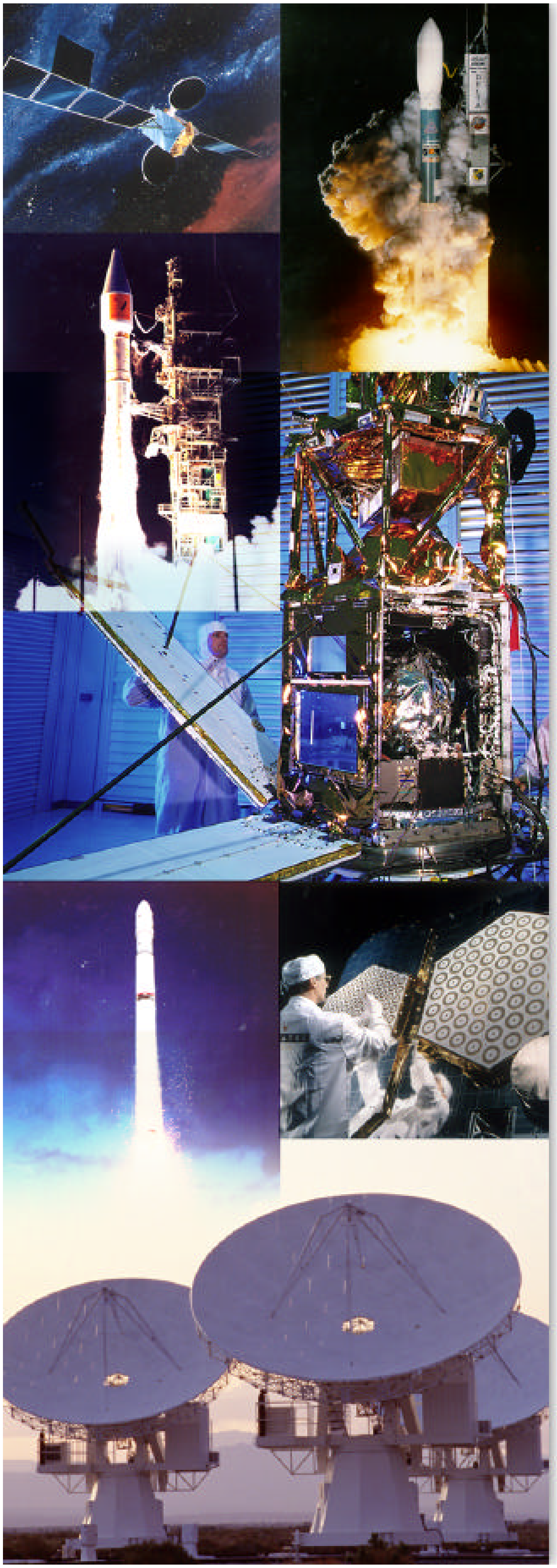

2000 COMMERCIAL SPACE TRANSPORTATION FORECASTS

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

and the

Commercial Space Transportation Advisory Committee (COMSTAC)

May 2000

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 (clockwise from top left):

Alcatel Space (1999). Artist's conception of one of the WorldSpace system satellites, which will provide digital audio broadcasting services via satellite.

Boeing Corporation (1999). Image is of the Delta 2 7420 launch on July 10, 1999, from the Cape Canaveral Air Station. It successfully orbited four Globalstar communications satellites.

Orbital Sciences (1998). Image is of the OrbView-2 satellite prior to launch.

Alcatel Space (1999). An engineer working on one of the Globalstar mobile telephony satellites.

PhotoDisc, Inc. (1999). Ground antennae for satellite communications signals.

Sea Launch (1999). Image is of the Zenit 3SL launch on October 9, 1999, from the Odyssey Sea Launch Platform. It successfully deployed the DirecTV 1R satellite.

International Launch Services (2000). Image is of the Atlas 2AS launch on February 3, 2000, from the Cape Canaveral Air Station. It successfully deployed the HISPASAT 1C communications satellite.

TABLE OF CONTENTS

LIST OF FIGURES

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 2000 to 2010. The *2000 Commercial Space Transportation Forecasts* combines:

- The ***COMSTAC 2000 Commercial Geostationary Launch Demand 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 ***2000 Commercial Space Transportation Projections For Non-Geosynchronous Orbits (NGSO)***, which projects commercial launch demand for all space systems in non-geosynchronous orbits, 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 41.4 commercial space launches worldwide will occur annually through 2010. This is an increase of 15 percent from the 36 commercial launches conducted worldwide in 1999. However, the forecast is down close to 20 percent from last year, which projected an average of 51 launches per year. This downturn in expectations is the result of difficulties encountered by NGSO systems over the last year, such as the failure of Iridium and bankruptcy of ICO.

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

- 23.5 launches of medium-to-heavy launch vehicles to GSO
- 7.5 launches of medium-to-heavy launch vehicles to LEO, or NGSO orbits
- 10.4 launches of small vehicles to LEO.

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 2000 to 2010. The jointly published *2000 Commercial Space Transportation Forecasts* includes:

- The ***COMSTAC 2000 Commercial Geostationary Launch Demand 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 ***2000 Commercial Space Transportation Projections For Non-Geosynchronous Orbits (NGSO)***, 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 18 launches to GSO in 1999, there were an additional 18 launches to LEO to deploy global satellite communications systems, remote sensing spacecraft, and scientific payloads.

About the COMSTAC 2000 Commercial Geostationary Launch Demand Model

At the request of the Federal Aviation Administration, COMSTAC compiles the *Commercial Geostationary Launch Demand 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 NGSO Commercial Space Transportation 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 NGSO 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 *NGSO Commercial Market Projections* develops two scenarios for deployment of NGSO 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 *2000 Commercial Geostationary Launch Demand Model* and the *2000 NGSO Commercial Space Transportation Projections* present an overall picture of expected demand for commercial launch services for the 11-year period 2000 to 2010. On average, 41.4 commercial launches are projected to occur worldwide each year through 2010. This is an increase of 15 percent from the 36 launches conducted in 1999.

Combined GSO & NGSO Payload Projections

The combined GSO and NGSO forecasts project that 889 payloads will be deployed between 2000 and 2010, as shown in Figures 1, 2, and 3. The projected payload demand is dominated by the high number of NGSO payloads expected to be launched for low and medium Earth orbiting communications constellations which fluctuates considerably year to year. Deployment of NGSO satellites reaches a low of 19 payloads in 2001 and a high of 74 payloads only two years later in 2003 and again in 2010. By contrast, the number of GSO payloads does not fluctuate as much, with a high of 35 in 2002 and a low of 28 in 2007.

Projected payload demand is based on the COMSTAC GSO mission model and the baseline scenario of the FAA NGSO forecast. Additional detail on the breakout of payload projections for the various types of NGSO systems are contained in the *2000 NGSO Commercial Space Transportation Projections*.

Combined GSO and NGSO Launch Projections

After taking into account the dual manifesting of GSO payloads and the multiple manifesting of NGSO payloads, the forecasts project that 454 launches will be conducted through 2010, as shown in Figures 1, 2, 3, and 4. The projected launch demand is an average of 41.4 launches per year, consisting of:

- 23.5 launches of medium-to-heavy launch vehicles to GSO
- 7.5 launches of medium-to-heavy launch vehicles to LEO, or NGSO orbits
- 10.4 launches of small vehicles to LEO.

The forecast is down close to 20 percent from last year's projected average of 51 launches per year. This downturn in expectations is the result of difficulties encountered by NGSO systems over the last year, including Iridium's failure. Figure 5 shows forecasts for 1998 to 2000.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	TOTAL	Avg
Payloads													
GSO Forecast (COMSTAC)	30	31	35	31	32	31	30	28	30	29	30	337	30.6
LEO Forecast (FAA)	23	19	29	74	62	59	74	45	37	56	74	552	50.2
Total Payloads	**53**	**50**	**64**	**105**	**94**	**89**	**103**	**72**	**67**	**84**	**104**	**889**	**80.8**
Launch Demand													
GSO Medium-to-Heavy	26	26	30	25	25	23	21	20	21	20	21	258	23.5
LEO Medium-to-Heavy	6	6	8	8	5	5	14	10	8	4	8	82	7.5
LEO Small	7	7	9	13	13	10	10	9	9	13	14	114	10.4
Total Launches	**39**	**39**	**47**	**46**	**43**	**37**	**45**	**37**	**39**	**36**	**43**	**454**	**41.4**

