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Report of the
COMSTAC Technology & Innovation Working Group

COMMERCIAL SPACECRAFT MISSION MODEL UPDATE

May 1997

Paul Fuller, Chairman
Technology & Innovation Working Group

Commercial Space Transportation Advisory Committee (COMSTAC)
Office of the Associate Administrator for Commercial Space Transportation
Federal Aviation Administration
U.S. Department of Transportation

TABLE OF CONTENTS

COMMERCIAL MISSION MODEL UPDATE

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. An important element of these efforts is to establish the commercial space industry's view of future space launch requirements. Since 1993, the DOT has requested that its industry advisory group, the Commercial Space Transportation Advisory Committee (COMSTAC), prepare and maintain a commercial spacecraft launch demand mission model.

This report presents the 1997 update of the worldwide commercial geosynchronous transfer orbit (GTO) satellite mission model for the period 1997 through 2010. It is based on market forecasts obtained in early 1997 from major spacecraft manufacturers, satellite operators and launch service providers. The mission model is limited to "addressable" payloads only. In other words, it is limited to payloads open to internationally competitive launch service procurements. Payloads captive to any launch system are excluded from the mission model. Also note that the number of vehicle launches per year resulting from this payload launch demand mission model will be a subset of this data due to the potential for multiple manifesting on launch vehicles. The FAA/AST develops low-earth-orbit (LEO) and medium-earth-orbit (MEO) market forecasts separately from this report (Reference 1).

1997 Mission Model Update Methodology

Through a process similar to that in 1996, the Technology and Innovation Working Group solicited input from industry via a letter sent over the signature of the Associate Administrator for Commercial Space Transportation (Reference 2). The letter requested market projection data representing the best forecast of the number of addressable commercial GTO payloads per year in the period 1997 - 2010. Respondents completed a table which segregated payloads into categories of "Medium," "Intermediate" and "Heavy" based on separated mass inserted into a nominal transfer orbit, inclined at 28 degrees. The classifications are representative of a clustering of similar capability launch vehicles with examples as follows:

GTO Launch Capability (200 nm x GEO orbit @ i=28°)	**Mass Classification**	**Representative Launch Vehicle**
2,000-4,000 lb 900-1,814 kg	Medium	Dual Ariane 4/5, dual H-II/H-IIA, Delta 2, Long March 3 or 3A
4,000-9,000 lb 1,814-4,090 kg	Intermediate	Dual Ariane 4/5, Atlas IIA, IIAS or IIAR, Delta 3, H-II/HII-A, Long March 2E or 3C, Sea Launch, Proton D1e
>9,000 lb >4,090 kg	Heavy	Dedicated Ariane 4/5, H-IIA, Proton M, Sea Launch, Long March 3B

In 1997, the following organizations responded with data used in the development of this report:

Asiasat*	Lockheed Martin Telecommunications*
Boeing*	Matra Marconi
COMSAT	McDonnell Douglas Aerospace*
CTA	Motorola
GE Americom	Optus Communications
Hughes Space and Communications*	Orbital Sciences
Inmarsat	Space Systems/Loral*
INTELSAT	Telesat Canada
Lockheed Martin Int'l Launch Services*	TRW

Comprehensive mission model forecasts (total market of addressable GTO satellites seeking launch services) were received from those organizations marked by an asterisk (*). Other responses provided partial market or company-specific demand information.

Conclusions

The following conclusions are based on the results of this 1997 update of the worldwide commercial GTO mission model:

- The 1997 COMSTAC Commercial Mission Model (Figure 1.0) indicates average demand for launch of commercial GTO payloads will be approximately 33 per year in the period 1997 - 2010. This compares to a forecast average of 31 in 1996 (Reference 3). The high-low dispersions, which represent the highest or lowest data point in any given year, underscore the uncertainty in predicting the market. The consensus is that the average of the company inputs is representative of the overall market size.

- The 1997 forecast compares closely to the 1996 forecast (Figure 2.0). It validates a projection of significant growth in 1998-1999 followed by a decline, with a second, but less aggressive, cycle of growth beginning in the 2003-2004 time frame. The primary change from 1996 is the flattening out of the curve, particularly in the years following the 1998 peak where it appears that ongoing demand for satellite services may offset the traditional "bow wave" effect noted in previous forecasts.

- The mass distribution of commercial payloads reflects a trend toward heavier satellites (Figure 3.1) echoing the Continued Mass Growth case presented in the 1996 report. Factors influencing the demand for heavier commercial satellites include the availability of several new heavy-lift launch vehicles, the increased cost effectiveness of larger spacecraft (on a dollars per transponder basis), increasing spacecraft power requirements, larger antennae and increased orbital congestion.

