2008

# Commercial Space

Diane Howard
*Embry-Riddle Aeronautical University*, howard19@erau.edu

# SPACE SECURITY 2008

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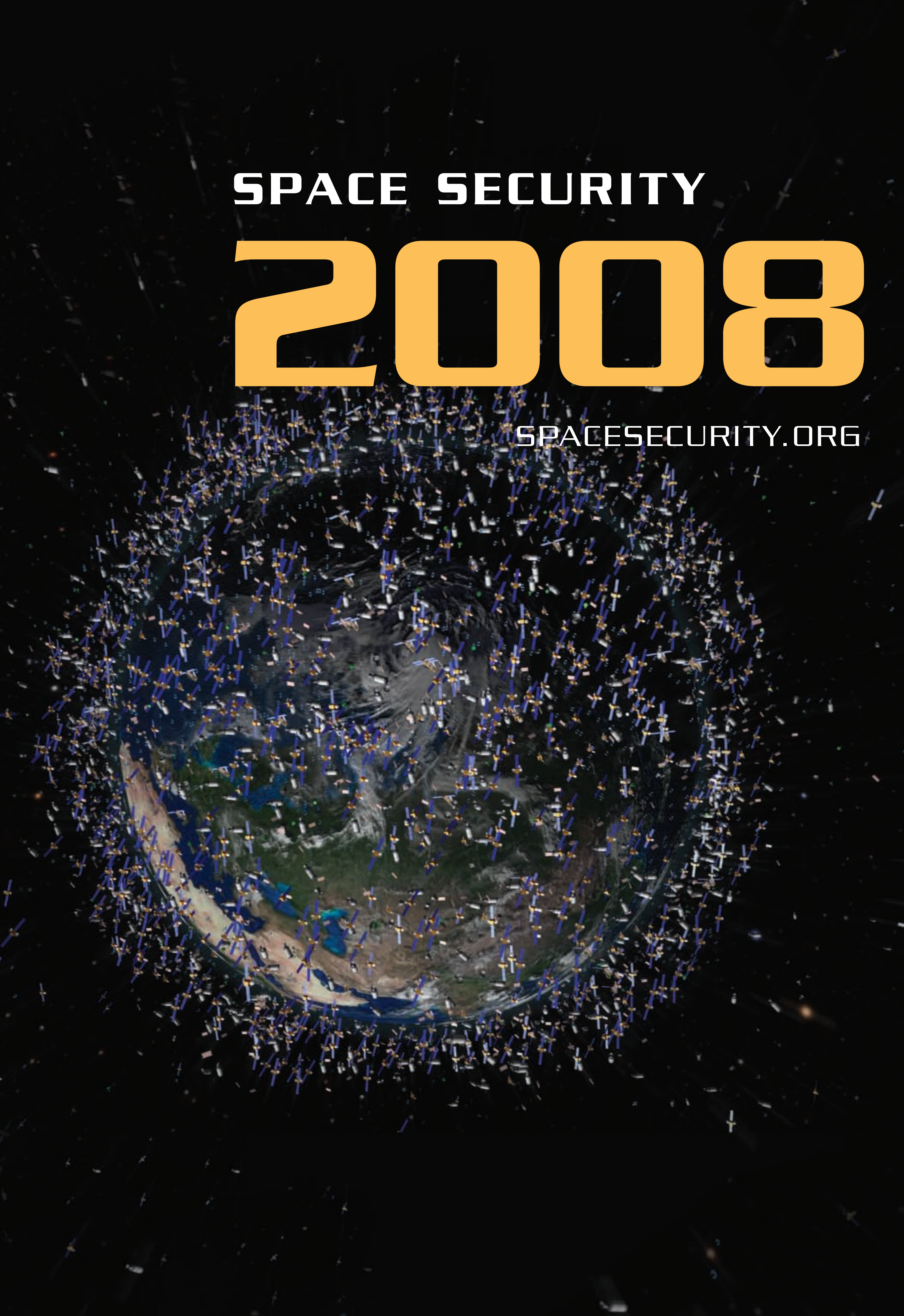

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Please direct inquiries to:
**Project Ploughshares**
57 Erb Street West
Waterlo, Ontario
Canada N2L 6C2
Telephone: 519-888-6541
Fax: 519-888-0018
Email: plough@ploughshares.ca

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# ACRONYMS

| | |
|---|---|
| 3GIRS | Third Generation Infrared Surveillance Program (formerly AIRSS) |
| ABM | Anti-Ballistic Missile |
| ABL | Airborne Laser |
| AEHF | Advanced Extremely High Frequency system |
| AIRSS | Alternative Infrared Satellite System |
| ANGELS | Autonomous Nanosatellite Guardian for Evaluating Local Space |
| ASEAN | Association of Southeast Asian Nations |
| ASAT | Anti-Satellite Weapon |
| ASI | Italian Space Agency |
| AWS | Advanced Wideband System |
| BOC | Besoin Operationnel Commun |
| BMD | Ballistic Missile Defense |
| BNSC | British National Space Centre |
| CASC | China Aerospace Corporation |
| CAV | Common Aero Vehicle |
| CD | Conference on Disarmament |
| CFSP | Common Security and Foreign Policy (Europe) |
| CNES | Centre National d'Études Spatiales |
| CNSA | Chinese National Space Administration |
| COPUOS | United Nations Committee on the Peaceful Uses of Outer Space |
| COSPAS-SARSAT | Committee On Space Research – Search and Rescue Satellite-Aided Tracking |
| COSTIND | Commission of Science, Technology, and Industry for National Defense (China) |
| COTS | Commercial Orbital Transportation System |
| CSA | Canadian Space Agency |
| DARPA | Defense Advanced Research Projects Agency |
| DART | Demonstration of Autonomous Rendezvous Technology |
| DBS | Direct Broadcasting by Satellite |
| DGA | Délégation Générale pour l'Armement |
| DISCOS | Database and Information System Characterising Objects in Space |
| DLR | German Aerospace Center |
| DOD | Department of Defense (US) |
| DRDC | Defence Research and Development Canada |
| DRDO | Defence Research and Development Organization (India) |
| DSCS | Defense Satellite Communications System |
| DSP | Defense Support Program |
| EADS | European Aeronautics Defence and Space Company |
| EC | European Commission |
| EELV | Evolved Expendable Launch Vehicle |

| | |
|---|---|
| EHF | Extremely High Frequency |
| EKV | Exoatmospheric Kill Vehicle |
| ELINT | Electronic Intelligence |
| EMP | Electromagnetic pulse |
| ESA | European Space Agency |
| ESDP | European Security and Defence Policy |
| EUMETSAT | European Organization for the Exploitation of Meteorological Satellites |
| FAA | Federal Aviation Administration (US) |
| FCC | Federal Communications Commission (US) |
| FMCT | Fissile Material Cut-off Treaty |
| FIA | Future Imagery Architecture |
| FOBS | Fractional Orbital Bombardment System |
| FSS | Fixed Satellite Service |
| GAGAN | GPS and GEO Augmented Navigation (India) |
| GEO | Geostationary Orbit |
| GEOSS | Global Earth Observation System of Systems |
| GLONASS | Global Navigation Satellite System (Russia) |
| GMES | Global Monitoring for Environment and Security |
| GMTI | Ground Moving Target Identification |
| GNSS | Global Navigator Satellite System |
| GPS | Global Positioning System |
| GRAVES | Grande Réseau Adapté à la Veille Spatiale |
| GSLV | Geostationary Satellite Launch Vehicle |
| HAND | High Altitude Nuclear Detonation |
| HAPS | Hydrazine Auxiliary Propulsion System |
| HEO | Highly Elliptical Orbit |
| IADC | Inter-Agency Space Debris Coordinating Committee |
| IAI | Israeli Aerospace Industries |
| IASF | Israeli Air and Space Force |
| ICBM | Intercontinental Ballistic Missile |
| IGS | Information Gathering Satellites |
| IIRS | Indian Institute of Remote Sensing |
| ILS | International Launch Services |
| Inmarsat | International Maritime Satellite Organization |
| Intelsat | International Telecommunications Satellite Consortium |
| IRNSS | Indian Regional Navigation Satellite System |
| ISI | ImageSat International |
| ISR | Intelligence, Surveillance, Reconnaissance |
| ISRO | Indian Space Research Organization |
| ISS | International Space Station |
| ITAR | International Traffic in Arms Regulation |

| | |
|---|---|
| ITU | International Telecommunications Union |
| JAXA | Japan Aerospace Exploration Agency |
| JHPSSL | Joint High-Power Solid-State Laser |
| JSpOC | Joint Space Operations Center (US) |
| JSSP | Joint Space Support Project (Canada) |
| KARI | Korean Aerospace Research Institute |
| KEI | Kinetic Energy Interceptor |
| KSLV | Korean Space Launch Vehicle |
| LAD-C | Large Area Debris Collector |
| LOAC | Laws of Armed Conflict |
| LEO | Low Earth Orbit |
| MAWS | Missile Attack Warning System (Russia) |
| MDA | Missile Defense Agency (US) |
| MEO | Medium Earth Orbit |
| Milstar | Military Satellite Communications System |
| MIRACL | Mid-Infrared Advanced Chemical Laser |
| MiTEX | Micro-satellite Technology Experiment |
| MKV | Miniature Kill Vehicle |
| MOST | Microvariability and Oscillations of Stars |
| MPX | Micro-satellite Propulsion Experiment |
| MSS | Mobile Satellite Service |
| MTCR | Missile Technology Control Regime |
| NATO | North Atlantic Treaty Organization |
| NASA | National Aeronautics and Space Administration (US) |
| NEO | Near-Earth Object |
| NEOSSat | Near Earth Object Surveillance Satellite |
| NFIRE | Near-Field Infrared Experiment |
| NGA | National Geospatial-Intelligence Agency (US) |
| NGO | Nongovernment Organization |
| NOAA | National Oceanic and Atmospheric Administration (US) |
| NORAD | North American Aerospace Defense Command |
| NPOESS | National Polar-orbiting Operational Environmental Satellite System |
| NRO | National Reconnaissance Office (US) |
| NSSO | National Security Space Office (NSSO) |
| NTM | National Technical Means |
| ORS | Operationally Responsive Spacelift |
| OST | Outer Space Treaty |
| PAROS | Prevention of an Arms Race in Outer Space |
| PLA | People's Liberation Army (China) |
| PPWT | Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects |

