2001 Commercial Space Transportation Forecasts

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

and the

Commercial Space Transportation Advisory Committee (COMSTAC)

May 2001

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.

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EXECUTIVE SUMMARY

The Federal Aviation Administration's Associate Administrator for Commercial Space Transportation (FAA/AST) and the Commercial Space Transportation Advisory Committee (COMSTAC) have prepared projections of global demand for commercial space launch services for the period 2001 to 2010. The *2001 Commercial Space Transportation Forecasts* report combines:

- The ***COMSTAC 2001 Commercial Geosynchronous 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 ***2001 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 32 commercial space launches worldwide will occur annually through 2010. The forecast is down over 22 percent from last year's, which projected an average of 41.4 launches per year from an 11 year period (2000-2010). This downturn in expectations is the result of continued funding difficulties encountered by NGSO systems in the wake of bankruptcies and market uncertainties. The GSO launch demand forecast is similar to last year.

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

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

- 1.5 launches of medium-to-heavy launch vehicles to NGSO orbits; and

- 6.5 launches of small vehicles to NGSO.

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 2001 to 2010. The jointly published *2001 Commercial Space Transportation Forecasts* report includes:

- The ***COMSTAC 2001 Commercial Geosynchronous 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 ***2001 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 currently represents around 35 percent of worldwide launches conducted annually. Until the late 1990s, 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. In 1998 and 1999, commercial launches accounted for half of all worldwide launches, and launches to NGSO launches nearly equaled those to GSO. In 2000, there were 20 actual commercial launches to GSO and nine actual to NGSO.

About the COMSTAC 2001 Commercial Geosynchronous Launch Demand Model

At the request of the FAA, COMSTAC compiles a 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 and takes into account 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 forecast 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 numbers and types of satellites to be deployed are converted to a launch demand forecast.

COMBINED PAYLOAD AND LAUNCH PROJECTIONS

Taken together, the *2001 Commercial Geosynchronous Launch Demand Model* and the *2001 NGSO Commercial Space Transportation Projections* present an overall picture of expected demand for commercial launch services for the ten year period 2001 to 2010. On average, 32 commercial launches are projected to occur worldwide each year through 2010. This is a decrease of 22 percent from 41.4 launches forecast last year (covering 11 years, 2000-2010).

Combined GSO & NGSO Payload Projections

The combined GSO and NGSO forecasts project that 456 payloads will be deployed between 2001 and 2010, as shown in Figures 1, 2, and 3. The projected payload demand for GSO is twice that of NGSO in the overall forecast. This is the first time the total GSO payloads in the forecast period have been greater than NGSO since the FAA began NGSO forecasts in 1994. The GSO forecast averages 30.5 payloads per year with a low of 24 payloads in 2001 and a high of 34 in 2009. With the exception of 2003, deployment of NGSO is relatively constant. In 2003, 53 NGSO payloads are expected to launch. In the other nine years of the forecast, the projected numbers of payloads per year fall within the 6-18 range, resulting in an overall ten-year average of 15 NGSO payloads per year.

Projected payload demand is based on the COMSTAC GSO mission model and the baseline scenario of the FAA NGSO forecast. Additional details on the breakout of payload projections for the various types of NGSO systems are contained in the *2001 NGSO Commercial Space Transportation Projections*.

Combined GSO & NGSO Launch Projections

After taking into account the dual manifesting of GSO payloads and the multiple manifesting of NGSO payloads, the forecasts project that 322 launches will be conducted through 2010, as shown in Figures 1, 2, 3, and 4. The projected launch demand is an average of 32 launches per year, consisting of:

- 24 launches of medium-to-heavy launch vehicles to GSO;
- 1.5 launches of medium-to-heavy launch vehicles to NGSO orbits; and
- 6.5 launches of small vehicles to NGSO.

The forecast is down over 22 percent from last year’s projected average of 41.4 launches per year. This decrease in expectations is the result of continued difficulties encountered by NGSO systems and a reduction of total systems in this year’s forecast compared to last year. Figure 5 shows forecasts for 1998 to 2001.

Figure 1: Commercial Space Transportation Payload and Launch Projection

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Average
Payloads												
GSO Forecast (COMSTAC)	24	28	32	33	30	30	29	32	34	33	305	30.5
NGSO Forecast (FAA)	8	18	53	15	7	11	11	7	15	6	151	15.0
Total Payloads	**32**	**46**	**85**	**48**	**37**	**41**	**40**	**39**	**49**	**39**	**456**	**45.5**
Launch Demand												
GSO Medium-to-Heavy	20	23	27	27	24	23	22	24	26	25	241	24.0
NGSO Medium-to-Heavy	1	3	5	5	0	1	0	0	0	0	15	1.5
NGSO Small	7	5	12	7	5	6	6	5	8	4	65	6.5
Total Launches	**28**	**31**	**44**	**39**	**29**	**30**	**28**	**29**	**34**	**29**	**321**	**32**

Figure 2: GSO Satellite and Launch Demand

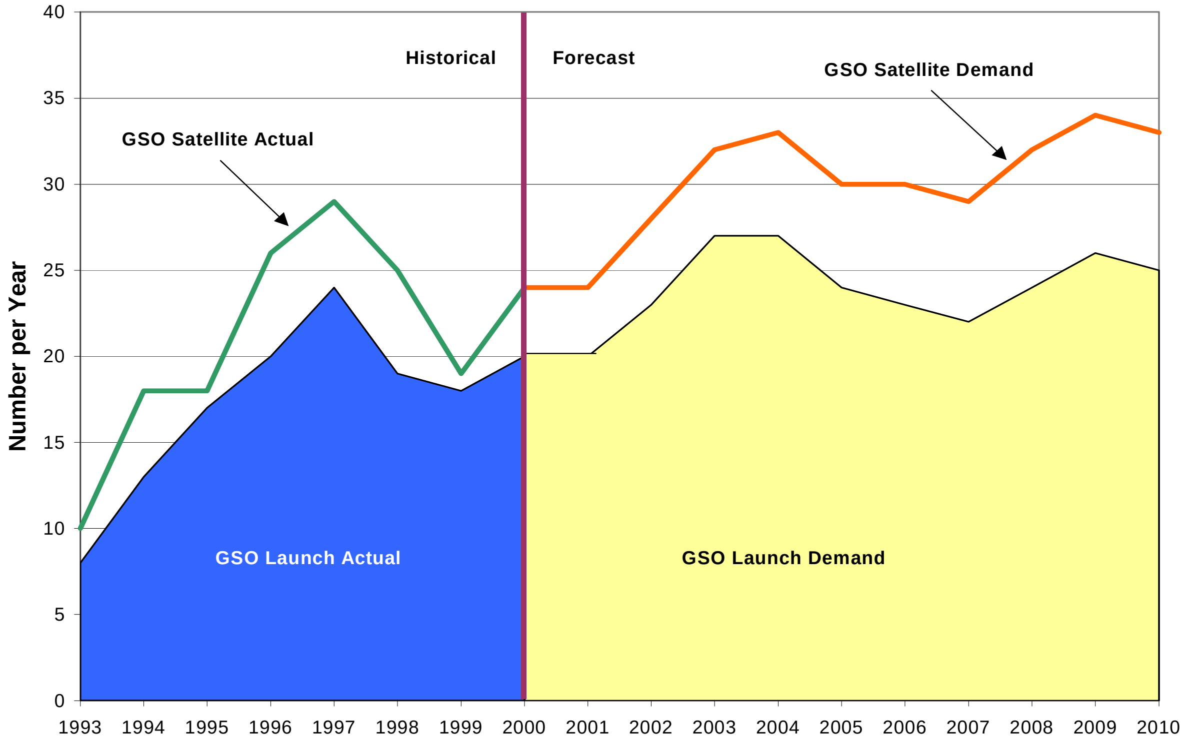


Figure 3: NGSO Satellite and Launch Demand

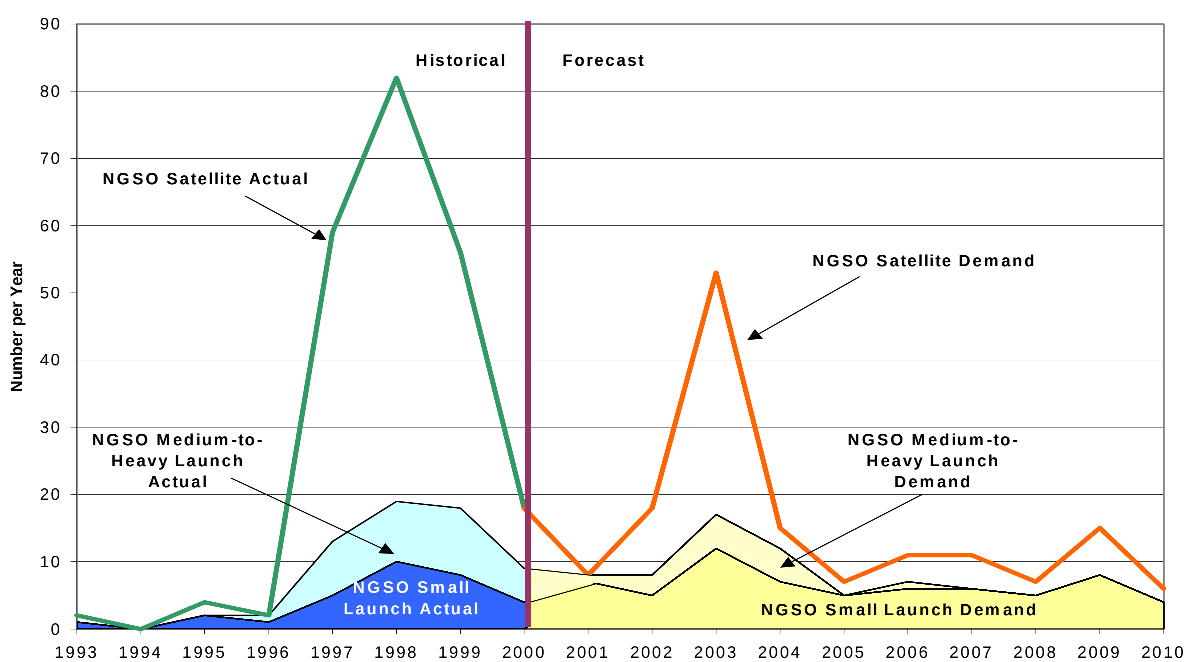


Figure 4: Combined GSO and NGSO Launch Projections

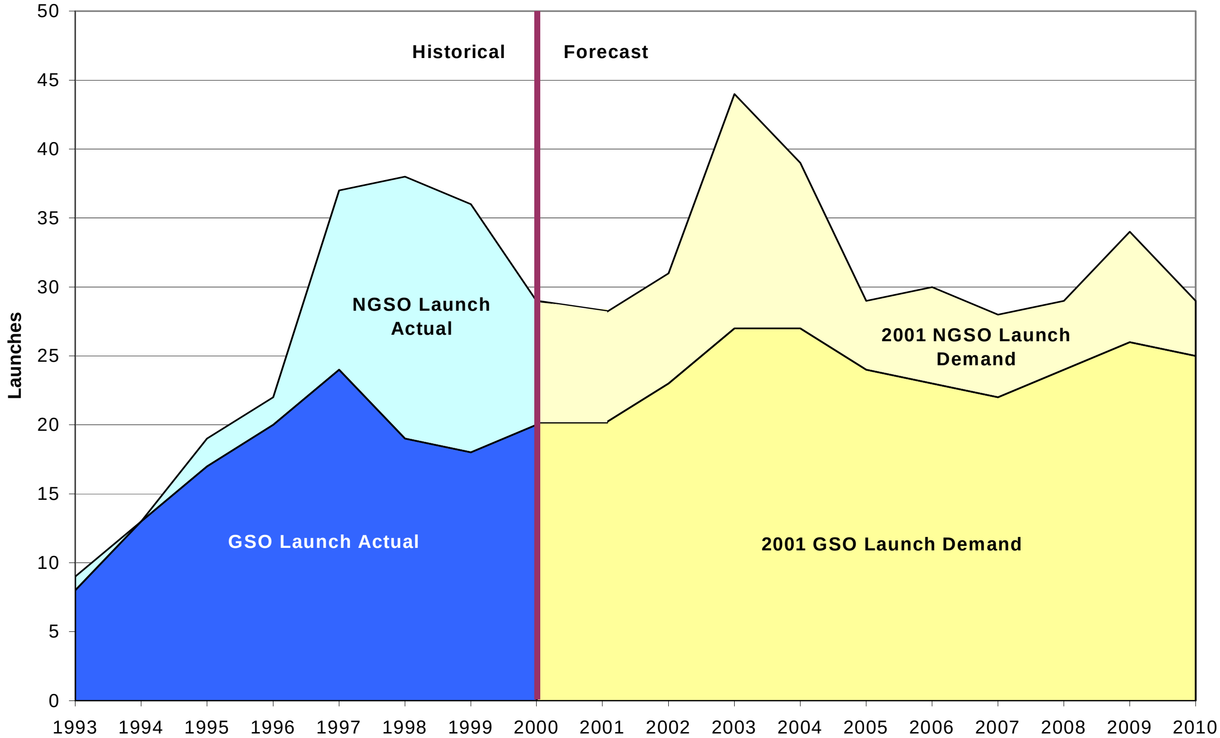
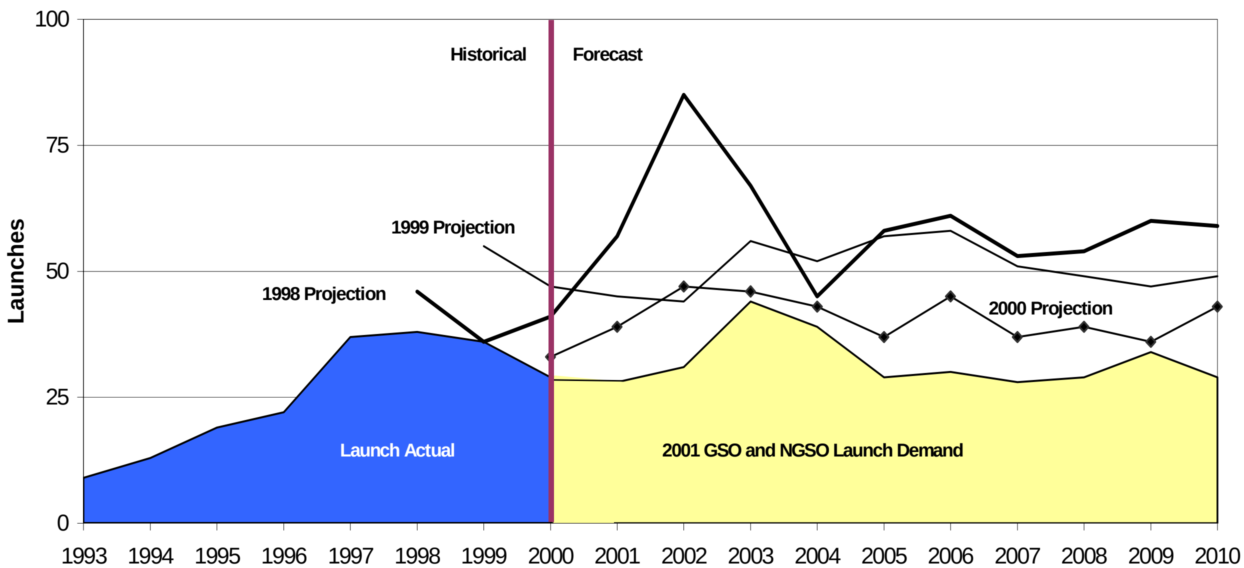


Figure 5: Historical Commercial Space Transportation Projections



COMSTAC 2001 Commercial Geosynchronous Orbit (GSO) Launch Demand Model

May 2001

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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 *2001 Commercial Geosynchronous Orbit (GSO) Launch Demand Model* is the ninth 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. In this report COMSTAC produces 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 2001 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 2001 through 2003, shows 24 satellites to be launched in 2001, 28 in 2002, and 32 in 2003. The average annual COMSTAC demand forecasts of 1998 and 1999 reports were 32.8 and 33 satellites per year, respectively. This year's mission model predicts an average demand of 30.5 satellites to be launched per year over the period from 2001 through 2010 which is very similar to the average demand of 30.6 satellites per year forecast in the 2000 report. 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 20 launches for 2001, 23 launches for 2002, and 27 launches for 2003. This year's forecast continues the trend of last year's in that the near-term demand has lessened. Table 1 shows the projected number of dual payloads to be launched.

