolution[111] and in 2000, the ZY-2 satellite.[112]

[104] Gerald Steinberg, "Dual Use Aspects of Commercial High-Resolution Imaging Satellites," *Mid-east Security and Policy Studies*, No. 37, Section IV, February 1998.
[105] IRS-P6, also called Cartosat-1, is scheduled for launch in 2001-2002. See "World Survey of Remote Sensing Satellites," *Air and Cosmos/Aviation International*, April 4, 1997. FBIS translation FTS19970801001299. Additional information on IRS satellites is available from the Indian Space Organization website, http://www.isro.org.
[106] "Worldwide Survey of Remote Sensing Satellites," *Air & Cosmos/Aviation International*, April 4, 1997. FBIS translation FTS19970801001299.
[107] Marco Caceres, "Focus Sharpens for Imaging Satellite Market," *Aerospace America*, September 2000, 18.
[108] West Indian Space intends to offer one-meter imagery at a substantial discount to imagery obtained from Space Imaging's Ikonos satellites, which Israeli industry considers to be its greatest competitor. Amnon Barzilay, "Israel: Launch of First Eros Satellite Postponed," *Ha'aretz*, December 30, 1999. FBIS Translation FTS20000102000353.
[109] Sovinformsputnik, http://www-com.iasis.svetcorp.net.
[110] "Kosmos Satellite Reaches Orbit, Starts Operation," *Interfax*, February 18, 1999. FBIS translation FTS19980218001178.
[111] China is responsible for about 70% of the costs of the joint program. "China-Brazil EO Bird Alive and Well In Orbit," *SpaceDaily*, 3 February 2000. Retrieved October 28, 2000, from the World Wide Web: http://www.spacer.com/news/china-00d.html.
[112] "China Launches Remote Sensing Satellite," *SpaceViews*, 1 September 2000. Retrieved October 28, 2000, from the World Wide Web: http://www.spaceviews.com/2000/09/01a.html.

D. National Security Implications

The commercial satellite remote sensing sector has important implications for U.S. national security—both as challenges and opportunities. The objective of Presidential Decision Directive 23 is "to support and enhance the U.S. industrial competitiveness in the field of remote sensing space capabilities while at the same time protecting U.S. national security and foreign policy interests."[113]

Foreign suppliers such as Spot Image of France have an established market for imagery data from their commercial satellite operations. The Japan NASDA ALOS (Advanced Land Observation Satellite),[114] a mapping and environmental research applications satellite with resolution in the 2.5-meter range, is considered by some observers to be "nothing more than a Japan Defense Agency mission in disguise."[115] Moreover, the technologies on these ostensibly commercial programs are likely to be adapted for the reconnaissance satellites currently being developed by Mitsubishi Electric Corporation as the lead contractor.[116] India views its remote sensing space programs as a matter of national prestige; Prime Minister A.B. Vajpayee, who presided over India's nuclear tests in May 1998, has praised the scientists at ISRO, saying that satellites are part of "the cardinal principle of self reliance."[117] By offering its satellite imagery on the commercial market, India can gain needed funding to support its space development programs.[118] Israel's expertise in military imaging satellites will increase its competitiveness in the commercial market. Israel expects to sell its satellite products to both government and commercial users.[119]

[113] White House Press Release, "Foreign Access to Remote Sensing Space Capabilities," Fact Sheet, 10 March 1994.

[114] ALOS is thought to be scheduled for launch about 2002. John C. Baker, "High Expectation: Japan Bolsters Its Imaging Satellite Capability," Centre for Defence and International Security Studies, Guest Columnist section (May 14, 1999), http://www.cdiss.org.

[115] Kyle T. Umezu, "EarlyBird Tweaks the Law," *Japan Space Net*, 1997, http://www.spacedaily.com.

[116] The firing of a North Korean Taepo Dong missile over the territory of Japan in August 1998 has galvanized public opinion about developing additional defense capabilities such as observation satellites. The Japanese government is planning to introduce four reconnaissance satellites, two with optical sensors in the one meter range and two with SAR in the one-three meter range. Japan Defense Agency, *Defense of Japan 1999* (Japan: Urban Connections, 1999), 207.

[117] "Vajpayee Laud's ISRO's Space Program," *Deccan Herald*, November 2, 1998. FBIS translation FTS19981102001620.

[118] India hopes to attract business by offering its space launch capabilities at lower prices than American or European facilities. It has signed agreements, for example, to launch South Korean satellites. "Commentary Notes Scope for Commercial Use of Space," *All India Radio General Overseas Service*, September 30, 1997. FBIS translation FTS19970930000411.

As the global market is becoming increasingly competitive, the challenge to U.S. industry to compete is greater. At the same time, U.S. Government regulation requires companies to permit the U.S. government access to all records for satellite tasking and to notify the U.S. government of any new foreign customers.[120] In addition, U.S. government regulation prohibits U.S. companies from offering better than two-meter resolution images of Israel on the commercial market.[121] These regulatory restrictions create impediments and uncertainties with consequence.

Slowing growth of the U.S. remote sensing satellite industry not only has economic and market effects, but also affects availability of commercial satellite imaging products for the U.S. Government. The success of U.S. remote sensing satellite companies could potentially benefit the U.S. government by creating a solid base of American suppliers to support the government's requirements for satellite imaging data. For example, the National Imagery and Mapping Agency (NIMA)[122] plans to buy $35 million worth of commercial imagery and ground equipment in fiscal year 2001 for uses ranging from military planning to disaster relief operations.[123] It has noted that the organization would like to purchase more commercial satellite imagery but the existence of a single supplier (at this time) has limited its plans. In addition, in support of the U.S. Government's recent half-meter license authorization, NIMA noted that the use of commercial imagery is important to relieve pressure on heavily tasked U.S. intelligence sources.[124]

An independent Commission established by Congress to review NIMA (NIMA Commission) stated in its December 2000 report that it "endorses the move to allow US companies to move to higher resolution as required by the competition and demanded by the marketplace. It will demonstrate continued technical superiority and signal US government intent to keep US companies in the forefront."[125] The NIMA Commission

[119] West Indian Space's biggest client is the Israeli Defense Ministry, but the company, expects to sell commercial imagery to defense ministries of other countries. Amnon Barzilay, "Israel: Launch of First Eros Satellite Postponed," *Ha'aretz*, December 30, 1999. FBIS Translation FTS20000102000353.

[120] Jonathon Ball, *Trends in Commercial Space in 1996: Satellite Remote Sensing*. Retrieved October 17, 2000 from the World Wide Web: http://www.ta.doc.doc.gov/oasc/tics/rmtsens.htm.

[121] This restriction is based on the Kyl-Bingaman amendment to the Fiscal Year 1997 DoD Authorization bill. Dee Ann Davis, "Shutter Control Rattles Industry," *Geo Info Systems*, September 1999, http://www.geoinfosystems.com.

[122] Established in 1996, NIMA provides the U.S. Government, including the Department of Defense and the Intelligence Community, imagery and geospatial information.

[123] Andrew Koch, "Space Imaging Gets .5m Go Ahead," *Jane's Defence Weekly*, 10 January 2001.

[124] Ibid.

also explained that "improved resolution clearly allows new information to be extracted from an image. As imagery moves … to one meter and below, military applications move beyond terrain analysis, through gross targeting, to precision targeting, bomb damage assessment, order-of-battle assessment, to technical intelligence findings."[126]

(Section V.E. below, which discusses the implications of multinational alliances and globalization with respect to communications satellites, is generally applicable to other satellite services, including remote sensing satellites. In addition, Section VII. below, which discusses legal and regulatory issues and the need for interagency coordination involving all four space sectors, has applicability to remote sensing satellite services.)

IV. Location, Navigation and Timing Satellite Services

A. Background

Global Positioning System (GPS) satellites broadcast signals that allow receivers to derive precise timing, location and velocity information. The U.S. GPS consists of three components: the space segment, the control segment and the user segment. The GPS space segment, which the Department of Defense owns and operates, consists of a minimum of 24 satellites (six planes of at least four satellites each) in near-circular semi-synchronous orbits (one orbit every 12 hours) evenly spaced around the earth. Each plane is inclined 55 degrees to the Earth's equator. This configuration allows any GPS user anywhere on the earth to see at least four satellites.[127] The satellites carry very stable atomic clocks that are used to derive the ranging signals.

The Department of Defense also owns and operates the GPS operational control segment, which consists of monitor stations, ground antennae and a master control station. The five monitor stations located around the world track and monitor GPS satellite navigation and timing

[125] Independent Commission on the National Imagery and Mapping Agency, "The Information Edge: Imagery Intelligence and Geospatial Information in an Evolving National Security Environment," Report of the Independent Commission on the National Imagery and Mapping Agency, Final Report (December 2000) (*2000 NIMA Commission Report*).
[126] Ibid., 15.
[127] Three satellites are required to "fix," or locate a position, and a fourth determines the precise time of the fix.

signals to estimate the orbits and clock behavior. The four ground antennae located around the world upload information to the satellites and monitor satellite state of health. The Master Control Station in Colorado Springs processes data, generates satellite commands and new navigation updates provided to the satellites once or twice daily.

The user segment consists of GPS receivers that are hand carried or installed on aircraft, ground vehicles, or sea-going vessels. The receivers, which are owned by both civilian and military users, detect, decode and process the signals transmitted by the satellites. The receivers convert the signals into position, velocity, and time estimates, allowing the user to determine a location instantaneously with a high degree of accuracy.

The U.S. Government originally developed GPS for military applications with limited provisions for civil access on a subscription basis. The Department of Transportation is the lead agency for all federal civil GPS matters. The Department of State is charged with developing bilateral and multilateral guidelines on the provision of GPS services. Since 1984, however, the U.S. government has allowed free public access to GPS signals, albeit at a downgraded quality.[128] In May 2000, the U.S. government ended the practice of downgrading the quality of signals from its GPS satellites.[129] The ending of "Selective Availability" allowed users worldwide to obtain location accuracy within less than10 meters.[130] The improved accuracy is expected to increase the use of GPS-related technology in the commercial market.

Over the past three to four years, the location/navigation sector has been growing at an annual rate of about 20-25% and is expected to continue to become a major revenue-producing part of worldwide commercial space industry within the next five years. One estimate is that GPS equipment and services revenue will increase from about $6.1 billion in 1999 to about $16.1 billion in 2005.[131] GPS equipment and services are expected to produce about 10% of the total world space revenue by

[128] Jonathon Ball, et. al. "Positioning and Navigation with GPS," 1997. Retrieved October 15, 2000, from the World Wide Web: http://www.comlinks.com.
[129] "U.S. Improves Quality of GPS Signals," *SpaceViews*, 2 May 2000. Retrieved October 15, 2000, from the World Wide Web: http://www.spacenews.com.
[130] Department of Defense, "Global Positioning System (GPS) 2000," *Report to Congress* (October 2000), 2 (DOD, *2000 GPS Report to Congress*).
[131] ISBC, *Space Industry 2000*, 17, *supra* n.37.

2005.[132] The Department of Commerce estimates worldwide annual sales of GPS goods and service of at least $16 billion by 2003, with the United States expected to retain about a third of the global market share.[133]

B. Commercial Applications

The number of commercial applications for location/navigation satellite signals is increasing. The precisely timed signals emitted by the satellites can be used for a multitude of purposes, including the control of automated farm equipment, emergency location services, the timing of signals for the wireless telephone industry, and as the basis for a U.S. national air traffic control system.

1. Navigation Services

Over the near term, the GPS car navigation market is expected to increase in the United States, Europe and Japan. The International Trade Administration projects that the car navigation segment will continue to be the largest revenue-producing GPS segment through 2003, but growth in the segment is expected to slow as the market becomes saturated.[134] GPS signals can be combined with communications satellite assets to provide efficient routing and scheduling information, as well as the real time tracking of high-value or dangerous cargoes. GPS location signals can be used to track and locate most transportation vehicles in the ground, sea, or air.[135] GPS provides life-saving location and navigation information in search and rescue and emergency situations. For example, on December 17, 2000, U.S. Coast Guard helicopters rescued 34 crewmembers from a passenger ship, *Sea Breeze I*, which was sinking about 200 miles east of Cape Charles, Virginia. GPS technology allowed rescuers to identify the location of the ship and enabled the timely and successful rescue of the ship's entire crew.[136]

[132] GPS revenues are estimated at $16 billion in 2005, compared to direct-to-home revenues at about $36 billion, and broadband revenues at about $15 billion. Ibid.
[133] DOD, *2000 GPS Report to Congress*, 9-10, *supra* n.130.
[134] International Trade Administration, *Global Positioning System: Market Projections and Trends in the Newest Global Information Utility* (September 1998), 5.
[135] The tracking segment is expected to grow almost as large as the car navigation segment within a few years.
[136] "Coast Guard Rescues 34 People Update 1," *Coast Guard News*, 17 December 2000. Retrieved December 19, 2000, from the World Wide Web: http://www.uscg.mil/d5/news/2000/rl62_00.html.

GPS signals are considered extremely reliable and efficient for aircraft tracking applications. In 2002, the Federal Aviation Administration (FAA) intends to implement an all-GPS location/navigation system throughout the National Airspace System (NAS) as a means to save on operating costs[137] to provide basic navigation capability.[138] Another valuable GPS application is related to emergency services. The Federal Communications Commission (FCC) has mandated that by October 2001, mobile cellular telephones must be capable of providing users' positions within 25 meters in case of an emergency.[139]

GPS technologies are extremely valuable for agriculture purposes, and can help guide farm equipment for planting and other uses,[140] increasing efficiency and reducing per acre costs.[141] GPS signals may be used to measure structural deformities in infrastructure such as bridges and railroad tracks[142] or to measure structural movements of hydroelectric dams or of high-speed rail tracks.

2. Timing Services

The extremely accurate atomic timing clocks in the GPS satellites transmit information to any point in the world, twenty-four hours per day. GPS clocks provide ideal solutions to many of these synchronization requirements.[143] It is becoming less expensive for telecommunications companies to deploy GPS receivers to synchronize their network clocks rather than maintain a separate timing system, which is not likely to be as

[137] The FAA's *GPS Transition Plan* estimated the operations and maintenance (O&M) costs of the existing aircraft navigation systems at $200 million per year, compared to an O&M cost of about $80 million for the GPS-based system. *GPS Transition Plan*, Federal Aviation Administration Office of System Architecture and Investment Analysis, 30 October 2000, Chapter 4, p.14. Retrieved October 30, 2000, from the World Wide Web: http://www.faa.gov/asd/gpstrans.htm.
[138] Paula Shaki Trimble, "FAA Slows GPS Plans," *Federal Computer Week* (27 March 2000). Retrieved October 30, 2000, from the World Wide Web: http://www.fcw.com./fcw/articles/2000/0327/news-faa-03-27-00.asp.
[139] Paula Shaki, "GPS Poses Marketing Challenge," *Space News*, 15 February 1999, 10. Retrieved October 29, 2000, from the World Wide Web: http://search.mconetwork.com/smembers/sarch/sarch99/sno215fg.htm.
[140] "Trimble Brings GPS Precision to Agriculture," *Space Daily*, 8 February 2000. Retrieved October 30, 2000 from the World Wide Web: http://www.spacedaily.com/news.
[141] For example, GPS can help reduce "Guess rows" refer to the portions of a field that may be missed or where wasteful overlap may occur as the equipment makes pass after pass in a field. Ibid.
[142] The Applied Research Laboratories at the University of Texas has developed a prototype GPS-based bridge monitoring system. Keith Duff and Michael Hyzak, "Structural Monitoring with GPS," *Public Roads*, (Spring 1997). Retrieved October 29, 2000, from the World Wide Web: http://www.tfhrc.gov/pubrds/spring97/gps.htm.
[143] "Trimble Offers Internet GPS Time Standard," *SpaceDaily*, 3 August 1999. Retrieved October 30, 2000, from the World Wide Web: http://www.spacedaily.com.

accurate. These applications are expected to increase as new information technologies are developed and introduced. The range of applications for GPS and its necessity in an increasingly information-technology dominated world are making GPS an indispensable part of the infrastructure of modern global societies. The GPS timing segment grew at a rate of 65% in 1997, compared to the 23% rate in the overall GPS market itself.[144]

The timing mechanism in the GPS system is critically important to a number of other technologies and services. For example, technologies for the electronic switching and transmission of voice, data and video require extremely accurate time synchronization. Broadcast radio and television and wide and local area networks require accurate time transfer.[145] Cellular telephones that operate on a time-based technology also rely on accurate timing. Financial banking and the growing e-commerce industry, require some form of accurate synchronization to certify the time of transactions. Network routers and switches require timing synchronization that GPS signals can provide. Wireless telecommunications data transfer requires an independent timing source so that signals are not lost or dropped because of electronic interference with system clocks of wireless stations.

