# Chapter 6:

## The Commercial Space Industry: A Critical Spacepower Consideration

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Spacepower is a function of multiple factors including military, civil, and commercial space capabilities. Without considering all three capabilities, formulation of thought on spacepower would fall short of reality. The commercial space industry is an evolving part of global space activity and is driving innovative technologies and applications in conjunction with government missions. It is critical to understand the major characteristics of the commercial space market, not only because the size of the industry and its technical applications have a great effect on the global economy, but also because the assets and services of commercial space are often used by government customers.

Two major industry themes exist that affect issues of national interest. First is the interdependence between commercial industry and government space. Without the activities of one, the other would be operationally deficient. A second theme is the existence of government incentives and impediments that influence the landscape of the commercial space industry and its contributions to national goals. These themes will be examined in this chapter.

The following sections provide insight into the space industry and activity in the commercial market for space products and services. The commercial industry, although an interconnected whole, is defined by four major components: satellite services, satellite manufacturing, launch services, and ground equipment. Breaking down the industry by sector provides a better understanding of the major trends and wide-ranging components that make up commercial space. An explanation of market activity, major players, and other critical characteristics of each sector is provided, followed by an outlook for the future commercial space industry and its implications for spacepower.

### Historical Overview

Aerospace and other companies have been involved in the space industry since the beginning of the space age, initially as contractors to government programs. However, the commercial space industry did not emerge in its current recognizable form until the 1980s. Growing demand for satellite communications, particularly television broadcasting, provided new business for satellite manufacturers and led to the creation of new companies to provide satellite services. At the same time, changes in U.S. national space policy in the wake of the space shuttle *Challenger* accident, as well as the emergence of competition from Europe's Ariane launch vehicle, stimulated the development of a domestic commercial launch industry.

The commercial space industry continued to grow through the 1990s, in part due to increasing demand for broadcasting and other communications services, but also because companies sought to branch out into other areas, from mobile communications to remote sensing. This growth, fueled by billions of dollars of investment in new ventures such as Globalstar, Iridium, and Teledesic, created optimistic forecasts for continued future expansion into the next decade and led to investment in new commercial launch ventures, including companies that planned to develop reusable launch vehicles that would greatly reduce the cost of space access. However, by 2000, many of these new ventures were struggling: new communications companies found it difficult to compete with low-cost terrestrial alternatives, deterring other ventures from starting up and causing a ripple effect that reduced demand for satellite manufacturing and launch services. The industry retrenched for several years, falling back on its core, relatively mature satellite communications markets. However, entrepreneurs continue to explore new commercial space markets, with suborbital and orbital space tourism now one of the leading areas of interest.

## Industry Sectors: Satellite Services

### Market Overview

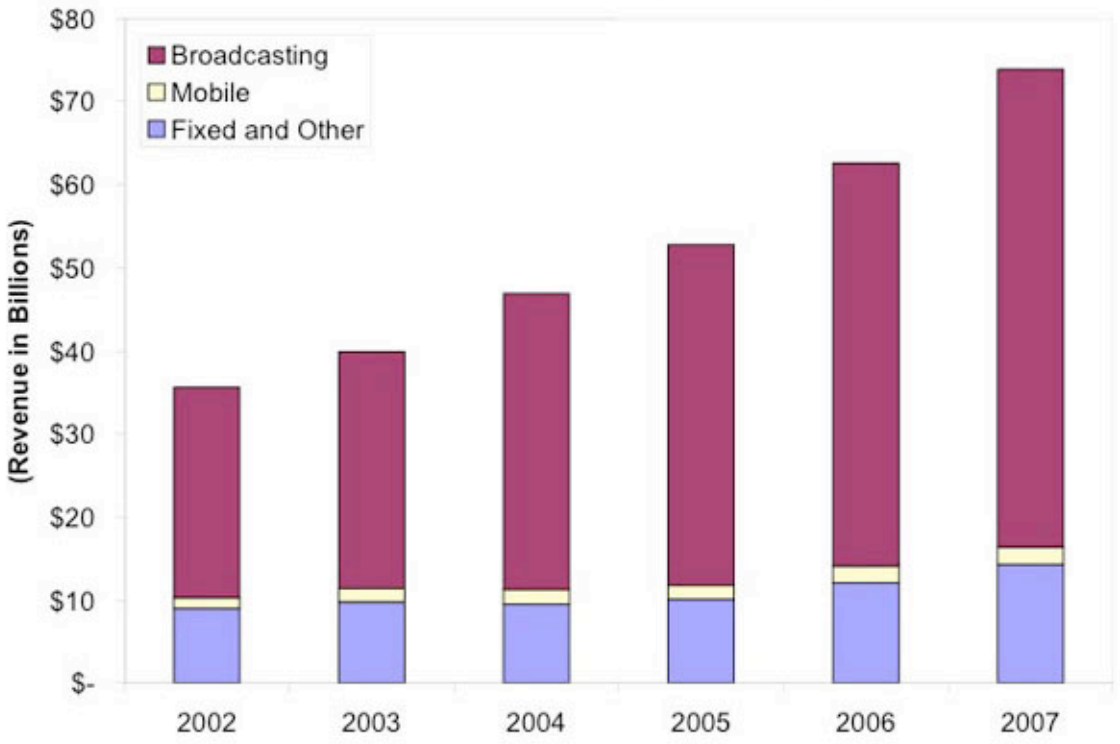
The satellite services sector refers to communications and remote sensing provided by commercially owned or operated satellites. Three categories define the sector, based upon the type of service being offered: fixed satellite service, mobile satellite service, and direct broadcast service. These categories include lease and purchase agreements for on-orbit transponders, retail or subscription services (such as direct-to-home [DTH] television and digital audio radio service), and commercial satellite remote sensing.

Since the earliest stages of the space age, commercial companies have provided services through the satellites they own or operate. In the early 1960s, the first satellite communications systems for commercial use were developed. The Telstar program produced the first active communications satellite, launched in 1962, that was developed using government-industry cooperation between the National Aeronautics and Space Administration (NASA) and AT&T. In 1965, the first commercial communications satellite was launched, the Communications Satellite Corporation's Early Bird, which acted as a line-of-sight communications repeater between North America and Europe. This satellite demonstrated the feasibility of geosynchronous satellite communications, which is the mainstay of the satellite services sector today. Satellite operators have proliferated worldwide and provide satellite communications capabilities in nearly every part of the globe while developing innovative technologies that expand available services.

Commercial satellite remote sensing operators have also developed a presence in many parts of the world and have continually improved satellite imagery services. Growth in this market has not been as significant as in communications. Remote sensing providers serve the geospatial information services market and supply overhead intelligence to governments worldwide.

The satellite services sector is larger than any other sector in the commercial space industry and has experienced sustained growth from 2002 through 2007. As figure 6–1 shows, estimated worldwide revenues earned by satellite service providers grew from 2000 to 2005, despite increasing global deregulation that has increased price competition, resulting in decreasing revenues per transponder during this period.[1]

**Figure 6–1. World Satellite Services Revenue by Service Type, 2002-2007**




Regulation plays a significant role in shaping the satellite services sector. The industry is licensed by regimes that differ according to the type of service provided and the geographical location of the company or of the service provided. Individual countries have the responsibility to allocate bandwidth and regulate the use of particular satellites within national borders (or *landing rights*) in the communications and remote sensing sectors. In the United States, the Federal Communications Commission regulates satellite communications, while the National Oceanic and Atmospheric Administration in the Department of Commerce regulates commercial satellite remote sensing operators. Two documents that provide the foundation of regulatory guidance in the United States are the Communications Satellite Act of 1962 and the 1992 Land Remote Sensing Policy Act.

Similarly, other countries have regulatory entities that levy rules on commercial service providers within their jurisdiction. Because regulatory regimes vary from country to country, this creates additional complexity and potential difficulty for companies seeking allocated bandwidth and landing rights in a given country.