- The trends in mass evolution portrayed in Figure 3.2 suggest that the Intermediate payload market is likely to decrease as a percent of the total annual market, while the heavy segment will increase. The Medium GTO category represents a small fraction of the market and is relatively stable. An emerging heavy lift segment includes a significant number of payloads that are forecast to exceed the capability of current U.S. launchers.

Complete tabular data is contained in Tables 1.0 and 2.0. A discussion of the data analysis and market projection results is contained in Appendix A. The detailed 1997-1999 Near Term Mission Model is contained within Appendix B. The 1988-1996 Payload Launch History is contained in Appendix C.

Recommendations

The following recommendations are made based on the implications of this 1997 update of the worldwide commercial mission model:

- U.S. launcher programs and initiatives should include a >9,000 lb. to GTO capability to maximize commercial market viability.

- The 1997 COMSTAC Mission Model report should be provided to appropriate U.S. government agencies for their use, and be made available for release to the general public.

The Technology and Innovation Working Group identified the following process improvements that will be implemented following approval and release of the report:

- COMSTAC will prepare and provide briefings on the interpretation and implications of this 1997 Mission Model Report to appropriate agencies/organizations.

- COMSTAC will plan to incorporate LEO and MEO payloads launch demand into the 1998 update of the COMSTAC Mission Model.

References

1. Department of Transportation letter, “LEO Market Study”, dated 2/02/96, F. Weaver

2. Depart of Transportation Letter, dated 1/30/97, F. Weaver

3. COMSTAC Report, “Commercial Spacecraft Mission Model Update,” dated 25 July 1996, P. Fuller, COMSTAC Office of Commercial Space Transportation, Federal Aviation Administration, U.S. Department of Transportation.

