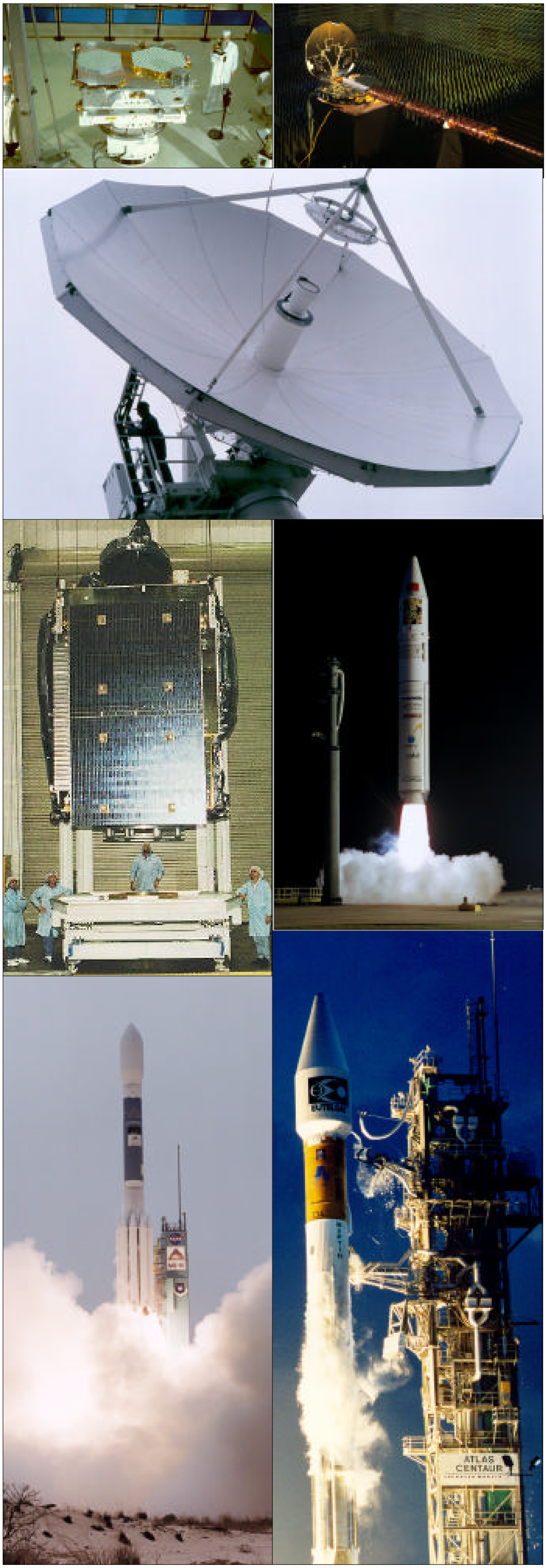

1999 Commercial Space Transportation Forecasts

Federal Aviation Administration's Associate Administrator for Commercial Space Transportation (AST)

and the

Commercial Space Transportation Advisory Committee (COMSTAC)

May 1999

ABOUT

THE ASSOCIATE ADMINISTRATOR FOR COMMERCIAL SPACE TRANSPORTATION (AST)

AND THE

COMMERCIAL SPACE TRANSPORTATION ADVISORY COMMITTEE (COMSTAC)

The Federal Aviation Administration's Associate Administrator for Commercial Space Transportation (AST) licenses and regulates U.S. commercial space launch activity as authorized by Executive Order 12465, *Commercial Expendable Launch Vehicle Activities*, and the *Commercial Space Launch Act of 1984*, as amended. AST's mission is to license and regulate commercial launch operations to ensure public health and safety and the safety of property, and to protect national security and foreign policy interests of the United States during commercial launch operations. The *Commercial Space Launch Act of 1984* and the *1996 National Space Policy* also direct the Federal Aviation Administration to encourage, facilitate, and promote commercial launches.

The Commercial Space Transportation Advisory Committee (COMSTAC) provides information, advice, and recommendations to the Administrator of the Federal Aviation Administration within the Department of Transportation (DOT) on matters relating to the U.S. commercial space transportation industry. Established in 1985, COMSTAC is made up of senior executives from the U.S. commercial space transportation and satellite industries, space-related state government officials, and other space professionals.

The primary goals of COMSTAC are to:

- Evaluate economic, technological and institutional issues relating to the U.S. commercial space transportation industry
- Provide a forum for the discussion of issues involving the relationship between industry and government requirements
- Make recommendations to the Administrator on issues and approaches for Federal policies and programs regarding the industry.

Additional information concerning AST and COMSTAC can be found on AST's web site, at http://ast.faa.gov.

Cover Photo Credits (from top left):

Alenia Aerospazio Space Division (1998). Panoramic view of alignment tests for Globalstar satellite.

Orbital Sciences Corporation (1999). Orbcomm LEO communications satellite undergoing testing.

ICO Global Communications Services, Inc. (1999). A 7.6 meter-diameter antenna installed at ICO's satellite access node site in Brewster, Washington.

Florida Today Space Online (1998). Intelsat 806 spacecraft during testing. Intelsat 806, based on a Lockheed Martin Satcom 7000 satellite bus, was launched successfully from Cape Canaveral Air Station, Florida, on an Atlas 2AS on February 27, 1998.

Lockheed Martin Corporation (1999). Athena I launch on January 26, 1999, of the Republic of China's first satellite, ROCSAT-1, from Spaceport Florida Authority's Launch Complex-46 at Cape Canaveral Air Station, Florida.

The Boeing Company (1998). Delta 7920 launch on September 8, 1998, of Iridium mission MS-10 carrying five Iridium satellites from Vandenberg Air Force Base, California.

International Launch Services (1998). Atlas 2AS launch on October 9, 1998, of the Hot Bird 5 communications satellite into geosynchronous transfer orbit from Cape Canaveral Air Station, Florida.

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EXECUTIVE SUMMARY

The Federal Aviation Administration's Associate Administrator for Commercial Space Transportation (FAA/AST) and the Commercial Space Transportation Advisory Committee (COMSTAC) have prepared projections of global demand for commercial space launch services for the period 1999 to 2010. The jointly published *1999 Commercial Space Transportation Forecasts* combines:

- The ***COMSTAC 1999 Commercial GSO Spacecraft Mission Model***, which projects demand for commercial satellites that operate in geosynchronous orbit (GSO) and the resulting launch demand to geosynchronous transfer orbit (GTO); and

- The FAA's ***1999 LEO Commercial Market Projections***, which projects commercial launch demand for all space systems in non-geosynchronous orbits (NGSO), such as low Earth orbit (LEO), medium Earth orbit (MEO), and elliptical orbits (ELI).

Together, the COMSTAC and FAA forecasts project that an average of 51 commercial space launches worldwide will occur annually through 2010. This is an increase of over 40 percent from the 36 commercial launches conducted worldwide in 1998.

Specifically, the forecasts project that on average the following type and number of launches will be conducted each year:

- 25 launches of medium-to-heavy launch vehicles to GSO;

- 15 launches of medium-to-heavy launch vehicles to LEO, or NGSO orbits; and

- 11 launches of small launch vehicles to LEO.

The demand for commercial launches is expected to fluctuate on a year-to-year basis, peaking at 56 in 2003 and again in 2006 with 58 launches.

INTRODUCTION

The Federal Aviation Administration's Associate Administrator for Commercial Space Transportation (FAA/AST) and the Commercial Space Transportation Advisory Committee (COMSTAC) have prepared projections of global demand for commercial space launch services for the period 1999 to 2010. These projections—which have historically been published separately—are jointly published in *1999 Commercial Space Transportation Forecasts*. This document includes:

- The ***COMSTAC 1999 Commercial GSO Spacecraft Mission Model***, which projects demand for commercial satellites that operate in geosynchronous orbit (GSO) and the resulting launch demand to geosynchronous transfer orbit (GTO); and

- The FAA's ***1999 LEO Commercial Market Projections***, which projects commercial launch demand for all space systems in non-geosynchronous orbits (NGSO), such as low Earth orbit (LEO), medium Earth orbit (MEO), and elliptical orbits (ELI).

Growth of Commercial Space Transportation

Commercial launch activity has steadily increased since the early 1980s, and now represents over 40 percent of worldwide launches conducted annually, ending the domination of space by government activities. Until the last couple of years, commercial spacecraft were almost exclusively telecommunications satellites located in geosynchronous orbit. In 1997, however, full-scale deployment began of the first of several communications constellations consisting of multiple spacecraft in low Earth orbit. While there were 19 launches to GSO in 1998, there were an additional 17 launches to LEO to deploy global satellite communications systems, remote sensing spacecraft, and a space burial capsule.

About the COMSTAC Commercial GSO Spacecraft Mission Model

At the request of the Federal Aviation Administration, COMSTAC compiles the *Commercial GSO Spacecraft Mission Model*, forecasting worldwide demand for commercial launches of spacecraft which operate in geosynchronous orbit. First compiled in 1993, the model is updated annually and is prepared using plans and projections supplied by U.S. and international commercial satellite and launch companies. Projected payload and launch demand is limited to those spacecraft and launches that are open to internationally competed launch services procurements. Since 1998, the model has also included a projection of launch vehicle demand, which is derived from the payload demand due to dual manifesting of satellites on some launch vehicles.

About the FAA LEO Commercial Market Projections

Since 1994, the FAA has compiled an assessment of demand for commercial launch services to non-geosynchronous orbits, i.e. those not covered by the COMSTAC GSO forecast. The LEO forecast is based on an assessment of multi-satellite communications systems being developed to service the low data rate communications, telephony, and broadband data markets, as well as remote sensing and other spacecraft using commercial launch services.

The *LEO Commercial Market Projections* develops two scenarios for deployment of LEO satellite systems—a "baseline" scenario, considered the most likely to occur, and a "robust market" scenario, considered likely to occur if demand for LEO satellite services is sufficiently greater. For each of these two scenarios, the number and type of satellites to be deployed are converted to a launch demand forecast.

COMBINED PAYLOAD AND LAUNCH PROJECTIONS

Taken together, the *1999 Commercial GSO Spacecraft Mission Model* and the *1999 LEO Commercial Market Projections* present an overall picture of expected demand for commercial launch services for the 12-year period 1999 to 2010. On average, 51 commercial space launches a year are projected to occur worldwide through 2010. This is an increase of over 40 percent from the 36 commercial launches conducted in 1998.

Combined GSO and LEO Payload Projections

The combined GSO and LEO forecasts project that 1,369 payloads will be deployed between 1999 and 2010, as shown in Figures 1 and 2. The projected payload demand is dominated by the high number of LEO payloads expected to be launched for low Earth orbiting communications constellations which fluctuates considerably year to year. Deployment of LEO satellites reaches a low of 64 payloads in 2001 and a high of 192 payloads only two years later in 2003. By contrast, the number of GSO spacecraft projected to be launched does not fluctuate as much, with a high of 39 in 2001 and a low of 29 in 2003 and 2004.

Projected payload demand is based on the COMSTAC GSO mission model and the baseline scenario of the FAA LEO forecast. Additional detail on the breakout of payload projections for the various types of LEO systems are contained in the *1999 LEO Commercial Market Projections*.

Combined GSO and LEO Launch Projections

After taking into account the dual manifesting of GSO payloads and the multiple manifesting of LEO payloads, the forecasts project that 610 launches will be conducted through 2010, as shown in Figures 1 and 3. The projected launch demand is an average of 51 launches per year, consisting of:

- 25 launches of medium-to-heavy launch vehicles to GSO;
- 15 launches of medium-to-heavy launch vehicles to LEO, or NGSO orbits; and
- 11 launches of small launch vehicles to LEO.

The demand for commercial launches is expected to fluctuate annually, peaking at 56 in 2003 and again in 2006 with 58 launches. Launch demand is based on the COMSTAC GSO launch vehicle demand and the baseline scenario of the FAA LEO forecast.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	TOTAL	Avg
Payloads														
GSO Forecast (COMSTAC)	33	31	39	31	29	29	31	32	32	35	35	37	394	33
LEO Forecast (FAA)	77	40	25	71	163	120	123	121	83	65	43	44	975	81
Total Payloads	**110**	**71**	**64**	**102**	**192**	**149**	**154**	**153**	**115**	**100**	**78**	**81**	**1,369**	**114**
Launch Demand														
GSO Medium-to-Heavy	28	26	33	24	21	20	21	22	22	25	25	27	294	25
LEO Medium-to-Heavy	17	13	3	7	23	25	23	25	15	11	12	11	185	15
LEO Small	10	8	9	13	12	7	13	11	14	13	10	11	131	11
Total Launches	**55**	**47**	**45**	**44**	**56**	**52**	**57**	**58**	**51**	**49**	**47**	**49**	**610**	**51**

Figure 1 1999 Commercial Space Transportation Combined Payload and Launch Projections

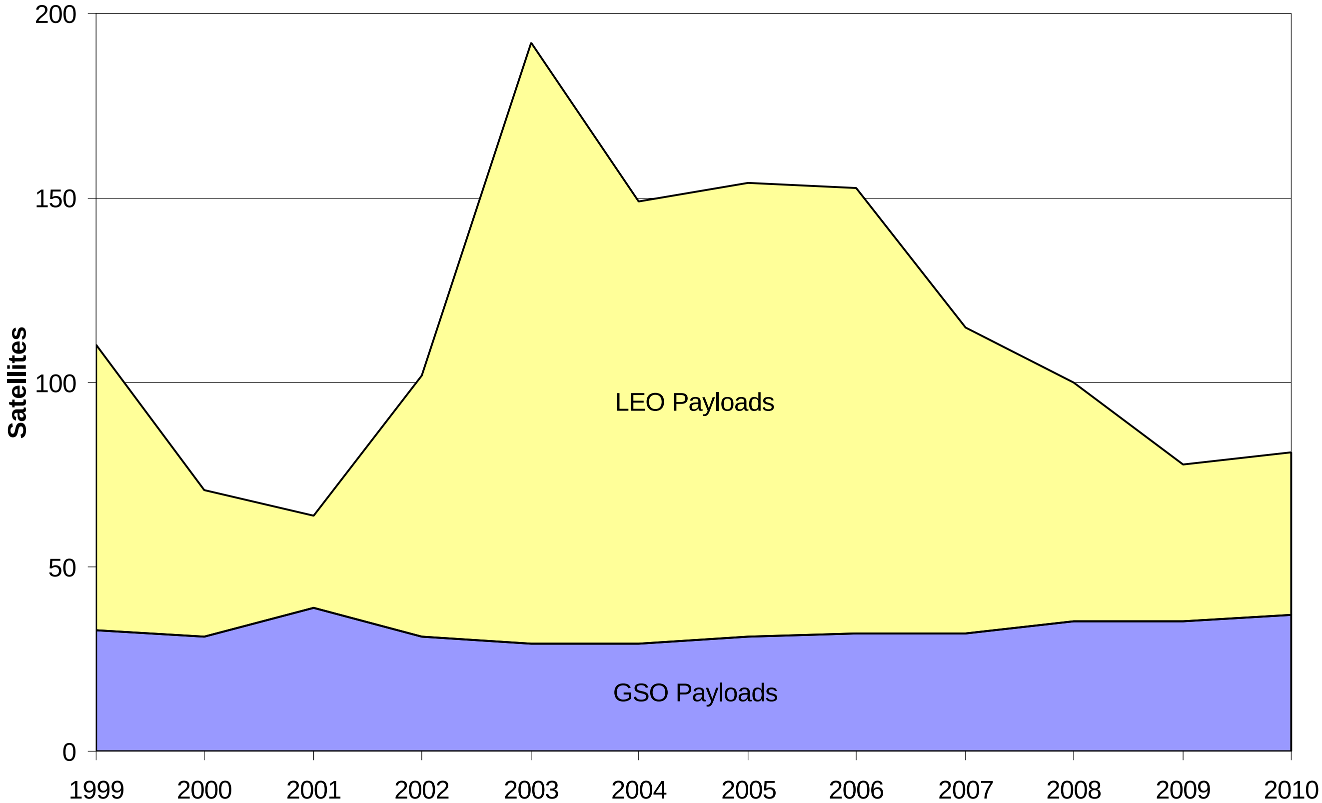

Figure 2 Combined GSO and LEO Payload Projections

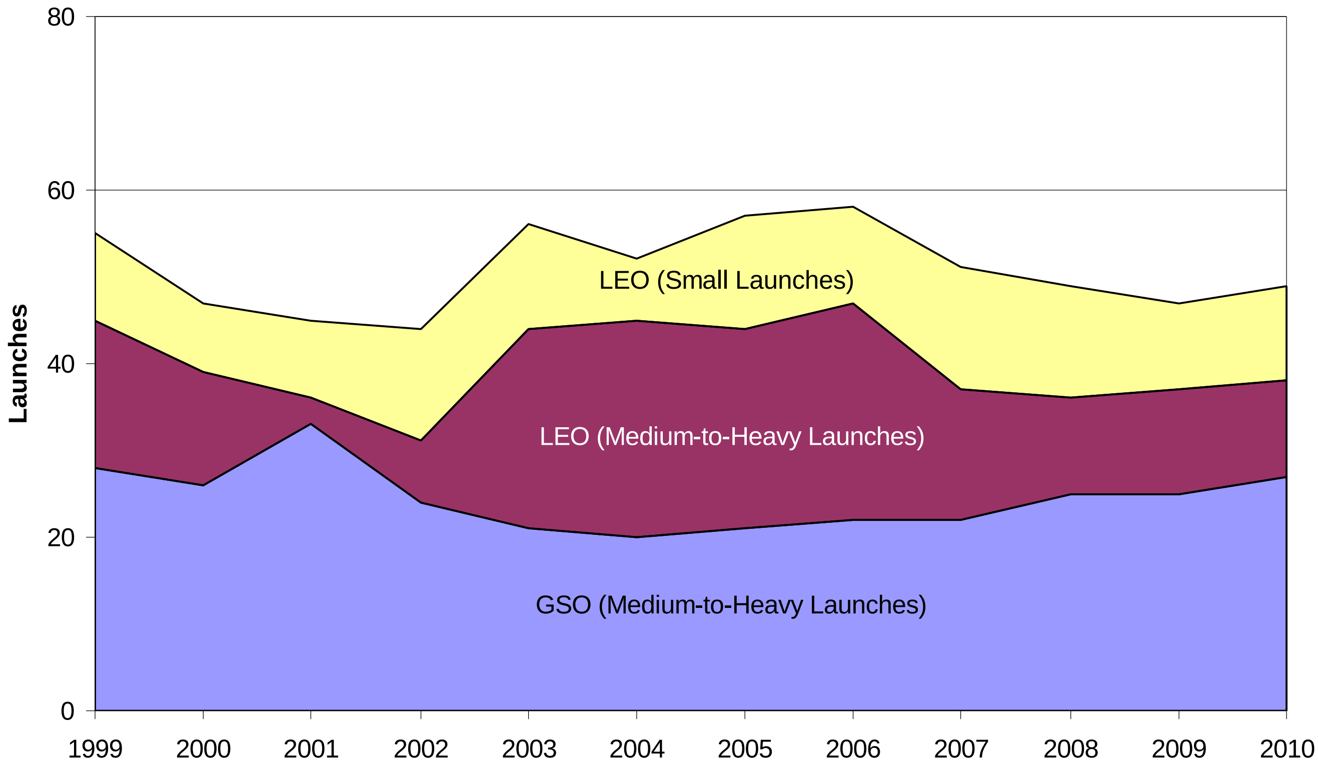

Figure 3 Combined GSO and LEO Launch Demand Projections

COMSTAC 1999 COMMERCIAL GSO SPACECRAFT MISSION MODEL

May 1999

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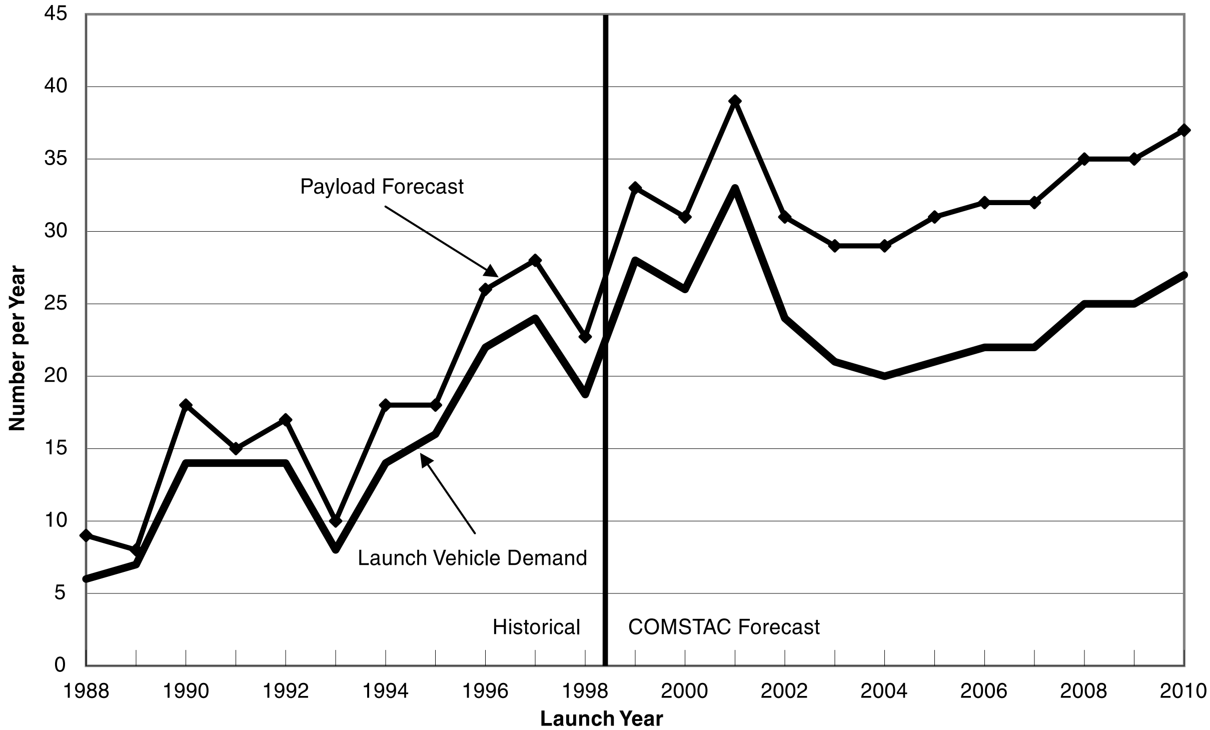
Executive Summary

The following report was compiled by the Commercial Space Transportation Advisory Committee (COMSTAC) for the Office of the Associate Administrator for Commercial Space Transportation (AST) of the Federal Aviation Administration (FAA). This mission model is a forecast of the worldwide demand for commercial geosynchronous orbit (GSO) launches as seen by the U.S. commercial space industry. It is intended to assist the AST in its efforts to foster a healthy commercial space launch capability in the United States.