Figure 1 COMSTAC Commercial GSO Launch Demand Forecast

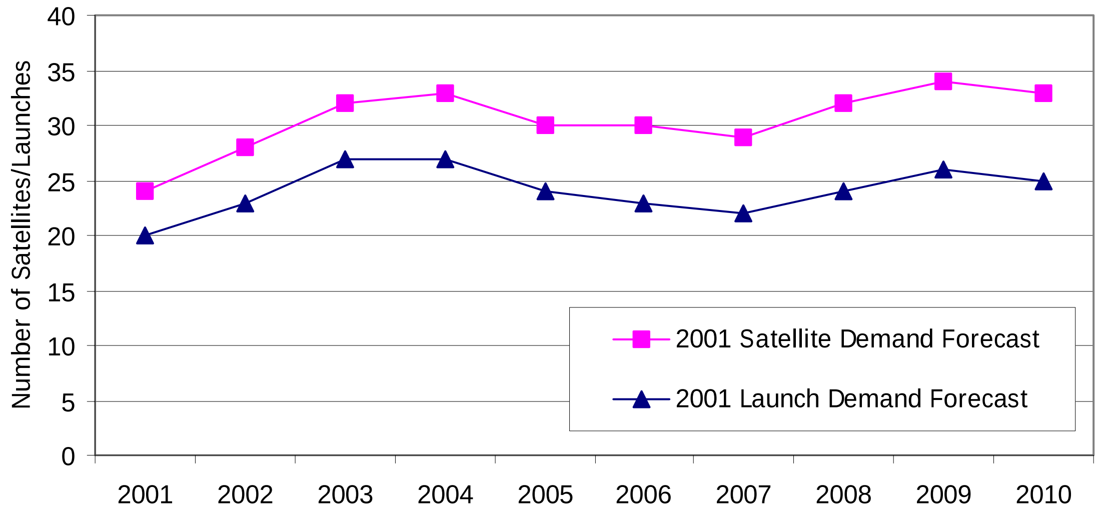


Table 1 Commercial GSO Launch Demand Forecast Data

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Average 2001 to 2010
Satellite Demand	24	28	32	33	30	30	29	32	34	33	305	30.5
Dual Launch Forecast	4	5	5	6	6	7	7	8	8	8	64	6.4
Launch Demand Forecast	20	23	27	27	24	23	22	24	26	25	241	24.1

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 2001 update of the worldwide commercial geosynchronous orbit (GSO) satellite mission model for the period 2001 through 2010. It is based on market forecasts obtained in early 2001 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 U.S. 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 27 inputs from U.S. and non-U.S. satellite manufacturers, operators and launch vehicle providers. COMSTAC would like to thank all the participants in the 2001 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 2001 - 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.

The remainder of the commercial market (non-GSO) is addressed in a separate forecast 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 mass classes based on separated mass inserted into a nominal geosynchronous transfer orbit (GTO), assuming launch to 28° inclination. The satellite mass classes are representative of a clustering of similar capability launch vehicles as shown in Table 2.

Table 2. Satellite Mass Classes

GTO Launch Capability (185km x GEO orbit @ i=28°)	Launch Vehicle
Below 1,815 kg (<4,000 lbm)	Dual Ariane 4/5, Delta II, Dual H-IIA, Long March 3
1,815- 4,082 kg (4,000 - 9,000 lbm)	Dual Ariane 4/5, Atlas II, Atlas III, Atlas V, Delta III, Delta IV, H-IIA, Long March 3, Proton, Sea Launch
4,082 – 5,445 kg (9,000-12,000 lbm)	Ariane 4/5, Atlas III, Atlas V, Delta IV, H-IIA, Long March 3, Proton, Sea Launch
Above 5,445 kg (>12,000 lbm)	Ariane 5, Atlas V, Delta IV, H-IIA, Sea Launch

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

- Alcatel Space Industries*
- Astrium*
- Astrolink
- The Boeing Company*
- Broadcasting Satellite System Corp.
- China Great Wall Industries, Inc.*
- Chunghwa Telecom Company, Limited
- Destiny Cable Inc.
- DirecTV
- Hyundai Electronics Industries
- Kistler Aerospace Corp.*
- Lockheed Martin Space Systems Company*
- Loral Skynet
- Loral Space & Communications*
- Miraxis
- Mobile Broadcasting Corporation
- Motient Corporation
- NahuelSAT
- National Space Program Office of Taiwan
- PanAmSat
- Space Communications Corporation
- Shin Satellite Plc.
- SingTel
- Sirius Satellite Radio Inc.
- StarOne
- Thuraya Telecommunications
- U.K. Ministry of Defence

Comprehensive mission model forecasts were received from those organizations marked by an asterisk (*). The comprehensive inputs were of the total addressable market of customers seeking commercial launch services for GSO spacecraft from the years 2001 to 2010. Other responses provided partial market or company specific satellite launch demand information.

The near-term COMSTAC mission model (2001-2003) 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 delays resulting from 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 consistent over the history of the industry. An attrition rate factor of 10% of annual launch demand was also assumed. This factor includes on-orbit satellite and launch vehicle failures.

The Working Group used the comprehensive inputs from the U.S. respondents to derive the average launch rate for years 2004 through 2010. The comprehensive inputs for each mass category in a given year are averaged. The total forecast for that year is then calculated by adding the averages for each of 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 these comprehensive inputs.

Some of the factors that were considered by respondents 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. 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.

2001 Mission Model

The 2001 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 2001 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 2000 and the COMSTAC 2001 forecast for the years 2001 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 for each year from 1993 to 2000 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 3A. 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

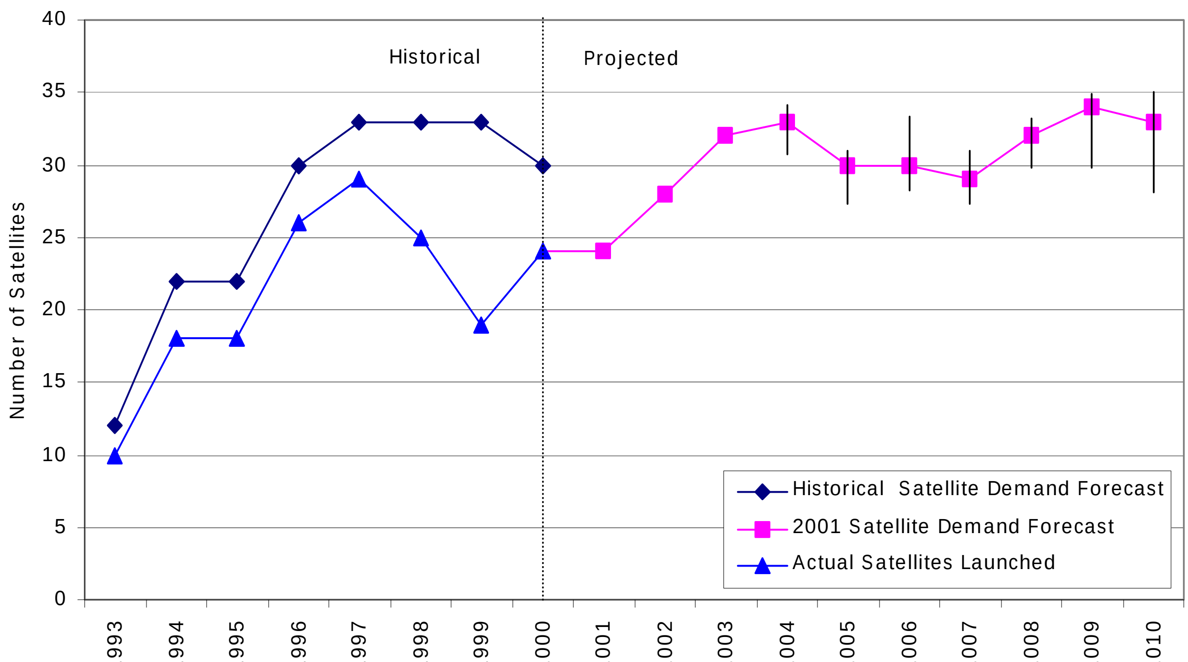


Table 3A. COMSTAC Commercial GSO Satellite Forecast

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Average
High	24	28	32	34	31	33	31	33	35	35	316	
2001 Satellite Demand	24	28	32	33	30	30	29	32	34	33	305	30.5
Low	24	28	32	29	27	28	27	30	30	28	283	

The near-term forecast shows 24 satellites to be launched in 2001, 28 in 2002, and 32 in 2003. This year's mission model predicts an average demand of 30.5 satellites to be launched per year over the period from 2001 through 2010. The COMSTAC average annual demand forecasts of 1998 and 1999 reports were 32.8 and 33 satellites per year, respectively. This year's average forecast of 30.5 satellites per year is approximately the same as the 2000 report average forecast of 30.6 satellites per year. Note that the average annual demand for the 1999, 2000, and 2001 reports cover different spans of time. The 1999 report average annual demand is the average demand from 1999 to 2010, the 2000 report from 2000 to 2010, and the 2001 report from 2001 to 2010.

International comprehensive inputs are shown below in Table 3B, in the aggregate, provided a confirmation of the U.S. inputs shown above as well as insights to the trends into satellite size.

Table 3B. International Comprehensive Inputs

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Average
High	33	36	40	35	32	30	35	39	40	40	360	
Average	27	32	33	31	28	26	28	30	32	30	297	29.7
Low	22	26	26	26	21	20	19	21	22	18	221	

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 A of this report.

Table 4 shows the consensus near term mission model for 2001 through 2003 which 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.

Table 4. Commercial GSO Near-Term Mission Model

Forecasted Payloads as of April 4, 2001

	2001	2002	2003
Total	24	28	32
Below 1,815 kg (<4,000 lbm)	3	3	3
	Ariane-BSat-2A Ariane-BSat-2B Ariane-Skynet 4F	Ariane-Astra 3A Ariane-e-Bird 1 Ariane-N-Star C	Ariane-AMOS 2 TBD-Galaxy Unnamed TBD-PanAmSat
1,815 – 4,082 kg (4,000-9000 lbm)	11	11	8
	Ariane-Ameristar 1 Ariane-Atlantic Bird 2 Ariane-DirecTV-4S Ariane-EurasiaSat 1 Ariane-EUROBIRD Ariane-Insat 3C Atlas-DirecTV-5 Atlas-EchoStar 7 Long March-Atlantic Bird 1 Proton-Astra 2C Proton-PAS 10	Ariane-Agrani 2 Ariane-GE 9 Ariane-Hot Bird 6 Ariane-Insat 3A Ariane-JCSAT 8 Ariane-L-Star 1 Atlas-Asiasat 4 Atlas-Hispasat 1D Long March-INTELSAT APR-3 Proton-GE 2A TBD-Hot Bird 7	Ariane-Insat 3E TBD-Eutelsat W3A TBD-GE 10 TBD-Hot Bird 8 TBD-MBSAT 1 TBD-Measat 3 TBD-Thor 4 TBD-Attrition/Relaunches
4,082 – 5,445 kg (9,000 – 12,000lbm)	10	11	13
	Ariane-INTELSAT 901 Ariane-INTELSAT 902 Ariane-INTELSAT 904 Ariane-NSS 7 Long March-Chinasat 8 Proton-Astra 1K Proton-INTELSAT 903 Sea Launch-Galaxy IIIC Sea Launch-XM 1 Sea Launch-XM 2	Ariane-INTELSAT 905 Ariane-INTELSAT 906 Ariane-INTELSAT 907 Ariane-NSS 6 Ariane-Optus C1 Ariane-Stellat Ariane-WildBlue 1 Delta-Estrela do Sul Proton-EchoStar 8 TBD-EchoStar 9 TBD-Attrition/Relaunches	Atlas-GE 2I Long March-Apstar 5 Delta-M2A Proton-GE 1I Sea Launch-Assuresat 1 Sea Launch-Assuresat 2 TBD-Amazonas TBD-DirecTV-7S TBD-Galaxy 8IR TBD-INTELSAT 10-01 TBD-INTELSAT 10-02 TBD-Thuraya 2 TBD-Attrition/Relaunches
Over 5,445 kg (>12,000 lbm)	0	3	8
		Ariane-Anik F2 Sea Launch-Spaceway 1 Sea Launch-Telstar 8	Atlas-Astrolink 1 Proton-Astrolink 2 Sea Launch-NSS 8 Sea Launch-Spaceway 2 TBD-Inmarsat 4 F1 TBD-Inmarsat 4 F2 TBD-iPSTAR TBD-SatMex 6

Satellite Launch Mass Classes

Figure 3 shows the forecasted distribution of the satellite demand by mass. The satellites are forecasted in four mass classes; below 1,815 kilograms (<4,000 pounds); 1,815 to 4,082 kilograms (4,000 to 9,000 pounds); 4,082 to 5,445 kilograms (9,000 to 12,000 pounds); and above 5,445 kilograms (>12,000 pounds). As described earlier, these mass classes 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 185 km (100 nm) x 35,786 km (19,323 nm) at an inclination of 28°. In the near-term forecast, the Working Group tried to place each satellite in the appropriate class based on what was known of its mass. The remainder of the forecast derives from the estimates by each of the respondents of the potential breakdown between the classes for that year, where each mass class is an average of the domestic comprehensive inputs for each mass class for each year beyond the near-term forecast. The prediction of future satellite sizes was calibrated by inputs received from satellite operators.