**Key Satellite Service Providers**

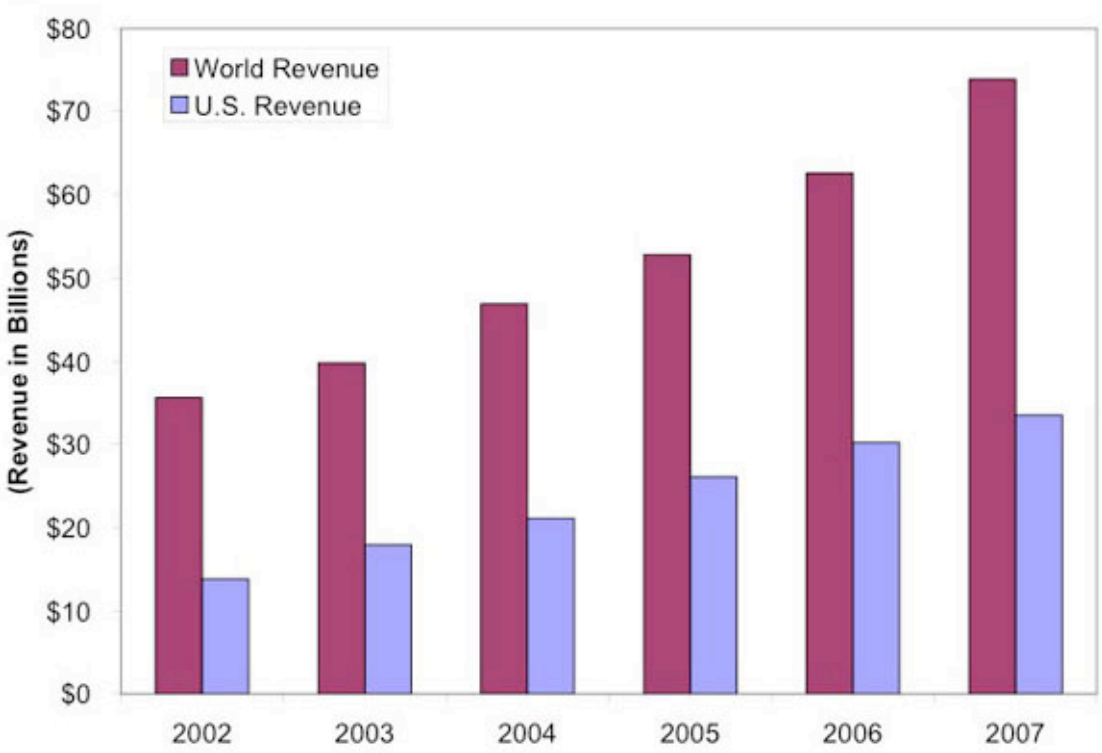
The satellite services sector is composed of numerous global and regional companies providing various services to most regions of the world. Select companies with the greatest impact on the market for different types of services are listed in table 6–1. The services are an integral part of personal and business activity globally, as well as government communications and intelligence collection. For this reason, commercial satellite assets are critical infrastructure that promote economic growth, sustain well being, and enhance security.

**Table 6–1. Significant Worldwide Satellite Services Companies**

| FSS | MSS | DBS | DARS | Remote Sensing, U.S. | Remote Sensing, Non-U.S. |
|---|---|---|---|---|---|
| Eutelsat | Globalstar | DirecTV | Sirius Satellite Radio | DigitalGlobe | ImageSat International |
| Intelsat | Inmarsat | DishTV | WorldSpace | GeoEye | Infoterra |
| SES Americom/New Skies | Iridium | EchoStar | XM Satellite Radio | | MDA Geospatial Services |
| Telesat | Thuraya | | | | RapidEye |
| | | | | | Spot Image |

The size of this sector, in terms of worldwide revenues by satellite services companies, exceeded $70 billion in 2007. Companies based in the United States play a significant role in this sector: about 45 percent of 2007 revenue can be attributed to U.S. companies (see figure 6–2).Moreover, from 2002 to 2007, these U.S. companies maintained a relatively steady percentage of all satellite services revenue, ranging a low of 39 percent to a high of 49 percent in 2007.[2]

**Figure 6–2. World versus U.S. Satellite Services Revenue, 2002-2007**



In addition to the companies that own and operate satellites, private equity firms are playing an increasingly important role in this sector. This trend is particularly the case in the U.S. market; the effect of private equity in the sector varies by location. Private equity firms are purchasing satellite assets at an increasing pace, which could potentially affect the future landscape of the entire industry. The long-term nature of satellite planning is in conflict with the short-term business nature of the private equity planning horizon. Absent the traditional longer term technology development focus, this could affect the procurement of future satellites if there is insufficient attention to recapitalization and investment in physical assets. In this case, the business environment of commercial services could affect whether there is sufficient capacity available to government and nongovernmental customers.

**Industry Sectors: Satellite Manufacturing**

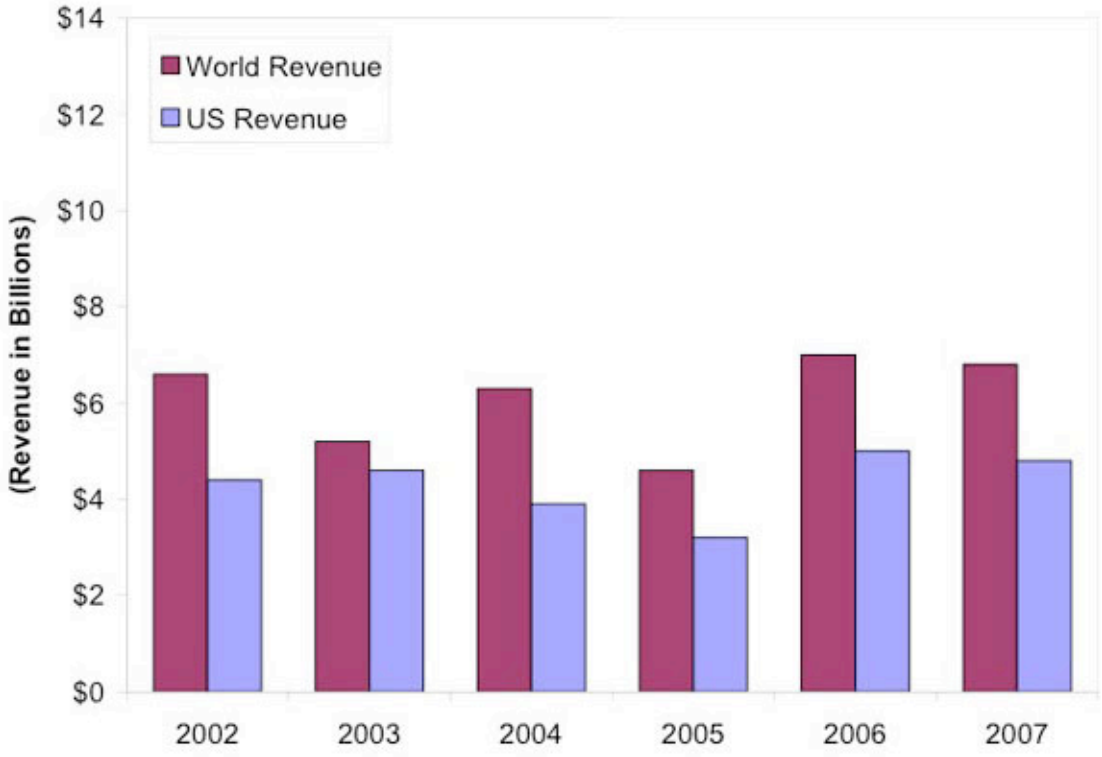
**Market Overview**

The commercial satellite manufacturing sector, historically dominated by a handful of American and European firms, has diversified both geographically and technologically in the past decade. A host of Asia-Pacific companies has entered the market. Meanwhile, European companies have partnered to take advantage of market opportunities created by U.S. export regulations, which are generally perceived to have precipitated a decline in the U.S. share of the market. Established and new satellite manufacturers, both in the United States and abroad, have sought competitive advantages in technologies such as small satellites, customizable modular bus designs into which standardized interoperable payload components can be inserted according to the desired function of the satellite (known as *plug-and-play* modular buses), and advanced remote sensing, imagery, and communications instrumentation.