C. Technological Trends

The two most important technological trends in the GPS industry are the decreases in cost of GPS receivers and the productivity gains from embedded software. Hardware cost decreases have made GPS technology affordable to many more consumers and hardware size reductions have made GPS technology much more convenient. In 1983, when GPS commercial receivers became available, the cost was over $150,000 for equipment that weighed over a hundred pounds. In 1998, GPS receivers were available in handheld versions weighing less than 12 ounces for about $100.[146]

[144] Paula Shaki, “GPS Firms Capitalize on Boom in Timing Market,” *Space News,* 7 September 1998, 22.
[145] ISBC, *Space Industry 2000*, 44, *supra* n.37.
[146] Scott Pace and James E. Wilson, *Global Positioning System: Market Projections and Trends in the Newest Global Information Utility,* International Trade Administration, Office of Telecommunications, U.S. Department of Commerce (September 1998), 40.

U.S. firms are principal providers of GPS products. Trimble Navigation, Orbital Science, Rockwell, and Motorola produce and package complete GPS user equipment, while Boeing Corporation manufactures GPS satellites. Outside of the United States, the Japanese market has the largest GPS revenues and is expected to increase in proportion to other regional markets in the short term, mostly because of car navigation sales.[147] Japanese companies involved in the manufacture of GPS receivers are Nippon Motorola, Mitsui, Pioneer Electronic, Sharp Sony and Toyota. The Japanese GPS industry tends to receive substantial support from the government and from private Japanese car and railroad manufacturers, which are major users of Japanese GPS equipment.[148]

D. National Security Implications

1. U.S. GPS System

Some of the GPS satellites currently on orbit lack redundancy and there is a small probability that three or more satellite could fail. The Department of Defense is committed to ensuring that adequate satellites are available, in orbit and ready for launch. Should the number of operational satellites fall below desired levels, however, GPS users in some areas could experience reduced accuracy and coverage could be affected that will be launched prior to the cessation of on-orbit satellites."[149]

2. Foreign Navigation and Location Satellite Systems

Foreign country development of navigation and location satellite services raise issues regarding radio frequency spectrum, interference and compatibility issues regarding the GPS system. In addition, the foreign satellite systems may be used for military purposes.

Russia has a navigation and location system called the Global Navigation Satellite System (GLONASS). It is similar to U.S.-based GPS, but is considered to be less reliable by most worldwide users. The

[147] Ibid., 29.
[148] The Japanese OEM companies, the major users, and the Ministry of Posts and Telecommunications, as well as the Japan National Police Agency, belong to the Japan GPS Council, which is the counterpart of the U.S. GPS Industry Council. Ibid., 29.
[149] DOD, *2000 GPS Report to Congress*, 1-2, *supra* n.130.

European Union has plans for developing a constellation of global positioning satellites called Galileo.[150] A purpose of the project is to provide an alternative system in the event that the region would be denied access to the U.S. GPS system during a regional crisis within Europe.[151] In addition, the European Union expects to receive substantial industrial benefits from implementing a global navigation and positioning system, principally improving the technological competitiveness of European manufacturers.[152] The Galileo system has required negotiations between the United States and the European Union regarding coordination of links between the Galileo constellation and the U.S.-operated GPS system.[153]

The Japanese government also has studied the possibility of developing a navigation and location satellite system of its own. In 1996, Japan's National Space Development Agency (NASDA) submitted a plan to deploy a four-satellite test system in 2002 to support local GPS systems in Japan and the Asian region with the option of building a larger system later. Like the Europeans, Japanese observers have recognized that Japan should develop or at least explore alternatives to the U.S.-controlled GPS signals.

Given these foreign sentiments, it is likely that foreign nations, in addition to Russia, will begin to deploy their own navigation and locations systems within the next decade. Despite the technical considerations and costs of doing so, other countries have concerns about depending on the U.S. government for global positioning requirements. Once these countries deploy navigation and location systems of their own, they and others may derive similar national security, commercial, civil, economic and technological benefits that the U.S. GPS system affords this nation.

(Section V.E. below, which discusses the implications of multinational alliances and globalization with respect to communications satellites, is generally applicable to other satellite services, including location, navigation and timing satellite services. In addition, Section VII. below, which discusses legal and regulatory issues and the need for interagency coordination involving all four space sectors, has applicability to location, navigation and timing satellite services.)

[150] Council of the European Union, *Council Resolution On the Involvement of Europe in a New Generation of Satellite Navigation Services—Galileo Definition Phase*, 19 July 1999.
[151] The European Commission, *Galileo Definition Phase: Initial Results*, 7 June 2000, 20.
[152] Ibid., 21.
[153] Sandra I. Erwin, "Europe's Galileo Plans to Challenge U.S. GPS Dominance," *National Defense Industrial Association Feature* (June 2000).

V. Communications Satellite Services

A. Background

The commercial communications satellite sector provides an array of services to millions of users around the globe. Satellite communications services allow businesses to track inventory, a journalist to file a story from abroad, a U.S. Navy sailor to call home from sea, a student in Africa to access the Internet or a U.S. company to beam video programming in South America. Commercial satellite systems also support intelligence, defense and foreign policy missions of the United States and its allies.

Today, the commercial communications satellite segment represents a significant portion of the worldwide space industry. ING Barings estimates that global commercial communications satellite revenues in the year 2000 will total $50.1 billion, nearly double to $95.4 billion by 2005 and reach $121.7 billion in 2009.[154] Although competition from other types of telecommunications services—principally fiber—and regulatory policies affect the commercial communications satellite services segment, analysts forecast that the satellite industry will grow,[155] particularly for broadband and Internet services.[156]

The number of commercial communications satellites is expected to increase. Futron Corporation forecasts that the number of commercial communications geostationary satellites will almost double by 2010, from approximately 200 today to approximately 290 in 2005 and 375 in 2010.[157]

[154] ING Barings, *Satellite Communications*, 7, Exhibit 1-3, *supra* n.45. This figure includes expected revenues from broadband, U.S. Direct Broadcast Satellite Services (DBS), Direct-to-Home (DTH) Satellite Service, international DBS/DTH, Digital Audio Radio Satellite Service, Mobile Satellite Service, Fixed Satellite Service, Very Small Aperture Terminals (VSATs), Little Low Earth Orbit Satellites and Manufacturing and Launch Services.

[155] *See, e.g.,* Booz, Allen & Hamilton, *2000 Defense Industry Viewpoint*, *supra* n.36 (stating that many companies such as GM Hughes Electronics are "now focusing on the higher growth/higher return businesses of satellite services"); ISBC, *Space Industry 2000*, 10, *supra* n.37 ("the satellite services market is experiencing tremendous growth").

[156] *See, e.g.,* Merrill Lynch, *Satellite Communications, supra* n.8; ING Barings *Satellite Communications*, *supra* n.45; James M. Gifford, "Analysts Predict Industry Growth Via Internet," *Space News*, 4 December 2000, 8 ("Analysts expect the global growth of the Internet to provide healthy revenues for commercial satellite communications companies over the next couple of years").

[157] Futron Corporation's 10 Year Commercial Satellite Forecast (October 2000). These figures are based on demand forecasts for communications services in 42 geographic areas of the world, taking into account projected infrastructure buildout, regulatory environment and other factors. The figures exclude remote sensing and navigation satellite services.

Highest growth is expected in data communications, with business data communications accounting for about 60% of the geostationary commercial data communications satellite market.[158]

B. Communications Satellite Technology and Investment Incentives

The technological characteristics of any telecommunications source, as well as the geographic and demographic features of a service area, influence investment incentives and infrastructure deployment. For example, in urban areas in the United States with high-density population, the traditional infrastructure has been wireline networks. Areas with low-density populations, such as rural areas, however, generally have fewer wireline networks because the return on investment is not commercially viable. In some rural or remote areas, satellites provide basic telecommunications services. Satellites also are useful for serving geographic areas that have rough terrain where it is more difficult or expensive to install fiber networks. Where there are no ground-based telecommunication sources available—ships at sea, for example—satellites offer the only alternative.

Industry observers link the technological features of satellites to the industry's growth potential. ING Barings states that "While it is true that a host of terrestrial technologies … will challenge broadband satellite networks for market share in the broadband sector, satellites are poised to claim a substantial portion of the total broadband market due to a number of advantages they hold over terrestrial competitors."[159]

[158] Ibid.

[159] ING Barings, *Satellite Communications*, 22-23, *supra* n.45. ING Barings cites the following advantages of satellites: distance and terrain insensitivity (making satellites "ideal solutions" for broadband services to remote or underdeveloped areas where terrestrial technologies are not cost effective or geographically feasible); satellite systems avoid interruptions that frequently occur over congested terrestrial networks; satellites easily can be designed to deliver bandwidth on demand to users within a coverage area; satellites are the "most cost-effective" solution for providing broad-band services on a global basis because terrestrial systems are significantly more expensive to deploy worldwide; satellites can be deployed more rapidly than terrestrial alternatives (three-five years). ING Barings notes that higher-powered transmission capabilities, narrow spot beams and improvements in switching technologies could make satellite systems compet-itive (or at least an alternative) to terrestrial communications systems. *See also* Merrill Lynch, "Eye in the Sky: 4Q00 Preview," 9 January 2001, 9 (Merrill Lynch, *4Q00 Pre-view*).

Satellites have both technical limitations and advantages. For example, because of the far distance of satellites from the Earth, especially geosynchronous satellites, there is a slight delay in communication transmissions. Voice communications are especially affected by this delay. In addition, atmospheric conditions such as rain can affect quality. At the same time, satellite technology is improving. Technological developments permit more economical use. For example, satellites can operate on-orbit for longer periods of time, reducing replacement and launch costs. While Early Bird, the world's first commercial communications satellite, had a four-year consecutive lifespan,[160] a satellite's lifetime now is about 15 years.

Today's new, larger satellites can deliver more tailored and smaller spot beams to serve different types of customers. Differential capacity and longer satellite lifetimes allow for lower costs per digital bit of data than those offered by smaller satellite designs.[161] Multicasting eliminates need for redundant, multiple data streams when many users request identical data. Caching will enable the transmission to and storing of Internet data on local servers, reducing the need to retrieve data directly from the content source, thereby reducing congestion in the U.S. terrestrial backbone, particularly at frequently-accessed Internet sites. In addition, satellites are heavily used to "backhaul" Internet traffic to and from Internet Service Providers (ISPs) located outside the United States.

Very Small Aperture Terminals (VSAT) networks are particularly efficient means of point-to-multipoint distribution. VSAT networks consist of a satellite, a central ("hub") ground antenna about three to six feet in size, and up to thousands of remote smaller ground antenna.[162] VSATs provide two-way voice, data and video communications. They offer fast delivery, flexibility, low cost solutions, user control, low expansion costs, high reliability, predictability and overall network availability at levels up to 99.9%.[163] Financial institutions utilize VSAT networks for credit authorizations and on-line trading services; energy companies use VSATs to monitor pipelines; and shipping companies use VSAT networks to track shipping, provide on-time delivery, and conduct customer business. Wal-

[160] http://www.hsc.com/factsheets/376/earlybird.

[161] James M. Gifford, "Analysts Predict Industry Growth Via Internet," *Space News*, 4 December 2000, 8.

[162] Merrill Lynch, *Satellite Communications*, 63, *supra* n.8. VSATs are best-suited for situations in which the transmission from the hub to the remote site is faster than that from the remote sites to the hub. Ibid.

[163] Merrill Lynch, *Satellite Communications*, 65-66, *supra* n.8.

Mart, for example, uses a PanAmSat-based VSAT system to connect more than 3,000 of its stores, Sam's Clubs and distribution centers across the United States.[164]

Availability of sufficient satellite capacity also affects the industry's viability. Satellite companies often sell most of the capacity on a satellite prior to launch, leaving little excess capacity. In addition, broadband applications—for which satellites hold great potential—need tremendous amounts of bandwidth. The capacity on terrestrial wireline systems generally far exceeds satellite capacity.[165] Another concern is current delays in the development of new launch vehicles to launch the next generation of satellites, which are heavier due to enhanced capabilities. In addition, companies cite lack of public awareness of satellite technology and other factors as affecting the market. For example, lack of trained satellite service people in the quickly changing field of satellite technology is a another challenge.[166]

Financial, economic and competition factors substantially influence viability. As a result, the commercial communications satellite market has fluctuated. Competition from land-based systems, steep initial costs of designing, constructing and launching satellite systems, particular business plans and regulatory delay have created problems for some types of satellite services.[167] Consequently, some commercial satellite providers have been forced to change their marketing strategies, merge with other companies or file for bankruptcy.

Satellite systems that have experienced difficulty are global mobile low earth orbit (LEO) (nongeosynchronous) systems such as those of Iridium, Globalstar and ICO. These systems each involve large constellations, require high start-up costs and face stiff competition from terrestrial systems. For example, Iridium developed a global constellation of 66 LEO satellites to provide mobile telephone services. Iridium started operating in 1998, filed for bankruptcy in 1999 and became a new

[164] http://www.panamsat.com/serv/vsat.htm. Private businesses and corporations also access satellites directly. Walgreens, for example, links more than 2,000 store locations using PanAmSat's Galaxy VI domestic U.S. satellite to relay voice and data communications via dedicated transmission links, enabling inventory tracking, interoffice e-mail, point-of-purchase transactions and other functions. Ibid.

[165] James Careless, "A Look Ahead: 2001's Triumphs and Tribulations," *Via Satellite* (January 2001), 38.

[166] Ibid., 40 quoting Dianne VanBeber, Vice President of Investor Relations, Gilat.

[167] For example, C.E. Unterberg Towbin cites reservations about some satellite economic models because satellites are generally the most expensive form of high-speed two-way connectivity. C.E. Unterberg, Towbin, *Satellite Communications 2001 Outlook*, 143, *supra* n.38.

company, Iridium Satellite LLC in late 2000.[168] Globalstar, which is a consortium of international telecommunications companies led by U.S.-based Loral, provides global wireless digital telephone, data transmissions, paging, facsimile and position location services to mobile users worldwide, has encountered similar problems, stemming in part from a slow start-up in service. ICO, which originally planned a voice satellite service, and later filed for bankruptcy, has emerged as New ICO and entered an arrangement with Teledesic.[169]

In sum, some commercial communications satellite services have faced challenges. Others have been successful. Looking ahead, financial analysts see certain communications satellite services—television, radio and broadband, for example—as having long-term viability. In any event, as detailed in the following section, communications satellite services have many applications in American life and commerce.

C. Principal Applications

Commercial communications satellite systems provide a variety of services in the United States and around the globe. These include for example, telephone, electronic newsgathering, data, video, television, radio and Internet services to both fixed (stationary) and mobile users.