| | |
|---|---|
| PSLV | Polar Satellite Launch Vehicle |
| QZSS | Quazi-Zenith Satellite System (Japan) |
| RAIDRS | Rapid Attack Identification Detection and Reporting System |
| RAMOS | Russian-American Observation Satellite program |
| RFTWARS | Radio Frequency, Threat Warning, and Attack Reporting |
| ROEM | Renseignement d'Origine ElectroMagnétique |
| Roscosmos | Russian Federal Space Agency |
| SALT | Strategic Arms Limitations Talks |
| SAR | Synthetic Aperture Radar |
| SBI | Space-Based Interceptors |
| SBIRS | Space Based Infrared System |
| SBL | Space Based Laser |
| SBSS | Space Based Surveillance System |
| SDI | Strategic Defense Initiative |
| SHF | Super High Frequency |
| SIGINT | Signals Intelligence |
| SM-3 | Standard Missile 3 |
| SMV | Space Maneuver Vehicle |
| SSA | Space Situational Awareness |
| SSN | Space Surveillance Network (US) |
| SSS | Space Surveillance System (Russia) |
| STSS | Space Tracking and Surveillance System |
| TCBM | Transparency and Confidence-Building Measure |
| TICS | Tiny Independent Coordinating Spacecraft |
| TSAT | Transformational Satellite Communications system |
| TT&C | Tracking, telemetry, and command |
| UHF | Ultra High Frequency |
| UAV | Unmanned Aerial Vehicle |
| UNGA | United Nations General Assembly |
| UNISPACE | United Nations Conference on the Exploration and Peaceful Uses of Outer Space |
| UNITRACE | United Nations International Trajectography Centre |
| UN-SPIDER | United Nations Platform for Space-based Information for Disaster Management and Emergency Response |
| USAF | United States Air Force |
| USML | United States Munitions List |
| USSPACECOM | US Space Command |
| USSTRATCOM | US Strategic Command |
| WGS | Wideband Global SATCOM |
| XSS | Experimental Spacecraft System |

CHAPTER FOUR

# 4. Commercial Space

This chapter assesses trends and developments in the commercial space sector, including the builders and users of space hardware such as rockets and satellite components, and space information technologies such as telecommunications, data relay, remote sensing, and imaging. It also examines the relationships between governments and the commercial space sector, including the government as partner and the government as regulator. Much work on civil and military programs is contracted out to the commercial sector, which today has the same capabilities as any other space actor.[1]

The commercial space sector has experienced dramatic growth over the past decade, largely related to rapidly increasing revenues associated with satellite services. These services are provided by organizations that operate satellites, as well as the ground support centers that control them, process their data, and sell that data to others. The bulk of the revenue in the satellite services sector is generated by telecommunications.[2]

The second largest contribution to the growth of the commercial space sector has been made by satellite and ground equipment manufacturing. This includes both direct contractors that design and build large systems and vehicles, smaller subcontractors responsible for system components, and software providers.

This chapter also assesses trends and developments associated with launch vehicles and launch services developed by commercial sector programs. The companies that operate launch facilities, design and manufacture vehicles intended to place payloads in space, and manufacture launch components and subsystems are examined. In the early 2000s, overcapacity in the launch market and a reduction in commercial demand combined to depress the cost of commercial space launches. More recently, an energized satellite communication market and launch industry consolidation have resulted in a stabilization and increase in launch pricing.

Governments play a central role in commercial space activities as users of certain services, by supporting research and development, by subsidizing certain space industries, by underwriting insurance costs, and by adopting enabling policies and regulations. Indeed the space launch and manufacturing sectors survive largely on government funding. Conversely, because space technology is often dual-use, governments have sometimes taken actions, such as the imposition of export controls, which have constrained the growth of the commercial market.

Several states have begun to consider commercial space as a critical infrastructure for national security. In addition, the military sector, which has been unable to meet its communication and imagery needs with its own assets, has taken advantage of commercial capacity, thereby creating a dependence on commercial systems for military applications.

*Space Security Impact*

The pervasive role that the commercial space sector plays in launch, communications, imagery, and manufacturing, in addition to its role of supporting government civil and military programs, means that the commercial space sector both affects and is effected by changes in space security. A healthy space industry will tend to increase commercial competition and can lead to decreasing costs for space access and use. This could have a positive impact on space security by increasing the number of actors who can access and use space or space products, thereby increasing the number of stakeholders in the maintenance of space security. Increased competition can also lead to the further diversification of capabilities to access and use space.

Commercial space efforts have the potential to increase the level of transnational cooperation and interdependence in the space sector, building transparency and trust through international collaboration. Additionally, the development of the space industry could influence international space governance. To thrive, sustainable commercial markets must have the freedom to innovate, but they also require a framework of laws and regulations on issues of property, standards, and liabilities.

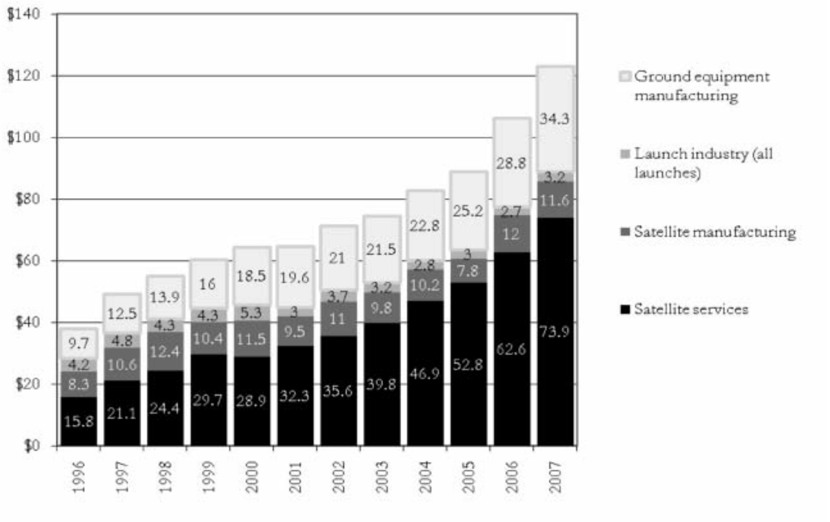
Some commercial space actors also note that issues of ownership and property pose an increasing challenge to the growth of the industry. For example, while the non-appropriation clause of the Outer Space Treaty is generally understood to prohibit states from making sovereignty claims in space, this clause also raises questions about the allocation and use of space resources. There is concern that the clause could stifle entrepreneurship and growth in the commercial space industry. As well, future conflicts over the issue could decrease space security if not addressed in a timely manner.

Growth in space commerce has already led to greater competition for scarce space resources such as orbital slots and radio frequencies. To date, national regulators and the International Telecommunication Union have been able to manage inter- and intraindustry tensions. However, strong terrestrial demand for additional frequency allocations and demands of emerging nations for new orbital slots will provide new challenges for domestic and international regulators The dependence of the commercial space sector on military clients or, conversely, the reliance of militaries on commercial space assets could also have an adverse impact on space security by making the industry overly dependent on one client, or by making commercial space assets the potential target of military attacks.

## Trend 4.1: Continued overall growth in the global commercial space industry

The commercial space sector continues to grow, but at an uneven rate. The years 2003 and 2004 saw the slowest annual growth rates since the mid-1990s, followed by a rebound in 2005. Global space revenues have been estimated as totaling $143.31-billion in 2006 — a growth of almost 23 percent over 2005, overwhelmingly led by satellite services.[3] The satellite services sector more than tripled in size between 1996 and 2006, generating revenues estimated at between $62.6-billion and $111.14-billion in 2006, or up to 60 percent of the commercial satellite sector's total revenues (see Figure 4.1).[4]

Figure 4.1: World satellite industry revenues by sector (billion)[5]



The telecommunications industry has long been a driver of commercial uses of space. The first commercial satellite was the Telstar-1, launched by NASA in July 1962 for the telecommunications giant AT&T.[6] Satellite industry revenues were first reported in 1978, when *US Industrial Outlook* reported 1976 Communication Satellite Corporation operating revenues of almost $154-million.[7] By 1980 it is estimated that the worldwide commercial space sector already accounted for $2.1-billion in revenues,[8] and in 2006, the sector collected revenues estimated at between $106.1-billion and $143.31-billion.[9] A significant portion of this growth can be assigned to individual users, particularly for Direct Broadcasting Services but also use of satellite navigation services and commercial satellite imaging.

A number of new companies were founded in the 1980s to take advantage of anticipated growth in the space telecommunications services sector. This sector was deregulated in many countries during the 1990s; the previously government-operated bodies International Maritime Satellite Organisation (Inmarsat) and International Telecommunications Satellite Organization (Intelsat) were privatized in 1999 and 2001 respectively.[10] PanAmSat, New Skies, GE Americom, Loral Skynet, Eutelsat, Iridium, EchoStar, and Globalstar were some of the prominent companies to emerge during the 1990s. Hughes also entered the market with DirecTV, a new satellite television broadcast system.