One driving force behind this internationalization and specialization of the satellite manufacturing sector has been the changing levels of demand.Traced over the past decade (1999–2008), the financial performance of the satellite manufacturing sectors forms a U-curve:a marked decline, a period of leveling, followed by a resurgence.In the late 1990s, surging Internet usage and the need for increasingly sophisticated, globally available communications services fueled expectations that many fleets of new satellites would be needed. Instead, the telecom bubble burst, and satellite manufacturers have since competed for a limited number of contracts. Non-geosynchronous orbit (NGSO) communications ventures such as Globalstar and Iridium experienced financial failures and both underwent extensive restructuring before returning to their current operational status.During this period, geosynchronous Earth orbit (GEO) commercial providers ordered fewer replacement satellites, opting instead to consolidate their fleets and to invest only in maintaining or replacing spacecraft as required to preserve their current constellations.However, after several years of shrinking demand, beginning in 2006, satellite manufacturing revenues began to rebound.After falling from $11 billion in 2002 to $7.8 billion in 2005, satellite manufacturing revenues rose sharply to $12 billion in 2006.This trend was sustained in 2007 with satellite manufacturing revenues of $11.6 billion recorded.

Importantly, the slight drop between 2006 and 2007 was due not to fewer satellites being produced for launch but rather to the decrease in the average mass of the satellites launched in 2007.This highlights another trend in the satellite manufacturing market, the growing importance of small satellites, or *smallsats*, which will be discussed later in this section (see figure 6–3).[3]

**Figure 6–3. Worldwide Satellite Manufacturing Revenues, 2002-2007**




Despite the recent resurgence in satellite manufacturing revenues, the deep global recession that began in 2008 and continued in early 2009 will likely impact the satellite manufacturing sector. There is typically a period of many months, often extending to years, between completion of a satellite manufacturing contract and delivery of the satellite. This gap means satellite manufacturers usually have a backlog of contracts. When the recession began, satellites manufacturers were building spacecraft ordered before the global downturn; many had very high backlogs in late 2008 and early 2009. The duration of the recession can create a risk that fewer new satellite orders will be placed overall, despite the ability of some major players to accelerate purchases opportunistically during this period of market contraction. For this reason and the ongoing difficulties in the credit markets, satellite manufacturing could suffer from a delayed recession impact, leading to a potential contraction in manufacturing revenues in 2010 and beyond.

In response to this tightening market, manufacturers in China, India, and other Asian countries have sought to compete on a price basis. Asian manufacturers benefit from a large pool of skilled low-cost labor and maintain considerable, but nontransparent, collaborative relationships with government-funded space agencies and science institutes in their home countries. These factors keep costs low and create mechanisms for leveraging public sector research and development resources toward commercial ends, enabling Asian manufacturers to offer satellite buses on the world market at comparatively lower rates.

Meanwhile, U.S. companies, stimulated partly by government-sponsored responsive space and other initiatives, have pursued a technological edge. They have invested in facilities to develop smallsats, which can offer the same functionality as larger satellites at a fraction of the cost. Interest in smallsats has also prompted U.S. manufacturers to explore plug-and-play technology.

The global market has been slower to adopt the smallsat concept, and despite the technical advances, U.S. manufacturers have experienced declining market share since the beginning of the decade. In 2000, 51 percent of worldwide satellite manufacturing revenues went to U.S. companies. By 2007, this proportion had decreased to 41 percent. The industry consensus is that a significant portion of this decline has been caused by U.S. Department of State International Traffic in Arms Regulations (ITAR) controls, which make it difficult and sometimes impossible for U.S. manufacturers to build satellites for or provide components to foreign clients.

The application of ITAR regulations has become a subject of consternation in this U.S. commercial space sector. From component suppliers to bus providers and payload integration companies, all tiers of the American satellite manufacturing sector have seen their global market potential reduced by ITAR restrictions. As American firms have explored state-of-the-art technologies to gain a market advantage, European, Russian, and other international firms have specialized by marketing satellites that are not subject to ITAR controls. These export control rules, which were designed to protect U.S. technology, have created a market based solely on avoidance of the controls. Among the most prominent examples is the case of Chinasat-8, a communications satellite serving the China Satellite Communications Corporation (Chinasat) of Beijing. In 1998, Loral Space and Communications, a U.S. manufacturer, completed construction of Chinasat-8 but was prevented by ITAR rules from exporting it for launch aboard a Chinese Long March vehicle. The satellite remained in storage for 6 years while Loral sought export approval from the Department of State. Loral's efforts were ultimately unsuccessful. As a result, Chinasat awarded a $145-million manufacturing contract for the follow-on satellite, Chinasat-9, to Alcatel Alenia Space (now Thales Alenia Space), a European company not subject to ITAR. Thales Alenia has meanwhile also taken the lead in developing an "ITAR-free" satellite whose components are supplied wholly by manufacturers outside the United States. Similar collaborations among international satellite manufacturers in this market space were in various stages of progress as of early 2009.

Cases like Chinasat-8 have prompted a consensus among American satellite manufacturers that by disadvantaging U.S. firms in the global marketplace, ITAR rules harm the national interest more than help it. However, others continue to cite the need to limit technology transfers to possible adversaries. It is important to consider that, now, there are non–U.S. companies providing the international market with technology of equal or better quality than U.S. technology. Against this backdrop of foreign competition and dual-use issues, the debate continues over how best to balance American commercial and security interests as they pertain to satellite manufacturing.

**Key Satellite Manufacturers**

Five companies currently dominate the commercial satellite manufacturing sector: The Boeing Company, Lockheed Martin Commercial Space Systems, and Space Systems/Loral in the United States; and Alcatel Alenia Space and EADS Astrium in Europe. Together, these companies have won approximately three-fourths of announced GEO commercial payload manufacturing contracts in the past decade. The remaining contracts were distributed among a handful of smaller players: Orbital Sciences Corporation in the United States; Khrunichev State Research and Production Space Center, NPO PM, and Energiya in Russia; Mitsubishi Electric in Japan; and the Chinese Academy of Space Technology (CAST).

In addition to commercial GEO satellite contracts, a number of companies manufacture NGSO satellites as well as GEO satellites whose contracts are not openly competed on the commercial market. Other U.S. satellite manufacturers include Northrop Grumman Corporation, Aero Astro, Ball Aerospace, General Dynamics, and several firms specializing in small satellites, such as Instarsat, Microsat Systems, SpaceDev, and Swales Aerospace.

Beyond Thales Alenia and EADS, Europe is also home to smaller satellite manufacturers. Two significant smaller manufacturers are Germany's OHB–System AG and Britain's Surrey Satellite Technology Ltd., one of the world's foremost smallsat builders. Like American firms, European satellite manufacturers often partner and subcontract with one another. Unlike American firms, European manufacturers are not subject to ITAR restrictions, enabling them to collaborate more easily with firms abroad. While European manufacturers are subject to some export controls, European Union rules are not as strict as those of its U.S. counterparts. This has allowed collaboration with Russian and other international firms, including a 2005 accord between EADS Astrium and Antrix, the commercial arm of the Indian Space Research Organization, to jointly address the commercial market.

In Asia, Japanese companies such as Nippon Electric Corporation and Mitsubishi were for many years the only satellite manufacturing market contenders. But in the past decade, Chinese and Indian firms have emerged. In addition to producing a steady flow of payloads for Chinese government and commercial purposes, CAST has contracted to build satellites for the Venezuelan and Nigerian governments and has established ties with Thales Alenia to cooperate in addressing the satellite export market. India's Antrix is

pursuing a similar path, building satellites for domestic Indian clients while enhancing its focus on international customers. The success in February 2006 of the joint EADS Astrium-Antrix bid to manufacture the Eutelsat W2M communications satellite marked India's first major international satellite manufacturing contract. China and India are positioning themselves to compete primarily on a cost basis. If satellite demand begins to stagnate or decline due to the current recession, the price advantages both countries can offer may prove decisive in a tightening market.