The commercial mission model is updated annually, and is prepared from the inputs of commercial companies across the satellite and launch industries. The launch demand is derived by forecasting the number of "addressable" payloads to be launched to GSO each year (i.e., GSO payloads open to internationally competed launch service procurements). Government and captive payloads are not included. This number is then decremented by the number of payloads forecasted to be launched in a dual launch configuration.

The following data is the result of the COMSTAC 1999 Commercial Mission Model update. It shows the forecast of the demand for commercial GSO payloads and the resulting launch demand. The assumptions and methodology used for this forecast are explained in the body of this report.

This year's mission model predicts an average demand of 32.8 payloads per year over the period from 1999 through 2010, very close to the 1998 COMSTAC forecast of 33 payloads per year. The near-term forecast, which is based on actual payloads for 1999 through 2001, shows 33 payloads in 1999, dropping to 31 in 2000, and increasing again to 39 in 2001.



COMSTAC Launch Demand Forecast

Launch Forecast Data

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Avg 1999 to 2010
Payload Forecast	**33**	**31**	**39**	**31**	**29**	**29**	**31**	**32**	**32**	**35**	**35**	**37**		
Dual Launch Forecast	5	5	6	7	8	9	10	10	10	10	10	10		
Launch Vehicle Demand	**28**	**26**	**33**	**24**	**21**	**20**	**21**	**22**	**22**	**25**	**25**	**27**	**294**	**25**

Introduction

The Federal Aviation Administration's (FAA) Office of the Associate Administrator for Commercial Space Transportation (AST) of the U.S. Department of Transportation (DOT) endeavors to foster a healthy commercial space launch capability in the United States. The DOT feels that it is important to obtain the commercial space industry's view of future space launch requirements and has therefore requested that its industry advisory group, the Commercial Space Transportation Advisory Committee (COMSTAC), prepare a commercial spacecraft launch demand mission model and update it annually.

This report presents the 1999 update of the worldwide commercial geosynchronous orbit (GSO) satellite mission model for the period 1999 through 2010. It is based on market forecasts obtained in early 1999 from major spacecraft manufacturers, satellite operators and launch service providers. The mission model is limited to "addressable" payloads only (i.e., payloads open to internationally competed launch service procurements). Payloads captive to any launch system and government payloads are excluded from the mission model. Note that the number of projected *vehicle* launches per year is a subset of this *payload* launch demand forecast due to the potential for multiple manifesting of satellites on launch vehicles. Also, low-earth orbit (LEO) and medium-earth orbit (MEO) payloads are not included in this mission model. The FAA/AST LEO market forecast is developed separately and is included as a separate report in this package.

Background

COMSTAC prepared the first commercial mission model in April 1993 as part of a report on commercial space launch systems requirements. Each year since 1993, COMSTAC has issued an updated model. The process has been continuously refined and industry participation has broadened each year to provide the most realistic portrayal of space launch demand possible. Over the years, the COMSTAC mission model has been well received by industry, government agencies and international organizations.

The first report in 1993 was developed by the major launch service providers in the US and covered the period 1992-2010. In the next few years, the major US spacecraft manufacturers and the satellite operators began to contribute to the market demand database. In 1995, the Technology and Innovation Working Group was formally chartered to prepare the annual Commercial Spacecraft Mission Model Update. Since then, the participation in the preparation of this report has continued to grow. This year the committee received more than 20 inputs from both U.S. and foreign satellite manufacturers, operators and launch vehicle providers. COMSTAC would like to thank all the participants in the 1999 mission model update.

Methodology

The Technology and Innovation Working Group solicited input from industry via a letter from the Associate Administrator for Commercial Space Transportation (Appendix C). The letter requested that each company provide a forecast of the number of addressable commercial GSO payloads per year for the period 1999 - 2010. Respondents were asked to segregate their forecast into payload categories based on separated mass inserted into a nominal geosynchronous transfer orbit (GTO), assuming launch at 28° north latitude. The categories are representative of a clustering of similar capability launch vehicles with examples as follows:

GTO Launch Capability (200 nm x GEO orbit @ i=28°)	**Representative Launch Vehicle**
Below 4,000 lbs (<1,815 kgs)	Dual Ariane 4/5, Delta II, Dual H-IIA, Long March 3 or 3A
4,000 - 9,000 lbs (1,815- 4,083 kgs)	Dual Ariane 4/5, Atlas IIA/IIAS, Atlas IIIA, Atlas V, Delta III, Delta IV, HII-A, Long March 2E/3C, Proton D1e, Sea Launch
9,000-12,000 lbs (4,083 – 5,445 kgs)	Ariane 4/5, Atlas IIIA/B, Atlas V, Delta IV, HII-A, Long March 3B, Proton M, Sea Launch
Above 12,000 lbs (>5,445 kgs)	Ariane 5, Atlas V, Delta IV, H-IIA

The 1999 mission model includes a new mass category to reflect the trend in satellite mass growth. This new category is defined as 9,000 to 12,000 pounds with the heaviest mass range set at 12,000 pounds or greater. The largest mass category in the 1998 mission model was 9,000 pounds and greater. The reasons behind this change are discussed later in this report.

The following organizations responded with data used in the development of this report:

- American Mobile Satellite Corp.
- Arianespace, Inc.
- Asia Satellite Telecommunications, Ltd.
- The Boeing Company*
- Broadcasting Satellite System Corp (B-SAT)
- CD Radio
- COMSAT
- DirecTV
- GE American Communications, Inc.
- Hispasat
- Hughes Space & Communications*
- ICO Global Communications
- INMARSAT
- International Launch Services/ Lockheed Martin*
- Optus Communications
- Orbcomm
- PanAmSat
- Rocket System Corporation
- Space Systems/Loral*
- Thuraya Telecommunications
- TRW

Comprehensive mission model forecasts (of the total addressable market of payloads seeking GTO launch services) that were used in this forecast were received from those organizations marked by an asterisk (*). Other responses provided partial market or company specific payload launch demand information. Market demand data was received from foreign as well as domestic organizations.

The Working Group used the data from the all of the domestic comprehensive inputs to derive the average launch rate for years 2002 through 2010. The inputs for each mass category in a given year were averaged over the four comprehensive inputs. The total forecast for that year is then calculated by adding the averages for the four mass categories. The highest and lowest inputs (shown in Figure 1 and Table 1) represent the single highest or lowest estimated number of payloads to be launched in that year from the submitted forecasts. No single comprehensive forecast was consistently higher or lower than the average throughout the forecast period. Therefore, the maximum inputs and minimum inputs are not additive.

The near-term COMSTAC mission model for 1999-2001 (shown in Table 2) is a compilation of the currently manifested launches and an assessment of the payloads soon to be assigned to launch vehicles. This forecast reflects a consensus developed by the Working Group based on the current manifests of the launch vehicle providers and the satellite operators. Since these missions are identified by name, the near-term forecast does not account for unanticipated launch failures from previous years, nor delays in the launch vehicle or satellite supply chain. Minor delays at the end of a year due to launch vehicle problems or satellite manufacturing issues can cause launches to slip into the following year. This pattern of firm schedule commitments, followed by modest delays has appeared consistently in previous editions of our mission model forecasts.

Some of the factors that were considered in creating this forecast include:

- Firm contracted missions
- Current satellite operator planned and replenishment missions
- Projected operator growth
- An estimate of “unidentified growth.”
- Attrition
- Competition from Non-GSO systems
- Regulatory restrictions

"Unidentified growth” is used to include information that may be proprietary or competition sensitive such as company-specific plans on future systems and trends, and assumptions on possible new markets. For the near term projections, an attrition rate factor of 10% of annual launch demand was also assumed. This factor includes on-orbit satellite and launch vehicle failures. Other factors may have influenced each individual company’s specific inputs.

Forecast Uncertainties – There is a certain amount of difficulty and uncertainty involved in forecasting the commercial launch market beyond a five-year horizon. Beyond five years there is a problem with visibility into new commercial programs and new markets that may emerge. As we have seen in the past, entirely new systems can spring up in less than three years, from both new and existing companies. The long-term growth shown in this forecast, therefore, is based on both the replenishment of existing satellites and assessments of potential new markets and satellite concepts.

1999 Mission Model

The 1999 COMSTAC mission model consists of three elements. The first element is a forecast of demand for competed launches of commercial payloads to geosynchronous orbit (GSO) from 1999 to 2010. The second element is an estimate of the mass distribution of these payloads. The third element is a launch vehicle demand projection derived from the payload launch demand forecast.

Payload Launch Demand Model

Figure 1 shows the COMSTAC Technology and Innovation Working Group's forecast for commercial payload launch demand to GSO. The figure plots the actual number of payloads launched from 1988 through 1998. It then displays the COMSTAC Forecast for the years 1999 through 2010 (Table 1). The range of individual estimates are plotted as high-low marks above

Table 1. COMSTAC Commercial Payload Forecast

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Avg 1999 to 2010
Highest Inputs	33	31	39	37	34	37	38	39	40	41	43	45		
COMSTAC Forecast	**33**	**31**	**39**	**31**	**29**	**29**	**31**	**32**	**32**	**35**	**35**	**37**	**394**	**32.8**
Lowest Inputs	33	31	39	26	24	24	26	25	26	26	24	26		

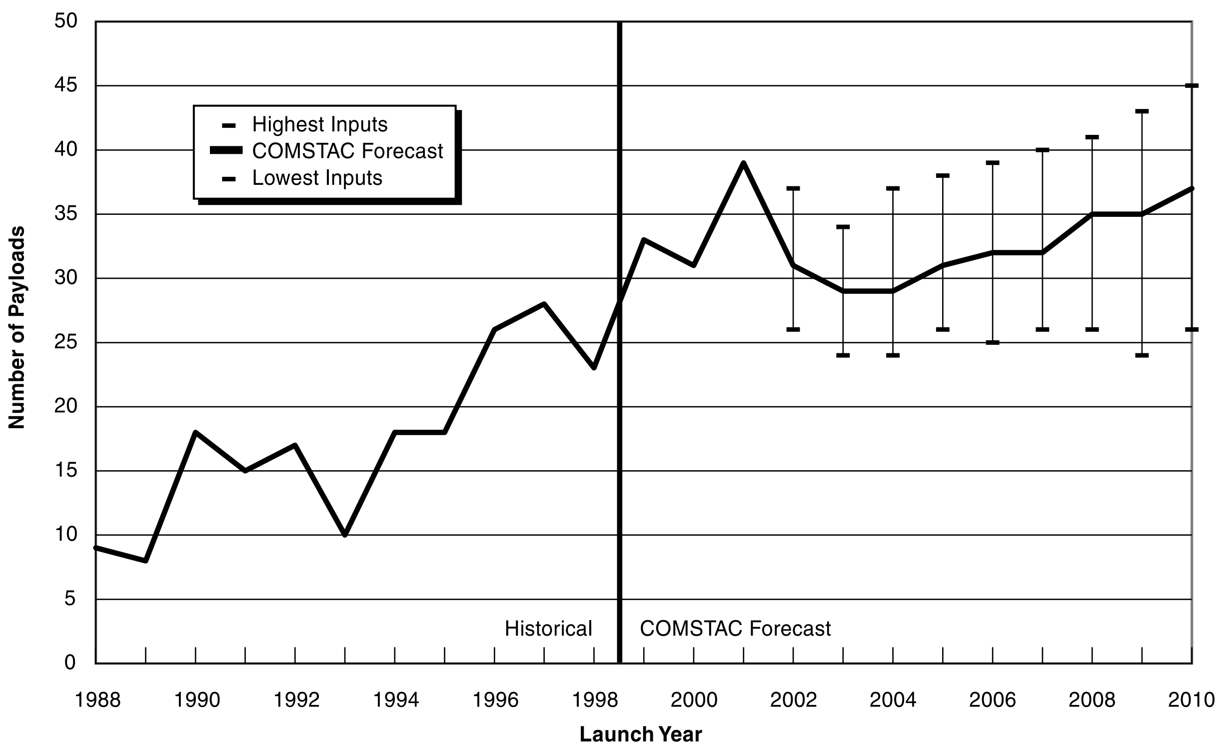


Figure 1. COMSTAC 1999 Commercial GSO Mission Model

and below the average. This information is presented to give a sense of the variations in the forecasts for any given year. Each high-low line represents the highest and lowest individual estimate provided in any one year.

This year's mission model predicts an average demand of 32.8 payloads per year over the period from 1999 through 2010, very close to the 1998 COMSTAC forecast of 33 payloads per year. In the near-term, the consensus forecast for 1999 through 2001 shows 33 payloads in 1999, dropping to 31 in 2000, and increasing again to 39 in 2001. The near-term 1999 to 2001 mission model is presented in Table 2. The remainder of the forecast stays fairly constant with an upward trend toward the end of the forecast period.

Comparison with 1998 Report

Figure 2 compares this year's forecast with last year's forecast. The average payload demand over the forecast period for both mission models is very similar. Both the 1999 and 1998 mission models forecast that approximately 33 payloads per year will be launched into geosynchronous orbit between 1999 and 2010.

In the near term however, there is a significant difference in the two models. Specifically, in 1998, only 23 addressable payloads were launched versus the COMSTAC forecast for the year of 33 payloads. When the 1998 mission model was published, there were 33 payloads manifested on the various launch vehicles as shown in the near-term payload list for that year. However, during the year industry suffered from a record number of satellite manufacturing and satellite processing center problems that resulted in significant delays to satellite deliveries.

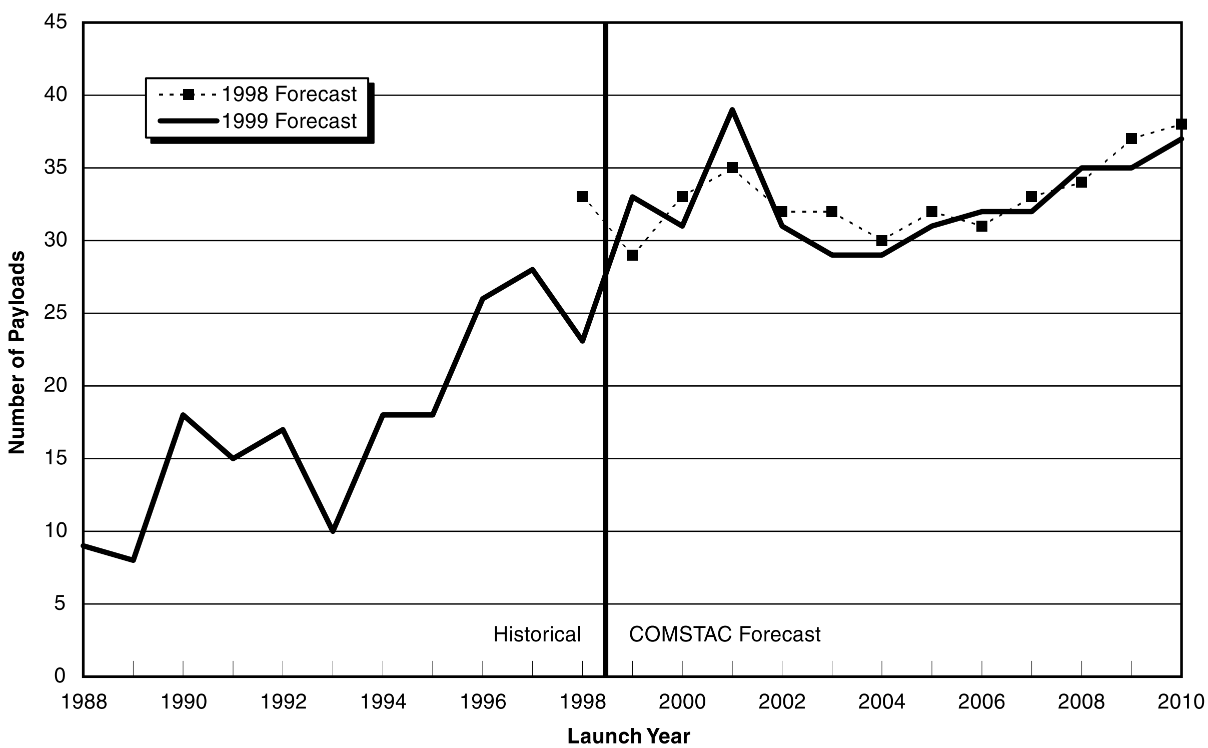


Figure 2. 1998 versus 1999 COMSTAC Mission Model Comparison

Table 2. Commercial GSO Near-Term Mission Model
Forecasted Payloads as of March 26, 1999

	1999	2000	2001	Avg
Total	33	31	39	34
>12,000 lbs	0	0	1	0
			TBD-Anik F2	
9,000 - 12,000 lbs	9	10	20	13
	Ariane-Galaxy 10R Ariane-Galaxy 11 Ariane-PAS 1R Ariane-Superbird 4 Long March-Chinasat 8 Proton-Astra 1H Proton-Galaxy 4R Proton-Garuda 1 Proton-Telstar 6	Ariane-Anik F1 Ariane-Intelsat 902 Proton-Intelsat 901 Sea Launch-Thuraya 1 Sea Launch-XM Radio 1 Sea Launch-XM Radio 2 TBD-Asiasat 4 TBD-Astra 1K TBD-Europe*Star 1 TBD-PAS 3C	Ariane-Intelsat 903 Ariane-Intelsat 904 TBD-Agrani 1 TBD-APMT 1 TBD-Assuresat 1 TBD-Assuresat 2 TBD-DTV 4 TBD-Europe*Star 2 TBD-Garuda 2 TBD-Horizons 1 TBD-Intelsat 905 TBD-JCSat 7 TBD-Nahuel 2 TBD-Optus C1 TBD-Sirius 4 TBD-Spaceway 1 TBD-Telstar 9 TBD-Telstar Ka TBD-Thuraya 2 Attrition-1999 Relaunch	
4,000 - 9,000 lbs	22	16	15	18
	Ariane-Arabsat 3A Ariane-Asiastar 1 Ariane-Astra 2B Ariane-Brasilsat B4 Ariane-Eutelsat W4 Ariane-Insat 3B Ariane-K-TV 1 Ariane-Koreasat 3 Ariane-Orion 2 Ariane-Telkom 1 Atlas-Eutelsat W3 Atlas-Hispasat 1C Atlas-JCSat 6 Atlas-Sky 1 Atlas-Telstar 7 Delta-Orion 3 Proton-Asiasat 3S Proton-GE 1A Proton-GE 4 Proton-LMI 1 Proton-Nimiq 1 TBD-DTV 1R	Ariane-Ameristar Ariane-Eurasiasat 1 Ariane-Eutelsat W1R Ariane-NSat 110 Atlas-Sky 2 TBD-GE 6 TBD-GSat 1 TBD-Insat 3A TBD-Measat 3 TBD-PAS 9 TBD-Ressat 1 TBD-Telstar 8 TBD-Tempo 1 TBD-Thor 4 TBD-Worldstar 4 Attrition-1999 Relaunch	TBD-Astra 2C TBD-EuropeSat 1 TBD-GE 2A TBD-GE X1 TBD-GE X2 TBD-GSat 2 TBD-Hispasat 1D TBD-Insat 3C TBD-K-TV 2 TBD-LMI 2 TBD-Measat 4 TBD-Palapa X TBD-PAS X TBD-RASCOM 1 Attrition-1999 Relaunch	
2,000 - 4,000 lbs	2	5	3	3
	Ariane-Insat 2E Ariane-Skynet 4E	Ariane-GE 7 Ariane-GE 8 Ariane-Skynet 4F TBD-Bsat 2a TBD-Nilesat 2	TBD-AMOS 2 TBD-Bsat 2b TBD-GE 9	

The late satellite deliveries caused launches to bunch up at the end of the year and, in some cases, to slip into 1999. Other factors that affected the near term forecast is the current Asian economic problems and delays due to launch vehicle failures. Many of these payloads are now manifested for launch in 1999 and are shown in the near-term forecast for this year. This shift is the primary reason for the increase in the 1999 forecast over last year (from 29 payloads to 33).

