Trends in Space Commerce

Office of Space Commercialization

Prepared by Futron Corporation

Foreword from the Secretary of Commerce

As the United States seeks opportunities to expand our economy, commercial use of space resources continues to increase in importance. The use of space as a platform for increasing the benefits of our technological evolution continues to increase in a way that profoundly affects us all. Whether we use these resources to synchronize communications networks, to improve agriculture through precision farming assisted by imagery and positioning data from satellites, or to receive entertainment from direct-to-home satellite transmissions, commercial space is an increasingly large and important part of our economy and our information infrastructure.

Once dominated by government investment, commercial interests play an increasing role in the space industry. As the voice of industry within the U.S. Government, the Department of Commerce plays a critical role in commercial space. Through the National Oceanic and Atmospheric Administration, the Department of Commerce licenses the operation of commercial remote sensing satellites. Through the International Trade Administration, the Department of Commerce seeks to improve U.S. industrial exports in the global space market. Through the National Telecommunications and Information Administration, the Department of Commerce assists in the coordination of the radio spectrum used by satellites. And, through the Technology Administration's Office of Space Commercialization, the Department of Commerce plays a central role in the management of the Global Positioning System and advocates the views of industry within U.S. Government policy making processes.

I am pleased to commend for your review the Office of Space Commercialization's most recent publication, *Trends in Space Commerce*. The report presents a snapshot of U.S. competitiveness as well as a forecast of trends into the near future.

While the report indicates future growth in space commerce, it also shows that we in the United States have work to do to improve our competitive position. As Secretary of Commerce, I look forward to working with industry, the Congress, and other parts of the Executive branch to enhance the commercial use of space and American competitiveness in this area.

Donald L. Evans

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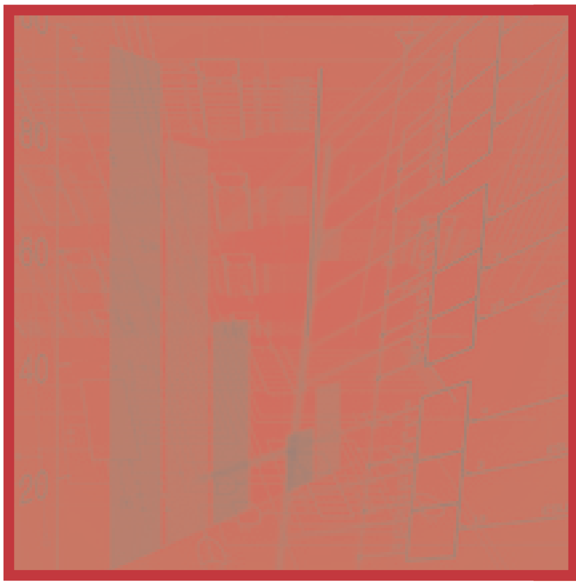


Section One

Overview

1.1 Purpose of report

Understanding the current size of the space industry, the likely future industry trends, and the effects of these trends is an enormous challenge to industry and to policy makers. The challenge in understanding the space industry stems from two factors. First, the space industry is broader than most people realize. It is not only composed of satellites and their launches, but now encompasses many direct-to-consumer applications, Internet services, and entertainment applications. Second, the industry is rapidly evolving from an industry dominated by civil government and military activities to an industry experiencing dramatic growth in commercial arenas. The unprecedented demand for commercial telecommunications services and new commercial applications are the primary driving forces of the space industry today.

With recent and continuing advances in the space industry, the Department of Commerce's (DOC) Office of Space Commercialization sought to produce a publication detailing current indicators and near-term future trends for major space industry segments. This document, *Trends in Space Commerce,* provides benchmark indicators and trend information that can be used by Congress, the industry, and other interested parties.

Futron Corporation assisted the DOC Office of Space Commercialization in the development and preparation of *Trends in Space Commerce.* This document details the results of an analysis of the space transportation, satellite communications, remote-sensing, and global positioning system (GPS) industry segments. The document includes indicators for each industry segment for 1996 to 1999, with projections for 2000 to 2002. Data on global revenue, U.S. revenue, and U.S. employment are included for each industry segment, along with other relevant indicators. Finally, *Trends in Space Commerce* contains a discussion of the trends revealed by these indicators, along with information on key industry events.

1.2 General methodology

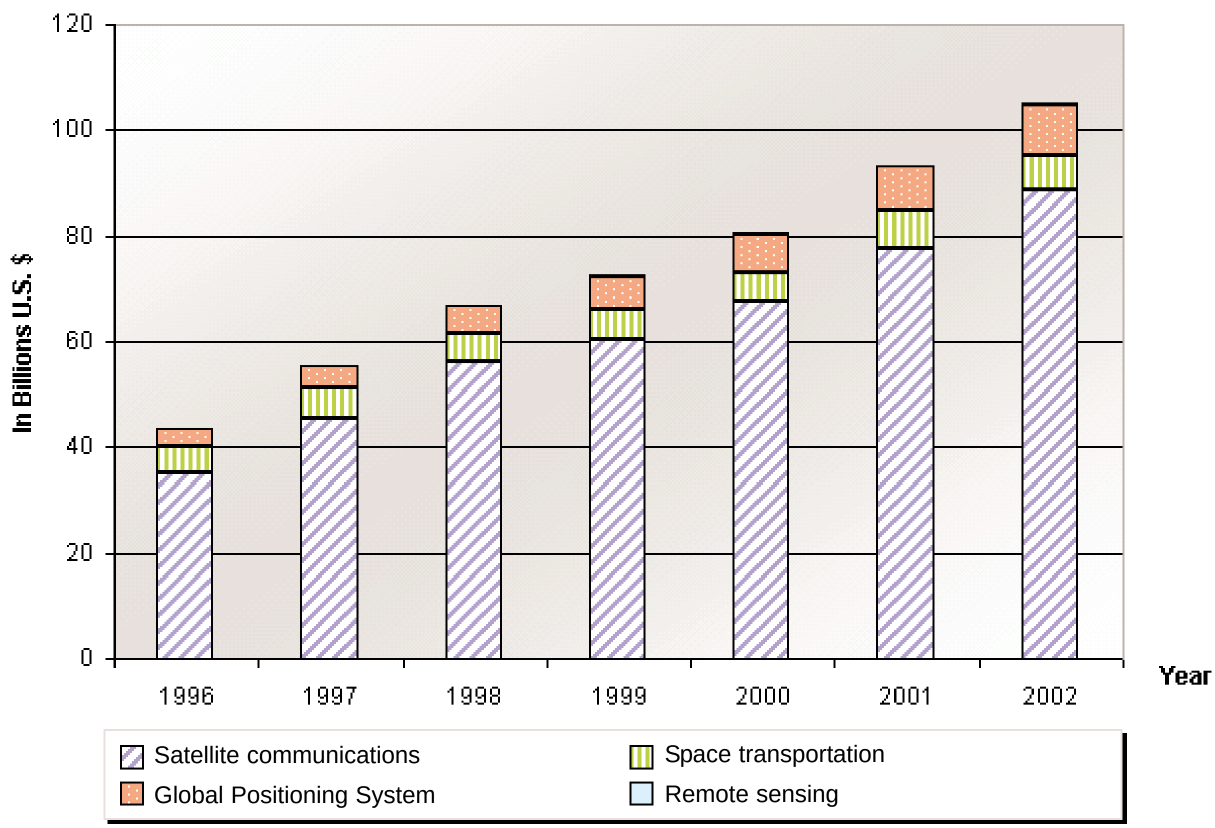
Data was brought together from key industry sources, including DOC bodies such as the International Trade Administration, as well as data from previous Futron activities, to develop indicators and projections for the space transportation, satellite communications, remote-sensing, and GPS segments of the space industry. For development of most of the baseline indicators, data was drawn from the *Satellite Industry Indicators Survey*. The Satellite Industry Association (SIA) and Futron Corporation conduct an annual global survey designed to collect and publish comprehensive statistics on the commercial satellite industry. The *Satellite Industry Indicators Survey* polls more than 700 leading aerospace, telecommunications, and information services companies worldwide in order to provide accurate indicators on industry revenue, employment, and other metrics. The results of the *Survey* and other key industry sources provided the foundation for *Trends in Space Commerce.*

Information was also provided by the Federal Aviation Administration (FAA) Office of Commercial Space Transportation. The FAA publishes annual ten-year forecasts of the number of commercial satellites and the number of commercial launches. The information provided in the satellite manufacturing section and the space transportation section of this document is consistent with the FAA forecasts. All revenue figures represent current, or "then-year," dollar figures. All growth rates, unless otherwise noted, are compound annual growth rates and will be referred to as "annual growth" or "growth" throughout the report. Figures may not add exactly to totals due to rounding errors.

Methodology specific to each industry segment is discussed in the specific sections.

1.3 Overview of industry segments

Figure 1.1 shows historical and projected revenue for each of the industry segments covered in this report. Overall, the industry experienced a 16 percent annual growth rate.



	1996	1997	1998	1999	2000	2001	2002
Satellite communications	35.33	45.46	56.10	60.52	67.57	77.74	88.69
Space transportation	4.89	5.65	5.49	5.65	5.39	7.04	6.60
Global Positioning System	3.39	4.15	5.14	6.22	7.34	8.42	9.47
Remote-sensing	0.10	0.12	0.14	0.15	0.17	0.20	0.23
Total	*43.71*	*55.38*	*66.87*	*72.54*	*80.47*	*93.40*	*104.99*

Figure 1.1.
World revenue for space industry segments, in billions U.S. $, 1996-2002

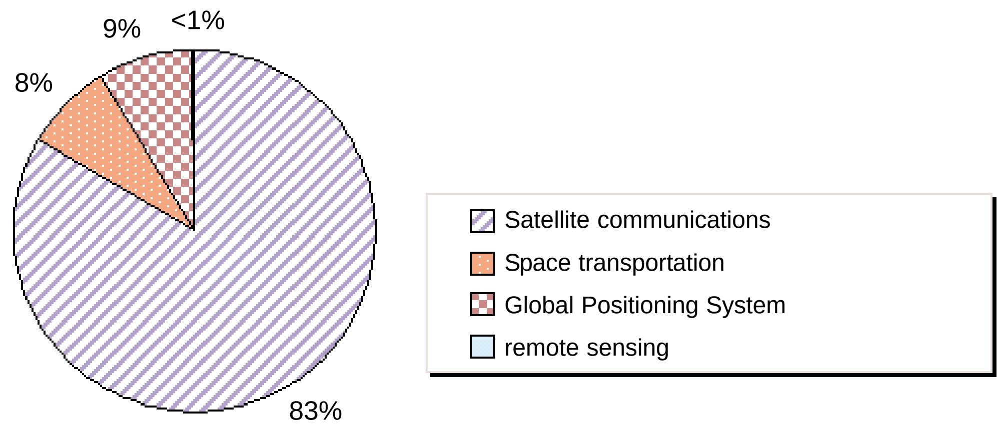
Satellite communications (encompassing satellite services, transponder leasing, ground equipment manufacturing, and satellite manufacturing) represents the largest and fastest growing segment of the industry, with 2000 annual revenues of over $67 billion and a growth rate of 17 percent. Demand for direct-to-home television service and other satellite services is fueling this growth. Other factors shaping industry segment trends have been the global deregulation of telecommunications markets, the introduction of large non-geostationary orbit satellite constellations for mobile communications, and the emergence of the Internet as a demand driver for satellite data communications.

Space transportation revenue is over $5 billion in 2000. Space transportation revenue exhibits year-to-year variations, but experiences growth overall. Launch vehicle failures, satellite manufacturing delays, satellite in-orbit anomalies, and other factors contribute to the year-to-year fluctuations in the launch vehicle market. Because of the relatively few commercial launches in any given year, these fluctuations can translate into significant annual surges and dips in revenues as calculated here (see Section 2). Also, all launch revenues for purposes of this document are counted in the year of launch.

GPS revenue is over $7 billion in 2000, growing at a 19 percent rate. The development of GPS receivers as consumer electronic devices and the integration of GPS chip sets into multifunction products are two emerging trends in this industry. Demand for these new services, coupled with continuing demand for traditional GPS services (e.g., tracking and navigation tools for land and marine vehicles), contribute to a positive outlook for the GPS industry.

Pre-valued-added raw satellite imagery generated an estimated $173 million in revenues in 2000. The broader remote sensing industry includes raw satellite imagery, aerial imagery, and Geographic Information System (GIS) software and services. The 2000 global value of this broader industry was $3.3 billion. The current report deals only with pre-value-added satellite imagery because this is the only portion of the industry that relies directly on space assets. While the commercial market for such imagery is growing at a moderate rate of 14 percent annually, this growth should accelerate after 2002 when more commercial platforms come on line. Historically, the predominant consumers of remotely sensed data have been governments in areas such as environmental monitoring, weather forecasting, and intelligence gathering. With the expansion of personal computing power and the increased resolution promised by emerging systems, the remote-sensing industry is poised to generate increasing commercial revenues in the future.

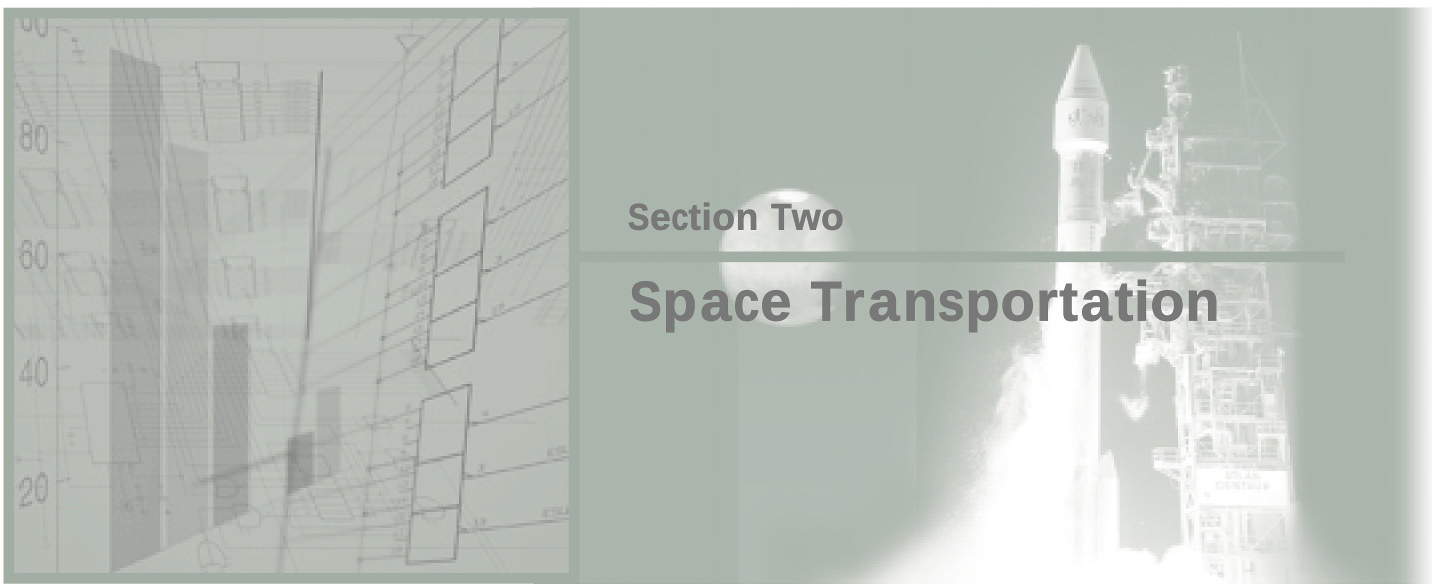
Figure 1.2 shows the contribution to total revenue for each industry segment for 1996 through 2002. As noted, satellite communications dominates the industry in total revenues. GPS and space transportation are the next largest segments, respectively, followed distantly by remote-sensing.



Industry Segment	*1996-2002 Revenues ($B U.S.)*
Satellite communications	431.41
Space transportation	40.71
Global Positioning System	44.13
Remote sensing	1.11
Total	*517.36*

Figure 1.2.
Space industry revenues by industry segment, in billions U.S. $, 1996-2002

There are several other space industry segments not covered in this document. Among them are microgravity hardware and services, technical and business consulting, legal services, space software development, and others. Should markets for these industry segments develop or differentiate themselves, they may warrant specific sections in future editions of this document.



Section Two

Space Transportation

2.1 Overview of trends, drivers, and events

The commercial launch industry experienced significant change in the late 1990s. Launches to low Earth orbit (LEO) emerged as an important addition to the market. Also, launch systems from the former Soviet Union and China increased worldwide commercial capacity and competition. In addition, all the world's major launch providers began preparing for heavier, more powerful satellites by developing new technologies and system upgrades. Lastly, the United States moved toward developing commercial launch ranges, and the Federal Aviation Administration (FAA) licensed four commercial spaceports: the Virginia Space Flight Center, Kodiak Launch Complex, Spaceport Florida, and the California Spaceport.

In addition to maintaining a steady launch rate for geosynchronous orbit (GSO) launches, launch providers began commercial launches to LEO in 1997. From 1997 to 1999, 20 launches by three launch providers deployed 88 satellites for the Iridium constellation. Fourteen launches deployed the Globalstar system from 1998 through early 2000. The promise of the commercial LEO market prompted private start-ups to begin developing new reusable and expendable launch systems. Expectations for the LEO market segment have declined in the wake of the primary business model failure of Iridium, the first of the "Big LEO" satellite systems (capable of carrying voice), and an oversupply of launch vehicles is expected by many analysts in the next few years.

Eight vehicle families from the former Soviet Union across all mass lift ranges are now marketed commercially. The three largest, the *Proton, Soyuz,* and *Zenit*, have captured a significant share of worldwide commercial launches. Russia's *Proton,* marketed through the International Launch Services (ILS) partnership with Lockheed Martin, deployed over 14 percent of the GSO payloads since 1996. *Soyuz* , a cornerstone of Soviet space launch capability, is now marketed through the French-Russian Starsem partnership and deployed 38 percent of the payloads launched for Globalstar. The *Zenit* vehicle, manufactured in Ukraine, was combined with a Russian-made upper stage and launched from an ocean platform through the Boeing-led Sea Launch partnership. Finally, several Russian-made small launch vehicles are marketed through multi-national partnerships. These vehicles include *Cosmos, Rockot*, START, *Dnepr*, and *Shtil*.

Another trend affecting the space transportation market is the fact that commercial communications satellites are getting larger and heavier as manufacturers build payloads with greater power and more transponder capacity. Each of the world's launch service providers now offers upgraded vehicles to accommodate larger and heavier satellite payloads. American launch service providers Boeing and Lockheed Martin are developing significantly redesigned launch systems with the Delta 4 and Atlas 5 family of vehicles, with partial support from the Air Force through the Evolved Expendable Launch Vehicle program.

Lastly, there was significant activity in the mid-to-late 1990s on commercial reusable launch vehicles (RLVs). Several companies began development of new and innovative RLV concepts, including:

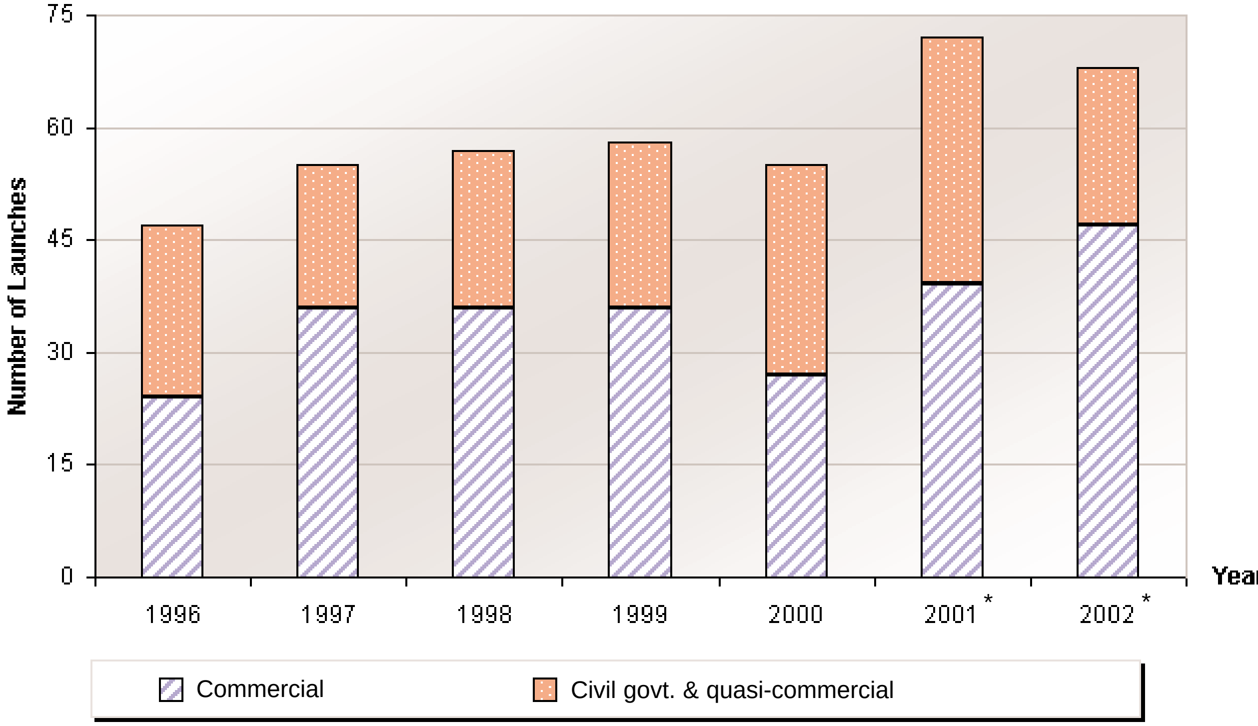
- Astroliner - Kelly Space and Technology
- K-1 - Kistler Aerospace Corporation
- Pathfinder - Pioneer Rocketplane
- Roton c-9 - Rotary Rocket Company
- SA-1 - Space Access LLC
- Space Cruiser System - Vela Technology Development
- VentureStar - Lockheed Martin Corporation

This increase in activity was in response to strong growth in projected demand for launches, fueled primarily by LEO satellite telecommunications constellations. As mentioned above, the operators and proponents of LEO systems have suffered several significant setbacks recently. As a result, it has been increasingly difficult for commercial RLV companies to obtain the needed capital to complete their vehicle development. The Year 2000 was particularly difficult for commercial RLV companies, with many vehicle development programs delayed or discontinued due to lack of funds.

2.2 U.S. and world launches, 1996-2002

Various industry sources characterize commercial space launches in subtly different ways, so comparing data sets from different sources can be daunting, if not impossible. A "commercial launch" may carry a commercial, civil, or military payload, but is commercial if the payload owner commercially procured the launch service. Commercial launches may also include test launches with dummy payloads or any privately financed launch activity, such as certain flights to the *Mir* space station. In the United States, the launches for some government payloads are commercially procured, while others are launched by the U.S. Air Force or the National Aeronautics and Space Administration (NASA), often using the same make of vehicles.