Finally, a collection of other international satellite manufacturers occupies small niches within the market. Israel Aircraft Industries and Elbit Systems together manufacture sophisticated remote sensing satellites for Israeli military use. Iran is seeking to build a similar indigenous satellite capability via Shahid Hemmat 1G, a government-funded manufacturer about which little information is known. In South America, Argentina's INVAP, a research incubator sponsored by the government, has attempted to foster a national commercial satellite manufacturing industry with little success thus far. The Korean Aerospace Research Institute has pursued the same goal in South Korea, but despite these efforts, that country has not yet joined China and India as a contender in the commercial satellite manufacturing marketplace. Finally, Canada's MacDonald, Dettwiler, and Associates is seeking to enhance its payload manufacturing offerings.

**Satellite Technologies and Trends**

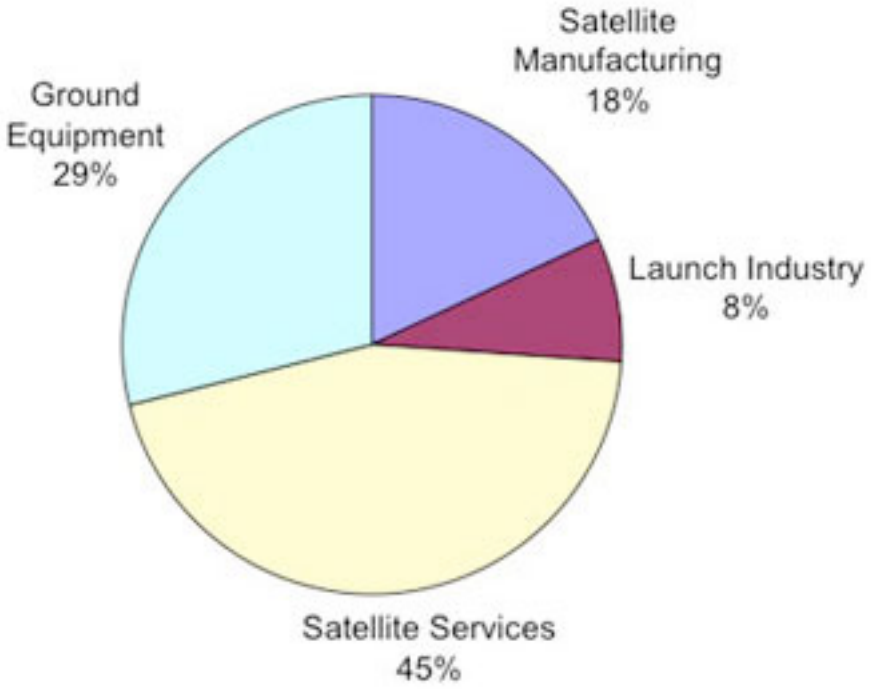
Small satellites are a key emerging technology area in the satellite manufacturing sector. The ability to conduct functions currently handled by larger satellites using smaller, lighter payloads promises to increase payload versatility while reducing manufacturing and launch costs. While smallsats promise advantages due to their launch and operational flexibility, their strategic value has not yet been demonstrated in operational scenarios. The U.S. military has funded the building and test launch of several smallsats, and numerous universities worldwide have designed 1-kilogram cube-shaped satellites for similar experimental missions. These have been used mainly for technology development rather than commercial applications. While there will continue to be military, scientific, and nonprofit interest in smallsat technologies, the manufacturing tempo of small satellites appears unlikely to increase significantly until their commercial viability has been demonstrated.

Other satellite technologies under development also have strategic implications. Several U.S. and international satellite manufacturers continue to produce intelligence, surveillance, and reconnaissance satellites. More recent models of these satellites feature technologies such as synthetic aperture radar, which allow satellites to analyze ground images despite interference from low light and cloud cover, and high-resolution cameras and imagers. Meanwhile, the U.S. global positioning system (GPS) constellation and other navigation systems programs are seeking to bolster future satellites with advanced positioning, navigation, and timing technologies. These technologies will increase the overall accuracy of the satellite navigation systems they serve—including a diverse array of critical military, commercial, and civil applications. Other technologies will be applied

to space surveillance, situational awareness space asset defense, and possibly offensive counterspace.

Despite these high value-added technology developments, the satellite manufacturing sector now contributes proportionately less to the overall economic valuation of the commercial space industry than it did at the beginning of the decade (see figure 6–4). In 2000, revenues from the satellite manufacturing sector constituted 18 percent of worldwide space industry revenues. By 2007, the proportion had shrunk to 9 percent.[4]

**Figure 6–4. Composition of Worldwide Space Industry Revenues, 2002**




Given these market dynamics, the satellite manufacturing sector will likely face growing pressures to adapt to a tightening market in the 2010 timeframe and beyond. Although government requirements will continue to generate demand for new satellites and satellite technologies, the ongoing recession suggests that the recent rebound in the satellite manufacturing sector might be short-lived. The sector appears poised to enter another period of change in which satellite manufacturers with the most diverse portfolios of satellite hardware offerings and capabilities will likely benefit from comparative advantages over their counterparts.

**Industry Sectors: Launch Services**

**Launch Market Overview**

Commercial payloads have created demand for launch services since the early communications satellites of the 1960s. Initially, those launches were provided by government organizations, such as NASA. By the 1980s, a commercial launch industry had emerged with the rise of Arianespace, the European company that markets launches of the Ariane launch vehicle family, and the 1986 decision by President Ronald Reagan to move commercial and many government payloads from the space shuttle to expendable launch vehicles intensified these developments. Competition increased in the 1990s with the introduction of the Chinese Long March and various Russian vehicles to the global market.

The commercial launch sector has experienced wide variations in activity in the last 10 years (see figure 6–5). In the latter half of the 1990s, commercial launch activity surged primarily because of the launch of a growing number of GEO communications satellites, as well as the deployment of three low Earth orbit (LEO) communications systems: Globalstar, Iridium, and ORBCOMM. However, after the telecommunications boom ended in 2000 and the LEO satellite operators filed for bankruptcy protection, launch activity dropped precipitously. Forecasts for launch activity through the middle of the next decade, as generated by the U.S. Federal Aviation Administration's (FAA's) Office of Commercial Space Transportation and the Commercial Space Transportation Advisory Committee, do not foresee a return to the peak levels of the late 1990s, although launch activity is projected to remain above the early 2000s nadir, in part because of efforts to replace the original LEO satellite constellations with new generations of spacecraft (see figure 6–6).[5]