Another factor influencing some of the inputs to this year's mission model is the recent changes in the US Government policy regarding satellite and launch vehicle export control. US satellite suppliers and launch vehicle providers are being hampered in their efforts to work with their international customers by the new policy and the delays being caused by its enforcement. Satellite buyers could potentially move to non-US sources for both satellites and launch vehicles. The higher costs and hardships caused by these regulations could also cause them to look to terrestrial systems to provide services previously performed by satellite systems. Some of the participants in this update feel that this policy has caused potential overseas customers to believe that they can no longer rely exclusively or principally on US satellite or launch vehicle suppliers. Some participants feel that this will cause a gradual downturn in space based services and thus a reduction in launch vehicle demand.

Payload Launch Mass Ranges

Figure 3 shows the forecasted distribution of the payload demand by mass. The payloads are forecasted in four mass ranges (Below 4,000 pounds; 4,000 to 9,000 pounds; 9,000 to 12,000 pounds; and Above 12,000 pounds). As described earlier, these mass ranges are representative of the capabilities of various launch vehicles. More specifically, the definition refers to launch vehicle *performance* (vs. launch mass) to a nominal geosynchronous transfer orbit of 200 nm x GEO at an inclination of 28° north. The forecasted values for each mass range are an average of the domestic comprehensive inputs for each mass category for each year. In the near-term

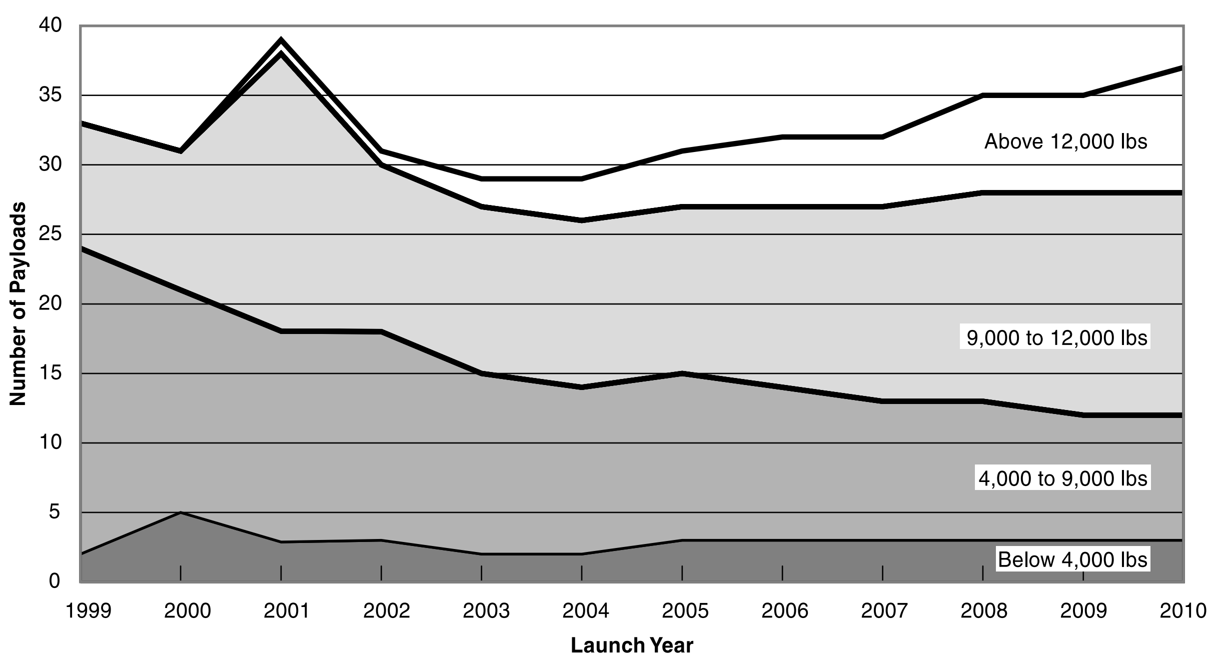


Figure 3. Forecast Trends in Annual GSO Payload Mass Distribution

forecast, the Working Group tried to place each satellite in the appropriate category based on what was known of its mass. The remainder of the forecast is an estimate by each of the participants of the potential breakdown between the categories for that year.

The most significant change to this year's forecast is the addition of a new mass category at the top of the range. The payload mass class definitions were refined in 1997 to reflect new market entrants like Delta III and Atlas III. In that year, the upper mass category was changed from 8,000 pounds and above to 9,000 pounds and above. The purpose of this was to keep the largest mass category definition consistent with a performance greater than that available from a U.S. launch site. But based on the significant trend toward heavier satellites and the introduction of new, higher performing launch vehicles such as Atlas V and Delta IV, the Working Group determined that better distinction in the "heavy" category was needed. Therefore, the upper mass range was modified to 9,000 to 12,000 pounds, and a new category was created for 12,000 pounds and above. Previous to this year, there have been no addressable payloads in the 12,000 pounds and above category. The first satellites in the 12,000 pounds and above category show up in the forecast in 2001.

Growth of Commercial Satellites

In past mission models, the potential mass growth of satellites has been an issue. In 1996, two cases were presented, one for "Stable Mass Growth" and one for "Continued Mass Growth." The "Stable Mass Growth" scenario predicted that 4,000 to 9,000 pound payloads would represent 70% of the market for GSO payloads over the forecast period, while the "Continued Mass Growth" case reflected the emergence of a segment of heavy payloads, which would represent 42% of the total market. In the following years, however, consensus was reached on the continuing growth of commercial satellites.

This trend continues in the 1999 mission model. As shown in Table 3, the projected number of payloads in the 9,000 to 12,000 pound mass category continues to grow, as well as in the new Above 12,000 pound category. One of the factors involved in the growth of satellites is the overall system cost. Larger satellites are more cost effective on a dollars per transponder basis.

Table 3. Forecast Trends in Payload Mass Distribution

Payload Mass	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Avg 1999 to 2010	% of Total
Below 4,000 lbs	2	5	3	3	2	2	3	3	3	3	3	3	35	2.9	9%
4,000 to 9,000 lbs	22	16	15	15	13	12	12	11	10	10	9	9	154	12.8	39%
9,000 to 12,000 lbs	9	10	20	12	12	12	12	13	14	15	16	16	161	13.4	41%
12,000 lbs and above	0	0	1	1	2	3	4	5	5	7	7	9	44	3.7	11%
Total Forecast	**33**	**31**	**39**	**31**	**29**	**29**	**31**	**32**	**32**	**35**	**35**	**37**	**394**	**32.8**	**100%**

And the cost to launch these larger satellites is coming down with the introduction of competition in the heavy-lift launch vehicles. Other factors include the need for higher power satellites and onboard processing to support the latest applications. This does not indicate, however, that smaller satellites will disappear. As can be seen, payloads are still forecasted in each of the mass categories through the end of the forecast period.

Launch Vehicle Demand

Since inception, the COMSTAC mission model has provided commercial launch demand forecasts in terms of the number of GSO payloads to be launched. However, the actual number of commercial GSO launches recorded from 1988 through 1998 is lower than the number of payloads launched due to dual manifesting on certain launch vehicles. In the fall of 1997, the Working Group decided it was necessary to estimate the demand for launch vehicles based on the payload launch forecast because of the dual manifesting of a portion of the payloads. Figure 4 presents the payload demand forecast described earlier in terms of actual and projected *launches* from the 1988 to 2010 time frame.

The data for 1988 to 1998 is based on actual dual-manifest historic information. In cases where two internationally competed GSO payloads were carried on the same launch vehicle, one "payload equivalent" was subtracted from the payload count in the mission model. In cases where one commercial GSO payload was launched with another non-commercial or non-GSO payload, that commercial payload was counted as a single commercial launch. Projections from 1999-2010 are based on assumptions using the same dual-manifest factors.

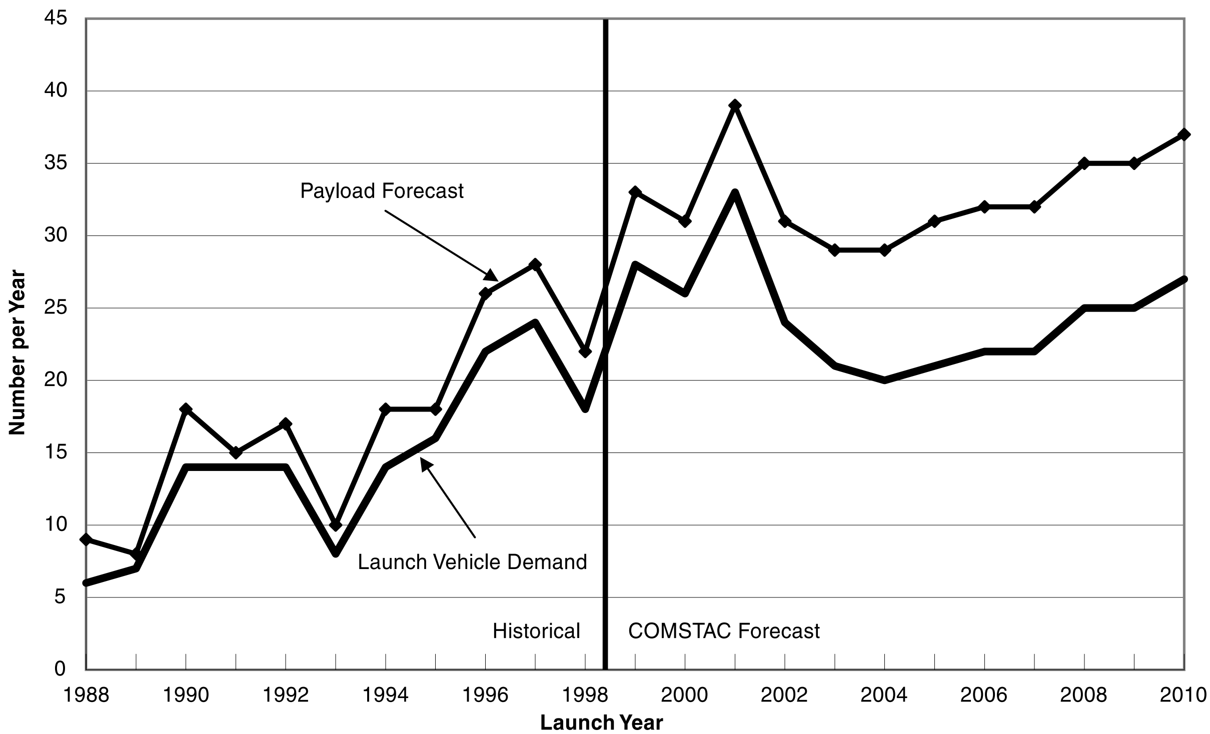


Figure 4. COMSTAC Launch Demand Forecast

Table 4. COMSTAC Launch Demand Forecast Summary

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Avg 1999 to 2010
Payload Forecast	**33**	**31**	**39**	**31**	**29**	**29**	**31**	**32**	**32**	**35**	**35**	**37**		
Dual Launch Forecast	5	5	6	7	8	9	10	10	10	10	10	10		
Launch Vehicle Demand	**28**	**26**	**33**	**24**	**21**	**20**	**21**	**22**	**22**	**25**	**25**	**27**	**294**	**25**

Historically, there has only been one launch vehicle capable of launching dual payloads (Ariane), and its highest publicly announced dual launch capability is approximately 8 flights per year. This 8 flight maximum is discounted to an average of 5 dual commercial flights per year, based on historical data.

A second dual launch capability is postulated to become commercially available beginning in 2001, with more coming on line around 2003. As these new systems mature, customers will become more comfortable with their capabilities and will begin to use their dual manifest services. The Working Group feels that this will cause the annual number of dual manifested payloads to increase gradually from the current 5 per year to 10 per year by the year 2005. Table 4 shows the estimated number of dual launches forecasted.

Summary

Results of the COMSTAC Technology and Innovation Working Group 1999 report shows a total of 394 addressable payloads expected to be launched from 1999 to 2010. On average, the demand forecast equates to a total of 33 payloads seeking launch services each year. This is the third year in a row the overall average has been approximately 33 addressable payloads, indicating industry continues to see a steady demand for commercial communication satellites (Appendix A).

While the overall average continues to be 33 payloads, the forecasts for any given year indicate a degree of uncertainty within the industry. Except for the near term forecast which is developed through consensus, individual forecasts varied by as much as 10 to 20 payloads each year. Part of this variability is the result of uncertainties relating to the timing of replacement satellites, the timing of fleet expansions, and the timing of new venture starts. In addition, this year several members changed their forecast to reflect an unfavorable impact on demand due to changing U.S. Government regulations and the interpretation and application of these regulations.

Launch demand on average over the forecast period is approximately 25 launches per year, unchanged from the 1998 forecast. Dual payload launches start at 5 in 1999 and gradually increase to a maximum of 10 in 2005.

The forecast by mass category reveals a significant shift in industry expectations. This year the 9,000 pound and up mass categories represent 52% of the projected market, an 11% increase from 1998 and a 17% increase from 1997. To provide more precision in the forecasts, a new mass category was added to the 1999 survey request. The 9,000 pound and up mass category was divided into a 9,000 to 12,000 pound category and a greater than 12,000 pound mass category. Results of the survey show that over the forecast period the 9,000 to 12,000 pound mass category is 41% of the market, approximately equal in market share to the 4,000 to 9,000 pound mass category. The greater than 12,000 pound category represents 11% of the market. The first payload from this mass category is projected to be ready for launch in 2001.

In the near term model, we have consistently seen a difference between the current year launch demand forecast and actual launches. In 1998, there were a total of 23 addressable payloads launched, 10 less than forecasted for that year in the 1998 Commercial Spacecraft Mission Model Update. The actual payloads launched in 1998 are shown in the historical launch tables in Appendix A and can be compared to the actual spacecraft forecasted in last year's near term forecast. This difference is typically the result of supply side issues which are not a part of the Commercial Spacecraft Mission Model such as late satellite deliveries and delays due to launch vehicle failures.

It is also becoming more difficult to distinguish which payloads constitute commercially competed geosynchronous commercial communication satellites. The difficulty in forecasting payloads which fall into this category is a direct result of mergers within the industry, the use of launch services block buys by all the satellite manufacturers, and the change in classification of satellites like CD Radio and other elliptical orbit satellites. CD Radio satellites were classified as GSO in the 1998 forecast and by agreement are now classified as Non-GSO. Appendix B contains near term launch forecasts for non-addressable payloads.

Overall, this forecast shows a continuing demand over the next eleven years for the launch of commercial geosynchronous orbit payloads.

Appendix A. Historical Launches

COMSTAC Report Summaries

COMSTAC prepared the first commercial mission model in April 1993 as part of a report on commercial space launch systems requirements (Reference A1). Each year since 1993, COMSTAC has issued an updated model. The process has been continuously refined and industry participation has broadened each year to capture the most realistic portrayal of space launch demand possible. Over the years, the COMSTAC mission model has been well received by industry, government agencies and international organizations.

1993: The first report was developed by the major launch service providers in the US and covered the period 1992-2010. The report projected only modest growth in telecommunications markets based mainly on replenishment of existing satellites, with only limited new satellite applications. Annual forecast demand averaged about 10.5 payloads per year.

1994: Beginning in 1994, major US spacecraft manufacturers (Hughes Space and Communications, Martin Marietta AstroSpace, Space Systems/Loral and TRW) also began to contribute to the market demand database. The 1994 mission model (Reference A2) projected an average demand of 17 payloads per year over the forecast period of 1994-2010, with some members of the spacecraft manufacturing community believing the mission model to be too conservative.

1995: In 1995, the Technology and Innovation Working Group was formally chartered to prepare an annual Commercial Spacecraft Mission Model Update Report (Reference A3). The organizations from which the market demand forecasts were requested was further expanded to include satellite operators, in addition to spacecraft manufacturers and launch service providers. The 1995 data contained sizable variations in projected launch demand with a significant degree of polarization around two differing viewpoints. Therefore, a two case scenario was adopted for the 1995 mission model. A “Modest Growth” scenario projected an average launch demand of approximately 20 payloads per year over the period 1995-2010. A “Higher Growth” scenario forecast the demand to be an average of 32 payloads per year. The primary difference between the two was the assumption of a segment called “unidentified growth” in the “Higher Growth” scenario based on proprietary information from the survey respondents.

In the 1995 model there was general agreement among the participants regarding the distribution of payloads among the different weight classes. In both the “Modest Growth” and “Higher Growth” cases, approximately 70% of the payloads were forecast to be in the Intermediate category (4000-8000 lb), with 15% each in the Medium (2000-4000 lb) and the Heavy (>8,000 lb) classes.

1996: The 1996 annual update expanded the request for input data to a greater number of companies and satellite operators. The resulting forecast (Reference A4) represented a consensus on the size of the market, which was close to the 1995 “Higher Growth” case, with average annual demand of 31 payloads per year. However, in the case of mass distribution, the group agreed to portray two cases: “Stable Mass Growth” and “Continued Mass Growth.” The “Stable Mass Growth” scenario predicted that Intermediate payloads would represent 70% of the market over the forecast period, while the "Continued Mass Growth" case reflected the emergence of a segment of Heavy payloads, representing 42% of the total market.

1997: The annual mission model update in 1997 (Reference A5) included a section discussing the forecast data from foreign organizations, which are not included in our formal COMSTAC mission model. It also included a first attempt to derive *vehicle* launch demand from the *payload* launch demand projections by consideration of dual manifesting of spacecraft on launch vehicles. The market forecast from US inputs predicted an average annual spacecraft demand of 33 payloads per year from 1997 – 2010. Ofthese, it was projected that an average of 6 co-manifested launches per year would occur through 2002, and 10 per year from 2003 – 2010. Consensus was reached on the mass growth, with projected demand for Heavy (> 9,000 lb to GTO) reaching over 50% of the annual demand by 2010.

1998: The 1998 annual mission model predicts an average demand of 33 payloads per year over the period from 1998 to 2010. The near-term forecast from 1998-2000 shows that the demand of 33 launches in 1998 drops to 29 in 1999, then increases again to 33 in 2000. Demand remains relatively constant until a cyclic dip occurs around the year 2004. The forecast for 1999 showed a sizable drop from the prior years forecast; from 40 payloads to 29 payloads, a reduction of 11 satellites. This was attributed as a short term response to the Asian economic crisis since the majority of the payloads that dropped from the forecast were Asian owned satellites.

1989-1998 Worldwide Launch History

Figure A-1 plots the total number of vehicle launches in the various spacecraft categories defined in Tables A.1 through A.4 that were performed in the period 1989 through 1998.