For the purposes of this analysis, launches are classified under three primary categories: non-commercial, civil government and quasi-commercial, and commercial. Launches of military satellites not procured through a commercial launch service provider and Space Shuttle launches are considered non-commercial. Civil government and quasi-commercial launches are launches procured by governments through commercial launch service providers, which the purchaser typically restricts to the launch providers of a single country. Also included here are test launches with dummy payloads and certain privately-financed fights to the *Mir* space station. Commercial launches are those launches procured on the international launch services marketplace; this definition is consistent with the Commercial Space Transportation Advisory Committee (COMSTAC) forecast and mission model for GSO satellites and the FAA's forecast for launches to non-geosynchronous orbits (NGSO).

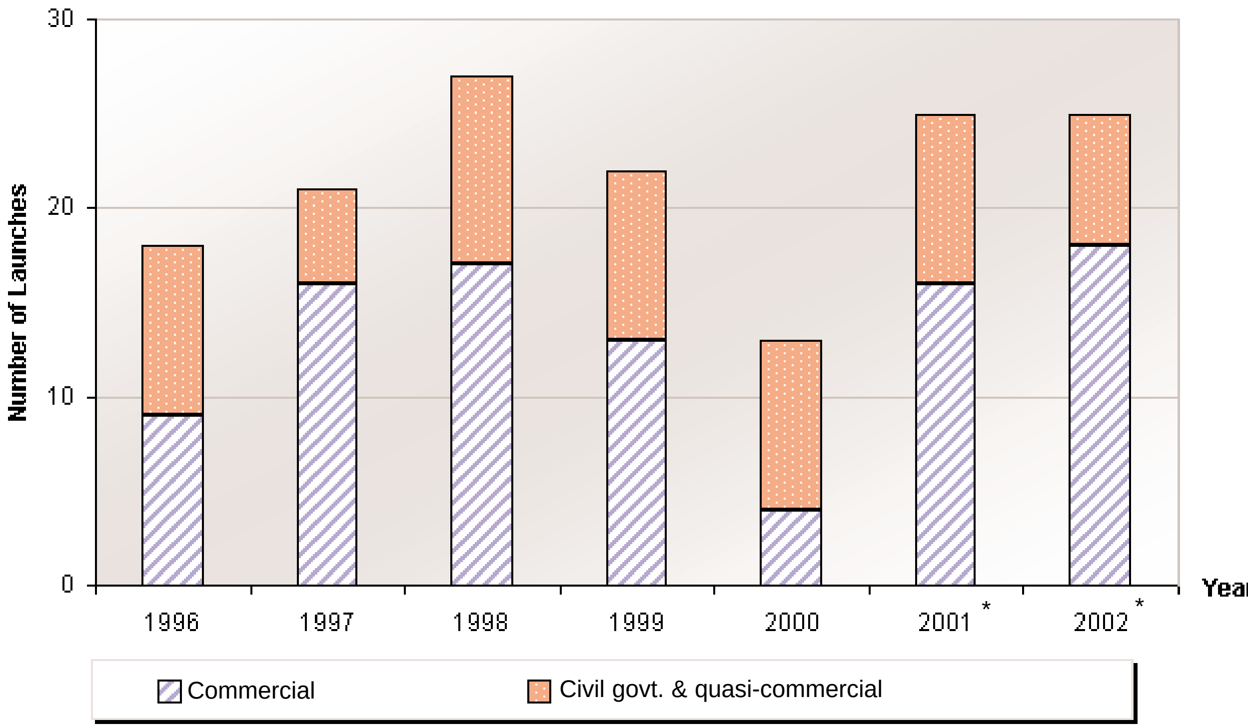


	1996	*1997*	*1998*	*1999*	*2000*	*2001**	*2002**
Commercial	24	36	36	36	27	39	47
Civil government & quasi-commercial	23	19	21	22	28	33	21
Total	*47*	*55*	*57*	*58*	*55*	*72*	*68*

* Projections

Figure 2.1.
World commercial and civil government and quasi-commercial launches, 1996-2002

Since 1996 the commercial launch industry has experienced the sudden rise and fall of the market for LEO and other NGSO launches. By early 2000, the initial deployments of both Iridium and Globalstar were completed, and three planned launches for Sirius Satellite Radio and one unsuccessful launch for ICO Global accounted for the remaining launches to NGSO in 2000. Most industry analysts expect NGSO launch rates over the next few years to be lower than previously anticipated. While the end of NGSO constellation deployments accounted for most of the drop in commercial launches in 2000, there was a higher than usual rate of civil government launch activity. Civil launches include test launches of new systems, Russian domestic communications, and U.S. weather and science payloads. Based on planned launches and given no unexpected delays, the commercial launch rate will increase in 2001 and 2002.



	1996	*1997*	*1998*	*1999*	*2000*	*2001 **	*2002 **
Commercial	9	16	17	13	4	16	18
Civil government & quasi-commercial	9	5	10	9	9	9	7
Total	*18*	*21*	*27*	*22*	*13*	*25*	*25*

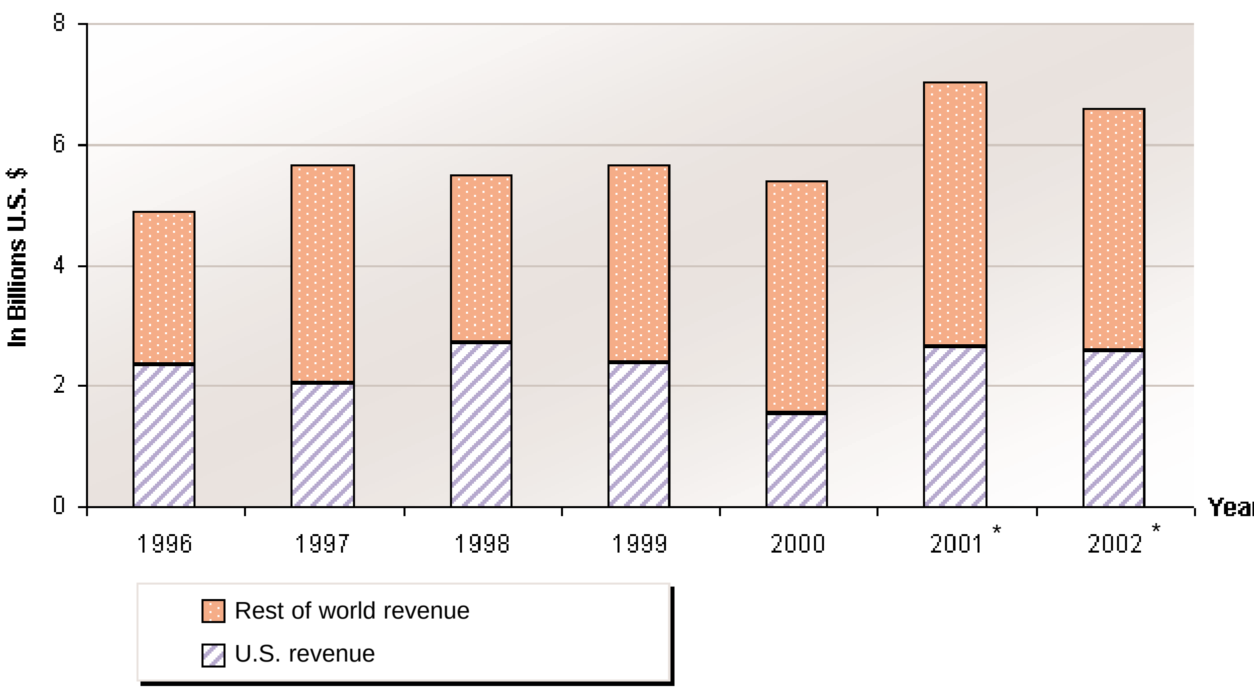
* Projections

Figure 2.2.
U.S. commercial and civil government and quasi-commercial launches, 1996-2002

The United States experienced a drop in commercial launches in 2000. The new Atlas 3A launch vehicle successfully deployed its first payload, but did not fly again in 2000. Only three of the eight launches of the Atlas 2 deployed commercial GSO payloads. The Delta 3 flew only one successful test flight, and the Delta 2 flew only once when it deployed four Globalstar satellites. U.S. launch providers have consistently conducted about 30 percent of GSO launches and 60 percent of NGSO launches in recent years, though it is uncertain whether these shares will continue in a diverse and competitive industry.

Launch industry revenue

Revenue generated by the launch industry varies from year to year with the rate of launch activity and the mix of heavy and small vehicles used. The revenues in Figure 2.3 are derived from the Satellite Industry Association's *Satellite Industry Indicators Survey.* Payments to subcontractors are included in order to capture the extent of the economic impact of the space industry. The Satellite Industry Association defines commercial and civil launches slightly differently than COMSTAC does. Therefore, the Satellite Industry Association revenue numbers were adjusted to represent the same set of commercial and civil government launches shown above; revenue from military launches is not included. The dip in U.S. commercial revenue for 2000 is a reflection of that year's low launch rate. The industry segment can expect a 1.5 percent annual growth for U.S. revenues for 1996-2002 and about 8 percent for the rest of the world.



	1996	1997	1998	1999	2000	2001*	2002*
United States revenue	$2.35	$2.04	$2.70	$2.37	$1.54	$2.64	$2.57
Rest of world revenue	$2.54	$3.61	$2.79	$3.28	$3.85	$4.39	$4.03
Total	*$4.89*	*$5.65*	*$5.49*	*$5.65*	*$5.39*	*$7.04*	*$6.60*

* Projections

Figure 2.3.
U.S. and rest of world launch industry revenue, in billions U.S. $, 1996-2002

Launch services employment

Employment estimates for the launch segment of the space industry represent total personnel engaged in launch vehicle manufacturing and launch services, regardless of whether the payload is commercial, civil, or military. Personnel at launch facilities and government employees are not included. Employment estimates are related to commercial launch revenue, overall launch rate for commercial and government launches, and the mix of small and heavy vehicles used.

	1996	1997	1998	1999	2000	2001*	2002*
United States employment	18,100	18,900	19,400	17,600	11,400	19,700	19,100
Rest of world employment	16,300	17,600	16,600	14,500	19,200	20,300	18,400
Total	*34,400*	*36,500*	*36,000*	*32,100*	*30,600*	*40,000*	*37,500*

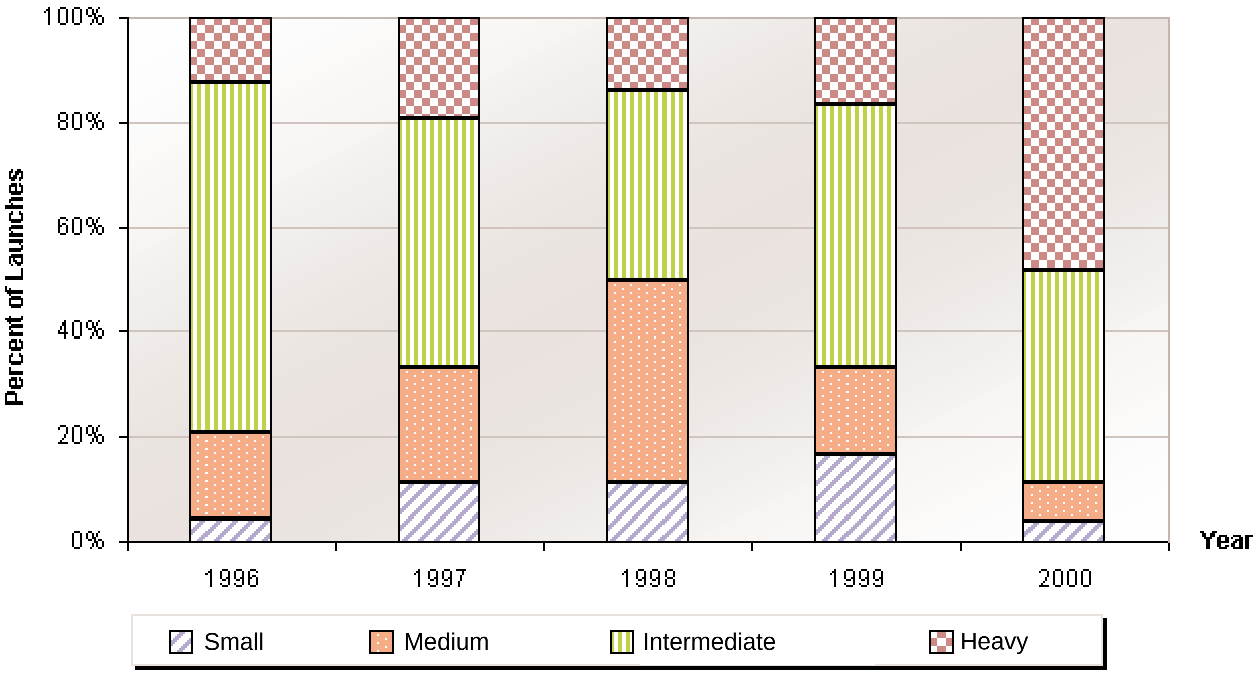
* Projections

Table 2.1
U.S. and rest of world launch services employment, 1996-2002

2.3 U.S. & world commercial launch trends

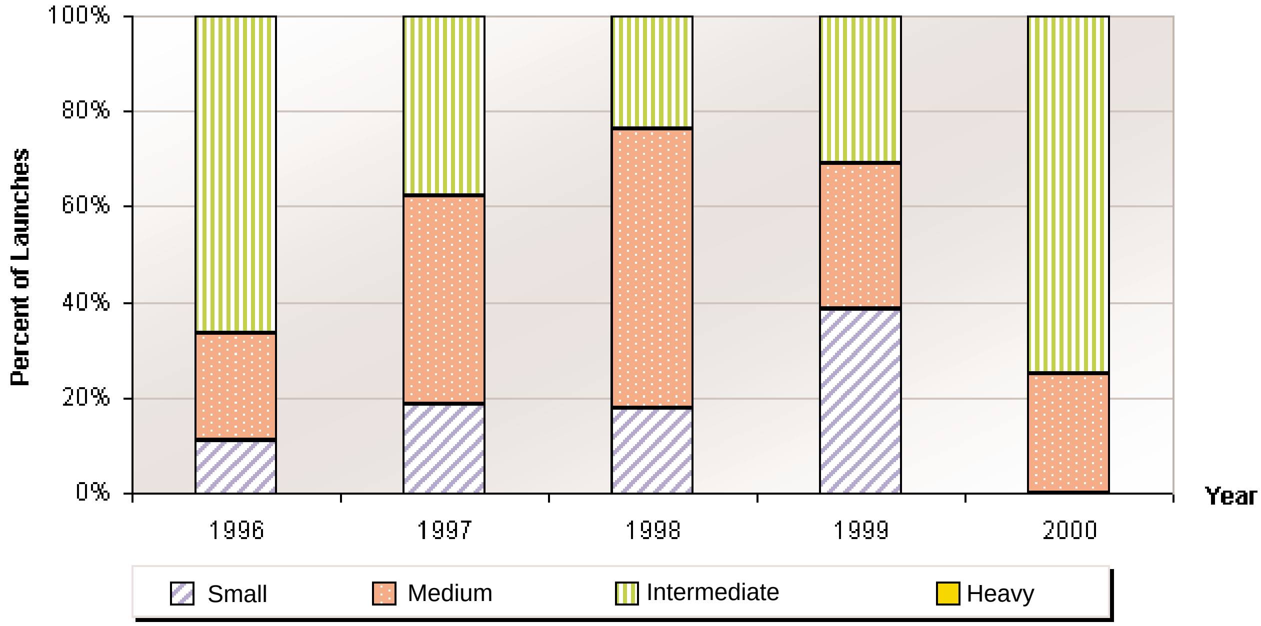
Trends in lift capacity

Over the last five years, there has been a greater proportion of intermediate and heavy launches for GSO payloads as manufacturers built larger satellites with greater power and transponder capacity. While fewer GSO payloads were deployed on medium class vehicles because of the increased size of GSO satellites, medium vehicles were used extensively to deploy payloads for the NGSO constellations. Consequently, the proportion of payloads that flew on medium class launch vehicles increased during the 1997 to1998 period. However, the proportion tapers off in 1999 to 2000 because of the diminished requirements for NGSO satellite launches. U.S. service providers currently can launch all but the heaviest commercial payloads. All launch service providers plan or have already implemented upgrades to their vehicles to accommodate heavier GSO payloads.



	1996	1997	1998	1999	2000
Small	1	4	4	6	1
Medium	4	8	14	6	2
Intermediate	16	17	13	18	11
Heavy	3	7	5	6	13
Total	*24*	*36*	*36*	*36*	*27*

Figure 2.4.
World-wide commercial launches by mass class capacity of launch vehicle, in maximum pounds to LEO: small, < 5,000; medium, 5,001 to 12,000; intermediate, 12,001 to 25,000; heavy, > 25,000

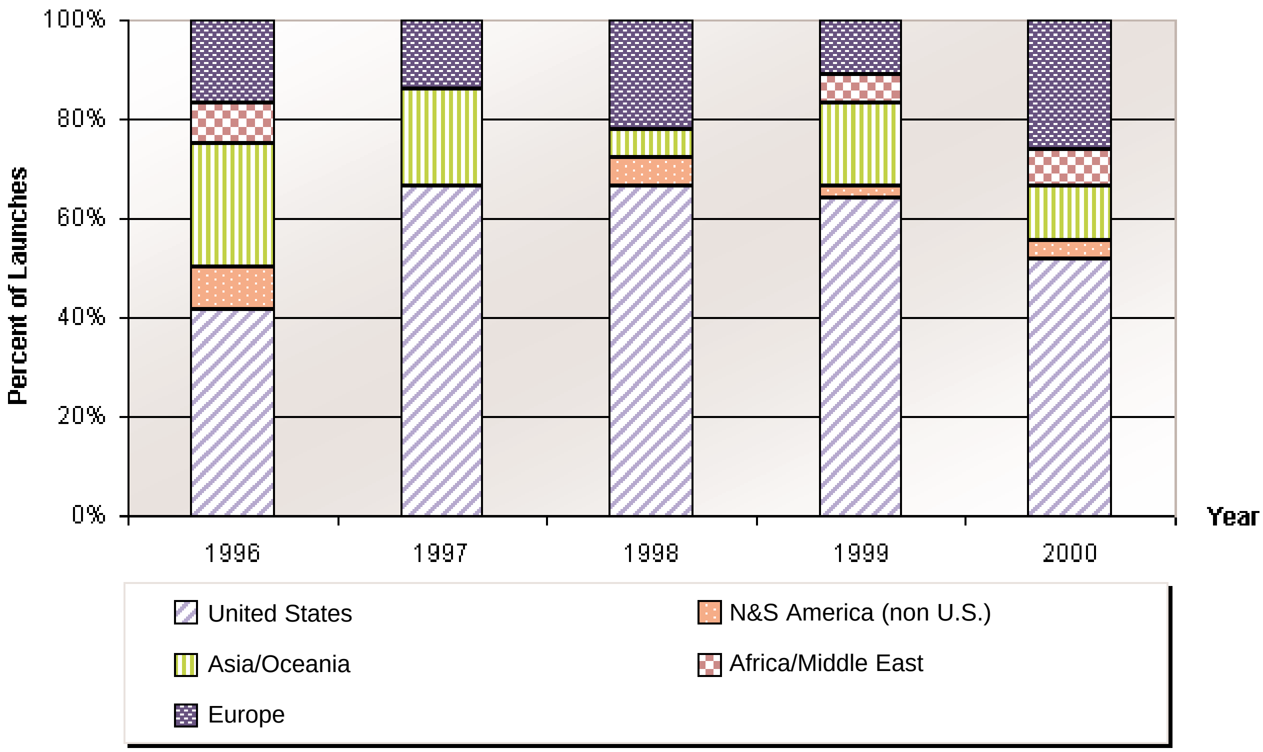


	1996	*1997*	*1998*	*1999*	*2000*
Small	1	3	3	5	0
Medium	2	7	10	4	1
Intermediate	6	6	4	4	3
Heavy	0	0	0	0	0
Total	*9*	*16*	*17*	*13*	*4*

Figure 2.5.
U.S. commercial launches by mass class capacity of launch vehicle, in maximum pounds to LEO: small, < 5,000; medium, 5,001 to 12,000; intermediate, 12,001 to 25,000; heavy, > 25,000

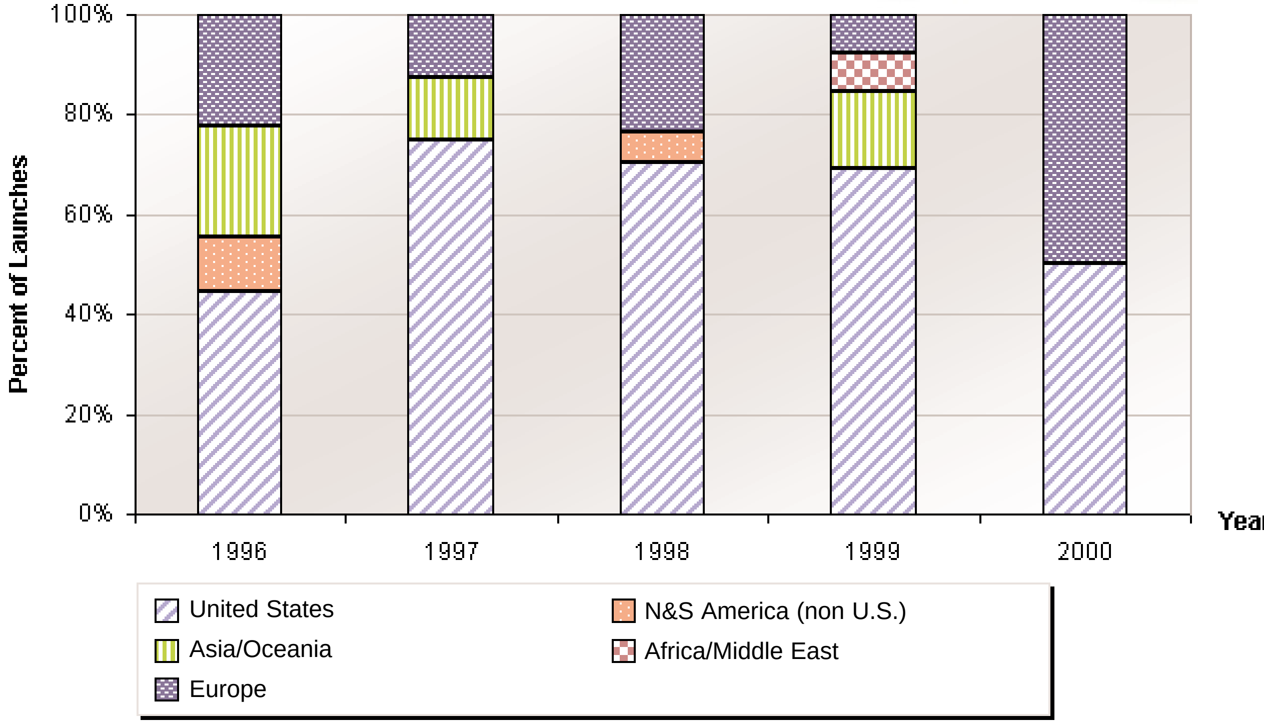
Trends in launches by customer region

Figure 2.6 and Figure 2.7 show the number of launches by the region where the headquarters of the payload owner is located. For example, Loral Space and Communications, which is headquartered in New York City, owns Globalstar satellites. Consequently, all Globalstar launches are applied to the U.S. region. Table 2.2 shows some of the major payloads associated with each region. As shown in Figures 2.6 and 2.7, launches of U.S.-owned payloads surged from 1997 through 1999 due to the deployment of the Iridium and Globalstar constellations.