**Figure 6–5. Composition of Worldwide Space Industry Revenues, 2007**

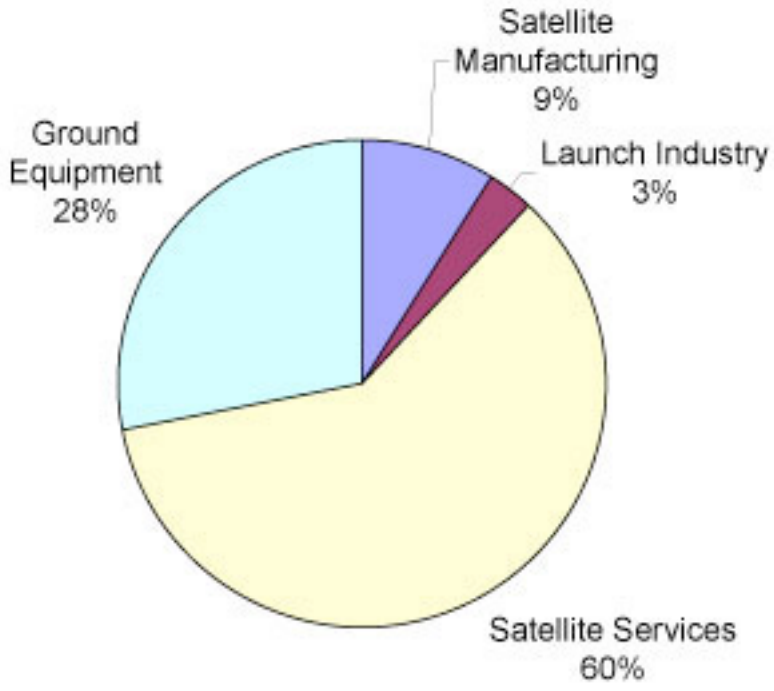
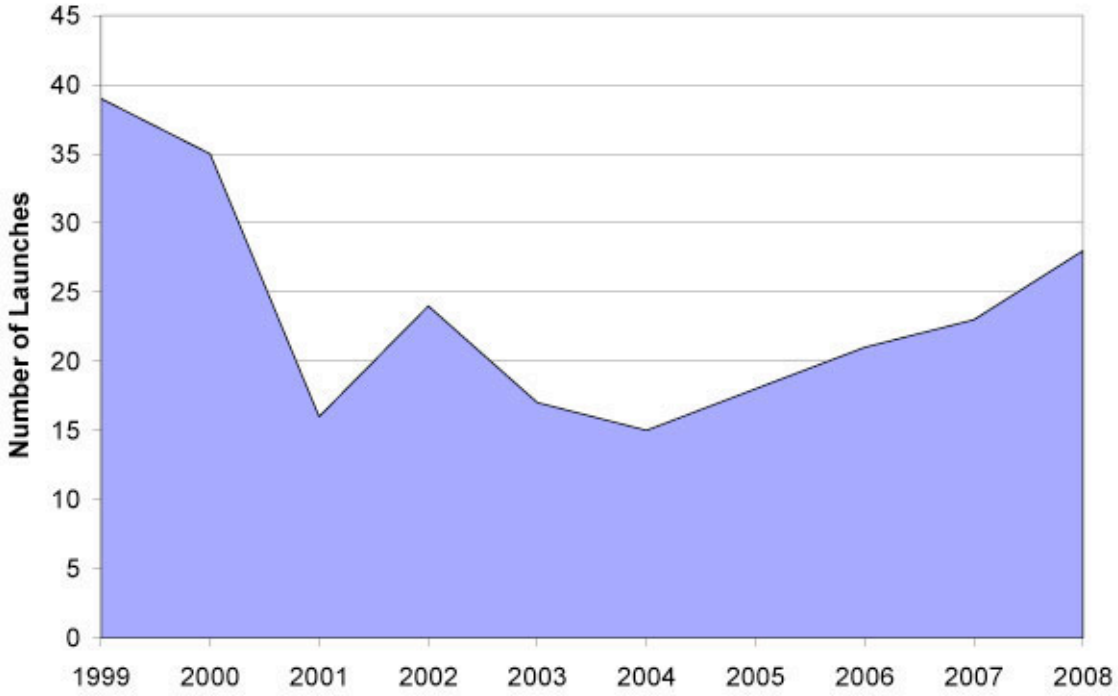
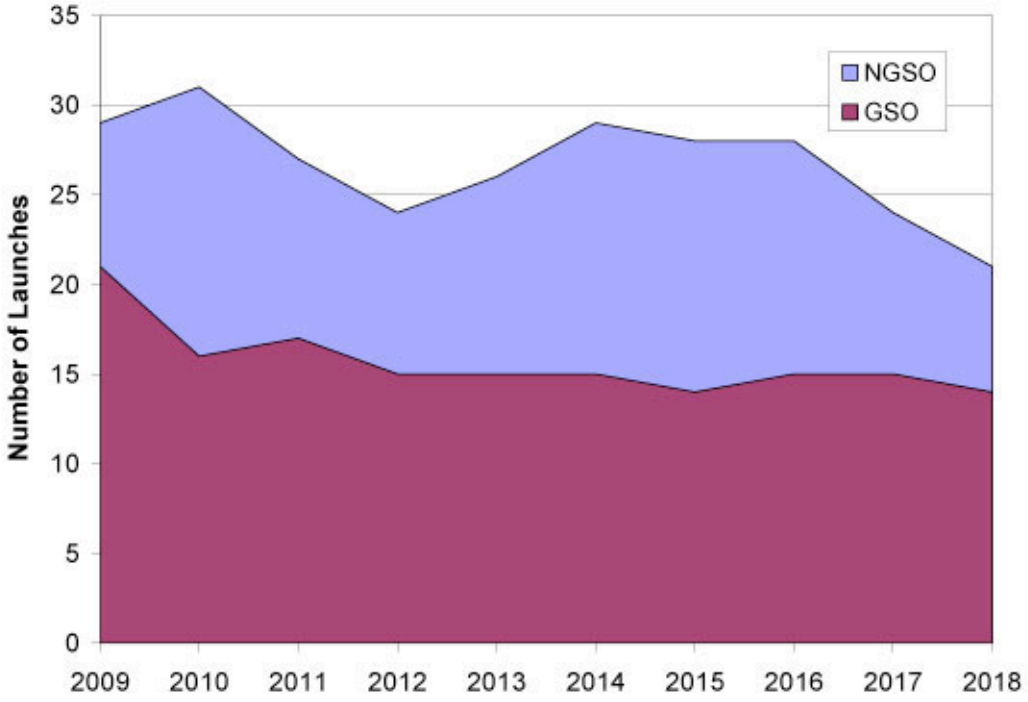


**Figure 6–6. Worldwide Commercial Launches, 1999-2008**



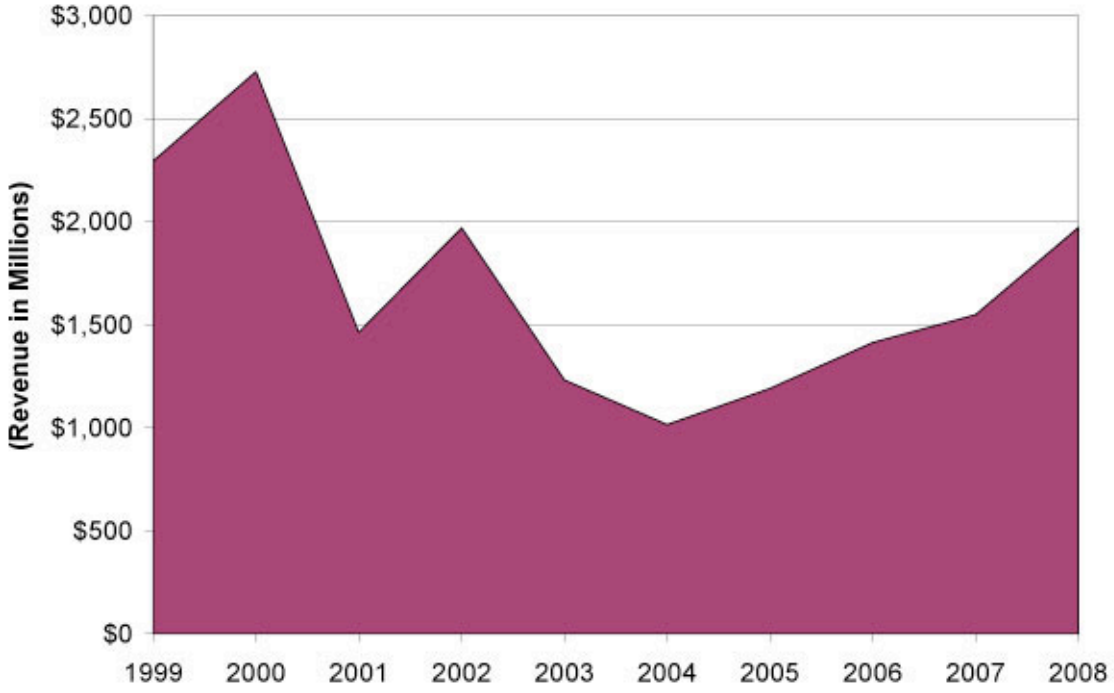

Translating launch activity into revenue for the industry has been notoriously difficult because of the lack of independently verifiable pricing data. Launch services providers, with rare exceptions, do not publish prices for either individual launch contracts or vehicles in general. Anecdotal data suggest that launch prices have varied considerably in the last decade, falling early in the decade because of considerable oversupply in the market but later recovering somewhat because of an increase in demand and short-term supply constraints. By early 2009, there was some evidence of a renewed decline in launch prices, at least by some launch providers. Figure 6–7 provides an approximation of launch services revenue, based on FAA-approved estimates of commercial launch prices.