1. Voice, Messaging and Tracking Services

One of the first communications services by satellite was basic voice telephone service. Beginning in the 1960s and continuing today, COMSAT (now Lockheed Martin), provides international satellite telephony through the INTELSAT system using geosynchronous satellites. Thereafter, the former American Mobile Satellite Company (now Motient)[170] provided domestic voice services to fixed and mobile users through its own geosynchronous satellites. In recent years, other companies have developed new nongeosynchrounous satellite systems to deliver voice and other

[168] Specifically, in August 1999, Iridium filed for bankruptcy and on March 17, 2000, announced that it was ceasing service. After obtaining new investors and insurance arrangements, in late 2000, Iridium emerged as a new commercial enterprise—Iridium Satellite LLC of Arnold, Maryland.
[169] "ICO-Teledesic Global Announces Investment Agreements Totaling More Than $1 Billion," Teledesic Press Release (July 11, 2000). Retrieved November 13, 2000, from the World Wide Web: http://www.teledesic.com/newsroom/articles/2000-7-11_ITGLinvestment.htm.
[170] The Motient website is: http://www.motient.com.

communications services. As described above, the satellite telephony segment has not proved to be as strong as other commercial satellite service segments.

Geosynchronous and nongeosynchronous satellites systems also provide data services. For example, LEO satellite systems operating in lower bandwidths provide data messaging services such as paging, e-mail and remote meter reading. These systems enable tracking of government assets, rail cars, trailers, locomotives, heavy equipment an containers, monitoring of environmental projects, remote electric utility meters, oil an gas storage tanks, wells and pipelines and messaging services for consumers, businesses and governments. Like LEO telephone satellite systems, LEO data systems generally have faced financial difficulties.

2. Broadband and Internet Services

The fastest growing commercial communications application for satellites is the provision of broadband services. Generally, broadband services are robust, content-oriented communications that use large amounts of capacity and move at fast speeds. Broadband applications include high-speed data over private corporate-based VSAT networks, business television services by satellite to corporations for distance training, teleconferencing, special events and Internet access. Wall Street analysts consider satellites to be well-positioned to provide broadband services.[171] Satellites avoid the congestion of Internet networks and efficiently address the asymmetrical flow of Internet traffic.[172] Merrill Lynch forecasts that future broadband opportunities "should provide a significant source of growth in the satellite sector over the next decade."[173] ING Barings projects that broadband satellite services will become a $20 billion industry by 2009.[174] C.E. Unterberg, Towbin, however, cautions that growth in the broadband satellite sector could be constrained by high space segment costs.[175]

[171] ING Barings, *Satellite Communications,* 20, *supra* n.45; Merrill Lynch, *Eye in the Sky: 3Q00* Preview, 4 October 2000, 2.
[172] Merrill Lynch, *4Q00 Preview,* 9 *supra* n.159; ING Barings, *Satellite Communications,* 20-21, *supra* n.45. It is estimated that over 75% of all Internet content exists on computers in the United States and that 90% of all Internet traffic originates, terminates or passes through the United States. This results in an imbalance of Internet flow because large quantities of data exit the United States while smaller amounts remain in the United States. Ibid.
[173] Merrill Lynch, *4Q00 Preview,* 1, *supra* n.159.
[174] ING Barings, *Satellite Communications*, 13.
[175] C.E. Unterberg, Towbin, *Broadband Over Satellite*, Industry Update, 12 October 2000, 3.

Several satellite companies are providing either connectivity to the Internet backbone or Internet service directly, avoiding the terrestrial Internet network. For example, PanAmSat,[176] has provided international Internet services since the early 1990s, initially in collaboration with the National Science Foundation to connect Mongolia to the U.S. backbone.[177] Loral provides access to U.S.-based content to more than 130 Internet Service Providers in over 32 countries.[178] Africa Online[179] offers Internet access services to residential consumers, home offices and businesses.[180]

The potential for growth in broadband applications has encouraged development of new satellite systems that would provide broadband access directly to end users. These include the Hughes' Spaceway system, Lockheed Martin's Astrolink system, the Teledesic system and the Skybridge system. For example, ICO-Teledesic Global Limited, plans to be a global provider of wireless Internet-in the-SkyTM satellite communications service, including Internet Protocol-based mobile and fixed broadband services.[181] New ICO plans to offer satellite Internet service worldwide in 2003 and Teledesic intends to deliver broadband data and value-added services over a global network in late 2004.

3. Satellite Television Services

One of the most successful uses of satellites to date is the provision of television service by satellite. Called the "Direct Broadcast Satellite service (DBS)" or "Direct to Home" (DTH),[182] like cable television, this satellite service provides hundreds of channels of television programming directly to homes and businesses. DBS providers in the United States include EchoStar Communications Company (EchoStar), Hughes Network Systems (DirecTV) and Pegasus, which serves rural and unserved areas.[183]

[176] PanAmSat operates the largest fleet of commercial communications satellites in the world. Its fleet has 21 satellites and upon the successful launch of two additional satellites in the first half of 2001, will expand to 23 satellites.
[177] http://www.panamsat.com/serv/internet.htm.
[178] The Loral website is: http://www.loral.com/overview.overview.html.
[179] The Africa Online website is: http://www.africaonline.com. Africa Online was founded in 1994 by three Kenyans studying at Massachusetts Institute of Technology and Harvard University. It provides Internet services to thousands of individuals and businesses throughout the African continent.
[180] ING Barings, *Satellite Communications,* 21, *supra* n.45.
[181] "ICO-Teledesic Global Announces Investment Agreements Totaling More thank $1 Billion," Teledesic Press Release (July 11, 2000). Retrieved November 13, 2000, from the World Wide Web: http://www.teledesic.com/newsroom/articles/2000-7-11_ITGLinvestment.htm.
[182] This terminology reflects differences in the parts of the radio frequency spectrum used to provide the service and difference in the size of the receiving dishes.

DBS, which began in the United States in 1994, is a success. In 2000, there were approximately 15.94 million DBS subscribers in the United States, representing approximately 18.16% of the U.S. home subscription television market.[184] DBS provides direct competition to cable and other multichannel services. DBS providers have begun to offer interactive television. As of year-end 2000, there were approximately five million interactive-capable satellite households in the United States.[185] ING Barings predicts that U.S. DBS revenues in 2000 will be $7.9 billion and in 2009, triple to $23.1 billion. [186]

Although DBS is expected to continue to grow in number of subscribers and amount of revenues, it is not expected to exceed cable's share of the U.S. home subscription television market. For example, in 2008, though the number of U.S. subscribers will rise to 28.75 million, this figure will represent 27.4% of the subscription television market.[187] On the other hand, as DBS companies expand their offerings to include broadband applications, they are expected to "add a significant advantage in the competition for customers with digital cable."[188] "We believe that broadband data transmission applications and new interactive video services should continue to drive the [DBS] sector."[189] Some of these advantages are diminishing, however, as cable operators offer digital services that will match DBS channels and signal quality. Cable systems, are increasingly providing high-speed Internet access.

Satellite television services are widespread outside the United States where cable systems are not as prevalent as they are in the United States. Operators include both U.S. and non-U.S. entities, such as European based-SES Astra and EUTELSAT, a European treaty-based satellite organization, which delivers satellite television to millions of homes in Europe, Africa and Asia.[190] ING Barings estimates that international U.S. DBS revenues will more than double from $14.6 billion in 2000 to $32.8 billion in 2009.[191]

[183] Merrill Lynch, *Satellite* Communication, 3, 209-29, *supra* n.8; ING Barings, *Satellite Communications*, 344-50, *supra* n.45.
[184] C.E. Unterberg, Towbin, *Satellite Communications 2001 Outlook,* 58, *supra* n.38.
[185] Ibid, 61-62.
[186] ING Barings, *Satellite Communications,* 7, 54, *supra* n.45.
[187] Ibid.
[188] Merrill Lynch, *4Q00 Preview,* 9, *supra* n.159.
[189] Ibid., 3.
[190] http://www.eutlesat.org/about_eutlesat/rub_part1.htm.
[191] ING Barings, *Satellite Communications*, 54-55, *supra* n.45.

4. Satellite Radio Services

Satellites also provide radio services. This service is called the "Digital Audio Radio Satellite Service" (DARS). In 2001, for the first time in the United States, two U.S. DARS licensees, XM Satellite Radio and Sirius Satellite, are expected to deliver radio channels directly to vehicles and homes.[192] Financial analysts are positive about DARS. According to C.E. Unterberg Towbin, DARS "promises to revolutionize the radio industry, much the same way cable and satellite television revolutionized the television industry." [193] DARS is described as a "quintessential" satellite business because it can serve a large geographic region with hundreds of millions of consumers and its offerings of ethnic programming, world and business news, fewer commercials and digital quality "will drive consumers to satellite radio."[194]

DARS already is available in other countries. For example, WorldSpace provides DARS service in Africa and Asia and reportedly is forming an alliance with Alcatel to seek partners in a consortium to provide up to 100 channels of radio, plus short messaging services throughout Europe.[195]

5. Service to Rural and Unserved Areas

Traditionally, it has not been cost effective to deploy fiber systems in remote, low density areas. As a result, those areas have had inadequate telecommunications services. Largely through use of satellites and other wireless technologies, this situation is changing. Wall Street views rural and unserved regions as growth areas for the satellite industry. Governments and companies worldwide are undertaking efforts to increase telecommunications services to these areas. For example, various U.S. Government agencies and states have launched initiatives to encourage deployment of telecommunications services to unserved areas, including Native American lands.[196] "We remain committed to encouraging the

[192] XM Satellite Radio website: http://www.XM Radio.com; Sirius Radio website: http://www.Sirius Radio.com.

[193] C.E. Unterberg, Towbin, *Satellite Communications 2001 Outlook*, 15, *supra* n.38.

[194] Ibid.

[195] "Partnership Would Bring Satellite Radio to Europe," *Space News*, 8 January 2001, 2.

[196] *See, e.g., Extending Wireless Telecommunications Services to Tribal Lands*, WT Docket No. 99-266, Report and Order and Further Notice of Proposed Rulemaking, FCC 00-209 (released June 30, 2000); *Promoting Deployment and Subscribership in Unserved and Underserved Areas, Including Tribal and Insular Areas*, CC Docket No. 96-45, Twelfth Report and Order, Memorandum Opinion and Order and Further Notice of Proposed Rulemaking, FCC 00-208 (released June 30, 2000).

expeditious delivery of telecommunications services, via satellite services, to unserved communities. The comments in this proceeding support our belief that satellites are an excellent technology for delivering these services."[197] In Somalia, where the state telephone system was destroyed by war, new satellite telephone booths enable residents to call anywhere in the world.[198] As a result of these measures, large populations of people that just a short time ago did not have even basic telecommunications capabilities readily available now have access to communications technology.

6. Disaster Relief and Emergency Services

Satellites are instrumental in delivering disaster relief and emergency services.[199] Satellites are particularly advantageous for emergency purposes in rural and remote areas that lack other communications capabilities.[200] For example, in Native American areas in the United States, satellite systems have been used to provide police dispatch and other emergency services to tribal residents. In addition, in emergency and distress situations, an individual can use a satellite telephone, like other phones, to call someone for assistance.[201]

[197] *Establishment of Policies and Service Rules for the Mobile Satellite Service in the 2 GHz Band*, Report and Order, IB Docket No. 99-81 (August 25, 2000), par. 33.
[198] "Call Africa, and Wait and Wait …," *The Economist*, 25 November 2000, 53.
[199] *See, e.g.*, "Crew of 18 Rescued Off Chilean Coast Using ORBCOMM Satellite Network," Company News Release, 11 September 2000. Retrieved October 8, 2000, from the World Wide Web http://www.orbcomm.com.newsroom/latestnews/pr-09-11-00.htm. ORBCOMM is a Virginia-based commercial satellite company using a low-earth orbit constellation.
[200] Brown, *Satellite Telephony*, 42-53, *supra* n.2 (describes various U.S. and foreign commercial and civil satellite systems and initiatives for emergency and disaster relief, including U.K.-based Surrey Satellite Technology Ltd.'s Disaster Monitoring Constellation, Volunteers in Technical Assistance, UNICEF, U.K.-based Inmarsat, U.S.-based Globalstar and West Virginia-based Chesapeake Satellite).
[201] In the United States, satellite telephones are not yet required to be equipped with 911capability. Basic 911 is the delivery of emergency 911 calls to a Public Safety Answering Point (PSAP). A PSAP is a point that has been designated to receive 911 calls and route them to emergency service personnel. Enhanced 911includes additional features such as the automatic routing of the caller's location and telephone number. The Federal Communications is addressing applicability of 911 features to mobile satellite service telephones in a pending proceeding. "International Bureau Invites Further Comment Regarding Adoption of 911 Requirements for Satellite Services," IB Docket No. 99-67, DA 00-2826 (December 15, 2000). *See also Establishment of Policies and Service Rules for the Mobile Satellite Service in the 2 GHz Band*, Report and Order, IB Docket No. 99-81 (August 25, 2000), par. 117-127 (as an interim measure, requiring labels on mobile satellite telephones notifying consumers that the phones do not have 911 emergency capability).

7. Enabling Services

Commercial satellites enable various businesses and technologies to provide services.[202] As described above, satellites support some components of the U.S. critical infrastructures.[203] Many traditional over-the-air television and radio broadcasters, including the major networks, deliver programming to affiliates in the United States in part by satellite.[204] Satellites also deliver programming to cable television company facilities, which those companies then transmit via cable lines to their subscribers. As a result, consumers worldwide are able to see and hear in present time, up-to-the-minute news, sports and entertainment programming on a range of subjects and interests. Estimates are that approximately 30-35% of transponder capacity on commercial geosynchronous satellites is used to relay broadcast and cable television programming.[205] In addition, satellites are part of some terrestrial wireless networks. For example, they transmit information and communications in terrestrial wireless paging services.[206]

Commercial satellite systems provide protection services for communications networks. Massachusetts-based Wang Recovery Services uses a GE American Communications (GE Americom) satellite to provide telephone backup solutions in situations in which a company loses service because of the catastrophic failure of a telephone company's local central office or corporation's own network. Wang reportedly is working with GE Americom to offer its service in Europe.[207] In addition, Wang is now joining with California-based Esat Inc. to provide Esat's Internet and network continuity service via satellite. Esat also can provide a redundant satellite-powered virtual private network to substitute for failed systems. Rotterdam-based Satellite Safe Ltd. serves corporate clients in Europe and South Africa by detecting viruses that can cause significant damage to corporate networks in Europe and South Africa and distributes anti-virus software over satellite.[208] "The only way to deliver this service when the Internet is blocked is from the air.'"[209]

[202] *See, e.g.,* Satellite Industry Association and Satellite Broadcast and Communications Association, *The Global Satellite Industry, Proven Success and Failure* (October 2000) (SBCA & SIA, *Global Satellite Industry*).
[203] *See supra* Section II.C.
[204] SBCA & SIA, *Global Satellite Industry*, *supra* n. 202.
[205] Rob Fernandez, "Global Satellite Survey," *Via Satellite* (July 2000), 36 (referring to Futron figures).
[206] SBCA & SIA, *Global Satellite Industry*, *supra* n. 202.
[207] Ibid.
[208] Brown, *Satellite Telephony*, 48, *supra* n.2.
[209] Ibid.

(Section VII. below discusses legal and regulatory issues and the need for interagency coordination involving all four space sectors, which includes commercial communications satellite services.)