Payload Owner Region	*1996*	*1997*	*1998*	*1999*	*2000*
N&S America (non U.S.)	2	0	2	1	1
Asia/Oceania	6	7	2	6	3
Africa/Middle East	2	0	0	2	2
Europe	4	5	8	4	7
United States	10	24	24	23	14
Total	*24*	*36*	*36*	*36*	*27*

Figure 2.6.
Worldwide commercial launches by payload owner region, 1996-2000



Payload Owner Region	*1996*	*1997*	*1998*	*1999*	*2000*
N&S America (non U.S.)	1	0	1	0	0
Asia/Oceania	2	2	0	2	0
Africa/Middle East	0	0	0	1	0
Europe	2	2	4	1	2
United States	4	12	12	9	2
Total	*9*	*16*	*17*	*13*	*4*

Figure 2.7.
U.S. commercial launches by payload owner region, 1996-2000

Payload Owner Region	*Major Payloads Within Regions*
N&S America (non U.S.)	Anik F1; Brazilsat B3 & B4; MSAT 1; Nahuel 1A; Nimiq 1; SatMex 5
Asia/Oceania	Agila 2; Garuda 1; Insat 2D; 2E; & 3B; JCSAT 4, 5, & 6; Thaicom 3
Africa/Middle East	Nilesat 102; Arabsat 3A; Nilesat 101; Arabsat 2B; Arabsat 2A
Europe	Astra 1F, 1G, 1H, 2A, 2B, & 2D; Eutelsat W1R, W2, W3, & W4; Hotbird 2, 3, 4, & 5; Thor 2 & 3
United States	Multiple payloads for Echostar; Galaxy; GE; Intelsat; PanAmSat; Telstar; Iridium; Globalstar

Table 2.2.
Selected payloads by payload owner region

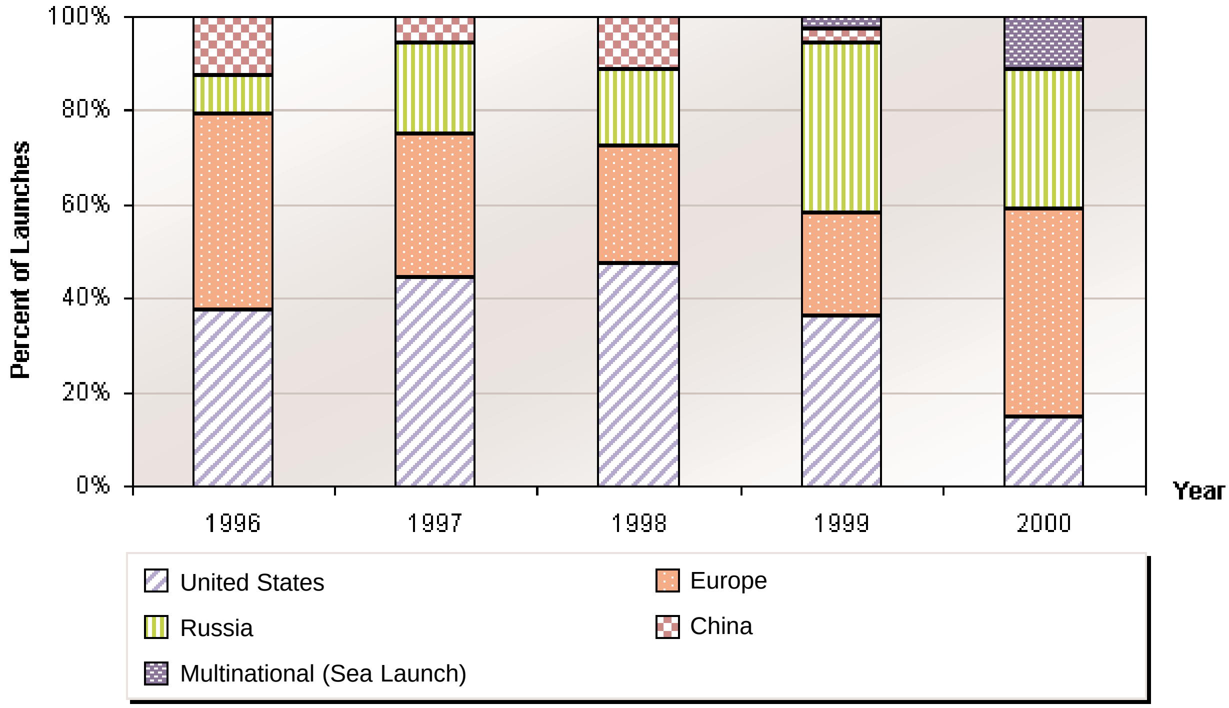
Launches by service provider region

Perhaps the biggest shift in the commercial launch market in recent years was caused by the introduction of vehicles from the former Soviet Union. Starting with the first commercial *Proton* launch of an Inmarsat satellite in 1996, the *Proton* has launched a significant portion of commercial GSO satellites. In the NGSO market, the French-Russian partnership Starsem launched a large portion of the Globalstar constellation on Russian *Soyuz* rockets.

Figure 2.8 shows worldwide commercial launches by region of the launch provider. Launches are attributed to the region in which the primary vehicle manufacturer is based, with the exception of Sea Launch, which has been designated as "Multinational." Table 2.3 shows the commercial launch vehicles associated with each region.

Launch Provider Region	*Commercial Vehicles Within Launch Provider Region*
United States	Athena, Atlas, Delta, Pegasus, Taurus
Europe	*Ariane* 4 & 5
Russia	*Cosmos, Dnepr, Soyuz, Proton, Rockot, Shtil,* START
China	Long March
Multinational	Zenit 3SL

Table 2.3.
Commercial launch vehicles by region

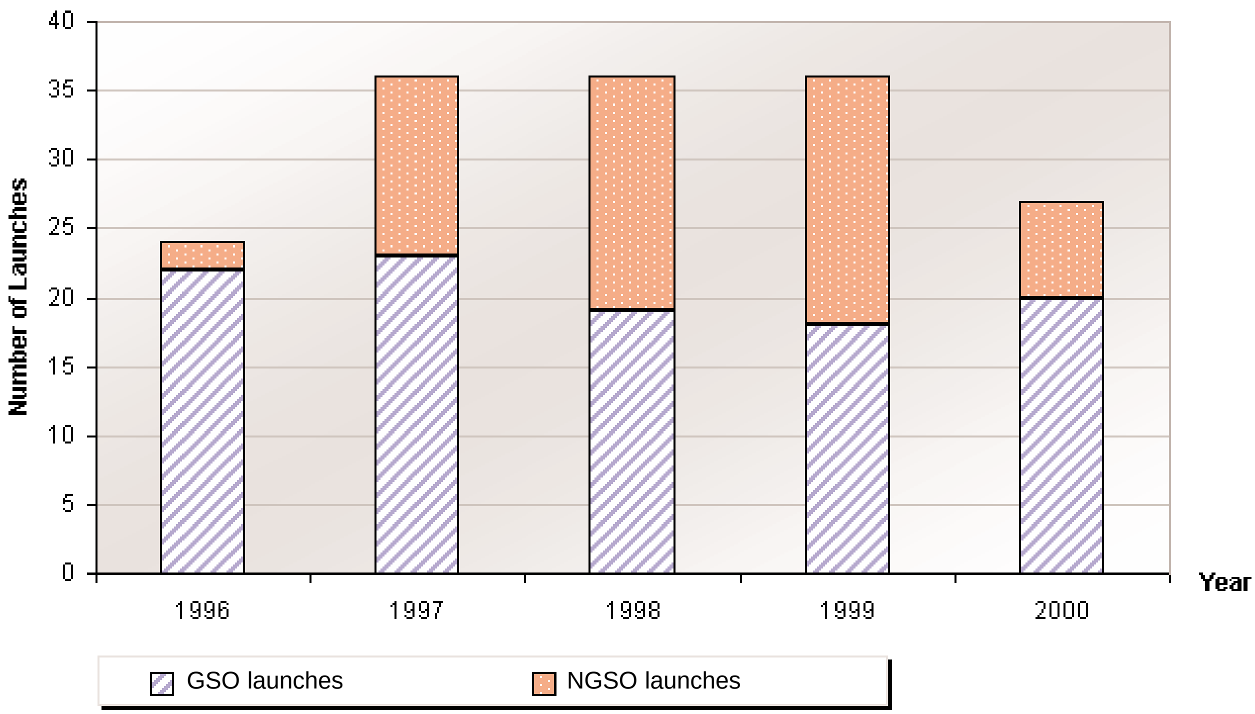


	1996	*1997*	*1998*	*1999*	*2000*
United States	9	16	17	13	4
Europe	10	11	9	8	12
Russia	2	7	6	13	8
China	3	2	4	1	0
Multinational (Sea Launch)	0	0	0	1	3
Total	*24*	*36*	*36*	*36*	*27*

Figure 2.8.
Worldwide commercial launches by provider region, 1996-2000

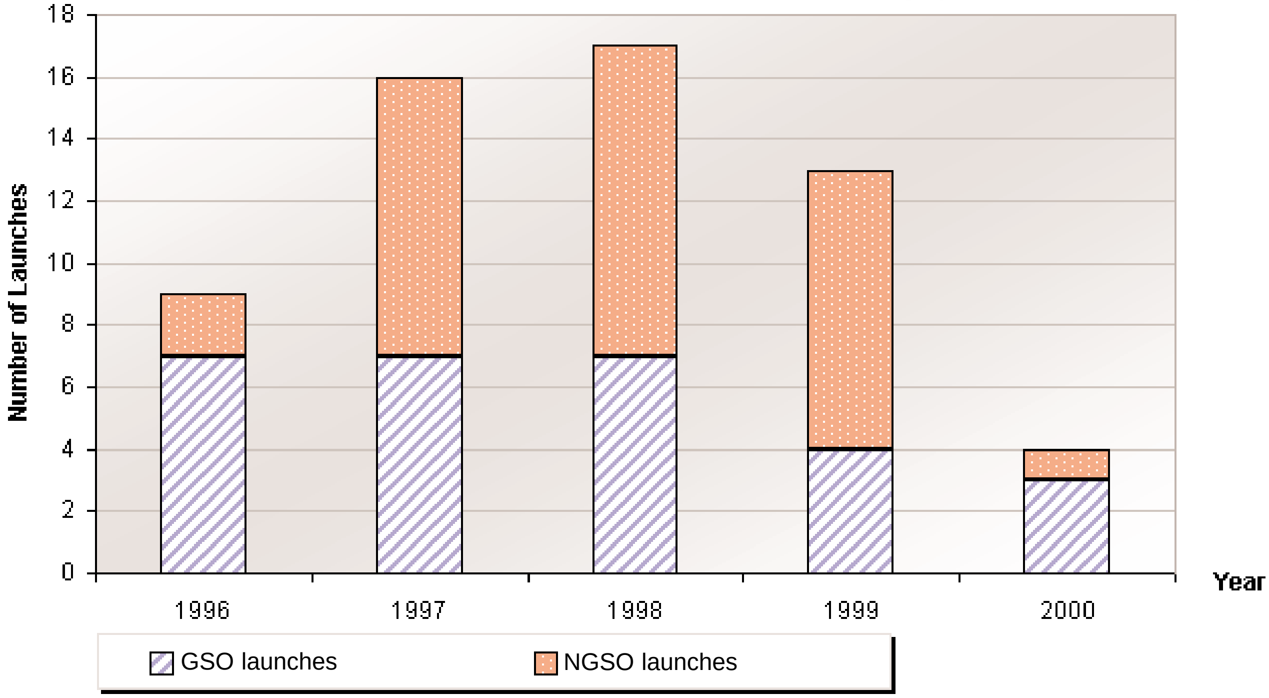
Launches by orbit type

When reviewing the number of launches by orbit type, the impact of the deployment of the NGSO constellations in 1997 to 1999 becomes apparent. Aside from the two NGSO constellations, only a handful of remote-sensing and foreign science payloads were launched to NGSO through procurements in the international launch services market. Three launches of Sirius direct radio satellites and one unsuccessful launch of a satellite for ICO Global Communications account for NGSO launches in 2000. While the worldwide number of GSO launches remained steady at an average of just under 21 per year, the United States experienced a decline in 1999 and 2000 because of delays in the Delta 3 program following a 1999 failure and the cancellation of launches for the ICO mobile satellite system.



	1996	*1997*	*1998*	*1999*	*2000*
GSO launches	22	23	19	18	20
NGSO launches	2	13	17	18	7
Total	*24*	*36*	*36*	*36*	*27*

Figure 2.9.
Worldwide commercial launches by orbit, 1996-2000



	1996	1997	1998	1999	2000
GSO launches	7	7	7	4	3
NGSO launches	2	9	10	9	1
Total	*9*	*16*	*17*	*13*	*4*

Figure 2.10.
U.S. commercial launches by orbit, 1996-2000

2.4 Launch sites

In the United States, most launches take place from the Cape Canaveral Air Force Station in Florida and from Vandenberg Air Force Base in California. Cape Canaveral is the only site that conducts GSO launches in the United States, while Vandenberg is used for high inclination orbit payloads. The FAA Associate Administrator for Commercial Space Transportation has licensed a total of four commercial spaceports to date. They are the Virginia Spaceflight Center on Wallops Island, VA; Spaceport Florida located on Cape Canaveral; the California Spaceport in Lompoc, CA; and the Kodiak Launch Complex in Alaska. In addition, several states proposing new spaceports are working to attract potential commercial business, especially from firms developing reusable launch vehicles.

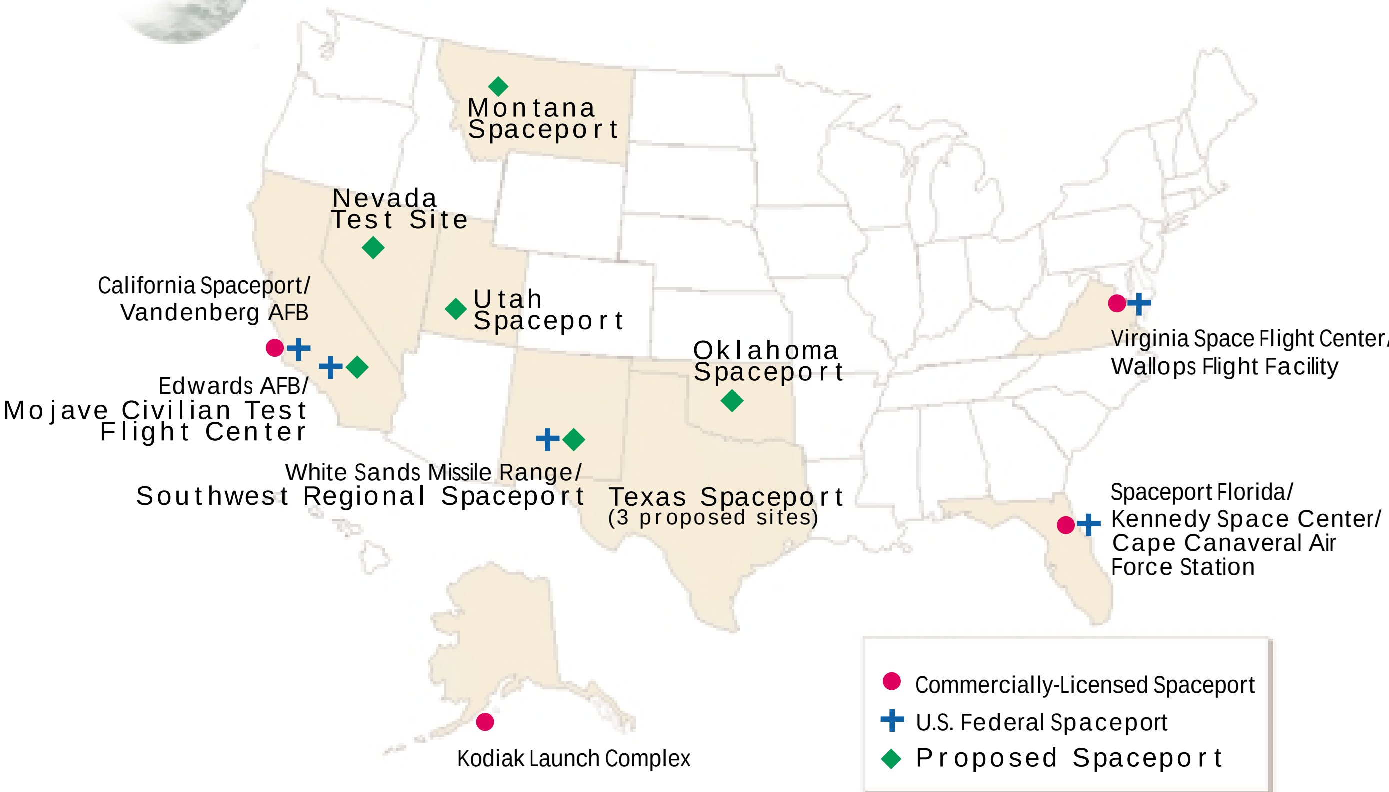


Figure 2.11.
U.S. operational and proposed orbital launch sites

Site	*Vehicles*	*Launch Service Provider*
Cape Canaveral Air Force Station	Atlas	International Launch Services
	Delta	Boeing
Vandenberg Air Force Base	Athena	Lockheed Martin Astronautics
	Delta	Boeing
	Pegasus	Orbital Sciences Corp.
	Taurus	Orbital Sciences Corp.
Spaceport Florida	Athena	Lockheed Martin Astronautics
	(will launch various small vehicles)	
California Spaceport	(will launch various small vehicles)	
Kodiak Launch Complex	Athena	Lockheed Martin Astronautics
	(will launch various small vehicles)	
Virginia Space Flight Facility	(will launch various small vehicles)	

Table 2.4.
U.S. active and licensed orbital launch sites

Figure 2.12.
World (non-U.S.) active orbital launch sites

Country	*Site*	*Major Vehicles*	*Service Provider*
Australia	Woomera	K-1 (proposed)	Kistler
Brazil	Alcantara	VLS	IAE
China	Jiuquan Taiyuan Xichang	Long March 2C, 2D, 2F Long March 4, 4B Long March 3, 3A, 3B, 3C	China Great Wall Industry Corp. China Great Wall Industry Corp. China Great Wall Industry Corp.
French Guyana	Kourou	Ariane 4 & 5	Arianespace
India	Srihirakota	PSLV & GLSV	India Space Research Organization
Multinational	Odyssey	*Zenit* 3SL	Sea Launch
Japan	Kagoshima Tanegashima	M5 H2 & H2A	Inst. of Space and Astronautical Science Rocket Systems Corp.
Kazakhstan (leased by Russia)	Baikonur	*Dnepr 1* *Proton* *Soyuz* *Zenit 2*	Kosmotras International Space Co. International Launch Services Starsem National Space Agency of Ukraine
Russia	Kapustin Yar Plesetsk Svobodny	*Cosmos* *Cosmos* *Rockot* START 1 START 1	Puskovie Uslugi Puskovie Uslugi Eurockot Launch Services Puskovie Uslugi Puskovie Uslugi

Table 2.5.
World (non-U.S.) orbital launch sites and vehicles

2.5 Selected references

Associate Administrator for Commercial Space Transportation (AST) and the Commercial Space Transportation Advisory Committee (COMSTAC), Federal Aviation Administration, *2000 Commercial Space Transportation Forecasts, May 2000.*

Satellite Industry Association and Futron Corporation, *Satellite Industry Indicators Survey,* 2000.

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International Trade Administration, Office of Telecommunications, U.S. Department of Commerce, *U.S. Industrial Outlook 2000,* 2000.

Section Three

Satellite Communications

3.1 Overview of trends, drivers, and events

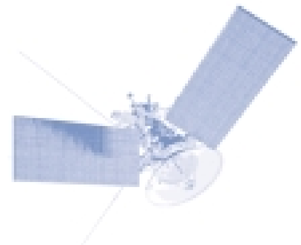
The satellite communications market has developed significantly over the past five years. The industry has extended its offerings to include telecommunications services via low Earth orbit (LEO) satellite constellations and enhanced its capabilities in such high-growth areas as direct-to-home (DTH) television. Despite these expansions, many sectors of the satellite communications industry have experienced mergers among major providers and operators aimed at creating consolidated companies that are more competitive nationally and internationally. New broadband services and bundled offering packages to end-user consumers promise to maintain, or perhaps even increase, recent growth over the next few years.

Figure 3.1 shows world revenue growth in the four industry sectors examined in this section: transponder leasing, retail/subscription satellite services, ground equipment manufacturing, and satellite manufacturing. The revenue estimates for satellite manufacturing include payments to subcontractors in order to reflect the component's full impact on the U.S. and world economies. The total satellite communications market segment grew at an annual growth rate of 17 percent from 1996 to 2000 and is forecasted to continue at this pace through 2002.