**Figure 6–7. Commercial Launch Forecast, 2009-2018**




From 1999 to 2008, the U.S. share of the global commercial launch market significantly declined. The United States held a de facto monopoly on the commercial market prior to the entry of Arianespace in the 1980s and maintained a significant share of this market through much of the 1990s.The U.S. share of the commercial launch market fell significantly this decade, however, and has declined even more in recent years (see figure 6–8). Much of the decline has to do with price: while individual purchase decisions are not especially price sensitive (since the cost of launch is only a fraction of the overall cost to build and deploy a large commercial GEO communications satellite), non–U.S. launch vehicles on the market have proven to be both equally reliable and less expensive, providing better service to commercial customers.One U.S. company, Space Exploration Technologies (SpaceX), is attempting to reverse this trend with its Falcon line of launch vehicle that can launch spacecraft at prices significantly below not just other U.S.–built vehicles, but international competitors as well.

**Figure 6–8. Estimated Worldwide Commercial Launch Revenues, 1999-2008**




**Key Launch Service Players**

Three providers currently dominate the commercial launch services market. Arianespace, a French company, provides the Ariane 5 launch vehicle, the only vehicle that offers dual-manifesting for large GEO satellites. Arianespace is also now selling launches on the Russian-built Soyuz rocket, which will begin flights out of the European spaceport in Kourou, French Guiana, in 2010. Sea Launch is a multinational venture led by a U.S. company, Boeing, and includes companies from Ukraine, Russia, and Norway. It offers flights on the Zenit-3SL, a Ukrainian-built launch vehicle with a Russian upper stage that is launched from a mobile launch platform on the Equator in the Pacific Ocean to maximize its performance. A version of the same vehicle, designated Zenit-3SLB, entered service in 2008 from the Baykonur cosmodrome in Kazakhstan under the Land Launch brand.

International Launch Services (ILS) formed in 1995 as a joint venture between Lockheed Martin, Khrunichev, and Energiya. It originally sold commercial launches on the Atlas family of vehicles and the Proton. In October 2006, Lockheed sold its majority stake in ILS to a new venture, Space Transport, and retained commercial marketing rights for the Atlas 5. Space Transport sold its stake in ILS to Khrunichev in 2008. ILS continues to offer the Proton and plans to offer its eventual successor, the Angara, once it enters service.

Boeing withdrew the Delta 4 vehicle from the commercial market in 2003, citing poor market conditions, but continues to sell the smaller Delta 2 commercially for launches of NGSO spacecraft, such as commercial remote sensing satellites. Lockheed Martin offers

only the Atlas 5 commercially, having retired older variants of the Atlas family earlier in the decade. SpaceX successfully flew its small Falcon 1 launch vehicle in 2008 and plans to launch the larger Falcon 9 for the first time in 2009.

Several companies also offer smaller launch vehicles intended for NGSO communications and remote sensing satellites as well as government spacecraft whose launches are procured commercially. These companies include U.S.-based Orbital Sciences Corporation, which offers the Pegasus and Taurus; Eurockot, a German-Russian joint venture that markets the Russian-built Rockot; and Kosmotras, a Russian company that offers the Dnepr, a converted SS–18 intercontinental ballistic missile. Arianespace also plans to market the Vega small launch vehicle currently under development by the European Space Agency (ESA).

Several other countries are interested in entering or reentering the commercial launch market. China, which offered commercial launches on its Long March family of boosters through 2000, exited the market when U.S. export control changes made the transfer of satellites to China for launch effectively impossible. China hopes to be able to reenter the market by providing launches for so-called ITAR-free satellites being developed by European manufacturers, notably Thales Alenia Space, and has won several launch contracts for such spacecraft in the last few years. Japan has expressed an interest in making its H–2A vehicle available to commercial customers. India has sold one commercial launch on its Polar Satellite Launch Vehicle to the Italian space agency for a small astronomy satellite and is seeking commercial orders for its larger Geosynchronous Satellite Launch Vehicle.

Suborbital launch services have traditionally been limited primarily to government markets, from scientific research to missile defense development. However, there has been renewed interest in commercial suborbital spaceflight, primarily for the emerging personal spaceflight (better known as space tourism) industry. SpaceShipOne, a piloted reusable suborbital spacecraft built by Scaled Composites, won the $10-million Ansari X Prize in 2004, helping generate interest in this market. Virgin Galactic has licensed the SpaceShipOne technology and is working with Scaled Composites to develop SpaceShip Two, which is beginning flight tests in 2009 Other entrants in this field include Armadillo Aerospace, Rocketplane Global, and XCOR Aerospace in the United States; PlanetSpace, a joint U.S.-Canadian venture; and Starchaser Ltd. in the United Kingdom.

## Industry Sectors: Ground Equipment

### Market Overview

Satellite ground equipment is an important component in the provision of satellite services. In the early days of satellite communications, ground equipment consisted of dishes dozens of feet in diameter supported by rooms filled with electronics, requiring budgets in the millions of dollars to build, maintain, and operate. Present-day technologies, such as very small aperture terminals (VSATs), miniaturized antennas, and microelectronics, have made DTH television and Internet services and satellite phones

affordable and useful to a wide range of users. In the future, advanced technologies such as laser links and conformal array antennas will bring new capabilities to commercial and defense applications alike.

Ground equipment includes a broad array of devices and components used for satellite communications. Ground equipment can be divided into three major categories: Earth stations, VSATs, and consumer electronics. Earth station components include the equipment required for uplinking and downlinking transmissions to and from satellites and the equipment required to control satellites on orbit. Earth stations usually utilize large aperture satellite dishes capable of high bandwidth data transmission. VSATs provide businesses and other relatively high bandwidth users with flexible, transportable, and cost-effective satellite communications. Consumer electronics include devices employed by end users to receive satellite services for both mobile and fixed applications. In addition, GPS devices are also a part of this sector, using the military satellite signals for positioning by a varied user group. Table 6–2 describes these market segments and their applications.