Table A-1 presents historical addressable commercial spacecraft launches during the period 1989 to 1998.

Table A-2 is the history of worldwide non-addressable spacecraft launches that utilized the same launch systems and launch sites that are used for the addressable Commercial GSO Spacecraft Mission Model.

Table A-3 is the history of non-addressable spacecraft launches that utilized domestic launch sites not used for the addressable commercial launches to GTO.

Table A-4 is the history of non-addressable spacecraft launches that utilized foreign launch sites not used for the addressable commercial launches to GTO.

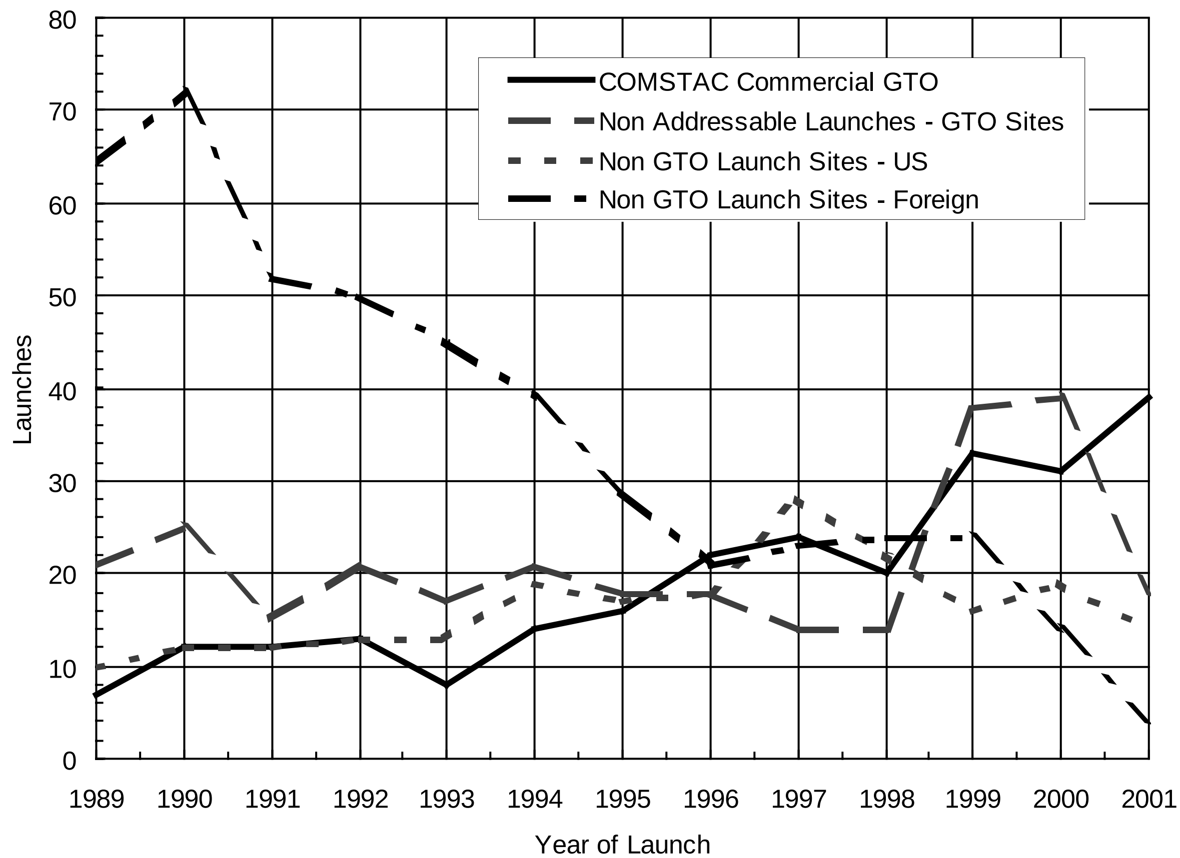


Figure A-1. Launches by Category

Table A-1. 1989-1998 COMSTAC GSO Commercial Spacecraft Mission Model

		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	TOTAL	Average Rate
Total Launches		7	12	12	13	8	14	16	22	24	19	147	14.7
Total Spacecraft		8	18	14	17	10	18	18	26	28	23	180	18.0
Arianespace		6	4	6	5	6	8	7	10	11	9	72	7.2
	HLV	1 Intelsat 602 1 Japan-JCSat1 1 Japan-Superbird A	1 Japan-Superbird B 1 US-SBS 6	1 Canada-Anik E1 1 Canada-Anik E2 1 Intelsat 601 1 Intelsat 605 1 Luxembourg-Astra 1B	1 US-Galaxy 7 1 Japan-Superbird B1 1 Japan-Superbird A1	1 Intelsat 701 1 Luxembourg-Astra 1C 1 Mexico-Solidaridad 1 1 US-DBS 1 1 US-Galaxy 4	1 Intelsat 702	1 Intelsat 706A 1 Japan-NStar CS-4A	1 Intelsat 707A 1 Intelsat 709	1 Intelsat 801 1 Intelsat 802 1 Intelsat 803 1 Intelsat 804 1 US-GE Americom GE2 1 US-PAS 6			
	ILV	1 Germany-DBP TVSat 2 1 Intelsat 515A 1 Sweden-SSC Tele X	0 Eutelsat 201	0 Eutelsat 202 1 Italy-Italsat 1	0 Eutelsat 204 1 India-Insat 2A 1 Spain-Hispasat 1A	0 India-Insat 2B 1 Spain-Hispasat 1B	1 Brazil-Brazilsat B1 0 Eutelsat-II F5 1 Luxembourg-Astra 1D 1 Mexico-Solidaridad 2 1 Turkey-Turksat 1A 0 Turkey-Turksat 1B 1 US-Telstar 402 1 US-Panamsat 2 1 US-Panamsat 3	1 Brazil-Brazilsat B2 0 Eutelsat-Hotbird 1 0 India-Insat 2C 1 Luxembourg-Astra 1E 1 US-AT&T 402R 1 US- DBS 3 1 US-PAS 4	1 Arabsat 2A 1 Arabsat 2B 1 Canada-TMI MSat M1 1 Indonesia-Palapa C2 1 Italy-Italsat 2 1 Japan-NStar CS-B 0 Turkey-Turksat 1C 1 US-Echo Star 2 1 US-PAS 3R	0 Argentina-Nahuel 3 1 Eutelsat-Hotbird 3 0 India-Insat 2D 1 Inmarsat 304 1 Japan-JCSat 5 (1R) 1 Sweden-Sirius 2 1 Thailand-Thaicom 3	1 Brazil-Brazilsat B3 0 Inmarsat 3-F5 1 Eutelsat-Hotbird 4 1 Egypt-Nilesat 1 0 Bsat-1b 1 Indonesia-Telkom 1 1 US-PAS 7 1 Eutelsat-W2 1 Afristar 0 US-GE5 1 Satmex-5 1 US-PAS 6B		
	MLV	0 Germany-DBP DFS 1	0 Germany-DBP DFS 2 0 Japan-BS 2X 1 UK-Skynet 4C 1 US-GE Satcom C1 0 US-GTE GStar 4 0 US-Galaxy 6	0 Inmarsat 2 F3	0 US-GE C3 0 Arabsat 1C 0 Inmarsat 2 F4	0 Thailand-Thaicom 1	0 Thailand-Thaicom 2 0 Japan-NHK BS 3N		0 Israel-Amos 1 0 Malaysia-MeaSat 1 0 Malaysia-MeaSat 2	0 Indonesia-Indostar 1 0 Japan-BSat 1A	0 Sweden-Sirius 3		
Atlas		0	0	2	3	1	3	5	5	6	3	28	2.8
	HLV						1 Intelsat 703	1 Intelsat 704 1 Intelsat 705		1 Japan-Superbird C			
	ILV			1 Eutelsat 203	1 Intelsat K1	1 US- Telstar 401	1 US- DBS 2 1 US-Orion 1	1 Japan-JCSat 3 1 US-MSat M2 1 US-Galaxy 3R	1 Eutelsat-Hotbird 2 1 Indonesia-Palapa C1 1 Inmarsat 301 1 Inmarsat 303 1 US-GE1	1 Japan-JCSat 4 1 US-Echostar 3/DBSC 1 1 US- GE 3 1 US-Galaxy 8i 1 US-Tempo FM 2	1 Intelsat 806 1 Intelsat 805 1 Hot Bird 5		
	MLV			1 Japan- BS 3H	1 US-Galaxy 1R 1 US-Galaxy 5								
Delta		1	4	4	3	1	1	1	2	1	4	22	2.2
	ILV										1 Galaxy 10		
	MLV	1 UK-BSB/Marcopolo 1	1 India-Insat 1D 1 Indonesia-Palapa B03 1 Inmarsat 2 F1 1 UK-BSB/Marcopolo 2	1 Inmarsat 2 F2 1 NATO 4A 1 US-GE C5 1 US-GTE 4	1 Germany-DBP DFS 3 1 Indonesia-Palapa B4 1 US-GE C4	1 NATO 4B	1 US-Galaxy1R-2	1 KoreaSat 1	1 KoreaSat 2 1 US- Galaxy 9	1 Norway-Thor 2A	1 UK-Skynet 4D 1 Norway-Thor III 1 Russia-Bonum 1		

Table A-1. 1989-1998 COMSTAC GSO Commercial Spacecraft Mission Model (continued)

Vehicle	Class	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	TOTAL	Average Rate
H-IIA		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.0**
	HLV												
	ILV												
	MLV												
Long March		**0**	**1**	**0**	**2**	**0**	**2**	**3**	**3**	**2**	**0**	**13**	**1.3**
	HLV								1 Intelsat 708A	1 Philippine-Mabuhay 1			
	ILV				1 Australia-Optus B1 1 Australia-Optus B2		1 Australia-Optus B3	1 China-APStar 2 1 China-Asiasat 2 1 US-Echo Star 1					
	MLV		1 China-Asiasat 1				1 China-APStar 1		1 China-APStar 1A 1 China-Chinasat 7	1 China-APStar 2R			
Proton		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**4**	**3**	**9**	**0.9**
	HLV									1 China-Asiasat 3 1 Luxembourg- Astra 1G 1 US-PAS 5 1 US-Telstar 5	1 US-PAS 8		
	ILV								1 Inmarsat 302 1 Luxembourg- Astra 1F		1 US-Echostar 4 1 Luxembourg- Astra 2A		
Zenit 3 SL		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.0**
	HLV												
	ILV												
Titan 3		**0**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0.3**
	HLV		1 Intelsat 603 1 Intelsat 604										
	ILV		1 Japan-JCSat 2										
	MLV		0 UK-Skynet 4A										

Table A-2. 1989-1998 Non-Addressable Payloads Using GTO Launch Sites

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	TOTAL	Average Rate
Total Launches	21	25	15	21	17	21	18	18	14	15	185	18.5
Total Spacecraft	27	30	20	25	20	29	25	22	27	27	252	25.2
Ariane	1	2	2	2	1	0	4	1	0	2	15	1.5
	1 ESA-Olympus 1 0 ESA-Hipparcos 0 ESA-Meteosat 4	1 France-Spot 2 1 France-TDF 2	1 ESA-ERS 1 0 ESA-Meteosat 5 1 France-Telecom 2A 0 US-OSC-Orbcom	1 France-Telecom 2B 1 NASA-TOPEX	0 Eumetsat-Meteosat 6 1 France-Spot 3		1 ESA-ERS 2 1 ESA-ISO 1 France-Helios 1 1 France-Telecom 2C	1 ESA-European Cluster 0 France-Telecom 2D	0 Eumetsat-Meteosat(MOP	1 CNES SPOT-4 1 ARD		
Atlas	1	1	0	2	4	2	6	2	2	3	23	2.3
	1 US Navy Fltsatcom 8	1 US-NASA/AF CRESS		1 USAF-DSCS 3 B01 1 USAF-DSCS 3 B02	1 US-AF DSCS 3-03 1 US-AF DSCS 3-04 1 USN-UHF F01 1 USN-UHF F02	1 US-Navy UHF F03 1 US-NOAA Goes 8	1 ESA-SOHO 1 USAF DSCS 3-05 1 NASA Goes J 1 US Navy UHF F4 1 US Navy UHF F5 1 US Navy UHF F6	1 ESA-SAX-Astronomy 1 US Navy UHF F7	1 USAF DSCS 3-06 1 NASA Goes K	1 USAF NRO 1 US Navy UHF F8 1 US Navy UHF F9		
Delta	6	7	1	8	6	2	0	6	4	4	44	4.4
	1 US-AF Delta Star 1 US-AF GPS Navstar 01 1 US-AF GPS Navstar 02 1 US-AF GPS Navstar 03 1 US-AF GPS Navstar 04 1 US-AF GPS Navstar 05	1 Germany-Rosat-X Ray 1 US-AF GPS Navstar 06 1 US-AF GPS Navstar 07 1 US-AF GPS Navstar 08 1 US-AF GPS Navstar 09 1 US-AF GPS Navstar 10 0 US-AF LowPwrAtmosCom 1 US-AF RelayMirrorExp	1 US-AF GPS-Navstar 11 0 US-AF LOSAT (SDI)	1 Japan-Geotail 1 US-AF GPS Navstar 12 1 US-AF GPS Navstar 13 1 US-AF GPS Navstar 14 1 US-AF GPS Navstar 15 1 US-AF GPS Navstar 16 1 US-AF GPS Navstar 17 1 US-NASA EUVE	1 US-AF GPS 2 Blk 2 01 1 US-AF GPS 2 Blk 2 02 1 US-AF GPS 2 Blk 2 03 1 US-AF GPS 2 Blk 2 04 1 US-AF GPS 2 Blk 2 05 1 US-AF GPS Navstar 18	1 NASA-Wind 1 US-AF GPS 2 Block 2 06 0 US-AF SEDS		1 US-AF-GPS 2-Block 2-07 1 US-AF-GPS 2-Block 2-08 1 US-AF-GPS 2-Block 2-10 1 US-NASA-Mars Global Surv 1 US-NASA-MESUR Pathfinder 1 US-NASA-NEAR	1 US-AF-GPS 2-Block 2-28 1 US-AF-GPS 2R-01 1 US-AF-GPS 2R-02 1 US-NASA-ACE	1 Globalstar 01 - 4 1 Globalstar 02 - 4 1 NASA Deep Space 1 1 NASA Mars Climate Orbiter		
Japan	1	2	1	1	0	2	1	1	1	1	11	1.1
	1 Japan-GMS 4	1 Japan-BS 3A 1 Japan-MOS 1B	1 Japan-BS 3B	1 Japan-JERS		1 Japan-ETS 6 1 Japan-OREX	1 Japan-GMS 0 Japan-SFU	1 Japan-ADEOS	1 Japan-ETS-7/TRMM	1 Japan-COMETS		
Long March	0	2	1	0	0	2	0	0	2	2	9	0.9
		1 China-DFH 203 1 Pakistan-Badar 1	1 China-DFH 204			1 China-DFH 301 1 China-SJ 4			1 China-DFH 302 1 China-Fen Yun 2	1 China-Sinosat 1 1 China-Chinastar		
Proton	12	11	10	8	6	13	7	8	5	3	83	8.3
	1 Gorizont 17 1 Gorizont 18 1 Gorizont 19 1 Raduga 1-1 1 Raduga 23 1 Raduga 24 6 Russia-Mil/Science	1 Ekran 1 Gorizont 20 1 Gorizont 21 1 Gorizont 22 1 Raduga 1-2 1 Raduga 25 1 Raduga 26 4 Russia-Mil/Science	1 Gorizont 23 1 Gorizont 24 1 Raduga 27 1 Raduga 28 6 Russia-Mil/Science	1 Ekran 20 1 Gorizont 25 1 Gorizont 26 1 Gorizont 27 4 Russia-Mil/Science	1 Gorizont 1 Gorizont 28 1 Gorizont 29-Rimsat 1 Raduga 29 1 Raduga 30 1 Russia-Mil/Science	1 Express 01 1 GALS 1 1 Gorizont 30-Rimsat 1 Luch 1 1 Raduga 1-3 1 Raduga 31 1 Raduga 32 6 Russia-Mil/Science	1 GALS 2 1 Luch 1-1 5 Russia-Mil/Science	1 Russia-Express 02 1 Russia-Gorizont 31 1 Russia-Gorizont 32 1 Russia-Raduga 33 3 Russia-Mil/Science 1 Mars Mission	1 Iridium 01 - 7 1 Iridium 02 - 7 1 Russia-Cosmos 2344 1 Russia-Cosmos 2345 1 Russia-Coupon 01 - 1	1 Iridium 03 - 7 1 Russia-Cosmos 2350 1 Russia-Zarya- ISS FGB		

Table A-3. 1989-1998 United States Non-GTO Launch Sites

		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	TOTAL	Average Rate
United States Ranges													
Total Launches		10	12	12	13	13	19	17	18	28	22	164	16.4
Total Spacecraft		18	25	26	18	19	23	23	22	61	60	295	29.5
Eastern Ranges													
STS		5	6	6	8	7	7	7	7	8	5	66	6.6
	RLV	1 US-STS-029 Discovery 0 US-NASA TDRS D 1 US-STS-030 Atlantis 0 US-NASA Magellan 1 US-STS-028 Columbia 0 US-DoD (Jumpseat) 0 US-DoD (Jumpseat) 1 US-STS-034 Atlantis 0 US-NASA Galileo 1 US-STS-033 Discovery 0 US-DoD (Magnum)	1 US-STS-032 Columbia 0 US-Navy Syncom IV-5 1 US-STS-036 Atlantis 0 US-DoD (KH-11A) 1 US-STS-031 Discovery 0 US-NASA Hubble 1 US-STS-041 Discovery 0 US-NASA Ulysses 1 US-STS-038 Atlantis 0 US-DoD (Magnum) 1 US-STS-035 Columbia	1 US-STS-037 Atlantis 0 US-NASA GRO 0 US-US AF MPEC-AF P675 1 US-STS-039 Discovery 1 US-STS-040 Columbia 1 US-STS-043 Atlantis 0 US-NASA TDRS E 1 US-STS-048 Discovery 0 US-NASA UARS 1 US-STS-044 Atlantis 0 US-DoD (DSP 14)	1 US-STS-042 Discovery 1 US-STS-045 Atlantis 1 US-STS-049 Endeavour 1 US-STS-050 Columbia 1 US-STS-046 Atlantis 0 ESA-Eureka 0 US-NASA/Italy TSS 1 US-STS-047 Endeavour 1 US-STS-052 Columbia 0 US-NASA Lageos II 1 US-STS-053 Discovery 0 US-DoD (Jumpseat) 0 US-DoD (DSP)	1 US-STS-054 Endeavour 0 US-NASA TDRS F 1 US-STS-056 Discovery 0 US-NASA Spartan 1 US-STS-055 Columbia 1 US-STS-057 Endeavour 1 US-STS-051 Discovery 0 US-NASA ACTS 0 German-Orgeus-Spas 1 US-STS-058 Columbia 1 US-STS-060 Discovery	1 US-STS-060 Discovery 1 US-STS-062 Columbia 1 US-STS-059 Endeavour 1 US-STS-065 Columbia 0 US-NASA-Intl Microgravity 1 US-STS-064 Discovery 0 US-NASA-Spartan 1 US-STS-068 Endeavour 1 US-STS-066 Atlantis 0 US-NASACrista-SPAS	1 US-STS-063 Discovery 0 US-NASA-Spartan 1 US-STS-067 Endeavour 1 US-STS-071 Atlantis 1 US-STS-070 Discovery 0 US-NASA TDRS G 1 US-STS-069 Endeavour 0 US-NASA-Spartan 0 US-NASA WSF 2 1 US-STS-073 Columbia 1 US-STS-074 Atlantis	1 US-STS-072 Endeavour 0 US-NASA-Spartan 1 US-STS-075 Columbia 0 US-NASA-Spartan 1 US-STS-076 Atlantis 1 US-STS-077 Endeavour 1 US-STS-078 Columbia 1 US-STS-079 Atlantis 1 US-STS-080 Columbia 0 US-NASA WSF 3	1 US-STS081-Atlantis 1 US-STS082-Discovery 1 US-STS083-Columbia 1 US-STS084-Atlantis 1 US-STS085-Discovery 1 US-STS086-Atlantis 1 US-STS087-Columbia 1 US-STS094-Columbia	1 US-STS089-Endeavour 1 US-STS090-Columbia 1 US-STS091-Discovery 1 US-STS095-Discovery 1 US-STS088-Endeavour		
Athena		0	0	0	0	0	0	0	0	0	1	1	0.1
	Small										1 NASA Lunar Prospector		
Pegasus		0	0	0	0	1	0	0	1	3	3	8	0.8
	Small					1 US-Orbcomm/CDS 0 Brazil-SCD			1 Argentina-SAC-B 0 US-SAC-B/HETE	1 Spain-Minisat 1 US-Orbcomm 01-8 1 US-Step 4	1 US-Orbcomm 02-8 1 US-Orbcomm 03-8 1 Brazil-SCD2		
Taurus		0	0	0	0	0	0	0	0	0	0	0	0.0
	Small												
Titan		3	2	0	1	0	4	4	3	3	2	22	2.2
	HLV	1 US-AF Titan 34D (Chatlet) 1 US-AF Titan 34D (DSCS) 0 US-AF Titan 34D (DSCS) 1 US-AF Titan 4 (DSP 13) 0 US-AF Titan 4 (DSP 16)	1 US-AF Titan 4 (DSP 15) 0 US-AF Titan 4 (DSP 17) 1 US-AF Titan 4 (NOSS) 0 US-AF Titan 4 (NOSS)		1 US-NASA T3 Mars Observer		1 US-AF T4 (Adv Jumpseat) 1 US-AF T4 (DoD) 1 US-AF T4 (DSP 17) 1 US-AF T4 (Milstar 1)	1 US-AF T4 (Adv Jumpseat) 1 US-AF T4 (DoD) 1 US-AF T4 (DoD) 1 US-AF T4 (Milstar 2)	1 US-AF T4 (Adv Jumpseat) 1 US-AF T4 (DoD) 1 US-AF T4 (DoD)	1 US-AF T4 DSP 18 1 US-NASA T4 Cassini 1 US-NRO T4 Trumpet	1 US-AF T4 (NRO) 1 US-AF T4A (NRO)		