D. Business and Regulatory Trends

1. Privatization and Competition

It is an historical time in the global telecommunications marketplace. In the last five years, the market has become more competitive. "The telecommunications and information revolution is bringing dramatic growth and change to the nation's economic, social and political life." [210] Governments are recognizing the advantages of competition in the telecommunications sector in general, and satellites in particular, for their economies, businesses and people. Government-owned telecommunications monopolies have begun to privatize and other nations are opening their markets to foreign entry. In addition, intergovernmental satellite organizations, which as explained below, have enjoyed special legal status for decades, are privatizing in order to respond to competitive pressures in the satellite marketplace.[211]

Privatization of Multilateral Satellite Treaty Organizations

From the 1970s until a few years ago, the majority of satellites providing nonmilitary applications were owned and operated by multilateral treaty organizations. The three largest of these organizations are: Washington, D.C.-based INTELSAT, London-based INMARSAT and Paris-based EUTELSAT. Each of these satellite organizations was formed pursuant to a multilateral treaty.[212] They have been comprised of government entities representing the nations that are party to the treaty and commercial companies that operate and use the services of the respective

[210] Department of Commerce, National Telecommunications and Information Administration (NTIA), http://www.ntia.doc.gov/ntiahome/aboutntia.htm.
[211] Decision making within these organizations involves consensus of up to over 140 different Members, many of whom do not have commercial experience. Consequently, intergovernmental satellite organizations customarily have not been able to make and implement business strategies as quickly as private companies, a significant disadvantage in the fast-paced global telecommunications market.
[212] *See, e.g.,* Agreement Relating to the International Telecommunications Satellite Organization, "INTELSAT," 23 U.S.T. 4091 (February 12, 1973); Operating Agreement Relating to the International Telecommunications Satellite Organization, "INTELSAT," 23 U.S.T. 3813 (August 20, 1971).

satellite systems.[213] By treaty, these organizations have held special legal status and enjoyed certain privileges and immunities. For example, INTELSAT is immune from taxes and from suits in national courts, unless it waives its immunity. The intergovernmental satellite organizations are privatizing. INMARSAT, a global mobile satellite service provider, privatized last year and is expected to conduct an initial public offering in 2001.[214] EUTELSAT, the European, treaty-based satellite organization also will privatize by mid-2001.[215]

INTELSAT will privatize in July 2001.[216] As a U.S. company, INTELSAT will be subject to U.S. competition laws and domestic regulations. (INTELSAT has never before been under the jurisdiction of any nation in the world.) As such, INTELSAT will operate as a private entity subject to the global competitive satellite marketplace and will be positioned to offer competitive satellite services to the benefit of U.S. consumers, including the U.S. Government. Location of privatized INTELSAT in the United States will be beneficial to the United States. Its assets include nearly 20 satellites and accompanying orbital locations estimated to be worth billions of dollars. With INTELSAT as a U.S. company, it will be easier for other U.S. companies to coordinate their satellite systems than if INTELSAT were located in a foreign jurisdiction. In addition, as the largest, longest-lasting, multinational communications satellite entity in the world, and a provider of satellite services for commercial and U.S. Government use, INTELSAT and its workforce offer extraordinary technical, international and business expertise. Finally, when INTELSAT is privatized, the United States will host the two largest geosynchronous satellite companies in the world—INTELSAT and PanAmSat.

[213] The organizations generally have three organs: a large body consisting of all of the government representatives ("parties"), a board of directors of commercial entities and a management body. In countries in which the government owns and operates the telecommunications systems and use the services of it, the representatives generally are the same entity, giving rise to potential conflicts of interest.

[214] Inmarsat Website: http://www.inmarsat.org/about2/aboutint.html.

[215] EUTELSAT website: http://www.eutelsat.org/about_eutelsat/rub_part1.htm. EUTELSAT will transfer all of its assets and activities to a new private company (based in France) and establish a separate intergovernmental organization to ensure that the company observes basic principles of pan-European coverage, universal service, nondiscrimination and fair competition.

[216] "Historic Assembly Says 'All Systems Go' for 2001: INTELSAT Privatization Plan and Schedule Formally Approved by Governments," http://www.intelsat.int/news/press.

The 1997 WTO Basic Telecommunications Services Agreement

The principal historic step toward a more competitive commercial global satellite market was the signing of the1997 World Trade Organization (WTO) Fourth Protocol to the General Agreement on Trade in Services (WTO Agreement).[217] Sixty-nine WTO members originally signed the WTO Agreement representing over 90% of the world's basic telecommunications revenues.[218] The United States committed, among other things, to provide market access for satellite services.[219] The WTO Agreement imposes competitive safeguards on most signatories, including the United States, such as impartial regulatory treatment and nondiscriminatory allocation and use of scarce resources.

The Federal Communications Commission implemented the WTO Agreement in 1997, establishing open entry standards for WTO members consistent with the U.S. schedule of commitments.[220] The WTO Agreement contains an exception for measures required to protect national security.[221] In implementing the WTO Agreement, the Federal Communications Commission adopted rules according deference to the expertise of the Executive Branch on licensing matters involving national

[217] The commitments that the signing countries made as a result of the WTO negotiations on basic telecommunications services are incorporated in the General Agreement on Trade in Services by the Fourth Protocol to the GATS. Fourth Protocol to the General Agreement on Trade in Services (WTO 1997), 36 I.L.M. 354, 366 (1997). These commitments generally are referred to as "the WTO Basic Telecom Agreement," which is not a separate, stand-alone agreement. Laura B. Sherman, "Wildly Enthusiastic' About the First Multilateral Agreement on Trade in Telecommunications Services," *Federal Communications Law Journal*, Vol. 51, No. 1 (December 1998): 62, n.2.

[218] The WTO telecommunications commitments of other countries varied in terms of types of services covered, nature of commitments and effective date of commitments. Any country may accelerate implementation of its commitments or improve them. The WTO Agreement does not limit the right of any WTO Member to manage spectrum, including the ability to allocate frequency bands taking into account existing and future needs.

[219] DBS, DTH and DARS services were excluded from U.S. commitments. The United States also agreed to competitive safeguards such as impartial regulatory treatment and nondiscriminatory allocation and use of scarce resources.

[220] *Amendment of the Commission's Regulatory Policies to Allow Non-U.S. Licensed Space Stations to Provide Domestic and International Satellite Service in the United States*, 12 FCC Red 24094 (1997) (*DISCO II*).

[221] General Agreement on Trade in Services, Article XIV bis. The exception states that " Nothing in this Agreement shall be construed: (a) to require any Member [of the WTO] to furnish any information, the disclosure of which it considers contrary to its essential security interests; or (b) to prevent any Member from taking any action which it considers necessary for the protection of its essential security interests: (i) relating to the supply of services as carried out directly or indirectly for the purpose of provisioning a military establishment; (ii) relating to fissionable and fusionable materials or the materials from which they are derived; (iii) taken in time of war or other emergency in international relations; or (c) to prevent and Member from taking any action in pursuance of its obligations under the United Nations Charter for the maintenance of international peace and security." Ibid.

security, foreign policy, law enforcement and trade.[222] In addition, the U.S. WTO commitments contain foreign ownership limitations consistent with the proscriptions in the Communications Act of 1934.

In the three years since its implementation, the WTO Agreement has made a difference. "Clearly, the WTO has set an important benchmark for opening markets to satellite services around the world. Many countries—particularly in Latin America and increasingly in Europe, Africa, and Asia as well—have liberalized their regulations."[223] The WTO Agreement has provided new business opportunities and increased opportunities for competition in the provision of telecommunications services, including satellite services, in the United States and abroad. New WTO trade talks are underway. There are efforts to increase the number of signatory countries and to improve and clarify existing commitments.

Effects and Benefits

Privatization, liberalization and competition are having a substantial effect on the commercial communications satellite industry. Progressive regulatory actions and market expansion are producing tremendous benefits for consumers worldwide. Users are receiving the benefits of lower prices, greater service choices and innovative technology.[224] As a result of liberalization, satellite companies are seizing the opportunity to provide services in previously-closed markets and to expand in existing ones. They are forming new multinational alliances to gain access to capital, to develop better products, to obtain requisite licenses in foreign countries and to market services in other nations.[225] This new competitive dynamic is driving the commercial satellite communications industry in two related directions: toward multinational alliances and globalization. Examples of this trend, by geographic region, follow below.

[222] *DISCO II,* par. 180. "The Commission will consider any such legitimate concerns as we undertake our own independent analysis of whether grant of a particular applications is in the public interest." Ibid., par. 179.
[223] *Report on International Telecommunications Market Update 1999*, prepared for Senator Ernest F. Hollings, Committee on Commerce, Science and Transportation, United States Senate, by the Federal Communications Commission, International Bureau, DA 00-87 (January 14, 2000) (*1999 International Telecommunications Update*), 15.
[224] Ibid.
[225] *See, e.g.,* James M. Gifford, "Analysts Predict Industry Growth Via Internet," *Space News*, 4 December 2000, 8 (noting that because orbital positions from which satellites can serve customers are in short supply, the industry is likely to see "'quite a few partnerships blossoming' as companies work to secure more access to orbital parking spots for satellites").

2. Business Trends by Region

North America

Foreign companies view the United States as favorable for satellite services because of its accessible market, transparent licensing and legal system, access to capital, and large, relatively affluent consumer base. A satellite does not have to be licensed by the United States in order to provide service within the United States. Since the WTO Agreement liberalized the U.S. market, several foreign companies have sought to provide satellite services in the United States. In 1999, Canadian-based TMI Communications and Company, L.P. and Netherlands-based New Skies Satellites, N.V. (the INTELSAT spin-off), received authorization to operate in the United States.[226] In 2000, the Federal Communications Commission authorized foreign satellites from Argentina, Brazil, Canada, Japan, Mexico, the Phillipines (Indonesian registry) and EUTELSAT to serve the United States.[227] North America is expected to be the largest market for broadband services.[228]

Telesat Canada owns and operates several communications satellites. In 2000, the company launched its newest generation satellite, the Boeing-built Anik F1, which will serve North and South America. In late 2002, Telesat Canada plans to provide Ka-band multimedia satellite services in North America.[229] Telesat Canada also owns and operates satellite serving the direct-to-home broadcast (satellite television) market.[230]

Latin and South America

The market for satellite telephone, Internet and television services has become increasingly competitive in South America. Data services have dominated the growth of applications in the region, as nations upgrade their infrastructures to meet the strong and sustained growth of the Internet. One projection is that the Internet will grow in Latin and South America at an annual rate of 32% over the next five years, representing a $5 billion

[226] *TMI Communications and Company*, L.P., Order and Authorization, FCC 99-344 (November 30, 1999) (*TMI Communications*); *In the Matter of New Skies Satellites, N.V. for Authorization to Access the U.S. Market*, Order and Authorization, 14 FCC Rcd 13003 (1999) (*New Skies*).
[227] *See, e.g.*, EUTELSAT Press Release, "Eutelsat Open for Business in the USA!," 2 February 2000. Retrieved January 11, 2001, from the World Wide Web: http://www.eutelsat.com.
[228] ING Barings, *Satellite Communications*, 13, *supra* n.45.
[229] Telesat Canada website, http://www.telesat.ca.
[230] "This Week in Brief," *Space News*, 22 May, 2000, 2. Retrieved January, 11, 2000, from the World Wide Web: http://www.spacenews.com.

market by 2005.[231] As described below, the region is developing its own satellites, while at the same time a number of U.S. and other companies have started satellite ventures in Latin and South America.

The rapid development of satellite services in Brazil is an example of new satellite markets. Embratel, Brazil's primary communications provider and domestic satellite operator, now is owned partially by U.S.-based MCI Worldcom and SESAstra.[232] With a fleet of four satellites, Embratel is providing various satellite communications services, including backbone connections to Internet service providers[233] and is exploring more broadband opportunities.[234] In November 2000, Globalstar Do Brasil announced that it was equipping buses in Brazil with mobile satellite telephones.[235]

Following its 1997 privatization, Mexico's Satmex has emerged as one of the region's largest satellite service providers. Satmex is a joint venture between Mexico-owned Principia and U.S.-based Loral Space & Communications.[236] It has sharply expanded its customer base by entering agreements with a number of Internet-related companies such as Tachyon, Hughes Network Systems and American Multiplexer. Satmex plans to obtain additional capacity through the Loral Global Alliance[237] and to launch two additional satellites after 2003.[238] Hispasat, Spain's satellite operator, has been authorized to serve Brazil and expects to increase its presence in South America.

[231] "South American Connection," *Aviation Week & Space Technology*, September 25, 2000, 23. Retrieved September, 29, 2000, from Lexis-Nexus, the World Wide Web: http://www.lexis-nexis.com.
[232] For more information regarding MCI's share in Embratel, see the MCI-Worldcom website, http://www.wcom.com/international/brazil.
[233] Theresa Foley, "Latin America: Satellites Add Spice to an Already Hot Market," *Via Satellite*, 14 June 2000, Vol. 15. No.6. Retrieved September 29, 2000, from the World Wide Web: http://www.lexis-nexis.com.
[234] "Embratel, France's SES to Build Satellites," *Valor*, 22 August, 2000. Retrieved January 11, 2001, from Foreign Broadcast Information Service (FBIS), FBIS-LAP20000822000064, the World Wide Web: http://www.199.221.15.211/.
[235] "Globalstar Do Brasil Signs Contract for Installation of Fixed Phones Aboard Inter-City Buses," Globalstar Press Release, 14 November 2000, http://www.globalstar.com.
[236] The Satmex website is: http://www.satmex.com.
[237] Ibid.
[238] "Plans for New Satellites Reported" *Reformat*, December 13, 2000, http://www.199.221.15.211. The Mexican government reportedly is to be granted 7% of Satmex VI's capacity for use in national security and social operations.

Nahuelsat S.A., Argentina's largest satellite service provider, is expanding throughout South America, including the Andean nations and Mexico.[239] General Electric Capital Corporation (GE) owns 28% of Nahuelsat, and may seek to acquire a larger share of the company. Intelsat has a strong presence in South America.

Venezuela, Ecuador, Peru, Bolivia, and Colombia are members of Andesat (the Andean Countries Satellite Project), a consortium designed to provide Andean nations with an independent satellite capability. Andesat and Alcatel Space are partners in a joint venture known as BolivarSat, which is licensed to operate and plans to launch its first communications satellite, Simon Bolivar, sometime in mid-2002.[240] Andesat intends to provide television, telephone, trunking, beeper, radio, telephony and broadband Internet service to consumers.[241]

In 2000, PanAmSat was licensed to offer Internet Protocol and telephony services in Peru[242] and launched two new satellites to serve Latin America. Loral Cyberstar provides data satellite services in the region and is considering providing distance learning and business television satellite services in the region as well. In July 2000, ORBCOMM, a U.S. low-earth orbit messaging company, received a license in Colombia and intends to serve Colombia's transportation, oil and gas, utility and other industries.[243] Eutelsat do Brasil plans to expand service in South America in 2001, providing video and Internet services.[244]

[239] Ibid.
[240] Geoffrey Cairn, "Wireless Networks: Excitement about MSS has Mostly Evaporated," *Financial Times*. Retrieved January 11, 2000 from the World Wide Web: http://www.ft.com/ftsurveys/sp7fa6.htm.
[241] "Andean Satellite Project Takes Off in Cartage," *Santa Fe de Bogotá El Tempo*, 9 June 1997. Retrieved January 11, 2001, from FBIS, FBIS-FTS19970610001291, the World Wide Web: http://www.199.221.15.211.
[242] PanAmSat also is participating in the development of a Network Access Point (NAP) of the Americas, which based in Miami, Florida, will link Internet Service Providers, Internet backbone providers, and other telecommunications services providers throughout the U.S., Latin America, Europe, and the Caribbean. PanAmSat Press Release, "PanAmSat Joins International Consortium to Develop New High Speed Exchange for Americas," 13 December 2000. Retrieved January 10, 2001, from the World Wide Web: http://www.panamsat.com/media.
[243] ORBCOMM website, http://www.orbcomm.com/newsroom/latestnews/colombia.htm. ORB-COMM Andes Carrie is owned by Virginia-based AES Corporation. It also has received operating licenses for ORBCOMM services in Venezuela, Panama and the Netherlands Antilles.
[244] "South American Connection," *supra* n.231.