**Table 6–2. Ground Equipment Market Segments**

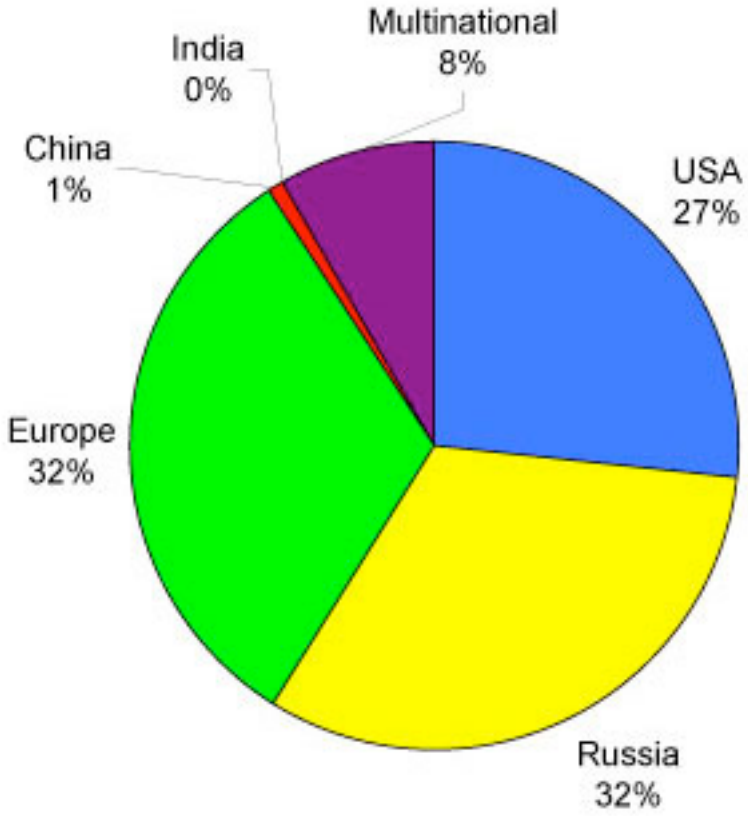
| | Description | Applications | |
|---|---|---|---|
| **Earth station** | Stationary equipment utilized to receive, convert, and transmit data to and from satellites utilized primarily by satellite service providers. | Telephony and internet backbone, television broadcast, defense, etc. | High |
| **Laser link & conformal arrays** | Next generation technologies that allow for high bandwidth, mobile, and versatile satellite | For now, primarily aerospace and defense applications | |
| **VSAT** | Small transportable dishes that can be moved and installed quickly in widely dispersed and remote locations | News trucks, emergency response, oil and gas, rural telephony and internet, defense, etc. | Bandwidth |
| **Consumer electronics** | **Fixed:** Direct-to-home television dishes and set-top boxes, satellite phone booth, etc. | Satellite television/internet, disaster or remotely located communications, etc. | |
| | **Mobile:** Fleet management equipment, GPS receivers, hand-held satellite phones, and satellite radio equipment. | Global asset tracking, entertainment, personal voice communications, defense, etc. | Low |

The large number of countries involved in producing ground equipment makes this segment of the space industry a truly global market. Hundreds of companies from many

countries produce the wide variety of electronic components required to manufacture Earth stations and consumer electronics. The United States was expected to manufacture roughly 20 percent of the approximately 5,300 Earth stations that were to be produced in 2007.[6]

Revenues from the sale of ground equipment have grown for the last 8 years (see figure 6–9). Sales of ground equipment grew by over 19 percent during 2007 versus 2006. The biggest driver of this revenue growth is end-user equipment, particularly for key consumer services: satellite radio and DTH television. While prices for some ground equipment, such as VSATs, continue to decline, prices for consumer service–related hardware, such as satellite radio receivers, are increasing as new technology and capabilities are introduced.

**Figure 6–9. Commercial Launch Market Share by Country, 1997-2001**




**Importance of Ground Equipment for National Security**

Satellite ground equipment is an important component in the provision of satellite services for the military and other security personnel. Low-cost commercial-off-the-shelf satellite communications and navigation ground equipment has been effectively utilized by blue forces and enemy combatants in recent conflicts around the globe. These

technologies also provide necessary support in homeland defense and crisis response situations, particularly when terrestrial technology options are hampered by the crisis situation. Users at the Federal (both military and nonmilitary agencies), state, local, corporate, and individual levels are all beneficiaries of advances in the commercial satellite ground equipment sector, though they must consider issues of communications interoperability to best use the technology. The development and deployment of advanced satellite ground equipment such as laser links and conformal array antennas could provide warfighters and crisis responders with increasingly decisive command, control, communications, and intelligence capabilities in the future.

**The Next Space Age: A Commercial Space Paradigm**

The world may already be witnessing the arrival of the next space age. Increased acceptance of high-risk commercial space business ventures as an element within an investment portfolio is one beginning. Space adventures such as personal spaceflight and the launch of private space habitats are another. The U.S. Government's commitment to purchase commercially produced space goods and services is yet another. Assuming success, these transformational changes will create new services and capabilities and greater interdependence among users, and thereby enhanced spacepower.

If these are indicators of a transition into the next space age, what signs might confirm the existence of a new paradigm for commercial space? How will the world know that its model of space commerce has permanently changed? Are such changes now observable? While the future is difficult to predict, certain observations might confirm a new paradigm.

One of the first signs of the new space age may be the way that space-related goods and services have become seamlessly integrated as a critical part of the human experience. Communications, navigation, weather, and satellite imagery are current applications affecting how people live on a daily basis. As barriers to entry fall and new space applications continue to increase our quality of life, the acceptance of space commerce as an investment opportunity, a business, and a career will become a naturally occurring human experience.

In the next space age, the commercial space industry will be an integral component of defense and civil space initiatives. Communications, GPS, weather, and remote sensing satellites are prominent examples of the growing interdependence identified in this chapter. Governments and private operators will seek to leverage commercially and strategically valuable space products and services. Whether private or government, space developers will consider all users in systems design and operations.

Also in the next space age, space technology will be ubiquitous and produced by many nations. The global manufacturing of satellite ground equipment is an example of what will exist more broadly in the next space age. Many of the current space-capable nations view themselves as commercial suppliers of space goods and services. New foreign space powers will utilize space in increasingly complex ways, creating competition for

established space powers and for each other in a global economy. This competition will drive technology development, reduce prices, improve capabilities, decrease risk, and improve value for consumers.

Several actions must be sustained to continue to encourage and facilitate transition to a new commercial space paradigm. Government research and development, as well as funding for industry, serve as rich sources of technology and inspiration for entrepreneurs and must continue. After the first few nonclassical commercial space ventures succeed financially, transition to a new paradigm will accelerate, paving the way for new commercial opportunities.

As for assurance of success, the numbers favor a breakthrough. A large number of truly bold private business ventures currently exist. Furthermore, this is a global, not just an American, phenomenon. Commercial space is a largely unexplored and untapped frontier. However, the explorers and investors currently considering space ventures may not be the first to succeed; they have been preceded by the industry's pioneers who have already committed to advance into the next space age.

**Future Projections and Implications for Spacepower**

Since the beginning of this decade, the four broad sectors that together compose the commercial space industry—satellite services, satellite manufacturing, launch services, and ground equipment—have experienced market fluctuations that are related. The bursting of the 1990s telecommunications bubble proved to be a seminal event that adversely impacted all four market segments and whose effects continue to linger. The telecommunications downturn shattered expectations that demand for satellite services would grow indefinitely. This led to fewer new satellites being ordered than widely projected at the beginning of the decade, which has resulted in more competition for fewer contracts in the satellite manufacturing industry. Fewer satellite orders have meant fewer launches needed, causing a decline in the launch services sector relative to the late 1990s. And the resulting general stagnation in all of these areas has reduced future demand projections in the ground equipment segment to a certain extent. A new generation of financial owners also emerged, and their business decisions coupled with the slower market growth have also contributed to this market conservatism.

However, following an industry-wide shakeout, the worldwide commercial space industry has rebounded. Between 2002 and 2007, worldwide space industry revenues grew by 73 percent, from $71 billion to $123 billion. The explanation for this surprising growth lies in the satellite services and ground equipment segments. Although satellite services have not grown at the meteoric pace envisioned during the telecommunications heyday of the late 1990s, global Internet, DTH television, telephony, and data usage have continued to grow steadily, fueling solid demand that has boosted revenues each year. The value of the satellite services industry nearly doubled between 2002 and 2007, increasing from $35.6 billion to $73.9 billion. This steady growth has also increased the relative weight of satellite services as a component of the overall space industry. Satellite

services accounted for 51 percent of industry revenue in 2002 but grew to 60 percent by 2007.[7]

Demand for satellite services, in turn, has sustained the growth of the ground equipment sector. Consumer demand for electronics to receive satellite radio and DTH video services has enabled the ground equipment sector to grow consistently each year in this decade thus far. In 2002, revenues for the ground equipment sector totaled $21 billion, increasing to $34.3 billion by 2007—an increase of 63 percent. This rapid growth in the satellite services and ground equipment markets has offset the comparative declines in the satellite manufacturing and launch services markets. As the former two markets have become linchpins for the sustained revenue growth of the space industry, the latter two have become relatively less of a factor, shrinking from 20 percent of total industry revenue in 2002 to 12 percent in 2007.[8]

The worldwide recession that began in 2008 and continues in 2009 will likely have an adverse, but delayed, impact on the commercial space industry.In the short term, backlogs from order completed prior to the recession can sustain the launch and satellite manufacturing industries.Meanwhile, satellite services and ground equipment will have become such a ubiquitous—if invisible—aspect of life that consumer demand will likely not begin to shrink significantly until the recession becomes especially prolonged. However, as unfavorable economic circumstances persist, the commercial space industry is likely to suffer the belated effects of the worldwide economic downturn.Many analysts predict that 2010 and 2011 may prove especially difficult years for the commercial space industry, with a significant flattening or contraction possible.