Figure 3. Forecast Trends in Annual GSO Satellite Mass Distribution

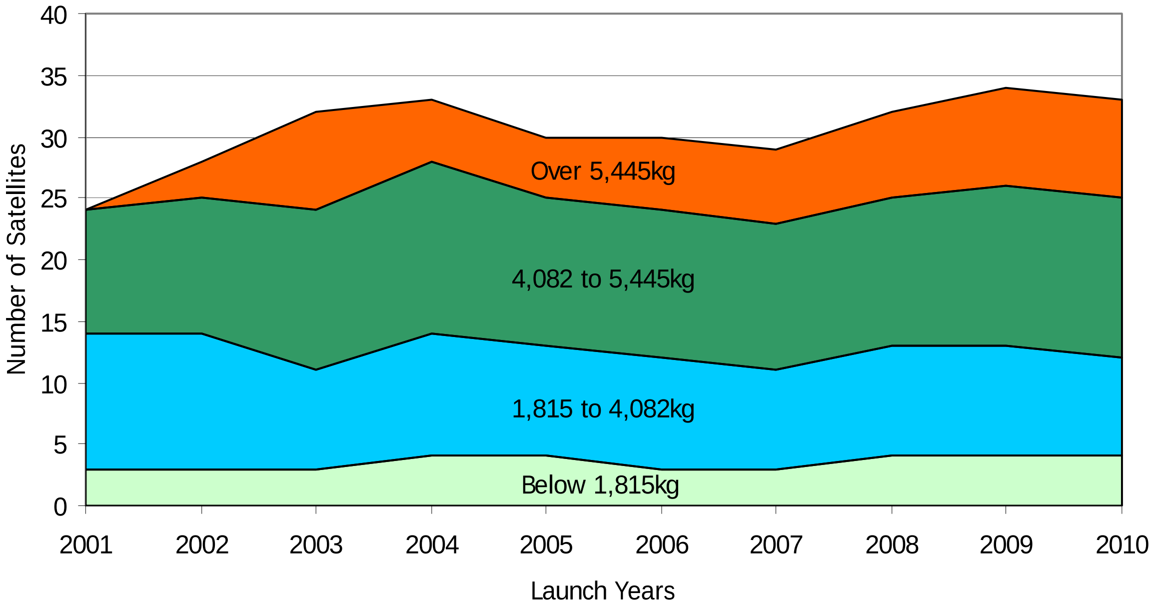


Table 5. Forecast Trends in Satellite Mass Distribution

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Average 2001 to 2010	Percent of Total
Below 1,815 kg (<4,000 lbm)	3	3	3	4	4	3	3	4	4	4	35	3.5	12%
1,815 to 4,082 kg (4,000 – 9,000 lbm)	11	11	8	10	9	9	8	9	9	8	92	9.2	30%
4,082 to 5,445 kg (9,000 – 12,000 lbm)	10	11	13	14	12	12	12	12	13	13	122	12.2	40%
Above 5,445 kg (>12,000 lbm)	0	3	8	5	5	6	6	7	8	8	56	5.6	18%
Total Satellite Forecast	**24**	**28**	**32**	**33**	**30**	**30**	**29**	**32**	**34**	**33**	**305**	**30.5**	**100%**

Commercial GSO Satellite Trends

In the early years of publication of this mission model report, commercial satellites were not projected to grow much beyond the 1,815 – 4,082kg (4,000 to 9,000 lbm) mass class. Over the past five years, however, the mass range of commercial satellites has exhibited a profound shift from this original projection. As shown in Table 5 in the previous section, the projected number of satellites in the Above 5,445kg (>12,000 lbm) mass class continues to grow, while the number in the 1,815 – 4,082kg (4,000 to 9,000 lbm) mass class begins to decline.

Very heavy commercial satellites, over 5,445kg (>12,000 lbm), have been developed and ordered over the last few years to address some specific market segments. Satellites designed to provide broadband data communication services (such as Spaceway and Astrolink) and mobile communication services (such as Thuraya and Garuda) require high levels of power and sophisticated on-board processing circuitry. These requirements have driven designs of these satellites to approach and exceed 5,445kg (12,000 lbm).

Other heavy-class commercial satellites have been developed to serve traditional broadcast applications with broader scope and greater efficiency. The previous generations of satellites for operators such as Loral Skynet, Telesat Canada, and PanAmSat were generally designed into the 1,815 – 4,082kg (4,000 to 9,000 lbm) mass class. Many of the next generation of satellites for operators such as these (launching recently and in the future) have exceeded 4,082kg (9,000 lbm), such as PanAmSat's PAS 1R, and even 5,445kg (12,000 lbm) such as Telesat's Anik F2.

This growth has occurred for a few key reasons. Many global and regional satellite operators are attempting to maximize their capacity and geographic coverage at prime orbital locations. Many operators that were originally authorized to provide service to specific areas have been granted permission to expand their coverage areas to entire regions. For these missions, they have ordered heavy-class satellites with large hybrid C/Ku-band transponder payloads and multiple coverage beams. Also introducing upward pressure on the mass of traditional satellites is the demand for greater on-orbit lifetime, which generally requires greater amounts of station-keeping fuel, which in turn drives up the satellite mass. These types of large satellites typically offer a lower cost per transponder, making them more attractive to the operators' bottom line.

Allowing such designs to be launched is the next generation of commercial launch vehicles. The Atlas V and Delta IV vehicle families feature GTO lift capability exceeding 8,165kg (>18,000 lbm). The improvements in launch vehicle capability have aided the introduction of these large satellites into the market.

This general trend toward larger satellites is complemented by what appears to be a stable niche for smaller satellites in the Below 1,815kg (<4,000 lbm) class, with some designs reaching the lower region of the 1,815 - 4,082kg (4,000 to 9,000 lbm) mass class. Some of the same operators that have recently ordered very heavy satellites have also ordered smaller satellites as well. These smaller satellites are used to fill in specific frequency allocations where about 20 to 24 transponders are needed. In addition, emerging operators may use smaller satellites to build up capacity gradually while generating revenue. Smaller satellites are attractive to existing and emerging operators because they often require a smaller up-front investment, and can be built and launched more quickly than larger satellites.

Comparison with Previous COMSTAC Demand Forecasts

The forecasts of the prior three years are compared to this year's forecast in Figure 4. They are all characterized by a near-term rise , intermediate-term decline and long-term moderate growth (less so in the 2000 forecast). The near-term rise and fall is, perhaps, inherent in the near-term forecast methodology, which centers on identifiable programs. The consequence of this approach, when considering that progressively higher attrition in the second and third years (i.e., 2002 and 2003) is yet to be realized, creates the near-term rise, or "bow wave".

The average satellite demand over the forecast period 2001 to 2010 is similar to last year's average, although demand is lower in the first two years and higher in the last four years. This year's model has an average demand of 30.5 GSO satellites per year for the period 2001 to 2010 with a modest increase in the last three years. The average demand in the 1998 and 1999 mission models was approximately 33 satellites per year between 1999 and 2010 with an upswing in demand in the last six years. Last year's model showed a flatter demand with a slight decline in the last six years. This flatter predicted demand accounted for the drop from 33 average GSO satellites per year in the 1998 and 1999 demand models to 30.6 in the 2000 demand model.

Although the average demand predicted in the 2000 and 2001 forecasts are almost equal, the 2001 forecast projects fewer satellites in the near term and slightly more satellites than the 2000 forecast in the later years. This year's forecast continues the trend of last year's in that the near-term demand has lessened. Further, *for the launch year 2001*, we note a total drop in demand of fifteen (15) satellites relative to the 1999 forecast...down eight (8) from 1999 to the 2000 forecast, and down seven (7) from 2000 to this year's forecast. Contributors were the sharp decline in the S.E. Asia market and cumulative postponements of other programs.

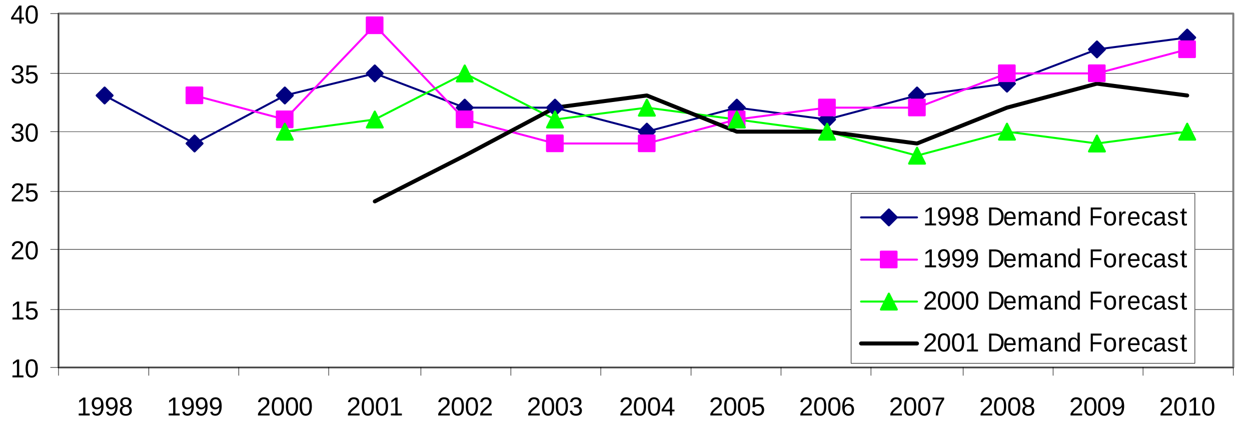
There are several factors that may be affecting the projected demand for satellites. Consolidation has occurred in the satellite services industry, with mergers, buyouts, and alliances reducing the customer base and resulting in more effective use of current in-orbit assets. Current satellites are also experiencing longer than expected on-orbit life, which causes orders for replacement satellites to shift further into the future.

The longer design lifetimes 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 larger satellites also affects the total number of satellites on order. Larger satellites are typically more cost effective allowing more transponders to be placed in space for each dollar spent. In conjunction with the demand for larger satellites, the cost to launch these heavier satellites is being reduced with the introduction of new 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 space-based businesses. New business concepts using satellites are getting more financial scrutiny, which has caused a slowdown in the launch of new ventures.

Figure 4. 1998 to 2000 versus 2001 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 2000 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 as well as actual values for 1993 through 2000.

Historically, only Arianespace has been capable of dual manifesting commercial GSO satellites, and its highest publicly announced launch capability is approximately eight flights per year. Historically some portion of Arianespace's commercial GSO manifest has been launched on a dedicated or single manifest basis. Arianespace will also launch payloads other than commercial GSO satellites that must fit within this launch capacity.

Other launchers capable of dual manifesting will become commercially available in a few years. As these new systems mature, it is believed 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. 2001 COMSTAC Launch Demand Forecast

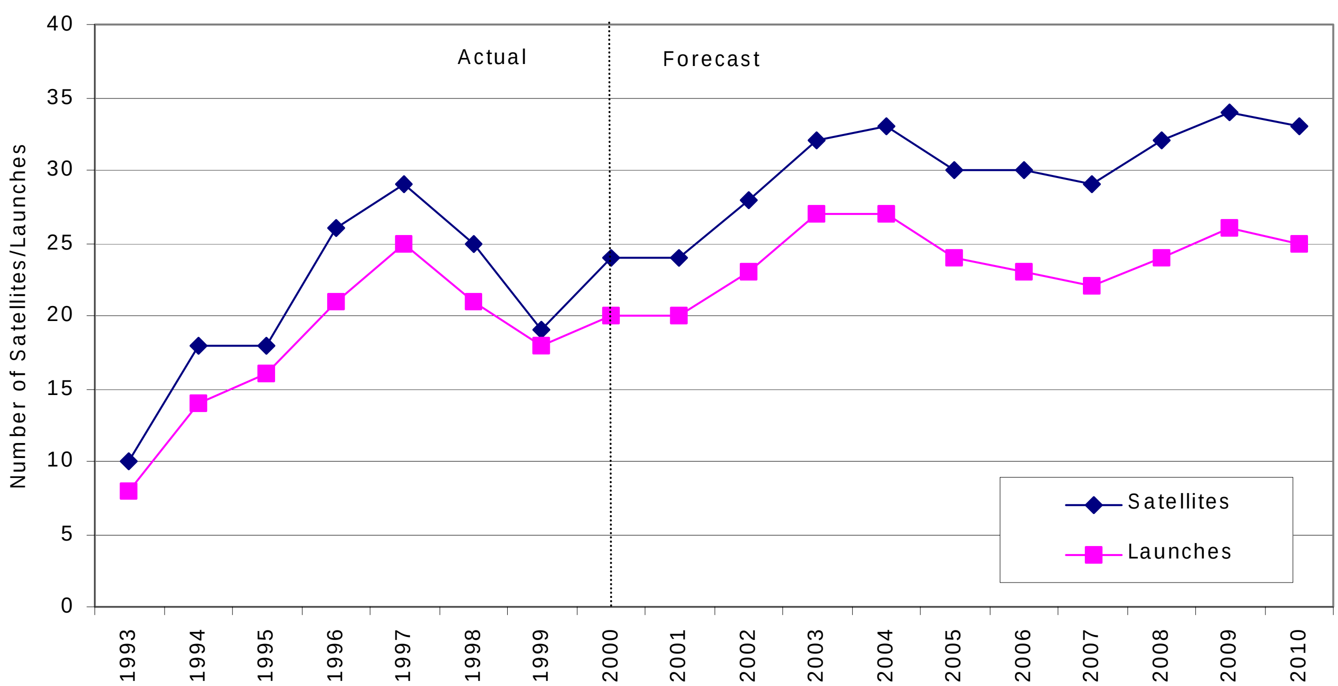


Table 6. COMSTAC Launch Demand Forecast Summary

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Average 2001 to 2010
Satellite Demand	24	28	32	33	30	30	29	32	34	33	305	30.5
Dual Launch Forecast	4	5	5	6	6	7	7	8	8	8	64	6.4
Launch Demand Forecast	20	23	27	27	24	23	22	24	26	25	241	24.1

Factors That May Affect Future Launch Demand

Last year, the Working Group noted that "several anticipated events and compelling factors have the potential to impact satellite and launch demand." These events and factors are expected to continue through at least 2002. Inaugural flights of several new families of launch vehicles will occur this year and next. Complementary and in some cases supplementary to these new launch vehicles will be the introduction of newly designed components and subsystems on these vehicles. Potential new applications, specifically broadband coupled with a focus on utilization of Ka-band spectrum, are supporting satellite and launch demand in the years just ahead, but this possible growth is threatened by a much more cautious business environment. The restrictive U.S. Government regulatory environment is a catalyst for a redistribution of the sources of supply of satellites and launches.

This year, the demonstration flights for the Japanese H-IIA launch vehicle are scheduled to occur. Next year, the inaugural flights of Boeing family of Delta IV launchers are scheduled, as is the case for the Lockheed Martin family of Atlas V rockets. If all of these new initiatives are successful, two impacts can be anticipated. The first is that the competition among Launch Services providers for the heavier classes of satellites can be expected to be fierce. The second is that the availability of capable and competitively priced launch services will facilitate a previously observed, if modest, trend toward heavier satellites. However, since satellites are likely to be manifested on the new domestic launch vehicles, any early failure of one or more of these systems will cause delays in, or migration of, scheduled launches. To the extent that alternatives are limited, the expected launch demand in a particular year is likely to be deferred into the next year. It is difficult to predict the actual "ripple" effect of any one failure on launch demand that is actually served.