Figure 1: Commercial Space Transportation Payload and Launch Projections

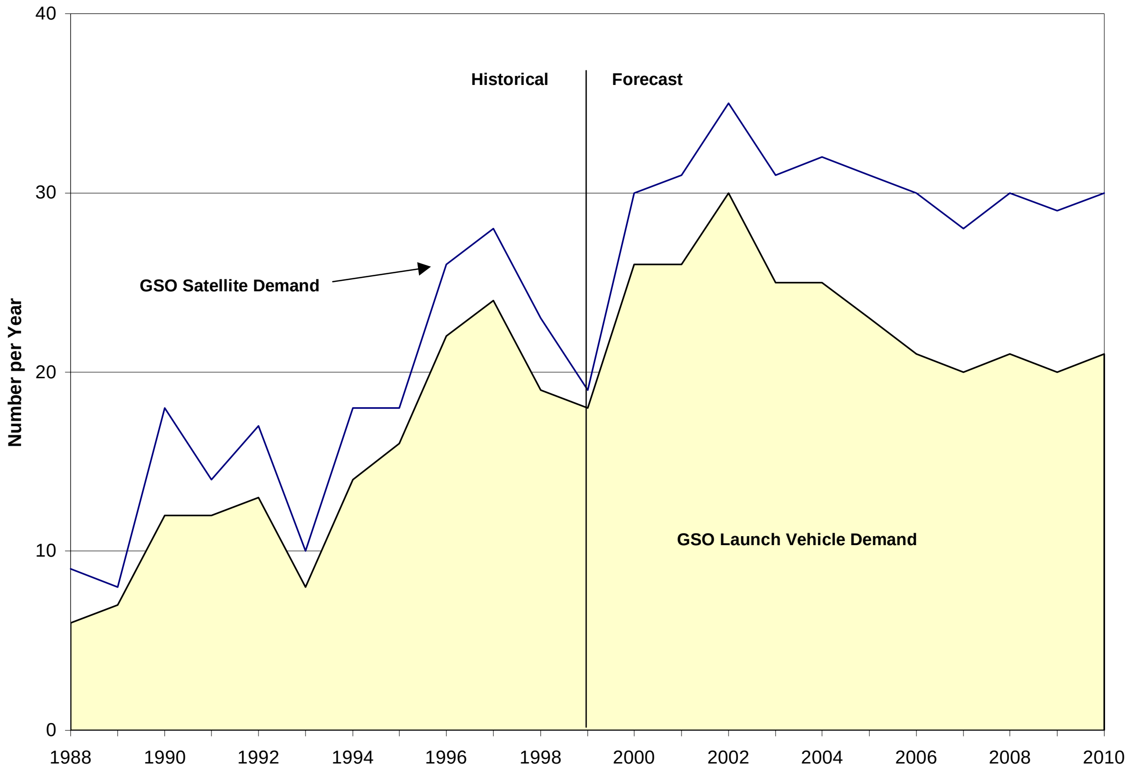

Figure 2: GSO Satellite and Launch Demand

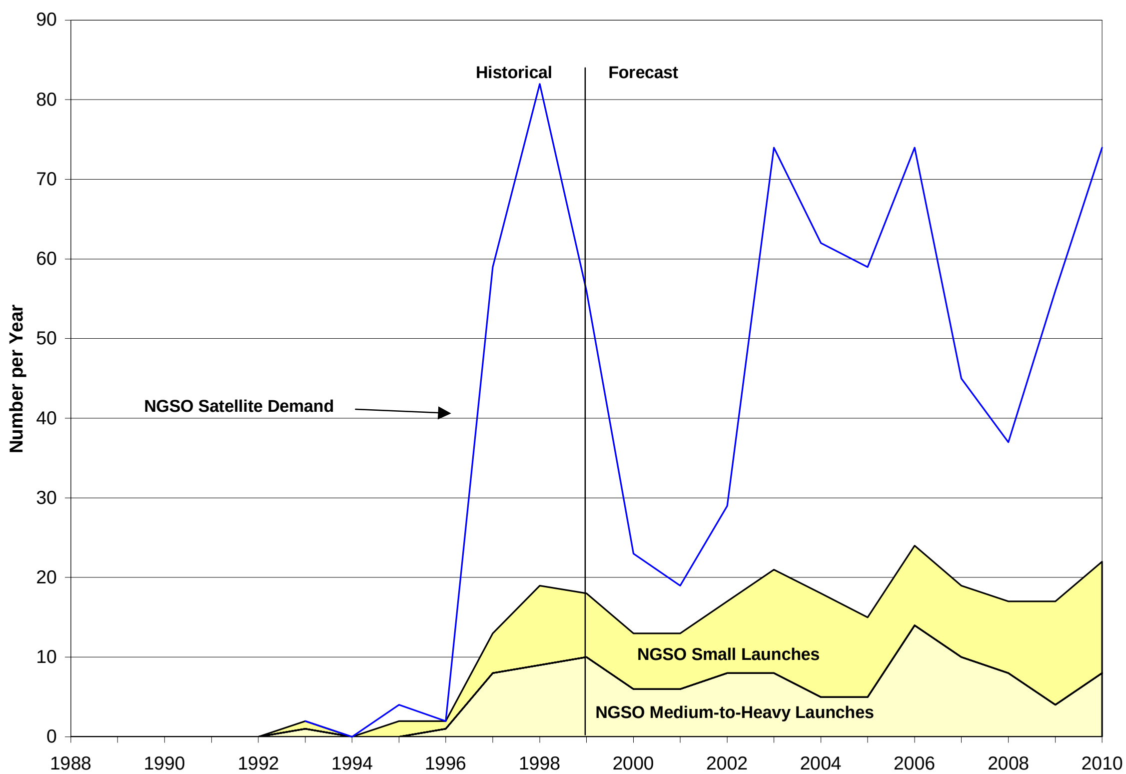

Figure 3: NGSO Satellite and Launch Demand

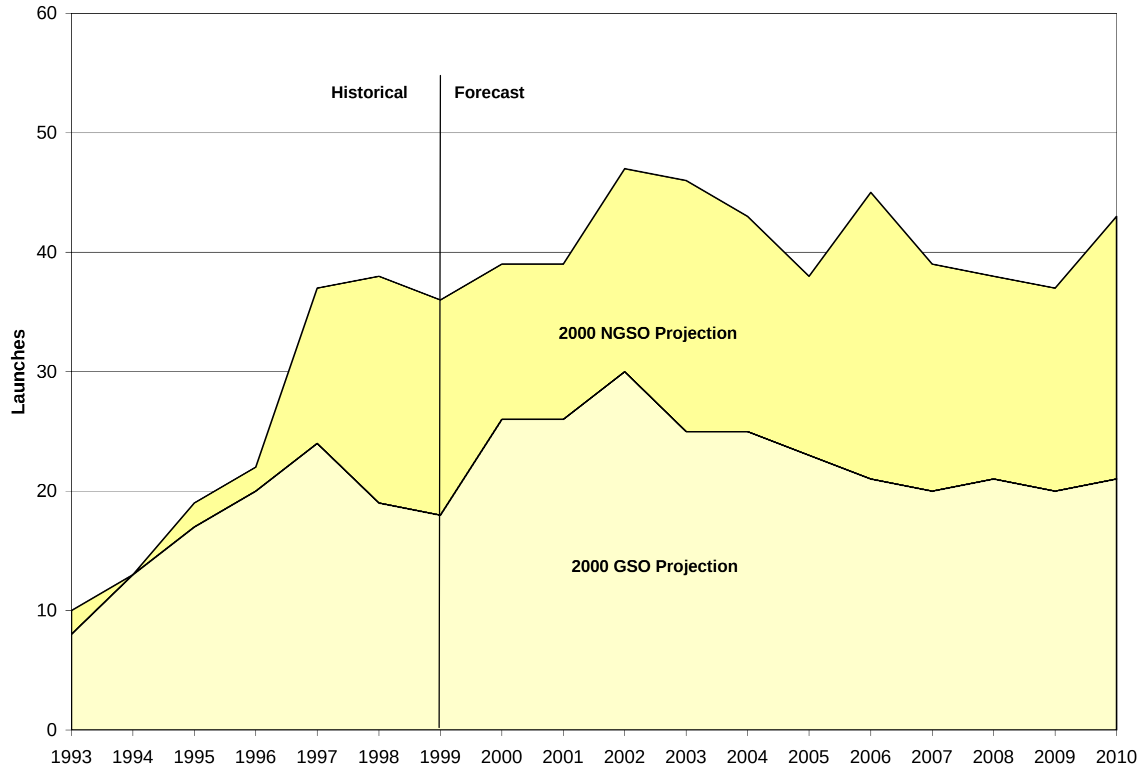

Figure 4: Combined GSO and NGSO Launch Projections

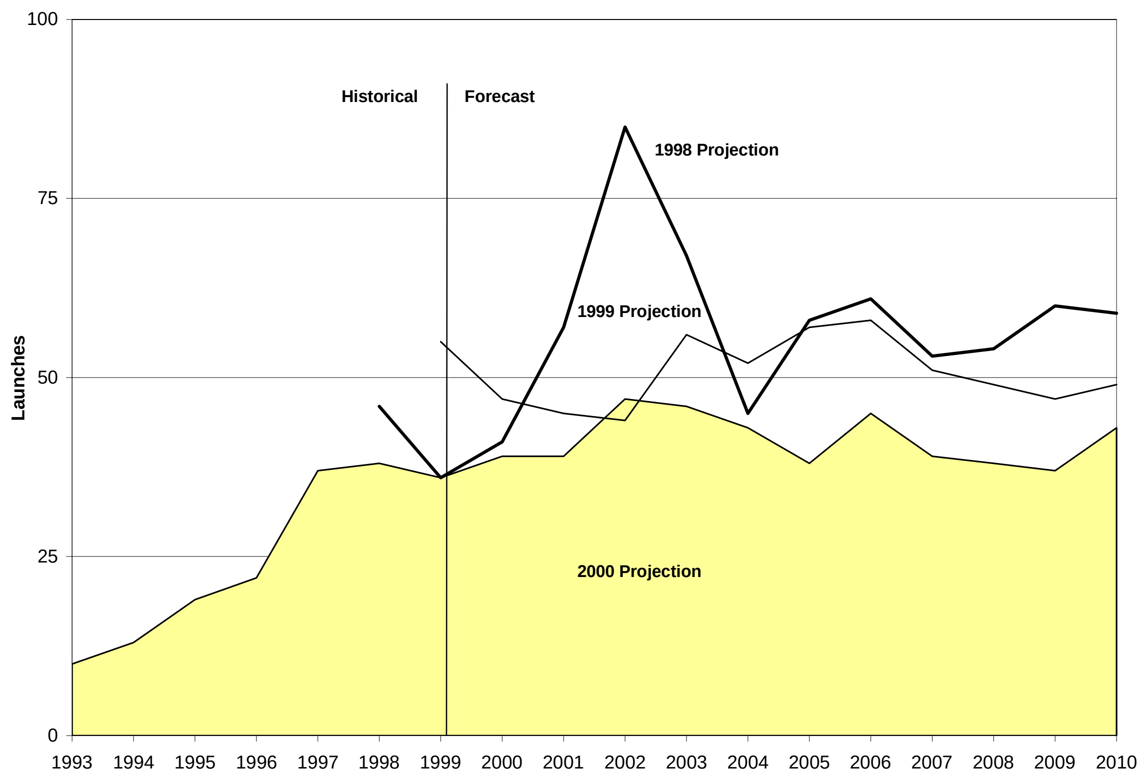

Figure 5: Historical Commercial Space Transportation Projections

COMSTAC 2000 Commercial Geosynchronous Orbit (GSO) Launch Demand Model

May 2000

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TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

Executive Summary

This 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). The *2000 Commercial Geosynchronous Orbit (GSO) Launch Demand Model* is the eighth annual 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. COMSTAC produces in this report, a satellite and launch demand forecast. The satellite demand is derived by forecasting the number of satellites to be placed in GSO that are open to internationally competed launch service procurements. To determine the number of possible launches in a year, the satellite demand is decreased by the number of satellites forecasted to be launched in a dual launch configuration.

This report is the result of the COMSTAC 2000 Commercial Mission Model update. It shows the forecast of the demand for commercial GSO satellites and the resulting launch demand. The assumptions and methodology used for this forecast are explained in the body of this report.

The near-term forecast, which is based on existing satellite programs for 2000 through 2002, shows 30 satellites to be launched in 2000, 31 in 2001, and 35 in 2002. The average annual COMSTAC demand forecasts of 1998 and 1999 were 32.8 and 33 satellites per year, respectively. This year's mission model predicts an average demand of 30.6 satellites to be launched per year over the period from 2000 through 2010. This is approximately a 10% decrease in forecasted demand as compared to 1998 and 1999. Figure 1 shows the graphical representation of the COMSTAC Demand Forecast in terms of number of satellites and launch demand.

The near-term launch demand forecast equates to 26 launches for 2000, 26 launches for 2001, and 30 launches for 2002. Table 1 shows the projected number of dual payloads to be launched.

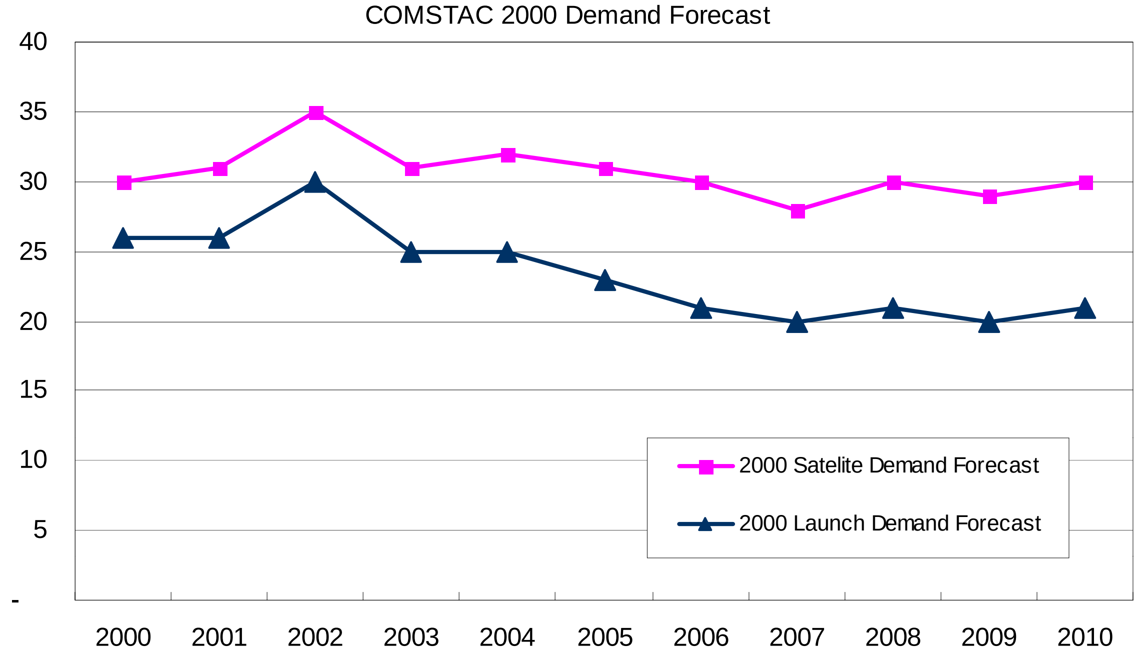

Figure 1 COMSTAC Commercial GSO Launch Demand Forecast

Table 1 Commercial GSO Launch Demand Forecast Data

	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Total**	**Average 2000 to 2010**
Satellite Demand	30	31	35	31	32	31	30	28	30	29	30	337	30.6
Dual Launch Forecast	4	5	5	6	7	8	9	8	9	9	9	79	7
Launch Demand Forecast	26	26	30	25	25	23	21	20	21	20	21	258	23

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 satellite launch demand mission model and update it annually.

This report presents the 2000 update of the worldwide commercial geosynchronous orbit (GSO) satellite mission model for the period 2000 through 2010. It is based on market forecasts obtained in early 2000 from major satellite manufacturers, satellite operators and launch service providers.

It should be emphasized that this is not a forecast of *actual* launches for any given year. It is a forecast of the *demand* for launches, i.e., the number of launches needed to fulfill the projected delivery of satellite orders in a given year. The number of actual launches for that year will then depend on other factors such as satellite delivery, launch failures, etc. Appendix A gives a full explanation of this difference and the factors that potentially affect the actual launches for a given year.

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 satellite manufacturers and the satellite operators began to contribute to the market demand database. In 1995, the Technology and Innovation Working Group (the Working Group) was formally chartered to prepare the annual Commercial Payload Mission Model Update. Since then, the participation in the preparation of this report has grown. This year the committee received 20 inputs from U.S. and foreign satellite manufacturers, operators and launch vehicle providers. COMSTAC would like to thank all the participants in the 2000 mission model update.

Methodology

With minor adjustments, the Working Group's launch demand forecast methodology has remained consistent. As in previous years, they solicited input from industry via a letter from the Associate Administrator for Commercial Space Transportation. This letter is shown in Appendix C. The letter requested that each company provide a forecast of the number of addressable commercial GSO payloads per year for the period 2000 - 2010.

Launch vehicle payloads in this context are satellites that are open for internationally competitive launch service procurement. These satellites are considered the "addressable" market. Not included in this forecast are those satellites 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).

Note that the number of projected vehicle launches per year is a subset of this satellite 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) satellites are not included in this mission model. A separate forecast is developed by the FAA/AST Commercial Space Transportation for Non-Geosynchronous Orbits (NGSO) market. These projections are included as a separate report in this document.

Respondents were asked to segregate their forecast into satellite categories based on separated mass inserted into a nominal geosynchronous transfer orbit (GTO), assuming launch at 28° inclination. The categories are representative of a clustering of similar capability launch vehicles as shown in Table 2.

Table 2. Satellite Weight Classes

GTO Launch Capability (200 nm x GEO orbit @ i=28°)	Launch Vehicle
Below 4,000 lb. (<1,815 kg)	Dual Ariane 4/5, Delta II, Dual H-IIA, Long March 3 or 3A
4,000 - 9,000 lb. (1,815- 4,083 kg)	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 lb. (4,083 – 5,445 kg)	Ariane 4/5, Atlas IIIA/B, Atlas V, Delta IV, HII-A, Long March 3B, Proton M, Sea Launch
Above 12,000 lb. (>5,445 kg)	Ariane 5, Atlas V, Delta IV, H-IIA, SeaLaunch

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

- American Mobile Satellite Corp.
- Arianespace, Inc.
- Asia Satellite Telecommunications Company, Ltd.
- The Boeing Company*
- Broadcasting Satellite System Corp (B-SAT)
- COMSAT
- Hughes Space & Communications*
- ICO Global Communications
- Lockheed Martin Space Systems Company*
- Motorola
- Optus Communication
- PanAmSat
- PT. Telkomunikasi Indonesia
- Rocket System Corporation
- Space Systems/Loral*
- Shin Satellite Plc.
- Singapore Telecommunications Ltd.
- Sirius Satellite Radio
- Skynet/ SatMex/ EuropeStar
- Spectrum Astro

Comprehensive mission model forecasts that are used in this forecast were received from those organizations marked by an asterisk (*). The comprehensive inputs were of the total addressable market of satellites seeking GTO launch services from the years 2000 to 2010. Other responses provided partial market or company specific satellite launch demand information.

The near-term COMSTAC mission model (2000-2002) is a compilation of the currently manifested launches and an assessment of satellites 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 demand does not account for unanticipated launch failures, 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 push launches into the following year. These factors will cause differences between the demand for launches and the actual launches for that year. This pattern of firm schedule commitments, followed by modest delays, has been consistently over the history of the industry.

The Working Group used the data from all of the domestic comprehensive inputs to derive the average launch rate for years 2003 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 2 and Table 3) represent the single highest or lowest estimated number of satellites to be launched in that year from the submitted forecasts. As in prior forecasts, no single comprehensive forecast was consistently higher or lower than the average throughout the forecast period. Therefore, one company's input did not radically influence the forecast average.

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.

There is a certain amount of difficulty and uncertainty involved in forecasting the commercial launch market. The satellite production cycle of an existing design is on the order of two years. Orders within a two year window are generally known. Satellites in the third year and beyond become more difficult to identify by name as many of these satellites may be in various stages of the procurement cycle. Beyond a five-year horizon, new markets or new uses of satellite technology may emerge. As 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.

2000 Mission Model

The 2000 COMSTAC mission model consists of three elements. The first element is a forecast of demand for competed launches of commercial satellites to geosynchronous orbit (GSO) from 2000 to 2010. The second element is an estimate of the mass distribution of these satellites. The third element is a launch vehicle demand projection derived from the satellite launch demand forecast.

Satellite Launch Demand Model

Figure 2 shows the COMSTAC Technology and Innovation Working Group's demand forecast for commercial satellite launches to GSO. The figure plots the historical COMSTAC forecasted launch demand from 1993 through 1999 and the COMSTAC 2000 forecast for the years 2000 through 2010. The historical demand is a series of one year projections from every COMSTAC mission model report. For example, the historical demand value shown for 1997 is the forecasted demand for 1997 taken from the 1997 COMSTAC mission model. Also plotted in Figure 2 is the actual number of satellites launched from 1993 to 1999 for reference. The factors causing the difference between these lines are addressed in Appendix A.

The range of individual estimates from the various comprehensive inputs is plotted as high-low marks above and below the average. A list of the average, high, and low inputs is shown in Table 3. This information is presented to give a sense of the variations in the forecasts for any given year. COMSTAC does not present "high" or "low" cases for the demand forecast. The high and low inputs are simply the highest and lowest of all individual estimates provided for any one year.

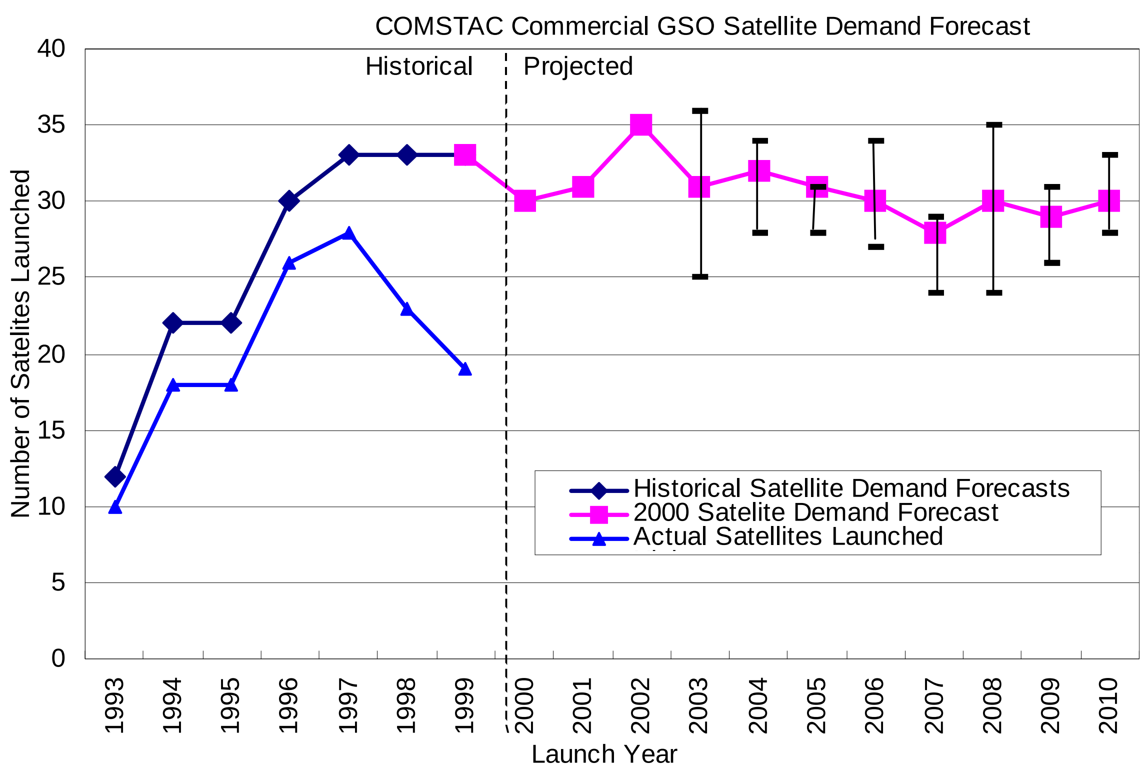

Figure 2. COMSTAC Commercial GSO Satellite Demand Forecast

Table 3. COMSTAC Commercial GSO Satellite Forecast

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Average
High	30	31	35	36	34	31	34	29	35	31	33	346	
2000 Satellite Demand	**30**	**31**	**35**	**31**	**32**	**31**	**30**	**28**	**30**	**29**	**30**	**337**	**30.64**
Low	30	31	35	25	28	28	27	24	24	26	28	319	

The near-term forecast, (Table 4) which is based on existing satellite programs for 2000 through 2002, shows 30 satellites to be launched in 2000, 31 in 2001, and 35 in 2002. This year's mission model predicts an average demand of 30.6 satellites to be launched per year over the period from 2000 through 2010. The COMSTAC average annual demand forecasts of 1998 and 1999 were at 32.8 and 33 satellites per year, respectively. This is approximately a 10% decrease in forecasted demand as compared to the 1998 and 1999 forecasts. Note that the average annual demand for 1998, 1999, and 2000 cover different spans of time. The 1998 average annual demand is the average demand from 1998 to 2010, for 1999 from 1999 to 2010, and for the 2000 demand model from 2000 to 2010.