Europe and the Middle East

Internet and DTH expansion is expected to drive growth of satellite services across Europe. Approximately 97 satellites and 1,100 transponders with regional and/or international coverage were serving Europe in 1999.[245] Industry analysts predict that the number of transponders dedicated to providing Internet service will need to increase from 27 in 1999 to 343 in 2009 to support backbone trunking and Internet access.[246] European operators could face serious capacity shortages without a substantial increase in satellites on-orbit.[247]

EUTELSAT is experiencing strong growth in Europe and abroad. EUTELSAT's fleet contains 17 satellites and nearly 300 transponders that cover all of Europe and Africa, as well as parts of Asia and North America.[248] With its fleet near capacity, the organization is procuring additional satellites.[249] EUTELSAT is venturing into educational services through a partnership with the CNIT (Italy's inter-university consortium for telecommunications) to broadcast distance learning courses for postdoctoral students.[250]

SES Astra is expanding its presence in Europe and Asia, two growing markets. In July 2000, SES Astra purchased a 50% stake in the Nordic Satellite Co. of Scandinavia. This move gives SES Astra an expanded geographic market in the Nordic region, and will be critical in SES Astra's efforts to spread Astra Net broadband services across Europe. Although SES Astra has expressed considerable interest in partnering with a North American company in order to gain a foothold in the American and Canadian satellite service market, it has not yet done so. SES Astra operates eleven satellites through which it transmits more than 950 television and radio channels, multimedia and Internet services to 78 million homes.[251] Four more satellites are planned for launch in 2001.

[245] Theresa Foley, "Europe: The Continent Beckons," *Via Satellite* 10 September 2000, Vol. 15, No. 9. Retrieved September 29, 2000, from Lexis-Nexus, on the World Wide Web: http://www.lexis-nexis.com.
[246] Ibid.
[247] Ibid.
[248] EUTELSAT website, http://www.eutelsat.org/home.html.
[249] Foley "Europe: The Continent Beckons."
[250] EUTELSAT Press Release, "Eutelsat and the Italian Inter-University Consortium for Telecommunications to Provide a Tele-Education Network Using Ka-Band Frequencies and Bandwidth-On-Demand," 7 December 2000. Retrieved January, 10 2000, from the World Wide Web: http://www.eutelsat.com.

Europe*Star, a joint venture between Alcatel Spacecom and Loral Space and Communications, entered the European market with the launch of its first satellite in October 2000. Europe*Star is forming partnerships with other companies to deliver end-to-end solutions to ISPs.[252] The partners will provide gateway connections, uplinking, fiber and connection to the Internet and production facilities. Europe*Star is part of the Loral Global alliance and has an agreement with Loral Skynet under which the companies can access each other's capacities.[253] Inmarsat Venture is targeting business users to expand into fixed-satellite services in Europe. It has acquired Scotland's EAE Ltd., a VSAT services company that specializes in providing 2 Mbps connections to the oil, gas and maritime industries from both fixed and mobile terminals.[254]

Monaco-based Eurasiasat, a joint venture of Turk Telecom and Alcatel, is expected to launch its first satellite in early 2001 to serve broadcasters in Turkey, Europe and Central Asia.[255] A new company, Eurasianet, has been created within Eurasiasat to provide end-to-end connectivity with ISPs. This service uses Turksat and INTELSAT capacity. Saudi Globalstar has introduced full commercial service in Saudi Arabia.[256]

[251] "SATELLITE: Giant's footprint extends its mark," *Financial Times Survey: Luxembourg 2000.* Retrieved January, 11, 2001, from the World Wide Web: http://www.ft.com/ftsurveys/country/scf2fa.htm.
See also "Astra 2D Blasts Off from Kourou," SES Astra Press Release, Betzdorf, Luxembourg, 19 December 2000. Retrieved January 10 2000, from the World Wide Web: http://www.ses-astra.com/corporate/press.
[252] Foley, "Europe: The Continent Beckons," *supra* n.245.
[253] Sylvia Dennis, "Alcatel, Loral in EuropeStar satellite joint venture 12/21/98," *Newsbytes*, 21 December, 1998. Retrieved January 11, 2001, from the World Wide Web: www.findarticles.com/m0HDN/1998_Dec_21/53455284/p1/article.html. Europe*Star activities are not isolated to Europe. The company has signed a deal to provide capacity for Sinhalese television broadcasts by the Sri Lankan telecom carrier Electroteks. See EuropeStar "Sri Lankan Programming to Broadcast Direct to Europe," Europe*Star Press Release, 21 December 2000. Retrieved January 10, 2001, from the World Wide Web: http://www.europestar.co.uk.
[254] Foley, "Europe: The Continent Beckons," *supra* n.245.
[255] Eurasiasat website, www.eurasiasat.com/index.htm**.** The Eurasiasat satellite was originally scheduled for launch on November 28, 2000, but was postponed four times. "Turkey Delays Launching of Turksat 2A Once Again Because of Bad Weather" *Ankara Anatolia*, 9 January, 2001. Retrieved 10 January, 2001, from FBIS, FBIS-GMP20010109000172, on the World Wide Web: http://199.221.15.211.
[256] Reportedly, less than 10% of Saudi Arabia is covered by cellular service. C.E. Unterberg, Towbin, "Hotbird," Vol. 3, No. 5, 23 October 2000, 26.

Africa

African nations have undertaken substantive measures over the last decade to both create and upgrade telecommunications networks.[257] There is a focus on providing low-cost services, particularly telephony, to rural regions through the use of satellites. A number of African nations have privatized and deregulated their communication industries to open them up to competition, foreign investment and new technology.[258]

The Regional African Satellite Communications Organization (RASCOM), a consortium of 46 African nations, is planning to construct a dedicated satellite system for Africa. Rascom's first satellite is scheduled to be launched in 2002. France's Alcatel has provided funding and engineering expertise for the project.[259] RASCOM intends to launch two geosynchronous satellites to provide telephony, data and video services across Africa and encourage the exchange of television and radio programming among African nations.[260] In addition, Egypt has entered the African service market in recent years providing television satellite services across Northern Africa.[261]

African countries rely on the INTELSAT system for traditional voice, data and video services. In addition, INTELSAT has promoted the growth of Internet services throughout Africa. PanAmSat also has a presence in Africa, providing comprehensive television coverage to the entire African continent[262] and Telesat Canada is entering the market.[263]

Asia-Pacific

Like other regions of the world, the Asia Pacific region is now experiencing satellite growth from both local ventures and outside investment. After a decline in the late 1990s, the market for

[257] Africa has only 14 million telephone lines for a population of 740 million people. Mark Turner, "Lagging in the Information Revolution: Africa" *The Financial Times,* 8 October 1999, 32. Retrieved October 3, 2000, from Lexis-Nexis, on World Wide Web: http://www.lexis-nexis.com.

[258] Michael Holman, "African Overview: Revolution Finally Gets Underway," *The Financial Times*, 17 March 1998, 5. Retrieved January 11, 2001, from Lexis-Nexis, the World Wide Web: http://www.lexis-nexis.com.

[259] Sara Frewen, "RASCOM releases satellite launch schedule," *RCR Radio Communications Report,* Vol. 19: 104, 28 February 2000. Retrieved October 3, 2000, from Lexis-Nexis, the World Wide Web: http://www.lexis-nexis.com.

[260] Ibid.

[261] "Nilesat 2 with Skyplex Gets the Go-Ahead," *Interspace*, No. 656, 18 November 1998. Retrieved October 3, 2000, from Lexis-Nexis, the World Wide Web: http://www.lexis-nexis.com.

[262] PanAmSat website, http://www.panamsat.com/comp/brochure2/africa/continent.

[263] Holman, *supra* n.258.

geosynchronous satellites in the Asia Pacific region is beginning to grow.[264] More than 25 satellites are under construction to serve the region, most of which will provide data and Internet services. As a result of the growth of the Internet in Asia, there is increased demand for Ku-band transponders. Some analysts contend that as the economy improves in Asia, nations will seek to upgrade and expand their bandwidth, digital traffic and packet switching capabilities.[265] Pacific Century Cyberworks, based in Hong Kong, plans to introduce a satellite platform to deliver Internet services to cable head ends. In turn, cable operators would provide Internet services to their own cable subscribers.[266] Industry analysts expect that the growth of DTH and cable television services throughout Asia in the next decade will require increased availability and deployment of geosynchronous satellites. Analysts predict that the DTH and cable market could grow from 84 million users in 1997 to an estimated 237 million users by 2007.[267]

Two geosynchronous systems—Thuraya Satellite Communications Company (Thuraya) and AceS—plan to provide regional telephone service in the Middle East, Central Africa and Europe.[268] Using Boeing-built satellites, in 2001, Thuraya will offer satellite-based mobile services to nearly one-third of the globe, including 99 countries in Europe, the Middle East, North and Central Africa, the Indian subcontinent and Central Asia.[269] The Thuraya system will employ both satellite pay phones and dual mode handsets integrating satellite, terrestrial cellular and location determination (GPS) capabilities in a single handset offering voice, data,

[264] Bruce S. Middleton, "The Asia-Pacific GEO Satellite Market Beginning the 21st Century," 3 (Paper released by the Pacific Telecommunications Council). Retrieved September 29, 2000, from www.ptc.org/planetptc/sessions/Wednesday/w31/w311. Until the financial crisis in the Asia-Pacific region in October 1997, the region led the world in the number of geosynchronous satellites launched during the 1990s. Market demand for satellites in Asia dropped sharply in 1998 and 1999 when the regional economic crisis peaked. For the first time in January 2000, the number of transponders in service in the Asia-Pacific was less than the number the prior year.
[265] Ibid, 5.
[266] Merrill Lynch, *Satellite CEO Conference 2000*, 9 February 2000,17.
[267] Ibid.
[268] Thuraya website, http://www.thuraya.com/corporate.htm. *See also* ING Barings, *Satellite Communications,* 103 *supra* n.45. AceS is jointly owned by PT Pasifik Satelit Nusantara (PSN) of Indonesia, Lockheed Martin Global Telecommunications (LMGT), the Philippine Long Distance Company (PLDT) and Jasmine International Public Company Ltd. of Thailand.
[269] Thuraya signed a deal with the Mauritanian-Tunisian Telecommunications Company (Matel) for Matel to act as Thuraya's service provider in Mauritania. Thuraya Press Release, "Matel Becomes Thuraya's Service Provider in Mauritania," 20 December 2000. Retrieved January 10, 2001, from the World Wide Web: http://www.thuraya.com/corporate.htm. *See also* ING Barings, *Satellite Communications*, 103, *supra* n.45.

fax and short messaging services.[270] In Japan, NTT acquired a 20% stake in Japan satellite systems and consolidated two of its NSTAR satellites into the JSAT fleet.

Companies outside the Asia Pacific region such as Lockheed Martin Global Telecommunications, the Loral Global Alliance, Luxembourg's Societe Europeenne des Satellites (SES Astra) and British Telecom are investing in the Asia-Pacific satellite market and forming new multinational alliances. In Indonesia, for example, Lockheed Martin Global Telecommunications acquired a 30% stake in Asia-Cellular satellite through Pasifik Satelit Nusantara and its regional partners.[271] In 1999, British Telecom acquired a 33% stake in Malaysia's Binariang system, which operates the nation's Malaysia East Asia Satellite (Measat) and SES Astra acquired a 34% stake in Asiasat from Hutchinson Wampoa.[272] SES Astra intends to construct a gateway in Cyprus, which will allow European broadcasters and multimedia companies to distribute services to Asia, Australasia and the Middle East.[273] Europe*Star plans to enter the South Asian market with its 30 Ku-band transponder satellite.[274] The company has stated that it will use two collocated Ku-band satellites to "interconnect" Europe with South Africa, the Middle East, Indian Subcontinent and Southeast Asia.[275]

E. National Security Implications of Globalization

As the prior section illustrates, there is a tremendous increase in multinational alliances and globalization—across the entire commercial space sector, especially in the communications satellite segment. The rise in multinational alliances and globalization presents both new challenges and opportunities for U.S. national security.

[270] http://www.thuraya.com/corporate.htm, See also ING Barings, *Satellite Communications*, 103, *supra* n.45.
[271] Pasifik Satelit Nusantara website, http://www.psn.co.id/.
[272] "Broadband Services, Asiasat Stake Position SES as Global Player," *Aviation Week and Space Technology*, Vol. 150, No. 1, 4 (January 1999), 28. Retrieved September 29, 2000, from Lexis-Nexis, the World Wide Web: http://www.lexis-nexis.com. *See also Aviation Week and Space Technology*, "SES Takes on World from Tiny Luxembourg, Vol. 150, No. 14, 5 (April 1999), S6. Retrieved September 29, 2000, from Lexis-Nexis, the World Wide Web: http://www.lexis-nexis.com.
[273] Ibid.
[274] "Europestar to offer broadband services from Europe," *Hindu Business Line*, 18 August, 2000. Retrieved October 2, 2000, from the World Wide Web: http://www.hindubusinessline.com/2000/08/18/stories/151839rr.htm.
[275] Foley "Europe: The Continent Beckons," *supra* n.245.

1. Challenges

U.S. companies are forming alliances with foreign companies, entering foreign markets and investing U.S. dollars and resources overseas. At the same time, foreign companies are forming partnerships with U.S. businesses in this country, entering the U.S. satellite market and investing foreign dollars and resources in the United States. As a result of these trends, companies are becoming more global. One company may have multiple owners around the globe and one product may have multiple producers.

That companies of one nation are gaining greater access to the business strategies, systems, products and employees of companies from other nations is not necessarily of concern. Particular alliances or circumstances, however, could create national security considerations. Any such potential concerns would depend on various factors such as the nations, entities, policies and technologies involved. In these situations, the U.S. Government should balance national security and commercial space considerations, including enhancing U.S. competitiveness.

Another consideration is the pending privatization of the multilateral satellite organizations. Those entities hold a tremendous amount of valuable assets—numerous satellites and accompanying orbital locations. Upon privatization, those assets will migrate to the commercial satellite sector and inure to the benefit of the respective country of incorporation of each privatized entity. Furthermore, the privatized entities will have extensive multinational compositions, initially in the form of shareholders and continuously in the form of employees. Based on their historical operations, these entities enjoy longstanding relationships with people in regional and local satellite markets across the globe. The new privatized entities will have the opportunity to leverage those relationships, which depending on the circumstances, could give rise to competition or national security considerations.

As foreign commercial communications satellite companies have sought entry to the U.S. market, the Executive Branch has raised national security, law enforcement and public safety concerns regarding applications that have involved foreign ownership or foreign telecommunications facilities.[276] Some of these applications include U.S. companies in various partnerships with foreign applicants. The specific

[276] *See, e.g., TMI Communications.*

Executive Branch agencies raising concerns—the Department of Justice and the Federal Bureau of Investigation, as well as the Department of Defense in some cases—have addressed their concerns through written agreements with the applicants. Where foreign facilities are involved, these agreements require construction of a gateway in the United States to enable law enforcement to conduct wiretaps. They also limit foreign access to certain information, impose citizenship requirements, require disclosure of personal data regarding personnel occupying certain sensitive network positions and establish reporting requirements.

Consistent with its *DISCO II* decision implementing the WTO Agreement, the Federal Communications Commission accords deference to the expertise of Executive Branch agencies in identifying and interpreting national security and law enforcement matters, making compliance with these agreements a condition of licensing. In its assessment of the implications of foreign ownership of critical U.S. telecommunications facilities on national security and emergency preparedness services, in May 2000, the Legislative and Regulatory Working Group of the President's National Security Telecommunications Advisory Committee found that the "current regulatory structure effectively accommodated increasing levels of foreign ownership of United States telecommunications facilities, while allowing the Federal Government to retain authority to prevent any such foreign ownership that might compromise national security interests."[277]

In some cases, the amount of time involved in reaching these agreements has caused substantial licensing delays.[278] In the fast-paced, competitive global satellite marketplace, such delays can be costly. As delineated below, these licensing matters call for a more effective,

[277] *Globalization Task Force Report,* The President's National Security Telecommunications Advisory Committee (May 2000), ES-1. The "current regulatory structure effectively accommodated increasing levels of foreign ownership of United States telecommunications facilities, while allowing the Federal Government to retain authority to prevent any such foreign ownership that might compromise national security interests." Ibid.