The trend toward heavier satellites is accompanied by the trend toward satellites capable of longer lifetimes, as customer preferences for as much as 15 years usable lifetime on orbit is becoming routine. This obviously slows the pace of replenishment, thereby delaying demand.

This has been somewhat offset by demand for broadband applications, where a satellite's capability to satisfy the "last mile" dilemma, among other attributes, has in the last couple of years had a positive effect on the demand for satellites and attendant launches. However, demand for these Ka-band/broadband satellite applications may become impaired by "time to market" concerns versus terrestrial alternatives. Additionally, some of these initiatives as well as future initiatives are potentially threatened by the poor results of various satellite telephony projects specifically, and tighter economic circumstances generally.

While probably not affecting absolute satellite and launch demand, many observers cite the U.S. Government regulatory environment as the probable cause of a redistribution of market share from domestic to non-U.S. suppliers. U.S. satellite manufacturers and launch vehicle providers continue to be hampered in meeting the expectations of their international customers due to this environment. The impact is not limited to delays in the initiation and execution of programs, but now the actual capture of business. Last year, the Working Group reported that one satellite contract was cancelled and another satellite was (and remained) in storage pending receipt of a license in order to deliver. Now, there is reason to believe that new orders were lost due to the continuation of this environment.

Summary

This year's COMSTAC Commercial Mission Model forecast predicts a slight absolute decrease in average annual demand for satellites. This change, from 30.6 satellites forecast to be launched per year, on average, to 30.5 is such a minor change as to be insignificant. Nevertheless, the forecast may be providing some further clues of potential future trends in the industry that could affect the type of launch demand forthcoming. Notably, this year's forecast continues the trend of last year's in that the near-term demand has lessened.

Before considering these observations concerning the longer term, the near-term forecast for this year shows 24 satellites to be launched, followed by 28 in 2002 and 32 in 2003. After taking into account probable dual launches, launch vehicle demand was estimated to be 20 launches in 2001, 23 launches in 2002, and 27 launches in 2003.

Last year, various factors were identified that served to constrain the demand for satellites in the future. Among these factors was consolidation in the industry, which now has been seen (e.g. the SES – GE Americom combination). This particular trend is likely to continue. Extended satellite lifetimes was noted, and this trend continues unabated, as satellite lifetime requirements are typically in the range of 12 to 15 years, and moving increasingly toward the lengthier end of that range. Another trend cited in the 2000 forecast was "conservatism in the space industry". The current status of several satellite telephony projects has introduced this conservatism, which is expected to continue to be an issue until new projects prove financially viable. While broadband applications have been, and remain, a source of demand for satellites and launches, any growth in this area will likely await the results of current initiatives.

Thus the Working Group continues to foresee market events that have the potential of impacting the launch industry. In addition to the above, other key factors are:

1. Two inaugural or demonstration flights of the Japanese H-IIA rocket are scheduled to occur this year, while inaugural Atlas V and Delta IV flights are expected to launch next year. This portends a significant increase in the industry's capacity to launch heavy and extra heavy payloads at competitive prices. This could and does seem to influence a modest trend toward heavier satellites, but any failures could cause delays of planned launches.

2. Interestingly, from the 2001 Commercial Mission Model, there is also a discernable, if modest, trend toward lighter satellites. Possible reasons for this were addressed on page 11 of this report.

3. The restrictive U.S. Government regulatory environment continues to have an impact. While this factor does not necessarily diminish the level of demand for satellites and launches, there is evidence that this more restrictive environment is impacting the distribution of that demand. This does not bode well for the advent of new commercial U.S. launch vehicles.

Given the prospective nature of many of these factors, it is expected that there will be greater visibility available to the Working Group in the foreseeable future. We will look forward to assessing these factors again next year.

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 2001 Mission Model Update named *actual* satellite programs that were currently manifested on each of the launch providers for 2001. Though 24 satellite programs were named for the year 2001, the industry may not execute all corresponding launches in that year. However, the *demand* on the launch industry for 2001 is for the launch of 24 satellites (20 launches after discounting for 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.

2000 Space Industry Performance on Launch Demand

In the 2000 COMSTAC Commercial GSO Demand Model, the working group listed 30 satellites that were then manifested in that year. Yet of the 30 satellites manifested in 2000, only 23 of these satellites were actually launched while one satellite manifested in 2001 actually launched in 2000. And while there was a *demand* for 30 satellites to be launched as forecasted by the COMSTAC Working Group, the execution on the manifest was impacted primarily by satellite production delays. A list of the factors that affected the 7 satellites that did not make their launch dates follows. Of the 2000 manifested satellites:

- 24 satellites were launched
    - 23 satellites were launched that were forecast to be launched in 2000
    - 1 satellite was launched that was forecast to launch in 2001
- 6 satellites were delayed due to satellite and/or manifest issues
- 1 satellite continued to be delayed due to regulatory issues (export control compliance)

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 class, 1,815-3,629kg (4,000-8,000 lbm), with 15% each in the Medium, 907-1,815kg (2,000-4,000 lbm), and the Heavy, over 3,629kg (>8,000 lbm) 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 non-U.S. 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 U.S. 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 (> 4,082kg 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 satellites 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 satellites per year over the period from 1999 through 2010, very close to the 1998 COMSTAC forecast of 33 satellites per year. The near-term forecast, which is based on actual satellite for 1999 through 2001, shows 33 satellites in 1999, dropping to 31 in 2000, and increasing again to 39 in 2001.

2000: The 2000 annual mission model (Reference B8) predicts an average demand of 30.6 satellites per year over the period from 2000 through 2010, which was approximately 10% lower than the 1998 and 1999 COMSTAC forecasts of 33 satellites per year. The near-term forecast, which is based on actual satellite for 2000 through 2002, shows 30 satellites in 2000, dropping to 31 in 2001, and increasing again to 35 in 2002.

Figure B-1 shows the demand models for the past COMSTAC reports. At first glance, there seems to be quite 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 Models from 1993 through 2001

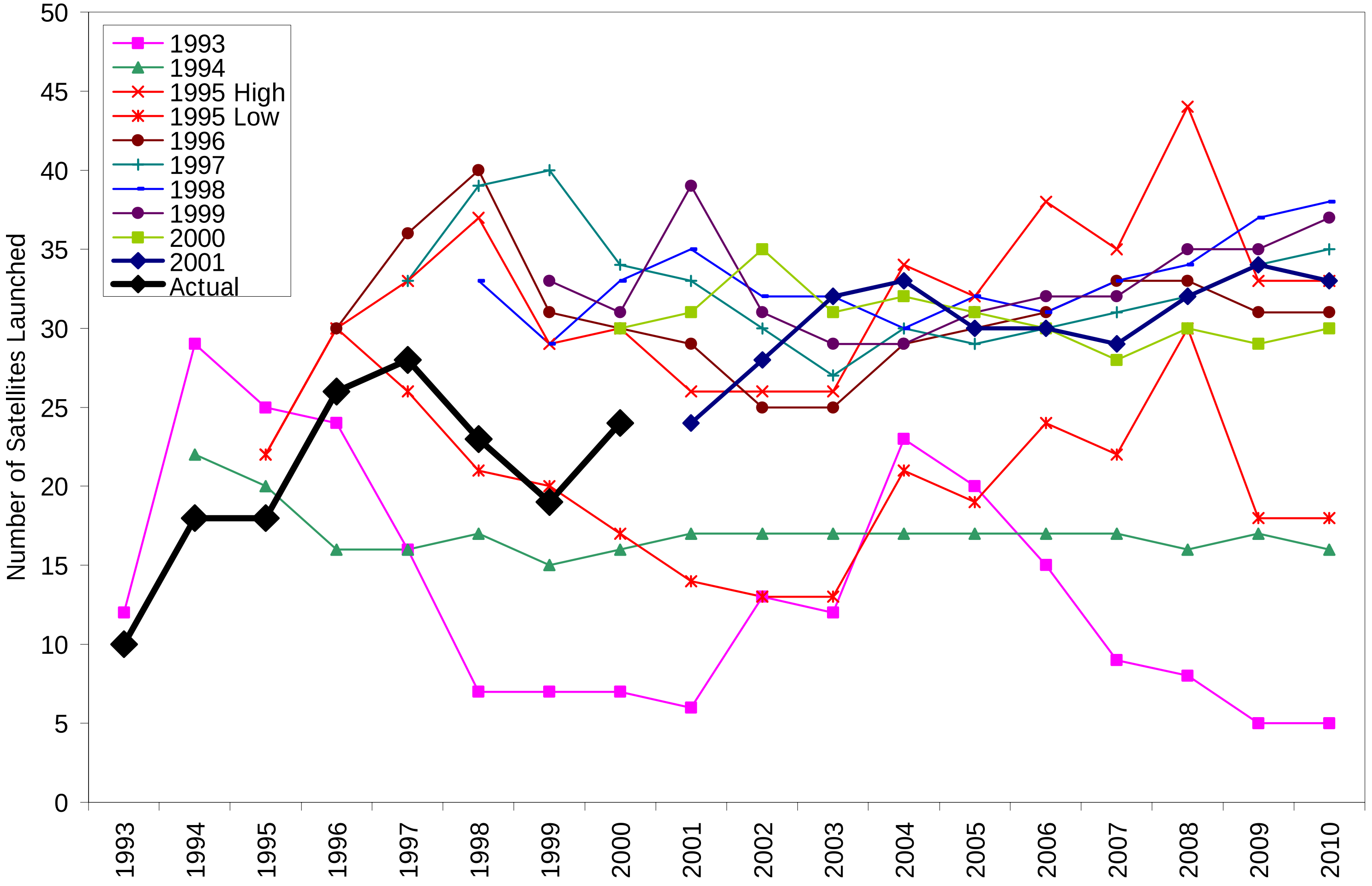


Table B-1. 1988-2000 COMSTAC GSO Commercial Satellite Mission Model

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	TOTAL	Average Rate
TOTAL LAUNCHES =	6	7	13	13	14	8	14	16	21	25	21	18	20	196	15.1
TOTAL SPACECRAFT =	9	8	18	14	17	10	18	18	26	29	25	19	24	235	18.1
Arianespace	6	6	5	7	6	6	8	7	9	11	9	8	11	99	7.6
HLV		1 Intelsat 602 1 JCSat1 1 Superbird A	1 Superbird B 1 SBS 6	1 Anik E1 1 Anik E2 1 Intelsat 601 1 Intelsat 605 1 Astra 1B	1 Galaxy 7 1 Superbird B1 1 Superbird A1	1 Intelsat 701 1 Astra 1C 1 Solidaridad 1 1 DBS 1 1 Galaxy 4	1 Intelsat 702	1 Intelsat 706A 1 NStar CS-4A	1 Intelsat 707A 1 Intelsat 709	1 GE 2 1 Intelsat 801 1 Intelsat 802 1 Intelsat 803 1 Intelsat 804 1 PAS 6	1 SatMex 5	1 Galaxy 11	1 Anik F1 1 Europe*Star 1 1 PAS 1R		
ILV	1 Intelsat 513A 0 Astra 1	1 TVSat 2 1 Intelsat 515A 1 Tele X	1 Eutelsat 201	1 Eutelsat 202 0 Italsat 1	0 Eutelsat 204 1 Insat 2A 1 Hispasat 1A	0 Insat 2B 1 Hispasat 1B	1 Brazilsat B1 0 Eutelsat-II F5 1 Astra 1D 1 Solidaridad 2 1 Turksat 1A 0 Turksat 1B 1 Telstar 402 1 PAS 2 1 PAS 3	1 Brazilsat B2 0 Hotbird 1 0 Insat 2C 1 Astra 1E 1 AT&T 402R 1 DBS 3 1 PAS 4	1 Arabsat 2A 1 Arabsat 2B 1 EchoStar 2 0 Italsat 2 1 MSat M1 1 NStar 2 1 Palapa C2 1 PAS 3R 0 Turksat 1C	1 Hotbird 3 1 Inmarsat 304 1 JCSat 5 (1R) 0 Nahuel 1A 1 Sirius 2 1 Thaicom 3	1 Afristar 1 1 Eutelsat W2 1 Hotbird 4 1 Inmarsat 305 1 Nilesat 1 1 PAS 6B 1 PAS 7 1 ST 1	1 Arabsat 3A 1 GE 4 1 Insat 2E 1 Koreasat 3 1 Orion 2 1 Telkom 1 1 Telstar 7	1 AsiaStar 1 1 Astra 2B 1 Eutelsat W1 1 Galaxy 4R 1 GE 7 0 GE 8 0 Insat 3B 1 Nilesat 102 1 NSAT 110 1 Superbird 4		
MLV	0 Eutelsat 105 1 Insat 1C 1 Skynet 4B 0 SBS 5 1 GStar 3 1 Spacenet 3R 1 PAS 1	0 DFS 1	1 DFS 2 0 BS 2X 0 Skynet 4C 1 Satcom C1 0 GStar 4 0 Galaxy 6	1 Inmarsat 2 F3	0 Satcom C3 0 Arabsat 1C 1 Inmarsat 2 F4	0 Thaicom 1	0 Thaicom 2 0 BS 3N		0 Amos 1 0 MeaSat 1 0 MeaSat 2	0 BSat 1A 0 Indostar 1 0 Insat 2D	0 Brasilsat B3 0 BSat 1B 0 GE 5 0 Sirius 3	0 Skynet 4E	0 Astra 2D 0 Brazilsat B4		
Atlas	0	0	0	2	3	1	3	5	5	6	3	3	4	35	2.7
HLV							1 Intelsat 703	1 Intelsat 704 1 Intelsat 705		1 Superbird C					
ILV				1 Eutelsat 203	1 Intelsat K1	1 Telstar 401	1 DBS 2 1 Orion 1	1 JCSat 3 1 MSat M2 1 Galaxy 3R	1 Hotbird 2 1 Palapa C1 1 Inmarsat 301 1 Inmarsat 303 1 GE 1	1 JCSat 4 1 Echostar 3 1 GE 3 1 Galaxy 8i 1 Tempo FM 2	1 Intelsat 806 1 Intelsat 805 1 Hot Bird 5	1 EchoStar 5 1 Euutalsat W3 1 JCSat 6	1 Echostar 6 1 Eutelsat W4 1 Galaxy 10R 1 Hispasat 1C		
MLV				1 BS 3H	1 Galaxy 1R 1 Galaxy 5										
Delta	0	1	4	4	3	1	1	1	2	1	4	1	0	23	1.8
ILV											1 Galaxy 10	1 Orion 3			
MLV		1 Marcopolo 1	1 Insat 1D 1 Palapa B03 1 Inmarsat 2 F1 1 Marcopolo 2	1 Inmarsat 2 F2 1 NATO 4A 1 Satcom C5 1 Spacenet 4	1 DFS 3 1 Palapa B4 1 Satcom C4	1 NATO 4B	1 Galaxy1R-2	1 KoreaSat 1	1 KoreaSat 2 1 Galaxy 9	1 Thor 2A	1 Skynet 4D 1 Thor III 1 Bonum 1				

Table B-1. 1988-2000 COMSTAC GSO Commercial Satellite Mission Model (continued)

		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	TOTAL	Average Rate
H-IIA		0	0	0	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	3	2	0	0	16	1.2
	HLV									1 Intelsat 708A	1					
	ILV					1 Optus B1 1 Optus B2		1 Optus B3	1 APStar 2 1 Asiasat 2 1 EchoStar 1			1 Chinastar 1 1 Sinosat				
	MLV			1 Asiasat 1				1 APStar 1		1 APStar 1A 1 Chinasat 7	1 Agila 2 1 APStar 2R					
Proton		0	0	0	0	0	0	0	0	2	4	3	5	3	17	1.3
	HLV										1 Asiasat 3 1 Astra 1G 1 PAS 5 1 Telstar 5	1 PAS 8	1 Astra 1H 1 Telstar 6	1 Garuda 1		
	ILV									1 Inmarsat 302 1 Astra 1F		1 EchoStar 4 1 Astra 2A	1 Asiasat 3S 1 LMI 1 1 Nimiq 1	1 GE 1A 1 GE 6		
Zenit 3 SL		0	0	0	0	0	0	0	0	0	0	0	1	2	3	0.2
	HLV													1 Thuraya 1		
	ILV												1 DirecTV 1R	1 PAS 9		
Titan 3		0	0	3	0	0	0	0	0	0	0	0	0	0	3	0.2
	HLV			1 Intelsat 603 1 Intelsat 604												
	ILV			1 JCSat 2												
	MLV			0 Skynet 4A												

Legend:

Spacecraft failed to reach operating status as planned

Spacecraft partially failed after achieving operating status

References:

B1. "Commercial Space Launch System Requirements - 28 April 1993," P.N. Fuller, Report of the COMSTAC Technology & Innovation Working Group, Commercial Space Transportation Advisory Committee (COMSTAC), Office of Commercial Space Transportation, U.S. Department of Transportation, Washington, D.C.