More recently, increased demand from individual users has driven significant growth in satellite services such as direct broadcast services. Other factors fueling sector growth include the decreasing costs of both communications equipment and launches. Current major satellite telecommunications companies include SES Global, Intelsat, Eutelsat, and Telesat Canada.[11]

The 2000 downturn in the technology and communications sectors affected the commercial space sector, reducing market take-up of satellite telephony, thus creating a related launcher overcapacity problem. Commercial satellite launches dropped from a peak of 38 in 1999 to 16 in 2001, but are beginning to recover.[12] Revenue from commercial satellite launches peaked at $5.3-billion in 2000, but has since leveled at around $3-billion annually.[13] Despite the persistent overcapacity of the space-launch market, there has been a consolidation of space launch prices since 2004[14] (see Trend 4.2). In 2006 commercial launch revenues hit their highest point since 2002 with an increase of 20 percent over 2005, reflecting the joint trends of higher demand for launches to GEO and higher launch costs. These figures are only beginning to reflect the rising costs to access space, however, as most launches in 2006 were ordered prior to price increases.[15] The commercial launch market has shifted away from the trend of low demand and high capacity, which had kept prices low. While government payloads still account for the majority of launch revenues, the proportion of commercial customers and revenues is increasing.[16] Of the 21 commercial launches in 2006, 16 went to GEO — the highest number since 2002, reflecting the growing demand for telecommunications services.[17] Moreover, revenues for commercial launches in 2006 reached their highest point since 2002, increasing 20 percent over those for 2005.

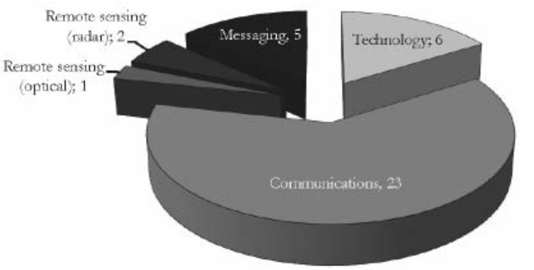
Satellite manufacturers worldwide collected an estimated $12.0-billion in 2006, close to the record high of $12.4-billion in revenue set in 1998; 2006 revenues grew by almost 54 percent over those for 2005.[18] Revenue is unevenly divided between government and commercial launches. The estimated value of government payloads was 75 percent of total revenues in 2006.[19] The five major manufacturers of commercial communications satellites are Alcatel Alenia Space, Boeing Satellite Systems, EADS Astrium, Lockheed Martin, and Space Systems/Loral. Newcomers NPO Prikladnoy Mekhaniki (Russia) and the Indian Space Research Organization (ISRO) are expected to make an impact in the future.[20]

## 2007 Development

### Commercial space industry continues to grow, with individual users becoming more important stakeholders and new market entrants

The commercial space industry continues to rebound from a previous low with increasing revenues in the launch, services, and manufacturing sectors. The Space Foundation Index, which tracks the industry's growth based on 31 publicly traded companies, reported growth of 29 percent from June 2005 to December 2007. Although growth was only 8.4 percent in 2007, it outperformed the Standard and Poor's 500 Index.[21] Worldwide industry revenue growth is estimated at 16 percent from 2006 to 2007.[22]

Figure 4.2: Commercial spacecraft launched in 2007




Demand for commercial space transportation services, which are directly linked to activities in the global satellite market, continued to increase in 2007.[23] Of the 68 successful orbital launches in 2007, 23 were commercial launches,[24] marking the third consecutive annual increase since 2004.[25] These 23 launches carried 49 payloads, of which 27 were commercial spacecraft. Russia continued to lead the industry with 12 successful launches (Figure 4.6).[26] Revenue for commercial launches also increased modestly by $125-million to reach $1.55-billion. Although Russia dominated the industry in terms of the number of launches, Europe received the largest revenue, an estimated $840-million compared to Russia's $477-million.[27] The year 2007 was a record year for non-geostationary (GEO) launches, with 15 of 23 commercial launches executed largely to replace existing spacecraft. In contrast, since 2003 72 percent of all commercial launches have been to GEO; such launches generate the majority of revenue and are likely to continue to drive the market.

Satellite services continued to account for approximately 60 percent of total satellite industry revenues, growing by 18 percent in 2007.[28] Individual users are a significant driver of this growth, particularly through demand for satellite television, direct broadcasting, and navigation/positioning services. Satellite television and direct broadcasting posted an estimated 18 percent revenue increase in 2007; another estimate puts revenue from GPS equipment at 56.2-billion in 2007, a growth of 20 percent.[29] Satellite radio also continues to grow significantly, with profits doubling from 2005 to 2006 and increasing by another 33 percent in 2007 to $2.1-billion,[30] but as a new entrant it retains a small market share. Fixed Satellite Services and Mobile Satellite Services have grown by 20 percent and 18 percent respectively.

This steady growth of consumer services is also driving the ground equipment market, which holds the second largest share of market revenues and grew by 19 percent in 2007.[31] End-user products for services such as HD TV, satellite radio, and navigation are key drivers.

More satellite launches and a growing satellite services sector have a direct impact on the commercial manufacturing industry. Although satellite manufacturers continued to suffer from pressure to lower prices, strong demand for broadcasting, broadband, and mobile satellite services drove an increase in orders, which is projected to continue.[32] Nonetheless, revenues decreased slightly in 2007, in part due to the launching of a higher proportion of microsatellites.[33] Revenue from commercial satellites increased from 25 percent of all sales to 33 percent.

Although US industries continued to dominate the satellite manufacturing market, producing 46 of the 107 payloads launched in 2007 (43 percent), US market share declined by 10 percent from 2005.[34] Different strategies are being used to achieve growth in this industry. For example, EADS Astrium has leveraged its Skynet success into expansion beyond the UK, particularly to the US and Middle East/Saudi Arabia.[35] Thales-Alcatel, on the other hand, plans to consolidate two of its satellite product lines, radar and optical observation, into one line of products that could be used for either mission.[36] Boeing is using a multiple market approach — civil, military, and commercial — to maintain a stable business, while acknowledging that it preferred government sales to less lucrative commercial business; this position is shared by Lockheed Martin and EADS Astrium.[37]

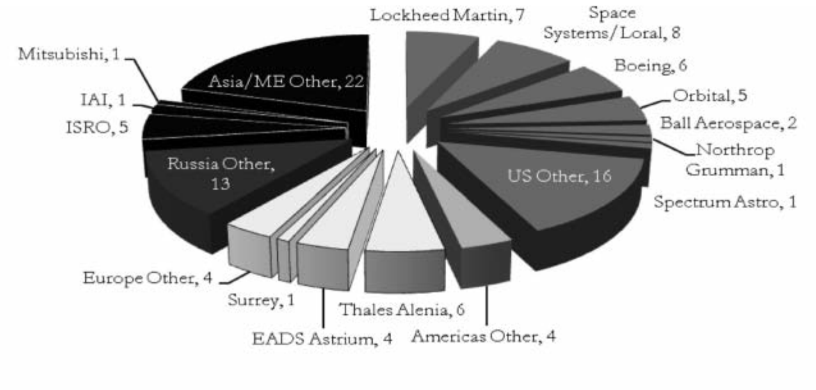
## 2007 Development

### India and China influence the commercial space industry

India re-affirmed its entry into the commercial launch market on 23 April 2007 when the Polar Satellite Launch Vehicle (PSLV) took the Italian astronomy satellite AGILE into space. It has another contract in place to launch an Israeli classified remote sensing satellite in 2008.[38] India is reportedly positioning itself to compete for a portion of the commercial launch service market by offering low-cost launches. Although at $11-million to send a 352-kilogram spacecraft into low Earth orbit, rates do not appear to be far below similar, publicly known launch costs, it is difficult to compare costs across different launches and launchers.[39] India also intends to compete in the satellite manufacturing industry.[40] Affirming its growing importance in the space industry, an Aerospace Industries Association (AOA) survey showed that more than 86 percent of US civil and military aerospace contractors plan to sign agreements to form joint ventures or partnerships with small Indian aerospace companies in the next year, just as India is seeking new international partners for its space industry.[41] The European Space Agency has also expressed a desire to outsource to India subsystems and components for space missions to leverage cost benefits and reliable Indian research, but cannot because of constraints under current trade rules.[42] India bolstered its presence in the commercial space market with strong sales of remote sensing images to other countries. In September 2007 India claimed to have captured 20 percent of the global market.[43]

Although not commercially competed, China launched Nigeria's Nigcomsat-1 communications satellite on a Long March 3-B rocket to geostationary orbit. This marked the first time that China had both manufactured and launched a satellite for another country[44] and signaled its reentry into the commercial launch market. Chinese officials claim that China has been "commissioned to send about 30 foreign satellites into space and signed several contracts offering commercial launching services for foreign satellites."[45] Developing countries are the prime focus of these efforts.[46] Moreover, because it uses no US components, China is marketing its manufactured satellites as ITAR-free at prices below industry standard. This new reality spurred Arianespace to call for vigilance against Chinese dumping (see Trend 4.3).[47]

Figure 4.3: Manufacturer share of satellites launched in 2007[48]




## 2007 Space Security Impact

Continued growth in the commercial space sector is reflected largely by higher revenues and not necessarily an increase in space activity. However, individual users are becoming more important stakeholders in space as they demand not only more communications services, but also satellite navigation/positioning and remote sensing products. Ongoing growth of the industry suggests that there is overall confidence in the security of space and the ability of both companies and consumers to continue to rely on space resources. Growing competition in the commercial launch market may also contribute to space security by providing greater access to outer space, although tensions may arise if future demand for space resources exceeds supply.