Past COMSTAC reports showed actual satellite launched data and forecasted satellite demand as a single graphical representation of satellite projections. Note that this year's graphical representation of the satellite demand forecast attempts to illustrate the difference between satellite demand and actual satellites launched. Though there are two lines shown in Figure 2, it is important to note that there are four components to this graph:

1) Satellite demand curve which consists of:
   a) The historical demand (a series of one-year projections from each COMSTAC mission model report through 1999)
   b) The current three year satellite near-term demand projection comprised of programs identified by name (2000 through 2002)
   c) The projected demand average from the Working Group based on each participant's projection methodology.
2) The actual satellites launched for a given year (1993 through 1999)

It is not the intent of the Working Group to project the actual number of satellites to be launched. In this report, COMSTAC strives to provide the user with the best knowledge possible of the number of satellites that could be launched. This is further explained in Appendix 1 of this report.

Table 4. Commercial GSO Near-Term Mission Model
Forecasted Payloads as of March 26, 2000

	2000	2001	2002
Total	30	31	35
Below 4,000 lb.	5	2	3
	Ariane-Astra 2D Ariane-Brasilsat B4 Ariane-Bsat 2A Ariane-Nilesat 102 Ariane-Skynet 4F	Ariane-Bsat 2B Ariane-PAS X1	MBSat-TBD Nstar C-TBD TBD-JCSat 8
4,000-9000 lb.	14	13	13
	Ariane-AsiaStar 1 Ariane-Eurasiasat 1 Ariane-Europe*Star 1 Ariane-GE 7 Ariane-GE 8 Ariane-Insat 3C Ariane-Insat 3B Ariane-Nsat 110 Ariane-PAS 1R Atlas-Echostar 6 Atlas-Eutelsat W4 Atlas-Hispasat 1C Proton-GE 1A Proton-GE 6	Ariane-Astra 2B Ariane-AmeriStar 1 Ariane-Insat 3A Atlas-DirecTV N(Tempo 1) Long March-Atlantic Bird 1 Proton-GE 2A TBD-Asiasat 4 TBD-Astra 2C TBD-Atlantic Bird 2 TBD-DirecTV 4S TBD-Europesat 1B TBD-PAS X2 TBD-Attrition/Relaunches	TBD-AirTV 1 TBD-AirTV 2 TBD-Arabsat 3B TBD-Echostar 7 TBD-Echostar 9 TBD-Europe*Star2 TBD-GE X TBD-Telstar 9A TBD-Telstar Latin America TBD-Thaicom 4 TBD-Thor 4 TBD-Attrition/Relaunches TBD-Attrition/Relaunches
9,000 – 12,000lbs	10	16	14
	Ariane-Eutelsat W1R Ariane-Galaxy 4R Ariane-Galaxy 10R Ariane-Superbird 4 Long March-ChinaSat 8 Proton-Garuda 1 Proton-PAS 10 Sea Launch-PAS 9 Sea Launch-Thuraya 1 Sea Launch-XM Radio 1	Ariane-Intelsat 901 Ariane-Intelsat 902 Ariane Intelsat 904 Ariane-iSky 1 Ariane-NSS 7 Ariane-Optus C1 Proton-Intelsat 903 Sea Launch-Galaxy 3C Sea Launch-XM Radio 2 TBD-Assuresat 1 TBD-Assuresat 2 TBD-Astra 1K TBD-Echostar 8 TBD-Hot Bird 6 TBD-M2A TBD-Thuraya 2	Ariane-iSky 2 TBD-Apstar 3A TBD-Asiasat 5 TBD-GE 2E TBD-Intelsat 905 TBD-Intelsat 906 TBD-Intelsat 907 TBD-Measat 3 TBD-NetSat 28 TBD-NSS 8 TBD-PAS X TBD-Telstar 8 TBD-Telstar 9B TBD-Attrition/Relaunches
>12,000 lb.	1	0	5
	Ariane-Anik F1		TBD-Anik F2 TBD-CyberStar 1 TBD-Garuda 2 TBD-Spaceway 1 TBD-Spaceway 2

Satellite Launch Mass Ranges

Figure 3 shows the forecasted distribution of the satellite demand by mass. The satellites 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 (19,323 nm) at an inclination of 28°. 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 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.

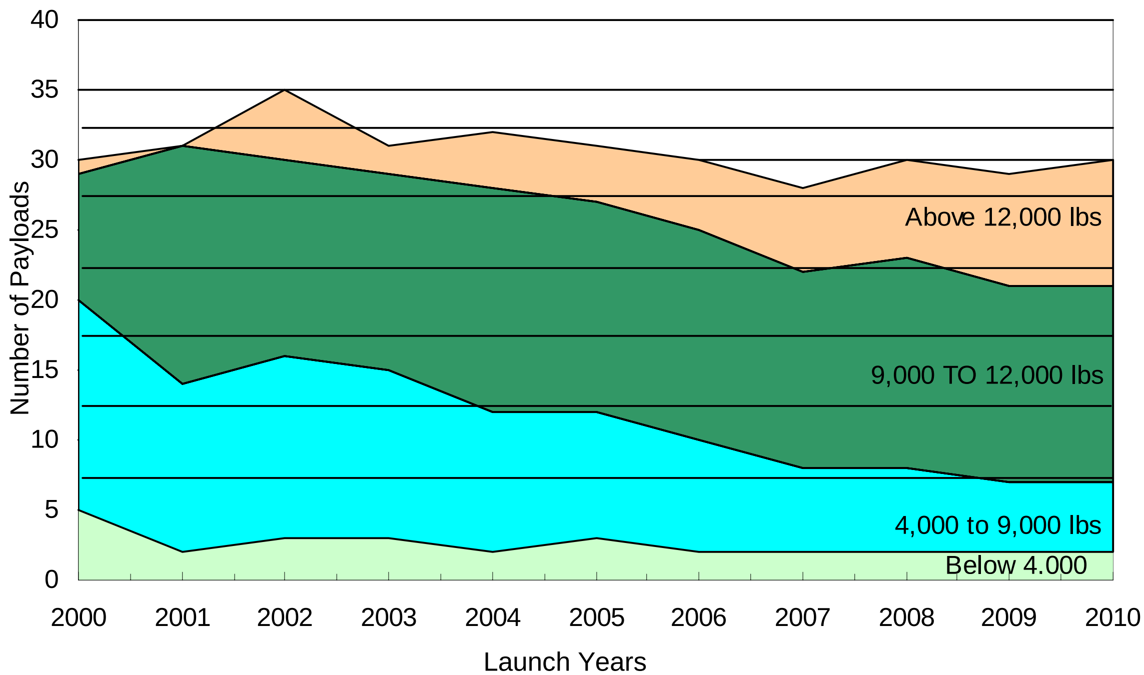

Figure 3. Forecast Trends in Annual GSO Satellite Mass Distribution

Growth of Commercial Satellites

In the early years of publication of this mission model report, commercial satellites were not projected to grow much beyond the 4,000 to 9,000 pound category. In the past few years, however, there has been a consensus that commercial GEO satellites are growing, necessitating the addition of a new weight category last year. This trend continues in the 2000 mission model. As shown in Table 5, the projected number of satellites in the 9,000 to 12,000 pound mass category continues to grow, as well as in the Above 12,000 pound category. One of the factors involved in the growth of satellites is the overall system cost. Larger satellites are typically more cost effective on a dollar per transponder basis. The cost to launch these larger satellites is decreasing with 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, satellites are still forecasted in each of the mass categories through the end of the forecast period.

Table 5. Forecast Trends in Satellite Mass Distribution

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Average 2000 to 2010	Percent of Total
Below 4,000 lbs	5	2	3	3	2	3	2	2	2	2	2	28	2.5	8
4,000 to 9,000 lbs	15	12	13	12	10	9	8	6	6	5	5	101	9.18	30
9,000 to 12,000 lbs	9	17	14	14	16	15	15	14	15	14	14	157	14.27	47
12,000 lbs and above	1	0	5	2	4	4	5	6	7	8	9	51	4.64	15
Total Satellite Forecast	**30**	**31**	**35**	**31**	**32**	**31**	**30**	**28**	**30**	**29**	**30**	**337**	**30.64**	**100**

Comparison with 1999 Demand

Figure 4 compares this year's COMSTAC 2000 Mission Model forecast with the forecasts from 1998 and 1999. As shown, the demand forecast for the 2000 mission model is lower in the later years than the 1998 and 1999 forecasts. The 2000 Mission Model forecast shows a relatively even market throughout the forecast period where the previous years' forecasts showed growth in the out-years.

The average satellite demand over the entire forecast is also lower than in previous years. The average demand over the forecast period in the 1998 and 1999 mission models were very similar, showing approximately 33 satellites per year between 1999 and 2010 with an upswing in demand in the later years. This year's model shows a flatter market with no upturn in demand in the later years. This flatter predicted demand accounts for the drop in the 33 average GEO satellites per year in 1998 and 1999 demand models to the 30.6 in this year's demand model.

There are several factors, which may have affected the projected demand for satellites in the future. Consolidation within space industry, with many mergers, buyouts, and alliances, has created a smaller customer base, which more effectively uses the current in-orbit assets. The current satellites are also experiencing longer than expected on-orbit life, which causes the orders for replacement satellites to shift further into the future.

The longer design life may also be playing a role in the flattening of the demand curve. Increased on-orbit life of the current generation of GSO satellites would reduce the magnitude and increase the period of the replacement cycle for existing spacecraft.

The trend toward more functional satellites also affects the total number of satellites on order. The larger satellites are typically more cost effective allowing the same amount of transponders to be placed on one satellite instead of two. In concert with the demand for larger satellites, the cost to launch these assets is coming down with the introduction of competition in the heavy-lift launch vehicles.

Finally, there seems to be a more cautious view of proposed space-based programs due to recent financial problems of some of the LEO telecommunication systems. New business concepts using satellites are also getting more financial scrutiny, which has caused a slowdown in the launch of new ventures.

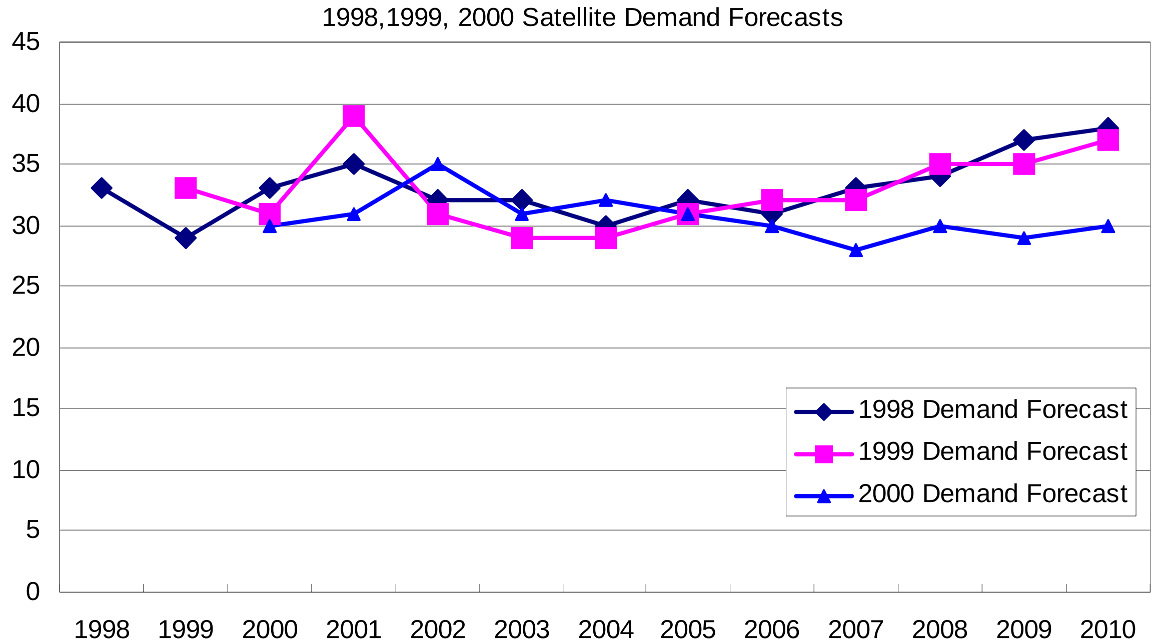

Figure 4. 1998 and 1999 versus 2000 COMSTAC Mission Model Comparison

Launch Vehicle Demand

Since inception, the COMSTAC mission model has provided commercial launch demand forecasts in terms of the number of GSO satellites to be launched. However, the actual number of commercial GSO launches recorded from 1988 through 1999 is lower than the number of satellites launched due to dual manifesting on certain launch vehicles. In the fall of 1997, the Working Group decided to estimate the demand for launch vehicles based on the satellite launch forecast because of the dual manifesting of a portion of the satellites. Figure 5 presents the satellite demand forecast described earlier in terms of actual and projected launches from the 1988 to 2010 time frame.

Historically, there has only been one launch vehicle capable of launching dual manifested satellites (Ariane), and its highest publicly announced dual launch capability is approximately 8 flights per year. This eight-flight maximum is discounted based on historical data.

Other dual capable launchers are postulated to become commercially available in the future. 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 satellites to increase gradually. The predicted number of dual launches takes this into consideration, as well as the mass of available satellites in a given year. Table 6 shows the estimated number of dual launches forecasted.

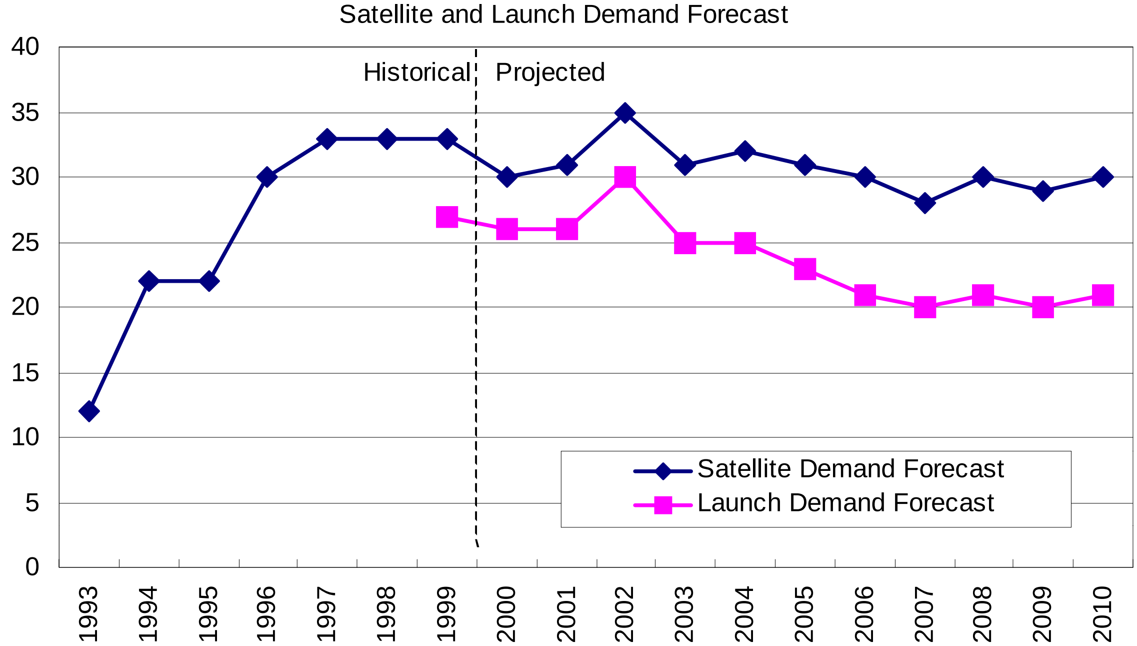

Figure 5. 2000 COMSTAC Launch Demand Forecast

Table 6. COMSTAC Launch Demand Forecast Summary

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Average 2000 to 2010
Satellite Demand	30	31	35	31	32	31	30	28	30	29	30	337	30.6
Dual Launch Forecast	4	5	5	6	7	8	9	8	9	9	9	79	7
Launch Demand Forecast	26	26	30	25	25	23	21	20	21	20	21	258	23

Factors That May Affect Future Launch Demand

Several anticipated events and compelling factors have the potential to impact the satellite and launch demand. These include the inaugural flights of several new launch vehicles, first use of newly designed major components, and the restrictive US government regulatory environment. These factors may affect the launch industry and its ability to perform delivery on projected manifests.