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B6. "Commercial Spacecraft Mission Model Update - May 1998," Commercial Space Transportation Advisory Committee (COMSTAC), Report of the COMSTAC Technology & Innovation Working Group, Associate Administrator for Commercial Space Transportation, Federal Aviation Administration, U.S. Department of Transportation, Washington, D.C.

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)

B8. "2000 Commercial Space Transportation Forecasts," Federal Aviation Administration, Associate Administrator for Commercial Space Transportation (AST), and Commercial Space Transportation Advisory Committee, May 2000, Washington, D.C. ("COMSTAC 2000 Commercial GSO Spacecraft Mission Model - May 2000," 33-page COMSTAC report included in document)

Appendix C. Letter from the Associate Administrator

January 2001

Ms./Mr. President
President
XYZ Space Company
1234 Street Address
Anytown, State, 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 Commercial Spacecraft Mission Model is now in the process of being updated for 2001. In support of this effort, our office requests inputs from companies and organizations based on their forecasts of future spacecraft and launch needs. The COMSTAC Technology and Innovation Working Group then develops the comprehensive mission model update based on these inputs.

The FAA and the industry use 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 23, 2001.

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 from 2001 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.

Again, your response is needed by February 23, 2001 to ensure that the mission model update is available to the FAA and the Space Industry in May, 2001. Please forward this request to the department most appropriate within your organization (e.g., market analysis, marketing, contracts). The attachment will give you more detailed information on how and where to respond and contact points. Of course you may also contact my office with any questions or comments at your convenience.

Thank you for your support of this activity.

Sincerely,

Patricia G. Smith
Associate Administrator for Commercial Space Transportation
Enclosures

2001 Commercial Geo-Synchronous Satellite Mission Model Update Instructions

As with the 2000 and previous year efforts, the goal for the 2001 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 and a combined projection will be published.

Your inputs, along with those of other satellite manufacturers and launch vehicle suppliers 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 which they know best. In your case, we anticipate that you will submit a comprehensive world market demand model. Data from this type of input are essential to assuring a complete and comprehensive forecast of the future commercial satellite and launch needs. This data will be used by corporations in their planning processes and governments in the administration of international space launch policy and decisions. As such, an accurate and realistic projection is vitally important.

We are looking forward to receiving your response by February 23, 2001 in order to support our update schedule. Your responses should be sent directly to Mr. Gary Goodwin at the following address:

Gary Goodwin
Space Systems/Loral
3825 Fabian Way
Palo Alto, CA 94303-4604

Phone: 650 852-5738
Fax: 650 85204573
Email: goodwin.gary@ssd.loral.com

If you have any questions, please contact Mr. Goodwin directly.

Appendix C. Letter from the Associate Administrator (continued)

January 2001

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

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2001 Commercial Space Transportation Projections for Non-Geosynchronous Orbits (NGSO)

Federal Aviation Administration

Associate Administrator for
Commercial Space Transportation (AST)

May 2001

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EXECUTIVE SUMMARY

The Federal Aviation Administration's Associate Administrator for Commercial Space Transportation (AST) has prepared the eighth annual assessment of the non-geosynchronous commercial satellite launch market for 2001 to 2010. The *2001 Commercial Space Transportation Projections for Non-Geosynchronous Orbits (NGSO)* projects launch demand for all commercial space systems expected to be deployed in orbits other than geosynchronous orbit (GSO), that includes low Earth orbit (LEO), medium Earth orbit (MEO), and elliptical orbits (ELI). Launch demand was derived from AST analysis for Little, Big, and Broadband NGSO telecommunications systems, remote sensing satellites, foreign scientific and other payloads.

This year's forecast shows a dramatic reduction in AST's evaluation of the number of telecommunications satellites expected to be launched to NGSO destinations from 2001-2010 as compared to prior forecasts. Bankruptcies and business restructuring by high profile systems coupled with the high cost of start-up have led to a loss of financial investor confidence in the NGSO telecommunications sector. In addition, competition from GSO systems and uncertainties about the marketing and technology approach for broadband have all contributed to a reduction of satellites in the forecast.

These factors have slowed the development of new market entrants and second generation systems. Ironically, new entrants find themselves in competition with companies that are operating after filing for Chapter 11 bankruptcy with little or no debt to service.

As with previous forecasts, AST has developed two scenarios assessing satellite and launch services demand —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 additional service providers.

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

- **Baseline Scenario**: deployment of one Little LEO systems (in addition to ORBCOMM), one Big LEO system (in addition to Iridium and Globalstar), and no Broadband LEO systems.

- **Robust Market Scenario**: deployment of two Little LEOs (in addition to ORBCOMM), one Big LEO (in addition to Iridium and Globalstar), and one Broadband system.

The baseline scenario projects that 151 commercial payloads will be deployed between 2001 and 2010, a reduction of 73 percent from the 552 payloads forecast last year. The robust market scenario projects 252 satellites, down from 685 last year or a change of 63 percent.

The demand for commercial launches to NGSO in the baseline scenario is for an average of 1.5 launches by medium-to-heavy launch vehicles and 6.5 launches by small launch vehicles per year from 2001 to 2010. These add up to a combined average demand of 8 launches per year or 80 launches throughout the forecast, a drop of 59 percent from the 196 launches projected in the 2000 forecast. The robust scenario includes 104 launches overall, averaging 3.1 launches by medium-to-heavy vehicles per year and 7.3 launches by small vehicles per year. These numbers are down 62 percent from the 272 total launches that were projected last year.

INTRODUCTION

In 1990, the Federal Communications Commission (FCC) received 6 applications for low Earth orbit (LEO) satellite constellations later dubbed "Big LEO" systems because of their high frequency band, beginning a wave of interest in global telecommunications for mobile users. Development capital, from investors, was relatively plentiful during the 1990s, a time marked by the longest sustained growth period in U.S. economic history. By the end of 1997, applications for follow-on Big LEO systems had been filed even as the first generation began launching. New services such as commercial remote sensing, broadband "internet in the sky" and digital radio were envisioned. Up until 1997, the market for commercial launches to LEO and other non-geosynchronous orbits (NGSO) were practically non-existent, with only the occasional launch of a scientific payload for a foreign country. The dynamics of the launch market changed in 1997 with the deployment of Iridium, the first Big LEO system.

At the peak of NGSO activity in 1998, the Federal Aviation Administration's Associate Administrator for Commercial Space Transportation (AST) issued a forecast based on available market activity that projected a remarkable 1,044 payloads would be launched from 1998-2010. An average launch demand of 19 medium-to-heavy launch vehicles and 9 small launch vehicles were also forecast during this period.

Despite the many FCC applications and proposals for a variety of telecommunications systems, the bulk of NGSO activity to date has come from three satellite systems: ORBCOMM, Iridium, and Globalstar. [See Figure 1.] Together, these three systems accounted for 37 launches or 86 percent of worldwide commercial NGSO launches from 1997-1999. Launches to NGSO during this timeframe also accounted for 45 percent of the overall launch market, just behind traditional geosynchchronus orbit (GSO) satellites. [Figure 2.]

Figure 1: Bulk of NGSO Market 1997-1999

Satellite System	1997	1998	1999	**Total Satellites**	**Total Launches**
ORBCOMM	8	18	7	33*	4
Iridium	46	40	2	88	20
Globalstar	0	8**	40	48^	13
TOTAL	**54**	**66**	**49**	**169**	**37**
WORLDWIDE NGSO 1997-1999				*195*	*43*

*Not including 2 ORBCOMM satellites launched in 1995
**Not including 12 satellites lost in one 1998 Zenit-2 launch failure
^Globalstar launched 4 more satellites in February 2000

Since the completion of ORBCOMM, Iridium and Globalstar deployments, NGSO activity has fallen. No new Little LEOs, Big LEOs, or any Broadband systems have been deployed and many systems under development have stalled.

Figure 2: Commercial Competed Launches

	NGSO	GSO	**Total**
1996	2	21	**23**
1997	13	25	**38**
1998	19	21	**40**
1999	18	18	**36**
2000	9	20	**29**
2001 est.	8	20	**28**

Includes payload missions open to international launch services procurement and other commercially sponsored payloads. Does not include government captured or dummy payloads launched commercially.

Unfortunately, the number of customers needed by NGSO systems to pay back capital investment did not appear. Iridium, ICO Global, and ORBCOMM have declared bankruptcy. New companies that rose from Iridium and ORBCOMM Chapter 11 filings continue to operate the existing satellite constellations while New ICO plans a launch in 2001 (after a launch failure in 2000). While there are no expected second generation systems at this time, this forecast includes a few replacement launches, which will occur before the lifespan of the three active constellations ends. Despite the difficulties experienced thus far by deployed NGSO systems, there are still companies that plan on launching NGSO services. However, the number of new entrants expected to enter the market has dwindled. High start-up costs, investor skepticism after bankruptcies, market uncertainty and competition from other sectors all confront companies seeking the commercial promise of NGSO.

In order to assess demand for commercial launch services resulting from the deployment of NGSO satellite systems, 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 Federal Aviation Administration support or preference for any particular proposal or system. Rather, the information provided reflects an AST assessment of overall trends in the NGSO 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 divided into three categories:

- "Little LEO" systems, which provide narrowband data communications such as e-mail, two-way paging, and messaging using frequencies below 1 GHz. Target markets include automated meter reading and vehicle fleet tracking.

- "Big LEO" and other mobile satellite services (MSS) systems, which provide voice and data communications and operating in the 1-2 GHz frequency range. Markets include mobile phone and data users and fixed-site users in areas not served by terrestrial systems.

- "Broadband LEO" systems, which provide 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. Markets include internet service, streaming video, and other data communications.

While voice and data communications services have comprised most of the payloads and launches to NGSO, new satellite services in NGSO also contribute to launch demand [Figure 3].

Commercial and international civil remote sensing systems are expected to be deployed in steady, albeit small, numbers. These remote sensing systems, encompassing a range of passive and active space-based techniques for observing the Earth, are typically launched on small vehicles. The first high resolution remote sensing satellite to become operational, Space Imaging's Ikonos, was launched by the Athena 2 launch vehicle in September 1999.

In 2000, the first three Digital Audio Radio Services satellites were launched for Sirius into a highly elliptical orbit by a Proton launch vehicle. XM Satellite Radio, a competitor radio service, will operate from GSO.

Figure 3: Commercial Services Debut in NGSO

Satellite Service	First Satellite Launch	Beginning of Formal Service
Narrowband Data Messaging	1995	1998
Mobile Satellite Telephony	1997	1998
High Resolution Remote Sensing	1999	1999
Digital Audio Radio Services	2000	Scheduled 2001

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

Market Scenarios

For each publicly announced system, AST assessed progress in design maturity, licensing, financing, partnerships, target market development, spacecraft development, launch services contracts, and deployment plans, inter alia. Based on this information and a review of the satellite services sectors, 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 would attract enough business to prosper after deployment. The baseline scenario assumes that once failed satellites will be replaced as needed, and that entire constellations will be replaced at the end of their useful lives 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 NGSO satellite services is sufficiently great to support the entrance of additional service providers or expanded follow-on systems.

The robust market scenario reflects more optimistic 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 were assessed for both small and medium-to-heavy lift launch vehicles. Small launch vehicles are defined by a payload performance less than 2,268 kilograms (5,000 pounds) to LEO, at 139.7 kilometers (100 nautical miles) altitude and 28.5^o inclination. Medium-to-heavy launch vehicles are capable of carrying more than 2,268 kg (5,000 lb) to a 139.7 km (100 nm) altitude and 28.5^o inclination.

System Orbits

Commercial non-geosynchronous systems use a variety of orbits, including:

- Low Earth orbits (LEO) 559–2,096 km (400-1,500 nm) in altitude, varying between 0^o inclination for equatorial coverage and 101^o inclination for global coverage;
- Medium Earth orbits (MEO) 7,826 km (5,600 nm) in altitude and 45^o inclination for global coverage using fewer higher-powered satellites; and
- Elliptical orbits (ELI, also known as high Earth orbits or HEO) with apogees ranging

from 5,729.8 km (4,100 nm) to 35,497 km (25,400 nm) in altitude and up to 116.5° inclination, allowing satellites to "hang" over certain regions on Earth, such as North America.

The following sections present AST's review of NGSO satellites systems and baseline and robust market scenarios that determine launch services demand.

NGSO SATELLITE SYSTEMS

"Little LEO" Telecommunications Systems

"Little LEO" systems were dubbed "little" by the FCC because they are at comparatively lower frequencies than Big LEO systems. Little LEOs 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. A wide variety of commercial and quasi-commercial organizations have proposed Little LEOs using store-and-forward capabilities (storing received messages until in view of a ground center) or functioning as relay systems. Two-way communication between the satellite and the ground is maintained through small mobile or fixed transmitter/receivers, using low-power omni-directional antennas. Costs to deploy Little LEO systems vary between $2 million and $650 million depending on system design. Operational and proposed Little LEO systems are shown in Figure 4.