## Trend 4.2: Commercial sector supporting increased access to space

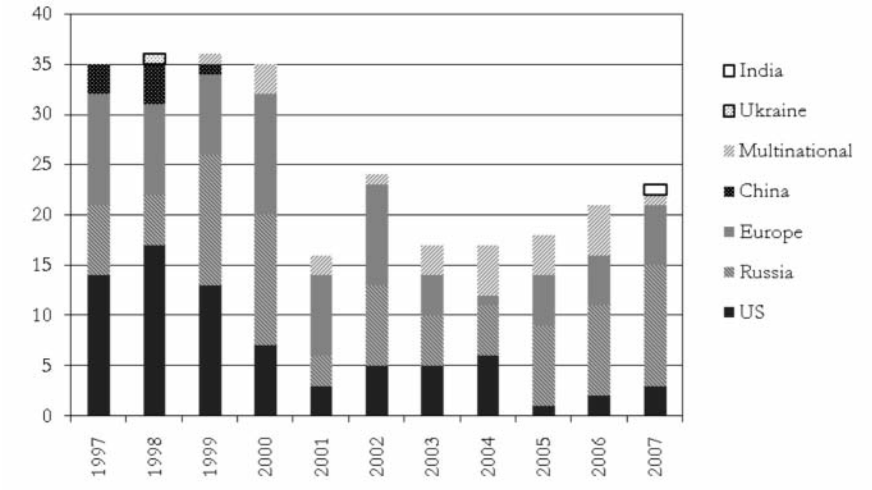
**Space launches**

A commercial launch is defined as one in which at least one satellite payload's launch was contracted internationally, so that, in principle, a launch opportunity was available to any capable launch services provider.[49] Russian, European, and American companies remain world leaders in the commercial launch sector, with Russia launching the most satellites, both commercial and in total in 2007.[50] Generally, launch revenues are attributed to the country in which the primary vehicle manufacturer is based, except in the case of Sea Launch, which is designated as "multinational."[51]

Commercial space access grew significantly in the 1980s. At that time, NASA viewed its provision of commercial launches more as a means to offset operating expenses than as a viable commercial venture. European and Russian companies chose to pursue commercial launches via standard rocket technology, which allowed them to undercut US competitors during the period when the US was only offering launches through its Shuttle.

Increasing demand for launch services and the ban of commercial payloads on the Space Shuttle following the 1986 Challenger Shuttle disaster encouraged further commercial launch competition. The Ariane launcher, developed by the French in the 1980s, captured over 50 percent of the commercial launch market during the period 1988-1997.[52] The Chinese Long March and the Russian Proton rocket entered the market in the early and mid-1990s. The Long March was later pressured out of the commercial market due to "reliability and export control issues."[53] China has opened the possibility of reentering the commercial spaceflight market by 2020.[54] Today Ariane, Proton, and Zenit rockets dominate the commercial launch market.

Figure 4.4: Worldwide Commercial Orbital Launches (1997-2007)[55]




Japanese commercial efforts have suffered from technical difficulties and its H-2 launch vehicle was shelved in 1999 after flight failures.[56] Although the H-2 was revived in 2005, Japan lags behind Russia, Europe, the US, and China in global launches.[57] India's Augmented Polar Satellite Launch Vehicle performed the country's first Low Earth Orbit (LEO) commercial launch, placing German and South Korean satellites in orbit in May 1999.[58]

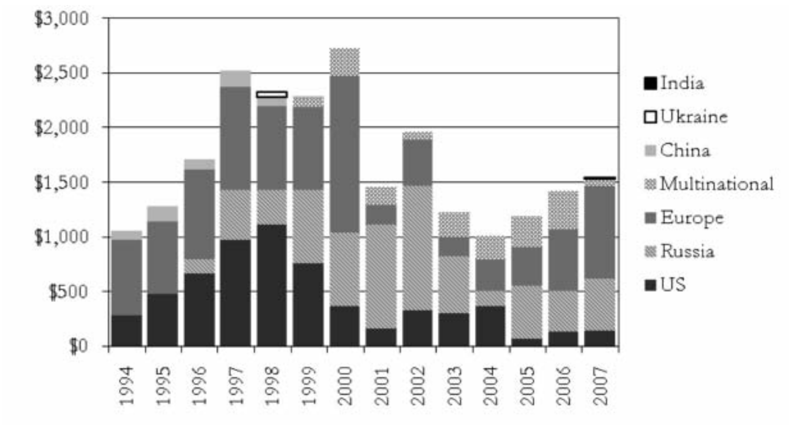
Today's top commercial launch providers include Lockheed Martin and Boeing Launch Services in the US, Arianespace in Europe, Energiya in Russia, and two international consortia — Sea Launch and International Launch Service (ILS).[59] Sea Launch, comprised of Boeing (US), Aker Kvaerner (Norway), RSC-Energiya (Russia), and SDO Yuzhnoye/PO Yuzhmash (Ukraine), launches from a sea-based platform located on the equator in the Pacific Ocean.[60] ILS was established as a partnership between Khrunichev State Research and Production Space Center (Russia), Lockheed Martin Space Systems (US), and RSC-Energiya (Russia). In 2006 Lockheed sold its share to US Space Transport Inc. New commercial launch vehicle builders such as Space Exploration Technologies (SpaceX) are seeking to compete by providing cheaper, reusable launch vehicle designs.

In addition to a proliferation of rocket designs, the launch sector has also seen innovations in launch techniques. For example, since the early 1990s companies such as the UK's Surrey Satellite Technology Ltd. have used piggyback launches — a small satellite is attached to a larger one to avoid paying for a dedicated launch. It is now also common to use dedicated launches to deploy clusters of smaller satellites on small launchers such as the Cosmos rocket. Emerging technologies such as air-launch vehicles and hypersonic "scramjet" engines may lead to further cost reductions of space launch into LEO.[61]

Competition and the entry of non-Western launchers have supported a decrease in space access costs. Specific launch cost data indicates that the cost to launch commercial payloads into GEO declined by approximately 35 percent in the 1990s, from an average of about $40,000 per kilogram to $26,000 per kilogram in 2000. There was no clear pricing trend for commercial payloads going to LEO during this decade, but launches between 1995 and 2000 clustered around $5,000 per kilogram, with significant variances.[62] It should be noted that it is difficult to compare launch costs across payloads and launch vehicles due to the number of important differences between them and the fact that launches are negotiated project-by-project. Moreover, the price of a launch is often not made public, especially since the increase in competition after 2000.[63] Nonetheless, based on current public data it would appear that the trend in declining costs of the 1990s has ended and prices have consolidated.[64]

Greater launcher competition and stable launch costs have facilitated steady growth in the number of actors that can access space either through an independent launch capability or via the launch capability of others. Forty-seven states have now accessed space; almost all have been enabled in some way by the commercial sector. Yet despite significant decreases there has not been a notable increase in commercial space activity.[65]

Figure 4.5: Revenues for commercial space launches (million)I[66]




**Commercial remote sensing imagery**

Until a few years ago only a government could gain access to remote sensing imagery; today any individual or organization with access to the Internet can use these services through Google Maps, Google Earth, and Yahoo Maps programs.[67] Companies such as Surrey Satellite Technology Ltd. and SpaceDev have commercialized private research in the area of space and satellite technologies. There are currently seven companies in Canada, France, Germany, Israel, Russia, and the US providing commercial remote sensing imagery. The resolution of the imagery has become progressively more refined and affordable. In addition to optical photo images, synthetic aperture radar images up to one meter in resolution are coming on the market. A growing consumer base is driving up revenues. Global commercial remote sensing revenue is estimated $1.12-billion for 2005 — an 18 percent increase over 2004 — and rose another 16 percent in 2006, with one report putting global expenditures on remote sensing products as high as $7-billion in 2006.[68] Security concerns have been raised, however, due to the potentially sensitive nature of the data (see Trend 4.3).

**Commercial satellite positioning**

The commercial GPS market has rapidly expanded with the introduction of new devices marketed to individual users. Handheld GPS equipment, which often integrates the GPS function into other electronics, is increasing demand for what was once a technology used primarily by government and large businesses.[69] The market for these converged devices is just starting to accelerate in the US, but has been strong in Europe and Japan for several years.[70] Sales of satellite navigation devices in Europe, the Middle East, and Africa doubled in 2006 and a significant increase in GPS-enabled Location Based Services subscribers is expected in the coming years. Consumer demand is also increasing for dedicated portable navigation devices.[71] Revenue, not included in the satellite market statistics above, is estimated at $40.7-billion for 2006 compared to $28.5-billion for 2005, as more and more consumers choose to access this space service.[72]

**Commercial space transportation**

An embryonic space tourism industry continues to emerge, seeking to capitalize on new concepts for advanced, reliable, reusable, and relatively affordable technologies for launch to near-space and low earth orbit. In early December 2004 the US Congress passed into law the "Commercial Space Launch Amendments Act of 2004." Intended to "promote the development of the emerging commercial human space flight industry," the Act establishes the authority of the Federal Aviation Administration (FAA) over suborbital space tourism in the US, allowing it to issue permits to private spacecraft operators to send customers into space.[73] In 2006 the ESA announced the "Survey of European Privately-funded Vehicles for Commercial Human Spaceflight" to support the emergence of a European commercial space transportation industry.[74]

The market for commercial space transportation remains small but has attracted a great deal of interest. By 2006 four orbital space tourists had flown, all on the Russian Soyuz, and Space Adventures had taken deposits for over 100 space flights, with the cost increasing from $20-million to between $30- and $40-million.[75] In June 2004 SpaceShipOne, developed by US Scaled Composites, became the first private manned spacecraft.[76] By 2005 there were 19 suborbital launch vehicles under development, primarily for the space tourism market.[77] This market is also generating commercial investment in space infrastructure. For example, Bigelow Aerospace is building a privately owned, inflatable in-space platform.[78] While the industry continues to face challenges — including a lack of international legal safety standards, high launch costs, and export regulations[79] — important liability standards are beginning to emerge. In 2006 the FAA released final rules governing private human spaceflight requirements for crew and participants.[80] Final rules were also issued for FAA launch vehicle safety approvals.[81]