Table A-3. 1989-1998 United States Non-GTO Launch Sites (continued)

United States-Vandenberg Test Center

Vehicle	Class	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	TOTAL	Average Rate
Athena		**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**2**	**0.2**
	Small							1 US-GEMStar (Vita Sat)		1 US-NASA-Lewis			
Atlas		**0**	**2**	**2**	**0**	**1**	**2**	**1**	**0**	**0**	**0**	**8**	**0.8**
	MLV		1 US-AF DMSP F10 1 US-AF Stacksat	1 US-AF DMSP F11 1 US-NOAA 12		1 US-NOAA 13	1 US-AF DMSP F12 1 US-NOAA 14	1 US-AF DMSP F13					
Delta		**1**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**6**	**5**	**16**	**1.6**
	MLV	1 US-AF Cos Bkgnd Exp						1 Canada-Radarsat 1 US-NASA-XTE	1 US-AF-Midcourse Space Exp 1 US-NASA-Polar	1 Iridium 01 - 05 1 Iridium 02 - 05 1 Iridium 03 - 05 1 Iridium 04 - 05 1 Iridium 05 - 05 1 Iridium 06 - 05	1 Iridium 07 - 05 1 Iridium 08 - 05 1 Iridium 09 - 05 1 Iridium 10 - 05 1 Iridium 11 - 05		
Pegasus		**0**	**1**	**1**	**0**	**1**	**3**	**2**	**4**	**4**	**3**	**19**	**1.9**
	Small		1 US-Pegsat 0 US-SECS	1 US-SARA 0 US-DARPA Sats		1 US-Alexis	1 US-APEX 1 US-Step 1 1 US-Step 2 (P-91)	1 US-Orbcomm 0 US-Orbcomm 1 US-Step 3 (P92-2)	1 US-FAST 1 US-MSTI 3 1 US-REX II 1 US-TOMS CP	1 US-Orbview 1 US-FORTE 1 US-Orbcomm 01-2 1 US-Orbcomm 02-2	1 Teledesic T1/SNOE 1 NASA-TRACE 1 NASA-SWAS		
Scout		**0**	**1**	**1**	**2**	**1**	**1**	**0**	**0**	**0**	**0**	**6**	**0.6**
	Small		1 Domestic	1 Domestic	2 Domestic	1 Domestic	1 Domestic						
Taurus		**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**2**	**3**	**0.3**
	Small						1 US-STEP/TAOS 0 US-DarpaSat				1 US-Navy GEOSAT/ORBCOMM 1 US-NRO-STEX		
Titan		**1**	**0**	**2**	**2**	**2**	**1**	**0**	**1**	**3**	**1**	**13**	**1.3**
	HLV			1 US-AF T4 (Lacrosse) 1 US-AF T4 (NOSS)	1 US-AF T4 (KH-12)	1 US-AF T4 (NOSS)			1 US-AF T4	1 US-Lacrosse K18	1 US-AF T2 (NOAA-K)		
	MLV	1 US-AF T2 (Ferrett)			1 US-AF T2 (DoD)	1 US-NASA T2 (Landsat 6)	1 US-NASA T2 (Clementine)			1 US-AF (DMSP 38) 1 US-NASA-TIROS			

Table A-4. 1989-1998 Foreign Non-GTO Launch Sites

		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	TOTAL	Average Rate
Foreign Launch Sites													
Total Launches		64	72	52	50	45	39	29	21	23	24	419	41.9
Total Spacecraft		81	89	75	67	56	49	33	28	34	49	561	56.1
China-Taiyuan/Jiyuan													
Long March		0	2	0	2	1	1	0	1	3	4	14	1.4
	ILV												
	MLV		1 China-FenYun 2 1 China-FSW 1-02		1 China-FSW 1-03 1 China-FSW 1-04	1 China-FSW 2-01	1 China-FSW 2-02		1 China-FSW 2-03	1 China-FSW 1C 1 Iridium Sim-02 1 Iridium 01 - 2	1 Iridium 02 - 2 1 Iridium 03 - 2 1 Iridium 04 - 2 1 Iridium 05 - 2		
India													
PSLV/GSLV		0	0	0	1	1	2	0	1	1	0	6	0.6
					1 India-SROSS C	1 India-IRS 1E	1 India-IRS P2 1 India-SROSS C		1 India-IRS P3	1 India-IRS 1D			
Israel													
Shavit		0	1	0	0	0	0	1	0	0	1	3	0.3
	Small		1 Israel-Ofeg 2					1 Israel-Ofeq 3			1 Israel-Ofeq 4		
Japan													
M-3S/M-5		1	1	1	0	1	0	1	0	1	1	7	0.7
	Small	1 Japan-Exos	1 Japan-Hagoromo	1 Japan-Solar		1 Japan-Asuka		1 Japan-Express		1 Japan-Test Launch	1 Japan-Nozomi (Hope)		
Russia-Baikonur													
Energia		0	0	0	0	0	0	0	0	0	0	0	0.0
	HLV												
Molniya		0	0	1	0	0	0	1	0	0	1	3	0.3
	MLV			1 Russia-Domestic				1 Russia-Domestic 0 Russia-Domestic			1 Molniya M		
Rockot		0	0	0	0	0	1	0	0	0	0	1	0.1
	Small						1 Russia-Domestic						
Soyuz		13	12	12	11	10	11	8	6	8	7	98	9.8
	HLV	1 Russia-MIR Manned 4 Russia-MIR Supply 8 Russia-Domestic	3 Russia-MIR Manned 4 Russia-MIR Supply 5 Russia-Domestic	2 Russia-MIR Manned 5 Russia-MIR Supply 5 Russia-Domestic	2 Russia-MIR Manned 5 Russia-MIR Supply 4 Russia-Domestic	2 Russia-MIR Manned 5 Russia-MIR Supply 3 Russia-Domestic	3 Russia-MIR Manned 5 Russia-MIR Supply 3 Russia-Domestic	2 Russia-MIR Manned 5 Russia-MIR Supply 1 Russia-Domestic	2 Russia-MIR Manned 3 Russia-MIR Supply 1 Russia-Domestic	1 Russia-Cosmos 2343 1 Russia-Photon 1 Russia-Progress M34 1 Russia-Progress M35 1 Russia-Progress M36 1 Russia-Progress M37 1 Russia-Soyuz TM 25 1 Russia-Soyuz TM 26	1 Russia-MIR TM27 Manned 1 Russia-Cosmos 2349 1 Russia - Progress M38 1 Russia - Progress M39 1 Russia-Cosmos 2359 1 Russia-MIR TM28 Manned 1 Russia-Progress M40		
Tskylon		3	4	0	0	4	0	4	1	1	0	17	1.7
	MLV	3 Russia-Domestic	4 Russia-Domestic			4 Russia-Domestic		2 Russia-Domestic 1 Chili-Fiasat 1 Russia-Domestic	1 Russia-Domestic	1 Russia-Cosmos 2347			
Vostok		0	0	0	0	0	0	0	0	0	0	0	0.0
	MLV												
Zenit		0	2	1	3	2	4	1	1	1	3	18	1.8
	HLV		1 Russia-Cosmos 2082 1 Russia-Cosmos xxxx	1 Russia-Cosmos xxxx	1 Russia-Cosmos xxxx 1 Russia-Cosmos 2219 1 Russia-Cosmos 2227	1 Russia-Cosmos 2237 1 Russia-Cosmos 2263	1 Russia-Cosmos 2278 1 Russia-Cosmos 2290 1 Russia-Resurs 1 1 Russia-Cosmos 2297	1 Russia-Cosmos 2322	1 Russia-Cosmos 2333	1 Russia-Cosmos	1 Russia-Resurs-O/Others 1 Russia-Cosmos 2360 1 US-Globalstar 01-12		

Table A-4. 1989-1998 Foreign Non-GTO Launch Sites (continued)

Russia-Plesetsk

Vehicle	Class	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	TOTAL	Average Rate
Cosmos		9	10	12	7	6	5	5	5	2	2	63	6.3
	MLV	9 Russia-Domestic	10 Russia-Domestic	11 Russia-Domestic 1 Russia-Domestic	7 Russia-Domestic	6 Russia-Domestic	5 Russia-Domestic	5 Russia-Domestic	5 Russia-Domestic	1 Russia-Cosmos 2341 1 Russia-Cosmos 2346	1 Russia-Astrid2/Nadezhda 5 1 Russia-Cosmos 2361		
Molniya		5	12	4	8	8	3	3	3	3	3	52	5.2
	MLV	5 Russia-Domestic	11 Russia-Domestic 1 India-IRS 1B	4 Russia-Domestic	8 Russia-Domestic	8 Russia-Domestic	3 Russia-Domestic	3 Russia-Domestic 0 Czech-Magion 4	3 Russia-Domestic 0 Czech-Magion 5	1 Russia-Cosmos 2340 1 Russia-Cosmos 2342 1 Russia-Molniya	1 Russia-Cosmos2351 1 Russia-Molniya 3 1 Russia-Molniya 1T		
Soyuz		25	20	12	13	7	4	4	3	2	1	91	9.1
	HLV	25 Russia-Domestic	18 Russia-Domestic 2 Russia-Domestic	12 Russia-Domestic	13 Russia-Domestic	7 Russia-Domestic	4 Russia-Domestic	4 Russia-Domestic	2 Russia-Domestic 1 Russia-Domestic	1 Russia-Cosmos 2337-9/3 (1 Russia-Cosmos 2348	1 Russia-Cosmos 2358		
Start		0	0	0	0	1	0	1	0	1	0	3	0.3
	Small					1 Russia-Domestic		1 Israel-Gurwin		1 Russia-Zeya 0 US-Early Bird 1			
Tskylon		8	8	9	5	4	8	0	0	0	1	43	4.3
	MLV	8 Russia-Domestic	8 Russia-Domestic	9 Russia-Domestic 0 Czech-Magion 3	5 Russia-Domestic	4 Russia-Domestic	7 Russia-Domestic 1 Russia-Domestic				1 Russia-Cosmos (2352-2357)		

Appendix B. 1999–2001 Non-Addressable Payload Launch Demand

The following tables represent launch demand for missions not included in the near-term COMSTAC 1999 Commercial GSO Spacecraft Mission Model.

Table B-1 includes civil and military payloads, captive launches and Non-GSO spacecraft that utilize the same commercial launch systems and launch sites as the COMSTAC Commercial Mission Model.

Table B-2 captures launch demand for all U.S. Non-GTO launch sites. Some of the launch systems are the same launch systems used for the addressable payload forecast, but they utilize alternate launch sites. Both military and commercial launch systems are included in the forecast.

Table B-3 shows the forecast for non-addressable launch demand that utilizes foreign launch systems from launch sites not used for addressable commercial launches.

In the period through 1999, most launch procurement decisions have been made and the launch vehicle manifests have been established. Note, however, that even in this near-term period expected demand will vary from actual payloads launched due to supply side issues. The ground rules used to arrive at the forecasts presented are stated below:

Published manifests of the launch service providers were used unless a failure event or other recognizable event has caused a delay. Where manifests do not exist, or where an event which caused a delay has occurred, the subgroup relied on the data source within the subgroup that most likely had the superior knowledge. For example, the Boeing representative could modify the published manifest data for the Delta II, or a spacecraft manufacturer with knowledge of launch dates on a non-US launch system could provide the most up-to-date information on that system. Where the spacecraft has been ordered, but the launch company has not been selected, the date the operator contracted for satellite readiness was used. Plans of existing satellite service operators were used as available. Plans of new or potential operators (i.e., growth in demand) were subject to the judgment of the individual subgroup members.

Table B-1 1999-2001 Non-Addressable Payloads Using GTO Launch Sites
Payloads Not Included in COMSTAC Commercial Model
Forecasted Payloads as of March 26, 1999

	1999	2000	2001	Avg
Total	**38**	**39**	**18**	**32**
Ariane	**2**	**6**	**1**	**3**
	1 France-Helios 1B	1 ESA - XMM	0 ALP-Sat	
		1 ESA-Envisat 1	1 France-SPOT 5	
		1 France-Stentor		
		1 Italy-SICRAL		
		0 STRV 1C		
		0 STRV 1D		
		1 MSG 1		
Atlas	**6**	**6**	**1**	**4**
	1 NASA-GOES L	1 USAF	1 CD Radio 3	
	1 US Navy UHF-10	1 GOES M		
	1 USAF-DSCS MLV 8	1 NRO		
	1 ICO 1	1 ICO 6		
	1 NASA-TDRSS H	1 NASA-TDRSS I		
	1 US-NRO MLV 11	1 NASA-TDRSS J		
Delta	**11**	**11**	**10**	**11**
	1 NASA-Deep Space 2	1 Globalstar-4	1 NASA-Mars Orbiter	
	1 NASA-Stardust	1 ICO 7	1 Genesis	
	1 USAF-NAVSTAR 2R-3	1 SBIRS-LOW	1 GEOLITE	
	1 NASA-FUSE	1 ICO 10	1 USAF-NAVSTAR 2R-10	
	1 Globalstar-4	1 ICO 12	1 USAF-NAVSTAR 2R-11	
	1 Globalstar-4	1 NASA- MAP Probe	1 USAF-NAVSTAR 2R-12	
	1 ICO 4	1 USAF-NAVSTAR 2R-5	1 USAF-NAVSTAR 2R-13	
	1 Globalstar-4	1 USAF-NAVSTAR 2R-6	1 USAF-NAVSTAR 2R-14	
	1 USAF-NAVSTAR 2R-4	1 USAF-NAVSTAR 2R-7	1 USAF-NAVSTAR 2R-15	
	1 ICO 5	1 USAF-NAVSTAR 2R-8	1 SIRTF	
	1 Globalstar-4	1 USAF-NAVSTAR 2R-9		
H-II/A	**1**	**4**	**0**	**2**
	1 MTSat-1	1 ARTEMIS	1 MDS 2	
		1 ADEOS 2		
		1 MDS 1		
		1 DRTS-W		
Long March	**5**	**2**	**0**	**2**
	1 China Test	1 China 2EA Test		
	1 Tsinghua-1	1 Feng Yun 2C		
	1 Sinosat-2			
	1 Feng Yun 1C			
	1 Fenghuo 1			
Proton	**13**	**10**	**5**	**9**
	1 Raduga-37	1 CD Radio 1	1 Yamal 2b	
	1 Globus 1	1 CD Radio 2	1 Yamal 3a	
	1 Sesat	1 ICO 8	1 Yamal 3b	
	1 ICO 2	1 ICO 9	1 Ekspress K2	
	1 ISS Service Module	1 Yamal 2a	1 Ekspress K3	
	1 Govt	1 Kupon 2		
	1 ICO 3	1 Kupon		
	1 Yamal 1a	1 GALS 3		
	1 Yamal 1b	1 Ekspress A3		
	1 Gorizont 33	1 Ekspress K1		
	1 Express A1			
	1 Express A2			
	1 GALS			
Sea Launch	**1**	**1**	**0**	**1**
	1 Demonstration Launch	1 ICO 11		
TBD	**0**	**0**	**1**	**0**
			1 NEAP	

Table B-2. 1999-2001 United States Non-GTO Launch Sites

Payloads Not Included in COMSTAC Commercial Model
Forecasted Payloads as of March 26, 1999

	1999	2000	2001	Avg
Total	**16**	**19**	**14**	**16**
U.S. Eastern Ranges				
STS KSC	**5**	**8**	**10**	**8**
	1 Discovery STS-96 ISS-2A.1 1 Columia STS-93 Chandra 1 Endeavour STS-99 SRTM 1 Discovery STS-103 Svc 1 Atlantis STS-101 ISS 2A.2	1 Discovery STS-92 ISS 3A 1 Endeavour STS-97 ISS 4A 1 Atlantis STS-98 ISS 5A 1 Discovery STS-102 5A.1 1 Atlantis STS-100 6A 1 Discovery STS-104 7A 1 Endeavour STS-105 7A.1 1 Discovery STS-106 ISS U-F1	1 Discovery STS-107 Module 1 Endeavour STS-108 ISS 8A 1 Atlantis STS-109 ISS U-F2 1 Columbia STS-110 X-38 1 Atlantis STS-111 ISS 9A 1 Endeavour STS-109 ISS 9A.1 1 Discovery STS-113 ISS 11A 1 Atlantis STS-114 ISS 12A 1 Columbia STS-115 1 Discovery STS-116 ISS 12A.1	
Athena CCAS	**1**	**1**	**0**	**1**
	1 ROCSAT 1	1 USAF SBIRS-LADS USAF SBIRS-LOW		
Pegasus	**0**	**1**	**1**	**1**
		1 HESI	1 GALEX 1	
Taurus	**0**	**0**	**0**	**0**
Titan	**5**	**3**	**1**	**3**
	1 USAF-DSP 19 1 USAF-Milstar 3 1 DoD 1 Milstar 4 1 USAF DSP 20	1 DMS PS16 1 USAF DSP 21 1 USAF DSP 22	1 Milstar 5	
U.S. Western Ranges				
Athena	**2**	**1**	**0**	**1**
VAFB	1 Ikonos-1 1 Ikonos-2			
Kodiak Island		1 NASA-VCL		
Atlas VAFB	**1**	**1**	**0**	**1**
	1 NASA-Terra	1 USAF		
Delta VAFB	**6**	**4**	**1**	**4**
	1 USAF-ARGOS 0 SUNSAT 1 Landsat 7 1 Iridium-5 1 Iridium-5 1 Globalstar-4 1 Earth Orbiter 1 0 SAC-C	1 NASA Image 1 NASA Jason 0 NASA TIMED 1 NASA Gravity Probe B 1 NASA EOS-PM	1 NASA Mars Lander	
Pegasus	**4**	**0**	**0**	**1**
VAFB	1 NASA-Wire 1 TERRIERS 0 MUBLCOM 1 USAF TSX-5 1 OrbView-3			
Pegasus	**2**	**0**	**0**	**1**
Kwajalein	1 NASA HETE-2 1 ORBCOMM-7			
Taurus	**2**	**0**	**0**	**1**
	1 KOMPSAT 1 Multi-Spectral Therm Imager 0 ACRIM			
Titan	**5**	**0**	**0**	**2**
	1 US DoD 1 NASA QuikSCAT 1 DMSP S-15 1 NRO 1 NOAA-L			
TBD	**0**	**0**	**1**	**0**
			1 SCISAT-1 0 TSIM	

Table B-3 1999-2001 Foreign Non-GTO Launch Sites

Payloads Not Included in COMSTAC Commercial Model

Forecasted Payloads as of March 26, 1999

	1999	2000	2001	Avg
Total	**24**	**14**	**4**	**14**
China Taiyuan/Jiquan Launch Site				
Long March	**2**	**2**	**0**	**1**
ILV	1 SAC-1 0 CBERS-1	1 HY-1 1 OCEAN-1		
MLV	1 Shijian-5			
Russia Baikonur Cosmodrome				
Molniya	**0**	**0**	**0**	**0**
Tskylon	**0**	**0**	**0**	**0**
Soyuz	**12**	**4**	**1**	**6**
	1 Globalstar-4 1 Soyuz TM-29 Mir-Crew 1 Globalstar-4 1 Progess Module M-41 1 Progess Module M-42 1 Cosmos 1 Globalstar-4 1 Globalstar-4 1 Globalstar-4 1 ISS Progress Resupply 1 Globalstar-4 1 ISS Progress Resupply	1 ISS 2R - Crew 1 Soyuz TM 1 ESA-Cluster 1 1 ESA-Cluster 2	1 Mars Express	
Zenit	**0**	**0**	**0**	**0**
Russia-Plesetsk/Svobondny				
Cosmos	**3**	**3**	**3**	**3**
	1 ABRIXAS 2 Cosmos	1 Signal 1&2 2 Cosmos	1 GRC 2 Cosmos	
Molniya	**0**	**0**	**0**	**0**
Soyuz	**0**	**0**	**0**	**0**
Start	**3**	**2**	**0**	**2**
	1 Quickbird 2 1 ODIN 1 EROS-1	1 Quickbird 1 1 EROS-2		
Tskylon	**0**	**0**	**0**	**0**
India				
PSLV/GSLV	**1**	**3**	**0**	**1**
	1 DLR TUBSAT C 0 KITSAT 3 0 OCEANSAT 1	1 CARTOSAT 1 1 RESOURCESAT 1 PROBA		
Israel Palmahim				
Shavit	**2**	**0**	**0**	**1**
	1 David 1 OFEQ 5			
Japan Tanegashima				
M-5	**1**	**0**	**0**	**0**
	1 Lunar A			

Appendix C. FAA Request for Information Letter

25 January 1999

to:

Dear Mr. ,

As you know, the Office of the Associate Administrator for Commercial Space Transportation (AST) of the Federal Aviation Administration (FAA) commissions an annual update to the Commercial Spacecraft Mission Model for geo-synchronous satellites. Th mission model update is developed for the FAA by the Commercial Space Transportation Advisory Committee (COMSTAC), which is the industry advisory body that provides recommendations to the FAA on issues that affect the U.S. commercial launch industry. This report is used by the FAA and others to identify projected commercial space launch user requirements and to facilitate the planning of FAA support of the commercial space transportation industry. We are requesting your participation and need your response by February 25, 1999.