Over the next several years, a number of new or modified launch vehicles are scheduled to perform first flights. Failure of any of these systems will cause delays in delivery of several satellites to orbit and disable a company from executing their business plan. Other effects will include changes in launcher manifests as some programs look to other vehicles that can deliver their hardware and consequently cause an adjustment to the demand model.

Another factor that may influence a change in the mission model demand is government regulatory compliance. US Government policy regarding satellite and launch vehicle export control in particular is constraining business with international customers and partners. US satellite suppliers and launch vehicle providers are having increasing difficulty serving the needs of their international customers due to government imposed regulations. There is a consensus that in most cases, the satellite and launch vehicle demand will be unchanged. However, foreign providers may meet this demand over US suppliers. A reduction in demand for satellite and launch services procurement may also be the result of governmental regulations. The delay in review of export control documentation for example has caused several problems in the US space industry. One satellite program has been canceled; another program has a completed satellite waiting to be delivered. Some customers may either delay their programs for both satellites and launch services or may transfer their business to foreign companies in light of difficult-to-manage data exchange controls. Some communication programs may move from space-based platforms to terrestrial systems, those platforms being less politically charged.

Summary

The COMSTAC Commercial Mission Model forecast overall shows a slightly lower, more conservative future. This year's mission model predicts an average demand of 30 satellites to be launched per year over the period from 2000 through 2010. This is approximately a 10% decrease in forecasted demand as compared to 1998 and 1999. A flatter predicted demand accounts for the drop of the 33 predicted average GEO satellites per year in 1998 and 1999 demand models to the 30.6 in this year's demand model.

The near-term forecast for 2000 through 2002, shows 30 satellite programs to be launched in 2000, 31 in 2001, and 35 in 2002. After dual launch considerations, launch vehicle demand was determined to be 26 launches for 2000, 26 launches for 2001, and 30 launches for 2002.

Several factors may be causing a reduction in the demand for satellites in the future. Consolidation in the industry, extended satellite life, a trend toward larger satellites and conservatism in the space industry are some of these factors.

The future of the launch industry foresees some potential market changing events. These include the inaugural flights of several new launch vehicles, first use of newly designed major components, and the current and increasingly restrictive US government's regulatory environment. These factors may have a significant effect on the launch industry and its ability of perform on upcoming programs and projected manifests.

Appendix A. Use of the COMSTAC GSO Launch Demand Model

Demand Model Defined

The COMSTAC Demand Model is a count of actual programs or of projected programs that are expected to be launched in a given year. This would be the peak load on the launch service providers if all projected satellite launches were executed. It is not a prediction of what will actually be launched in a given year. The satellite programs and launches in the demand forecast are affected by many factors, which may cause them to slip or be canceled. The actual launches conducted in a given year depend on what factors come into play during that year.

For example, the participants in the 2000 Mission Model Update named *actual* satellite programs that were currently manifested on each of the launch providers for 2000. Though 30 satellite programs were named for the year 2000, the industry may not execute all 30 GEO satellite launches in that year. However, the *demand* on the launch industry for 2000 is for the launch of 30 satellites (26 launches after discounting due to dual manifesting).

COMSTAC Demand Projection vs Actual Launches

Factors That Affect Launch Execution

Several factors can affect the execution of a scheduled launch. These can include launch failure, launch vehicle components problems, or manifesting issues. Satellite suppliers also have factory and/or supplier issues that can delay the delivery of a spacecraft to the launch site or halt a launch of a vehicle that is already on the pad.

Other factors influencing the mission model are regulatory issues, which affect the launch and satellite businesses. Export compliance problems, FCC licensing issues, and ITU registration can slow down or stop progress on a program. The US Government policy regarding satellite and launch vehicle export control is hampering US satellite suppliers and launch vehicle providers in their efforts to work with their international customers. This has caused both delays and cancellation of programs. The higher costs and hardships caused by these regulations could also cause satellite customers to look to terrestrial systems to provide services previously performed by satellite systems.

The customer may also raise issues including financing or reprioritizing their business focus thereby delaying or canceling satellite programs and their launches.

Satellites can have more than one issue involved. It is not uncommon to see, for example, a satellite delayed due to both factory and launch manifesting issues.

1999 Space Industry Performance on Launch Demand

In the 1999 COMSTAC Commercial GSO Demand Model, the working group listed 33 satellites that were then manifested in that year. Yet of the 33 satellites manifested in 1999, only 19 satellites were actually launched. And while there was a *demand* for 33 satellites to be launched as forecasted by the COMSTAC Working Group, the execution on the manifest was plagued with an unprecedented series of launch vehicle failures and satellite problems. A list of the factors that affected the 14 satellites that did not make their launch dates follows. Several of these satellite programs had a combination of delay issues involved. The most prominent issue was listed. It is not uncommon to see, for example a satellite delayed due to both factory and launch manifesting issues. Of the 1999 manifested satellites:

- 19 satellites were launched
- 5 satellites were delayed due to launch vehicle issues
    - 3 satellites were launched late due to launch vehicle manifesting issues
    - 1 satellite experienced a delay due to a dual manifesting issue
    - 1 satellite changed launch vehicles due to a failure
- 6 satellites were delayed due to factory issues
- 2 satellites were delayed due to regulatory issues (Export control compliance and FCC license problems)
- 1 satellite was canceled by customer

Projecting Actual Launches

There exists historical data which gives percentage of launches executed vs manifested. These numbers vary greatly from year to year and it was felt that suggesting a discount percentage would not be in the best interest of the users of this report.

To project an actual executed launch manifest for a year, the factors mentioned in the paragraphs above must be taken into account. The working group feels that it is best to let the user look at the potential factors affecting actual launches and determine the weight of each factor for a particular year.

Appendix B. 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 B1). 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 satellite 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 B2) projected an average demand of 17 payloads per year over the forecast period of 1994-2010, with some members of the satellite 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 Satellite Mission Model Update Report (Reference B3). The organizations from which the market demand forecasts were requested was further expanded to include satellite operators, in addition to satellite 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 B4) 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 B5) 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 satellite on launch vehicles. The market forecast from US inputs predicted an average annual satellite demand of 33 payloads per year from 1997 – 2010. Of these, 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 (Reference B6) 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.

1999: The 1999 annual mission model (Reference B7) predicts an average demand of 32.8 satellite per year over the period from 1999 through 2010, very close to the 1998 COMSTAC forecast of 33 satellite per year. The near-term forecast, which is based on actual satellite for 1999 through 2001, shows 33 satellite in 1999, dropping to 31 in 2000, and increasing again to 39 in 2001.

Figure B-1 shows the demand models for the past COMSTAC reports. At first glance, there seems to be quite a dispersion in the models. It is interesting to note that after closer examination, there seems to be a consensus forming as the models mature. From 1996 to this year’s demand model, the curves are converging on a launch demand of 30 to 35 satellites per year.

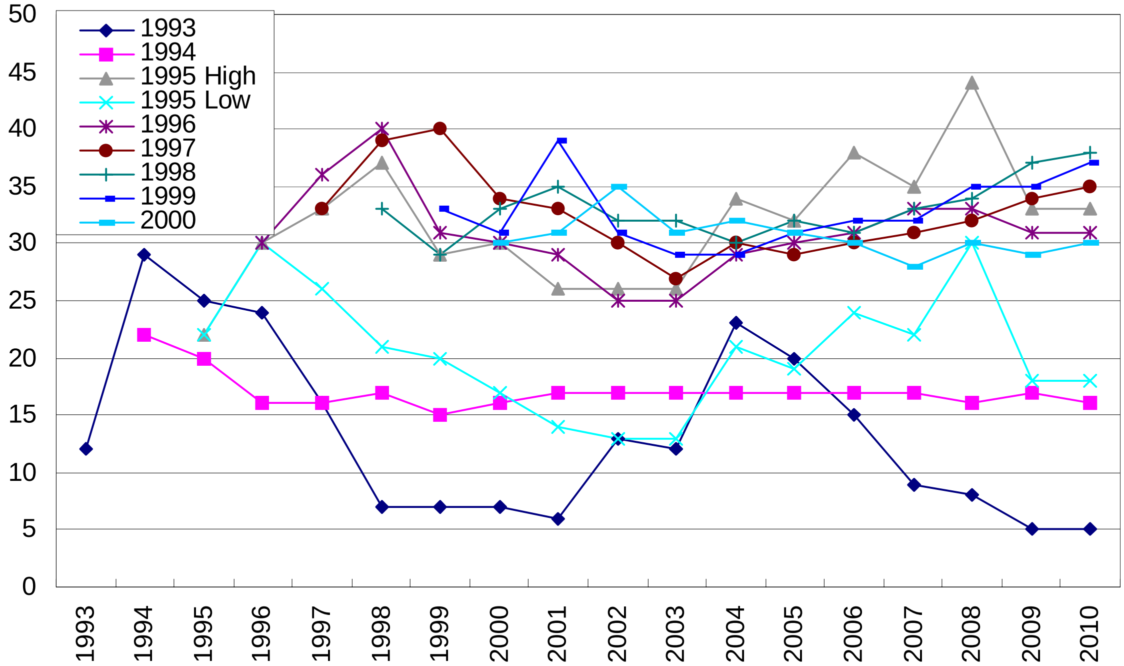

Figure B-1. Historical Satellite Demand Curves from 1993 through 2000

1989-1999 Worldwide Launch History

Figure B-2 plots the total number of vehicle launches in the various satellite categories defined in Tables B-1 through B-4 that were performed in the period 1989 through 1998.

Table B-1 presents historical addressable commercial satellite launches during the period 1989 to 1998.

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

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

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

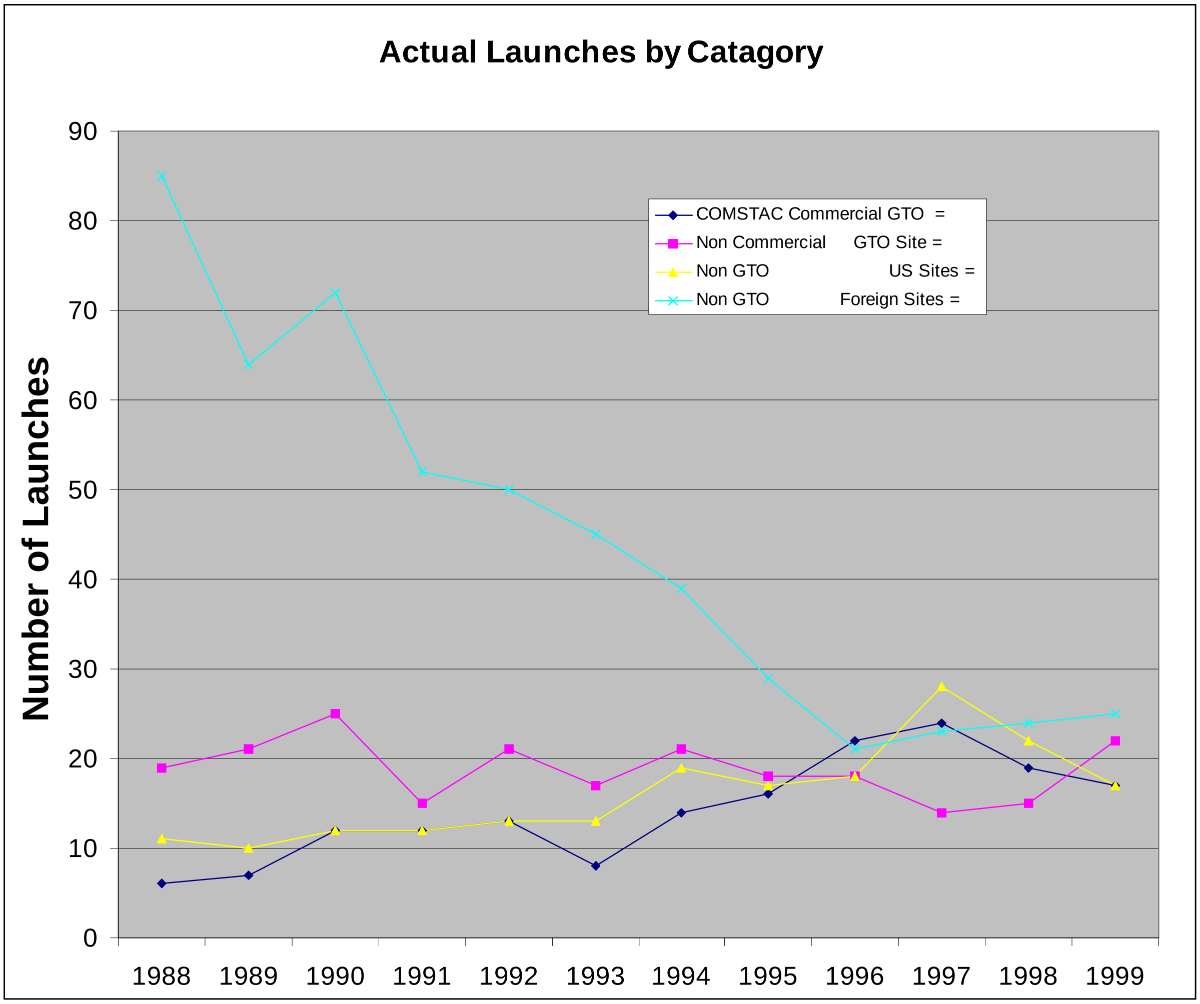

Figure B-2. Launches by Category

Table B-1. 1989-1999 COMSTAC GSO Commercial Satellite Mission Model

		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	TOTAL
TOTAL LAUNCHES =		6	7	12	12	13	8	14	16	22	24	19	17	170
TOTAL LAUNCHES =		6.003	7.001	12.006	12.002	13.004	8.002	14.004	16.002	22.004	24.004	19.004	17.000	164.033
TAL SPACECRAFT =		9	8	18	14	17	10	18	18	26	28	23	19	208
Arianespace		6.003	6	4	6	5	6	8	7	10	11	9	6	84
	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- GE2 1 US-PAS 6		1 US-Galaxy 11	
	ILV	1 Intelsat 513A 0 Luxembourg- Astr	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	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	0 Arabsat 3A 1 Koreasat 3 1 US-GE 4 1 US-Orion 2 1 Indonesia-Telkom 1	
	MLV	0 Eutelsat 105 1 India-Insat 1C 1 UK-Skynet 4B 0 US-SBS 5 1 US-GTE GStar 3 1 US-Spacenet 3R 1 US-Panamsat 1	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-Thaico	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	1 India-Insat 2E 0 US-Skynet 4E	
Atlas		0	0	0	2	3	1	3	5	5	6	3	4	32
	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 US- GE 3 1 US-Galaxy 8i 1 US-Tempo FM 2	1 Intelsat 806 1 Intelsat 805 1 Hot Bird 5	1 US-Echostar 5 (Sky 1) 1 Euutalsat W3 1 Japan-JCSat 6 1 US-Telstar 7 Orion 3	
	MLV				1 Japan- BS 3H	1 US-Galaxy 1R 1 US-Galaxy 5								
Delta		0	1	4	4	3	1	1	1	2	1	4	1	23
	ILV											1 US-Galaxy 10	1 US-Orion 3	
	MLV		1 UK-BSB/Marcopolo 1	1 India-Insat 1D 1 Indonesia-Palapa B0 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 B-1. 1989-1999 COMSTAC GSO Commercial Satellite Mission Model (continued)

		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	TOTAL
H-IIA		0	0	0	0	0	0	0	0	0	0	0	0	0
	HLV													
	ILV													
	MLV													
Long March		0	0	1	0	2	0	2	3	3	2	0	0	13
	HLV									1 **Intelsat 708A**	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	0	2	4	3	5	14
	HLV										1 **China-Asiasat 3** 1 Luxembourg- Astra 1G 1 US-PAS 5 1 US-Telstar 5	1 US-PAS 8	1 Luxembourg-Astra 1H 1 US-Telstar 6	
	ILV									1 Inmarsat 302 1 Luxembourg- Astra 1F		1 US-Echostar 4 1 Luxembourg- Astra 2	1 China-Asiasat 3S 1 LMI 1 1 Canada-Nimiq 1	
Zenit 3 SL		0	0	0	0	0	0	0	0	0	0	0	1	1
	HLV													
	ILV												1 US-DirecTV 1R	
Titan 3		0	0	3.001	0	0	0	0	0	0	0	0		3
	HLV			1 **Intelsat 603** 1 Intelsat 604										
	ILV			1 Japan-JCSat 2										
	MLV			0 UK-Skynet 4A										