[278] For example, in the case of the request of a Canadian company, TMI Communications and Company, L.P., to offer communications satellite services in the United States, including to the U.S. Government, the delay well-exceeded a year. *TMI Communications, supra* n. 226. "This [delay] prejudices … the parties' interest in a full, fair and prompt resolution… . [C]ompetitors now have an incentive to … slow down our approval. The resulting procedural morass undermines predictability and creates tremendous delays that deny American consumers' competitive service options… . The current process does not serve the parties or the American people well." *TMI Communications,* "Separate Statement of Commissioner Harold Furchtgott-Roth" (also raising questions regarding the proper branch of government with jurisdiction to enforce the agreements).

coordinated interagency process to simultaneously: safeguard U.S. national security, comply with U.S. treaty obligations and further competition in the commercial satellite market.

Finally, greater globalization, instant access to and transmission of information as well as the ability to communicate virtually anywhere anytime, may alter people's sense of national boundaries and allegiances. This shift could give rise to new risks and threats, as well as opportunities, as discussed below.

2. Opportunities

Multinational alliances and globalization provide opportunities to enhance U.S. national security. U.S. commercial ventures with foreign entities facilitate U.S. access to foreign funding, business systems, space expertise, technology and intellectual capital. As the Booz, Allen & Hamilton, *2000 Defense Industry Viewpoint* recognizes, "In order to have true competition, government customers will need to look to global competitors, and these relationships will need to extend beyond teaming to a more complete and permanent set of strategic alliances."[279] It identifies these advantages of strategic alliances: (1) strategic alliances provide capabilities to quickly expand service offerings and markets in ways not possible under time and resource constraints; (2) alliances earn a rate of return 50% higher than base businesses; "returns more than double as firms gain experience in alliances;" and (3) alliances are a powerful alternative to acquiring other companies because they "avoid costly accumulation of debt and buildup of balance sheet goodwill." [280]

In these respects, international commercial alliances can serve to strengthen the competitive position of the U.S. commercial satellite sector, providing economic benefits in the United States and furthering a core goal of the *1999 National Security Strategy*: to "bolster America's economic prosperity."[281] U.S. experiences with foreign entities in foreign markets could be beneficial in obtaining the requisite approvals to operate U.S. Government satellite systems in other countries, as well as for resolving satellite spectrum and coordination issues. The lessons of Desert Storm demonstrate that the ability—or inability—to work effectively with other nations to achieve mutual objectives is critical to success. As the *1999*

[279] Booz, Allen & Hamilton, *2000 Defense Industry Viewpoint*, 19, *supra* n.36.
[280] Ibid.
[281] *1999 National Security Strategy*: iii.

National Security Strategy states: “Many of our security objectives are best achieved—or can only be achieved—by leveraging our influence and capabilities through international organizations [and] our alliances.”[282]

In addition, multinational alliances provide opportunities for the United States to promote international cooperation and build support for U.S. positions with other countries. For example, they can help the United States build consensus on important space-related issues in bilateral or multilateral such as the United Nations, the International Telecommunication Union and the World Trade Organization. Working with emerging space-faring nations is particularly important because of their growing presence in the marketplace and participation in international organizations.[283] These alliances also serve as a bridge to future collaborative efforts between U.S. national security forces and U.S. allies. For example, civil multinational alliances like the International Space Station and the international search and rescue satellite consortium, Cospas-Sarsat, involve multiple countries partnering to use space for common public global purposes.[284] Finally, developing government, business and professional relationships with people in other countries provides opportunities for the United States to further the principles of competition, economic stability and democracy upon which U.S. national security relies.

[282] Ibid., 12.
[283] For example, of the 150 countries participating in the 2000 World Radiocommunication Conference, 100 were part of the developing world. “Recommendations to Improve United States Participation in World Radiocommunication Conferences,” Ambasssador Gail S. Schoettler, U.S. Head of Delegation, World Radiocommunication Conference 2000, 27 June 2000, 44. This report surmises that if there were a vote on an issue between developed countries and developing countries, “the developing countries would win it hands down.” With respect to radio frequency spectrum, the report notes that usable radio spectrum is a global, public and scarce resource. We need the goodwill and partnership of all countries to share it.” Ibid.
[284] The Cospas-Sarsat satellite system uses NOAA satellites and satellites from several other countries to detect and locate aviators, mariners, and land-based users in distress. The satellites relay distress signals from emergency beacons to a network of ground stations. Cospas-Sarsat began operating after a September 1982 aircraft accident in Canada in which three people were rescued. Since then, the system has been used for thousands of rescues worldwide.

VI. Weather Satellite Services

A. Background

Like the U.S. GPS satellites, U.S. weather satellites are owned and operated by the U.S. Government as a public service. Specifically, the Department of Commerce National Oceanic and Atmospheric Administration (NOAA) operates two types of weather satellites: the GOES (Geostationary Operational Environmental Satellites) and the POES (Polar Operational Environmental Satellites).

Each of the GOES satellites is able to view a given section of the earth on a constant basis, monitoring atmospheric conditions that trigger severe weather conditions such as tornadoes, flash floods, hailstorms and hurricanes.[285] GOES-8 and GOES-10 are the two most recent geosynchronous weather satellites, launched on April 13, 1994 and April 25, 1997, respectively. The POES satellites, also known as the Advanced Television Infrared Observation Satellite (TIROS-N), are set in sun-synchronous orbits. This allows them to pass over the equator at the same time each day. Operating as a pair, the POES provide data that is no more than six hours old for any region of the world. Data from these satellites is primarily used for longer-range forecasts that do not require 24-hour surveillance capability.[286]

The U.S. Government intends to merge its civilian and military weather satellite programs into the U.S. National Polar-Orbiting Operational Environmental Satellite System (NPOESS). Lockheed Martin and TRW are leading the two teams that will develop and manufacture the next generation satellites. The award of the NPOESS program is expected in 2002 with an anticipated launch date of 2008.[287]

[285] The main instruments aboard geosynchronous weather satellites are referred to as the imager and the sounder. The imager senses radiant and reflected energy from the earth's surface and atmosphere, while the sounder is able to determine the vertical temperatures associated with surface and cloud temperatures and the ozone distribution. In addition to these sensors, other common instruments are search and rescue transponders, data collection and relay systems, and space environment monitors.

[286] The primary instrument aboard polar orbiting weather satellites is the Advanced Very High Resolution Radiometer (AVHRR). Data is transferred to the ground through the High Resolution Picture Transmission (HRPT). Image data is transferred through two AVHRR channels called Automatic Picture Transmission (APT).

[287] Jeremy Singer, "Lockheed, TRW Compete to Build NPOESS/Military-Civilian Weather System Could Top $1 Billion," *Space News*, 10 January 2000, 18.

As in both the remote sensing satellite sectors and the location/ navigation sectors, the role of government in the control of satellite assets is central to the development of commercial industry. In the United States, civil weather satellites are operated by the National Weather Service (NWS),[288] which provides satellite data as an unrestricted public good.

Commercial weather services represent a niche market. Most of the commercial weather satellite service-related businesses in the United States are value-added providers that process raw weather information from the National Weather Service, then analyze the data to produce custom forecasts. These forecasts are then supplied to consumers such as agribusiness, retail businesses, the news and entertainment industry, local governments and many other customers whose lives or businesses may be affected by changes in the weather. Commercial weather industry analysts estimate that annual revenues in 2000 total about $430 million in the United States, $300 million in Japan and $170 million in Europe.[289] Comparisons to past estimates suggest that revenues in the U.S. commercial industry have been increasing over the past few years. In 1996, for example, Weiss and Backlund's estimate of revenues placed annual sales in the U.S. private weather services industry at $200-250 million.[290]

Based on the $400 million plus revenues generated by the weather service industry in the United States, there is a substantial market for value-added weather products. Moreover, the spread of information technologies such as mobile telephones and Internet services suggests that weather-related content could be packaged with other services intended for the end-user. It is even likely that a "space weather" industry could emerge. Companies that sell and support satellite constellations and/or the technologies that in turn support such space-based assets will require forecasts of extraterrestrial radiation or other phenomena that could affect their operations.[291]

[288] The U.S. National Weather Service is part of NOAA.
[289] Pirkko Saarikivi, *et al.,* "Free Information Exchange and the Future of European Meteorology: A Private Sector Perspective," *Bulletin of the American Meteorological Society*, Vol. 81, May, 2000: 831-836. Retrieved October 23, 2000 from the World Wide Web: http://www.ametsoc.org.
[290] Weiss, Peter N. and Peter Backlund, *International Information Policy in Conflict* (paper submitted to the Harvard Information Infrastructure Project, 20 June 1996). Retrieved October 23, 2000, from the World Wide Web: http://www.ksg.harvard.edu.
[291] NOAA issued a solicitation for proposals in 1997 for technologies that could assist private companies in the development of space weather services. *See* http://ts.nist.gov.

B. Principal Applications

The impact of weather satellites on our daily lives tends to go unnoticed. There are numerous commercial applications for weather satellite information, however, most support forecasts for specialized users. The various applications of weather-related products support a diverse group of customers.

One group of end-users is the large agribusiness industry in the United States. The agribusiness industry relies on accurate weather forecasts for making decisions about the best time to fertilize, apply pesticides, plant, or harvest their crops. Companies such as AccuWeather Inc. package forecasts of weather patterns into specialized reports for their customers.[292]

Another group of frequent users is the retail industry. For example, in the 1980s, Sears, Roebuck & Company typically employed a forecasting group to help it determine the potential for sales of seasonal items such as air conditioners, heaters, snow tires, and umbrellas.[293] By contrast, today, Sears purchases finished weather forecasting products directly from companies such as Strategic Weather Services, which purportedly combines raw weather satellite data with its own "secret formula" to predict Sears' seasonal sales.[294]

The news and entertainment industry also represents a large consumer market for processed satellite weather data. For example, reportedly, at one time the major television networks expressed interests in acquiring the most advanced weather satellites on the market.[295] Because audience share also attracts advertisement dollars, the news and entertainment industry has become an interested consumer of high-tech satellite weather products.

There are other profitable applications of weather satellite information. For example, local governments purchase forecasts from value-added weather service providers. In the aftermath of a blizzard in

[292] AccuWeather, like most value-added suppliers, applies computer programs to process raw data supplied by satellites, weather balloons and Doppler radar. The service can cost as much as $15,000 per month. Stephan Herrerra, "Weather Wise," *Forbes Magazine*, 14 June 1999. Retrieved October 23, 2000 from the World Wide Web: http://www.forbes.com/1999/0614/6312090a.html.
[293] Jerome Ellig, "Government and the Weather: The Privatization Option," *The Federal Privatization Project*, August 1989. Retrieved January 11, 2001, from the World Wide Web: http://www.rppi.org.
[294] Herrerra, *supra* n.292.
[295] "Satellites and Their Emerging Role in Commercial Ventures," (academic paper submitted by anonymous author) 17 April 1997. Retrieved October 23, 2000, from the World Wide Web: http://www.smgaels.org/physics/97/BKING.HTM.

1983, New York City government officials credited CompuWeather with predicting the storm, and thereby helping the city to have snowplows and road treatment equipment readily available.[296] In addition, large oil companies have paid $20,000 a month for forecasts of weather and ocean conditions near their offshore drilling platforms.[297] Railroads, ski resorts, airports and any number of other such businesses that are affected by the weather also are likely to purchase value-added services from private sector weather-forecasting companies.

C. Foreign Weather Satellite Programs

Many of the world's space-faring nations cooperate in providing and disseminating weather data to other nations. The principal foreign countries and international regions involved in maintaining weather satellites and their data are Europe, Japan, Russia, China and India.

The European countries operate their Meteosat geosynchronous weather satellites through Eumetsat, a consortium of 16 countries. The Meteosat satellites have similar sensors as the U.S. GOES series of satellites and provide weather observation data for the European continent. A follow-on program, the Meteosat Second Generation (MSG), includes three satellites with enhanced capabilities, including a multi-spectral imager that will acquire full-disc images of the earth at 15-minute intervals and improved geometrical resolution capabilities.[298]

Japan, Russia and China also have their own weather satellites. Japan's latest Geosynchronous Meteorological Satellite, GMS-5, was launched in 1995. Russia has several satellite systems for geological and environmental remote sensing, but its main space-based weather system consists of a single Geosynchronous Operational Meteorological Satellite (GOMS) (launched in 1994). In 1997, China launched its first geosynchronous satellite, the Fengyun-2A (FY-2A). It stopped operating in 1999[299] and in 2000, China successfully launched a second Fengyun satellite, FY-2B.[300]

[296] Ellig, 7.
[297] Ibid.
[298] http://www.esa.int/msg.
[299] "China Launches Weather Satellite," *SpaceViews,* 26 June 2000. Retrieved October 25, 2000, from the World Wide Web: http://www.spaceviews.com.
[300] Wei Long, "Chinese MetSat 'Sees' Heat and Moisture," *SpaceDaily*, 25 July 2000. Retrieved October 25, 2000, from the World Wide Web: http://www.spacer.com.

The Indian weather satellite program differs from those in other countries in that it combines television broadcasting, communications and meteorology.[301] The Indian Space Research Organization (ISRO) operates this satellite program, which is called the INSAT program. The INSAT program began in the early 1980s, with the launch of INSAT-1A. ISRO currently operates a second generation of weather satellites, the INSAT-2 series, which commenced in 1992.[302]

D. Public Good Versus Commercial Product

Most nations acknowledge that weather satellite data should be treated at least partially as a public good and that sharing data among nations is desirable. Even the U.S. weather satellite system, which provides the world's most premier weather satellite capabilities, requires data from other nations to make its models more accurate. Until recently, almost every nation exchanged such data freely within the World Meteorological Organization (WMO).

The view that governments should provide free access to satellite weather data has been called into question within the European Union. Several European governments contend that users should pay a fee for access to certain types of information. In 1995, the National Meteorological Services of Western Europe joined together to form a European Economic Interest Grouping called ECOMET, in part to commercialize the European weather information services.[303] ECOMET created a government commercial enterprise, allowing the members of ECOMET to charge user fees for services that they previously had provided without charge or restrictions. This development resulted in WMO Resolution 40, which created two classes of data: "essential" data on which no restriction could be placed, and "additional" data, on which conditions for use could be defined and imposed by the producer.[304]

WMO Resolution 40 has created friction between ECOMET and European private sector weather service companies that, prior to ECOMET's formation, had received satellite weather data at no cost on an

[301] U.S. Army Space Institute, Chapter 7, Section 5, *U.S. Army Space Reference Text* (U.S. Army Space Institute: Fort Leavenworth, KS, July, 1993). Retrieved January 11, 2001, from the World Wide Web: http://www.fas.org/spp/military/docops/army/ref_text/chap07e.htm.
[302] A history of INSAT, and other Indian space systems, is available at:
http://www.bharat-rakshak.com/SPACE/space-satellite1.html.
[303] Pirko Saarikivi, et al.
[304] Ibid.

unrestricted basis. European private sector weather service providers reportedly assert that the ECOMET nations charge unfair prices for satellite data that is subsidized to a large extent by European taxpayers. Private companies also claim that the European National Weather Services has created trade barriers by restricting access to free observational data to the ECOMET member nations and to select academic users such as universities.[305]

Despite these private sector concerns, the commercialization of government weather satellite data is proceeding. In October 1999, the European Commission authorized the sale of commercial products by ECOMET, ruling that there is adequate competition within ECOMET itself and that the "grouping operates in such a way as to permit fair competition with independent providers."[306] The ruling by the European Commission places the ECOMET nations' practices of commercializing government-supplied satellite information at odds with the policies of the U.S. Government. Although the U.S. Government recognizes the right of individual nations to impose restrictions and regulate markets within national territories, it has argued against the explicit adoption of an international policy to limit the flow of weather information.[307] The ECOMET nations have in turn threatened to cut off their supply of weather information to the WMO if the United States fails to prevent the re-export of ECOMET weather data.[308]

E. National Security Implications

Differing national policies on the commercialization of government-supplied weather data could lead to reduced availability of worldwide weather information if countries choose to withhold weather information in retaliation for the re-export of weather data. If this were to happen, negative effects would be unavoidable. In the absence of data from countries declining to supply weather observations, weather models may not be as accurate. Any consequential reduction in quality could affect U.S. use of the data and products for defense, intelligence, civil and commercial applications. For example, U.S. companies involved in value-added weather services and products could experience revenue loss.