The Commercial Spacecraft Mission Model is now in the process of being updated for 1999. In support of this effort, our office requests inputs from various companies and organizations based on their forecasts of future spacecraft and launch needs. The COMSTAC Technology and Innovation Working Group then puts together the comprehensive mission model update based on these inputs.

Attached is a table that shows the different launch mass ranges and the years that will be forecasted. Please complete this table with your forecast of potential commercial geo-synchronous satellite launches through 2010. Responses should be comprehensive and represent your organization's projection of the entire commercial geo-synchronous satellite market. Your inputs will be integrated with the inputs from other companies to create the updated mission model. Projections of your organization's own future satellite and launch plans are also useful and will be factored into the overall model.

Again, your response is needed by February 25, 1999 to insure that the mission model update is as accurate as possible. The attachment will give you more detailed information on how and where to respond and contact points. Of course you may also contact my office with any questions or comments at your convenience.

Thank you for your support of this activity.

Sincerely,

Patricia G. Smith
Associate Administrator for
Commercial Space Transportation

1999 Commercial Geo-Synchronous Spacecraft Mission Model Update Instructions

As with the 1998 effort, the goal for the 1999 COMSTAC geo-synchronous mission model update is to forecast the demand for worldwide commercial space launch requirements based on the projected sales of geo-synchronous satellites and the size, in terms of mass, of those satellites. We are requesting your assistance in this effort by filling out the following table with your forecast of the addressable commercial geo-synchronous satellites sales through 2010. A projection of the addressable payloads in the low and medium earth orbit market (i.e., nongeo-synchronous orbits) will be completed by the FAA separately and a combined projection will be published.

For reference purposes, "addressable" payloads in this context are those payloads that are open for internationally competitive launch service procurement. Please do not include in your forecast those payloads that are captive to national flag launch service providers (i.e., USAF or NASA satellites, or similar European, Russian, Japanese, or Chinese government satellites that are captive to their own launch providers). If possible, please identify specific missions by name. In addition, if your forecast has changed significantly from the forecast that you submitted last year, please provide a brief explanation of the changes.

Your inputs, along with those of other satellite manufacturers, launch vehicle suppliers, and satellite services providers will be combined to form a composite view of the demand for launch services through 2010. We ask that each respondent forecast that part of the market that they know best. In some cases, it may be a forecast of your company's needs, or a regional market view, or you may submit a comprehensive world market demand model. Data from all of these types of inputs are essential to assuring a complete and comprehensive forecast of the future commercial satellite and launch needs. Please indicate in your response what type of forecast you are submitting. As this data will be used by corporations and governments in the administration of international space launch policy and decisions, an accurate and realistic projection is vitally important.

We are looking forward to receiving your response by February 25, 1999 in order to support our update schedule. Your responses should be sent directly to Mr. Don MacKenzie at the following address:

Mr. Don MacKenzie
Hughes Space and Communications International
M.S. SC/S41/A378
P.O. Box 92919
Los Angeles, CA 90009-2919

Phone: (310) 662-6576
Fax: (310) 662-8242
Email: dmmackenzie@mail.hac.com

If you have any questions, please contact Mr. MacKenzie directly. Thank you for your help.

1999 LEO Commercial Market Projections

Federal Aviation Administration's
Associate Administrator for
Commercial Space Transportation (AST)

May 1999

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EXECUTIVE SUMMARY

The Federal Aviation Administration's Associate Administrator for Commercial Space Transportation (AST) has prepared a projection of the low Earth orbit (LEO) commercial satellite launch market for the period 1999 to 2010. The *1999 LEO Commercial Market Projections* is the sixth annual assessment of launch demand for all commercial space systems in orbits other than geosynchronous orbit (GEO), and addresses launches to LEO, medium Earth orbit (MEO), and elliptical orbits (ELI). Launch demand was assessed for Little, Big, and Broadband LEO telecommunications systems, remote sensing satellites, foreign scientific, and other payloads.

Demand for commercial launches to low Earth orbit has rapidly increased over the past two years as multi-satellite telecommunications constellations have begun launching. In 1998, almost half of commercial launches worldwide were to LEO, including 14 launches for the Iridium, Globalstar, and ORBCOMM systems.

Although the number of LEO launches has increased over the past few years, the *1999 LEO Commercial Market Projections* anticipates deployment of the same number of systems as last year's forecast. The total number of launches projected, however, has decreased as broadband proponents increasingly plan to launch their systems using new, larger-lift launch vehicles. Another notable change also involves planned Broadband LEO systems. In May 1998, broadband competitors Teledesic and Celestri merged, with Motorola becoming Teledesic's prime contractor. Teledesic's first deployment launch now appears to be early 2003, shifting launch demand 18 months into the future.

As with previous *LEO Commercial Market Projections*, AST has developed two scenarios assessing LEO satellite and launch services demand through 2010—a "baseline" scenario and a "robust market" scenario. The "baseline" scenario assesses launch demand for those systems whose development and deployment currently appears likely during the forecast period, as assessed by AST. The "robust market" scenario assumes that market demand for LEO satellite services is sufficient to support expanded follow-on systems, as well as the entrance of new service providers. Both scenarios also include commercial remote sensing, foreign scientific, and other payloads.

Based on the information provided in this report, AST projects the following scenarios:

- **Baseline Scenario**: deployment and replenishment of three Little LEO, four Big LEO, and two Broadband LEO systems.
- **Robust Market Scenario**: deployment and replenishment of four Little LEO, five Big LEO, and three Broadband LEO systems.

The baseline scenario projects that 975 payloads will be deployed between 1999 and 2010, compared with 1,095 over the same period projected in last year's baseline scenario. The robust market scenario projects that 1,195 payloads will be deployed between 1999 and 2010, compared with 1,433 payloads projected in last year's robust market scenario. The number reductions are due in large part to changes in the configurations of the Broadband LEO systems.

The demand for commercial launches to LEO for the baseline scenario is projected to be an average of 15 medium-to-heavy and 11 small launches per year from 1999 to 2010. The number of launches is lower than in the *1998 LEO Projections* due to the expected greater use of new heavy-lift vehicles for deployment of one of the Broadband LEO systems. Launch demand for the robust market scenario is projected to be an average of 21 medium-to-heavy and 13 small launches per year over the forecast period.

INTRODUCTION

Historically, commercial launch demand has been almost exclusively for telecommunications satellites which provide telephony, television broadcasting, and data communications from geosynchronous orbit (GEO). Beginning in 1997, however, launches have been increasingly for multi-satellite constellations placed into non-geosynchronous orbits (NGSO), such as low Earth orbit (LEO), medium Earth orbit (MEO), and elliptical orbits (ELI). Launches for these so-called "LEO systems" are expected to account for more than half of all commercial launches over the next ten years.

In order to assess the demand for commercial launch services resulting from the deployment of LEO satellite systems, the Federal Aviation Administration's Associate Administrator for Commercial Space Transportation (AST) compiles the *LEO Commercial Market Projections* on an annual basis. This report was developed based on AST research and discussions with industry, including satellite service providers, satellite manufacturers, launch service providers, and independent analysts.

LEO Commercial Market Sectors

To assess demand for commercial launches to LEO, it is first necessary to understand the range of proposed LEO satellite systems. Multi-satellite systems––dedicated to serving the telecommunications markets––will produce the highest level of demand for LEO launch services during the forecast period. Multi-satellite systems are being developed in three categories:

- "Little LEO" systems providing narrowband data communications such as e-mail, two-way paging, and messaging using frequencies below 1 GHz. Target markets include automated meter reading and fleet tracking.
- "Big LEO" and other mobile satellite services (MSS) systems providing voice and data communications and operating in the 1-2 GHz frequency range. Target markets include mobile business users and fixed-site users in rural areas not served by terrestrial systems.
- "Broadband LEO" systems providing high-bandwidth data communications, including Internet, videoconferencing, and high-speed data services using Ku-band (12/17 GHz), Ka-band (17/30 GHz), V-band (36/45 GHz), and Q-band (46/56 GHz) frequencies.

Each of the three LEO telecommunications market segments has a different effect on demand for commercial launch services because they are orders of magnitude apart in size (i.e. total mass of the constellation). This is demon-strated in Figure 1, which shows mass to orbit versus frequency (both uplink and downlink) for systems currently licensed by the Federal Communications Commission (FCC).

Applications to the FCC for new spectrum allocations for LEO systems continue to be filed at a more rapid pace than the deployment of such systems. In 1997, there were three major

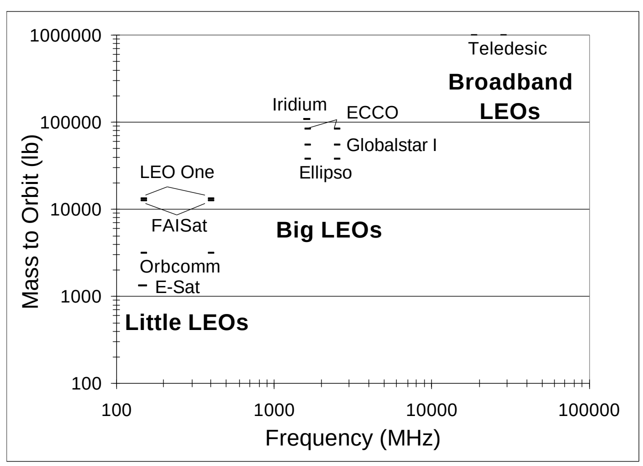

Figure 1 Licensed LEO Telecom Systems (Mass to Orbit vs. Frequency)

filings—one for mobile satellite services using the 2-GHz band, one for Broadband applications in the Q and V-bands, and one for fixed satellite services using the Ka-band. The latter filing included applications for new systems (both GEO and LEO), as well as additional spectrum for existing Ka-band licensees. In January 1999, five applications were filed for the Ku-band for Broadband LEOs, and Skybridge filed an amendment to its 1997 application.

While communications satellites are expected to be the primary driver of demand for commercial launch services to LEO, a number of commercial remote sensing systems are also expected to be deployed over the next decade. These remote sensing systems, encompassing a range of passive and active space-based techniques for observing the Earth, will contribute to demand for commercial launches, particularly for small launch vehicles.

In addition, foreign governments and research organizations generate a low but steady level of demand for commercial launches of payloads to LEO to conduct scientific research, including communications, microgravity exper-iments, and life sciences investigations.

Market Scenarios

For each publicly announced system, AST assessed progress in system design maturity, licensing, financing, contracting, target market development, and deployment plans, inter alia. Based on this information—and underlying assumptions about the LEO satellite services markets themselves—AST developed two market scenarios assessing LEO satellite and launch demand through 2010: a "baseline" scenario and a "robust market" scenario.

The "baseline" scenario assesses launch demand for those systems likely to be developed and deployed within the forecast period. The baseline scenario represents AST's assessment of how many systems will actually be launched, not how many will attract enough business to prosper after deployment. The baseline scenario assumes that once deployed, failed satellites will be replaced as needed, and that entire constellations will be replaced at the end of their useful life by systems of the same size and number, unless otherwise specified by the system proponent.

The "robust market" scenario assesses launch demand in the event that market demand for low Earth orbit satellite services is sufficiently great to support expanded follow-on systems, as well as the entrance of new service providers.

The baseline scenario reflects current development plans by the LEO satellite providers, and therefore represents the "baseline" expected to unfold over the forecast period. The robust market scenario reflects more optimistic—but reasonable—assumptions about greater than expected demand for LEO satellite services, representing a more "robust market" than the baseline.

Payload and Launch Projections

For each scenario, satellite projections were converted to launch projections based on an understanding of individual system deployment plans, satellite mass, and orbital configuration. Demand for commercial launches to LEO was assessed for two launch vehicle sizes—small launch vehicles (<5,000 lb to LEO, at 100 nm altitude and 28.5^{o} inclination), and medium-to-heavy launch vehicles (>5,000 lb, 100 nm, 28.5^{o}).

The study results do not indicate FAA support or preference for any particular proposal or system. Rather, the information provided reflects an AST assessment of overall trends in the LEO commercial satellite markets, with the ultimate purpose of projecting future space transportation demand.

LEO SATELLITE SYSTEMS

The demand for commercial launches to LEO is dominated by the deployment and maintenance of commercial communications constellations, i.e. the Little LEO, Big LEO, and Broadband LEO systems discussed above. Additional, but lower level demand is expected for launch of commercial and foreign remote sensing satellites, foreign scientific payloads, and others.

For each market segment, AST examined proposed systems to assess their progress toward development and launch. AST evaluated:

- System design maturity
- Licensing status and spectrum availability
- Business plan feasibility and/or maturity
- Spacecraft, ground services equipment, and launch services contracting status
- Financing status and partnerships secured
- Service provider agreement status

In addition, each market segment was examined to assess the number of systems it could sustain. AST assessed potential demand in each LEO market based on:

- Projected demand for target services (e.g. mobile telephony, data communications)
- Impact of competing technologies (e.g. cellular phones, GEO broadband systems, fiber optics)
- Government authorization and/or licensing processes, including spectrum availability
- Potential limitations on the availability of capital for space-based systems

Following examination of the data for each market segment, AST developed the baseline and robust market scenarios assessing LEO satellite and launch services demand through 2010, presented in the following section.

"Little LEO" Telecommunications Systems

The smallest of the LEO constellations, Little LEO systems provide narrowband data services such as e-mail, two-way paging, messaging, remote data monitoring, and asset tracking to fixed and mobile users using frequencies below 1 GHz. Little LEOs have been proposed by a wide variety of commercial and quasi-commercial organizations using store-and-forward capabilities (storing received messages until in view of a ground center) or functioning as relay systems. Two-way communication between the satellite and the ground is maintained through small mobile or fixed transmitter/receivers, using low-power omni-directional antennas. Proposed Little LEO systems are expected to cost between $50 and $300 million. Proposed Little LEO systems are shown in Figure 2.

In addition, a number of proposed "constellations" of mini- and micro-satellites and communications payloads exist to serve narrowband data markets, shown in Figure 4. These systems are expected to be deployed as secondary payloads or as piggybacks on other satellites. As such, they do not represent drivers of demand for commercial launch services.

Recent Developments In November 1998, ORBCOMM became the first Little LEO system to become operational, having completed deployment of its initial 28-satellite constellation in September 1998. ORBCOMM service rollout has encountered only minor difficulties rolling out its service which utilizes a wide variety of handsets and terminals optimized for different industrial and consumer applications. ORBCOMM has also developed a global network of 16 service distribution partners and is licensed to operate in over 100 countries. ORBCOMM has announced plans to expand its constellation to increase capacity, and received an amendment to its FCC license in March 1998 to allow operation of up to 48 satellites. Deployment of seven additional satellites in the equatorial plane is expected in mid-1999.

Progress toward deployment of the other Little LEO systems includes contract awards and equity partnerships. In January 1999, General Dynamics signed an agreement with Final Analysis to be an equity partner in FAISat. In April 1999, DBS Industries awarded contracts to Surrey Satellite Technology Ltd. and Eurockot Launch Services Gmbh to build and launch the six-satellite E-Sat constellation.

Licensing Status Five Little LEO systems have received licenses from the FCC—ORBCOMM, E-Sat, FAISat, Leo One USA, and VITASat. Licenses were issued in two rounds, in 1995 and 1998, both times following spectrum sharing agreements among the systems. Orbital Sciences, Starsys, and Volunteers in Technical Assistance (VITA) first filed applications with the FCC to operate Little LEO systems in 1990, receiving licenses in 1995 following spectrum allocation by the International Telecommunications Union (ITU) and agreement on spectrum sharing. In 1995, a second round of filings attracted five new applicants—E-Sat, CTA, Leo One USA, Final Analysis, and GE Americom. CTA’s GEMNet and GE Americom, which merged with Starsys, were withdrawn prior to being licensed. Following a second spectrum sharing agreement, licenses were awarded in 1998 to Leo One USA, FAISat, and E-Sat, and ORBCOMM and VITA received authority for modest system expansions.

Market Overview Business plans for ORBCOMM and the other Little LEOs center around corporate applications including monitoring of fixed assets, such as utility meters; mobile asset tracking, for trucking fleets; and two-way data messaging, for corporations and governments. As much as 70 percent of data messaging is expected to be machine-to-machine, without a person in the loop. The remaining 30 percent is expected to be paging, text messaging, and e-mail.

Little LEOs are targeted at corporations with far-flung assets, particularly with assets outside of dense urban areas where terrestrial systems are prevalent. According to an ITU study, the satellite addressable messaging market could be as large as 43 million subscribers, of which 18 million are in North America.

Competition Little LEO service providers will face competition from both terrestrial and satellite service providers. In dense urban areas, terrestrial providers are expected to dominate the market because the weaker satellite signals do not easily penetrate buildings. However, because of the relatively low system and ground terminal costs, as well as their global nature, Little LEO systems are expected to be competitive with conventional wireless technology in less dense and hard to reach areas.

Many proposed Big LEO systems also plan to offer position location, tracking, messaging, and e-mail as part of their core services, and may be competitive with Little LEOs on price in selected markets. However, the success of Little LEOs will depend on tailoring equipment to specific market niches, which Big LEO providers may not find economically viable. Additionally, American Mobile Corporation offers nationwide two-way data messaging using a combination of terrestrial networks and a GEO satellite.

Market Demand Scenarios It is AST’s assessment that under the baseline scenario, three Little LEO systems will be deployed and replenished over the forecast period. One system, ORBCOMM, has deployed an initial constellation and is expected to expand capacity in the coming year. Final Analysis has launched two experimental satellites for its FAISat constellation. Under the robust market scenario, AST projects deployment of four Little LEOs.