Legend:

[solid box] Spacecraft failed to reach operating status as planned (shown in bold above)

[dashed box] Spacecraft partially failed after achieving operating status

Table B-2. 1989-1999 Non-Addressable Payloads Using GTO Launch Sites

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	TOTAL
TOTAL LAUNCHES =	21	25	15	21	17	21	18	18	14	15	22	207
TOTAL LAUNCHES =	21.006	25.005	15.005	21.004	17.003	21.008	18.007	18.004	14.013	15.012		185.067
TAL SPACECRAFT =	27	30	20	25	20	29	25	22	27	27	37	289
Ariane	1	2	2	2	1	0	4	1	0	2	2	17
	0 1 ESA-Olympus 1 1 0 ESA-Hipparcos 0 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	1 CNES SPOT-4 1 ARD	1 Helios 1B 0 Clementine 1 XMM	
Atlas	1	1	0	2	4	2	6	2	2	3	1	24
	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- 1 US-AF DSCS 3- 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	1 US Navy UHF-F10	
Delta	6.000	7.001	1.001	8.000	6.000	2.001	0.000	6.000	4.000	4.006	10.000	54.009
	1 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 0 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 1 1 US-AF GPS Navstar 1 1 US-AF GPS Navstar 14 1 US-AF GPS Navstar 1 1 US-AF GPS Navstar 1 1 US-AF GPS Navstar 17 1 US-NASA EUVE	1 US-AF GPS 2 Blk 2 01 1 US-AF GPS 2 B 1 US-AF GPS 2 B 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 2-0 1 US-AF-GPS 2-Block 2-1 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	1 NASA Mars Polar 1 NASA Stardust 1 US-AF-ARGOS 0 Orstead 0 Sunsat 1 Landsat-7 1 Globalstar 03 - 4 1 NASA FUSE 1 Globalstar 04 - 4 1 Globalstar 05 - 4 1 Globalstar 06 - 4 1 US-AF NAVSTAR	

Table B-2. 1989-1999 Non-Addressable Payloads Using GTO Launch Sites (continued)

		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	TOTAL
Japan		**1.000**	**2.000**	**1.000**	**1.000**	**0.000**	**2.000**	**1.001**	**1.000**	**1.000**	**1.000**	**1.000**	**12.00**
	1	1 Japan-GMS 4	1 Japan-BS 3A	1 Japan-BS 3B	1 Japan-JERS		1 Japan-ETS 6	1 Japan-GMS	1 Japan-ADEOS	1 Japan-ETS-7/TRMM	1 Japan-COMETS	1 Japan-MTSAT	
	1		1 Japan-MOS 1B				1 Japan-OREX	0 Japan-SFU					
Long March		**0**	**2**	**1**	**0**	**0**	**2.001**	**0**	**0**	**2**	**2**	**0**	**9.00**
	1		1 China-DFH 203	1 China-DFH 204			1 China-DFH 301			1 China-DFH 302	1 China-Sinosat 1		
	1		1 Pakistan-Badar 1				1 China-SJ 4			1 China-Fen Yun 2	1 China-Chinastar		
Proton		**12.004**	**11.004**	**10.002**	**8.004**	**6.002**	**13.006**	**7.006**	**8.000**	**5.012**	**3.006**	**4.000**	**87.05**
	1	1 Gorizont 17	1 Ekran	1 Gorizont 23	1 Ekran 20	1 Gorizont	1 Express 01	1 GALS 2	1 Russia-Express 02	1 ***Iridium 01 - 7***	1 ***Iridium 03 - 7***	1 Russia-Raduga-1	
	1	1 Gorizont 18	1 Gorizont 20	1 Gorizont 24	1 Gorizont 25	1 Gorizont 28	1 GALS 1	1 Luch 1-1	1 Russia-Gorizont 31	1 ***Iridium 02 - 7***	1 Russia-Cosmos 2350	1 Russia-Raduga-2	
	1	1 Gorizont 19	1 Gorizont 21	1 Raduga 27	1 Gorizont 26	1 Gorizont 29-Rim	1 Gorizont 30-Rimsat		1 Russia-Gorizont 32	1 Russia-Cosmos 2344	1 Russia-Zarya- ISS FGE	1 Russia-Express A1	
	1	1 Raduga 1-1	1 Gorizont 22	1 Raduga 28	1 Gorizont 27	1 Raduga 29	1 Luch 1		1 Russia-Raduga 33	1 Russia-Cosmos 2345		1 Russia-Yamal 101	
	1	1 Raduga 23	1 Raduga 1-2			1 Raduga 30	1 Raduga 1-3			1 ***Russia-Coupon 01 - 1***		0 Russia-Yamal 102	
	1	1 Raduga 24	1 Raduga 25				1 Raduga 31						
	1		1 Raduga 26				1 Raduga 32		3 Russia-Mil/Science				
	6	6 Russia-Mil/Science	4 Russia-Mil/Science	6 Russia-Mil/Science	4 Russia-Mil/Science	1 Russia-Mil/Scie	6 Russia-Mil/Science	5 Russia-Mil/Science	1 Mars Mission				
Zenit 3 SL		**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**1.000**	**1.00**
												1 DemoSat	

Table B-3. 1989-1999 United States Non-GTO Launch Sites

		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	TOTAL
United States Ranges														
TOTAL LAUNCHES =		11	10	12	12	13	13	19	17	18	28	22	15	190
		11.005	10.008	12.013	12.014	13.005	13.006	19.004	17.006	18.004	28.033	22.038	17.000	192.136
TAL SPACECRAFT =		16	18	25	26	18	19	23	23	22	61	60	16	327
Eastern Ranges														
STS		2.002	5.006	6.005	6.005	8.005	7.004	7.003	7.004	7.003	8.000	5.000	3.000	71.037
	RLV	1 US-STS-026 Disc 0 US-NASA TDRS (1 US-STS-027 Atlar 0 US-DoD (Lacross	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 Columbi 0 US-Navy Syncom IV-5 1 US-STS-036 Atlantis 0 US-DoD (KH-11A) 1 US-STS-031 Discover 0 US-NASA Hubble 1 US-STS-041 Discover 0 US-NASA Ulysses 1 US-STS-038 Atlantis 0 US-DoD (Magnum) 1 US-STS-035 Columbi	1 US-STS-037 Atlantis 0 US-NASA GRO 0 US-US AF MPEC-A 1 US-STS-039 Discov 1 US-STS-040 Colum 1 US-STS-043 Atlantis 0 US-NASA TDRS E 1 US-STS-048 Discov 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 En 0 US-NASA TDRS 1 US-STS-056 Dis 0 US-NASA Spart 1 US-STS-055 Co 1 US-STS-057 En 1 US-STS-051 Dis 0 US-NASA ACTS 0 German-Orgeus 1 US-STS-058 Co 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 Micrograv 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 Endeavou 1 US-STS-071 Atlantis 1 US-STS-070 Discovery 0 US-NASA TDRS G 1 US-STS-069 Endeavou 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-Endeavo 1 US-STS090-Columbia 1 US-STS091-Discover 1 US-STS095-Discover 1 US-STS088-Endeavo	1 US-STS-96-Discovery 0 Starshine 1 US-STS-93-Columbia 0 Chandra Telescope 1 US-STS-103-Discovery	
Athena		0	0	0	0	0	0	0	0	0	0	1	3	4
	Small											1 NASA Lunar Prospec	1 ROCSAT 1 Ikonos-1 1 Ikonos Commercial	
Pegasus		0	0	0	0	0	1.001	0.000	0.000	1.001	3.007	3.014	3.000	11.023
	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	1 NASA WIRE 1 TERRIERS 0 MUBLCOM 1 US-Orbcomm 04-8	
Taurus		0	0	0	0	0	0	0	0	0	0	0	1	1
	Small												1 KOMPsat 0 ACRIMSAT 0 Celestis 3	
Titan		1.000	3.002	2.004	0.000	1.000	0.000	4.000	4.000	3.000	3.000	2.000	2.000	25.006
	HLV	1 US-AF Titan 34D	1 US-AF Titan 34D (Chat 1 US-AF Titan 34D (DSC 0 US-AF Titan 34D (DSC 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 Jumpsea 1 US-AF T4 (DoD) 1 US-AF T4 (DSP 17) 1 US-AF T4 (Milstar 1)	1 US-AF T4 (Adv Jumpse 1 US-AF T4 (DoD) 1 US-AF T4 (DoD) 1 US-AF T4 (Milstar 2)	1 US-AF T4 (Adv Jumpsea 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)	1 US-AF-Mission B-27 1 US-AF-Milstar	

Table B-3. 1989-1999 United States Non-GTO Launch Sites (continued)

United States-Vandenberg Test Center

Vehicle	Class	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	TOTAL
Athena		0	0	0	0	0	0	0	1	0	1	0	0	2
	Small								1 US-GEMStar (Vita Sat)		1 US-NASA-Lewis			
Atlas		2	0	2.002	2	0	1	2	1	0	0	0	1	11.002
	MLV	1 US-AF DMSP F09 1 US-NOAA 11		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				*1* NASA Terra	
Delta		0.000	1.000	0.000	0.000	0.000	0.000	0.000	2.000	2.000	6.024	5.020	0.000	16.044
	MLV		1 US-AF Cos Bkgnd Exp						1 Canada-Radarsat 1 US-NASA-XTE	1 US-AF-Midcourse Space 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	0	1.001	1.006	0.000	1.000	3.000	2.002	4.000	4.002	3.001	0.000	19.012
	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		4.002	0	1.001	1	2	1	1	0	0	0	0	0	10.003
	Small	3 Domestic 1 San Marcos		1 Domestic	1 Domestic	2 Domestic	1 Domestic	1 Domestic						
Taurus		0	0	0	0	0	0	1.001	0.000	0.000	0.000	2.003	1.000	4.004
	Small							1 US-STEP/TAOS 0 US-DarpaSat				1 US-Navy GEOSAT/OI 1 US-NRO-STEX	1 Korea-KOMPSAT	
Titan		2.001	1.000	0.000	2.003	2.000	2.001	1.000	0.000	1.000	3.000	1.000	3.000	18.005
	HLV	1 US-AF T34D (KH-11)			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)	1 US-NRO Mission B-12	
	MLV	1 US-AF T2 (Ferrett	1 US-AF T2 (Ferrett)			1 US-AF T2 (DoD)	1 US-NASA T2 (L	1 US-NASA T2 (Clementine)			1 US-AF (DMSP 38) 1 US-NASA-TIROS		1 US-AF-DMSP 1 NASA QuikScat	

Table B-4. 1989-1999 Foreign Non-GTO Launch Sites

		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	TOTAL
Non-United States Ranges														
TOTAL LAUNCHES =		85	64	72	52	50	45	39	29	21	23	24	21	525
TAL SPACECRAFT =		1097	81	89	75	67	56	49	33	28	34	49	42	1700
Brazil VLS		0	0	0	0	0	0	0	0	0	0	0	1	1
	Small												1 Brazil-SACI 2	
China-Taiyuan/Jiyuan Long March		2	0	2	0	2	1	1	0	1	3.002	4.004	4	20.006
	ILV													
	MLV	1 China-FSW 1-01 1 China-FenYun 1A		1 China-FenYun 2 1 China-FSW 1-02		1 China-FSW 1-03 1 China-FSW 1-04	1 China-FSW 2-0	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***	1 China-Fengyun 1C 0 Shi Jian 5 1 Iridium replaceme 1 Ziyuan-1 0 SACI-1 1 Shenzhou	
India PSLV/GSLV		1	0	0	0	1	1	2	0	1	1	0	1	8
		1 India-SROSS 2				1 India-SROSS C	1 India-IRS 1E	1 India-IRS P2 1 India-SROSS C		1 India-IRS P3	1 India-IRS 1D		1 OceanSat (IRS-P4) 0 Kitsat-3 0 TubSat	
Israel Shavit		1	0	1	0	0	0	0	1	0	0	1	0	4
	Small	1 Israel-Horizon		1 Israel-Ofeg 2					1 Israel-Ofeq 3			1 Israel-Ofeq 4		
Japan M-3S/M-5		0	1	1	1	0	1	0	1	0	1	1	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)		

Table B-4. 1989-1999 Foreign Non-GTO Launch Sites (continued)

		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	TOTAL
Russia-Baikonur														
Dnepr		**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**
	Small	1 Russia-Buran											1 UoSat 12	
Energia		**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
	HLV	1 Russia-Buran												
Molniya		**1**	**0**	**0**	**1**	**0**	**0**	**0**	**1.001**	**0**	**0**	**1**	**0**	**4.001**
	MLV	1 Russia-Domestic			1 Russia-Domestic				1 Russia-Domestic 0 Russia-Domestic			1 Molniya M		
Rockot		**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**
	Small							1 Russia-Domestic						
Soyuz		**22**	**13**	**12**	**12**	**11**	**10**	**11**	**8**	**6**	**8**	**7**	**10**	**130**
	HLV	3 Russia-MIR Mann	1 Russia-MIR Manned	3 Russia-MIR Manned	2 Russia-MIR Mannec	2 Russia-MIR Manned	2 Russia-MIR Mar	3 Russia-MIR Manned	2 Russia-MIR Manned	2 Russia-MIR Manned	1 Russia-Cosmos 2343	1 Russia-MIR TM27 Ma	1 Russia-Foton-12	
		6 Russia-MIR Suppl	4 Russia-MIR Supply	4 Russia-MIR Supply	5 Russia-MIR Supply	5 Russia-MIR Supply	5 Russia-MIR Sup	5 Russia-MIR Supply	5 Russia-MIR Supply	3 Russia-MIR Supply	1 Russia-Photon	1 Russia-Cosmos 2349	1 Russia-Mir Crew	
		13 Russia-Domestic	8 Russia-Domestic	5 Russia-Domestic	5 Russia-Domestic	4 Russia-Domestic	3 Russia-Domesti	3 Russia-Domestic	1 Russia-Domestic	1 Russia-Domestic	1 Russia-Progress M34	1 Russia - Progress M3	1 Russia-Mir resupply	
											1 Russia-Progress M35	1 Russia - Progress M3	1 Russia-Mir resupply	
											1 Russia-Progress M36	1 Russia-Cosmos 2359	1 US-Globalstar 01 - 4	
											1 Russia-Progress M37	1 Russia-MIR TM28 Ma	1 US-Globalstar 02 - 4	
											1 Russia-Soyuz TM 25	1 Russia-Progress M40	1 US-Globalstar 03 - 4	
											1 Russia-Soyuz TM 26		1 US-Globalstar 04 - 4	
													1 US-Globalstar 05- 4	
													1 US-Globalstar 06 - 4	

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B7. "1999 Commercial Space Transportation Forecasts," Federal Aviation Administration, Associate Administrator for Commercial Space Transportation (AST), and Commercial Space Transportation Advisory Committee, May 1999, Washington, D.C. ("COMSTAC 1999 Commercial GSO Spacecraft Mission Model - May 1999," 31-page COMSTAC report included in document)

Appendix C. Letter from the Associate Administrator

U.S. Department
of Transportation

Federal Avaiation Administration

JAN- 20, 2000

Mr./Ms. President
President
XYZ Space Company
1234 Street Address
Anytown, St. Country 12345

Dear _________,

The Office of the Associate Administrator for Commercial Space Transportation (AST) of the Federal Aviation Administration (FAA) commissions an annual update to the Commercial Satellite Mission Model for geo-synchronous satellites. The mission model update is developed for the FAA by the Commercial Space Transportation Advisory Committee (COMSTAC). COMSTAC is the industry advisory body that provides recommendations to the FAA on issues that affect the U.S. commercial launch industry. Last years report can be viewed on-line at http://ast.faa.gov/comstac_info/. The FAA and the industry uses this report to identify projected commercial space launch user requirements. It is also used 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, 2000.

The Commercial Satellite Mission Model is now in the process of being updated for 2000. In support of this effort, our office requests inputs from various companies and organizations based on their forecasts of future satellite 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, 2000 to ensure that the mission model update is as accurate as possible. Please forward this request to the department most appropriate within your organization (i.e. market analysis, marketing, contracts). The attachment will give you more detailed information on how and where to respond and contact points. 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

Enclosures

2000 Commercial Geo-Synchronous Satellite Mission Model Update Instructions

As with the 1999 and previous year efforts, the goal for the 2000 COMSTAC geo-synchronous mission model update is to forecast the demand for worldwide commercial space launch requirements. This demand is 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.