**Insurance**

Insurance is an important way of managing the risks associated with sustainable access to and use of space, with rates influencing both the cost of this access as well as the type of coverage pursued. Insurance rates also influence the ease with which start-up companies and new technologies can enter the market:[82] Although governments play an important role in the insurance sector insofar as they generally maintain a certain level of indemnification for commercial launchers, the commercial sector assumes most of the insurance burden. There are two types of coverage: launch insurance, which typically includes the first year in orbit, and on-orbit insurance for subsequent years. Most risk is associated with launch and the first year in orbit. Prior to 1998 the typical insurance rate for a launch plus 12 months of on-orbit coverage was about seven percent of the satellite and launch vehicle value; after that date a sharp increase in on-orbit anomalies forced rates up to 20 percent and higher.[83] In 2002 the space insurance industry paid out $830-million in claims while it collected just $490-million in premiums.[84] Eventually revenues stabilized with increasing premiums and few payouts, resulting in 2005 profits of $880-million.[85] As rates increased terms also became more restricted. Insurers do not generally quote premiums more than 12 months prior to a scheduled launch and in-orbit rates are usually limited to one-year terms and often do not cover events such as terrorism or "Acts of God."[86] Many companies abandoned insurance altogether. In recent years, however, there has been a softening of the launch insurance market, with rates dipping to the low teens.[87]

The market for in-orbit insurance has also been tumultuous, but operators have had more flexibility in dealing with it. Like launch insurance, rates skyrocketed in the early 2000s and terms tightened, leading many companies to discontinue insurance and instead self-insure through the production of satellite backups.[88]

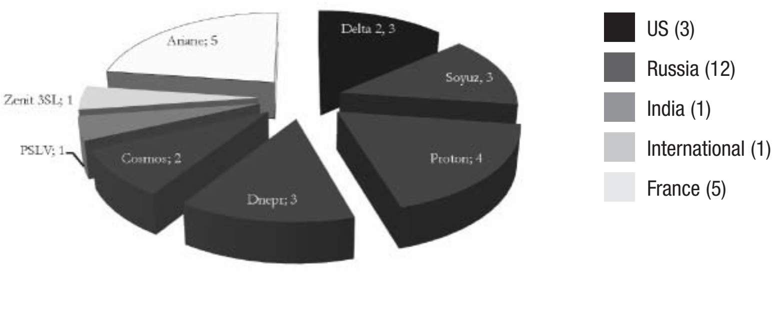
With the advent of space tourism, the space insurance industry may expand to cover human spaceflight. In the US, the FAA requires commercial human spacecraft operators to purchase third-party liability insurance, although additional coverage is optional. Each of the first two space tourists purchased policies for training, transportation, and time spent in space.[89]

## 2007 Development

**Launch costs remain high in a tight market following failures**

Following launch price increases in 2005 and 2006, prices remained high in 2007 as capacity remained tight following the 30 January 2007 explosion of Sea Launch's Proton rocket, which damaged the launch platform and gas deflector.[90] The Sea Launch failure also delayed the introduction of Land Launch, which will use the same technology to launch from the Baikonur site in Kazakhstan; launch activity is not expected until 2009.[91] A second launch attempt of the SpaceX Falcon-1 was made on 21 March 2007, following the failure of the Falcon-1 launch attempt by SpaceX in 2006, but the second stage failed to reach its intended orbit.[92] Overall, high demand coupled with supply restrictions and rising costs for materials in 2007 raised launch prices.[93] Still, there are downward pressures on launch prices that might have an effect in the near future, including lower insurance costs and new entrants to the launch market.

Figure 4.6: Commercial space launches in 2007[94]




## 2007 Development

### Lower insurance rates and new entrants to the launch market may reduce cost of access to space

Launch insurance affects both the cost and risk of access to space. In recent years some satellite owners had relied on self-insurance in the face of very costly insurance rates, but in 2007 many returned to more traditional risk management practices as rates declined.[95] Insurance capacity was greater than demand, allowing a 13 percent decrease in rates from the peak in 2004, while overall premiums have surpassed losses for five straight years. Premiums for launch and first year in orbit ranged from 12 to 18 percent, depending on the level of risk, with annual in-orbit rate at approximately 1.8 percent.[96] Moreover, rates for insurance seem to be gaining flexibility as the market matures. In May 2007 Intelsat secured insurance for eight of its satellites at well below going market rates, using leverage from the size of its fleet.[97] GeoEye was also able to obtain a good rate for its aging IKONOS satellite based on a new life expectancy analysis conducted by the manufacturer, Lockheed Martin.[98] New types of coverage such as third-party and product liability for private space ventures are being developed, which could lend support to small launch startups in the future; pricing is a sensitive issue that could constrain this emerging market.[99] Due to launch failures, however, insurers lost approximately $150-million in 2007, so premiums may rise in the coming year.[100]

New entrants to the space launch market may also contribute both extra capacity and competition, which may reduce the cost of space access. India and China are two such examples (see Trend 4.1), while others include Brazil and Ukraine, which entered into a partnership in 2007 to form a joint venture company to launch rockets and satellites from the Alcantara Base in the northeastern Brazilian state of Maranhao using Ukrainian launch technology. The commercial venture hopes to capture approximately 10 percent of the global market in the next eight years, marketing itself to countries with satellites, but without launch capability.[101] In the meantime, Arianespace moved to meet increased demand for launch services, entering into an agreement with Astrium to increase the production rate for Ariane-5 to seven per year beginning February 2008.[102] Arianespace also increased the mission capacity of Ariane-5, providing payload launch opportunities for MSS satellites of various sizes.[103]

In 2007 the first geostationary commercial launch contact for Falcon-9 was signed, bringing the total number of launch contracts to seven.[104] South Korea is developing a small launch vehicle, the Korea Space Launch Vehicle, which may signal Korea's entry into the commercial launch services market if it is successful.[105] Brazil may revamp its rocket launch capability. In December 2007 a Brazilian rocket commercially launched an Argentinean rocket 121 kilometers to conduct scientific experiments.[106] Brazil's first orbital launch attempt exploded in 1997. In the long term, Mitsubishi Heavy, which makes and markets Japan's H-2A heavy launcher, aims to compete in the commercial space market. Currently its launch costs, at roughly $90-million, are too high for the commercial market, but it is making efforts to bring down costs to between $60- and $70-million, in line with international rivals.[107] The H-2A conducted two successful launches in 2008. Even if new launchers do enter the market, however, untested technologies face significant challenges, including high insurance costs and a wary clientele.[108]

## 2007 Development

### Private human suborbital spaceflight expanding, but capabilities limited

The promise of commercial human spaceflight generated continued activity in 2007. To support the emerging industry, the US Federal Aviation Administration implemented new guidelines to obtain experimental launch permits for reusable spacecraft, allowing personal spaceflight entrepreneurs multiple vehicles of a specific design and unlimited launches of the same per permit. The US projects a $1-billion- per-year market for suborbital flights by 2021.[109] Space Adventures bought two more seats on Soyuz flights to the ISS, intending to market them to space tourists — one for late 2008 and one for early 2009.[110] However, this market is subject to the same capacity constraints as the unmanned launch market: retirement of the space shuttle in 2010 means that NASA will rely on the Soyuz vehicles to deliver astronauts to the International Space Station, thus decreasing the number of seats available for commercial passengers. The cost of a ticket to the Space Station has subsequently risen from between $20- and $25-million to between $30- and $40-million.[111] This industry may soon generate excess capacity, however. The European Space Agency has shown interest in personal spaceflight, performing a study assessing the commercial suborbital market, identifying hindrances to market development, and determining ways to achieve European entry into the marketplace.[112] EADS Astrium also announced its intention to garner a piece of the suborbital market, hoping for subsidization from regional development funding.[113] Finally, in 2007 Amazon founder Jeff Bezos began advertising for engineers to join his privately funded space program. His new company, Blue Origin 9, is focusing on human space exploration and affordable spaceflights for the masses.[114]

Following the launch on 28 June 2007 of Bigelow Aerospace's second inflatable module, Genesis-2, the company has decided to fast-track the launch of its habitable Sundance module, in part due to rising launch costs.[115] It could be capable of supporting a three-person crew by 2010.[116] Bigelow projects that user crews would primarily consist of industry workers, and would not be space hotels, although some tourist use could occur.[117] It has set the price for sovereign customers (nations wanting to send their astronauts into space) at $14.95-million for four weeks in the inflatable module, with a possibility of extending the stay for $2.95-million for each additional four-week period. Private companies could lease the module for research at $88-million per year for a full module and $4.5-million per month for a half-module.[118]

**2007 Development**

### Commercial spaceflight aims for the Moon

Google added its weight to the commercial spaceflight market in 2007: as the sponsor of the next X-Prize challenge it will provide $30-million to the first privately funded team that can soft-land a robot on the Moon, travel a minimum distance of 500 meters and transmit high-definition video and other images and data back to Earth for viewing over the Internet.[119] If the challenge is not met by 31 December 2012, however, the prize value will drop to $15-million; the final deadline for winning the prize is 31 December 2014, at which time it will be terminated unless extended by Google and the X Prize Foundation.[120] Seven teams have announced their intentions to compete for the Prize; the first official entrant is Odyssey Moon of the Isle of Man.[121] While the prospects of winning the prize remain distant, it is generating both substantial interest and substantial investments.