System	Operator	Prime Contractor	Satellites Number + Spares	Satellites Mass (lb)	Orbit	First Launch	Status
Operational							
ORBCOMM	ORBCOMM Global LP	Orbital	48	95	LEO	1997	Operational with 28 satellites on orbit; FCC licensed, October 1994
Under Development							
FAISat	Final Analysis	Final Analysis	38	332	LEO	2001	FCC licensed, March 1998; two test satellites launched in 1995 and 1997
LEO One USA	LEO One USA	TBD	48	275	LEO	2001[1]	FCC licensed, February 1998
E-Sat	E-Sat, Inc.	Alcatel	6	250	LEO	2002	FCC licensed, March 1998; launch contract signed with Eurockot
Gonets-D	Smolsat (Russia)	NPO PM	36	510	LEO	TBD	Status unknown; 6 test sats launched in 1996 and 1997 based on military system
KITComm	KITComm (Australia)	AeroAstro LLC	21	220	LEO	2000	Licensed by Australia
Proposed							
Courier/Convert	ELAS Courier (Russia)	Moscow Inst. Thermotechnics	8 to 12	1,107	LEO	TBD	Status unknown
LEO One Panamericana	LEO One Pan. (Mexico)	TBD	12	330	LEO	TBD	Licensed for operations by the Mexican government
LEOPACK	Space Agency of Ukraine	TBD	28	TBD	LEO	TBD	Unfunded
Canceled							
Starsys	GE/Starsys	Alcatel	24	165	LEO	--	FCC licensed, 1995; canceled 1997
GE Americom	GE Americom	--	24	33	LEO	--	Merged with Starsys in 1996
GEMNet	CTA	CTA	38	100	LEO	--	CTA bought by OSC; GEMNet canceled

(1) LEO One USA plans to launch two test satellites in 2000.

Figure 2 Little LEO Satellite Systems

System	Operator	Prime Contractor	Satellites Number + Spares	Satellites Mass (lb)	Orbit	First Launch	Status
VITASat	Volunteers in Technical Assistance	Final Analysis	2	198	LEO	2001	FCC licensed, 1995; communications package piggybacked on FAISat-2v satellite launch in 1997
SAFIR	OHB Teledata (Germany)	OHB Systems	6	132	LEO	TBD	In development; SAFIR 2 launched as secondary on Zenit in 1998; SAFIR 1 comm payload on Resurs-O1 in 1994
IRIS	SAIT RadioHolland (Belgium)	SAIT Systems	2-6	132	LEO	TBD	In development; derived from SAFIR; comm payload on Resurs-O1 in 1998
Temisat	Telespazio (Italy)	Kayser Threde	7	88	LEO	TBD	On hold; Temisat 1 launched in 1993
Elekon	NPO PM/ Elbe Space (Russia/German)	NPO PM	7	TBD	LEO	TBD	Status unknown; comm package piggybacks on Tsikada navigation sats

Figure 3 "Micro" LEO Satellite and Payload Proposals

"Big LEO" and MSS Voice Systems

Big LEO systems—such as Iridium and Globalstar—provide mobile telephony services on a global basis through a network of satellites to handheld receivers, similar to cellular phones. Also known as mobile satellite services (MSS) or global mobile personal communications systems (GMPCS), Big LEO systems are targeting two primary market segments—business users who want seamless communications wherever they go, and fixed-site users where terrestrial services are too expensive to provide.

Only one Big LEO—Iridium—has completed deployment of its constellation. A second, Globalstar, is currently deploying its system and ICO, an MSS voice system in the 2.0 GHz band, plans to begin launching in the summer of 1999. In addition, there have been proposals for at least 15 other systems, including follow-on systems for Iridium and Globalstar. Costs to develop and deploy these systems are estimated to be between $1.3 and $5 billion. Proposed Big LEO and MSS voice constellations are detailed in Figure 2.

Recent Developments In November 1998, Iridium became the first Big LEO system to become operational, completing deployment of a 66-satellite constellation. Iridium conducted 20 launches in 20 months, launching 88 satellites (including two mass simulators) on three vehicle types—Delta II, Proton, and Long March 2C.

Since its introduction, however, Iridium has encountered difficulties resulting in significantly lower subscriber levels and revenues than expected. Problems with Iridium's initial commercial operations include a lack of availability of phones and pagers, a shortage of fully-trained service providers and sales personnel, and a lack of effective marketing coordination among Iridium, its gateways and its service providers. In March 1999, Iridium was forced to renegotiate some of its debts to seek waivers from projected subscriber requirements.

The second Big LEO to begin deployment of its constellation—Globalstar—also encountered difficulties over the past year. After the successful launch of its first eight satellites aboard two Delta II rockets in early 1998, Globalstar suffered a serious setback when the first of three planned Zenit rocket launches failed on September 10, 1999, destroying 12 satellites. The failure forced Globalstar to significantly revise its deployment plans, adding nine additional flights—six on Delta II and three on Soyuz. The result was a six-month delay in orbiting the 48-satellite constellation to end-1999. Globalstar plans, however, to introduce commercial service by the end of September 1999 with 32 satellites on orbit.

Licensing Status In 1990, the FCC received applications from six companies for Big LEO systems to provide mobile satellite services. Following a spectrum sharing plan developed in 1994, licenses were granted to Iridium, Globalstar, and Odyssey in January 1995. Following this, AMSC withdrew its application. Licenses for both ECCO and Ellipso were granted in the summer of 1997.

In September 1997, the FCC finished accepting applications for use of the 2.0 GHz band. As part of this filing, all four Big LEO licensees expressed their intent to launch follow-on systems (licensed to operate at 1.8 and 2.2 GHz), as well as new constellations to use the 2.0 GHz spectrum. These new systems included Iridium Macrocell (also referred to as Salina), Globalstar GS-2, ECCO II, and Ellipso 2G. Boeing proposed a 2.0 GHz, 16-satellite MEO system to provide aeronautical support services to the commercial airline industry.

At the same time, Inmarsat spin-off ICO Global Communications filed a letter of intent with the FCC to operate in the United States. While ICO is not yet authorized to operate in the United States, the FCC reaffirmed allocation of the 2.0-GHz band—which ICO intends to use—

for mobile satellite services in December 1998. Following the September 1997 application, TRW withdrew its application for Odyssey in favor of a partnership with ICO.

In the international arena, Russian organizations have proposed a number of Big LEO systems, although their eventual deployment remains uncertain due to Russia's continued financial difficulties. The development of one or more of the proposed Russian systems will likely not affect U.S. commercial launch demand, as they will probably not use U.S. launch services. In August 1998, the Brazilian Space Agency resumed study of its proposed ECO-8 equatorial satellite system. The project was put on hold in early 1997.

Market Overview Planned Big LEO systems focus on providing mobile telephony and paging to two primary markets—international business travelers and rural fixed-site users. Big LEO systems can enable international travelers to connect to public switched telephone networks (PSTNs) from anywhere in the world via satellite. Several Big LEO systems also plan to provide telephone services to rural users in developing countries through fixed sites, or so-called "village phone booths." Installation of fixed-site satellite phones is expected to be more cost effective than building traditional terrestrial or cellular infrastructures.

While long-term demand for mobile telephony is expected to be extremely robust, the number of subscribers for satellite telephony systems remains a topic of much debate. While the service remains attractive due to its global, one-phone, one-bill service, higher costs and the continuing growth of terrestrial cellular systems will limit satellite systems to only a small percentage of worldwide mobile telephony users. With the increasing spread of terrestrial cellular systems, interoperability with existing cellular networks has become a central component of Big LEO business plans.

Competition Global mobile satellite telephony will face competition from the expansion of terrestrial and cellular networks as well as GEO satellite service providers offering regional telephony services. In general, satellite systems cannot compete directly with terrestrial wireless and wireline infrastructure in areas of high population density, either in terms of price or in terms of service quality. However, satellite service providers may be more effective in competing for international business travelers accustomed to paying high per-minute rates for telephone services. In addition, satellite systems can acquire fixed-site customers where terrestrial infrastructure does not exist, or is not practical due to low population density or terrain.

Competition will also come from GEO satellites providing regional mobile telephony, which have competitive advantages and disadvantages compared to LEO systems. While proposed GEO systems provide regional rather than global services, they will likely offer mobile and fixed-site telephony for lower cost than LEO systems. However, it is likely that both types of systems will be deployed, with each developing market niches based on price and service offered.

Market Demand Scenarios It is AST's assessment that under the baseline scenario, four Big LEO systems will be deployed and replenished through 2010. This includes Iridium, which has already been deployed, Globalstar which is currently deploying, and ICO which is under construction. AST projects deployment of a fourth Big LEO system in late 2000. AST projects that each Big LEO operator will deploy follow-on systems with similar characteristics at the end of each initial system's lifetime.

It is AST's assessment that under the robust market scenario, five Big LEO systems will be deployed and replenished. At the end of its on-orbit lifetime, each system would be replaced by higher capacity follow-on, or expansion, systems to meet growing market demand.

System	Operator	Prime Contractor	Satellites		Orbit	First Launch	Status
			Number + Spares	Mass (lb)			
Operational							
Iridium	Iridium LLC	Motorola	66 + 6	1,500	LEO	1997	FCC licensed, January 1995; constellation on-orbit and operational
Under Development							
Big LEO							
Globalstar	Globalstar LP	Alenia Spazio	48 + 8	985	LEO	1998	FCC licensed, January 1995; launching
ECCO	Constellation Communications	Orbital	46 + 8[1]	1,550	LEO	2001	FCC licensed, July 1997; Orbital chosen satellite, launch contractor, May 1998
Ellipso	Mobile Comm. Holdings (MCHI)	Boeing	16 + 1	2,200	LEO & ELI	2001	FCC licensed, July 1997; Boeing selected satellite contractor, May 1998
2.0 GHz							
ICO	ICO Global Communications	Hughes Space & Comm. (HSC)	10 + 2	6,050	MEO	1999	FCC letter of intent filed, September 1997; launch & satellite contracts signed
Proposed							
2.0 GHz							
Boeing 2.0 GHz	Boeing	TBD	16	6,400	MEO	2005 est.	FCC license applied for, September 1997
ECCO II	Constellation Communications	TBD	46 + TBD	1,290	LEO	2005 est.	FCC license applied for, September 1997
Ellipso 2G	Mobile Comm. Holdings (MCHI)	TBD	26 + TBD	2,900	LEO & ELI	2004 est.	FCC license applied for, September 1997
Globalstar GS-2	Globalstar LP	TBD	64 + TBD	1,830	LEO[2]	2005 est.	FCC license applied for, September 1997
Iridium Next Generation (INX)/Salina (aka Macrocell)	Iridium LLC	TBD	96 + TBD	3,775	LEO	2005 est.	FCC license applied for, September 1997
International							
ECO-8	Brazilian Space Agency	TBD	12	550	LEO	TBD	Study resumed in August 1998; Frequency use coordinated with ITU
Gonets-R	Smolsat (Russian)	NPO PM	48	2,100	LEO	TBD	Status unknown
Koskon	Koskon Consortium (Russian)	AKO Polyot	45	1,900	LEO	TBD	Status unknown; payload tested in 1991
Marathon/Mayak	Informkosmos (Russian)	NPO PM	10	5,533	ELI[3]	TBD	Status unknown
Rostelesat	Kompomash (Russian)	TBD	115	1,850	LEO & MEO	TBD	Concept definition complete; awaiting funding
Signal	KOSS Consortium (Russian)	NPO Energia	48	680	LEO	TBD	Status unknown
Tyulpan	NPO Lavotchkin (Russian)	TBD	6	TBD	MEO	TBD	Status unknown
Canceled							
AMSC	American Mobile Satellite	--	12	5,500	MEO	--	FCC application withdrawn, January 1997
Odyssey	TRW	TRW	12	4,880	MEO	--	FCC licensed; system canceled in 1997

(1) ECCO to initially consist of 12 satellites in equatorial orbit; 42 satellites in inclined orbit to follow.
(2) Globalstar GS-2 also requested authority to operate 4 GEO satellites in conjunction with the LEO.
(3) Marathon is also proposed to include three Arcos GEO satellites.

Figure 4 Big LEO and MSS Voice Satellite Systems

"Broadband LEO" Systems

While Big LEOs dominate near-term demand for commercial LEO launches, Broadband LEO systems, if deployed, will greatly increase launch demand in the 2001-2005 timeframe. Over the past year, a number of developments have altered the forecast for deployment of these systems, including the merger of Teledesic and Celestri, an expansion of SkyBridge's constellation, and additional filings with the FCC.

Proposed Broadband LEO systems provide high bandwidth data transmission for such applications as high-speed data communications, Internet access, and video-teleconferencing. Broadband systems are proposed for the Ku, Ka, and V/Q-band frequencies and are estimated to cost between $4 and $11 billion. Broadband LEO systems are summarized in Figure 5.

Recent Developments In May 1998, the two leading Broadband LEO systems—Teledesic and Celestri—consolidated efforts when Motorola became Teledesic's prime contractor, shelving its own Celestri system. Motorola received a 26 percent stake in Teledesic in exchange for an investment of $750 million which included cash and the value of design heritage from Celestri. Boeing's role, which was that of prime contractor, is now unclear, as is that of Matra Marconi, one of Celestri's equity partners.

Since the merger, Teledesic's satellite configuration has undergone major review by the project's partners. As of this writing, no changes to Teledesic's configuration have been announced, and no modifications to Teledesic's FCC license have been filed to reflect Motorola's participation. However, there is considerable speculation that the number of satellites in Teledesic's constellation will decrease to somewhere near the midpoint between the current 288-satellite configuration and Celestri's 63-satellite system. Individual satellite mass is also expected to increase closer to the midpoint between Teledesic's 3,300 lb and Celestri's 7,000 lb. For purposes of this report, Teledesic's configuration is based on the midpoint between the two configurations, i.e. 176 satellites weighing 5,150 lb each. The resulting constellation is only 5 percent lighter in terms of deployed mass on-orbit.

With no announcement on the system's final design and the role of each of the major participants, Teledesic's first launch is now expected no sooner than early 2003. In addition, the cost to develop and deploy the system is now estimated by Teledesic to be $11 billion, instead of $9 billion.

In June 1998, SkyBridge—the only other broadband system under active development—announced significant changes to its constellation, increasing the number of satellites from 64 to 80, and increasing the mass of each satellite from 1,770 to 2,750 pounds. SkyBridge plans to launch a sub-constellation of 40 satellites beginning in 2002, with the remaining 40 to follow for increased system capacity.

SkyBridge received a boost in its bid for a license from the FCC in November 1998 when the FCC opened a proceeding on rules for Ku-band non-geostationary satellite systems to share spectrum with existing geostationary satellites users. SkyBridge contends that the Ku-band can be shared without interfering with GEO satellites. SkyBridge's partners include the French space agency CNES and U.S.-satellite manufacturer Loral.

Licensing Status Currently, only one system—Teledesic—has received a license from the FCC to operate a Broadband LEO system; however, at least 20 systems have filed applications with the FCC and are awaiting licensing.

In 1997, the FCC issued licenses to several applicants for the use of Ka-band frequencies for broadband data applications. While the majority of these licenses are for GEO satellites, Teledesic received the only license issued for NGSO systems. Several months later, in September 1997, Teledesic filed an modification to its license proposing a 288-satellite configuration, down from the licensed 840 satellites. The amendment was approved in January 1999.

Three rounds of applications have been filed with the FCC for Broadband LEO systems. In September 1997, the FCC finished accepting applications for the use of frequency bands between 30 and 60 GHz, commonly referred to as V-band (36/45 GHz) and Q-band (46/56 GHz). The FCC received 13 applications, including seven proposals for constellations using LEO and MEO orbits. Several applicants proposed hybrid constellations that pair LEO or MEO satellites with GEO satellites.

Shortly thereafter, in December 1997, applications were filed for Ka-band systems which would use the same spectrum as the already-licensed Teledesic. Applications were filed for Hughes's Spaceway NGSO, Lockheed Martin's MEO proposal, Alcatel's SkyBridge II, and others. Motorola's Celestri, also a Ka-band proposal, was filed for in June 1997, but its future is uncertain, as mentioned above.

In January 1999, the FCC accepted applications for non-geostationary systems to use the Ku-band for which SkyBridge had filed in February 1997. SkyBridge had argued that its use of the Ku-band would not interfere with the operation of the existing geostationary satellites which use the Ku-band. Re-use of the spectrum by non-geostationary systems would increase spectrum availability.

Market Overview Proposed broadband data communication satellite systems plan to provide instant, worldwide high-speed data transmission. Target markets for broadband satellite systems include multinational corporate data transmission and Internet service providers. Global demand for future broadband communication services is expected to be robust; market estimates are in the range of $100 billion by 2006, with satellites able to address much of that market demand.

Competition Broadband LEO systems will face competition from planned terrestrial networks and GEO satellite systems capable of offering similar high-bandwidth data communications. The degree to which satellites can capture this market primarily depends on whether terrestrial systems will be able to cost-effectively serve the market. Satellites will be most competitive where there is no existing terrestrial infrastructure due to the high cost of installing wirelines, either fiber optic or copper. Satellites are less likely to be able to compete directly with terrestrial infrastructure that provides broadband services to consumer and business users; terrestrial systems are likely to be less expensive. Satellite systems also have the potential competitive advantage of providing "bandwidth on demand," allowing users to pay only for what they use, not for open-ended access to the network, enabling users to better manage costs.

LEO and MEO systems providing broadband services will also compete with planned GEO broadband systems. AST anticipates that neither type of system will have sufficient competitive advantages to outperform the other; the service quality of LEO systems will attract some users while the likely lower prices of GEO services will attract others. As a result, both types of systems are likely to be deployed.

Market Demand Scenarios It is AST's assessment that under the baseline scenario, two Broadband LEO systems will be deployed and maintained through 2010. The two systems under active development appear likely to be deployed, however, the actual timing and configuration of these systems are still in flux. Under the robust market scenario, AST projects that three Broadband LEO systems will be deployed and maintained through 2010.

System	Operator	Prime Contractor	Satellites Number + Spares	Satellites Mass (lb)	Orbit	First Launch	Status
Under Development							
Ka-Band							
Teledesic	Teledesic LLC	Motorola	63 - 288[1]	3,300 – 7,000[1]	LEO	2003 est[2]	FCC licensed, March 1997; license amended Jan 1999 for 288-sat system; current configuration in flux
Ku-Band							
SkyBridge	Alcatel Espace	TBD	80	2,750	LEO	2002 est.	FCC license applied for, February 1997
Proposed							
Ka-Band							
Celestri	Motorola	Matra Marconi	63 + 7	7,000	LEO	TBD	FCC license applied for, June 1997; application amended to eliminate frequency overlap with Teledesic after Motorola joined Teledesic in May 1998
@Contact	@Contact LLC	TBD	16 + 4	7,500	MEO	2006 est.	FCC license applied for, December 1997
LM-MEO[3]	Lockheed Martin	Lockheed Martin	32	4,800	MEO	2005 est.	FCC license applied for, December 1997
SkyBridge II	Alcatel Espace	TBD	96	5,850	LEO	2005 est.	FCC license applied for, December 1997
Spaceway NGSO	Hughes Comm. (HCI)	Hughes Space & Comm. (HSC)	20	6,300	MEO[4]	2005 est.	FCC license applied for, December 1997
WEST	Matra Marconi	Matra Marconi	9	8,800	MEO[5]	TBD	Under development
Ku-Band							
Boeing NGSO FSS	Boeing	TBD	20	8,515	MEO	2005 est.	FCC license applied for, January 1999
HughesLINK	Hughes Comm. (HCI)	Hughes Space & Comm. (HSC)	22	6,475	MEO	2005 est.	FCC license applied for, January 1999
HughesNET	Hughes Comm. (HCI)	Hughes Space & Comm. (HSC)	70	4,400	LEO	2005 est.	FCC license applied for, January 1999
Teledesic Ku-Band Supplement (KuBS)	Teledesic LLC	TBD	30 + 6	2,920	MEO	2005 est.	FCC license applied for, January 1999
Virtual GEO Satellite (VIRGO)	Virtual Geosatellite LLP	TBD	15 + 3	6,680	ELI	2005 est.	FCC license applied for, January 1999
V/Q-Band							
Globalstar GS-40	Globalstar LP	TBD	80 + TBD	2,700	LEO	2005 est.	FCC license applied for, September 1997
GSN (Global EHF Satellite Network)	TRW	TRW	15	13,150	MEO[6]	2005 est.	FCC license applied for, September 1997
LM-MEO[3]	Lockheed Martin	Lockheed Martin	32	4,800	MEO	2005 est.	FCC license applied for, December 1997
M-Star	Motorola	TBD	72 + 12	4,400	LEO	2005 est.	FCC license applied for, September 1996
Orblink	Orbital	Orbital	7 + TBD	4,450	MEO	2005 est.	FCC license applied for, September 1997
Pentriad	Denali Telecom	TBD	9 + 3	4,400	ELI	2005 est.	FCC license applied for, September 1997
Starlynx	Hughes Comm. (HCI)	Hughes Space & Comm. (HSC)	20	7,700	MEO[7]	2005 est.	FCC license applied for, September 1997
Teledesic V-Band Supplement (VBS)	Teledesic LLC	TBD	72 + 36	1,350	LEO	2006 est.	FCC license applied for, September 1997

(1) A revised Teledesic configuration may range from 288 satellites at 3,300 lb as licensed down to 63 sats at 7,000 lb as contained in Celestri's application.
(2) Teledesic launched the T-1 experimental satellite in February 1998.
(3) Lockheed Martin's MEO application is for both Ka- and V/Q-band.
(4) Spaceway NGSO to be operated with 16 Spaceway GEO satellites.
(5) Matra intends to operate 1 to 2 GEO sats in conjunction with the WEST MEO sats.
(6) TRW plans to operate 4 GEO sats with the 15 GSN MEO satellites.
(7) Starlynx plans to operate 4 GEO satellites in conjunction with its MEO system.