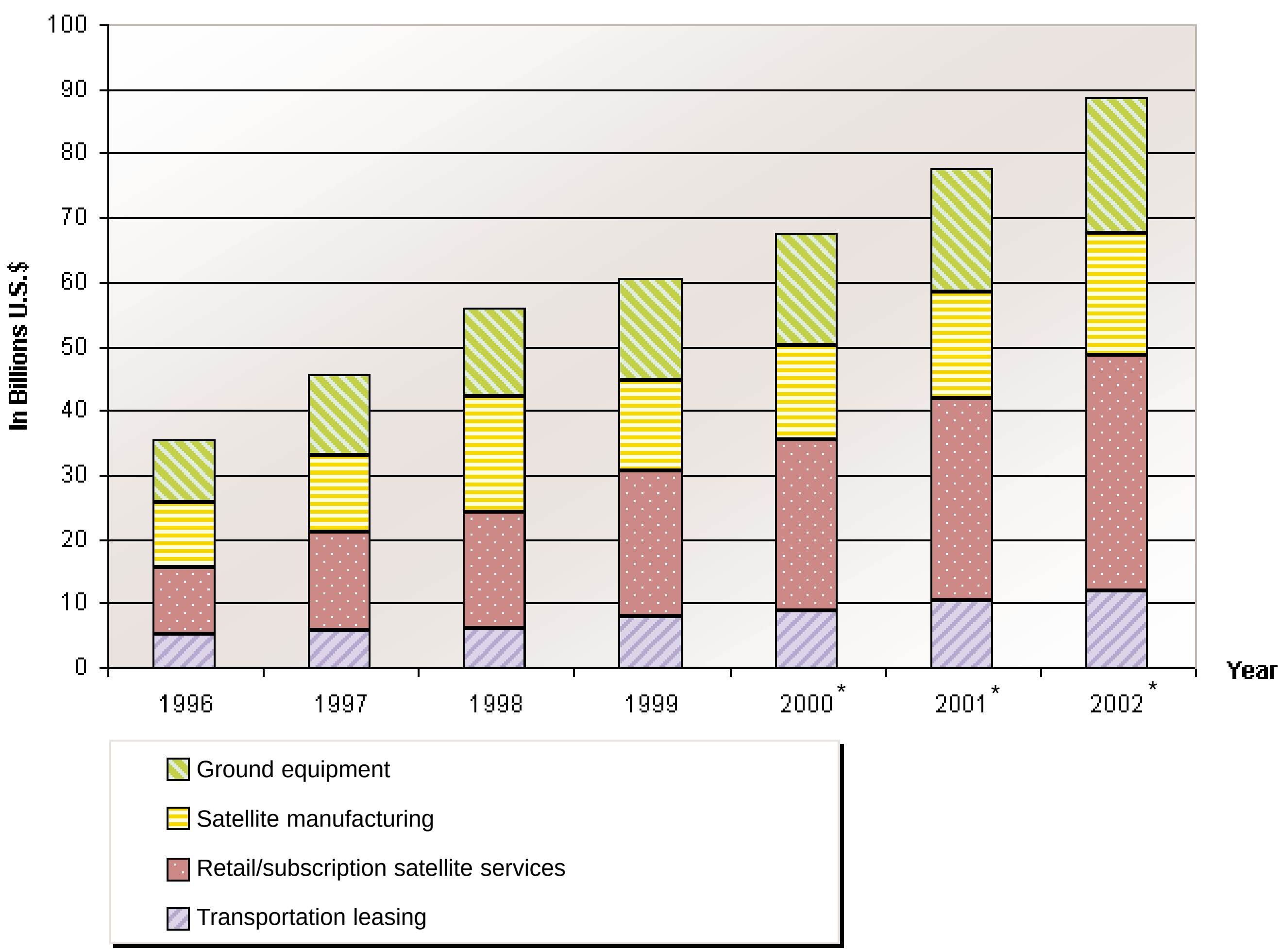
The highest revenue component of the satellite communications industry from 1996 to 2000 has been the satellite services sector. Within this sector, DTH television services have driven a large portion of the growth. The first Direct Broadcast Satellite system, Hughes Communications' DirecTV, debuted in 1994. This DTH satellite television service featured high-powered satellites transmitting in the Ku-band and required consumer reception dishes only 18 inches in diameter, significantly smaller than traditional C-band dishes typically measuring several meters across. As other providers rolled out similar services (Primestar's medium-powered system and Echostar Communications' Dish Network), competition among providers and with the cable industry led U.S. operators to significantly subsidize the cost of consumer equipment to expand their subscriber base.

In November 1999, the Satellite Home Viewer Improvement Act became law in the United States. A component of this legislation, the local-into-local provision, effectively removed previous legal barriers that limited transmission over satellite of local television signals. The inability to receive local stations through the satellite connection had been a severe competitive handicap for U.S. DTH satellite services in comparison to cable. With the availability of local stations, U.S. retail subscriptions to DTH services jumped in 2000, increasing by more than a third over 1999. International providers of Ku-band DTH services have similarly driven the international satellite services market, more than doubling DTH subscribers between 1996 and 1999. By the end of 2000, worldwide DTH subscriptions should top 67 million.[1]

[1] Media Business Corporation, *SkyREPORT*, 1999.



The advent of LEO telecommunications services marked a milestone in satellite technology and services offerings. Iridium, Globalstar, and ORBCOMM all successfully deployed their satellite constellations from 1997 through 2000. ICO Global Communications also began launching its satellites in 2000. Despite technological success, however, the industry has suffered several setbacks since 1998. Iridium and ICO both declared Chapter 11 bankruptcy in August 1999, with ORBCOMM following suit in September 2000. ICO has been able to restructure and emerge from Chapter 11, while Iridium was purchased by the newly named company, Iridium Satellite, for $25 million and without the original company's substantial debt burden. ORBCOMM anticipates uninterrupted service while it restructures. These setbacks to the industry notwithstanding, several systems still plan to unveil services in 2001 and 2002, including the Constellation Corporation's Constellation system and Mobile Communications Holdings' Ellipso.



	1996	1997	1998	1999	2000 *	2001 *	2002*
Transponder leasing	5.20	5.75	6.10	8.10	8.74	10.32	11.97
Retail/subscription satellite services	10.46	15.28	18.17	22.33	26.76	31.58	36.64
Satellite manufacturing	9.97	11.91	17.88	14.13	14.56	16.60	18.92
Ground equipment	9.70	12.52	13.95	15.96	17.50	19.25	21.17
Total	*35.33*	*45.46*	*56.10*	*60.52*	*67.57*	*77.74*	*88.69*

* Projections

Figure 3.1.
World satellite communications industry revenues, by sector, in billions U.S. $, 1996-2002

New broadband service offerings have been announced through the middle of this decade. Information distributors are increasingly demanding satellite transponder capacity for Internet content delivery. More than 40 prospective operators have license applications in to the Federal Communication Commission to operate broadband data relay satellite systems. SkyBridge and Teledesic currently plan for the earliest deployment of non-geostationary satellite systems to serve this target market. A slate of other proposed broadband services in the Ka, V, and Q bands may realize system deployment should the broadband market prove as promising as some projections anticipate.

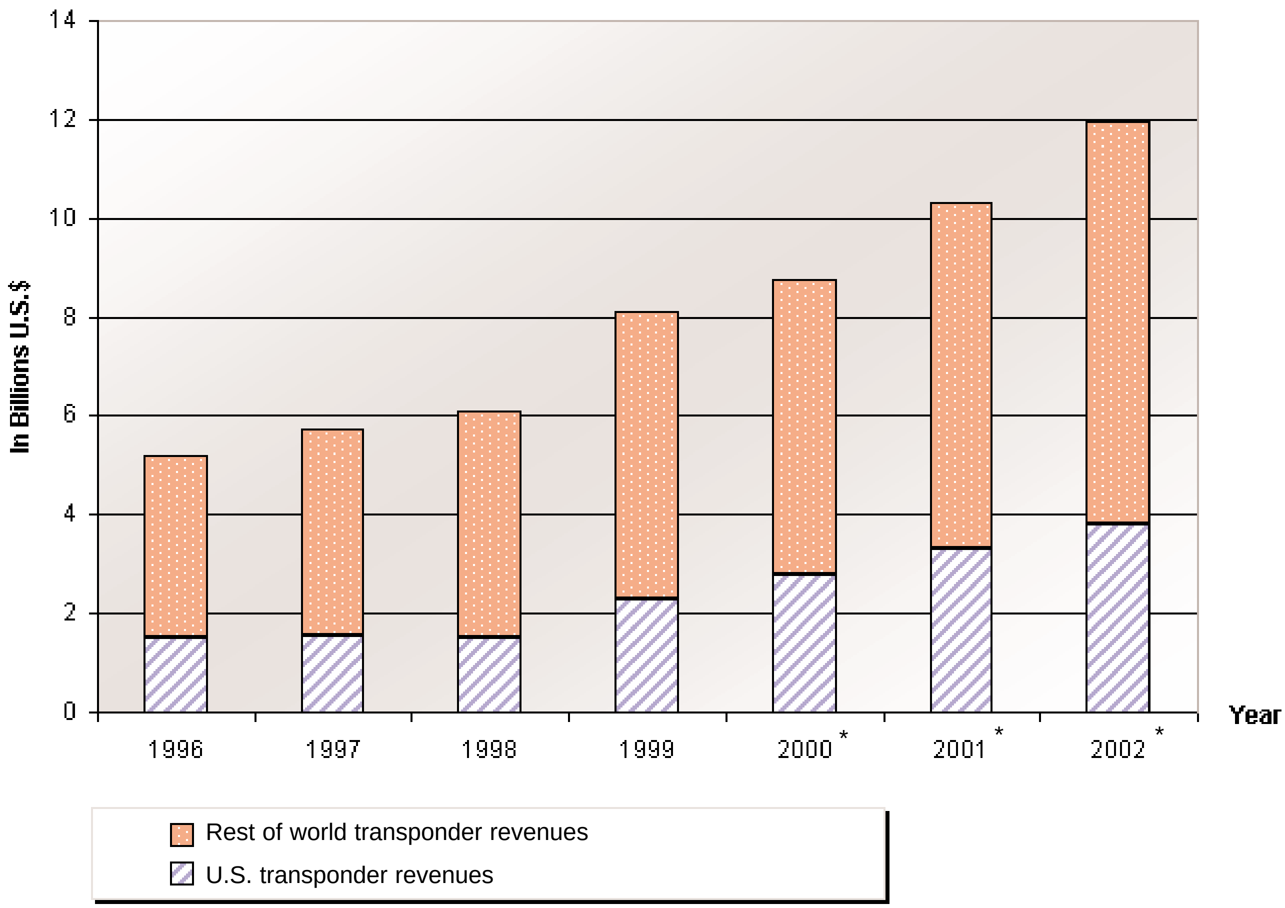
3.2 Transponder leasing

Firms that operate satellites often lease or sell access to their satellite transponders to service providers such as telecommunications and data relay firms; revenues realized by satellite operators through this leasing activity constitute the transponder leasing market. Firms may also act as intermediaries between satellite operators and service providers, serving as brokers or resellers of transponder capacity. Revenues from the resale market are not included here.

Transponder leasing revenues and employment figures as presented here for 1996 to 1999 are derived from the *Satellite Industry Indicators Survey*.[2] This annual survey solicits revenue estimates directly from U.S. and international firms engaged in the satellite industry. Futron augments this survey data with statistical analysis to produce regional satellite industry revenues and employment figures for select satellite industry sectors. The forecast for 2000 to 2002 applies recent average historical growth trends to produce estimates for out-year revenues and employment. Revenues are assigned to regions based on the geographic location of the satellite operator (with the exception of Intelsat, which is assigned to World for consistency with historical data and Intelsat's former international status). World numbers include estimates for the states of the former Soviet Union and the People's Republic of China. Revenues from the sales of resellers or brokers of transponder time are not reflected here.

[2] Survey data on 2000 revenues and employment will be garnered through the 2001 survey, the results for which will be released in Spring 2001.

Figure 3.2 shows that the world transponder leasing market grew at an annual average of just under 15 percent through the latter 1990s and should continue to do so through 2002. U.S. suppliers accounted for approximately 29 percent of transponder leasing revenues in 1996; by 2002, this share will have grown slightly, to just under 32 percent. Like other sectors of the satellite communications industry, transponder leasing revenues are driven by a surging satellite services sector, which propels the placement of increasing transponder/bandwidth capacity on orbit (see Section 3.3).

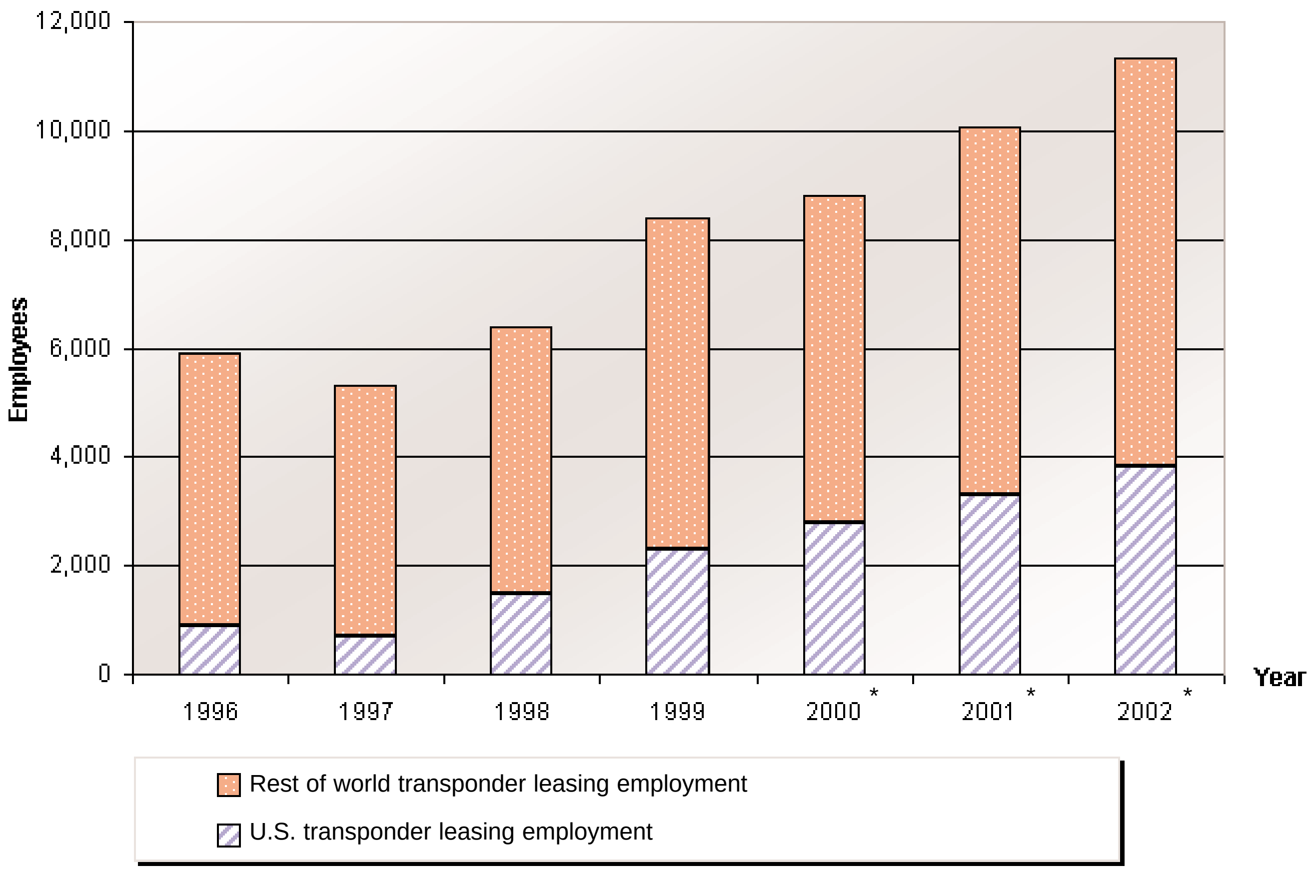


	1996	*1997*	*1998*	*1999*	*2000**	*2001**	*2002**
U.S. transponder revenues	1.50	1.54	1.50	2.30	2.79	3.30	3.82
Rest of world transponder revenues	3.70	4.21	4.60	5.80	5.96	7.02	8.15
Total	*5.20*	*5.75*	*6.10*	*8.10*	*8.74*	*10.32*	*11.97*

* Projections

Figure 3.2.
U.S. and rest of world transponder leasing revenues
(not including resale or brokering revenues), in billions U.S. $, 1996-2002

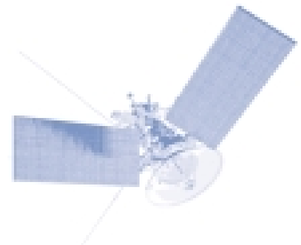
Worldwide employment in the transponder leasing market also continues to grow at about 11 percent. In recent years, U.S. employment in this sector surged and in 2000 constituted 32 percent of 2000 world employment in direct transponder leasing, up from 15 percent in 1996. The employment figures presented in Figure 3.3 do not include employment in second-tier resellers of transponder capacity.



	1996	1997	1998	1999	2000*	2001*	2002*
U.S. transponder leasing employment	900	700	1,500	2,300	2,785	3,300	3,823
Rest of world transponder leasing employment	5,000	4,600	4,900	6,100	6,015	6,778	7,522
Total	*5,900*	*5,300*	*6,400*	*8,400*	*8,800*	*10,078*	*11,345*

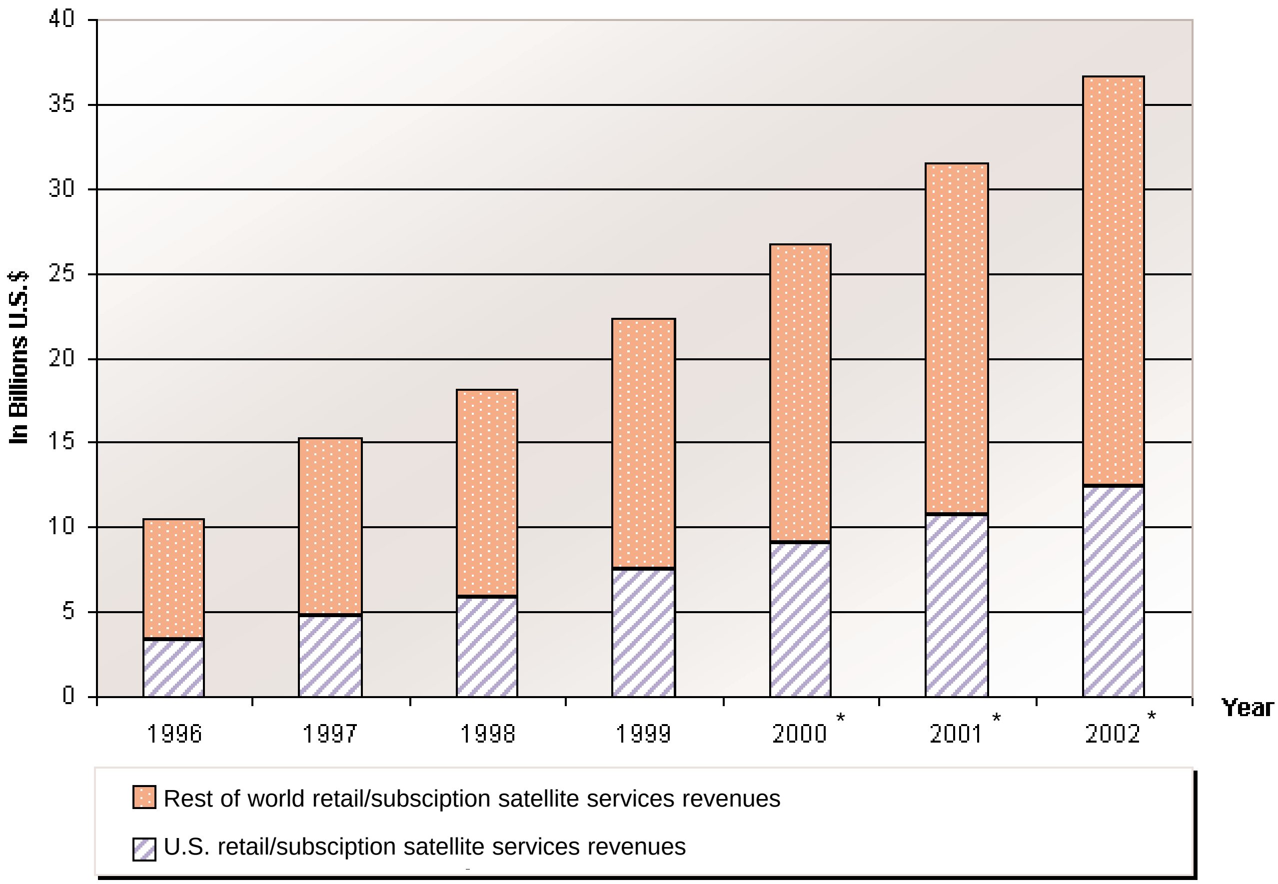
* Projections

Figure 3.3.
U.S. and rest of world transponder leasing employment (not including resellers or brokers), 1996-2002



3.3 Retail/subscription satellite services

Retail and subscription satellite services continue to drive the expansion of the entire satellite communications industry segment. Direct-to-home television, satellite mobile telephone and data services, and very small aperture terminal (VSAT) services constitute the retail/subscription satellite services presented in this section. Revenues presented here reflect payments to service providers by users of their services.



	1996	*1997*	*1998*	*1999*	*2000**	*2001 **	*2002 **
U.S. retail/subscription satellite services revenues	3.34	4.79	5.90	7.50	9.08	10.76	12.47
Rest of world retail/subscription satellite services revenues	7.12	10.49	12.27	14.83	17.68	20.82	24.17
Total	*10.46*	*15.28*	*18.17*	*22.33*	*26.76*	*31.58*	*36.64*

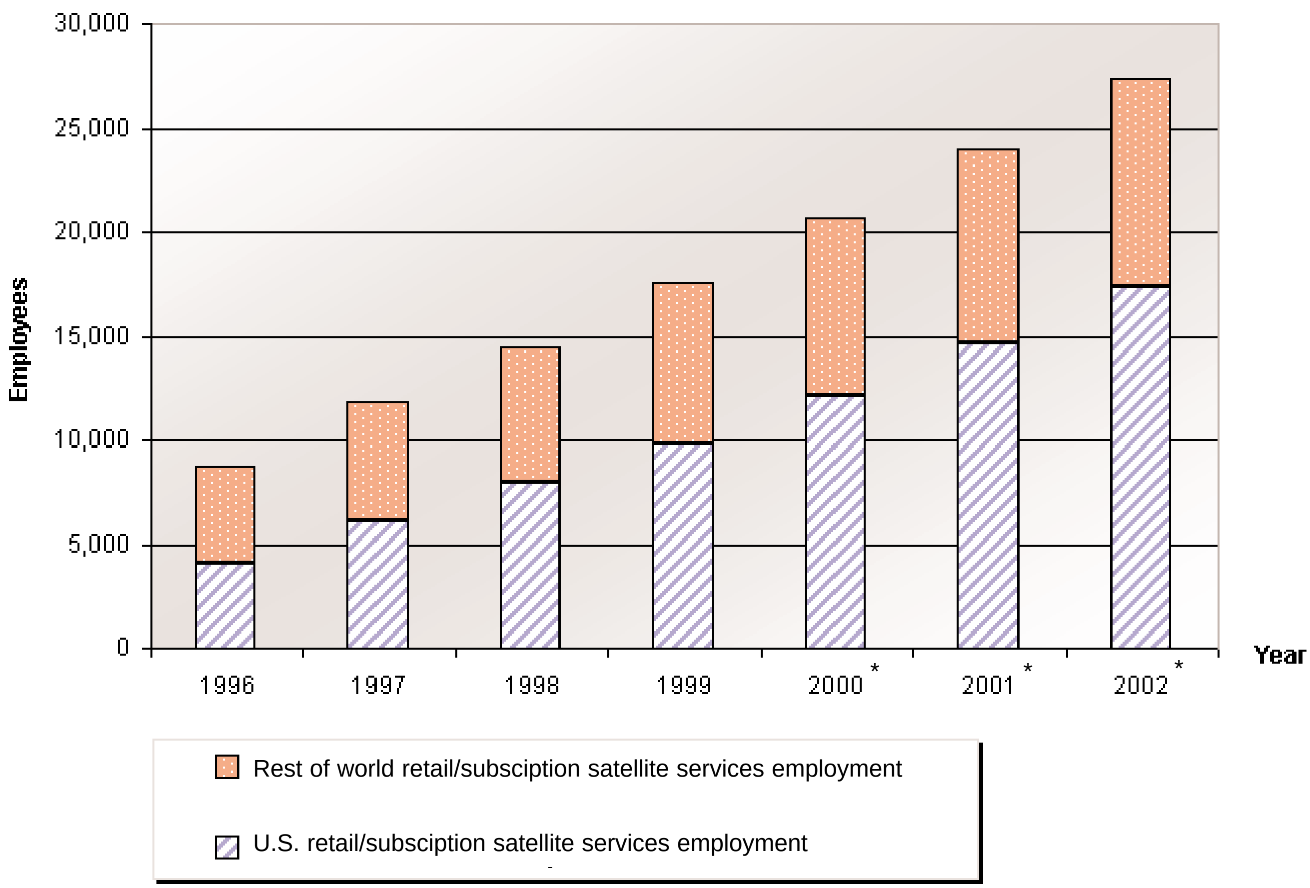
* Projections

Figure 3.4.
U.S. and rest of world retail/subscription satellite services revenues, in billions U.S. $, 1996-2002

1996 to 1999 retail/subscriptions satellite services revenues and employment figures in this section are taken from the *Satellite Industry Indicators Survey.* Average historical growth trends for both revenue and employment were applied to project this sector through 2002.