A downturn in the commercial space industry would have significant implications for spacepower.The existence of a commercial space industry outside of direct government spacepower efforts expands the range of spacepower options available to policymakers.If spacepower is ultimately about power projection—the ability to access and use space for strategic national needs and objectives and to deny adversaries that ability—then each of the four segments of the commercial space industry discussed in this chapter plays a key role in complementing the spacepower of the nation-state.

As the world moves into the 21st century, the possibility of asymmetric national security threats posed by terrorists or rogue states remains central to defense policymaking. In the U.S. space community, this has translated into efforts to ensure both traditional and responsive space capabilities that can deploy space assets with global effects on short notice. The U.S. Government continues to fund the development of vehicles designed for short launch turnaround times and maximum flexibility. Parallel to these efforts, the military is increasing research and development funding for smallsats, which promise to carry out many of the functions of larger satellites at a fraction of the cost.The U.S. Government is also promoting new technologies and markets through cash prizes such as the Centennial Challenges competitions, as well as initiatives such as the COTS agreements.These government-funded efforts to create an operationally responsive, comprehensive space capability will have increasing commercial implications. If the U.S. Government eventually permits nonsensitive technologies from these more agile vehicles

and smaller satellites to be used commercially, payload functionality may be increased and launch costs may be lowered to the point where both the satellite manufacturing and launch services markets can be reinvigorated. Heightened focus on national security threats and growing reliance on the availability of multiple data sources have also led to an increase in the demand for satellite communications by deployed U.S. personnel, with a focus on innovations such as communications-on-the-move. This increase has a generally positive effect on the satellite services and ground equipment sectors, which provide additional communications capability to the government.

For the more immediate present and future, the commercial sector is enabling new markets largely without government assistance. The successful capture of the Ansari X Prize by Scaled Composites' SpaceShipOne vehicle in October 2004 demonstrated that private incentives could entice entrepreneurs to develop their own launch systems and other space technologies independent of government assistance. The U.S. Government, though, is also promoting these new markets through the Centennial Challenges competitions and the Commercial Orbital Transportation Services agreements. At the same time, the SpaceShipOne vehicle itself brought the prospect of suborbital space tourism one step closer to reality. Virgin Galactic and other suborbital space tourism companies are currently expected to begin service by 2010. Since the cost of a suborbital space tourism flight is projected to be several orders of magnitude cheaper than that of an orbital flight—an expected $200,000 versus $20 million—the number of suborbital space tourism flights per year may be in the low hundreds within the next decade. This emerging market, when realized, will likely have a significant impact on the structure of the space industry as a whole.

Advances in space technology will have an impact on the commercial industry as well as the space community. An example of a significant technology issue is the active lifespan of satellites. The lifespan of an average satellite ranges roughly from 5 to 15 years depending on the application. Low and medium Earth orbit satellites tend to operate for shorter life spans than GEO satellites, which have planned design lives of about 15 years. Extending the average life of all satellites could impact the industry in a variety of ways. Longer-life satellites will reduce the need for replacements to maintain the same amount of capacity, which would be financially beneficial, but there are related limitations. For example, if a satellite is designed for 20 years of service but has a defect that renders the satellite useless in 10 years, operators and insurers would face significantly increased losses. If satellites worked perfectly for 20 years but a new technology development rendered them obsolete, there would be financial losses. Long-life satellites may in general have trouble adapting to changing market conditions and innovative technologies.Conversely, making satellites with shorter lifespans may give an operator the ability to adapt to changing economic, technological, and political forces.The shorter lifespan could allow for a greater quantity of industry activity using the most up-to-date technology, but would require more launches and more satellites to meet the capability of a longer life satellite on orbit, potentially increasing total costs.

Another issue that could have effects on the commercial space industry in the future is the threat of hostile attacks against its assets, which would be detrimental to the industry.

The U.S. military has continued to increase its reliance on commercial space assets, particularly communications and remote sensing capabilities. This reliance leads to concerns about attacks on commercial assets that are being used, or are perceived to be used, for military purposes. Vulnerabilities exist in the space and ground segments as well as in the transmission and sensing of data—the entire commercial industry is vulnerable, though efforts have begun to strengthen commercial space defenses against attacks. Potential attacks could range from physical to electronic attacks that destroy, deny, or disable space capabilities. If commercial assets are targeted and rendered inoperable, their operators will incur financial losses. Satellite operators who avoid working with the military may still have their assets targeted, and the consequences of attacks on noncommercial assets—for example, orbital debris—could affect commercial assets. If commercial assets are targeted, the military may be more inclined to build their own hardened spacecraft rather than purchase services from industry, meaning there will be significant consequences for the overall commercial industry.

Space activity itself is not a major economic force, but it is a potent economic enabler and a critical component of any nation's infrastructure. For example, timing signals from the GPS constellation are utilized by banks and other financial institutions around the globe to keep financial systems synchronized. Satellite communications systems facilitate the global communications necessary for international banking and commerce. The news and entertainment industries are also dependent on satellite capabilities. Overall, the globalized economy relies heavily on satellite technology and infrastructure.

The implications of these current and future commercial space industry trends for spacepower theory are best understood as they pertain to space assets. In all four market sectors that define the industry, any U.S. advantages that exist are being reduced by competition from European and Asian organizations. In the satellite services and ground equipment segments, U.S. commercial firms have the most advanced technologies and a stable customer base. The potential customer base and content demand in the European and Asian markets, though, suggest that the services sector will continue to grow in these locations. Similarly, new Asian entrants to the satellite manufacturing and launch services markets—particularly China and India—signal that other nations will increasingly compete with the United States in space technology and hardware.

Moreover, as American export restrictions increasingly encourage other nations to collaborate in order to achieve their space goals outside the framework created by the United States, it is reasonable to assume that the United States will continue to lose market share and related technological advantage. Given these realities, the ultimate solution for the United States to achieve its spacepower objectives may lie in some combination of U.S. military investments in cutting-edge technologies coordinated with incentives that more fully align the commercial space industry with strategic spacepower goals or a return to the public-private partnerships that established the industry.

The commercial industry is a critical part of national spacepower. It provides capabilities not only commercially as a major part of the global economy but also for government use. Market forces and the business environment often drive the industrial landscape, but

incentives and impediments from the government also provide significant influence. As such, when a nation is developing its spacepower, it must realize that its policies can affect the commercial industry with positive and negative results regarding national interests and the future of the space industry.

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# Notes

1. Satellite Industry Association and Futron Corporation, *State of the Satellite Industry Report*, June 2008, 10, available online at <www.futron.com/pdf/resource_center/reports/2008SSIR.pdf/PDF/2006SIAStateofSatelliteIndustryPres.pdf>.
2. Ibid., 10–12.
3. Ibid., 13.
4. Ibid., 9.
5. Federal Aviation Administration Office of Commercial Space Transportation and the Commercial Space Transportation Advisory Committee, *2006 Commercial Space Transportation Forecasts*, May 2008, available at <www.faa.gov/about/office_org/headquarters_offices/ast/media/2008%20Forecasts%20GSO%Commercial %20Space%Transportation%20May%202008%website.pdf>.
6. InfoCom and SagaTel, Global Telecommunications Markets and Forecasts for 2003–2007 (Stuttgart: InfoCom GmbH), 38.
7. Satellite Industry Association and Futron Corporation, *State of the Satellite Industry Report*, June 2008, available at <www.futron.com/pdf/resource_center/reports/2008SSIR.pdf>.
8. *Ibid., 7–8*.