**2007 Development**

### Greater commercial access to high-resolution remote sensing images

Higher resolution imaging is becoming increasingly accessible to the public market, with key developments taking place in 2007. The launch of DigitalGlobe's WorldView-1 spacecraft means that US DOD-sponsored 50-centimeter imagery will be commercially available at resolutions comparable to highly classified products. Moreover, Germany's TerraSar-X and Canada's Radarsat-2, launched in June and December 2007, are commercial radar remote sensing satellites offering high-quality resolution imaging, at one meter and three meters respectively (see Trend 4.3). India launched Cartosat II with one-meter resolution in January 2007, bringing Indian imagery in line with leading commercial services.[122]

In a separate development, Google and Spot Image entered into an agreement to improve the resolution of imagery available for Google Earth users. France's Spot Image will provide 2.5-meter resolution for extensive areas of Earth.[123] Although the data provided by Google Earth is not current, it has enhanced the general public's appetite for remote sensing.[124]

The use of commercial satellite remote sensing images by public users was demonstrated in 2007 when project "Crisis in Darfur" was launched to educate the 200 million users of Google Earth about the ongoing conflict in the region. The partnership between the US Holocaust Memorial Museum and Google Earth is being used to map the effects of the conflict, including the destruction of villages and movement of displaced persons. A similar initiative is planned to map key sites of the Holocaust.[125]

Demand for remote sensing products continues to grow, particularly as space-based data replaces aerial data; expenditures were almost $7.3-billion in 2007. Weather forecasting accounts for approximately 38 percent of the market — five times the market share of intelligence gathering.[126]

Figure 4.7: Commercial remote sensing satellites

| System | Operator | Current Satellites | Type | Highest Resolution (meters) |
|---|---|---|---|---|
| EROS | ImageSat International | EROS A | Optical | 1.5 |
| | | EROS B | Optical | 0.7 |
| | | EROS C | Optical | 0.7 |
| IKONOS | GeoEye | IKONOS-2 | Optical | 0.8 |
| OrbView | GeoEye | OrbView-1 | Optical | 10,000 |
| | | OrbView-2 | Optical | 1,000 |
| | | OrbView-3 | Optical | 1 |
| | | OrbView-4 | Optical | 1 |
| QuickBird | DigitalGlobe | EarlyBird | Optical | 3 |
| | | QuickBird-1 | Optical | 1 |
| | | QuickBird | Optical | 0.6 |
| Radarsat | MDA | Radarsat-1 | Radar | 8 |
| | | Radarsat-2 | Radar | 3 |
| SPOT | Spot Image | SPOT 2 | Optical | 10 |
| | | SPOT 4 | Optical | 10 |
| | | SPOT 5 | Optical | 2.5 |
| WorldView | DigitalGlobe | WorldView-1 | Optical | 0.5 |
| Disaster Monitoring Constellation | DMC International Imaging | AlSAT-1 (Algeria) | Optical | 32 |
| | | NigeriaSAT-1 (Nigeria) | Optical | 32 |
| | | UK-DMC (United Kingdom) | Optical | 32 |
| | | Beijing-1 (China) | Optical | 4 |
| TerraSar | | TerraSar-X | Radar | 1 |

### Space security impact

Sustained competition in commercial space launch may slightly reduce the cost of access to space in the near future, but in the absence of revolutionized technologies, there is not likely to be a significant impact on space access. Although the commercial human space flight industry continues to develop, it has yet to deliver sustainable, low-cost launchers. Moreover, while some regulatory efforts are being made to support the prospect of private human access to space, such access may cause challenges to space security, both in terms of the sustainability of the space environment as well as the applicability of international laws, such as the Outer Space Treaty. Finally, while the space industry is facilitating greater use of space applications, in particular remote sensing, there are legitimate fears about the implications for security on Earth (see Trend 4.3 below).

## Trend 4.3: Governments both support and regulate the commercial space sector as subsidies and national security concerns continue to play an important role

As national security concerns continue to play an important role in the commercial space industry, governments play the role of both partner and regulator. On the one hand, governments have played an integral role in the development of the commercial space sector. Most spacefaring states consider their space systems an extension of national critical infrastructure, and a growing number view their space systems as critical to national security. Full state ownership of space systems has now given way to a mixed system in which many larger commercial space actors receive significant government contracts and a variety of government subsidies. Certain commercial space sectors, such as remote sensing or commercial launch industries, rely more heavily on government customers, while the satellite communications industry is commercially sustainable even without government contracts. On the other hand, due to the security concerns associated with commercial space technologies, governments also play an active role in the sector through regulation, including export controls and controls on certain applications, such as Earth imaging.

The US Space Launch Cost Reduction Act of 1998 established a low-interest loan program for qualifying private companies to support the development of reusable vehicles.[127] In 2002 the US Air Force requested $1-billion in subsidies from Congress for the period 2004-2009 for Lockheed Martin's Atlas V and Boeing's Delta 4 development as part of the Evolved Expendable Launch Vehicle (EELV) program.[128] To maintain the financial feasibility of the program, the 2005 Space Transportation Policy requires the Department of Defense (DOD) to pay the fixed costs to support both companies until the end of the decade.[129] The Air Force accordingly announced that it will divide its planned 23 EELV missions between the two companies rather than force price-driven competition.[130] In 2006 these two launchers were merged into a single company, the United Launch Alliance. A report commissioned by the FAA indicates that the success of the US commercial launch industry is viewed as "beneficial to national interests."[131]

Government involvement in commercial activities extends beyond the launch market, however; the 2003 US Commercial Remote Sensing Space Policy directs the US government to "rely to the maximum practical extent on U.S. commercial remote sensing space capabilities for filling imagery and geospatial needs for military, intelligence, foreign policy, homeland security, and civil users" to "advance and protect U.S. national security and foreign policy interests by maintaining the nation's leadership in remote sensing space activities, and by sustaining and enhancing the US remote sensing industry."[132]

The European Guaranteed Access to Space Program adopted in 2003 requires that ESA underwrite the development costs of the Ariane 5, ensuring its competitiveness in the international launch market.[133] The program explicitly recognizes a competitive European launch industry as a strategic asset and is designed to ensure sustained government funding for launcher design and development, infrastructure maintenance, and upkeep.[134] It also supports a continued relationship with Russia to launch the Soyuz from the Kourou launch site in French Guiana.

Russia's commercial space sector maintains a close relationship with its government, receiving contracts and subsidies for the development of the Angara launcher and launch site maintenance.[135] The Russian space program receives subsidies from the US in the form of contracts for the International Space Station (ISS). The vulnerability of the Russian commercial space sector was demonstrated in 2002, when Russia's financial struggles and inability to fully meet its subsidy commitments forced the Russian space launch company Energiya to default on loan payments. According to Russian media, the Russian space industry was to receive only $38-million in subsidies in 2003, not enough to cover existing debts or ISS commitments.[136]

China's space industry also has a close relationship with its government. The 2006 Chinese White Paper on Space Activities identifies the development of an independent space industry as a key component to its goals for outer space.[137]

**Commercial satellite positioning**

Initially intended for military use, satellite navigation has emerged as a key civilian utility with a strong commercial market. The US government first promised international civilian use of its planned Global Positioning System (GPS) in 1983 following the downing of Korean Airlines Flight 007 that strayed over Soviet territory, and in 1991 pledged that it would be freely available to the international community beginning in 1993.[138] US GPS civilian signals have dominated the commercial market, but new competition may emerge from the EU's Galileo system, which is specifically designed for civilian and commercial use, and Russia's GLONASS.[139] China's regional Beidou system may also be available for commercial use by 2008.[140]

The commercial satellite positioning industry initially focused on niche markets such as surveying and civil aviation, but has since grown to include automotive navigation, agricultural guidance, and construction.[141] The crux of revenues to the commercial satellite positioning industry is sales of ground-based equipment. Sales to commercial users first outpaced those to military buyers in the mid-1990s.[142] The commercial GPS market continues to grow with the introduction of new receivers that integrate the GPS function into other devices such as cell phones, making it a mainstream electronic.[143] Global GPS revenues for 2005 were estimated at $21.8-billion.[144]

**Export controls**

Trade restrictions aim to strike a balance between commercial development and the proliferation of sensitive technologies that could pose security threats, but achieving that balance is not easy, particularly in an industry characterized by dual-use technology. Space launchers and intercontinental ballistic missiles use almost identical technology, and many civil and commercial satellites contain advanced capabilities with potential military applications. Dual-use concerns have led states to develop national and international export control regimes aimed at preventing proliferation. The regime most pertinent to commercial space security considerations is the Missile Technology Control Regime (MTCR).

The MTCR was formed in 1987 by a group of states seeking to prevent the further proliferation of capabilities to deliver weapons of mass destruction by collaborating on a voluntary basis to coordinate the development and implementation of common export policy guidelines.[145] The 34 members of the MTCR include Australia, Brazil, Canada, France, Germany, Japan, Russia, South Korea, the UK, and the US, with China formally expressing interest in becoming a member in 2003.[146] However, export practices differ among members. Although the American "Iran Nonproliferation Act" of 2000 limited the transfer of ballistic missile technology to Iran, for example, Russia is still willing to provide such technology under its Federal Law on Export Control.[147] Most states control the export of space-related goods through military and weapons of mass destruction export control laws, such as the Export Control List in Canada, the Council Regulations (EC) 2432/2001 in the EU, Regulations of the People's Republic of China on Export Control of Missiles and Missile-related Items and Technologies, and the WMD Act in India.[148]

From the late 1980s to late 1990s, the US had agreements with China, Russia, and Ukraine to enable the launch of US satellites from foreign sites. However, in 1998 a US investigation into several successive Chinese launch failures led to allegations about the transfer of sensitive US technology to China by aerospace companies Hughes and Loral. Concerns sparked the transfer of jurisdiction over satellite export licensing from the Commerce Department's Commerce Control List to the State Department's US Munitions List (USML) in 1999.[149] In effect, the new legislation treated satellite sales like weapons sales, making international collaborations more heavily regulated, expensive, and time consuming.