Direct-to-home television is the strongest player in this field. This sector of the satellite communications segment realized revenues of $9 billion in 2000 and high growth—23 percent—over the last 5 years (see Figure 3.4). The U.S. market outpaced this growth only slightly, posting an annual growth of 25 percent. U.S. providers should maintain an approximate one-third-market share in this sector through 2002. Satellite service providers continue to roll out new and bundled service offerings, including Internet services; these efforts should keep growth in this sector well over 20 percent through 2002.

Figure 3.5 shows that employment in the retail/subscription satellite services sector keeps pace with revenue growth. Over the seven-year period presented here, U.S. employment quadruples, while the rest of the world doubles its personnel working directly for retail/subscription satellite services firms.



	1996	1997	1998	1999	2000 *	2001 *	2002 *
U.S. retail/subscription satellite services employment	4,100	6,100	8,000	9,800	12,118	14,661	17,345
Rest of world retail/subscription satellite services employment	4,600	5,700	6,500	7,800	8,603	9,356	10,021
Total	*8,700*	*11,800*	*14,500*	*17,600*	*20,721*	*24,017*	*27,366*

* Projections

Figure 3.5.
U.S. and rest of world retail/subscription satellite services employment, 1996-2002

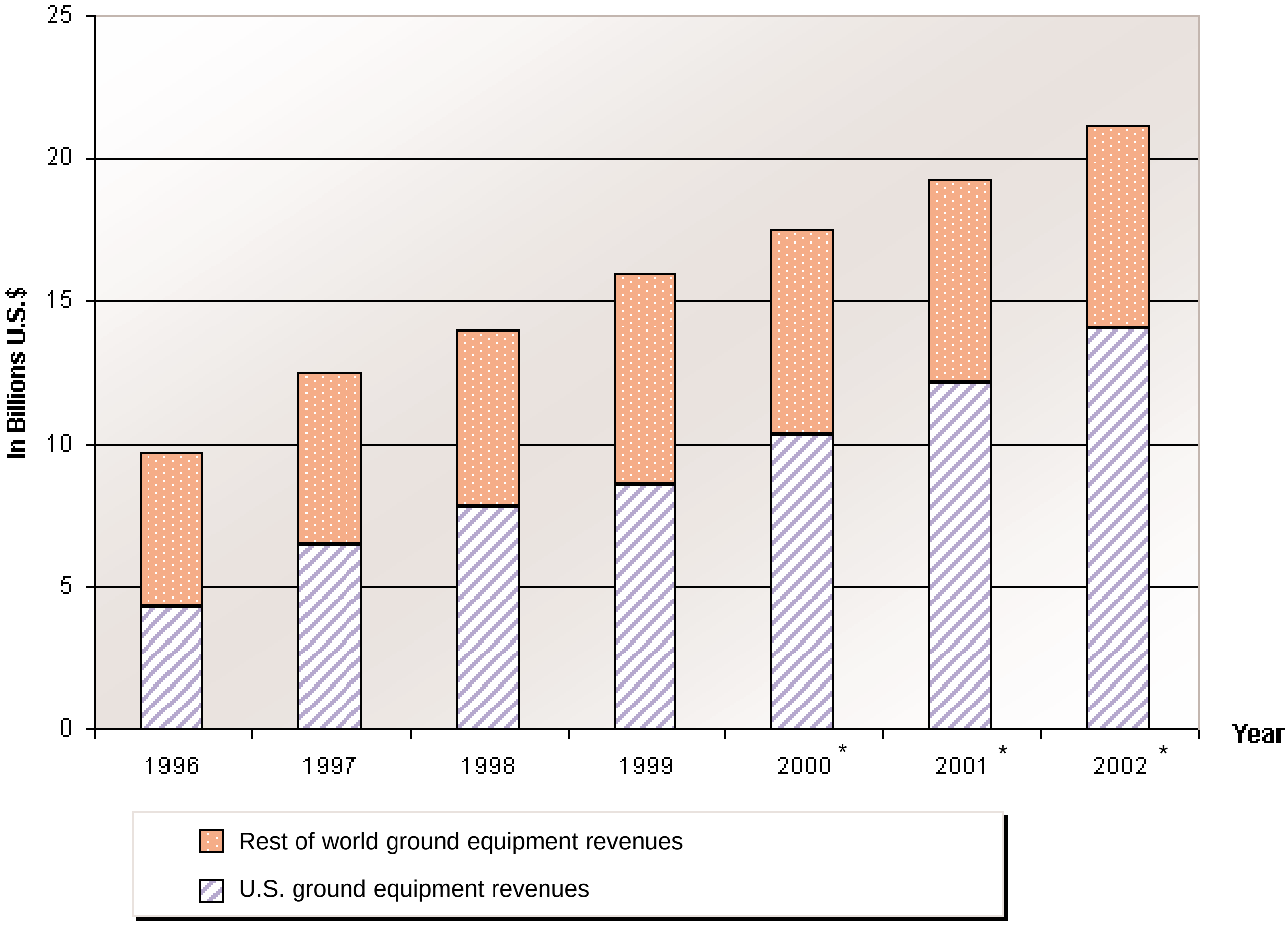
3.4 Ground equipment

The ground equipment-manufacturing sector, as analyzed here, consists of the manufacturing of satellite uplink and downlink terminals (including VSATs), consumer mobile satellite data and telephone units, and direct-to-home television receivers and dishes. This sector grew at a robust pace through the latter half of the 1990s as it provided the consumer equipment for the increasing offerings of the satellite services sector.

1996 to 1999 ground equipment revenues and employment figures in this section are taken from the *Satellite Industry Indicators Survey*. Average historical growth trends for both revenue and employment were applied to project this sector through 2002.

Worldwide revenues for the ground equipment-manufacturing sector grew at an annual rate of 14 percent from 1996 through 1999 (see Figure 3.6). Given the current strength of the satellite services sector, this growth is projected to continue though 2002. The U.S. market has outpaced the world market for the past few years, growing at a rate of 22 percent. While the United States accounted for only 44 percent of worldwide ground equipment manufacturing revenues in 1996, if current growth trends continue, the U.S. market share will have grown to almost two-thirds of the world market by 2002.

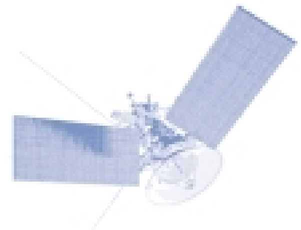
Employment growth in the ground equipment sector lagged behind revenue growth. Figure 3.7 shows that worldwide employment increases at a 6 percent annual rate from 1996 to 2002.

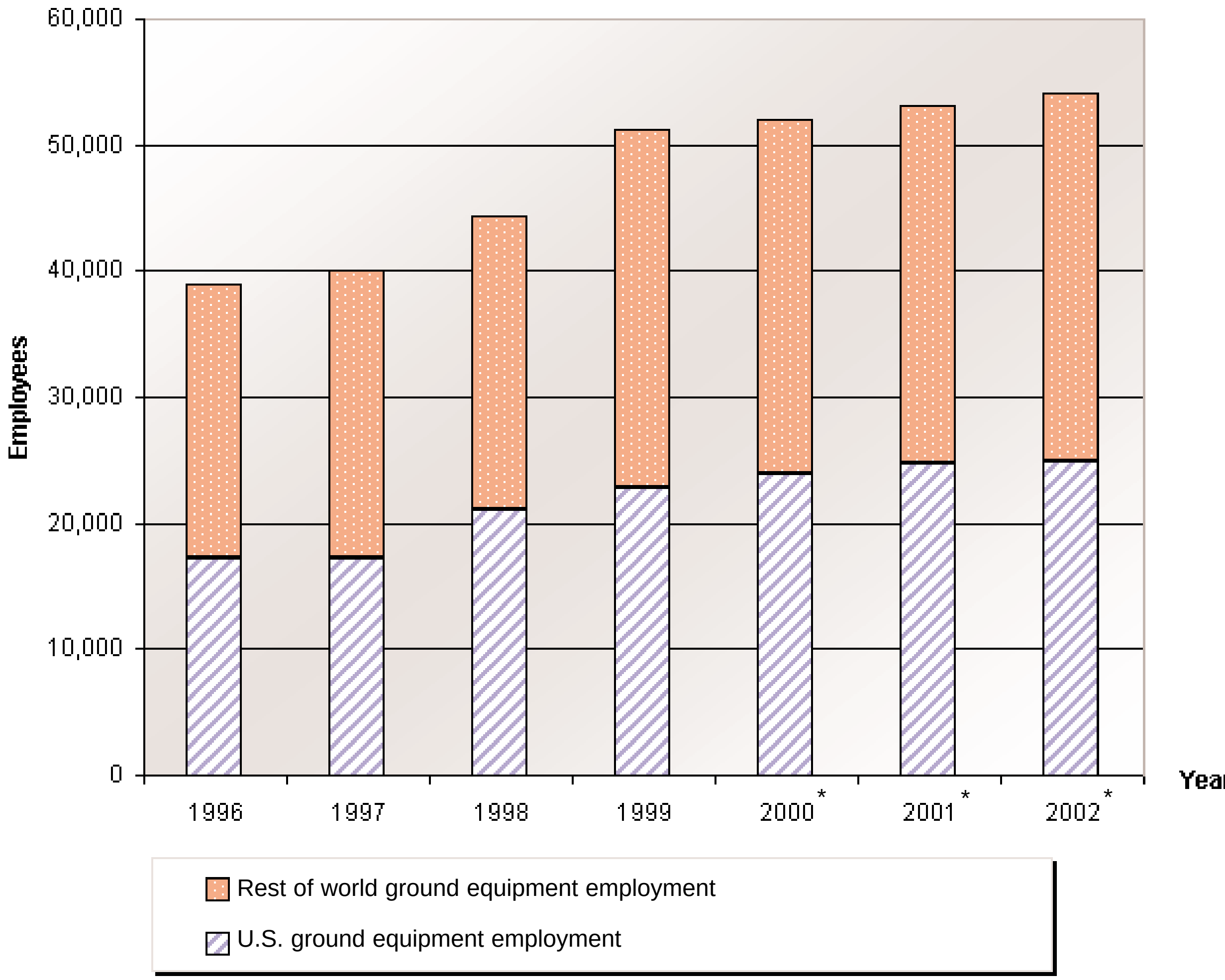


	1996	*1997*	*1998*	*1999*	*2000**	*2001**	*2002**
U.S. ground equipment revenues	4.30	6.47	7.78	8.55	10.30	12.15	14.04
Rest of world ground equipment revenues	5.40	6.05	6.17	7.41	7.19	7.09	7.14
Total	*9.70*	*12.52*	*13.95*	*15.96*	*17.50*	*19.25*	*21.17*

* Projections

Figure 3.6.
U.S. and rest of world satellite communications' ground equipment manufacturing revenues, in billions U.S. $, 1996-2002





	1996	*1997*	*1998*	*1999*	*2000**	*2001**	*2002**
U.S. ground equipment employment	17,200	17,300	21,000	22,800	23,989	24,717	24,930
Rest of world ground equipment employment	21,800	22,700	23,400	28,400	28,057	28,378	29,237
Total	*39,000*	*40,000*	*44,400*	*51,200*	*52,045*	*53,096*	*54,167*

* Projections

Figure 3.7.
U.S. and rest of world satellite communications' ground equipment manufacturing employment, 1996-2002

3.5 World commercial communications satellites on orbit

A total of 425 operational communications satellites offering commercial service currently orbit the Earth. Of these satellites, slightly under 54 percent operate from geostationary orbit (GEO), while 42 percent operate from LEO, and the remaining 4 percent circle Earth from elliptical (ELI) orbital planes. The United States operates 26 percent of operational GEO commercial communications satellites.[3]

Orbit type	*Number of satellites*
GEO	227
LEO	180
ELI	118
Total	*425*

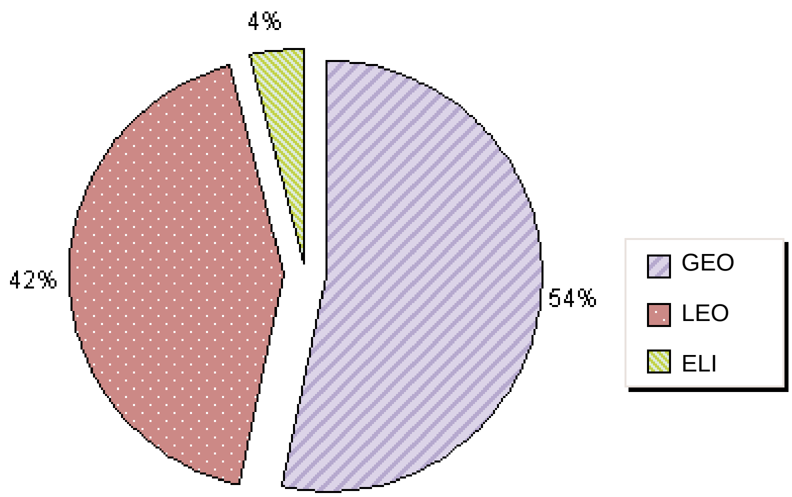


Figure 3.8.
Operational commercial communications satellites, by orbit type, as of December 31, 2000

A small number of satellite operators dominate the world satellite services market. The six companies called out in Table 3.1 that operate geostationary satellites represent almost 39 percent of the world's operational commercial communications geostationary satellites. The recently deployed Iridium, Globalstar, and ORBCOMM constellations constitute 86 percent of operational NGSO commercial communications satellites. In total, the nine companies in Figure 3.9 represent almost 61 percent of operational commercial communications satellites on orbit.

[3] For consistency with Section 3.2, Transponder Leasing, Intelsat and Inmarsat satellites are designated non-U.S. for this analysis.

Select major satellite operator	*Operational satellites*
Intelsat	17
Inmarsat	9
Eutelsat	17
Pan American Satellite Corp.	20
Societe Europeenne des Satellites (SES)	11
GE Americom	13
Iridium Satellite[4]	83
Orbital Communications Corp. (ORBCOMM)	36
Globalstar, Ltd. Partnership	52
Total	*259*

Table 3.1.
Select major satellite operators, worldwide, as of December 31, 2000

3.6 Satellite manufacturing

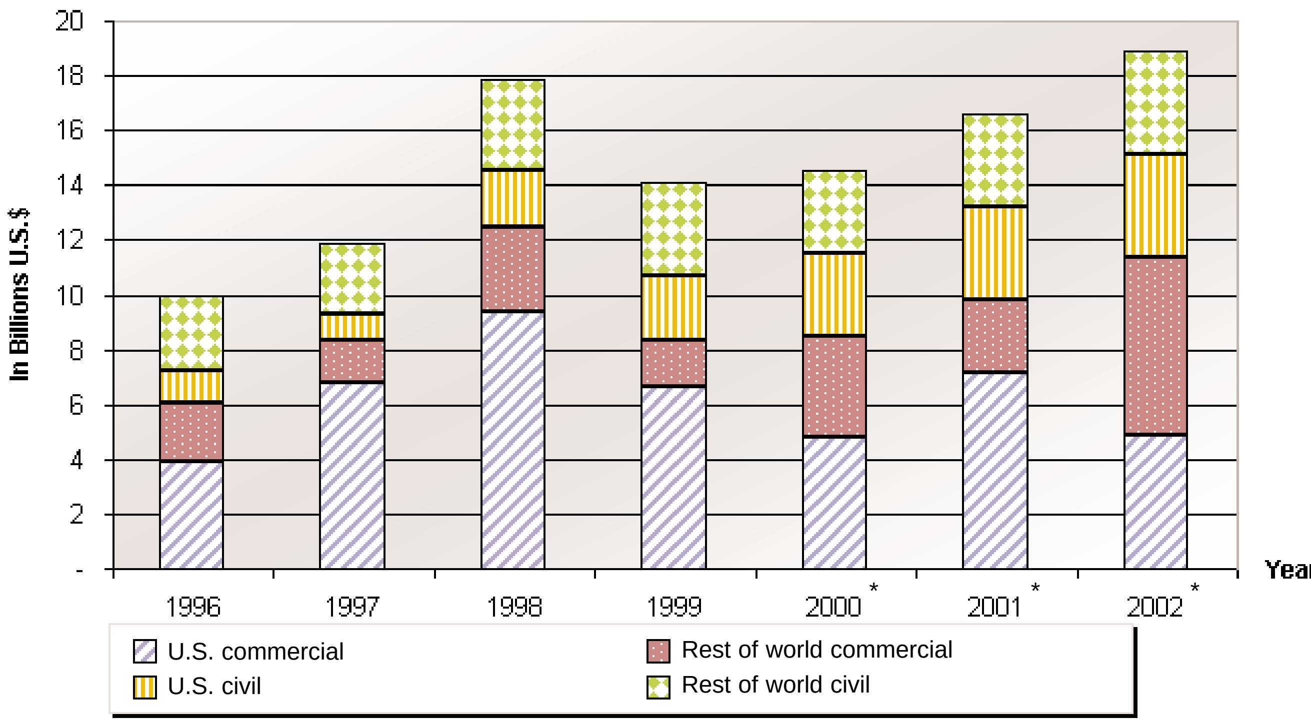
Satellite manufacturing revenues reflect revenues associated with the manufacture of commercial-use satellites and satellites for civilian government or non-profit use; revenues do not reflect payments received in association with the construction of military-use satellites, nor for manufacturing activities associated with any human space flight program. 1996-2000 revenues are calculated from the number of commercial use, civilian, and non-profit satellites launched in those years and from average revenue per satellite figures calculated from the *Satellite Industry Indicators Survey*. Satellites and average revenue figures are categorized by commercial GEO, commercial NGSO, and civil government (including non-profit). This approach was chosen over direct reporting of *Satellite Industry Indicators Survey* results because the *Survey* includes satellite revenues that are excluded here (e.g., from the construction of military satellites). The 1999 average revenue figure is used for 2000, 2001, and 2002. Projections for commercial GEO and NGSO satellites to be launched in 2001 and 2002 were derived from COMSTAC projections, with adjustments for definitional purposes.[5] Civil government figures for 2001 to 2002 satellites were based upon recent historical trends in the number of these satellites and represent a 10 percent annual growth. Satellites are multiplied by average revenue estimates to derive total satellite manufacturing revenues for each of the three

4 The newly formed company, Iridium Satellite, acquired the bankrupt Iridium operation in December 2000 for $25 million. The U.S. Department of Defense will operate as an anchor customer for the system, having signed a two-year deal to provide Iridium service to at least 20,000 defense personnel working overseas.

5 COMSTAC counts internationally competed launches. These launches do not always capture all actual commercial use satellites, which are sometimes captive, for a variety of reasons, to specific or national launchers.

categories. For purposes of this analysis, all revenues associated with the manufacture of a satellite are calculated in the year of the satellite's launch; this method of assignment can result in significant year-to-year fluctuations in reported manufacturing revenues as system deployment dates can be concentrated and the launch industry experiences periodic delays. The rapid deployment of several LEO satellite constellations in 1998, for instance, spiked commercial revenues associated with that year.

As seen in Figure 3.9, the satellite manufacturing sector experiences healthy overall growth over the 1996 to 2002 period, with world revenue growing at an annual rate of 11 percent. However, while the rest of the world grew at a pace slightly faster than the global average (13 percent), the United States lagged behind with an average annual growth of just over 9 percent. In fact, after historically garnering an average of 75 percent of the global marketplace for GEO satellites, only 43 percent of satellites projected for launch in 2002 are anticipated to be of U.S. manufacture. This figure represents the relatively low percentage of GEO satellite manufacturing contracts captured by U.S. firms in 2000. The reasons behind this drop are hotly debated and are explained by some by 1999 changes in U.S. law. In 1999, amid growing concerns about technology transfer to foreign governments and firms, the U.S. Congress passed legislation heightening federal export control of commercial satellite technology and transferring authority for satellite export licenses from the Department of Commerce to the Department of State. Other explanations for this drop include increasing competitiveness of foreign satellite manufacturers and an unfavorable U.S. dollar-Euro exchange rate in 2000.