The forecast will be of the addressable commercial geo-synchronous satellites sales through 2010.

"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). For reference purposes, 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.

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. A combined market projection will be published.

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, 2000 in order to support our update schedule. Your responses should be sent directly to Mr. Michael Izzo at the following address:

Mr. Michael Izzo

Lockheed Martin Commercial Space Systems

Building 551 Org K201

1272 Borregas Ave.

Sunnyvale, Ca. 94542

Phone: (408) 743-4863

Fax:(408) 743-4907

Email: michael.izzo@lmco.com

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

2000 Commercial Space Transportation Projections for Non-Geosynchronous Orbits (NGSO)

Federal Aviation Administration

Office of the Associate Administrator for Commercial Space Transportation

May 2000

TABLE OF CONTENTS

LIST OF FIGURES

EXECUTIVE SUMMARY

The Federal Aviation Administration's Office of Commercial Space Transportation (AST) has prepared a projection of the non-geosynchronous (NGSO) commercial satellite launch market for 2000 to 2010. The *2000 Commercial Space Transportation Projections for Non-Geosynchronous Orbits (NGSO)* is the seventh annual assessment of launch demand for all commercial space systems in orbits other than geosynchronous orbit (GSO), and addresses launches to low Earth orbit (LEO), medium Earth orbit (MEO), and elliptical orbits (ELI). Launch demand was assessed for Little, Big, and Broadband NGSO telecommunications systems, remote sensing satellites, foreign scientific, and other payloads.

While the number of commercial launches to non-geosynchronous orbits has rapidly increased over the past several years, the operators and proponents of NGSO systems have suffered several significant setbacks over the past year. In particular, the pioneering Iridium Big LEO mobile telephony system which deployed 88 spacecraft on 20 launches failed to attract enough subscribers to continue operating and was compelled to file for bankruptcy protection. As a result, many of the NGSO satellite constellations expected to be launched in the next five years now face increased skepticism and appear less likely to be launched within this timeframe.

The *2000 Commercial Space Transportation Projections for Non-Geosynchronous Orbits (NGSO)* reflects these reduced expectations. In both the Big LEO and Broadband LEO market segments, fewer systems are projected to be deployed and maintained over the forecast period resulting in significantly reduced demand for NGSO launches over the next decade.

As with previous NGSO launch forecasts, AST has developed two scenarios assessing 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 satellite services is sufficient to support 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 of two Little LEO systems (in addition to Orbcomm), one Big LEO system (in addition to Iridium and Globalstar), and one Broadband LEO system. Replenishment of Iridium is not expected.

- **Robust Market Scenario**: deployment of three Little LEOs (in addition to Orbcomm), two Big LEOs (in addition to Iridium and Globalstar), and two Broadband systems. Replenishment of Iridium is not expected.

The baseline scenario projects that 522 payloads will be deployed between 2000 and 2010, down almost 40 percent from projections in last year's baseline scenario due to the reduction in big and broadband systems expected to be deployed. The robust market scenario projects that 685 payloads will be deployed over the next 11 years, also a reduction of close to 40 percent from last year's projections.

The demand for commercial launches to LEO for the baseline scenario is projected to be an average of 7.5 medium-to-heavy and 10.4 small launches per year from 2000 to 2010. Demand for medium-to-heavy launch vehicles is about half that of last year, while small vehicle demand is unchanged. Launch demand for the robust market scenario is projected to be an average of 11.6 medium-to-heavy and 13.1 small launches per year.

INTRODUCTION

Up until 1997, the market for commercial launches to low Earth orbit (LEO) and other non-geosynchronous orbits (NGSO) was practically non-existent, with only the occasional launch of a scientific payload for a foreign country. In 1997, the dynamics of the commercial launch market changed with the deployment of the first constellations of communications satellites in low Earth orbit, resulting in significant additional demand for commercial launches. Launches to all non-geosynchronous orbits, including low Earth orbit (LEO), medium Earth orbit (MEO), and elliptical orbits (ELI), account for 44 percent of commercial launches worldwide since 1997.

Since the release of last year's projections, however, a number of NGSO systems recently deployed or under development have either failed to gain market acceptance, filed for bankruptcy, or both. The most prominent of these, Iridium LLC, filed for bankruptcy in August 1999 after failing to attract sufficient subscribers for its mobile telephony service. As a result, a second generation Iridium system is not expected to be deployed and many other systems projected to be launched in last year's forecast now appear less likely to be developed.

In order to assess demand for commercial launch services resulting from the deployment of NGSO satellite systems, the Federal Aviation Administration's Associate Administrator for Commercial Space Transportation (AST) compiles the *Commercial Space Transportation Projections for Non-Geosynchronous Orbits (NGSO)* 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.

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 NGSO, or LEO, commercial satellite markets, with the ultimate purpose of projecting future space transportation demand.

NGSO Commercial Market Sectors

To assess demand for commercial NGSO launches, it is first necessary to understand the range of proposed NGSO satellite systems. Multi-satellite systems—dedicated to serving the telecommunications markets—will produce the highest level of demand for NGSO launches 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 phone users and fixed-site users in areas not served by terrestrial systems.
- "Broadband LEO" systems providing high-bandwidth data links using Ku-band (12/17 GHz), Ka-band (17/30 GHz), V-band (36/45 GHz), and Q-band (46/56 GHz) frequencies.

Each successive type of NGSO constellation is an order of magnitude greater in size (i.e. total mass of the constellation) resulting in a different effect on demand for commercial launch services. For example, ORBCOMM consists of 35 satellites weighing a total of 3,325 lb and was launched on 4 Pegasus and 2 Taurus small launch vehicles. By contrast, Iridium launched 88 spacecraft weighing a total of 132,000 lb on 20 launch vehicles of varying sizes. This is demonstrated in Figure 1, which shows mass to orbit versus frequency (both uplink and downlink) for systems currently licensed by the Federal Communications Commission (FCC).

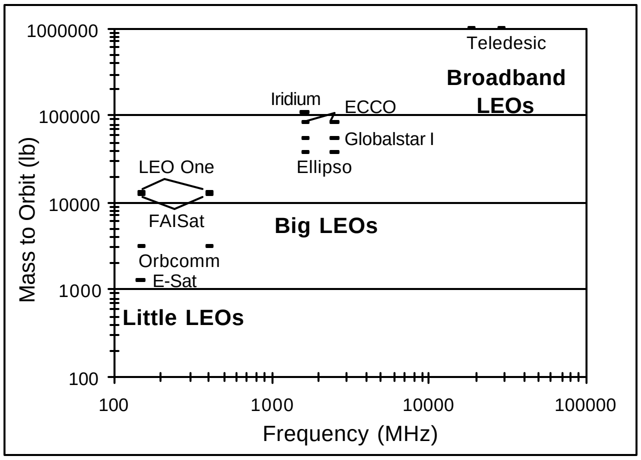

Figure 1: Licensed NGSO Telecom Systems (Mass to Orbit vs. Frequency)

While communications satellites are expected to be the primary driver of demand for commercial launch services to NGSO, commercial remote sensing systems are also being deployed for the first time. 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. The first of these to become operational, Space Imaging's Ikonos, was launched in September 1999.

In addition, foreign governments and research organizations generate a low but steady level of demand for commercial launches of scientific payloads to non-geosynchronous orbits.

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 satellite services markets themselves—AST developed two market scenarios assessing NGSO 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 the entrance of new service providers or expanded follow-on systems.

The baseline scenario reflects developments in the market for NGSO satellite services and the FAA's assessment of the number of additional systems likely to be deployed. The robust market scenario reflects more optimistic—but nonetheless reasonable—assumptions should NGSO satellite service providers gain increased market acceptance over the next several years. As such, it represents a more "robust market" scenario 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 NGSO launches 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).

NGSO SATELLITE SYSTEMS

The demand for commercial NGSO launches is dominated by the deployment and maintenance of commercial communications constellations, i.e. the Little LEO, Big LEO, and Broadband LEO systems outlined above. Additional, but lower level demand is expected for launch of commercial and foreign remote sensing satellites, foreign scientific satellites, and other payloads. These systems use a variety of orbits, including:

- Low Earth orbits 400-1,500 nm in altitude, varying between 0^o inclination for equatorial coverage and 101^o inclination for global coverage

- Medium Earth orbits 5,600 nm in altitude and 45^o inclination for global coverage using fewer higher-powered satellites

- Elliptical orbits with apogees ranging from 4,100 nm to 25,400 nm in altitude and up to 116.5^o inclination, allowing satellites to "hang" over certain regions on Earth, such as North America.

For each market segment, AST examined both operational and proposed systems to assess the number of systems likely to be deployed and sustained. AST evaluated:

- System design maturity
- Licensing status and spectrum availability
- Financing and partnerships secured
- Business plan, projected market demand, and impact of competing technologies
- Spacecraft, ground services equipment, and launch services contracting status.

Following examination of the data for each market segment, AST developed the baseline and robust market scenarios assessing NGSO 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 asset tracking, remote data monitoring, messaging, and two-way paging 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 capa-bilities (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. Costs to deploy Little LEO systems vary between $50 and $300 million depending on system design. Operational and 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 3. 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 The first Little LEO system to be deployed was ORBCOMM, which began operation in November 1998 after completing deployment of its initial 28-satellite constellation. ORBCOMM provides mobile asset tracking, fixed asset monitoring, and messaging utilizing a wide variety of handsets and terminals optimized for each industrial and consumer application. ORBCOMM's services are marketed through its global network of 17 service distribution partners which are licensed to operate in 194 countries. While ORBCOMM has been successful in securing subscribers for its service, it has also encountered difficulties converting orders into paying customers due to a number of delays in development of user hardware and software. As of April 2000, ORBCOMM had 26,000 units in service, with an additional 180,000 units on order.

Several potential providers of low data rate satellite services continued to make progress toward deployment of Little LEO systems. In April 2000, Raytheon joined General Dynamics as an equity partner in Final Analysis's FAISat, bringing total equity investment to $125 million. In October 1999, DBS Industries signed a $90 million contract with Alcatel Space to serve as prime contractor for the six-satellite E-Sat constellation. Also in October, Leo One Worldwide (formerly Leo One USA) selected Dornier Satellitensysteme Gmbh and Lockheed Martin Space Electronics & Communications to complete construction of its 48-satellite system and selected Eurockot as its launch provider.

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 face competition from both terrestrial wireless networks 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. Big LEOs may also compete with Little LEOs for data messaging services. American Mobile Satellite Company 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, two additional Little LEO systems will be deployed and replenished over the forecast period. One system, ORBCOMM, deployed a constellation of 35 satellites and is expected to add an additional 7 satellites in the coming year. Final Analysis has launched two experimental satellites for its FAISat constellation. Under the robust market scenario, AST projects deployment of three Little LEOs in addition to ORBCOMM, similar to last year's forecast.

Licensing Status Five Little LEO systems have received licenses from the FCC—ORBCOMM, E-Sat, FAISat, Leo One, 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. ORBCOMM and VITA received authority for modest system expansions.

System	Operator	Prime Contractor	Satellites		Orbit	First Launch	Status
			Number + Spares	Mass (lb)			
Operational							
ORBCOMM	ORBCOMM Global LP	Orbital	48	95	LEO	1997	Operational with 35 satellites on orbit; FCC licensed, October 1994
Under Development							
FAISat	Final Analysis	Final Analysis	32 + 6	332	LEO	2001	FCC licensed, March 1998; two test satellites launched in 1995 and 1997
Leo One Worldwide	LEO One USA	Dornier	48	275	LEO	2001[1]	FCC licensed, February 1998; launch contract signed with Eurockot
E-Sat	E-Sat, Inc.	Alcatel	6	250	LEO	2001	FCC licensed, March 1998; launch contract signed with Eurockot
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
Gonets-D	Smolsat (Russia)	NPO PM	36	510	LEO	TBD	Status unknown; 6 test sats launched in 1996 and 1997 based on military system
LEO One Panamericana	LEO One Pan. (Mexico)	TBD	12	330	LEO	TBD	Status unknown; 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

6

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

Figure 2: Little LEO Satellite Systems

System	Operator	Prime Contractor	Satellites		Orbit	First Launch	Status
			Number + Spares	Mass (lb)			
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
IRIS	SAIT RadioHolland	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	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 provide mobile telephony services on a global basis through a network of satellites to handheld receivers, similar to cellular phones. Two Big LEO systems have been deployed to date—Iridium and Globalstar—and a third, ICO, lost its first spacecraft when a Sea Launch rocket failed on March 12, 2000. Also known as mobile satellite services (MSS) or global mobile personal communications systems (GMPCS), development and deployment of these systems is estimated to cost between $1.3 and $7 billion each. Proposed Big LEO and MSS voice constellations are detailed in Figure 4.

Recent Developments Perhaps no other event has shaken the commercial space industry more than the recent failure of Iridium. The world's first global satellite telephony system, Iridium deployed 88 satellites on 20 launches and built a network of ground stations at a cost of $5.5 billion. Applauded as an incredible technological achievement, Iridium failed to attract a sufficient number of customers and was compelled to file for bankruptcy in August 1999, less than one year after entering commercial service in November 1998. After failing to attract additional investors, Iridium ceased operation in March 2000.

Difficulties for Big LEO providers are not limited to Iridium. The only other Big LEO to deploy its satellite constellation, Globalstar, appears to be attracting fewer customers than expected. It remains to be seen, however, whether these early indications are the result of a lack of market demand or merely distribution and marketing issues. Globalstar initiated service in October 1999 by conducting a "soft rollout" of its service, providing free service to a limited number of customers in order to fully test out their system. Following this limited offering, Globalstar initiated full commercial service in February 2000 in all of North America, plus parts of Europe, Asia, and South America.

A third mobile voice system, ICO, filed bankruptcy shortly after Iridium in August 1999 after failing to raise sufficient investor financing to complete construction of its satellites and gateways. Unlike Iridium, ICO has found investors to finance a restructuring of the program. In December 1999, the U.S. bankruptcy court overseeing ICO's restructuring approved a takeover of the company by a group of investors affiliated with the Teledesic broadband satellite company. In May 2000, ICO emerged from bankruptcy as New ICO and became a subsidiary of ICO-Teledesic Global Limited, a new holding company. ICO will be redesigned to provide medium-rate data communications such as wireless internet applications in addition to mobile telephony. It is not clear to what extent ICO's restructuring will alter Teledesic's design.

Market Overview Iridium's failure to attract customers for its pioneering global mobile telephony system is the direct result of the ubiquitous and inexpensive ground-based wireless telephony systems now available. Iridium's target market was the global business traveler, willing to pay as much as $8 per minute to remain in contact with the home office. That market, however, failed to materialize.

Owing to the complexity of its satellite and ground infrastructure, Iridium took 10 years to implement from concept to commercial operation. In the course of those 10 years, terrestrial cellular telephony experienced phenomenal growth in coverage area, number of subscribers, and quality of service while greatly reducing the price of that service. Once viewed as a technologically advanced system for which customers would be willing to pay a premium, Iridium provided a lesser quality service that was difficult to use and considerably more expensive than ground-based systems. Its only advantage—truly global coverage with one phone and one bill—failed to attract sufficient subscribers.

Iridium's failure does not necessarily mean that other Big LEOs will also fail. Globalstar, for example, has a less costly infrastructure and is able to offer service at prices far below those of Iridium. Learning from Iridium, Globalstar has also adapted its marketing to reflect the wide availability of terrestrial wireless service by making its phones interoperable with cellular networks, connecting via satellite only when cheaper cellular service is unavailable. In addition, Globalstar is targeting rural areas in developing countries where installation of fixed sites, or so-called "village phone booths," offers a more cost-effective service than building wireline or cellular infrastructures. Together, these factors may allow Globalstar to attract a sufficient customer base where Iridium did not.

At the same time, New ICO is making substantial changes to its plans in response to Iridium's failure to attract subscribers and its own subsequent bankruptcy. Under new leadership, ICO is adapting its system to target data communications and plans to offer medium-rate wireless internet access in addition to satellite telephony. Wireless internet applications are expected to be one of the next growth areas of internet access and New ICO appears to be re-positioning itself to capitalize on this new market. Originally scheduled to begin deploying its satellites in 1998, ICO's first satellite was lost when Sea Launch failed on March 12, 2000. ICO planned to use the spacecraft to test its new data applications to determine what modifications would be required to its satellite and ground systems before launching the full constellation.