Exports of USML items are licensed under the International Traffic in Arms Regulations (ITAR) regime, which adds several additional reporting and licensing requirements for US satellite manufacturers. A recent US Government report noted that, in total, it now takes "nine to 20 months on average to gain approval for a satellite export and notify Congress."[150] A subsequent study of the market conditions for US satellite manufacturers argued that "nearly every potential international buyer of satellites in 2002 … indicated that the US export control system is a competitive disadvantage for US manufacturers."[151] Recently European satellite firms have been developing 'ITAR free' satellites that use no US components and thus avoid all ITAR restrictions.[152]

Finally, because certain commercial satellite imagery can serve military purposes, a number of states have implemented regulations on the sector. The 2003 US Commercial Remote Sensing Policy sets up a two-tiered licensing regime that limits the sale of sensitive imagery.[153] In 2001 the French Ministry of Defense prohibited open sales of commercial Spot Image satellite imagery of Afghanistan.[154] Indian laws require the 'scrubbing' of commercial satellite images of sensitive Indian sites.[155] Canada has recently passed Bill C-25, creating a regulatory regime that will give the Canadian government "shutter control" — the control exercised by the executive branch of government over the collection and dissemination of commercial satellite imagery of a particular region due to national security or foreign policy concerns — and priority access in response to possible future major security crises.[156] Analysts note, however, that competition among increasing numbers of commercial satellite imagery providers may eventually make shutter control prohibitively expensive.[157]

**Commercial space systems as critical infrastructure**

Space systems, including commercial systems, are viewed by some states as critical national infrastructure and strategic assets, but the implications are not clear. During the overcapacity of the 1990s, the US military began employing commercial satellite systems for non-sensitive communications and imagery applications. During Operation Enduring Freedom in 2001 the US military used 700 megabytes per second of bandwidth, 75 percent of which was from commercial systems.[158]

The US DOD is the single largest customer for the satellite industry. By November 2003 it was estimated that the US military was spending more than $400-million each year on commercial satellite services.[159] This figure jumped to more than $1-billion a year for commercial broadband satellite services alone by 2006.[160] "DoD estimates that commercial satellite systems are providing over 80 percent of the satellite bandwidth supporting Operation Iraqi Freedom."[161] In response, DOD is examining ways to facilitate satellite service procurement by studying different acquisition methods.[162] This would provide a more long-term, strategic partnership between DOD and its commercial providers.

This growing dependence upon commercial services prompted a December 2003 US General Accounting Office report to recommend that the US military be more strategic in planning for and acquiring bandwidth by, among other things, consolidating bandwidth needs among military actors to capitalize on bulk purchases.[163] A 2004 study of the US National Security Telecommunications Advisory Committee Satellite Task Force noted the great dependence of the national security and homeland security communities on commercial space.[164]

## 2007 Development

### Governments and militaries partner with the commercial industry for satellite imaging, communications, and launch services

In 2007 governments and militaries continued to be significant consumers of commercial satellite imaging services, with the launch of publicly funded commercial remote sensing satellites. The first of two commercial WorldView satellites being developed by DigitalGlobe, and the only commercial imaging satellite to provide up to 50-centimeter resolution, was launched on 20 September 2007. It is part of the National Geospatial-Intelligence Agency's (NGA) NextView Program to combine commercial remote sensing with much more powerful optics, partly funded by the Pentagon.[165] NGA contributed $500-million to secure imagery for specific DOD high resolution needs.[166]

Canada's Radarsat-2 was launched on 14 December 2007. In a public-private partnership, the Government of Canada, primarily through the Canadian Space Agency, pre-purchased $445 million in data from Radarsat-2. The satellite's three-meter, all-weather, all-day, all-terrain satellite images will also be available for commercial sale in accordance with the terms of Canada's Remote Sensing Space Systems Act, administered by the Department of Foreign Affairs and International Trade.[167] Similarly, Germany's TerrSar-X, launched on 15 June 2007, is the result of a partnership between the German Ministry of Education and Science, the German Aerospace Center (DLR), and the Astrium GmbH.[168] It provides up to one-meter images for scientific research and applications and to the remote sensing market.[169] Finally, DigitalGlobe and GeoEye partnered with the US Geological Survey to support the many space and satellite agencies that form the International Charter "Space and Major Disasters."[170]

Remote sensing is not the only instance of such partnering. The Skynet-5 secure military communications satellite launched on 11 March 2007 is operated by Paradigm Secure Communications, a subsidiary of Astrium.[171] The UK has priority of use, with excess capacity available for sale to NATO and other UK allies. The US DOD partnered with Intelsat Ltd. and Cisco Systems Inc. in 2007 to initiate a technology development program that could eventually facilitate high-speed Internet access to mobile military units.[172] The initial technology development cost will be borne by Cisco and Intelsat, in the hope that the military will make long-term commitments to support future technologies and new acquisition procedures. The application will be added to an Intelsat satellite already under construction and is scheduled to be launched during the summer of 2009.

The US military has publicly recognized the importance of the commercial sector to meet capacity shortfalls.[173] The US National Security Space Office (NSSO) intends to upgrade the Transformational Communications Architecture (TCA), which serves the Department of Defense, intelligence community, and NASA; the new version will expand the potential role for COMSATCOM and leverage emerging commercial satellite capabilities. "Commercial satellites meet 80 percent of the needs of troops in Afghanistan and Iraq, four times as much as during Operation Desert Storm 16 years ago."[174] It is estimated that the US DOD is spending $1-billion a year on commercial satellite communications.[175] Former head of the NSSO Joe Rouge indicated that the US military will move forward on efforts to create long-term partnerships with industry.[176]

A key example of an attempt to shift the dynamic between commercial space and government space is NASA's $500-million Commercial Orbital Transportation Services (COTS) program. It is designed to spur private development of commercial spacecraft that can service the International Space Station when the Space Shuttle is retired in 2010, but is struggling.[177] The original program provided funding agreements to SpaceX and Rocketplane Kistler.[178] Although SpaceX remains on track,[179] Rocketplane Kistler was dropped from COTS in 2007 for failing to meet financial milestones; NASA then entered into agreements with SpaceDev, SPACEHAB, Constellation Services International, PlanetSpace, and t/Space.[180] NASA also plans to provide half of its space on the ISS as an incentive to participate in the COTS program,[181] and is shopping for commercial and military users of the Ares launch vehicles. NASA stated that "turning the taxpayer-funded launch vehicles over to other U.S. users would be an appropriate way for the U.S. government to support the commercial sector."[182] It is not clear if this strategy will be successful.

## 2007 Development

### Galileo demonstrates the limits to public-private partnerships

The success of public-private partnerships in the commercial space imaging and communications sectors contrasts sharply with the experience of the Galileo project in Europe. After a delay of five years, due largely to bureaucratic obstacles and the failure of a public-private consortium, European governments agreed in December 2007 to provide the necessary $5-billion to continue work on Galileo — a planned 30-satellite space navigation system intended to provide Europe with capabilities independent from the US GPS. The European Commission abandoned the original plan for substantial participation by the private sector after interests of member countries on behalf of their national industries created a stalemate.[183] This was the first attempt at a global navigation system funded by a public-private partnership. Unlike other successful examples, it placed a significant risk and cost burden on the public sector for investment in a public utility that would only see long-term returns and would have to compete with existing freely available government systems.

2007 Development

### Ongoing efforts to regulate access to commercial satellite imagery

Controversy surrounding the potential use of Google Earth images by terrorists in Iraq in 2007 sheds light on the ongoing struggle between access to commercial space services and security needs.[184] Although commercial services such as Google Earth are composed of unclassified photos many states have raised concerns and it is now routine for many commercial images to be blocked. Google replaced the images of Iraq with prewar data following complaints by the British government, and was asked by the Indian government to blur what it referred to as strategic locations in India. Similar policies exist in many other countries including Australia, Russia, South Korea, Thailand,[185] and Israel. In 2007, as commercial providers launched new, improved capabilities, the Director of the National Geospacial-Intelligence Agency acknowledged that controls on distribution might need to be put in place.[186] There is "little if any directly applicable international law" governing the controversy.[187] Images of China's new Jin-class submarine also appeared on Google Earth in July 2007.[188]

Germany has addressed the issue with its Satellite Data Security Act, which entered into force on 1 December 2007. The purpose of the law "is to provide a clearly defined and transparent procedure for the dissemination of RS [remote sensing]-data" and covers first-time marketing/dissemination of data, German satellites and satellites operated by German citizens, and high-grade remote sensing satellites, but excludes governmental satellites operated by either military or intelligence agencies.[189] Similarly, Canada's Radarsat-2 is the first commercial remote sensing satellite to be licensed under its new Remote Sensing Space Systems Act, which allows the government to regulate distribution of data and exercise shutter control to address issues of national or international security.[190]

In related developments, litigation was initiated between ImageSat International's (ISI) minor shareholders and current management based on claims of lost opportunities and company devaluaation through management decisions to bow to Israeli pressure and refuse to sell satellite imaging services to Venezuela.[191] Venezuela was able to obtain data from China, which is to be used in commercial and military applications, as well as satellite and launch facilities.[192] Similarly, Israel's Ministry of Defense sought agreement from the US government for China to participate as a Satellite Operating Partner with ISI, allowing it to select targets and stream images directly into Chinese ground stations. The US agreed, but not without several restrictions, which may disrupt the deal.[193] The issue of distribution of commercial satellite imagery is likely to intensify as technologies improve and capabilities proliferate.