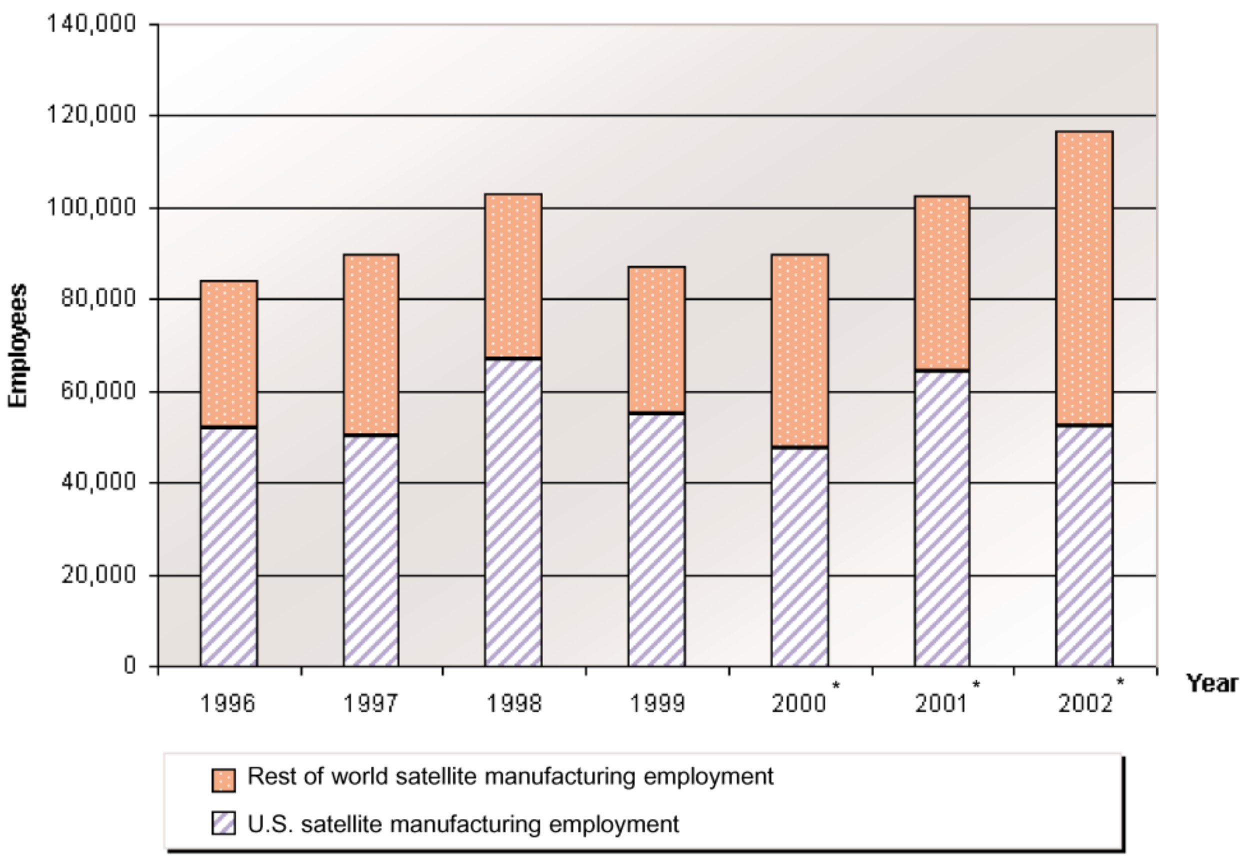


	1996	1997	1998	1999	2000 *	2001 *	2002 *
U.S. commercial	3.92	6.78	9.39	6.66	4.81	7.19	4.87
Rest of world commercial	2.17	1.55	3.07	1.65	3.70	2.64	6.51
U.S. civil	1.13	0.97	2.07	2.40	3.01	3.37	3.75
Rest of world civil	2.76	2.62	3.35	3.42	3.04	3.39	3.78
Total	*9.97*	*11.91*	*17.88*	*14.13*	*14.56*	*16.60*	*18.92*

* Projections

Figure 3.9.
U.S. and rest of world commercial and civil satellite manufacturing revenues, in billions U.S. $, 1996-2002

Satellite manufacturing employment remains relatively steady over the forecast period, with year-to-year fluctuations in the data due to satellite deployment realities. Employment estimates shown in Figure 3.10 reflect only those personnel employed by commercial manufacturing firms and not by any government agency.



	1996	1997	1998	1999	2000*	2001*	2002*
U.S. satellite manufacturing employment	51,800	50,400	66,700	55,100	47,614	64,255	52,483
Rest of world satellite manufacturing employment	32,100	39,200	36,400	32,200	42,352	38,299	64,398
Total	*83,900*	*89,600*	*103,100*	*87,300*	*89,965*	*102,554*	*116,881*

* Projections

Figure 3.10.
U.S. and rest of world satellite manufacturing employment (does not include government personnel), 1996-2002

3.7 Proposed satellite systems

The burgeoning data relay market led to an explosion in the past decade in proposed new satellite systems to handle a variety of global information transfer needs. Spectrum availability and technological advances have made higher frequency bands (Ku, Ka, V, and even Q bands) viable options for a variety of communications applications.

The "Little LEOs" are multiple satellite systems designed to handle narrow-band data streams for such applications as asset tracking, remote data monitoring, messaging, and two-way paging to fixed and mobile users utilizing frequencies below 1 GHz. Only one "Little LEO" is currently in orbit, ORBCOMM.

Numerous "Big LEO" systems have been proposed to address the market for voice and other mobile satellite services. Two systems, Iridium and Globalstar, have been deployed, while the ICO system began the launch process in 2000.

System	Operator	Prime Contractor	System Configuration	First Launch	FCC Filing Status
Operational					
ORBCOMM	ORBCOMM Global LP	Orbital	48 LEO satellites	1997	Licensed and operational with 35 satellites on orbit.[6]
Iridium	Iridium Satellite	Motorola	66 + 6 LEO satellites	1997	Licensed to Iridium LLC and on orbit. Originally ceased operations March 2000. Bought by Iridium Satellite in December 2000. Operational.
Globalstar	Globalstar LP	Alenia Spazio	48 + 8	1998	Licensed and operational.
Under Development					
ICO	New ICO	Hughes Space & Comm. (HSC)	10 + 2 MEO satellites	2000	Licensed.

Table 3.2.
Operational and/or deploying LEO commercial satellite constellations

Emerging markets for high-speed, broadband data relay have driven growth in applications for global satellite broadband data relay solutions. Ku- and Ka-band systems are proposed in the near-term, while applications have been filed with the FCC to use the newly opened V-and Q-bands within the next decade. Only one LEO system, Teledesic, has received an FCC license, while 7 operators have received licenses to operate GEO broadband systems. Sixteen more operators had active NGSO broadband licensing petitions with the FCC at the end of 2000, while thirteen operators had active GEO petitions. Meanwhile, a number of operators have begun offering broadband data services over existing satellites already on orbit.

[6] ORBCOMM filed for Chapter 11 bankruptcy in September 2000.

3.8 Selected references

Associate Administrator for Commercial Space Transportation (AST) and the Commercial Space Transportation Advisory Committee (COMSTAC), Federal Aviation Administration, 2000 *Commercial Space Transportation Forecasts,* May 2000.

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www.FCCFilings.com, accessed October-December, 2000.

Section Four

Remote Sensing

4.1 Overview of trends, drivers, and events

The commercial remote-sensing segment can be divided into three components: satellite systems, aerial imaging (i.e., images from aircraft), and value-added products and services such as geographical information systems (GIS) software.

The total market for remote sensing in 1998 was approximately $3.3 billion, with aerial imagery accounting for 65 percent of that figure. Pre-value-added satellite imagery (raw imagery) revenues were about $139 million for the same year, and include fees paid by ground stations worldwide for the rights to obtain commercial imagery. Top-level imagery analysis, with little to no image processing, raises the commercial revenues associated with satellite imaging to approximately $390 million. By 2000, pre-value-added satellite imagery accounted for an estimated $173 million worldwide, with the United States responsible for $50 million of the total. GIS software, which is used to overlay, enhance, or modify remote-sensing imagery, accounted for approximately $1.2 billion. The aerial imagery component was about $2.6 billion. Only the pre-value added satellite imagery industry component is emphasized in this report, the GIS software and aerial segments being beyond the scope of this study.

Key trends in remote sensing include a greater demand for high-resolution panchromatic, radar, and multispectral or hyperspectral imagery,[23] depending on application needs. Image processing has contributed to a growing GIS software segment, a trend that benefits customers who wish to manipulate such imagery on desktop computers. Enablers of efficient GIS software use are greater Internet bandwidth and faster computer processors, both of which are not currently at the desired performance level. A competitive market between commercial remote-sensing image providers and the sale of imagery from civil platforms like Landsat 7 has also emerged. The distribution of Landsat 7 images by the U. S. Geological Survey (USGS) Earth Resources Observation System (EROS) Data Center (EDC) has become a controversial activity to some commercial providers in the industry. The EDC sells medium resolution (15 meters panchromatic and 30 meters multispectral) imagery, but also provides images at no charge on a case-by-case basis. The USGS and the National Oceanic and Atmospheric Administration (NOAA), which licenses commercial remote-sensing satellites, view Landsat 5 and 7 as government assets and maintain that images derived from the platform should be readily available to the public. Several remote sensing

[23] Resolution refers to the level of detail viewable in an image and is usually expressed in meters or centimeters (for example, 1-meter resolution means that objects measuring 1 meter or greater in size can be discerned). Panchromatic imagers detect one wavelength, but at very high resolutions not currently possible with multispectral or hyperspectral imagers. Multispectral imagers are used to detect between four to ten spectral bands of reflected sunlight, while hyperspectral imagers can detect several hundred. The latter is particularly useful for geological mapping.

companies provide similar products at higher relative cost and feel they cannot compete with relatively cheap or free imagery distributed by EDC.[24] Examples of potential commercial customers using Landsat 5 and 7 images are other federal, state, and local agencies and farmers. Commercial remote sensing image providers do agree that scientists and universities benefit from government platforms like Landsat 5 and 7, but that these groups do not constitute a major part of the customer base.

Several governments are investing in their own remote-sensing satellites. Russia, China, India, Japan, Canada, and the European Space Agency (ESA) continue to launch Earth resources, meteorological, and intelligence (except ESA) satellites. Governments with modest space agencies also have active remote-sensing satellite programs, some of which are developed on a cooperative basis with other nations. Examples of these emergent systems can be found in Brazil, Argentina, Israel, Turkey, and some European countries. Governments with little or no space funding have expressed a strong interest in purchasing imagery from commercial entities for use in a wide range of applications, ranging from resource management to military strategic planning.

Another important trend impacting the remote-sensing industry is the increasing power and capacity of personal computers both at office and home. Raw remote-sensing images require a significant amount of memory to download and save, and manipulation of the images using GIS software requires a memory capacity not typically available to users. Continuing improvements to computers, typically focused on providing greater memory and faster processing time, will make GIS software more marketable and more affordable. A key ingredient is the Internet, which will be the conduit of choice between the customer and provider of remote-sensing products. Lower cost computers capable of manipulating images efficiently and an infrastructure capable of sending the data quickly to every corner of the globe will contribute to a more robust commercial remote-sensing satellite industry.

Certain drivers of commercial remote-sensing satellite systems are expected to influence the remote-sensing market within the next two years and beyond. Those drivers are:

[24] Title II of the 1992 Land Remote-sensing Policy Act was drafted in part to promote the commercial remote sensing industry in the United States, with exceptions related to national security programs. On July 31, 2000, NOAA issued regulations implementing Title II of the Act, which also lays the groundwork for the commercialization of certain government remote-sensing satellite imagery products (so far only Landsat 5 and 7). In addition, the new regulations codified the licensing process and established a shutter control policy. Many in the industry believe the new regulations are too restrictive and that they compromise the intent of the 1992 Act.

- Worldwide demand for high-resolution panchromatic and multispectral imagery will drive the development of more sophisticated commercial platforms, from which increases in the sale of raw data can be expected.

- More frequent revisit times will also drive the satellite systems component, since customers will require a greater degree of temporal fidelity. Foresters, insurance providers, and disaster management officials from all over the world will find this attribute essential.

- Greater area coverage than provided by aerial imagery is a significant driver, since relative cost is lower. In addition, a typical swath width of a satellite capable of 1-meter resolution is about 20 meters, wider than aerial imagery of comparable resolution.

- Falling launch costs and greater selection of competitive launch vehicles will reduce costs of sending a remote-sensing satellite into orbit, a factor that will translate to lower user costs.

Recently, ongoing discussions around the world concerning imaging rights and policies, shutter control, and export issues have become very important to the remote-sensing industry.

By 2000, the United States, Canada, ESA, France, Russia, China, India, Brazil, and Japan all had high-resolution space-based remote-sensing platforms. Several other countries, like Turkey and Pakistan, have expressed a strong interest in either purchasing high-resolution data or developing their own remote-sensing satellites. Realizing that an international competitive market was emerging and that it was in the interest of the United States to maintain a strong remote-sensing industry, the White House authorized companies in the United States to market 1-meter resolution products and services.[25] High-resolution satellite imagery, previously only captured by military platforms, has been identified by commercial remote-sensing companies as a critical market. This type of imagery can be used for urban planning, insurance assessments, and the development of precision navigation maps. High-resolution infrared imagery is difficult to obtain relative to visible wavelengths, but recent events related to forest fires may create a demand for such accuracy.

U.S. remote-sensing satellite manufacturers were authorized to build and sell satellites with high-resolution capability to foreign users. National security concerns must be addressed carefully for manufacturers, since any satellite sold to foreign buyers must meet the export control requirements of the Department of Defense, the Department of Commerce, and the Department of State. In addition, the United States has reserved the right to impose shutter controls on commercial imaging satellites during national crises.

[25] *Presidential Decision Directive 23, Foreign Access to Remote-sensing Space Capabilities,* March 10, 1994.

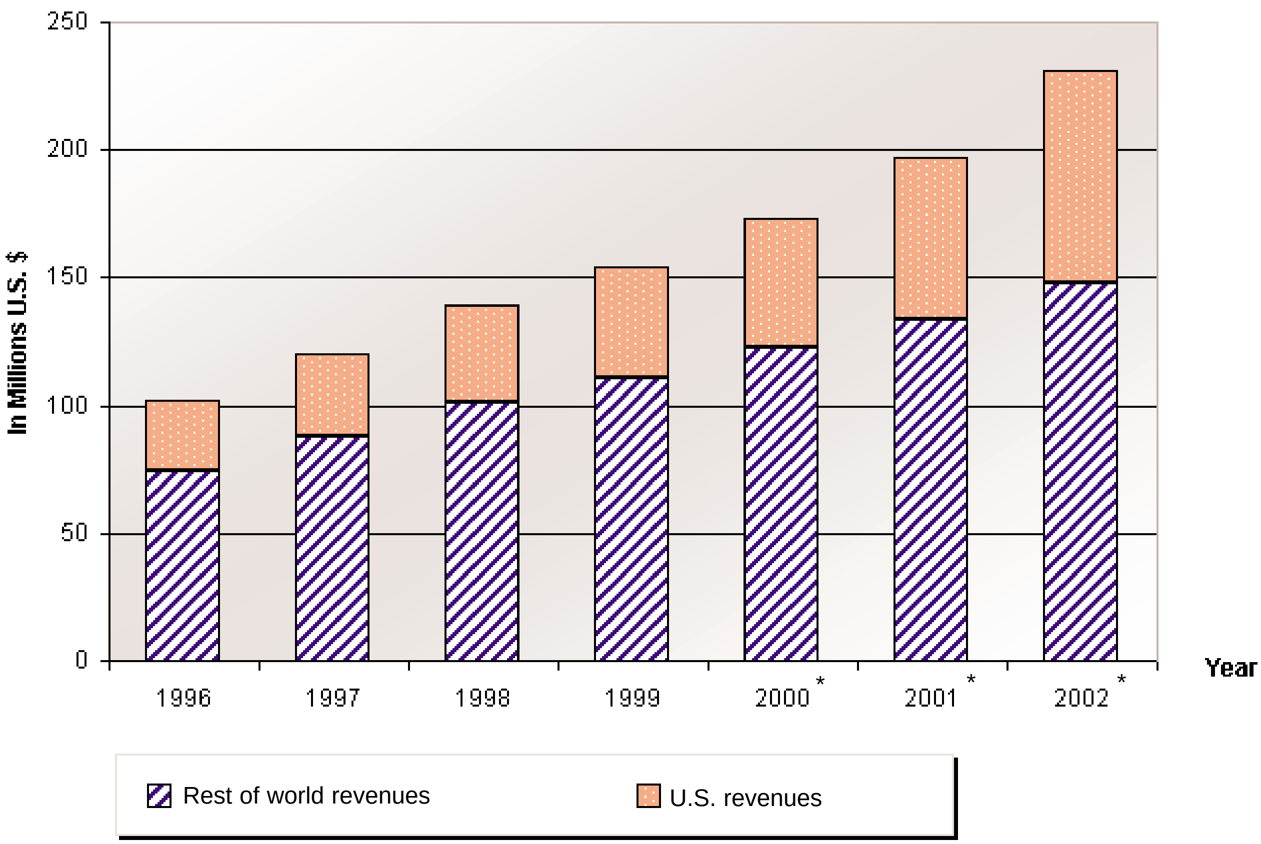
These recent events have become particularly important in light of the relative success of Space Imaging's 1-meter resolution Ikonos 2 satellite system. Ikonos 2 has provided high-resolution images that have energized the remote-sensing community, which hope to see a plethora of products ranging from near-real time environmental monitoring to urban planning charts. In terms of future plans, Space Imaging was recently granted a license for a 0.5-meter resolution remote-sensing platform, tentatively planned for a 2004 launch. On November 21, 2000, QuickBird 1, Earth Watch's 1-meter resolution remote-sensing platform and the second commercial 1-meter resolution satellite from the United States, failed to achieve orbit due to a suspected second stage failure of the *Kosmos-3* launch vehicle. While Earth Watch has had to reevaluate plans for the future, it is unclear if this event will have any impact on the industry as a whole.

As more 1-meter resolution remote-sensing satellites are launched, defense officials worldwide are becoming concerned about the potential use of high-resolution images by adversaries to gain tactical and strategic advantage in the future. Shutter control regulations are designed to address such concerns but tend to be vague and subject to broad interpretation. Most industry leaders in the United States believe the benefits of high-resolution imagery outweigh the disadvantages and that generally applied shutter control regulations impede growth of the remote-sensing industry. Most industry leaders recognize the need for shutter control during certain national security emergencies like war, but believe that regulations should clearly define the parameters justifying when and to what extent shutter control should be implemented.

4.2 U.S. and world commercial imagery sales

Figure 4.1 shows annual revenue totals for commercial pre-value-added imagery from remote sensing satellites operated worldwide and by the United States. Pre-value-added refers to revenues paid to civil and commercial remote-sensing satellite operating organizations for basic satellite data and enhanced satellite data distributed by Value Added Resellers (VARs), along with fees paid by operators of ground stations receiving remote-sensing satellite data. The figures do not include the development, manufacture, and operation of military satellite platforms and revenues to government agencies that operate remote-sensing satellites from which data are not commercially available (such as meteorological satellites).

The chart shows worldwide annual growth of 14 percent over the period 1996 to 2002. Revenues for U.S. pre-value-added imagery from remote-sensing satellites account for approximately 27 percent of the market in 1996, with a projected share of 36 percent in 2002. This percentage includes revenues from raw Landsat 7 images and commercial providers ORBIMAGE, Earth Watch, and Space Imaging. France's SPOT Image accounts for over 30 percent of revenues from 1996 through 2002, with India, Russia, Japan, Canada, and the European Space Agency accounting for approximately 40 percent through 2002. Significant growth is expected for the United States following the launch of several commercial platforms in 2001.



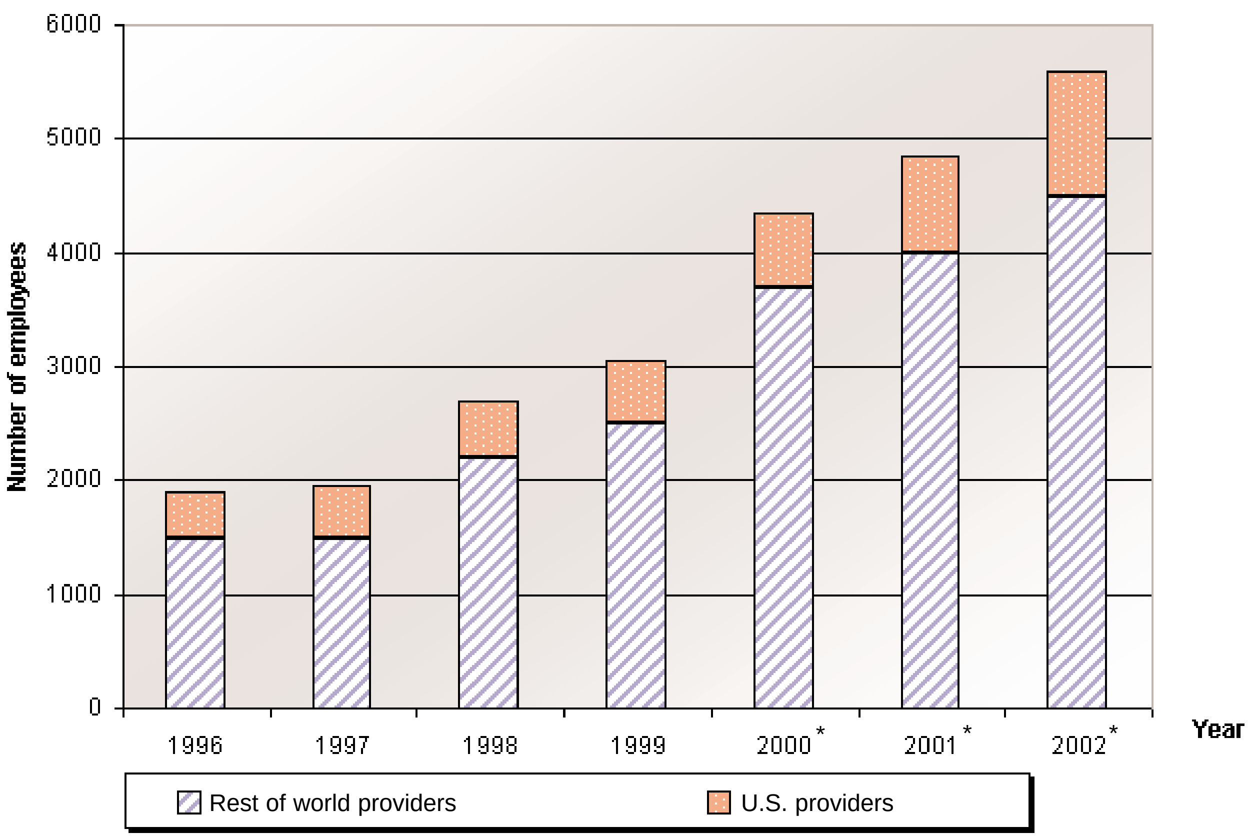
	1996	*1997*	*1998*	*1999*	*2000* *	*2001* *	*2002* *
U.S. pre-value added commercial imagery revenues	28	32	38	43	50	63	83
Rest of world pre-value added commercial imagery revenues	74	88	101	111	123	134	148
Total	*102*	*120*	*139*	*154*	*173*	*197*	*231*

* Projections

Figure 4.1.
U.S. and rest of world pre-value-added commercial remote-sensing satellite imagery revenues, in millions U.S. $, 1996-2002

Figure 4.2 shows both U.S. and rest of world employment figures for commercial remote-sensing satellite service providers. For purposes of this forecast, commercial remote-sensing employment figures include organizations that provide commercial, unclassified raw and process-enhanced satellite data to distributors, VARs, and other users. The figures do not include employment data from civil or military remote-sensing organizations in which data are not commercially available, nor do they include aerial imagery providers.

Estimating employment for satellite service providers is challenging and can vary depending on the labor category of each employee. For purposes of this analysis, a baseline figure of 100 employees per government remote-sensing organization was used, with 200 being used for commercial organizations. These figures are estimates based on interviews, publications, and press releases. The United States accounts for between 25 percent and 30 percent of the total worldwide employment figure and includes employees directly involved with the sale of pre-value-added remote-sensing satellite imagery from EROS (Landsat 5 and 7), Space Imaging, ORBIMAGE, Resource21, Earth Watch, and others. Data from the Satellite Industry Association were also used in determining worldwide remote-sensing satellite imagery employment figures.