Competition The near-universal coverage of terrestrial cellular telephony—which is now available to over 95 percent of the population in developed countries—provides the greatest competition for Big LEO systems as originally envisioned. Ground-based wireless telephony systems are rapidly starting to offer wireless internet applications as well. If ICO offers medium-rate access to the internet for fixed terminals, it will compete with existing terrestrial internet service providers. Competition will also come from GSO satellites which provide regional mobile telephony service at lower cost than NGSO systems.

Market Demand Scenarios It is AST's assessment that under the baseline scenario, only one new Big LEO system will be deployed in addition to Iridium and Globalstar. This is one system less than projected in last year's baseline scenario. Follow-on systems to be deployed at the end of each system's expected lifetime are included in the baseline scenario. As a result of Iridium's cessation of operations, however, replacement of Iridium satellites expected to occur around 2005 is no longer required. It is AST's assessment that under the robust market scenario, two new Big LEO systems will be deployed in addition to Iridium and Globalstar through the end of the forecast period.

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, licenses were granted to Iridium, Globalstar, and Odyssey in January 1995. AMSC withdrew its application prior to the granting of licenses for ECCO and Ellipso in the summer of 1997.

In September 1997, the FCC received applications for 2-GHz systems, including Iridium Macrocell, Globalstar GS-2, ECCO II, Ellipso 2G, and Boeing's 16-satellite MEO system for the commercial airline industry. At the same time, ICO Global Communications filed a letter of intent with the FCC to operate a 2-GHz system in the United States. Licenses for 2-GHz systems are expected in 2000. Following the September 1997 application, TRW withdrew its Odyssey application and joined with ICO.

The large number of Big LEOs proposed by Russian organizations remain unfunded and the status of the Brazilian Space Agency's ECO-8 equatorial satellite system is unknown.

System	Operator	Prime Contractor	Satellites		Orbit	First Launch	Status
			Number + Spares	Mass (lb)			
Operational							
Globalstar	Globalstar LP	Alenia Spazio	48 + 8	985	LEO	1998	Constellation on-orbit and operational; FCC licensed, January 1995
Iridium	Iridium LLC	Motorola	66 + 6	1,500	LEO	1997	Ceased operation in March 2000 following bankruptcy in August 1999
Under Development							
Big LEO							
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	New ICO (formerly ICO Global Comm.)	Hughes Space & Comm. (HSC)	10 + 2	6,050	MEO	2000	Filed for bankruptcy in August 1999; undergoing redesign; FCC letter of intent filed, September 1997
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	TBD	26 + TBD	2,900	LEO & ELI	2004 est.	FCC license applied for, September 1997
Globalstar GS-2	Globalstar LP	TBD	64 + 4	1,830	LEO[2]	2004 est.	FCC license applied for, September 1997
Iridium Next Generation (INX)/Salina	Iridium LLC	TBD	96 + TBD	3,775	LEO	2005 est.	Not expected following Iridium's failure; FCC license applied for, September 1997
International							
ECO-8	Brazilian Space Agency	TBD	11 + 1	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	AMSC	--	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

With the rise of the internet and data communications as increasingly formidable forces in consumer and business markets, the provision of high-speed data services through GSO satellites has risen dramatically over the past three years. Although still a relatively small percentage of overall satellite capacity, internet and data communications appears poised to become a significant market for satellite systems. Although internet directly via satellite is currently limited to GSO satellites, proposed Broadband LEO systems—such as Teledesic and SkyBridge—are designed to provide seamless connectivity to the internet and corporate data networks without the time delay associated with more distant GSO satellites. Broadband systems are proposed for the Ku, Ka, and V/Q-band frequencies and are estimated to cost between $4 and $15 billion each. Broadband LEO systems are summarized in Figure 5.

Recent Developments The takeover of the ICO Big LEO system by Teledesic co-founder Craig McCaw is likely to have significant implications for the planned Teledesic Broadband LEO system. Two years ago, Teledesic merged with rival Celestri, ousting prime contractor Boeing and replacing them with Motorola. Subsequently, the parties have missed several self-imposed deadlines to define the system configuration and sign contracts for its construction. 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. With the takeover of ICO and its redesign as a data communications system, the deployment of a separate, dedicated Teledesic constellation is less certain. Teledesic could use ICO to generate an early revenue stream for its future system or merge the two businesses. It is likely, however, that the future of Teledesic will remain in doubt until ICO's reorganization is complete, if not longer.

The only other broadband NGSO system under active development, SkyBridge, continued to make progress toward deploying its 80-satellite constellation over the past year. In December 1999, SkyBridge signed a contract with Boeing to launch 40 satellites on two Delta 3 launch vehicles and four Delta 4s. In April 2000, SkyBridge signed a second launch deal with Starsem, the French-Russian joint venture, for launch of 32 satellites on 11 Soyuz/Fregat launch vehicles. Both Boeing and Starsem took equity stakes in the company. SkyBridge plans to launch a sub-constellation of 40 satellites beginning in 2002, with the remaining 40 to follow for increased system capacity. SkyBridge partners include Alcatel, the French space agency CNES, and Loral Space & Communications.

Market Overview Currently, Broadband data communications is the focus of significant investment in the telecommunications industry with billions of dollars pouring into different technologies to meet business and consumer demand for high-speed connectivity. Fiber optic cables, new digital cable, integrated services digital network (ISDN) lines, and digital subscriber lines (DSL) are a few of the technologies actively competing with GSO satellites to provide high-speed data communications. 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 a portion of that market demand.

While not expected to dominate the data communications market in the foreseeable future, satellites appear well suited to capture part of this burgeoning market. Satellites are likely to provide internet backbone connectivity between continents and broadcast internet audio, video, and data simultaneously to thousands of internet service providers (ISPs) worldwide.

Competition Broadband LEO systems will face competition from the rapid build-out of terrestrial networks and GSO satellite systems targeting similar high-bandwidth data communications. For consumer applications, satellites will be most competitive where there is no existing terrestrial infrastructure due to the high cost of installing wirelines or wireless networks. Several GSO and NGSO broadband systems are targeting consumers with two-way broadband links to the internet using satellite dishes similar to those for direct broadcast television. Satellites also appear well suited to provide multicasting of internet content to multiple ISPs at the same time.

Because of the incredible growth potential for data traffic, a large number of GSO and NGSO broadband systems have been proposed. The distinguishing feature of NGSO systems is that because they are closer to the Earth, there is no latency, or time delay, associated with GSO satellites orbiting at 22,300 nm. While latency was assumed to be a significant impediment to internet transmission over satellite, this issue appears to have been mitigated for many applications, if not completely solved. The extent to which "seamless connectivity" with the internet as planned for NGSO systems is a marketable advantage remains to be seen.

NGSO systems also have some disadvantages relative to GSO systems. For example, because NGSO systems are global in nature, the entire system must be fully deployed to start service, whereas GSO systems may begin operation with only one satellite. In addition, much of the capacity of NGSO systems is unusable at any given time because each satellite spends about 70 percent of its time over water, making the system inherently more expensive.

It is not clear at this time whether one type of satellite system will have sufficient competitive advantages to outperform the other. It is possible that each will target niches in the market enabling both to be competitive with terrestrial alternatives. As a result, both types of systems appear likely to be deployed.

Market Demand Scenarios It is AST's assessment that under the baseline scenario, one Broadband LEO system will be deployed and maintained through 2010. This is one less than forecasted in last year's LEO forecast and is a reflection of the increased skepticism surrounding NGSO systems. Under the robust market scenario, AST projects that two Broadband LEO systems will be deployed and maintained through 2010. The second broadband was modeled based on a blend of proposed NGSO Ka, Ku, and V-band systems.

Licensing Status Currently, only one applicant, Teledesic, has received a license from the FCC to operate a Broadband LEO system. In 1997, Teledesic was licensed to operate an 840-satellite NGSO system. In January 1999, Teledesic's license was amended approving a 288-satellite constellation. No subsequent amendments have been filed.

SkyBridge filed its application to the FCC to operate a Ku-band NGSO system in January 1999. A licensing decision is not expected until issues are resolved pertaining to potential interference with other Ku-band users, including GSO satellites and terrestrial networks. In November 1999, preliminary agreement was reached on power limits and regulatory provisions to govern Ku-band frequency sharing and final approval is to be voted on at the World Radiocommunication Conference in May 2000.

Three rounds of applications have been filed with the FCC for broadband systems, with more than 20 applications involving satellites in NGSO orbits or with GSO 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). In December 1997, applications were filed for Ka-band systems. Applications were filed for Hughes's Spaceway NGSO, Lockheed Martin's MEO proposal, SkyBridge II, and others.

System	Operator	Prime Contractor	Satellites: Number + Spares	Satellites: Mass (lb)	Orbit	First Launch	Status
Under Development							
Ka-Band							
Teledesic[1]	Teledesic LLC	Motorola[1]	288[1]	3,300[1]	LEO[1]	2003 est[2]	FCC licensed, March 1997; license amended Jan 1999 for 288-sat system; current configuration in flux
Ku-Band							
SkyBridge	SkyBridge LP	Alcatel Espace	80	2,750	LEO	2002 est.	France license issued in Feb. 2000; 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	SkyBridge LP	Alcatel Espace	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 L	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) Teledesic configuration in flux and may range from 12 MEO satellites (similar to ICO) to 288 LEO satellites as currently licensed.
(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 commercial remote sensing systems are under development to provide high-resolution images of the Earth's surface for commercial and government customers. 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, they will generate a low but steady demand for launches of small launch vehicles. Commercial launch services may also be used to launch military remote sensing spacecraft for countries that lack domestic launch capabilities. Proposed remote sensing programs are detailed in Figure 6.

The first commercial remote sensing satellite to enter service was Space Imaging's Ikonos-2, launched September 24, 1999. Several other companies, including EarthWatch, West Indian Space, and ORBIMAGE, are expected to launch high-resolution satellites in 2000 after being delayed from 1999. EarthWatch's EarlyBird-1 failed in December 1997 after a successful launch and Space Imaging's, Ikonos-1, was lost in a failed launch attempt in April 1999.

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 *2000 NGSO Forecast* is Sirius Satellite Radio (formerly know as CD Radio), which plans to provide satellite radio to North America. Sirius originally planned to launch two GSO spacecraft, but now plans to launch three satellites to a highly elliptical orbit on three separate launches in mid-to-late 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
				163	OrbView-1	10 km	Launched 1995; weather info
				603	OrbView-2	1 km	Launched 1997; ocean imagery
				407	OrbView-3	1 m	Launch 2000; high resolution
				407	OrbView-4	1 m	Launch 2001; hyperspectral
Space Imaging	IKONOS	Lockheed Martin	1999	1,600	2	1 m	Ikonos-1 launch failed Apr 1999; Ikonos-2 launched Sep 1999
EarthWatch	QuickBird	Ball Aerospace	2000	2,000	2	1 m	QuickBird-1 to launch mid 2000
West Indian Space	EROS	Israeli Aircraft Industries	2000	550	8	1.8 – 0.82 m	Backed by Israeli government; EROS-A1 to launch in mid-2000
RapidEye AG	RapidEye	Surrey Satellite Technology Ltd.	2002 est.	TBD	4	TBD	Manufacturing contract signed Feb 2000; agricultural mapping
Resource-21	Resource-21	Boeing	2003	990	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

The 2000 payload and launch projections are lower than those in the 1999 forecast, reflecting reduced expectations for Big and Broadband LEOs in the wake of Iridium's demise. The projections are based on AST's assessment of proposed NGSO commercial satellite systems and include two scenarios—a "baseline" scenario and a "robust market" scenario—projecting satellite and launch demand through 2010. The baseline scenario includes those systems whose deployment currently appears likely. The robust market scenario assumes that higher demand for NGSO satellite services will allow the deployment of follow-on and expanded systems.

Both scenarios include additional satellites and launches beyond the initial deployments for continued operations and maintenance, and anticipate deployment of follow-on systems with similar characteristics at each constellation's end of life. Each also includes a low but steady demand for commercial launches to deploy remote sensing and select foreign payloads.

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. This is the case for all but one proposed system in each of the Little, Big, and Broadband LEO categories. If vehicle selection was not known, assumptions were made based on the number of spacecraft, mass, orbit, and number of satellites per plane. Deployment of Little LEOs, remote sensing, and foreign scientific payloads are expected to use only small launch vehicles.

Baseline Scenario

The baseline scenario reflects the deployment and replenishment of:

- Three "Little LEO" constellations, consisting of ORBCOMM plus two new systems, which is the same as projected in the 1999 forecast.
- Three "Big LEO" systems, consisting of one new system in addition to Iridium and Globalstar. Re-deployment of Iridium at the end of its useful lifetime is not expected. This is one fewer system than projected in the 1999 forecast reflecting the difficulties encountered by Iridium and other Big LEOs.
- One Broadband LEO system, which is one fewer system than projected last year.

The baseline scenario projects that 552 payloads will be deployed between 2000 and 2010, as shown in Figures 7 and 8. With 56 payloads launched in 1999, this represents a reduction of 38 percent from the 975 payloads projected in last year's baseline scenario. The decline is largely attributable to the removal of payloads for maintenance of Iridium and deployment of a second generation Iridium and the reduction in broadband systems.

Launch demand for the baseline scenario is projected to be an average of 7.5 medium-to-heavy and 10.4 small launches per year from 2000 to 2010. Demand for medium-to-heavy launch vehicles is half that projected last year due to the reduction in deployment of big and broadband systems. Small launch vehicle demand is the same as forecasted last year. Launch demand is shown in Figures 7 and 9.

Robust Market Scenario

The robust market scenario reflects the deployment and replenishment of:

- Four "Little LEO" constellations, consisting of ORBCOMM plus three new systems, the same as projected in the 1999 forecast.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	TOTAL	Avg
Payloads													
Broadband LEO	0	0	4	26	14	20	24	8	8	8	24	136	12.4
Big LEO	6	11	9	4	4	3	27	24	16	4	4	112	10.2
Little LEO	8	2	10	38	38	30	17	7	7	38	40	235	21.4
Remote Sensing/Science/Other	9	6	6	6	6	6	6	6	6	6	6	69	6.3
Total Payloads	**23**	**19**	**29**	**74**	**62**	**59**	**74**	**45**	**37**	**56**	**74**	**552**	**50.2**
Launch Demand													
Medium-to-Heavy (>5,000 lb LEO)	6	6	8	8	5	5	14	10	8	4	8	82	7.5
Small (<5,000 lb LEO)	7	7	9	13	13	10	10	9	9	13	14	114	10.4
Total Launches	**13**	**13**	**17**	**21**	**18**	**15**	**24**	**19**	**17**	**17**	**22**	**196**	**17.8**