Figure 5 Broadband LEO Satellite Systems

Remote Sensing Systems

A number of companies are developing remote sensing systems for LEO which will use commercial launch services. At least three companies—Space Imaging, ORBIMAGE, and EarthWatch—are expected to launch their first high-resolution satellites in 1999. Space Imaging's first spacecraft, Ikonos-1, was lost in a failed launch attempt in April 1999. Proposed remote sensing programs are detailed in Figure 6.

The development of commercial remote sensing systems has been given a boost over the past year by the U.S. National Imagery and Mapping Agency (NIMA), which has announced that it will invest hundreds of millions of dollars in utilizing imagery from commercial systems. NIMA has signed contracts with several firms, including EarthWatch and ORBIMAGE.

Because remote sensing satellites are not part of large constellations, they do not represent a significant demand for commercial launch services. However, if a viable market for commercial imagery appears, there will be a low but steady demand for launches of small launch vehicles for remote sensing satellites. Commercial launch services may also be used to launch military remote sensing spacecraft for countries without launch capabilities.

Foreign Scientific Payloads

Demand for commercial launch services also comes from foreign governments and research organizations that launch small spacecraft to conduct scientific research in LEO, including microgravity, life sciences, and communications experiments. Demand for such launches is expected to steadily increase over the forecast period and has been incorporated into the projections in this report. Projections of demand for launches of U.S. government-sponsored scientific payloads are not included in this report.

Other

Also included in the *1999 LEO Forecast* is CD Radio, which plans to provide satellite radio to North America. CD Radio originally planned to launch two GEO spacecraft, but now plans to launch three satellites to a highly elliptical orbit on three separate launches in early-to-mid 2000.

Operator	System	Manufacturer	First Launch	Mass (lb)	Satellites	Highest Resolution	Status
Under Development							
ORBIMAGE	OrbView	Orbital Sciences	1995	607	4		First 2 sats launched under NASA cooperative program
					OrbView-1	10 km	Launched 1995; weather info
					OrbView-2	1 km	Launched 1997; ocean imagery
					OrbView-3	1 m	Launch 1999; high resolution
					OrbView-4	1 m	Launch 2000; hyperspectral
Space Imaging	IKONOS	Lockheed Martin	1999	1,600	2	1 m	Ikonos-1 launch failed Apr 1999; Ikonos-2 to launch late 1999
EarthWatch	QuickBird	Ball Aerospace	1999	2,000	2	1 m	QuickBird-1 to launch late 1999
West Indian Space	EROS	Israeli Aircraft Industries	1999	550	8	1.5 m	Backed by Israeli government; EROS-A1 to launch late 1999
Resource-21	Resource-21	Boeing	2003	TBD	4	10 m	Definition studies underway
RDL Space Corp.	Radar1	TBD	2001	TBD	1	1 m	Licensed by Commerce, Jun 98
GER Corporation	GEROS	TBD	2002	1,750	6	12 m	Multi-spectral
Canceled							
EarthWatch	EarlyBird	Orbital Sciences	1997	686	EarlyBird-1	3 m	Sat failed after Dec 1997 launch

Figure 6 Commercial Remote Sensing Satellites

PAYLOAD AND LAUNCH PROJECTIONS

Following the assessment of proposed LEO commercial satellite systems, AST developed the baseline and robust market scenarios projecting LEO satellite and launch demand through 2010. The baseline scenario includes those systems whose deployment currently appears likely. The robust market scenario assumes that high demand for LEO satellite services will allow the deployment of follow-on and expanded systems.

Launch demand is assessed for two launch vehicle sizes—small launch vehicles (<5,000 lb, 100 nm, 28.5^{o}) and medium-to-heavy launch vehicles (>5,000 lb). If launch vehicle selection had already been made by the system operator, it was incorporated directly into the assessment. If vehicle selection was not known, assumptions were made based on the number of spacecraft, mass, orbit, and number of satellites per plane.

Launch vehicle selection for deployment of the initial Big LEOs is well understood, typically involving vehicles with performance of 6,000-11,000 lb to high inclination orbits, such as Delta II and Proton. For deployment of one Broadband LEO, a mix of medium-to-heavy vehicles with average performance of 30,000 lb per launch to high inclination orbit was assumed. This higher average performance reflects current plans to use heavier-lift launch vehicles such as the Delta 4 and Atlas 5 currently under development through the Evolved Expendable Launch Vehicle (EELV) program. Deployment of Little LEOs is expected to use only small launch vehicles.

Baseline Scenario

The baseline scenario reflects the deployment of four Big LEO, three Little LEO, and two Broadband LEO systems. It includes operations and maintenance, and anticipates deployment of follow-on systems with similar characteristics at each constellation's end of life. In addition, it includes a low but steady demand for commercial launches to deploy remote sensing and foreign scientific payloads.

The baseline scenario projects that 975 payloads will be deployed between 1999 and 2010, as shown in Figures 7 and 8. This is slightly lower than the 1,095 payloads projected over the same period in last year's baseline scenario. The slight decrease in payloads is due primarily to the reduction in the number of broadband satellites deployed as discussed in the section on Broadband LEOs.

Launch demand for the baseline scenario is projected to be an average of 15 medium-to-heavy and 11 small launches per year from 1999 to 2010. Demand for medium-to-heavy launch vehicles is level from 2003 to 2006 with the deployment of Broadband LEO systems in 2003 and 2004 and Big LEOs in 2005 and 2006. Launch demand is shown in Figures 7 and 9. Due to the increased use of larger launch vehicles by broadband systems, peak launch demand is expected to be lower than projected in 1998, as shown in Figure 13.

Robust Market Scenario

The robust market scenario reflects deployment and maintenance of five Big LEO, four Little LEO, and three Broadband LEO systems, and anticipates deployment of a mix of follow-on and expansion systems to meet robust market demand for LEO services. In addition, the scenario includes a low but steady demand for commercial launches to deploy remote sensing and foreign scientific payloads.

The robust market scenario projects that 1,195 payloads will be deployed over the forecast

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	TOTAL
Payloads													
Broadband LEO	0	0	0	10	108	104	21	31	23	13	13	13	336
Big LEO	62	17	10	18	13	9	69	70	18	13	9	9	317
Little LEO	8	16	10	38	38	2	26	14	36	32	14	14	248
Remote Sensing/Science/Other	7	7	5	5	4	5	7	6	6	7	7	8	74
Total Payloads	**77**	**40**	**25**	**71**	**163**	**120**	**123**	**121**	**83**	**65**	**43**	**44**	**975**
Launch Demand													
Medium-to-Heavy (>5,000 lb LEO)	17	13	3	7	23	25	23	25	15	11	12	11	185
Small (<5,000 lb LEO)	10	8	9	13	12	7	13	11	14	13	10	11	131
Total Launches	**27**	**21**	**12**	**20**	**35**	**32**	**36**	**36**	**29**	**24**	**22**	**22**	**316**

Figure 7 Baseline Scenario Payload and Launch Projections

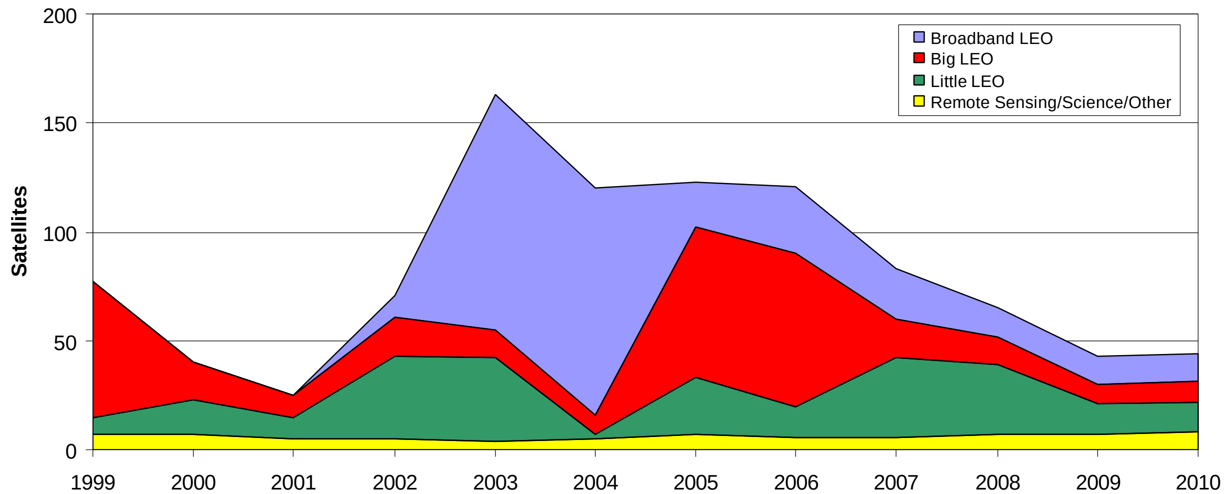

Figure 8 Baseline Scenario Payload Projection

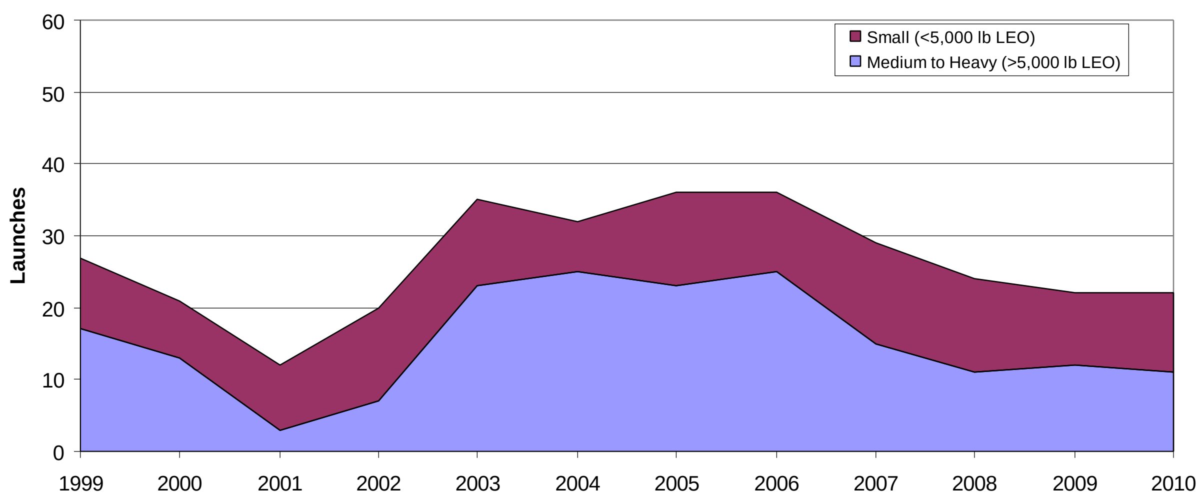

Figure 9 Baseline Scenario Launch Demand Projection

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	TOTAL
Payloads													
Broadband LEO	0	0	0	10	108	104	23	41	31	13	13	13	356
Big LEO	62	17	16	24	43	40	88	81	23	26	30	47	497
Little LEO	8	22	10	38	38	2	26	14	42	32	14	14	260
Remote Sensing/Science/Other	8	8	6	7	6	6	7	6	6	7	7	8	82
Total Payloads	**78**	**47**	**32**	**79**	**195**	**152**	**144**	**142**	**102**	**78**	**64**	**82**	**1,195**
Launch Demand													
Medium-to-Heavy (>5,000 lb LEO)	17	13	5	9	28	31	33	42	23	14	17	18	250
Small (<5,000 lb LEO)	11	11	10	15	15	8	14	14	20	14	11	12	155
Total Launches	**28**	**24**	**15**	**24**	**43**	**39**	**47**	**56**	**43**	**28**	**28**	**30**	**405**

Figure 10 Robust Market Scenario Payload and Launch Projections

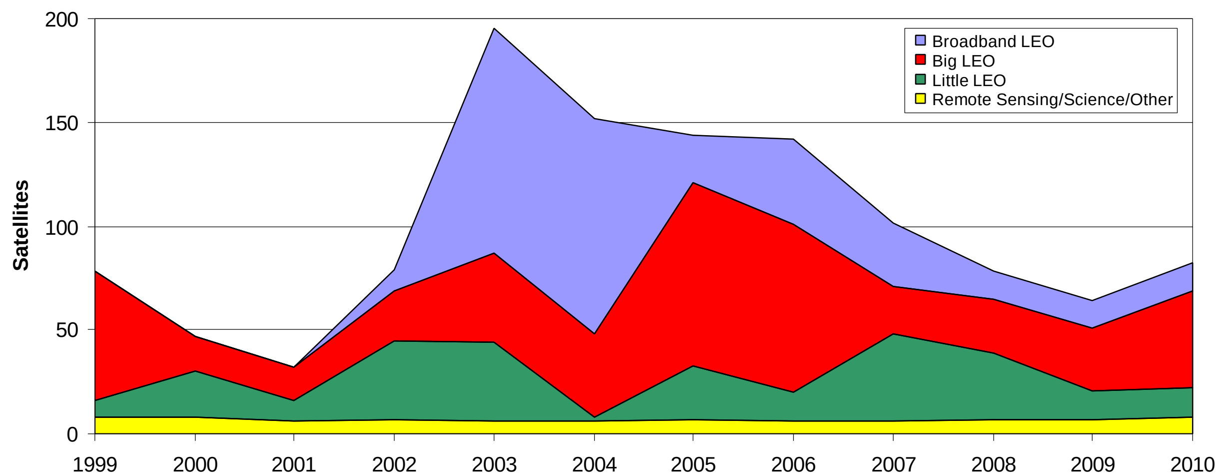

Figure 11 Robust Market Scenario Payload Projection

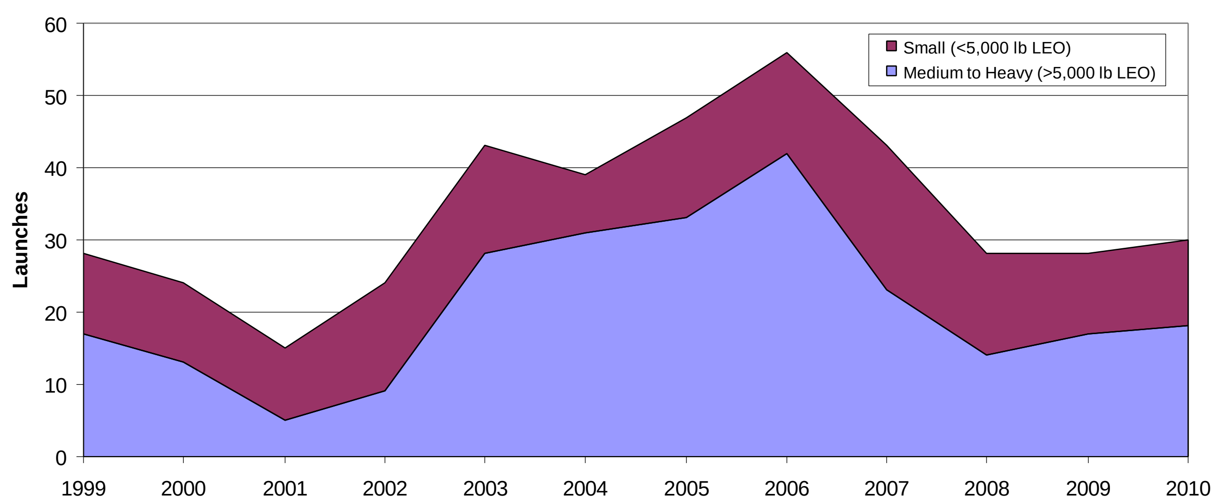

Figure 12 Robust Market Scenario Launch Demand Projection

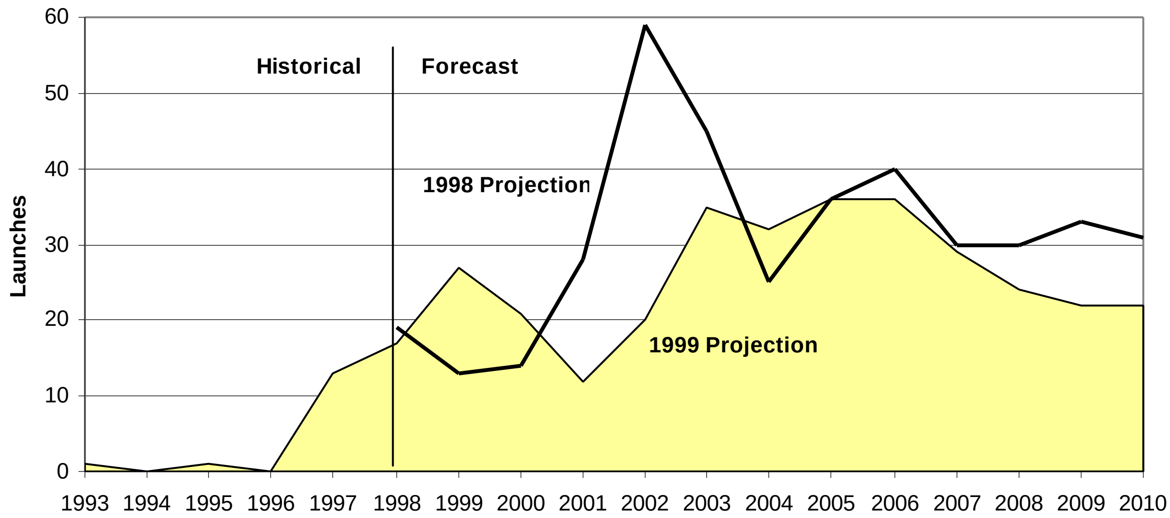

Figure 13 Comparison of 1998 and 1999 Baseline Launch Demand Projections

period 1999 to 2010, as seen in Figures 10 and 11. This is lower than the 1,433 payloads projected over the same period in last year's robust market scenario. As with the baseline scenario, the slight decrease is due primarily to the reduction in the number of broadband satellites deployed as discussed in the section on Broadband LEOs.

Based on these payload projections, launch demand for the robust market scenario is projected to be an average of 21 medium-to-heavy and 13 small launches per year over the forecast period. As with the baseline scenario, demand for medium-to-heavy launch vehicles peaks with the deployment of Broadband LEO systems in 2003 and again with the deployment of Big LEO follow-on systems in 2006. Launch demand is shown in Figures 10 and 12.

For both scenarios, the projected satellite and launch demand reflects system configuration and deployment timing as provided to AST by the system operators. Except where otherwise noted, actual system data as known at the time of writing was used without providing any subjective filtering of the data. It is highly likely that actual deployment configuration and timing for many of these systems will change as their development progresses.

Historical LEO Market Assessments

Since publication of the first *LEO Commercial Market Projections* in 1994, there has been tremendous growth in the number of proposed LEO systems and full deployment of two such systems, Iridium and ORBCOMM. Over this period, AST's forecast of systems likely to be deployed has also increased. Figure 14 summarizes AST's commercial LEO market projections for the past six years revealing significant growth in the number of systems expected to be deployed in all three LEO telecommunications market segments.

	1994	1995	1996	1997	1998	1999
Systems Projected *						
Big LEO	1-2	2-3	3-4	4-5	4-5	4-5
Little LEO	1-1	1-2	2-3	2-3	3-4	3-4
Broadband LEO	0	0	0	0-1	2-3	2-3

* The lower limit reflects the Baseline scenario and the upper reflects the Robust Market scenario (previously Modest and High Growth).

Figure 14 Past LEO Systems Projections