	1996	*1997*	*1998*	*1999*	*2000 **	*2001 **	*2002 **
U.S. commercial remote sensing satellite data providers	400	450	500	550	650	845	1098
Rest of world commercial remote sensing satellite data providers	1500	1500	2200	2500	3700	4000	4500
Total	*1900*	*1950*	*2700*	*3050*	*4350*	*4845*	*5598*

* Projections

Figure 4.2.
U.S. and rest of world commercial remote-sensing satellite data provider employment, 1996-2002

4.3 Current and future U.S. and world remote-sensing satellite systems

Table 4.1 shows overview information for U.S. and world remote-sensing satellites providing commercially available imagery operating as of December 2000. Table 4.2 contains technical data for each satellite listed in Table 4.1. Tables 4.3 and 4.4 cover the same type of data for future remote-sensing satellites with planned launches between 2001 and 2002. Some military intelligence satellites are not captured due to their classified nature.

Name	*Launch Year*	*Operator*	*Manufacturer*	*Country*
EROS A1	2000	West Indian Space	West Indian Space	Israel
ERS 2	1995	ESA	Deutsche Aerospace (DASA)/Dornier	ESA
IKONOS 2	1999	Space Imaging	Lockheed Martin	USA
IRS 1B	1991	Indian Space Research Organization (ISRO)	Indian Space Research Organization (ISRO)	India
IRS 1C	1995	Indian Space Research Organization (ISRO)	Indian Space Research Organization (ISRO)	India
IRS 1D	1997	Indian Space Research Organization (ISRO)	Indian Space Research Organization (ISRO)	India
IRS P3	1996	Indian Space Research Organization (ISRO)	Indian Space Research Organization (ISRO)	India
KOMPSAT 1	1999	Korea Aerospace Research Institute (KARI)	TRW and Korea Aerospace Research Institute (KARI)	South Korea
Landsat 5	1984	Space Imaging	General Electric	USA
Landsat 7	1999	USGS	Lockheed Martin	USA
Orbview 1	1995	ORBIMAGE	Orbital Sciences Corporation	USA
Orbview 2	1997	ORBIMAGE	Orbital Sciences Corporation	USA
Radarsat 1	1995	Orbital Sciences Corporation	Orbital Sciences Corporation	Canada/USA
Resurs F1M	1997	Russian MOD	Central Specialized Design Bureau (TsSKB)	Russia
Resurs O1-4	1998	Russia	VNII Elektromekhaniki	Russia
ROCSAT 1	1999	National Space Program Office	TRW and National Space Programs Office	Taiwan
SPIN 2	1998	SOVINFORMSPUTNIK	Unknown	Russia
SPOT 1	1986	SPOT Image	Matra Marconi Space	France
SPOT 2	1990	SPOT Image	Matra Marconi Space	France
SPOT 4	1998	SPOT Image	Matra Marconi Space	France
TiungSat 1	2000	Astronautic Technology	Surrey	Malaysia

Table 4.1.
Overview of current operational U.S. and world remote-sensing satellites producing commercially available imagery

Name	*Mission Life*	*Sensor Types*	*Spatial Resolution (m)*	*Revisit Time*	*Swath Width (m)*	*Spectral Bands*
EROS A1	4 yrs	Visible, IR	1.8 m	1-3 days	12.5 km	500-900 nm
ERS 2	3 yrs	Visible, IR, radar, microwave, laser	Unknown	35 days	AMI: 100 km	Visible (red), IR, radar, microwave wavelengths
IKONOS 2	3-5 yrs	Visible, NIR	Visible: 1 m, multispectral: 4 m	2.9 days at 1-meter, 1.5 days at 1.5 meter	11-13 km	Visible: 450-900 nm; multispectral: 450-530 nm, 520-610 nm, 640-720 nm, 760-880 nm
IRS 1B	3 yrs	Visible, NIR	LISS/1: 72.5 m, LISS/2: 36.25 m	5 days	LISS/1: 148 km, LISS/2: 74 km	450-520 nm, 520-590 nm, 620-680 nm, 770-860 nm
IRS 1C	3 yrs	Visible, NIR	PAN: 5.8 m, LISS/3: (visible 23 m, IR 70m), WiFS: 188 m	5 days	PAN: 70 km, LISS/3: 142 km, WiFS: 810 km	PAN: 500-750 nm; LISS/3: 520-590 nm, 620-680 nm, 770-860 nm, 1550-1700 nm; WiFS: 620-680 nm, 770-860 nm
IRS 1D	3 yrs	Visible, NIR	PAN: 5.8 m, LISS/3: (visible 23 m, IR 70m), WiFS: 188 m	5 days	PAN: 70 km, LISS/3: 142 km, WiFS: 810 km	PAN: 500-750 nm; LISS/3: 520-590 nm, 620-680 nm, 770-860 nm, 1550-1700 nm; WiFS: 620-680 nm, 770-860 nm
IRS P3	3 yrs	Visible, NIR	MOS: 520 m, WiFS: 188 m	5 days	MOS: 200 km, WiFS: 770 km	MOS: 403-413 nm, 438-448 nm, 480-490 nm, 515-525 nm, 565-575 nm, 610-620 nm, 645-655 nm, 680-690 nm, 745-755 nm, 7563-7577 nm, 7599-7613 nm, 7628-7642 nm, 7658-7772 nm, 810-820 nm, 865-875 nm, 940-950 nm, 1005-1015 nm, 1550-1650 nm; WiFS: 620-680 nm, 770-860 nm, 1550-1750 nm
KOMPSAT 1	3 yrs	Visible	EOC: 6.6 m, OSMI: 1 km	Unknown	EOC: 17 km, OSMI: 800 km	EOC: 510 nm- 730 nm; OSMI: 412-865 nm
Landsat 5	5 yrs	Visible, IR	TM: 30 m, MS: 80 m	16 days	185 km	450-520 nm, 520-600 nm, 630-690 nm, 760-900 nm, 1550-1750 nm, 2080-2350 nm, 10400-12500 nm
Landsat 7	6 yrs	Visible, IR	PC: 15 m, Visible: 30 m, TIR: 60 m	16 days	185 km	Visible: 450-520 nm, 520-600 nm, 630-690 nm; IR: 760-900 nm, 1550-1750 nm, 10400-12500 nm, 2080-2350 nm
Orbview 1	2 yrs	Visible	10 Km	Less than 2 days	1300 Km	777
Orbview 2	10 Yrs	Visible	1.1 Km	1 day	2800 Km	402-422, 433-453, 480-500, 500-520, 545-565, 660-680, 745-785, 845-885

Table 4.2.
Technical information on current operational U.S. and world remote-sensing satellites producing commercially available imagery

Name	Mission Life	Sensor Types	Spatial Resolution (m)	Revisit Time	Swath Width (m)	Spectral Bands
Radarsat 1	5 Yrs	Radar	10-100 m	3 days	35-500 km	Microwave range
Resurs O1-4	2 yrs	Visible, IR	MSU/E: 27-45 m, MSU/SK: 150-250 m	1-3 days	MSU/E: 45-60 km, MSU/SK: 600-700 km	MSU/E: 500-600 nm, 600-700 nm, 800-900 nm; MSU/SK: 500-600 nm, 600-700 nm, 700-800 nm, 800-1000 nm, 10400-12600 nm
ROCSAT 1	Unknown	Visible, IR	800 m	Unknown	691.2 km	443 nm, 490 nm, 510 nm, 555 nm, 670 nm, 865 nm
SPIN 2	2-3 yrs	Visible	2 m	1-3 days	TK-350: 200 km, KVR-1000: 180-200 km	TK-350: 510-760 nm, KVR 1000: 510-760 nm
SPOT 1	2 yrs	Visible, NIR	PAN: 10 m, XS: 20 m	16 days	60 km	PAN: 510-730 nm ; XS: 500-590 nm, 610-680 nm, 790-890 nm
SPOT 2	2 yrs	Visible, NIR	PAN: 10 m, XS: 20 m	16 days	60 km	PAN: 510-730 nm ; XS: 500-590 nm, 610-680 nm, 790-890 nm
SPOT 4	5 yrs	Visible, NIR	HRVIR/MS: 10 m, HRVIR/XS: 20 m, VMI: 1.15-1.7 km	16 days	HRVIR: 60 km, VMI: 2000 km	HRVIR: 510-590 nm, 610-680 nm, 790-890 nm, 1530-1730 nm; VMI: 430-470 nm, 610-680 nm, 780-890 nm, 1580-1750 nm
TiungSat	Unknown	Visible, NIR	MSEIS: 70 m, MEIS: 1.2 km	Unknown	MSEIS: 70 km, MEIS: 1200 km	Unknown

Table 4.2. (Continued)

Name	*Launch Year*	*Operator*	*Manufacturer*	*Country*
Aries 1	2001	Aries Operating Company	Auspace/Astrium	Australia
EagleEye	2001	Rapid Eye	Rapid Eye	Germany
Electro-GOMS	2001	Russian Academy of Sciences Space Research Institute	Russian Academy of Sciences Space Research Institute	Russia
ENVISAT 1	2001	ESA	ESA	Europe
EROS A2	2001	West Indian Space	West Indian Space	Israel
EROS B1	2001	West Indian Space	West Indian Space	Israel
EROS B2	2001	West Indian Space	West Indian Space	Israel
Insat 3D	2002	Indian Space Research Organization (ISRO)	Indian Space Research Organization (ISRO)	India
IRS P5	2001	Indian Space Research Organization (ISRO)	Indian Space Research Organization (ISRO)	India
IRS P6	2001	Indian Space Research Organization (ISRO)	Indian Space Research Organization (ISRO)	India
OrbView 3	2001	ORBIMAGE	Orbital Sciences Corporation	USA
Orbview 4	2001	ORBIMAGE	Orbital Sciences Corporation	USA
Resource21 1-2	2002	Resource21 LLC	Boeing	USA
RapidEye 1-2	2002	RapidEye AG	Surry	Germany
SPOT 5	2001	Spot Image	Astrium	France

Table 4.3.
Overview of future U.S. and world remote-sensing satellites that will be producing commercially available imagery

Name	*Mission Life*	*Sensor Types*	*Spatial Resolution (m)*	*Revisit Time*	*Swath Width (m)*	*Spectral Bands*
Aries 1	5 yrs	Visible	PAN: 10 m, HYP: 30 m	7 days	15 km	400-1100 nm, 2000-2500 nm
EagleEye	3-5 yrs	Visible	5-7 m	1 day	Unknown	Unknown
Electro-GOMS	3 yrs	Visible, IR	Visible: 1.25 km, IR: 6.25 km	GEO	Global, Eastern Hemisphere (Asia)	Visible: 460-700 nm; IR: 6000-7000 nm, 10500-12500 nm,
ENVISAT 1	5 yrs	Visible, IR, UV	ASAR: 30-1000 m, GOMOS: 1.7 km, MERIS: 260-290 m, MIPAS: 2.5 km, MWR: 20 km, RA-2: 1.7 km, AATSR: 1 km, SCIAMACHY: 2.4-3 km	1-3 days	ASAR: 100-405 km, MERIS: 1165 km, AATSR: 500 km, SCIAMACHY: 960 km	ASAR: 5.331 GHz; GOMOS: 250-952 nm; LRR: 532-694 nm; MERIS: 412-900 nm; MIPAS: 4150-14600 nm; MWR: 23.8 GHz,36.5 GHz; RA-2: 3.2 GHz, 13.575 GHz; AATSR: 555 nm, 670 nm, 865 nm, 1600 nm, 3700 nm, 10850 nm, 12000 nm; DORIS: 2.03625 GHz, 401.25 MHz; SCIAMACHY: 240-23800 nm
EROS A2	4 yrs	Visible, IR	1.8 m	1-3 days	12.5 km	500-900 nm
EROS B1	4 yrs	Visible, IR	.82 m	1-3 days	16 km	500-900 nm
EROS B2	4 yrs	Visible, IR	.82 m	1-3 days	16 km	500-900 nm
Insat 3D	7-10 yrs	Visible, IR	10 km (?)	GEO	Global, Eastern Hemisphere (India)	630-690 nm, 770-860 nm, 1550-1700 nm
IRS P5	3 yrs	Visible, IR	2.5 m	1-3 days	30 km	Unknown
IRS P6	3 yrs	Visible, IR	2.5 m	1-3 days	30 km	Unknown
OrbView 3	5 yrs	Visible, IR	PAN: 1 m, MS: 4 m	2-3 days	8 km	PAN: 450-900 nm; MS: 450-520 nm, 520-600 nm, 625-695 nm, 760-900 nm
Orbview 4	5 yrs	Visible, IR	PAN: 1 m, MS: 4 m, HYP: 8 m (U.S. customers), 20 m (all other customers)	2-3 days	PAN: 8 km, MS: 8 km, HYP: 5 km	PAN: 450-900 nm; MS: 450-520 nm, 520-600 nm, 625-695 nm, 760-900 nm; HYP: 450-2500 nm
Resource21 1-2	Unknown	Visible, IR	10 m	Unknown	Unknown	5 bands
RapidEye 1-2	6 yrs	Visible	6.5 m	15 times per day	150-170 km	6 bands
SPOT 5	5 yrs	Visible, IR	HRG: 2.5 m, 5 m, 10 m, 20 m; VEGETATION: 1.5 km	Unknown	HRG: 60 km, VEGETATION: 2250 km	HRG: 500-890 nm, 510-730 nm, 1580-1750 nm; VEGETATION: 430-470 nm, 610-680 nm, 780-890 nm, 1580-1750 nm

Table 4.4.
Technical information on future U.S. and world remote-sensing satellites that will be producing commercially available imagery

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Remote-sensing platform specifications provided by Futron proprietary database.

Section Five

GPS

5.1 Overview of trends, drivers, and events

Developed and operated by the U.S. Department of Defense, the Global Positioning System (GPS) is a constellation of 24 satellites that orbit about 11,000 miles above Earth. These satellites broadcast signals that can be used to determine timing, location, and velocity information used for both military and civilian applications. GPS serves a diversity of markets, including aviation, marine surveying, recreation, timing, and in-vehicle navigation. This section of the report includes data and information about the GPS industry. GPS-enhanced services, such as Differential GPS (DGPS) surveying, are not included.

The GPS industry segment has experienced healthy growth over the last few years and will continue to grow rapidly over the next two years, as "GPS" becomes an increasingly familiar term for the general population. Overall, the GPS market is expanding in terms of dollars spent by customers and revenues earned by manufacturers. Intensifying competition has led to several mergers and acquisitions in recent years as companies attempt to diversify their overall product lines, grow their market share, and increase bottom-line revenues. Manufacturers tend to continue producing their own specialized, niche products. In addition, there are partnerships emerging between GPS manufacturers and other industry manufacturers, telecommunications or automotive firms for example, as GPS products become more integrated into high value-added products ranging from cell phones to car navigation to flight management systems.

The industry remains sharply segmented with product applications extending from recreational to military and prices ranging from approximately two hundred dollars to thousands of dollars. In terms of revenue, over the course of 1999, the aviation market for GPS products grew around 10 percent, the land market grew just over 24 percent, the marine market grew 11 percent, the military and timing markets both grew just under 25 percent.[26] The land market comprised almost 62 percent of the total North American[27] GPS revenues in 1999 and will likely continue to make up the majority of industry revenues as recreational and car navigation systems gain popularity and as GPS timing products make their way into e-commerce and other Internet applications.[28]

On May 2, 2000, the U.S. government turned off selective availability (SA), the intentional degradation of the GPS signal, resulting in a dramatic improvement in GPS positioning accuracy. The new level of accuracy will likely encourage development of new products and will accelerate the transition of GPS products into the mainstream.

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26 Frost & Sullivan, *GPS Report,* May 2000.
27 United States and Canada.
28 Frost & Sullivan, *GPS Report,* May 2000.

When SA was turned on, GPS positioning accuracy was "no worse than" 100 meters horizontally and 150 meters vertically 95 percent of the time. With SA turned off, GPS positioning accuracy has been reported to be better than 10 meters. This difference will enhance the quality and probably increase sales of GPS equipment. Hikers who use hand-held recreational devices will be able to find their way easier when hiking in unfamiliar areas. Boaters will have an improved navigation tool, and fishermen will be better able to locate prime fishing spots. Beginning in 2001, the Federal Communications Commission (FCC) will require wireless carriers to be able to identify the location of cell phone users to within 150 meters 95 percent of the time, possibly by using GPS. This action was taken to improve 911 service by enabling emergency response teams to locate callers more quickly and precisely. Finally, GPS time data will improve to within 40 billionths of a second, improving the efficiency of Internet applications that use timing to reduce the space between data packets and maximize the use of bandwidth.

European states have proposed the development of a European Global Navigation Satellite System (GNSS). This system, named "Galileo," has the potential to compete with the U.S. GPS system or to enhance it. At this time, the European system is still in the early stages of development. While the European Commission (EC) and the European Space Agency (ESA) are enthusiastic about the proposed system, there remain some major issues that must be resolved before construction begins. The GNSS system could cost an estimated $3 billion. The EC governments have set aside half of the necessary funds, but hope to have private funding for the other half. There are other barriers such as assessing security issues, developing the system architecture, and establishing EU/ESA cooperation and responsibilities that could defer production of Galileo for many years. The EU has stated that the GNSS system will begin service in 2008.

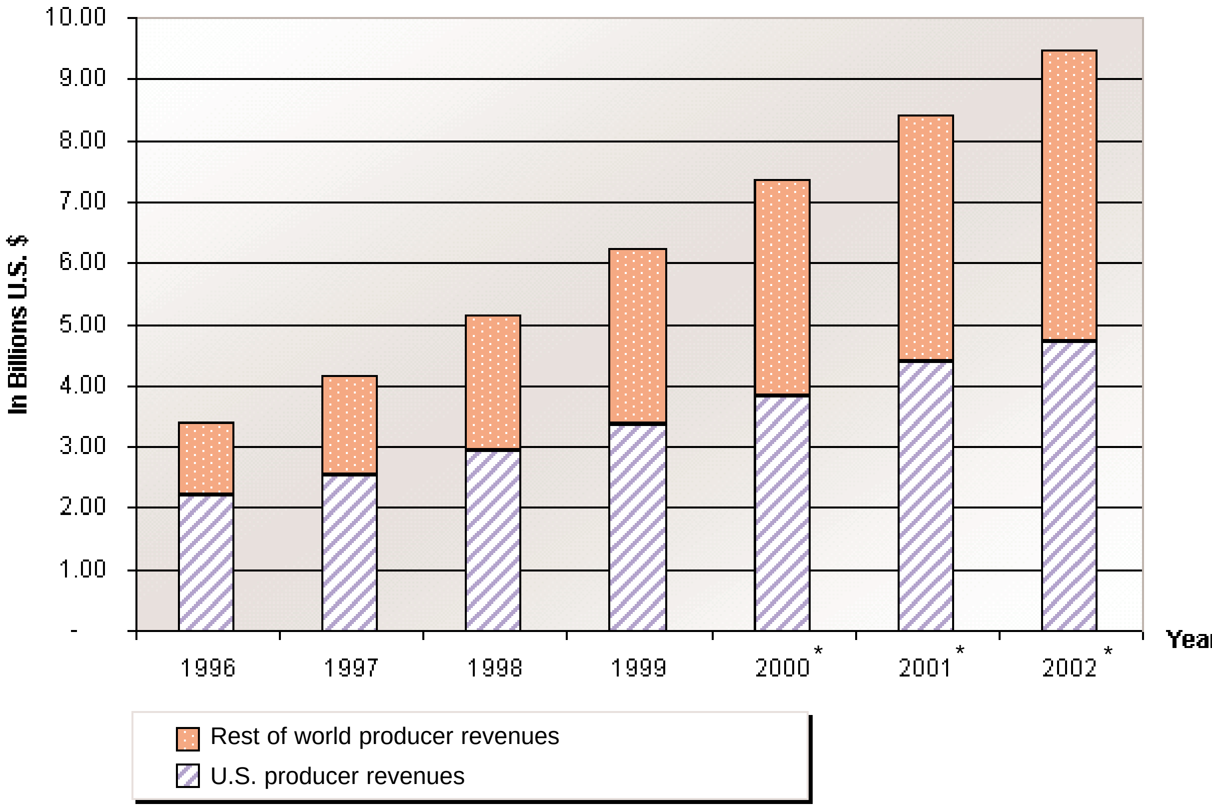
In the meantime, the United States has proposed to spend billions of dollars over the next five years to modernize the existing GPS system. The Department of Defense requested a total of approximately $440 million for fiscal year 2001 to upgrade the GPS system. The Air Force recently awarded Lockheed Martin Space Systems a $53 million contract to begin development of modernization changes for up to 12 GPS Block IIR satellites. These satellites will be modified to incorporate a second civil signal and two new military signals, providing military and civilian users improved navigation accuracy and increased signal power. The Air Force also plans to award two one-year study contracts for the GPS III program.

5.2 U.S. and world commercial GPS user equipment sales

As the world's dominant GPS hardware and software equipment manufacturer, the United States held a 65 percent share of the total GPS market in 1996.[29] Currently, the United States has a

[29] Allied Business Intelligence (ABI), *GPS 2005,* 1999.

52 percent market share and is projected to have a 50 percent share by 2002.[30] Despite the gradual decline of market share, U.S. producers will continue to earn increasing revenues from the sale of GPS equipment. Figure 5.1, below, shows that U.S. producers earned $2.20 billion in 1996 and earned about $3.82 billion in 2000 from the sale of GPS user equipment to customers worldwide. U.S. producers' revenues grow over the study period at an annual growth rate of almost 14 percent.