[305] Ibid.
[306] Ibid.
[307] Weiss and Backlund.
[308] Ibid.

The following section discusses legal and regulatory issues and the need for interagency coordination involving all four space sectors.

VII. Interagency Coordination and Legal and Regulatory Environment

A. Interagency Coordination

1. A National Policy Approach

Responsibility and accountability for space generally is diffused throughout the U.S. Government—from the Executive Office of the President to scores of other federal departments and agencies. This arrangement does not allow for focused attention to space matters. Consequently, issues may not necessarily enter the national security apparatus and opportunities may be lost for important dialogue and coordination regarding national security matters. The interdependence of the space sectors requires a more concentrated focus on space.

At the national level, the 1996 National Space Policy designates the National Science and Technology Council (NSTC), a Cabinet-level organization chaired by the President, as "the principal forum for resolving issues related to national space policy. As appropriate, the NSTC and NSC [National Security Council] will co-chair policy processes."[309] The Office of Science and Technology Policy (OSTP) coordinates federal polices for science and technology. The Director of OSTP serves as the Assistant to the President for Science and Technology and supports the NSTC.

Under the Clinton Administration, the principal position within the National Security Council with space responsibility was a Director reporting to the Senior Director, Defense Policy and Arms Control. The position within the Office of Science and Technology Policy was the Assistant Director for Space and Aeronautics reporting to Associate Director for Technology.

[309] *1996 National Space Policy Fact Sheet*, 2.

It is fundamental to U.S. national security that the United States establishes and implements a national approach for leading the country and coordinating U.S. Government departments and agencies regarding U.S. national security space issues. Space applications in the United States and the world have expanded to virtually every component of society and commerce. The commercial space sector is escalating. New foreign space programs are emerging. Globalization is expanding.

As a result, U.S. policies, laws, regulations and actions in a wide range of areas may affect national security space. Everyday, in domestic and international arenas, U.S. Government representatives enter bilateral and multilateral negotiations, assert U.S. positions, make recommendations and take actions on a plethora of issues that clearly do, or potentially could, involve any or all of the four space sectors and affect U.S. national security interests. Thus, there are a number of space-related arenas in which U.S. national security could be at issue, or worse, at stake.

U.S. Government departments and agencies need guidance and oversight. A timely and effective interagency coordination process is vitally necessary to properly evaluate and implement national security space policies. The United States must actively shape the U.S. and international legal and regulatory environment to further U.S. national security objectives, including enhancing American competitiveness. These actions are necessary to ensure U.S. national security and the success of each of the four space sectors. A coherent and effective interagency process also would promote efficient use of U.S. Government expertise and assets, reduce government costs and save resources. Furthermore, such a process would advance and strengthen the position of the U.S. Government internationally and would provide the nation with confidence in federal government processes and decision making.

2. Pending Agenda Items

The range of domestic and international radio frequency, orbital location and licensing issues facing the United States demand a coherent, national policy approach and deliberate direction. A sample of these pending issues include:

- WTO negotiations regarding market access for commercial satellite systems.

- Domestic allocation of spectrum for third generation wireless (scheduled to occur by July 1, 2001)[310] and the potential authorization of commercial ultrawide band services, both of which may affect Department of Defense use of spectrum for military operations, government use of commercial spectrum and commercial use of government spectrum.

- Claims of developing countries regarding equitable access to radio frequency spectrum and orbital locations.[311]

- Orbital debris and deorbiting policies in the United States and other countries.

- Domestic commercial satellite licensing matters involving national security or law enforcement issues, such as remote sensing policies, export control and foreign ownership.

- Licensing delays and increased difficulty in coordinating commercial satellite systems.

[310] An October 2000 Presidential Memorandum regarding spectrum for Third Generation (3G) Wireless Systems in the United States directs the Secretary of Commerce in cooperation with the Federal Communications Commission to work with government and industry representatives to develop plans to identify 3G spectrum and to make recommendations. "Memorandum for the Heads of Executive Departments and Agencies," The White House, 13 October 2000. The memorandum also provides that the Secretary of Defense, Secretary of Treasury, Secretary of Transportation, Secretary of State and the heads of any other executive department or agency that currently uses any of the 3G spectrum identified at the 2000 World Radiocommunication Conference to participate in the government-industry group. In addition, it directs the Department of State to present U.S. views to and coordinate with foreign governments and international bodies.

[311] For example, the 2000 World Radiocommunication Conference adopted a resolution instructing an organ of the ITU to study and consider possible draft recommendations linking the formal notification, coordination and registration procedures with ITU principles and regulations related to equitable access to spectrum and orbital resources. Under those principles and regulations, in the case of comparable requests for access to the spectrum/orbit resource by a country already having access to the orbit/spectrum resources and a developing country seeking it, the country having such access should take all practicable steps to enable the developing country to have equitable access to the requested orbit/spectrum resources. Provisional agenda items for the Spring 2001 Session of the Legal Subcommittee of the Committee on Peaceful Uses of Outer Space (COPUOS) are: the definition and delimitation of outer space, the character and utilization of the geosynchronous orbit, including consideration of ways and means to ensure the rational and equitable use of the geosynchronous orbit without prejudice to the role of the ITU. The continued international consideration and controversy regarding these spectrum-related issues underscores the importance of addressing them in the United States.

B. Satellite Regulatory Issues

1. Radio Frequency Spectrum and Orbital Locations

All wireless services use, and thus require, radio frequency spectrum. Satellites are just one of these services. Demands for radio frequency spectrum are escalating. This increase is the result of the pro-competitive market-opening effects of the WTO Agreement, as well as new and expanded uses of radio frequency spectrum for various technologies. As a result, the allocation, assignment and coordination of radio frequency spectrum and assignment of orbital locations for government and nongovernment purposes are becoming more difficult and time-consuming.[312]

Today, radio frequency spectrum and orbital location issues are pending on the agendas of various international organizations. Those issues are of strong importance to the United States and virtually every country in the world, including the developing countries, which are increasingly interested in establishing their own satellite systems. These issues matter because radio frequency spectrum and orbital locations are necessary to operate in space. As a result, access to and authority to use those assets have national security, foreign policy, economic, technological and societal implications worldwide.

2. Licensing of Satellite Systems

Licensing of satellite systems provides satellite providers opportunities and obstacles. The increasing globalization of the satellite market magnifies both of these—in market access decisions worldwide. In the United States, under the Administrative Procedures Act,[313] the U.S. Government must provide notice of certain proposed actions and provide the public opportunity to present its views in writing on the record. This deliberative process provides every segment of the public—the U.S. Government, U.S. industry, state and local governments, foreign

[312] To try to accommodate the high demand, regulators are devising spectrum sharing arrangements. Some observers have raised concerns that spectrum sharing may increase risk of service outages due to greater terrestrial interference. *See* Clayton Mowry, "Spectrum Sharing—Who Gets the Bigger Piece?," *Via Satellite* (January 2001), 16 ("spectrum-strapped regulators need to consider how satellites enable other technologies, provide high-quality competitive services and serve the public interest").
[313] 5 U.S.C. sec. 551-559.

governments, foreign companies and individuals worldwide—advance notice of policies and decisions that may affect them and opportunity to influence the U.S. regulatory process. By providing for an open and transparent process, this system promotes public confidence and creates investment incentives and rewards. Companies generally cite the relative certainty and fairness of the U.S. regulatory process, as well as its competitive policies as a reason to seek to provide service in the U.S. market. In addition, hundreds of regulators around the globe seek guidance from U.S. regulators about our procedures and policies in an attempt to adopt similar approaches in their countries.[314]

Licensing of commercial communications satellite systems in the United States also presents challenges for both government and industry. The Federal Communications Commission grants licenses and authorizations to commercial communications systems for spectrum frequencies, orbital locations, space stations and ground equipment. In doing so, based on its statutory mandate under the Communications Act of 1934, the agency applies a public interest standard.[315] Given the public participation requirements and increasing complexity of the issues, it can take more than two years to license a satellite system for which there already is an existing allocation and three years or more where there is not an existing allocation.

In the fast-paced commercial communications satellite market, where demands for radio frequency spectrum are high and competition from terrestrial wireless services is strong, time and certainty matter. While applications are pending, technology changes and market dynamics shift. Alternative licensing approaches may speed the length of time to award licenses, and thereby increase government efficiency, reduce government resource costs and enable the public, U.S. businesses and the economy to realize the benefits of competition more quickly.

[314] Various U.S. Government agencies and international organizations provide training and educational programs for foreign regulators. For example, the Federal Communications Commission's "International Visitors Program" annually provides tutorials and workshops to 400-500 visiting regulators representing approximately 100 countries. *See* http://www.fcc.gov/ib/ivp.
[315] Title III of the Communications Act of 1934.

3. Export Licensing

In March 1999, in response to concerns about the transfer of U.S. satellite-related technology to China, Congress reclassified commercial satellites and related components as munitions under U.S. export licensing laws. Congress also transferred the government licensing function from the Department of Commerce to the Department of State. Since the stricter controls became effective, the volume of export licensing applications has increased and decisions have been delayed.

Some industry observers have claimed that the new export regulations are causing the U.S. satellite industry to turn to foreign providers. [316] The Booz, Allen & Hamilton *2000 Defense Industry Viewpoint* found that while the United States historically has held approximately 70% of the global market for geosynchronous communications satellites, the competitiveness of the U.S. industry in international markets "has been significantly impacted" by the new export control regulations. [317] The study cautions that this segment of the U.S. industry could lose up to $1 billion annually if the export issues are not resolved. [318]

There are some reports that the export licensing process in the United States is improving.[319] That trend should continue. Progress is necessary for the strength of the U.S. commercial space sector as well as the national security space sector as well. "'[I]f weakened U.S. satellite makers cede this market to foreigners, it will jeopardize America's global surveillance, reconnaissance and communications network, the linchpin of the Pentagon's 21st century battle plan."[320]

[316] Evelyn Iritani and Peter Pae, " U.S. Satellite Industry Reeling Under New Export Controls," *Los Angeles Times*, 11 December 2000, 1 (citing Satellite Industry Association claim that since the new U.S. export restrictions took effect, the number of U.S.-manufactured spacecraft dropped). .
[317] Booz, Allen & Hamilton, *2000 Defense Industry Viewpoint*, 13.
[318] Ibid.
[319] *1996 National Space Policy Fact Sheet*, 2.
[320] Ibid.

VIII. U.S. Government Use of Commercial Satellites for National Security

A. Background

The national security space sector includes the defense space sector and intelligence space sector. Space-based technologies and information is an integral component of American military strategy and operations. Ability to communicate and to transmit information is fundamental to defense and intelligence activities and to U.S. national security.[321] These capabilities assist national leaders in implementing foreign policy, managing crises in distant places and conducting military actions. Military strategy and doctrine increasingly focus on information and its potential for improving combat performance. As the *2000 RAND Employing Commercial Satellite Communications Study* recognizes:

> Sufficient capacity for transmitting information must be obtained to support emerging military doctrine, including the uncertainties posed by the unknowable timing of future contingencies… . [C]ommercial systems and services may represent the best opportunity to achieve affordable communications capacity.[322]

U.S. intelligence space activities began in the 1960s, focusing on the USSR. The need for intelligence information continues today, including to collect information on various subjects in support of U.S. global security policy. Given the changing nature of international conflict and U.S. defense strategies, information and the ability to communicate are increasingly critical commodities for national security. U.S. military leaders and ground troops need timely access to quantities of quality intelligence information, imagery and weather data from satellites. They need to communicate that information rapidly via satellite.

[321] Ibid., 2.
[322] Tim Bonds *et al.*, "Employing Commercial Satellite Communications, Wideband Investment Options for the Department of Defense," *Project Air Force RAND* (2000) (*2000 RAND Employing Commercial Satellite Communications Study*), 2-3 (study examines high bandwidth, minimally-protected satellite communications).

The Department of Defense expects military demand for communications to grow over the next decade and beyond.[323] To fulfill its defense and intelligence needs for satellite services and products, the U.S.Government has two main options. One option is to acquire its own satellite assets. Examples of U.S.-owned systems include MILSTAR, Gapfiller and National Reconnaissance Office (NRO) satellites.[324] As an owner, the U.S. Government can operate a satellite system and maintain control over it. As a second option, the U.S. Government can lease satellite capacity from a commercial provider, either in whole or in part.

The commercial space sector provides valuable opportunities for the U.S. Government to execute its national security space missions.[325] "A major tenet of the future architecture and transition strategy is to reduce costs by leveraging advances in commercial satellite communications to the maximum extent practicable."[326] The sector has been providing communications satellite services to the U.S. Government for decades. From 1984-1996, for example, the U.S. Government leased the LEASAT satellite system from Hughes, which operated in the military UHF and X-bands.[327] In addition, the U.S. Government has procured or leased the following commercial satellite systems or products:

- In 1990-91, in Desert Storm, the U.S. Government used commercial satellite communications services and purchased remote sensing imagery from the French company, Spot Image.

- In 1995, the U.S. Navy purchased over two million minutes on the INMARSAT system for narrowband voice and data services to transmit medical data and supply orders.

- In 1996, the U.S. Government used leased capacity on the INTELSAT satellite system as part of a VSAT data network for field commanders in Bosnia and in 1999, leased capacity on an expedited basis for voice, Internet access and videoconferencing in Kosovo.

[323] Ibid.
[324] *2000 RAND Employing Commercial Satellite Communications Study*, 19, *supra* n.322.
[325] *See 1999 prepared Statement by Dr. John J. Hamre*, 278, *supra* n.47.
[326] Ibid., 294.
[327] *2000 RAND Employing Commercial Satellite Communications Study*, 19, n.19, *supra* n.322.

- The U.S. Army Trojan program has used a commercial satellite system to send communications to Department of Defense locations in the United States and Europe, as well as to Department of State locations overseas.

- On December 5, 2000, the Department of Defense awarded new Iridium Satellite LLC a $72 million contract for 24 months of satellite communications services.[328] In early 2001, Iridium is expected to offer a secure voice capability for existing and new users registered to the Department of Defense gateway, other federal agencies and selected allied governments.[329]

- The Department of Defense currently leases capacity from New Skies Satellites, N.V., a Netherlands company, for communications between the United States and Southwest Asia, as well as in Bahrain and Kuwait.

As government demand for satellite capacity has increased and commercial systems have evolved, government utilization of the commercial satellite sector has received greater attention, particularly regarding commercial satellite imagery, which has developed significantly. In addition to the services and products they provide, commercial systems also are beneficial because they already have orbital locations (in the case of geochronous satellites) and experience working with foreign countries to obtain requisite government approvals to receive and transmit signals to and from foreign countries.[330]

[328] "News Release," No. 729-00, Office of the Assistant Secretary of Defense, Department of Defense,
6 December 2000. The Iridium system will address Navy requirements, which are "more than twice the current capability," as well as support Special Forces operations and combat research and rescue activities. The contract includes options, which if exercised, would extend the contract to December 2007, at an increased value of $252 million. The Department of Defense states that it entered this arrangement because "the Iridium system offers state-of-the art technology… on-satellite signal processing and inter-satellite crosslinks allowing satellite-mode service to any open area on earth … mobile, cryptographically secure telephone service … at substantially cheaper rates." The system also "'will enable real civil/military dual use, keep us closer to the leading edge technologically, and provide a real alternative for the future.'" Ibid.