Figure 1.0. 1997 COMSTAC Commercial GTO Mission Model

Figure 2.0. 1996-1997 COMSTAC Mission Model Comparison

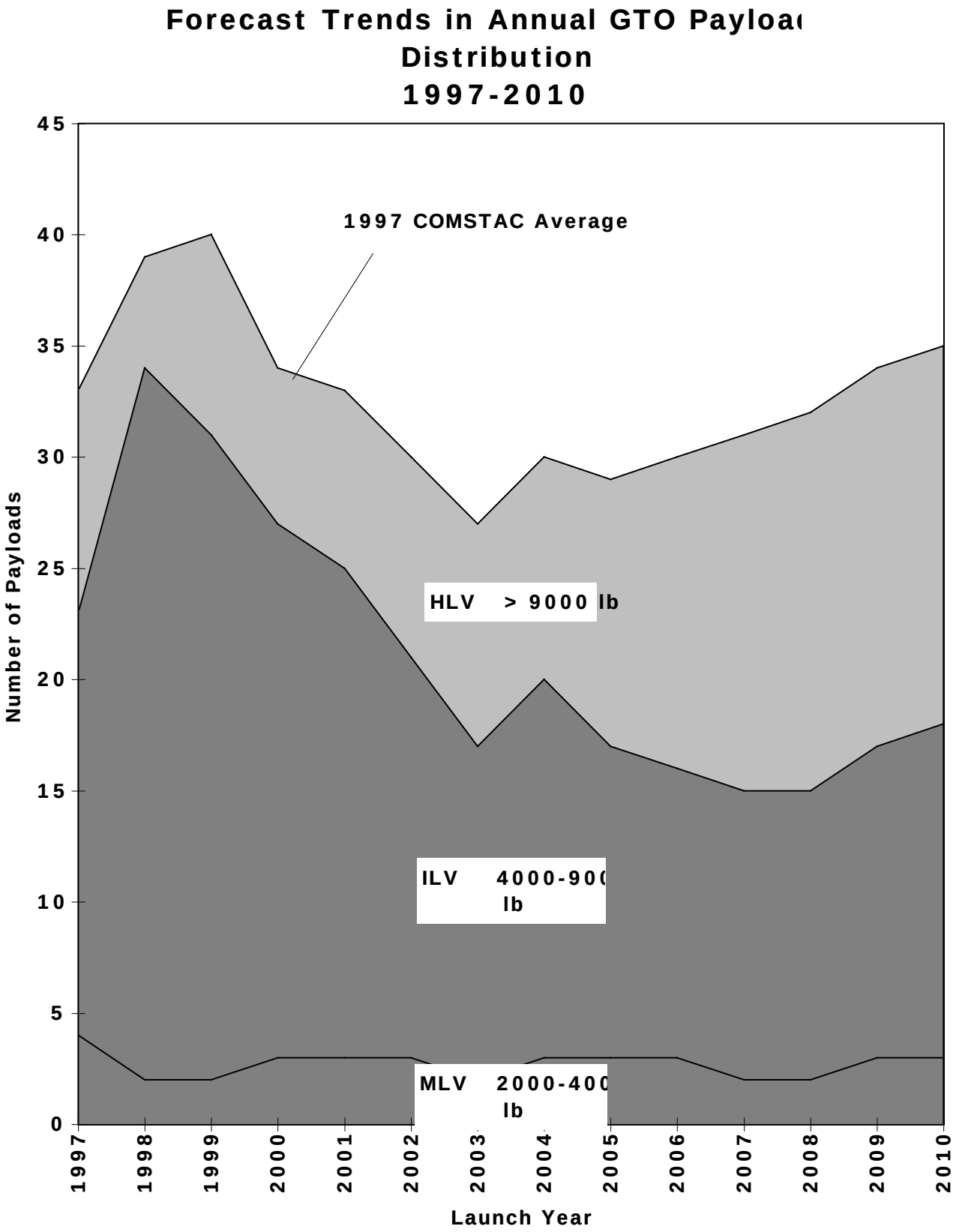

Figure 3.1. Forecast Trends in Commercial GTO Payload Mass Distribution

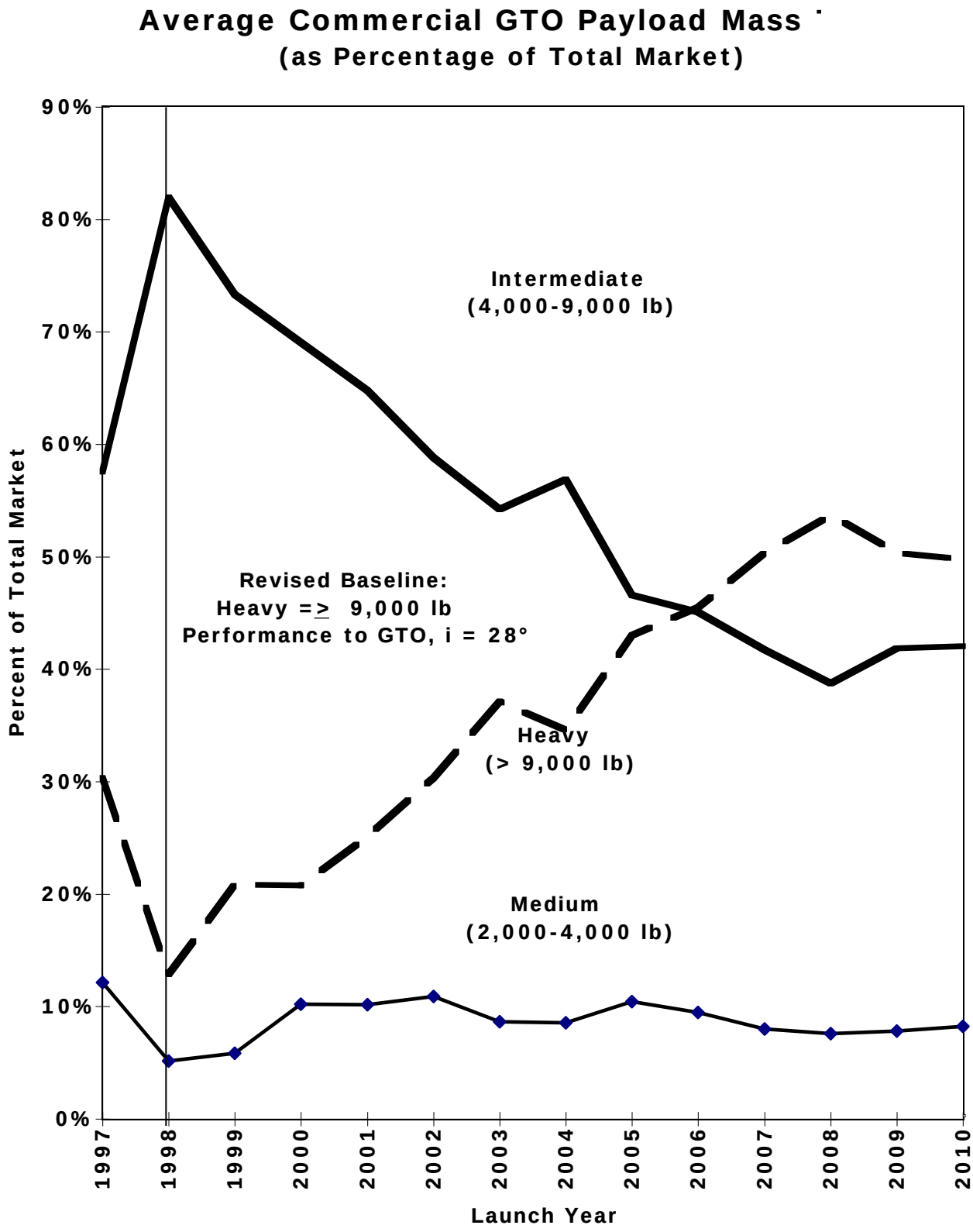

Figure 3.2. Forecast Average Mass Trends as a Percentage of Total Market

Table 1.0. 1997 COMSTAC Commercial GTO Mission Model Summary

COMSTAC 1997 Summary	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total 1997-2010	Avg 1997-2010
Highest Inputs	33	39	40	42	40	37	32	36	35	34	36	37	43	46		
Average Rate	**33**	**39**	**40**	**34**	**33**	**30**	**27**	**30**	**29**	**30**	**31**	**32**	**34**	**35**	**457**	**33**
Lowest Inputs	33	38	40	25	25	23	23	25	24	27	26	28	28	24		

Notes:

1) The “Average Rate” 1997 COMSTAC forecast represents the sum of all forecast payload launch rates divided by the number of all comprehensive U.S. forecasts provided.
2) The “Highest” and “Lowest” inputs reflect the maximum and minimum individual estimates provided for any one year. No working group member’s forecast was consistently higher or lower than the “Average Rate” throughout the forecast period.
3) The highest forecast was 499 addressable payloads to be launched from 1997 through 2010. The lowest forecast was 399 and the average was 457.
4) The 1997-1999 figures reflect the near consensus forecast developed by the working group members and is provided in detail in Appendix B, “1997-1999 Near-Term Mission Model.”

Table 2.0. Forecast Trends in Payload Mass Distribution

Payload Mass	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total 1997-2010	Avg 1997-2010	Percent of Total 1997-2010
MLV 2,000-4,000 lb	4	2	2	3	3	3	2	3	3	3	2	2	3	3	38	3	9
ILV 4,000-9,000 lb	19	32	29	24	22	18	15	17	14	13	13	13	14	15	258	18	56
HLV >9,000	10	5	9	7	8	9	10	10	12	14	16	17	17	17	161	12	35
Total Market	**33**	**39**	**40**	**34**	**33**	**30**	**27**	**30**	**29**	**30**	**31**	**32**	**34**	**35**	**457**	**33**	**100**

Notes:
1) MLV: Medium Class
2) ILV: Intermediate Class
3) HLV: Heavy Class

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APPENDIX A
1997 DISCUSSION AND RESULTS

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1997 DISCUSSION AND RESULTS

Background

COMSTAC prepared the first commercial mission model in April 1993 as part of a report on commercial space launch systems requirements (reference A1). Each year since 1993, COMSTAC has issued an updated model. The process has been continuously refined and industry participation broadened each year to capture the most realistic portrayal of space launch demand possible. Thus, 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 U.S. 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 commercial payloads per year.