Figure 7: Baseline Scenario Payload and Launch Projections

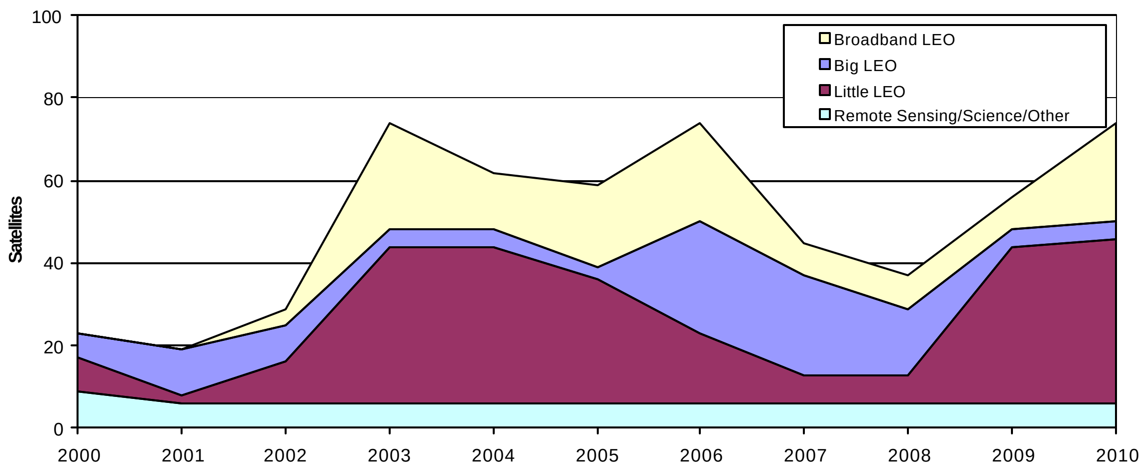

Figure 8: Baseline Scenario Payload Projection

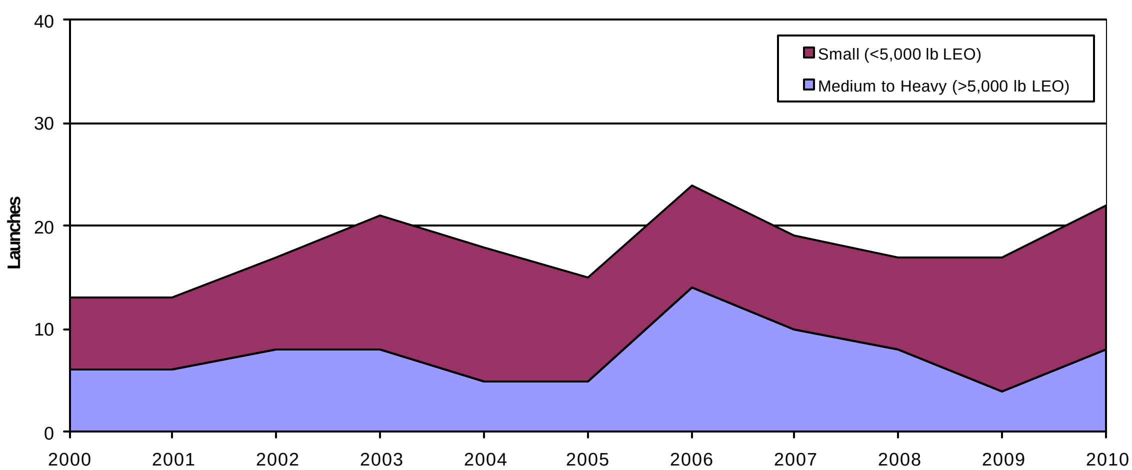

Figure 9: Baseline Scenario Launch Demand Projection

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	TOTAL	Avg
Payloads													
Broadband LEO	0	0	4	36	25	21	25	19	19	9	25	183	16.6
Big LEO	6	11	11	14	14	4	28	25	17	17	17	164	14.9
Little LEO	8	8	10	38	38	30	17	7	13	38	40	247	22.5
Remote Sensing/Science/Other	11	8	8	8	8	8	8	8	8	8	8	91	8.3
Total Payloads	**25**	**27**	**33**	**96**	**85**	**63**	**78**	**59**	**57**	**72**	**90**	**685**	**62.3**
Launch Demand													
Medium-to-Heavy (>5,000 lb LEO)	6	6	9	17	15	6	15	18	16	8	12	128	11.6
Small (<5,000 lb LEO)	9	11	11	15	15	13	13	12	14	15	16	144	13.1
Total Launches	**15**	**17**	**20**	**32**	**30**	**19**	**28**	**30**	**30**	**23**	**28**	**272**	**24.7**

Figure 10: Robust Market Scenario Payload and Launch Projections

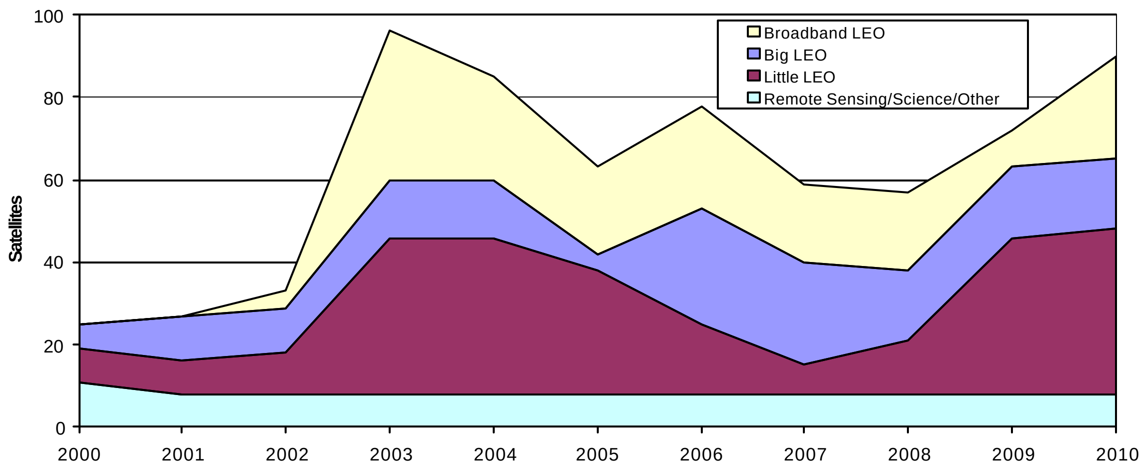

Figure 11: Robust Market Scenario Payload Projection

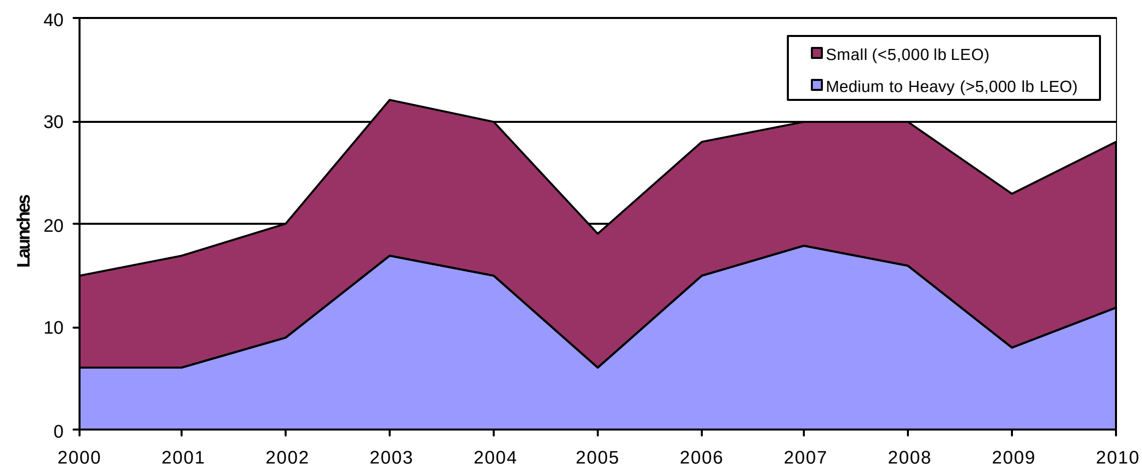

Figure 12: Robust Market Scenario Launch Demand Projection

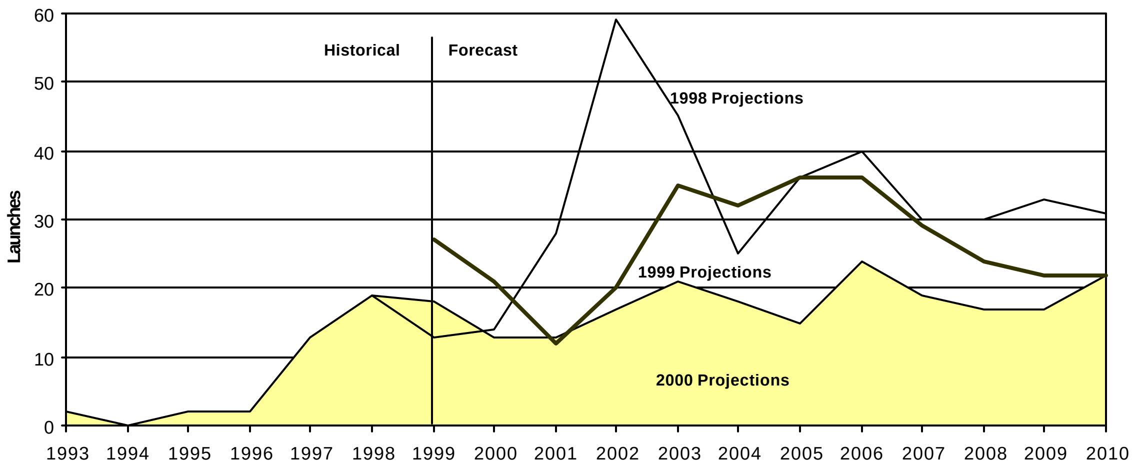

Figure 13: Comparison of Past Baseline Launch Demand Projections

- Four "Big LEO" systems, consisting of two new systems in addition to Iridium and Globalstar. Re-deployment of Iridium at the end of its useful lifetime is not expected. This is one fewer system than projected in the 1999 robust market scenario and is comparable to the 1999 baseline scenario with the exception of a second generation Iridium deployment.

- Two Broadband LEO systems, which is one fewer system than projected in last year's robust market scenario, and is comparable to 1999s baseline projection of two broadbands.

The robust market scenario projects that 685 payloads will be deployed between 2000 and 2010, as seen in Figures 10 and 11. With 56 payloads launched in 1999, this represents a reduction of 38 percent from the 1,195 payloads projected in last year's robust market scenario, the same percentage decline as in the baseline scenario. While the number of big and broadband systems projected in the robust market is comparable to last year's baseline scenario, the number of payloads remains 24 percent below the 1999 baseline forecast due to a reduction in satellites projected in modeling deployment of a second broadband system.

Based on these payload projections, launch demand for the robust market scenario is projected to be an average of 11.6 medium-to-heavy and 13.1 small launches per year over the forecast period. As with the baseline scenario, demand for medium-to-heavy launch vehicles is close to half that projected last year due to the reduction in deployment of big and broadband systems. Small launch vehicle demand is the same as forecasted last year. Launch demand is shown in Figures 10 and 12.

Historical NGSO Market Assessments

Since publication of the first projections for NGSO, or LEO, launches in 1994, there has been tremendous growth in the number of proposed NGSO systems, and deployment of three such systems—Iridium, ORBCOMM, and Globalstar. Over this period, AST's forecast of systems likely to be deployed also increased, growing from two-to-three systems in 1994 to nine-to-twelve systems in 1999. The *2000 Commercial Space Transportation Projections for Non-Geosynchronous Orbits* marks the first reduction in systems forecasted, with only seven-to-ten systems projected, three of which have already been deployed including the failed Iridium system which ceased operation in March 2000. Figure 14

	1994	1995	1996	1997	1998	1999	2000
Systems Projected *							
Broadband LEO	0	0	0	0-1	2-3	2-3	1-2
Big LEO	1-2	2-3	3-4	4-5	4-5	4-5	3-4
Little LEO	1-1	1-2	2-3	2-3	3-4	3-4	3-4

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

Figure 14: Past NGSO System Projections

summarizes AST's commercial LEO market projections for the past seven years.

With the deployment of the first NGSO constellations, the number of commercial payloads launched to low Earth orbits has risen from an average of less than one per year up to the mid-1990s to close to 70 per year over the past three years. Since 1997, 197 NGSO commercial payloads have been launched, including 150 Big LEO spacecraft for the Iridium, Globalstar, and ICO systems, 33 Little LEO spacecraft for ORBCOMM, 1 experimental Broadband LEO for Teledesic, 4 remote sensing spacecraft, and 9 foreign scientific payloads. The payloads were launched on 27 medium-to-heavy launch vehicles and 23 small launch vehicles, creating significant demand for launch services that did not exist earlier. Secondary, or piggyback, payloads on launches with larger primary payloads were not included in the payload or launch tabulations. Historical payload and launch data for the period 1993 to 1999 are shown in Figure 15.

Figure 15: Historical NGSO Payload and Launch Activities (1993-1999)

Summary	Market Segment	Date	Payload	Launch Vehicle	
1999					
56 Payloads	**Big LEO**	2/9/99	Globalstar (4 sats)	Soyuz	Medium-to-Heavy
42 Big LEO		3/15/99	Globalstar (4 sats)	Soyuz	Medium-to-Heavy
7 Little LEO		4/15/99	Globalstar (4 sats)	Soyuz	Medium-to-Heavy
2 Remote Sensing		6/10/99	Globalstar (4 sats)	Delta 2	Medium-to-Heavy
5 Foreign Science		6/11/99	Iridium (2 sats)	LM-2C	Small
		7/10/99	Globalstar (4 sats)	Delta 2	Medium-to-Heavy
18 Launches		7/25/99	Globalstar (4 sats)	Delta 2	Medium-to-Heavy
10 Medium-to-Heavy		8/17/99	Globalstar (4 sats)	Delta 2	Medium-to-Heavy
8 Small		9/22/99	Globalstar (4 sats)	Soyuz	Medium-to-Heavy
		10/18/99	Globalstar (4 sats)	Soyuz	Medium-to-Heavy
		11/22/99	Globalstar (4 sats)	Soyuz	Medium-to-Heavy
	Little LEO	12/4/99	Orbcomm (7 sats)	Pegasus	Small
	Remote Sensing	4/27/99	IKONOS 1	Athena 2	Small
		9/24/99	IKONOS 2	Athena 2	Small
	Foreign Science	1/26/99	Formosat-1	Athena 1	Small
		4/21/99	UoSat 12	Dnepr 1	Small
		4/29/99	Abrixas	Cosmos	Small
			MegSat 0		
		12/21/99	Kompsat	Taurus	Small
1998					
82 Payloads	**Big LEO**	2/14/98	Globalstar (4 sats)	Delta 2	Medium-to-Heavy
1 Broadband LEO		2/18/98	Iridium (5 sats)	Delta 2	Medium-to-Heavy
60 Big LEO		3/25/98	Iridium (2 sats)	LM-2C	Small
18 Little LEO		3/29/98	Iridium (5 sats)	Delta 2	Medium-to-Heavy
3 Foreign Science		4/7/98	Iridium (7 sats)	Proton	Medium-to-Heavy
		4/24/98	Globalstar (4 sats)	Delta 2	Medium-to-Heavy
19 Launches		5/2/98	Iridium (2 sats)	LM-2C	Small
9 Medium-to-Heavy		5/17/98	Iridium (5 sats)	Delta 2	Medium-to-Heavy
10 Small		8/20/98	Iridium (2 sats)	LM-2C	Small
		9/8/98	Iridium (5 sats)	Delta 2	Medium-to-Heavy
		9/10/98	Globalstar (12 sats)	Zenit 2	Medium-to-Heavy
		11/6/98	Iridium (5 sats)	Delta 2	Medium-to-Heavy
		12/19/98	Iridium (2 sats)	LM-2C	Small
	Little LEO	2/10/98	Orbcomm (2 sats)	Taurus 1	Small
		8/2/98	Orbcomm (8 sats)	Pegasus	Small
		9/23/98	Orbcomm (8 sats)	Pegasus	Small
	Broadband LEO	2/25/98	Teledesic T1 (BATSAT)	Pegasus	Small
	Foreign Science	7/7/98	Tubsat N & Tubsat N-1	Shtil	Small
		10/22/98	SCD 2	Pegasus	Small

Figure 15: Historical NGSO Payload and Launch Activities (1993-1999) - continued

Summary	Market Segment	Date	Payload	Launch Vehicle	
1997					
59 Payloads	**Big LEO**	5/5/97	Iridium (5 sats)	Delta 2	Medium-to-Heavy
48 Big LEO		6/18/97	Iridium (7 sats)	Proton	Medium-to-Heavy
8 Little LEO		7/9/97	Iridium (5 sats)	Delta 2	Medium-to-Heavy
2 Remote Sensing		8/20/97	Iridium (5 sats)	Delta 2	Medium-to-Heavy
1 Foreign Science		9/14/97	Iridium (7 sats)	Proton	Medium-to-Heavy
		9/26/97	Iridium (5 sats)	Delta 2	Medium-to-Heavy
13 Launches		11/8/97	Iridium (5 sats)	Delta 2	Medium-to-Heavy
8 Medium-to-Heavy		12/8/97	Iridium (2 sats)	LM-2C	Small
5 Small		12/20/97	Iridium (5 sats)	Delta 2	Medium-to-Heavy
	Little LEO	12/23/97	Orbcomm (8 sats)	Pegasus	Small
	Remote Sensing	8/1/97	Orbview 2	Pegasus	Small
		12/24/97	Earlybird 1	START 1	Small
	Foreign Science	4/21/97	Minisat 0.1	Pegasus	Small
1996					
2 Payloads	**Foreign Science**	4/30/96	SAX	Atlas 1	Medium-to-Heavy
2 Foreign Science		11/4/96	SAC B	Pegasus	Small
2 Launches					
1 Medium-to-Heavy					
1 Small					
1995					
4 Payloads	**Little LEO**	4/3/95	Orbcomm (2 sats)	Pegasus	Small
3 Little LEO		8/15/95	GEMStar 1	Athena 1	Small
1 Remote Sensing					
	Remote Sensing	4/3/95	Orbview 1 (Microlab)	Pegasus	Small
2 Launches					
2 Small					
1994					
0 Payloads					
0 Launches					
1993					
2 Payloads	**Little LEO**	2/9/93	CDS 1	Pegasus 1	Small
1 Little LEO					
1 Foreign Science	**Foreign Science**	2/9/93	SCD 1	Pegasus 1	Small
1 Launch					
1 Small					