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

Recent Developments ORBCOMM is the only Little LEO system that is deployed. 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. Among its largest customers are trucking firms. ORBCOMM's services are marketed through its global network of 17 service distribution partners, which are licensed to operate in 194 countries. Orbital Sciences Corporation first tested the ORBCOMM design with the launch of two satellites in April 1995. Operations began in November 1998. The ORBCOMM constellation comprises 35 satellites in orbits of 825 kilometers (512 nautical miles). Before the last deployment launch in 1999, ORBCOMM intended to launch another series of satellites into a zero degree plane.

While ORBCOMM has been successful in securing subscribers for its service and shipped some 30,000 units, it has also encountered difficulties converting orders into paying customers due to a number of delays in development of user hardware and software.

After nearly two years of slow growth, ORBCOMM filed for U.S. Bankruptcy Court protection in September 2000. International Licensees LLC obtained ORBCOMM after a bankruptcy auction in April 2001. The new company is comprised of service providers in Europe and Asia and at least two investment firms.

Other potential providers of low data rate satellite services continued to make progress toward deployment of Little LEO systems.

E-Sat is moving closer to lofting a six satellite constellation with launches on Russia's Rockot beginning in 2002. A piggyback payload called New Star to test out E-Sat technology was launched in 2001 aboard Surrey Satellite Ltd's SNAP-1, a 6.5 kilogram (15 pound) satellite. E-Sat was formed in 1994 and currently is comprised of DBS Industries Inc. (DBSI) and Echostar Communications Corporation.

Final Analysis intends to begin operations in 2003 although like other Little LEO firms, it has encountered challenges securing investment capital. The FAISat data messaging constellation will consist of 26 satellites plus 4 orbiting spares. (Final Analyis has applied with FCC for an expansion to 32 operational satellites and 6 orbiting spares.) In April 2000, Raytheon joined General Dynamics as an equity partner in Final Analysis's FAISat, bringing total equity investment to $125 million. A launch services agreement was signed with Polyot of Omsk, Russia for launches on Cosmos 3M from either Plesetsk or Baikonur. The first two FAISats were launched by Cosmos 3M in 1995 and 1997 and were built by General Dynamics.

Market Overview Little LEOs are targeted at corporations with geographically spread assets, particularly outside of dense urban areas where terrestrial systems are prevalent. 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 are expected to be paging, text messaging, and e-mail.

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, Little LEO systems are expected to be competitive with conventional wireless technology in less dense and hard to reach areas. Big LEOs also compete with Little LEOs for types of data messaging services. Inmarsat, TMI and Motient (formerly American Mobile Satellite Company or AMSC) currently offer data messaging via GSO satellites.

Market Demand Scenarios It is AST's assessment that under the baseline scenario, one additional Little LEO system will be deployed and replenished over the forecast period. ORBCOMM is expected to add additional satellites in forecast period. Under the robust market scenario, AST projects deployment of two Little LEOs in addition to ORBCOMM. This 2001 Little LEO forecast is a decrease of one system each from the baseline and robust scenarios presented in 2000.

Licensing Status ORBCOMM, Final Analysis and LEO One petitioned the FCC for authority to use additional spectrum at 1.4 GHz for feeder links during 2000. The 6 MHz of spectrum would be used for backhaul and satellite control functions. While the United States fought for this allocation at the ITU *World Radio Conference 2000*, the FCC later granted operators of wireless medical telemetry services half of the segment Little LEOs seek to use.

Five Little LEO systems have received licenses from the FCC—ORBCOMM, E-Sat, Final Analysis, Leo One, and VITASat. Licenses were issued in two rounds, in 1995 and 1998. Both licensing decisions were preceded by sharing agreements among the systems. Orbital Sciences Corporation, 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.

Figure 4: Little LEO Satellite Systems

System	Operator	Prime Contractor	Satellites: Number + Spares	Satellites: Mass kg (lb)	Orbit	First Launch	Status
Operational							
ORBCOMM	International Licensees LLC	Orbital	48	43 (95)	LEO	1997	Operational with 35 satellites on orbit; FCC licensed, October 1994
Under Development							
FAISat	Final Analysis	Final Analysis	32 + 6	151 (332)	LEO	2003	FCC licensed, March 1998; two test satellites launched in 1995 and 1997
Leo One Worldwide	LEO One USA	Dornier	48	125 (275)	LEO	2002	FCC licensed, February 1998; launch contract signed with Eurockot
E-Sat	E-Sat, Inc.	Alcatel	6	113 (250)	LEO	2002	FCC licensed, March 1998; launch contract signed with Eurockot
KITComm	KITComm (Australia)	AeroAstro LLC	21	100 (220)	LEO	TBD	Licensed by Australia
Proposed							
Courier/Convert	ELAS Courier (Russia)	Moscow Inst. Thermotechnics	8 to 12	502 (1107)	LEO	TBD	Status unknown
Gonets-D	Smolsat (Russia)	NPO PM	36	231 (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	150 (330)	LEO	TBD	Status unknown; licensed for operations by the Mexican government
LEOPACK	Space Agency of Ukraine	TBD	28	TBD	LEO	TBD	Unfunded
Micro Systems							
VITASat	Volunteers in Technical Assistance	Surrey Satellite Technology, Ltd.	2		LEO	1993	FCC licensed, 1995; communications package piggybacked on FAISat-2v satellite launch in 1997, but failed to operate. Temporarily relicensed by FCC to operate a transponder on Healthsat 2 as VITAsat 1R. Pending FCC applications submitted in August 2000 request full authority to operate VITAsat 1R and one transponder on Uosat 12 as VITAsat 2.
SAFIR	OHB Teledata (Germany)	OHB Systems	6	60 (132)	LEO	TBD	
IRIS	SAIT RadioHolland (Belgium)	SAIT Systems	6-Feb	60 (132)	LEO	TBD	In development; derived from SAFIR; comm payload on Resurs-O1 in 1998
Temisat	Telespazio (Italy)	Kayser Threde	7	40 (88)	LEO	TBD	On hold; Temisat 1 launched in 1993
Elekon	NPO PM/ Elbe Space (Russia/German)	NPO PM	7	TBD	LEO	TBD	Status unknown; comm package piggybacks on Tsikada navigation sats

"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. 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. Two Big LEO systems have been deployed to date—Iridium and Globalstar—and a third, New ICO plans a launch in 2001. Big LEO and MSS voice constellations are detailed in Figure 5.

Recent Developments The failure of Iridium has had a sustained negative impact on other commercial space ventures, including new entrants into the NGSO satellite market and the launch industry.

Iridium, the world's first global satellite telephony system, was an impressive technical achievement but it did not attract a sufficient number of customers and filed for bankruptcy in August 1999, only one year after entering commercial service. Following Iridium LLC's bankruptcy, the new operator of the Iridium constellation, Iridium Satellite, was awarded a contract worth $72 million for at least two years by the U.S. Department of Defense in December 2000. As part of the deal for up to 20,000 users with an unlimited number of minutes, DOD also agreed to indemnify Iridium from any potential future damages caused by satellite reentry.

Iridium Satellite paid $25 million for the Iridium constellation.

In March 2001, Iridium Satellite announced it would launch seven satellites in 2002. One launch will carry five satellites on a Boeing Delta II and another two satellites on Eurockot's Rockot. These launches were arranged prior to the 1999 bankruptcy. It is unclear if Iridium will be able to garner enough new customers to build and launch future satellites, let alone a follow-on generation.

Globalstar, the second Big LEO system operating in orbit, has been unable to attract enough worldwide customers to generate sufficient revenue to meet its financial obligations since service began in September 1999.

In January 2001, Globalstar suspended principle and interest payments on its debt in order to conserve cash. The company informed the Securities and Exchange Commission in April 2001 that it would seek bankruptcy protection if it could not raise more cash or arrange a solution with its creditors. Globalstar introduced data modem services in December 2000 and in February 2001 opened its 25th international gateway station. It reported 40,000 subscribers in March 2001.

The third Big LEO system, New ICO, the successor to the bankrupt ICO Global, plans a second attempt to launch its first satellite in summer 2001 on a Lockheed Martin Atlas IIAS launch vehicle. New ICO suffered a setback from a launch failure in 2000. A constellation of ten large satellites and two on-orbit spares to MEO are planned that will deliver data voice and fax services beginning in 2003. ICO will have 12 ground nodes, 11 of which are completed as of March 2001. The satellites will be in a circular orbit at an altitude of 10,390 kilometers (6,400 miles).

ICO Global filed bankruptcy in August 1999 after raising some $3 billion, not enough to complete construction of its satellites and gateways. 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 Teledesic, a broadband satellite company. According to documents filed with the court, ICO will be redesigned to provide medium-rate data communications such as wireless internet applications in addition to mobile telephony. In September 2000, the company announced that Boeing would modify 11 ICO satellites and build three additional ones. A merger between ICO and Teledesic was called off in March 2001.

Although ICO made a rapid recovery from bankruptcy and has several satellites built, its future is unclear. In March 2001, New ICO sent a letter to the FCC requesting a rule amendment that would allow use of its satellite frequencies for thousands of ground repeaters enabling a better connection to data users and callers indoors and in urban "canyons" or obstructed areas. The publicly available letter to the FCC stated that without a favorable ruling, 2-Ghz mobile satellites systems are not economically viable. The request has caused concern among cellular telephone companies who believe spectrum for ground use should be competitively bid in an auction.

Other satellite companies are interested in using ground repeaters, including Sirius Satellite Radio and XM Satellite. Rules governing the use of ground repeaters have not yet been established. The FCC is expected to begin evaluation of the New ICO's request in June 2001.

Market Overview Iridium and Globalstar's failure to attract enough customers for their pioneering global mobile telephony systems is the direct result of the ubiquitous and inexpensive ground-based wireless telephony systems now available. There is a market for mobile satellite telephones as seen by the existing customer bases each system has now, but this apparent niche market has proven to be too small for approaches used thus far.

Owing to the complexity of their satellite and ground infrastructure, it took ten years to implement mobile satellite telephony from concept to commercial operation. In the course of those ten years, terrestrial cellular telephony experienced phenomenal growth in coverage area, number of subscribers, and quality of service while greatly reducing prices of service. Once viewed as technologically advanced systems for which customers would be willing to pay a premium, Globalstar and Iridium now provide a service that is not as flexible as desired and more expensive than ground-based systems.

New ICO is adapting its satellites to target data communications and plans to offer medium-rate wireless internet access in addition to satellite telephony. ICO F2, the first test satellite, will be used to determine what modifications will be required to ICO's satellite and ground systems.

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 cellular and other wireless telephony units are cheaper and lighter, and new models and features develop rapidly. Wireless internet and e-mail capabilities are increasing with handheld computers, cellular telephones and other devices.

New ICO will offer medium-rate data access to the internet for fixed terminals and will compete with terrestrial internet service providers as well as GSO satellites. However, the internet market is large and demand for high bandwidth access at the right price may provide a niche for systems like ICO.

Market Demand Scenarios It is AST's assessment that under the baseline scenario, one new Big LEO system will be deployed in addition to Iridium and Globalstar.

A limited number of replacement launches for existing Big LEOs is expected: two launches of seven total satellites for Iridium in 2002 (or later) and eight satellites are "on call" for launches of Globalstar if necessary. No follow-on systems are scheduled during the forecast time period.

It is AST's assessment that no other Big LEO systems will emerge at this time, so the robust forecast includes the same number of systems as the baseline forecast. In addition, any new provider would have to compete against cellular land-based systems and Iridium and Globalstar until their lifespans run out.

Licensing Status In August 2000, the FCC released a "Report & Order" concluding that sufficient spectrum would be available for 2 Ghz mobile satellites systems. The report stated that the FCC will allocate spectrum based on the number of systems deployed, not the number of systems licensed.

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 (Motient) 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. Following the September 1997 application, TRW withdrew its Odyssey application and joined with ICO.

Big LEOs proposed by Russian organizations and other international companies remain unfunded.

Figure 5: Big LEO Satellite Systems

System	Operator	Prime Contractor	Satellites: Number + Spares	Satellites: Mass kg (lb)	Orbit	First Launch	Status
Operational							
Globalstar	Globalstar LP	Alenia Spazio	48 + 8	447 (985)	LEO	1998	Constellation on-orbit and operational; FCC licensed, January 1995.
Iridium	Iridium Satellite LLC	Motorola	66 + 6	680 (1500)	LEO	1997	Assets acquired in 12/00 bankruptcy proceeding. Constellation operated by DoD and Boeing. Data operations scheduled to commence by 6/1/01.
Under Development							
ECCO	Constellation Communications	Orbital	46 + 8[1]	703 (1550)	LEO	TBD	FCC licensed, July 1997; Orbital chosen as satellite, launch contractor, May 1998.
Ellipso	Mobile Comm. Holdings (MCHI)	Boeing	16 + 1	998 (2200)	LEO & ELI	TBD	FCC licensed, July 1997; Boeing selected satellite contractor, May 1998.
ICO	New ICO Global Communications (Holdings), Inc.	Boeing	10 + 2	2744 (6050)	MEO	2001	Company emerged from bankruptcy in May 2000 after $1.2 billion investment by Eagle River Investments, LLC. New ICO now focused on packet-switched data delivery. FCC 2 GHz MSS Report & Order released 8/14/00.
Proposed							
Boeing 2.0 GHz	Boeing	Boeing	16	2903 (6400)	MEO	TBD	FCC license applied for, September 1997. FCC 2 GHz MSS Report & Order released 8/14/01.
ECCO II	Constellation Communications	TBD	46 + TBD	585 (1290)	LEO	TBD	FCC license applied for, September 1997. FCC 2 GHz MSS Report & Order released 8/14/01.
Ellipso 2G	Mobile Comm. Holdings (MCHI)	TBD	26 + TBD	1315 (2900)	LEO & ELI	TBD	FCC license applied for, September 1997. FCC 2 GHz MSS Report & Order released 8/14/01.
Globalstar GS-2	Globalstar LP	TBD	64 + 4	830 (1830)	LEO[2]	TBD	FCC license applied for, September 1997. FCC 2 GHz MSS Report & Order released 8/14/01.
Iridum/Macrocell	Iridium LLC	TBD	96 + TBD	1712 (3775)	LEO	TBD	FCC license applied for, September 1997. FCC 2 GHz MSS Report & Order released 8/14/01. Motorola retained application for Macrocell, did not transfer to Iridium Satellite in bankruptcy.
International							
ECO-8	Brazilian Space Agency	TBD	11 + 1	249 (550)	LEO	TBD	Study resumed in August 1998; frequency use coordinated with ITU.
Gonets-R	Smolsat (Russian)	NPO PM	48	953 (2100)	LEO	TBD	Status unknown.
Koskon	Koskon Consortium (Russian)	AKO Polyot	45	862 (1900)	LEO	TBD	Status unknown; payload tested in 1991.
Marathon/Mayak	Informkosmos (Russian)	NPO PM	10	2510 (5533)	ELI[3]	TBD	Status unknown.
Rostelesat	Kompomash (Russian)	TBD	115	839 (1850)	LEO & MEO	TBD	Concept definition complete; awaiting funding.
Signal	KOSS Consortium (Russian)	NPO Energia	48	308 (680)	LEO	TBD	Status unknown.
Tyulpan	NPO Lavotchkin (Russian)	TBD	6	TBD	MEO	TBD	Status unknown.