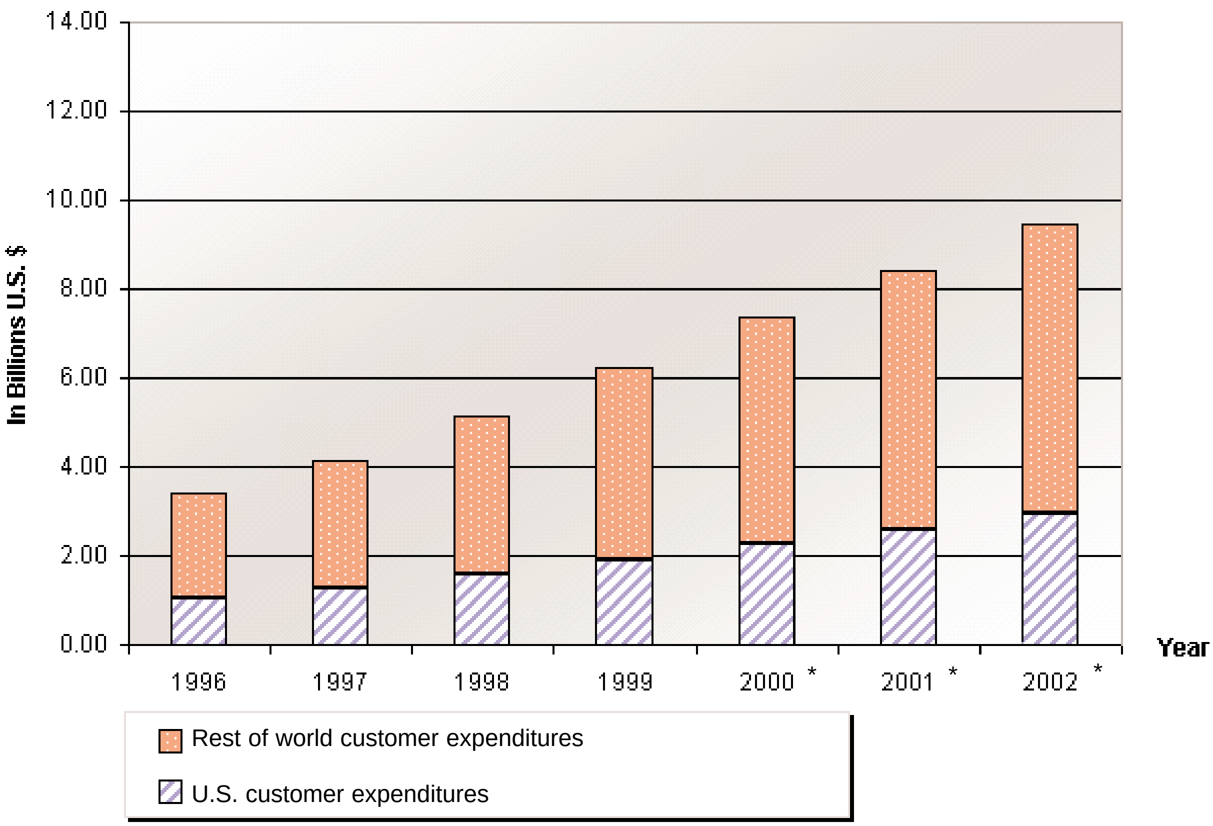
	1996	1997	1998	1999	2000 *	2001 *	2002*
U.S. producer revenues	2.20	2.53	2.93	3.36	3.82	4.38	4.73
Rest of world producer revenues	1.19	1.62	2.21	2.86	3.53	4.04	4.73
Total	*3.39*	*4.15*	*5.14*	*6.22*	*7.34*	*8.42*	*9.47*

* Projections

Figure 5.1.
GPS revenues earned by producers, in billions U.S. $, 1996-2002

30 Ibid.

During the period 1996 to 2002, U.S. customers account for a steady 31 percent of total sales of GPS user equipment, as shown in Figure 5.2.[31] U.S. government and commercial consumers' expenditures grew from approximately $1.05 billion in 1996 to $2.28 billion in 2000 and are projected to reach $2.93 billion in the next two years. While U.S. producers earn a majority of the total world GPS revenues, U.S. consumers comprise only about one third of their customer base. The increase in total GPS user equipment customers' expenditures suggest an annual growth rate of almost 19 percent for both the United States and the rest of the world over the study period.



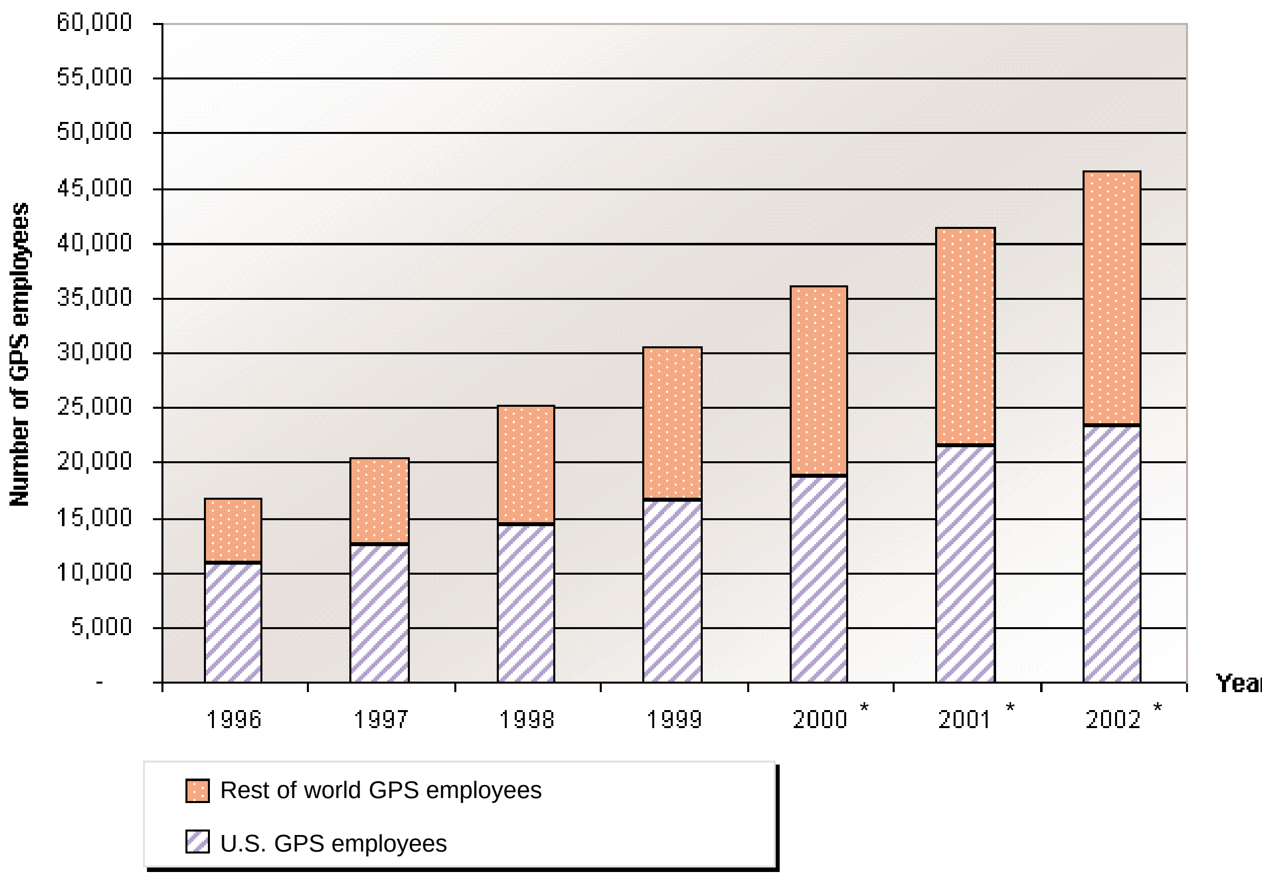
	1996	*1997*	*1998*	*1999*	*2000 **	*2001 **	*2002 **
U.S. customer expenditures	1.05	1.29	1.59	1.93	2.28	2.61	2.93
Rest of world customer expenditures	2.34	2.86	3.55	4.29	5.07	5.81	6.53
Total	*3.39*	*4.15*	*5.14*	*6.22*	*7.34*	*8.42*	*9.47*

* Projections

Figure 5.2.
Annual GPS customer expenditures, in billions U.S. $, 1996-2002

[31] Derived from International Trade Administration, Office of Telecommunications, U.S. Department of Commerce, *Global Positioning System Market Projections and Trends in the Newest Global Information Utility*, September 1998.

Based on the annual reports of several U.S. GPS equipment manufacturers, the average annual revenue per GPS employee was calculated at $203,227. As shown in Figure 5.3, the United States had 10,847 GPS industry employees in 1996 and is projected to have 23,288 GPS employees by 2002. Assuming constant average annual revenue per employee, the total employment in the U.S. GPS market will increase 115 percent over the study period. In 1996, there were an estimated 5,841 GPS employees worldwide, in addition to those in the United States. The number of employees outside the United States is expected to grow to 23,288 by 2002, a rise of 299 percent over the study period.



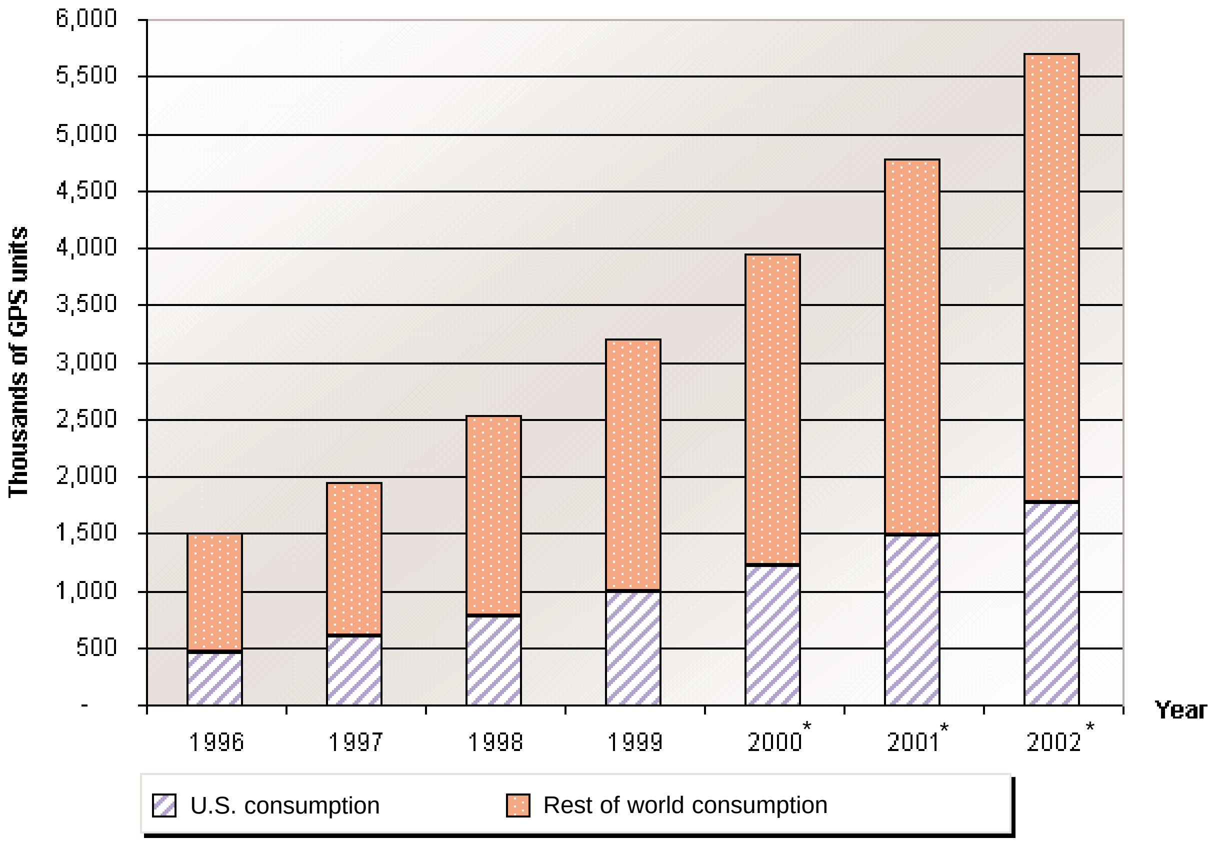
	1996	*1997*	*1998*	*1999*	*2000 **	*2001**	*2002**
U.S. GPS employees	10,847	12,444	14,414	16,536	18,793	21,532	23,288
Rest of world GPS employees	5,841	7,956	10,873	14,086	17,347	19,875	23,288
Total	*16,688*	*20,399*	*25,287*	*30,622*	*36,140*	*41,407*	*46,577*

* Projections

Figure 5.3.
GPS industry employees, 1996-2002

5.3 U.S. and world commercial GPS units sold

U.S. customers consumed about 464,000 of the 1,498,000 units in 1996.[32] In 2000, approximately 3.95 million GPS units were consumed worldwide and the U.S. consumed 1.22 million of those units. Figure 5.4 below shows that U.S. customers will buy up to 1.77 million GPS units in 2002 and 5.69 million units will be consumed worldwide in that year. There will be a 280 percent increase from 1996 to 2002 in the total number of GPS units bought, or an annual growth rate of 25 percent.



	1996	*1997*	*1998*	*1999*	*2000**	*2001 **	*2002**
U.S. consumption	464	605	783	991	1,225	1,481	1,765
Rest of world consumption	1,033	1,346	1,743	2,207	2,726	3,296	3,928
Total	*1,498*	*1,950*	*2,526*	*3,198*	*3,951*	*4,778*	*5,692*

* Projections

Figure 5.4.
Commercial GPS units sold, in thousands, 1996-2002

[32] Derived from Frost & Sullivan, *GPS Report,* May 2000.

Figure 5.5 shows the general distribution of the GPS units sold for the year 2000. The car navigation and consumer market segments made up the majority of sales in this year and will continue to dominate industry growth over the next few years.

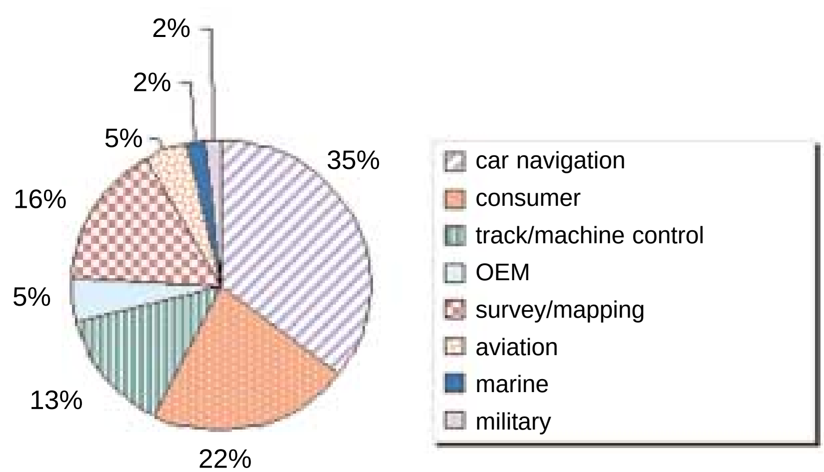


Figure 5.5.
Distribution of GPS units sold by market component, year 2000[33]

A summary of the overall world GPS market trends for 1996 to 2002 is shown in Figure 5.6. Using 1996 data as the base year, the figures show that while GPS revenues are increasing, prices are falling. Total revenues will continue to grow, although revenues per unit received by producers worldwide are decreasing. Total revenues for world GPS producers are growing faster than revenues for U.S. GPS producers. U.S. GPS manufacturers historically have enjoyed profit margins in the 30 to 40 percent range, but in the next few years, falling prices will lead to profits dropping by 10 to 15 percent.[34] However, due to growing sales, particularly in consumer application products such as car navigation and recreational hand-helds,

[33] International Trade Administration, Office of Telecommunications, U.S. Department of Commerce, *Global Positioning System Market Projections and Trends in the Newest Global Information Utility,* September 1998.

[34] Frost & Sullivan, *GPS Report,* May 2000.

GPS manufacturers will continue to see a growing GPS market, remaining profitable in the next few years. In the future, manufacturers may have the market power to maintain prices as the degree of accuracy and capabilities of GPS products improves.

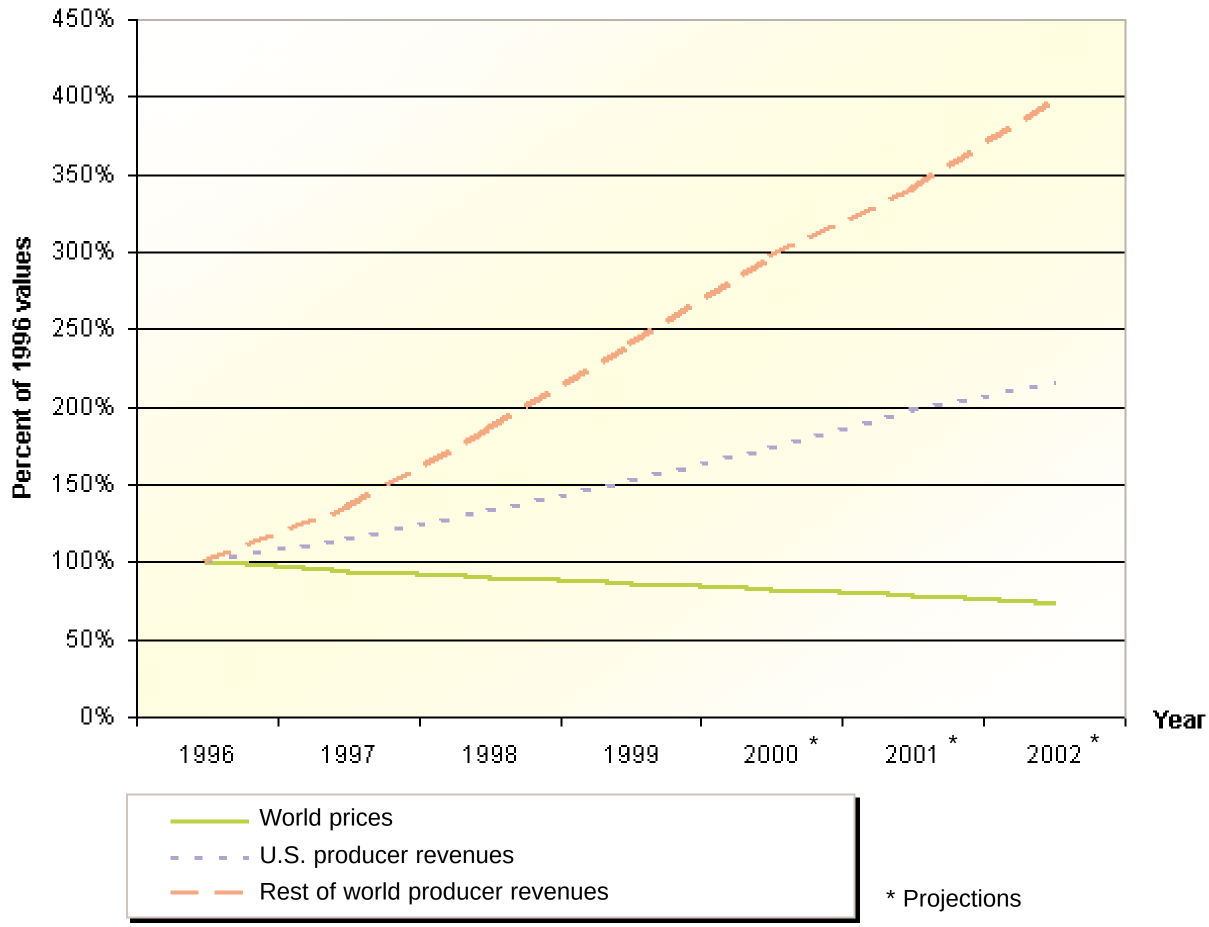


Figure 5.6.
GPS market trends, 1996-2002

5.4 Sample U.S. and world producers of GPS equipment

The following table lists the major U.S. and world manufacturers of GPS equipment, the country where their headquarters or primary office is located, and the major GPS market sectors served by the companies. Of the companies listed, Trimble Navigation is the most diverse GPS firm, specializing primarily in the navigation, surveying, and military market segments; Garmin, Magellan, and Lowrance are the leaders in the hand-held segment; Absolute Time, Truetime, and Zyfer are the main timing products manufacturers; SiRF is the leading producer of GPS chips; and Rockwell Collins is the frontrunner for the aviation market.

Company Name	*Country*	*Primary GPS Market Segment(s)*
Absolute Time Corp.	USA	Timing
Allen Osborne Associates, Inc.	USA	Survey, hand-held, timing, military
BAE Systems Canada Inc.	Canada	Navigation, aviation, marine, timing, OEM
Datum	USA	Timing
IBM Corp.	USA	Navigation
Furuno USA, Inc.	Japan	Marine, timing, OEM
Garmin International	USA	Hand-held
Japan Radio Co. Ltd.	Japan	Navigation, hand-held, marine, OEM, timing
Javad Positioning Systems	USA	Navigation, marine, military, OEM, survey, timing
Leica Geosystems AG	Switzerland	Survey
Lowrance Electronics	USA	Hand-held, navigation
Magellan Corp./Ashtech Precision Products	USA	Hand-held, navigation, aviation, marine, military, OEM, survey, timing
Motorola Space Systems and Services Division	USA	Navigation, military, timing
NAVSYS Corp.	USA	Navigation, survey, military, OEM, timing
NovAtel Inc.	Canada	Survey, marine, military, OEM, timing
Orbital Sciences Corp.	USA	Navigation
Rockwell Collins Government Systems	USA	Navigation, aviation, hand-held, military, OEM
SiRF	USA	GPS chips/receiver components, OEM
Sokkia Corp.	Japan	Survey, marine
Spectra Precision	Sweden	Survey, construction, agriculture
Topcon America	USA	Survey
Trimble Navigation Limited	USA	Navigation, aviation, survey, hand-held, marine, military, OEM, timing
TrueTime	USA	Timing
Zyfer, Inc.	USA	Timing

Table 5.1.
Sample U.S. and world GPS equipment producers, year 2000

5.5 Sample related GPS companies

The following table shows examples of firms that use GPS equipment in the production of their final goods, manufacture products necessary for the operation of the GPS system, or manufacture "complementary" GPS products, such as relevant software.

Company	*Country*	*Primary GPS-related products*
Andrew Corp.	USA	GPS antennas for base station, Earth station and automotive tracking
Autometric, Inc.	USA	Digital photogrammetric software, GPS satcom software
Ball Aerospace & Technologies Corp.	USA	Ceramic GPS antennas, SATCOM Antennas, new GPS Translator - artillery spotter round antenna
Boeing	USA	Navstar GPS satellites and advanced proprietary GPS systems (e.g., Space Shuttle GPS receiver)
Eastman Kodak Co.	USA	Digital cameras with new GPS printout on pictures
Etak, Inc.	USA	GPS trucking software (e.g., traffic locator "Etak Map")
Fugro	Netherlands	Differential GPS systems (Omnistar, Seastar, Starfix)
Honeywell Commercial Aviation Systems	USA	Avionic navigational GPS systems/units (GNSSU, RAIM)
Larson Systems	USA	GPS vehicle tracking and navigational software
Lockheed Martin Mission Systems	USA	GPS IIR satellites (21 in all) design, production and support
Nathan Telecom Ltd.	USA	Digital GSP systems for mobile radio and data communications
Navigation Technologies	USA	GPS mapping databases, in-vehicle navigation systems
Qualcomm, Inc.	USA	GPS wireless receivers, GPS cellular phones
Raytheon Marine Company	USA	GPS-guided military weaponry, "MAGR" - receiver used in most military airborne platforms
Science Applications International Corp. (SAIC)	USA	Software solutions using GPS (e.g. "Fleet Optimizer"), GPS products and services (e.g., "Vigilante" uncrewed transport aircraft using GPS for navigation)
Spectrum Astro	USA	Next generation GPS receivers (e.g., "AstroNav")

Table 5.2.
Sample related GPS companies, year 2000

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Office of Space Commercialization
Technology Administration
U.S. Department of Commerce
14th Street & Constitution Avenue, NW
Washington, D.C. 20230
www.ta.doc.gov/space

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