[329] On December 15, 2000, Globalstar LP, filed a protest with the Government Accounting Office (GAO) alleging that the Department of Defense failed to seek an open competition prior to awarding the Iridium contract. GAO is scheduled to rule on the protest on March 26, 2001. Jeremy Singer, "DISA Is Confident Pentagon's Iridium Contract Will Hold," *Space News*, 8 January 2001, 4.

[330] *2000 RAND Employing Commercial Satellite Communications Study*, 30 and n.13, *supra* n.322.

The feasibility and utility of using commercial satellite services and products has been part of numerous studies in recent years, some of which Congress, the Department of Defense or the Armed Services have conducted or authorized.[331] The following section discusses some of these studies and related issues.

B. Commercial Communications Satellite Services

The Department of Defense and the Air Force initiated satellite communications several decades ago.[332] Since then, satellite communications have become "an integral part of military operations—from transmitting a common operational picture to allowing rear-area units to perform otherwise-impossible logistical and intelligence functions."[333]

The Department of Defense satisfies about 60% of its satellite communications needs with commercial satellite systems.[334] The U.S. Air Force estimates that it currently relies on commercial systems for about 50% of its military satellite communications needs and that this figure will rise to 75% in the coming years.[335] According to the *2000 RAND Employing Commercial Satellite Communications Study*, however, "In the near term, there are not enough military systems to satisfy projected communications demand and commercial systems will have to be used. In the future, budgetary pressures will make it difficult for the services to satisfy the projected communications demand with dedicated military assets."[336] The study also finds that although about half of the Department of Defense's projected military satellite communication capacity needs

[331] *See, e.g., 2000 NIMA Commission Report, supra* n.125; *Commercial SATCOM Advisory Group Findings &Recommendations,* National Security Space Architect Briefing, 11-12 July 2000; *2000 RAND Employing Commercial Communications Satellite Study, supra* n.322; "Prioritizing Army Space Needs, " Army Science Board Summer Study, Final Report (1999); "Commercial Space Opportunity Study," Final Report, Department of the Air Force, 16 February 2000. (*CSOS Study*); Jeremy Singer, "Navy Pushing Commercial Satellite Communications," *Space News*, 7 August 2000, 1; "Military Satcom: A Delicate Balance of Interests," *Via Satellite*, July 2000, S10 (*Via Satellite Military Satcom*).
[332] *2000 RAND Employing Commercial Satellite Communications Study,* 5, *supra* n.322.
[333] Ibid.
[334] *2000 RAND Employing Commercial Satellite Communications Study,* 18, *supra* n.322. *See also Via Satellite Military Satcom,* S10 (according to U.S. Space Command in 1998, "[a]round 60 percent of the military bandwidth we use today comes from the commercial sector"), *supra* n.331.
[335] Peter B. de Selding, "U.S., Britain Differ on Use of Satellite Vendors for Defense," *Space News* 4 December 2000, 4.
[336] *2000 RAND Employing Commercial Satellite Communications Study*, 1, *supra* n.322.

from now until 2010 are for high bandwidth communications, currently programmed military satellite communications systems will not satisfy the demand.[337]

The Defense Information Systems Agency (DISA) is the Department of Defense's lead Agency for leasing commercial satellite services.[338] DISA's mission of providing services is highly dependent on both Department of Defense-owned and commercially-leased satellite communications and support. DISA works closely with the commercial satellite industry to understand the current and emerging systems and services in order to provide the best support to DISA's customers, which include the Armed Services, the CINCs, Department of Defense agencies and the White House Communications Agency. DISA's "TELEPORT Program" leverages existing and emerging military and commercial satellite communications systems.[339]

Several of the studies mentioned above evaluate the viability of using commercial satellite systems.[340] Some of the studies provide satellite need estimates, delineate requisite national security safeguards that must be met for specific operations and explore procurement options and alternatives. Sample eligibility criteria are: sufficient satellite capacity, proper geographic coverage, operational flexibility, interoperability with Department of Defense systems and ground equipment, access to communications services when needed, quality services that meet industry standards or military specifications for reliability and sufficient protection against attack, jamming and other national security risks.

As the studies explain, commercial systems complement military satellites. Commercial systems are not feasible for certain defense and intelligence functions. "Current and planned commercial satellite services will not support some of the Navy's unique requirements, such as communicating with forces under heavy jungle foliage or inside urban

[337] Ibid., xv.
[338] DISA does not operate space systems, but uses space systems to provide support.
[339] DISA currently has a multi-year contract with Lockheed Martin (formerly the COMSAT Corporation) called the "Managed Transponder Contract." That contract provides for annual leases of full transponders for world-wide, wideband commercial communications satellite services to the Department of Defense. DISA also has contract vehicles to meet short-term service needs and is expanding its commercial satellite service contracts. In addition, DISA evaluates commercial technologies and explores their applicability to follow-on Department of Defense satellites such as the Wideband Gapfiller Satellite.
[340] *See, e.g., 2000 RAND Employing Commercial Satellite Communications Study, supra* n.322; *Army Science Board 1999 Summer Study, supra* n.331; *Via Satellite Military Satcom,* S10, *supra* n.331.

buildings."[341] In addition, commercial capacity must be able to provide timely access to information that can be communicated rapidly; "there is an implied expectation that the military will have access to whatever type and amount of communications it requires to support operations."[342]

The *Army Science Board 1999 Summer Study* recommends that "the Army should continue and expand its efforts to exploit commercial systems and space-related technologies."[343] Additional recommendations for utilizing the commercial satellite sector are:

- Evaluate commercial options on a case-by-case basis, taking into account factors such as mission objectives, national security criteria, cost, projected viability of the particular commercial satellite service and feasibility of technological alternatives (e.g., terrestrial wireless or fiber-based systems).

- Consider early U.S. Government involvement as a customer so that commercial satellite system designs can properly address U.S. Government requirements.

- Consider anchor tenancy and other alternative lease arrangements that encourage availability of commercial capacity for U.S. Government use (e.g., commit to purchasing set amount of future service in exchange for commercial company incorporating features to satisfy military requirements in its system design).

- Encourage commercial development of interoperable systems and of hardening and other requisite national security protections. For example, Globalstar, a mobile satellite service provider, reportedly is studying ways to improve encryption, resiliency and compatibility and ways to increase mobility by reducing the size of ground stations and employing truck-mounted gateway facilities.[344]

[341] Jeremy Singer, "Navy Pushing Commercial Satellite Communications," *Space* News, 7 August 2000, 1.
[342] *2000 RAND Employing Commercial Satellite Communications Study*, 6, *supra* n.322.
[343] *Army Science Board 1999 Summer Study,* 48. The study also recommends that "it is imperative that the Army establish a funded program designed to understand all aspects of the commercial space industry, to learn how to best translate military requirements into commercial capabilities, and to develop an optimal procurement model which points the most efficient way to acquire needed capability." Ibid.
[344] Sam Silverstein, "Globalstar Considers Mobile Gateways," *Space News,* 27 November 2000, 1. Reportedly, according to Globalstar, if developed, these advancements would enable phone calls and data transmissions to bypass the commercial earth stations (gateways) that link the satellite system with terrestrial telephone networks. Ibid.

- Consider alternative lease length terms that make the U.S. Government a more desirable customer.

C. Commercial Satellite Imagery

The U.S. Government may obtain satellite imagery for defense and intelligence purposes either from its own satellites (generally those built and operated by the National Reconnaissance Office) or by purchasing satellite imagery on the commercial market. Since the U.S. Government used commercial imagery in the Persian Gulf War and Kosovo conflict, commercial imagery has improved. Today, the U.S. Government could request commercial remote sensing satellite imaging from a rented trailer in theater and in less than 20 minutes receive an image of a place on the earth in one-meter resolution and bulk imagery is available at discounted prices. As discussed above, recently, commercial providers have been licensed for half-meter imagery, which allows the human eye to see objects as small as an automobile. The U.S. Air Force is now the largest customer of commercial imagery in the world.

NIMA has the statutory responsibility for purchasing all commercial imagery and geospatial products. It also contributes to the policy processes by which the government regulates the commercial imagery industry. A Congressionally-chartered Commission found in a December 2000 Report that NIMA "has been characterized as an unreliable partner."[345] The NIMA Commission made several recommendations regarding NIMA's role, including that: NIMA should advocate commercial imagery, especially where it satisfies a unique need and/or offers unclassified information–sharing opportunities; there should be a senior officer responsible for NIMA's commercial imagery program; users should be empowered to make their own decisions; a commercial imagery fund (which NIMA could administer for the Department of Defense) should be available for end-users to buy raw imagery and a vendor's value-added offerings; there should be a policy review and coherent strategic direction for the use and reliance upon commercial products under the Future Imagery Architecture;[346] and NIMA should play a stronger advocacy role for commercialization, especially in light of consumer demand.[347]

[345] *NIMA Commission Report*, 60, *supra* n.125.
[346] FIA is the next complete constellation of imaging satellites distinguished by their greater numbers and larger pictures.
[347] *NIMA Commission Report,* 55-60, *supra* n.125.

The *Army Science Board 1999 Summer Study* recommends that the Army "[d]evelop an understanding of the availability and use of commercial imagery to support Army tactical users… . includ[ing] not just intelligence and engineering functions but also logistics and other support functions." In addition, the study recommends that the Army determine how commercial imagery systems could supplement standard weather satellite systems to improve forecasting methods, noting that the "Integrated Meterological System should include access to commercial products."[348] Finally, the *Army Science Board 1999 Summer Study* recommends that the Army address tactical needs "by ensuring that commercial geospatial workstation technology is rapidly moved to the field to supplement traditional NIMA products with tailored products that combine terrain data from commercial and other sources."[349]

IX. Conclusions and Recommendations

A. Conclusions

Commercial satellites provide valuable services in the United States and the world. These services allow businesses to operate, people to communicate and governments to serve the public. They also facilitate provisions of communications services provided mainly by other technologies.

Commercial satellite services contribute to U.S. national security in several ways. They provide satellite services and products to the U.S. Government for carrying out national security missions. In addition, use of commercial satellite services and products frees use of government satellites for other defense and intelligence missions more suited for government operation. Commercial satellites provide critical infrastructure to the nation as a whole, support U.S. industry and provide telecommunications and other services to U.S. users. In addition, the sector contributes to the U.S. economy and enhances the space leadership position of the United States in the global space market. Though difficult to quantify in dollars, the value of commercial satellite services to the United States can be measured in different ways: saved lives (voice communications in theater; emergency telephone call in rural parts of the

[348] *Army Science Board 1999 Summer Study*, 48-49, *supra* n.331.
[349] Ibid.

United States); enabling other applications (e.g., satellites enable over-the-air broadcasts); and competitive effects of availability of satellite alternatives (direct broadcast television as effective competitor to cable television, reducing prices and improving programming in cable and DBS markets).

There are several U.S. national security benefits in leveraging the commercial space sector. Greater use of commercial satellite services and imaging products will help solidify the position of U.S. companies in a fiercely competitive international market. Doing so will increase availability of alternative satellite providers and innovative technologies, increasing options for all U.S. consumers, including the U.S. Government. Given the increasing demand for communications and information capabilities, the U.S.Government should continue to pursue commercial options, subject to mission purpose, cost effectiveness and other appropriate factors. At the same time, the Department of Defense should continue to own and operate its own satellite systems to meet unique and critical military needs, as well as because of uncertain economic and market trends.

Though space has been a part of U.S. foreign and military policy for decades, today's combination of greater U.S. reliance on space and international use of space elevates space to an even higher level of importance. Satellite services are integral to American life and commerce, as well as to the national security of the United States. They provide enormous opportunities for growth and for the United States to safeguard the nation's security. At the same time, however, they create vulnerabilities. To be dependent is to be vulnerable. The United States relies more heavily on satellite services than any other country in the world. Satellites are part of the national's critical infrastructure and there are thousands of U.S. satellite ground stations on the earth. Space is within the reach of more nations. Through increased openness and globalization, other countries are gaining greater access to space-based technologies and prominence in the international regulatory environment. Increased capabilities of other countries also creates risks to U.S. national security interests.

To continue to further U.S. national security space objectives, including leveraging the commercial satellite industry, the United States must provide strong U.S. leadership and effective interagency coordination. It also must actively shape the U.S. and international legal and regulatory environment, promote competition in the global commercial satellite services market, and as appropriate, seek international cooperation.

B. Recommendations

To further U.S. national security space objectives, including ensuring U.S. national security and leveraging the commercial space sector, the U.S. Government should consider the following recommendations:

- In developing policies regarding U.S. national security, consider the role of the commercial space sector in national security and the implications of any policy (e.g., prospective effect of remote sensing policies on commercial interests; implications of hostilities in space for the commercial satellite sector; effect of foreign ownership and foreign facilities limitations on competitive commercial space sector and U.S. companies).

- In developing policies regarding the commercial space sector, consider U.S. national security and the implications of any policy (e.g., prospective effect of remote sensing policies on national security; effect of foreign ownership and foreign facilities limitations on national security).

- Use more expeditious licensing processes while safeguarding U.S. national security interests. Establish regulatory policies that encourage rather than restrict the availability of space products worldwide, while maintaining U.S. technological lead.

- Given the vital role of space in U.S. national security, provide for national-level guidance that establishes space activity as a fundamental interest of the United States.

- To assure that the United States continues its leadership role in space, a space advisory group could provide independent ideas to the President on ways to capitalize on the nation’s investment in people, technology, infrastructure and capabilities in all four space sectors.

- Establish a process to ensure that national-level policy guidance is carried out among and within the relevant agencies and departments. To this end, a standing senior interagency group for space within the National Security Council structure could serve to provide a deliberate, coherent approach to the implementation of national space policy and coordinate national security space matters government-wide. The group could focus on the most critical national security space issues, including those that span the civil and commercial space sectors. The group could have staff support that provides experience across the four space sectors.

- Consider designating a high-level staff responsibility within each U.S. Government agency that has jurisdiction over commercial space and/or national security issues to support the highest-level position in the agency responsible for national security issues. This staff function could include developing and implementing policy; creating initiatives for leveraging the commercial space sector for national security purposes; coordinating with the Department of Defense and other federal agencies; and serving as a liaison with industry.

- Consider that a centralized interagency process could leverage the collective investment in the commercial, civil, defense and intelligence sectors to advance U.S. capabilities in each and account for the increasingly important role played by the commercial and civil space sectors in the nation's domestic and global economic and national security affairs.

- Participate actively and on an on-going basis in the U.S. and international legal and regulatory environment to further U.S. national security space interests, including the commercial space sector. Shape the environment by initiating proposals and advocating changes as appropriate.

- Become a more reliable customer of commercial space products and services. Continue to pursue use of commercial satellite services for U.S. national security purposes as appropriate.

- Implement procurement policies that provide flexibility for the U.S. Government and make the U.S. Government a more reliable and viable customer.

X. Summary

In the days of Galileo, discoverers relied on the constellations to explore the earth. As Daniel Boorstin wrote in The Discoverers:

> The vast sameness of the oceans on the surface naturally drove sailors to seek their bearings in the heavens, in the sun and moon and stars and constellations. They sought skymarks to serve for seamarks… . With the aid of the newly invented telescope fixed on the heavens, … men discovered the seas, charted the oceans, and defined new continents.[350]

Four hundred years later, today, men and women continue to make new discoveries about space and earth through space. People worldwide are using space-based technologies and services to explore, conduct business, govern, teach, learn and defend their nations. More countries are discovering the virtues of space and developing the economical and technological means of using it. The United States relies on—and benefits from—space applications more than any other nation in the world. Thus, satellites in space are integral to U.S. national security, infrastructure and livelihood.

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[350] Daniel J. Boorstin, *The Discoverers* (Vintage Books 1983), 47.

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