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

"Broadband LEO" Systems

The tremendous market for high speed data communication pathways is evident for both ordinary consumers and business users seeking to apply the latest computer and communications technologies. Since the internet became "mainstream" worldwide around 1997, a race is on to wire-up the planet. Satellites do not have nearly enough bandwidth to service the entire user population but are playing an increasing role in delivering high data rate information. Satellites can reach customers that conventional landline services may not even attempt to access because of the high expense of installing landlines.

The term broadband encompasses a variety of multi-media services at high data speeds including audio, video, data and applications such as video teleconferencing.

Currently there are no NGSO systems delivering broadband services. There are several GSO transponders serving data roles between gateways and internet service providers (ISPs) and more operators plan to include broadband capabilities in future plans. Dedicated broadband systems in constellations of two to four GSO satellites are scheduled for launch in 2002 and 2003 by Spaceway, Wild Blue and Astrolink.

While NGSO systems could provide more focused coverage, offer higher data rates, reuse spectrum efficiently and have no latency (signal delay which could impact interactive users) compared to GSO, high start-up costs that range from $5-10 billion or more have slowed NGSO development. Broadband systems are proposed for the Ku, Ka, and V/Q-band frequencies. Broadband LEO systems are summarized in Figure 6.

Recent Developments SkyBridge plans an 80-satellite constellation with 140 earthstations capable of supporting 20 million users. The French-led company requires an estimated $6-7 billion in capital. In February 2001, Skybridge announced it would enter the broadband market by leasing transponders on existing GSO satellites, calling into question when and if an NGSO system would appear. The move was made because of the inability to attract investment from telecommunications companies. By testing the market from GEO, SkyBridge will potentially be able to gain some revenue to fund its future NGSO plans.

Prior to its decision to lease GSO transponders, SkyBridge signed a contract in December 1999 with Boeing to launch 40 satellites on two Delta III launch vehicles and four Delta IVs. Five months later, SkyBridge signed a second launch deal with Starsem, the French-Russian joint launch company, for launch of 32 satellites on 11 Soyuz/Fregat vehicles. Both Boeing and Starsem took equity positions in the company.

SkyBridge's plans were first announced in 1997 after a consortium was formed in 1993. Partners include Alcatel, the French space agency (CNES), and Loral Space & Communications. Alcatel has stopped development work on SkyBridge satellites until more equity is obtained. Loral's contribution began with a 14 percent investment. The satellite design phase has been completed.

Little is know about the internal future plans of Teledesic. Formed in 1990, Teledesic still has not publicly committed to a satellite design. The last known architecture is a 288 satellite system of 12 planes in a 1,375 kilometer (854 mile) orbit. In January 2001, the FCC instituted firm milestones for Teledesic's Ka band proposal, requiring the company to begin construction of its first two satellites by January 2002, launch the first satellite by an ITU deadline of September 2004 and have the entire system operational in 2007. One known launch services agreement was signed with International Launch Services (ILS) for three Atlas launches and three Proton

M launches plus options, leaving open future launch competitions depending on constellation size.

Market Overview Broadband data communications have been the focus of significant investment in the telecommunications industry: billions of dollars have been poured 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.

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 ISPs worldwide.

Many GSO operators have big plans for broadband although results have been mixed thus far. Starband from Gilat and DirecPC from Hughes, two companies that currently provide two-way internet service via GSO transponders, have not attracted as many customers as planned. Starband has delayed plans to purchase a dedicated broadband satellite. Satellite operator SES of Luxembourg has been cautious and devoted only about 5 percent of its capacity to broadband although growth is projected to rise to 15-30 percent by 2005 including a dedicated satellite. The FCC notified 7 Ka band licensees in 2001 that they must meet progress milestones or risk losing GSO "slots" granted by the ITU. Most of those license holders must launch by the end of 2005.

The Wall Street "dot com meltdown" of internet companies does not appear to be affecting plans of satellite providers.

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. Satellites lack bandwidth to service large populations in a dense area, so fiber optics and other land links, which do not require spectrum, are expected to capture most urban customers. In fact, there have been so many companies building fiber in the U.S. market that in some urban areas, main internet traffic routes now have more bandwidth than customers need and prices to use them have dropped during 2001.

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-to-home television. Satellites also appear well suited to provide multicasting of internet content to multiple ISPs at the same time.

NGSO systems have some disadvantages relative to GSO systems. For example, because NGSO systems are global in nature, the entire system must be fully deployed to provide service, whereas GSO systems may commence operation with only one satellite and begin to build revenue. In addition, much of the capacity of NGSO systems is untapped at any given time because each satellite spends about 70 percent of its time over water. While there may be potential air and sea passenger markets over oceans, the overall effect is a system inherently more expensive.

Another problem faced by complex NGSO systems is reflected by how fast computer technology changes: by the time a space system is designed and orbited, it could be obsolete or the consumer/business market may have shifted. This space technology time lag seriously hurt Iridium and Globalstar. One approach to alleviate this time lag is a “bent pipe” satellite design that relays incoming signals to sophisticated ground stations where technology can be upgraded without replacing the orbiting system. This option was chosen by SkyBridge which differs from Teledesic’s more complex satellites.

Market Demand Scenarios It is AST’s assessment that, under the baseline scenario, no Broadband LEO system will be deployed or maintained through 2010. This is the result of lost investor confidence in NGSO systems, high start up costs, competition from terrestrial services, competition from GSO broadband services, slow customer acceptance of existing broadband GSOs, and general uncertainty in business strategies thus far. Under the robust market scenario, AST projects that one Broadband LEO system will be deployed and maintained through 2010. This broadband system could be 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.

In May 2001, the FCC released a Notice of Proposed Rulemaking that proposed several sharing options and service rules for licensing the pending NGSO applicants in the Ku-band.

SkyBridge filed its application to the FCC to operate a Ku-band NGSO system in January 1999. An outstanding issue of Ku interference with GSO systems was overcome when the *World Radio Conference 2000* approved technical and regulatory parameters to allow NGSO systems to share Ku-band spectrum with GEO satellites systems. The FCC followed through on the same matter in December 2000. SkyBridge’s FCC license is still pending. The French government approved SkyBridge for service within France in March 2000.

Currently there are three application "processing rounds" pending at the FCC with proposed broadband systems. More than 20 applications involving satellites in NGSO orbits or with GSO systems are pending. An application filing window closed for use of frequency bands in the V-band (36/45 GHz) and in the Q-band (46/56 GHz) in September 1997. In December 1997, applications were filed in the Ka-band and in January 1999, applications for were filed for the Ku-band.

Figure 6: Broadband Systems

System	Operator	Prime Contractor	Satellites Number + Spares	Satellites Mass kg (lb)	Orbit	First Launch	Status
Ka-Band							
Teledesic[1]	ICO-Teledesic Global Ltd.	Motorola[1]	288	14969 (33001)	LEO[1]	TBD	FCC licensed, March 1997; license amended Jan 1999 for 288-sat system; firm milestones assigned by FCC in January 2001. Current configuration in flux.
Ku-Band							
SkyBridge	SkyBridge LP	Alcatel Espace	80	1247 (2750)	LEO	2003	FCC license applied for, February 1997.
Ka-Band							
Celestri	ICO-Teledesic Global Ltd.	Matra Marconi	63 + 7	3175 (7000)	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	3402 (7500)	MEO	TBD	FCC license applied for, December 1997.
LM-MEO[3]	Lockheed Martin	Lockheed Martin	32	2177 (4800)	MEO	TBD	FCC license applied for, December 1997.
SkyBridge II	SkyBridge LP	Alcatel Espace	96	2654 (5850)	LEO	TBD	FCC license applied for, December 1997.
Spaceway NGSO	Hughes Comm. (HCI)	Hughes Space & Comm. (HSC)	20	2858 (6300)	MEO[4]	TBD	FCC license applied for, December 1997.
WEST	Matra Marconi	Matra Marconi	9	3992 (8800)	MEO[5]	TBD	Under development.
Ku-Band							
Boeing NGSO FSS	Boeing	TBD	20	3862 (8515)	MEO	TBD	FCC license applied for, January 1999.
HughesLINK	Hughes Comm. (HCI)	Hughes Space & Comm. (HSC)	22	2937 (6475)	MEO	TBD	FCC license applied for, January 1999.
HughesNET	Hughes Comm. (HCI)	Hughes Space & Comm. (HSC)	70	1996 (4400)	LEO	TBD	FCC license applied for, January 1999.
Teledesic Ku-Band Supplement (KuBS)	Teledesic LLC	TBD	30 + 6	1325 (2920)	MEO	TBD	FCC license applied for, January 1999.
Virtual GEO Satellite (VIRGO)	Virtual Geosatellite LLP	TBD	15 + 3	3030 (6680)	ELI	TBD	FCC license applied for, January 1999.
V/Q-Band							
Globalstar GS-40	Globalstar LP	TBD	80 + TBD	1225 (2700)	LEO	TBD	FCC license applied for, September 1997.
GSN (Global EHF Satellite Network)	TRW	TRW	15	5965 (13150)	MEO[6]	TBD	FCC license applied for, September 1997.
LM-MEO[3]	Lockheed Martin	Lockheed Martin	32	2177 (4800)	MEO	TBD	FCC license applied for, December 1997.
M-Star	ICO-Teledesic Global Ltd.	TBD	72 + 12	1996 (4400)	LEO	TBD	FCC license applied for, September 1996.
Orblink	Orbital	Orbital	7 + TBD	2019 (4450)	MEO	TBD	FCC license applied for, September 1997.
Pentriad	Denali Telecom	TBD	9 + 3	1996 (4400)	ELI	TBD	FCC license applied for, September 1997.
Starlynx	Hughes Comm. (HCI)	Hughes Space & Comm. (HSC)	20	3493 (7700)	MEO[7]	TBD	FCC license applied for, September 1997.
Teledesic V-Band Supplement (VBS)	Teledesic LLC	TBD	72 + 36	612 (1350)	LEO	TBD	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 satellites.
(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.

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. As the market for commercial imagery evolves, they will generate a low but steady demand for launches of small launch vehicles. Commercial launch services may also be used to launch government remote sensing spacecraft for countries that lack domestic launch capabilities. Proposed remote sensing programs are detailed in Figure 7. The National Oceanic and Atmospheric Administration (NOAA) has issued 17 commercial remote sensing licenses; some companies hold more than one and some have been transferred.

The first one meter commercial remote sensing satellite to enter service was Space Imaging's Ikonos-2. OrbView 4 and QuickBird 2 are scheduled to launch in 2001. Space Imaging, ImageSat, ORBIMAGE, RESOURCE21 and GER Corporation plan future launches.

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 hold steady over the forecast period and has been incorporated into the projections in this report. The 1994 National Space Transportation Policy generally restricts U.S. Government payloads from launching on non-U.S. built vehicles so demand for these payloads is not included in this report.

Digital Audio Radio Services

Sirius Satellite Radio (formerly known as CD Radio) completed 3 launches to ELI in 2000 and is preparing to begin service in 2001 while its main rival, XM Satellite, will place its satellites in GSO. Other companies are considering NGSO orbits as well as GSO for satellite radio.

Figure 7: Commercial Remote Sensing Satellites

System	Operator	Manufacturer	Satellites	Mass (lb)	Highest Resolution	First Launch in System	Status
OrbView	ORBIMAGE	Orbital Sciences Corp.	Orbview 1 OrbView 2 OrbView 3 OrbView 4	74 (163) 372 (819) 185 (408) 185 (408)	10 km 1 km 1 m 1 m	1995	Launched 1995 Launched 1997 Launch planned 2001 Launch planned 2001
IKONOS	Space Imaging	Lockheed Martin	Ikonos 1 Ikonos 2 Ikonos 3 Ikonos 4	816 (1800) 816 (1800) TBD TBD	1 m 1 m 0.5 m 0.5 m	1999	Launch failed 1999 Launched 1999 Launch planned 2004 Launch planned 2004
Quickbird	EarthWatch	Ball Aerospace	Quickbird 1 Quickbird 2	815 (1797) 909 (2004)	1 m 1 m	2000	Launch failed 2000 Launch planned 2001
EROS	ImageSat International	Israel Aircraft Industries	EROS A1 EROS B1-B6	280 (617) 350 (771)	1.5 m 1.5 m	2000	Launched 2001 First launch planned 2003
RESOURCE21	RESOURCE21	Boeing	RESOURCE21 1-2	TBD	10 m	2005	First launch planned 2005
GEROS	GER Corporation	GER Corporation	GEROS 1-6	225 (496)	12 m	2003	First launch planned 2003 Plan to apply for license

PAYLOAD AND LAUNCH PROJECTIONS

The 2001 payload and launch projections are significantly lower than those in the 2000 forecast, reflecting reduced expectations for Big and Broadband LEOs in the wake of the demise of Big LEOs and finance uncertainties for NGSO Broadband. 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 additional systems.

Launch demand was assessed for two launch vehicle sizes: small launch vehicles capable of carrying less than 2,268 kilograms (5,000 pounds) of payload to 139.7 kilometers (100 nautical miles) at 28.5^{o} inclination and medium-to-heavy launch vehicles capable of carrying more than 2,268 kilograms (5,000 pounds) to at least the same orbital destination as small vehicles.

If the system operator had already made launch vehicle selection, it was incorporated directly into the assessment. This was the case for the majority of the most mature systems 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:

- One "Little LEO" constellation in addition to ORBCOMM. This is one less than the 2000 forecast.
- One additional "Big LEO" system to join Iridium and Globalstar. The latter two are planning a few replacement launches but not system replenishment. This is the same number of systems projected in 2000.
- No Broadband NGSO systems. There was one baseline broadband system last year.

The baseline scenario projects that 151 payloads will be deployed between 2001 and 2010, a reduction of 401 payloads from the 2000 forecast that covered 11 years (2000-2010). The decline is largely attributable to fewer systems in the baseline, only a few replacements for existing systems, removal of broadband, and a reduction in total years covered in the forecast (ten this year, down from 11 last year). The remote sensing and science satellite forecast is about the same as last year [Figures 8 and 9].

Launch demand for the baseline scenario is projected to be an average of 1.5 medium-to-heavy and 6.5 small launches per year from 2001 to 2010. Demand for medium-to-heavy launch vehicles are down, especially in the out-years, while small launches have a more steady demand. There are only 15 medium-to-heavy launch vehicles in the total forecast compared to 82 last year. Small launch demand is 65 launches compared to 114 in 2000 [Figure 8, 10].