2007 Development

### Private industry joins government in space safety efforts

Few rules govern security and safety in outer space, but following the Chinese intercept of one of its own satellites on 11 January 2007, Dave McGlade, CEO of Intelsat, added his voice to those of several governments in calling for a code of conduct or rules of the road to provide norms and guidelines on space activities.[194] The importance of the private sector in space safety and governance issues has also been highlighted by the US government. Under a program called Neighborhood Watch, the US DOD is attempting to align government and industry resources to address growing space security challenges and to increase space situational awareness.[195] The program is intended to enhance safety and reduce risk and contribute to the sustainable use of key orbits.[196]

## 2007 Development

### Export controls try to balance commercial interests with security concerns

US export controls remained a concern in the commercial space industry in 2007 and were an issue in the Aerospace Industries Association Election for 2008.[197] To facilitate reform, US industry groups formed a coalition to lobby administration officials to relax their interpretation of the export regulations and reduce the license applications backlog.[198] The effect of controls on industry is difficult to ascertain. While Boeing's chairman went on record stating that the company had become more efficient at working the ITAR process[199] — implying that they are not necessarily impeding sector growth — the impact on smaller businesses or start-ups with fewer resources to devote to the process may be different. In 2007 the US and the UK signed a treaty to ease ITAR restrictions after ITAR waiver discussions were aborted.[200] The same preferred status was given to Australia in a similar agreement.[201] Canada and the US also took a step to ease ITAR, beginning with access to defense articles and services for Canadian citizens with appropriate security clearance.[202]

Export controls were an issue in Europe as well in 2007; the European Commission unveiled its new European Space Policy to address the need for an appropriate legal and managerial framework and define security-related requirements.[203] The task is daunting as the many member states in the EU have their own separate national interests.[204]

An FBI investigation of India's Defense Research and Development Organization led to the arrest of at least five Indian nationals in 2007, creating tension between the countries. They were charged with acquiring and exporting US dual-use technologies, including computer chips for India's missile, space, and Light Combat Aircraft programs, without proper licenses from the Department of Commerce.[205] A Russian court convicted the Russian head of a Chinese rocket and space technology company in 2007 on similar charges of leaking sensitive technology.[206] Policy changes to a Commerce regulation in 2007 made it more difficult, but not impossible, for China to purchase high-tech items from the US; however, it only catches items not on ITAR or the normal Commerce Control List of export controls for China.[207]

Industries are maneuvering around ITAR restrictions by purchasing ITAR-free satellites and launch services, which do not use US components. China was able to launch the Chinasat 6B telecommunications satellite, built by Thales Alenia Space, in its Long March launcher because the satellite was built without US components. Thales Alenia Space is the only western company that has developed a product line deliberately designed to avoid US trade restrictions on its satellite components.[208] Arianespace denounced Thales for flouting ITAR, despite its contracts to launch multiple spacecraft for Globalstar and an option for as many more.[209] Arianespace also cautioned the US against possible Chinese "dumping."[210]

## Space security impact

The strong relationship between military and commercial uses of space and the security dimensions of many commercial services has a complex impact on space security. On the one hand, multiple-use spacecraft could become military targets in the future, resulting in an overall decrease in security. Alternatively, the proliferation of dual-use assets in space could make a military attack less useful and, therefore, less likely. Arguably, this could increase overall space security. There are also pros and cons for government users of commercial systems, including greater flexibility and options for using space, but fewer security features to protect this use. The failure of the Galileo partnership, however, demonstrates that the costs and risks of space access and use remain high, and governments must play a key role in ensuring that access. Efforts to regulate access to both commercial space technology and data in 2007 reflected ongoing attempts to balance the benefits of secure access to and use of space against the potential threats it may pose to space security. This balance was better addressed regarding access to commercial imagery in 2007, but striking a balance between these two components of space security will become more complicated if commercial capabilities continue to increase. Finally, the growing interest in the commercial space industry to advance and participate in space governance initiatives is a positive development for space security, since all actors share the same interest in the secure and sustainable access to space.

Figure 4.8: Commercial payloads launched in 2007

| COSPAR | Launch Date | Launch Vehicle | Satellite Name | Launch State | State | Primary Function | Primary Manufacturer | Orbit Type |
|---|---|---|---|---|---|---|---|---|
| 2007-012F | 4/17/07 | Dnepr | Aerocube 2 | Russia | Aerospace Corporation | Technology | Aerospace | SSO |
| 2007-020A | 5/29/07 | Soyuz-FG | Globalstar M065 | Russia | American Globalstar | Communication | Loral | LEO |
| 2007-020C | 5/29/07 | Soyuz-FG | Globalstar M069 | Russia | American Globalstar | Communication | Loral | LEO |
| 2007-020D | 5/29/07 | Soyuz-FG | Globalstar M072 | Russia | American Globalstar | Communication | Loral | LEO |
| 2007-020F | 5/29/07 | Soyuz-FG | Globalstar M071 | Russia | American Globalstar | Communication | Loral | LEO |
| 2007-028A | 6/28/07 | Dnepr | Genesis-2 | Russia | Bigelow Aerospace | Technology | Bigelow | LEO |
| 2007-036B | 8/17/07 | Ariane 5ECA | BSAT-3A | France | B-SAT | Communication | LM/Newtown | GEO |
| 2007-012M | 4/17/07 | Dnepr | CalPoly CP3 | Russia | CalPoly | Technology | Cal Poly | SSO |
| 2007-012Q | 4/17/07 | Dnepr | CalPoly CP4 | Russia | CalPoly | Technology | Cal Poly | SSO |
| 2007-021A | 5/31/07 | Chang Zheng 3A | Xinnuo 3 | China | China | Communication | CAST | GEO |
| 2007-031A | 4/5/07 | Chang Zheng 3B | Zhongxing 6B | China | China | Communication | Thales/Canne | HEO |
| 2007-041A | 9/18/07 | Delta 7920-10C | WorldView-1 | US | DigitalGlobe | Remote sensing (optical) | Ball | SSO |
| 2007-032A | 7/7/07 | Proton-M/Briz-M | DirecTV 10 | Russia | DireccTV | Communication | Boeing/ES | GEO |
| 2007-036A | 8/17/07 | Ariane 5ECA | Spaceway 3 | France | Huges Network System | Communication | Boeing/HB | GEO |
| 2007-007A | 3/11/07 | Ariane 5ECA | Insat 4B | France | Insat | Communication | ISRO/ISAC | GEO |
| 2007-037A | 9/2/07 | GSLV | INSAT 4CR | India | Insat | Communication | ISRO/IISAC | GEO |
| 2007-016B | 5/4/07 | Ariane 5ECA | Galaxy 17 | France | Intelsat | Communication | Thales/Canne | GEO |
| 2007-044B | 10/5/07 | Ariane 5GS | Intelsat IS-11 | France | Intelsat | Communication | Orbital | GEO |
| 2007-063D | 12/21/07 | Ariane 5GS | Horizons 2 | France | Intelsat and Jsat | Communication | Orbital | GEO |
| 2007-057A | 10/17/07 | Proton-M/Briz-M | Sirius 4 | Russia | NSAB | Communication | LMCSS | GEO |
| 2007-044A | 10/5/07 | Ariane 5GS | Optus D2 | France | Optus Networks | Communication | Orbital | GEO |

| COSPAR | Launch Date | Launch Vehicle | Satellite Name | Launch State | State | Primary Function | Primary Manufacturer | Orbit Type |
|---|---|---|---|---|---|---|---|---|
| 2007-012C | 4/17/07 | Dnepr | SaudiComsat-7 | Russia | Saudi Arabia | Messaging | Saudisat | SSO |
| 2007-012E | 4/17/07 | Dnepr | SaudiComsat-6 | Russia | Saudi Arabia | Messaging | Saudisat | SSO |
| 2007-012H | 4/17/07 | Dnepr | SaudiComsat-5 | Russia | Saudi Arabia | Messaging | Saudisat | SSO |
| 2007-012J | 4/17/07 | Dnepr | SaudiComsat-3 | Russia | Saudi Arabia | Messaging | Saudisat | SSO |
| 2007-012L | 4/17/07 | Dnepr | SaudiComsat-4 | Russia | Saudi Arabia | Messaging | Saudisat | SSO |
| 2007-016A | 5/4/07 | Ariane 5ECA | Astra 1L | France | SES Astra | Communication | LM/Sunnyvale | GEO |
| 2007-056A | 11/14/07 | Ariane 5ECA | Star One C1 | France | Star One | Communication | Thales/Canne | GEO |
| 2007-009A | 4/9/07 | Proton-M/Briz-M | Anik F3 | Russian | Telesat | Communication | Astrium | GEO |
| 2007-012K | 4/17/07 | Dnepr | MAST | Russia | Tethers Unlimited Ink | Technology | TUI | SSO |
| 2007-012R | 4/17/07 | Dnepr | CSTB 1 | Russia | UK | Technology | Boeing | SSO |
| 2007-048A | 10/20/07 | Soyuz-FG | Globalstar M067 | Russia | Globalstar | Communication | Loral | LEO |
| 2007-048B | 10/20/07 | Soyuz-FG | Globalstar M070 | Russia | Globalstar | Communication | Loral | LEO |
| 2007-048C | 10/20/07 | Soyuz-FG | Globalstar M066 | Russia | Globalstar | Communication | Loral | LEO |
| 2007-048D | 10/20/07 | Soyuz-FG | Globalstar M068 | Russia | Globalstar | Communication | Loral | LEO |
| 2007-061A | 12/14/07 | Soyuz-FG | Radarsat-2 | Russia | Canada | Remote sensing (radar) | MDA | LEO |
| 2007-026A | 6/15/07 | Dnepr | TerraSar-X | Russia | Germany | Remote sensing (radar) | EADS | LEO |