Figure 8: Baseline Scenario Payload and Launch Projections

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	TOTAL	Avg
Payloads												
Big LEO	1	9	8	5	0	4	0	0	0	0	27	2.7
Little LEO	0	6	37	2	0	0	6	0	6	0	57	5.7
Broadband	0	0	0	0	0	0	0	0	0	0	0	0
Remote Sensing/Science/Other	7	3	8	8	7	7	5	7	9	6	67	6.7
Total Payloads	**8**	**18**	**53**	**15**	**7**	**11**	**11**	**7**	**15**	**6**	**151**	**15.1**
Launch Demand												
Medium-to-Heavy Vehicles	1	3	5	5	0	1	0	0	0	0	15	1.5
Small Vehicles	7	5	12	7	5	6	6	5	8	4	65	6.5
Total Launches	**8**	**8**	**17**	**12**	**5**	**7**	**6**	**5**	**8**	**4**	**80**	**8.0**

Figure 9: Baseline Scenario Payload Projection

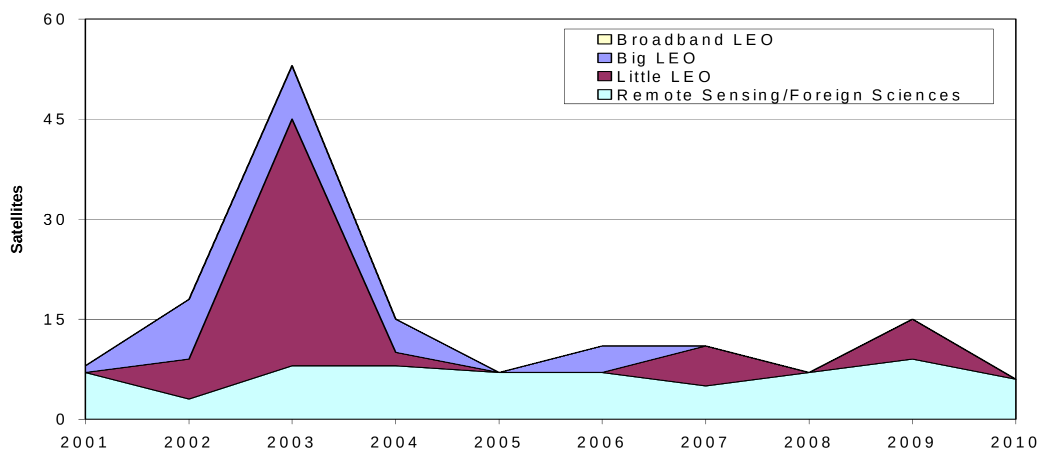
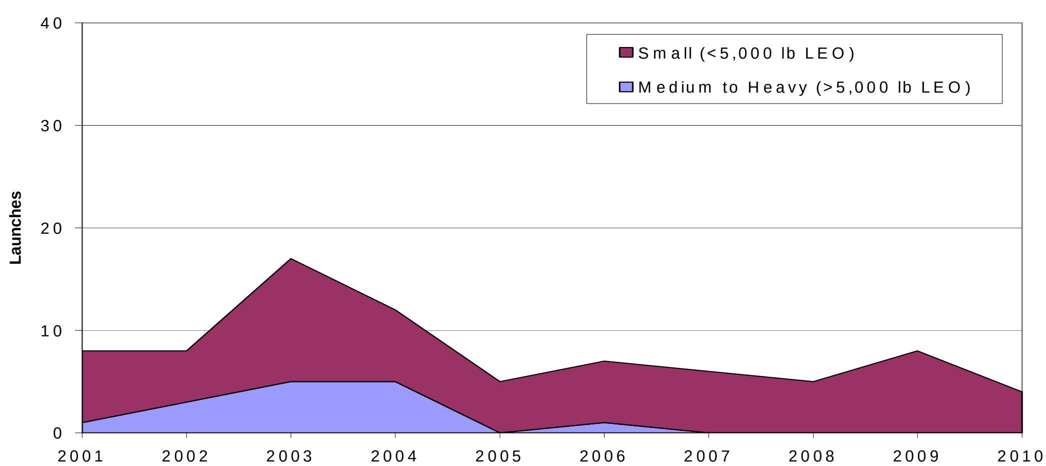


Figure 10: Baseline Scenario Launch Demand Projection



Robust Market Scenario

The robust market scenario reflects the deployment and replenishment of:

- Three "Little LEO" constellations, consisting of one new system in addition to ORBCOMM and one other system in the baseline. The 2000 forecast had four total Little LEO systems in the robust scenario.
- Three "Big LEO" systems, the same as in the baseline scenario. The robust scenario in the 2000 forecast included four total Big LEO systems. No second-generation systems are expected to be deployed in the forecast period.
- One Broadband NGSO system, which is one fewer system than projected in last year's robust market scenario.

The robust market scenario projects that 252 payloads will be deployed between 2000 and 2010, as seen in Figures 11 and 12. This represents a significant reduction from 685 payloads in the robust scenario from last year's forecast that covered 11 years. The robust scenario projects one less system in each category compared to last year.

Based on these payload projections, launch demand for the robust market scenario is projected to be an average of three medium-to-heavy and seven small launch vehicle launches per year over the forecast period. Similar to the baseline, there are fewer medium vehicles forecast in the robust scenario out-years compared to last year's forecast. A total of 128 total medium launches were in the 2000 forecast while only 31 are in this year's forecast. Small launch vehicles have a steadier demand on average in this year's robust forecast although the overall total launches of 73 is half of the 144 in the 2000 forecast. Robust launch demand is shown in Figures 11 and 13.

Figure 11: Robust Market Scenario Payload and Launch Projections

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	TOTAL	Avg
Payloads												
Big LEO	1	9	8	5	0	4	0	0	0	0	27	2.7
Little LEO	0	9	40	2	0	0	9	3	6	0	69	6.9
Broadband	0	0	0	20	40	20	0	4	0	0	84	8.4
Remote Sensing/Science/Other	7	4	8	9	7	8	5	8	9	7	72	7.2
Total Payloads	**8**	**22**	**56**	**36**	**47**	**32**	**14**	**15**	**15**	**7**	**252**	**25.2**
Launch Demand												
Medium-to-Heavy Vehicles	1	2	4	11	8	4	0	1	0	0	31	3.1
Small Vehicles	7	6	13	8	5	7	7	7	8	5	73	7.3
Total Launches	**8**	**8**	**17**	**19**	**13**	**11**	**7**	**8**	**8**	**5**	**104**	**10.4**

Figure 12: Robust Market Scenario Payload Projection

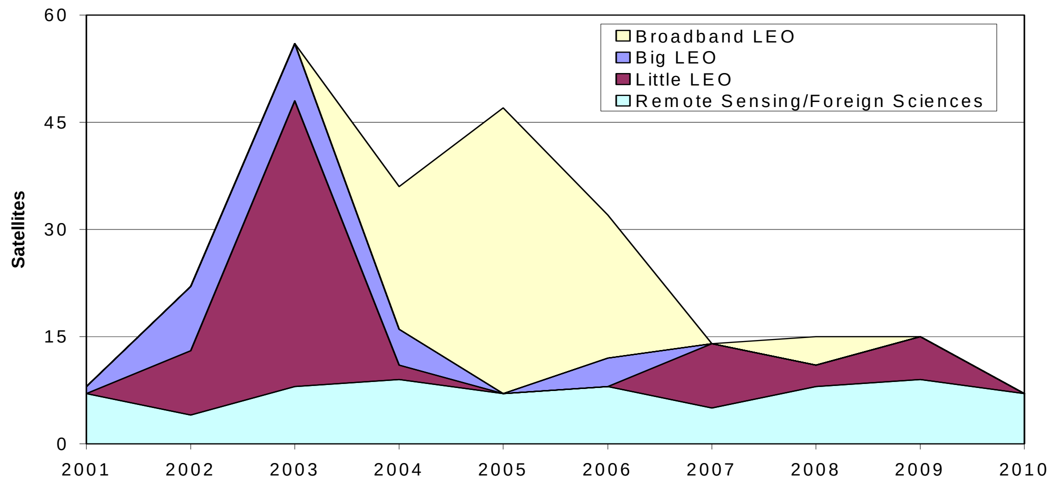


Figure 13: Robust Market Scenario Launch Demand Projection

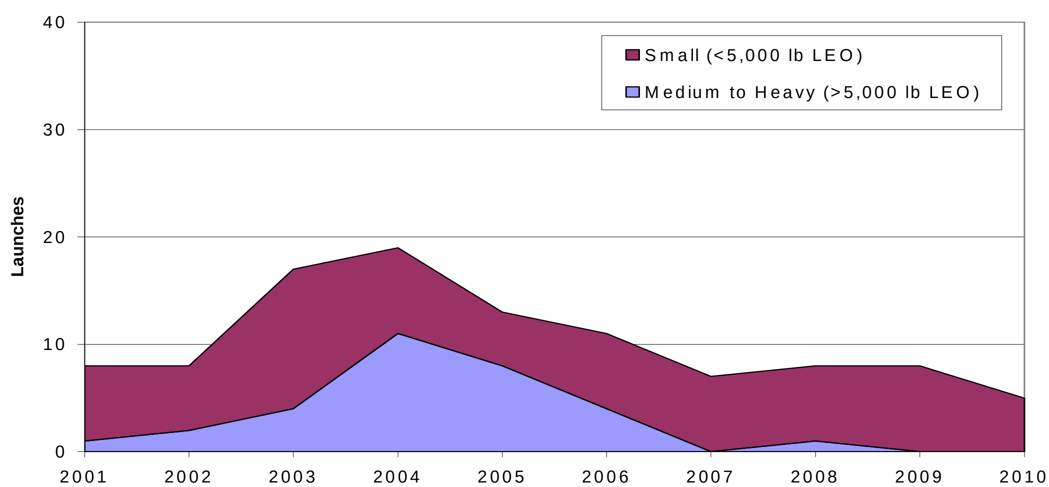
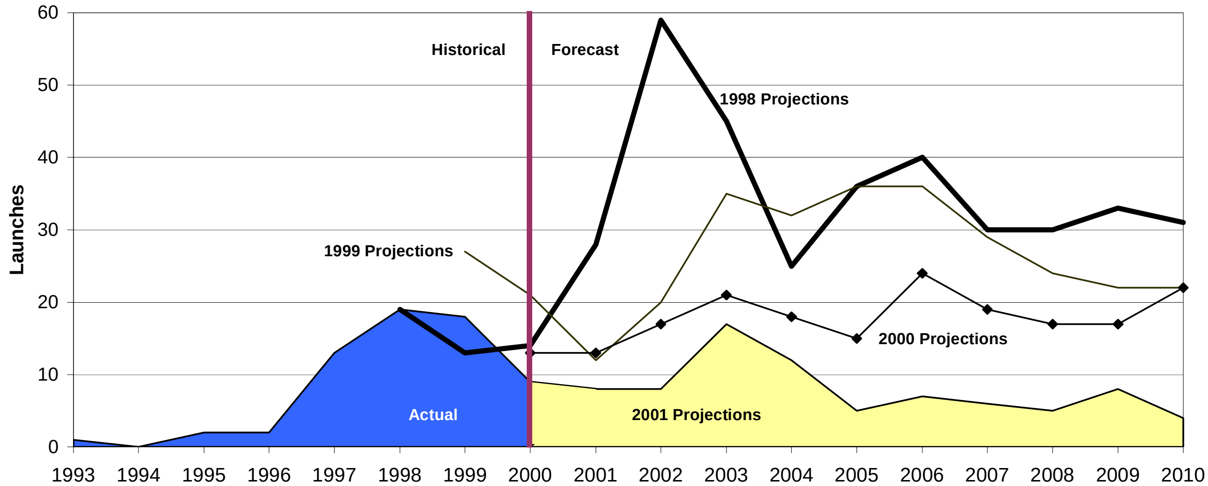


Figure 14: Comparison of Past Baseline Launch Demand Projections



Historical NGSO Market Assessments

A historical comparison of AST baseline forecasts from 1998 to the present is in Figure 14. Actual launches to date are also displayed. Since publication of the first projections for NGSO/LEO launches in 1994, there has been tremendous growth in the number of proposed NGSO systems. 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. Over this period, The *2000 Commercial Space Transportation Projections for Non-Geosynchronous Orbits* marked the first reduction in systems forecasted, with only seven-to-ten systems projected, the 2001 forecast reduces the numbers further with five-to-seven systems projected. Figure 15 summarizes AST's commercial NGSO system projections.

With the deployment of the first NGSO constellations, the number of commercial payloads launched to low Earth orbit has risen from an average of less than one per year up through the mid-1990s to close to 70 per year from 1997-1999. However, no new multiple constellation systems have deployed since the completion of Iridium, ORBCOMM, and Globalstar and fewer systems have been projected. Historical payload and launch data for the period 1993 to 1999 are shown in Figure 16. Secondary and piggyback payloads on launches with larger primary payloads were not included n the payload or launch tabulations.

Figure 15: Past NGSO System Projections

	1994	1995	1996	1997	1998	1999	2000	2001
Systems Projected *								
Little LEO	1-1	1-2	2-3	2-3	3-4	3-4	3-4	2-3
Big LEO	1-2	2-3	3-4	4-5	4-5	4-5	3-4	3-3
Broadband LEO	0	0	0	0-1	2-3	2-3	1-2	0-1

* The lower number reflects the baseline scenario and the upper reflects the robust market scenario (previously "modest and high growth").

Figure 16: Historical NGSO Payload and Launch Activities (1993-2000) *

Summary	Market Segment	Date	Payload	Launch Vehicle	
2000					
18 Payloads	**Big LEO**	2/8/00	Globalstar (4 sats)	Delta 2	Medium-to-Heavy
5 Big LEO		3/12/00	ICO Z-1	Zenit 3SL	Medium-to-Heavy
2 Remote Sensing					
8 Foreign Science	**Remote Sensing**	11/21/00	Quickbird 1	Cosmos	Small
3 Other		12/5/00	EROS A1	START 1	Small
	Foreign Science	7/15/00	Champ Mita RUBIN	Cosmos	Small
		9/26/00	MegSat 1 Saudisat 1-1 Saudisat 1-2 Tiungsat 1 Unisat	Dnepr 1	Small
9 Launches	**Other**	6/30/00	Sirius Radio 1	Proton	Medium-to-Heavy
5 Medium-to-Heavy		9/5/00	Sirius Radio 2	Proton	Medium-to-Heavy
4 Small		11/30/00	Sirius Radio 3	Proton	Medium-to-Heavy
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 MegSat 0	Cosmos	Small
		12/21/99	Kompsat	Taurus	Small

Summary	Market Segment	Date	Payload	Launch Vehicle	
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
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					

Summary	Market Segment	Date	Payload	Launch Vehicle
1994				
0 Payloads ***0 Launches***				
1993				
2 Payloads *1 Little LEO* *1 Foreign Science* ***1 Launch*** *1 Small*	**Little LEO** **Foreign Science**	2/9/93 2/9/93	CDS 1 SCD 1	Pegasus 1 Small Pegasus 1 Small

*Includes payloads open to international launch services procurement and other commercially sponsored payloads. Does not include dummy payloads. Also 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). Does not include piggy-back payloads.