1994: Key U.S. spacecraft manufacturers contributed to the 1994, report (reference A2) which represented an average of inputs by Hughes Space & Communications, Martin Marietta Astro Space and Space Systems Loral. The demand reflected an average of 17 payloads per year over the forecast period of 1994-2010, with some members of the spacecraft manufacturing community believing the mission model to be conservative.

1995: The Technology and Innovation Working Group was formally chartered to prepare an annual Commercial Spacecraft Mission Model Update Report (reference A3). The organizations from which the market demand forecasts were requested was further expanded to include satellite operators, in addition to spacecraft manufacturers and launch service providers. The 1995 data contained sizable variations in projected launch demand with a significant degree of polarization around two differing viewpoints. Therefore, a two case scenario was adopted for the 1995 report. A "Modest Growth" scenario projected an average demand for launch of approximately 20 payloads per year over the period 1995 to 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 "High Growth" 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 and Higher Growth cases approximately 70% of the payloads were forecast to be in the Intermediate category (4000 - 8000 lb.), with 15% each in the Medium (2000-4000 lb.) and the Heavy (>8,000 lb.) classes.

1996: The annual update included an expanded request for input to a greater number of companies and satellite operators. The resulting forecast (reference A4) represented a consensus on the size of the market, similar 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. Stable Mass Growth assumed the Intermediate payloads represented 70% of the market over the forecast period, while Continued Mass Growth reflected the emergence of a segment of Heavy payloads, representing 42% of the total market.

1997 Mission Model

The 1997 COMSTAC mission model contains two key elements. The first is a forecast of demand for internationally competed launches of commercial communications satellites to

geostationary transfer orbit (GTO) from 1997 to 2010. The second is an estimated payload mass distribution for those launches, using the payload mass categories defined earlier in the report. Findings in each of these elements are summarized below.

Forecast of Demand for Payload Launches

1997 Mission Model -- Figure 1.0 shows the COMSTAC Technology and Innovation Working Group's forecast demand for commercial launch services to GTO.

This year's mission model predicts an average demand of 33 payloads to be launched per year from 1997 to 2010. The forecast in the 1997-1999 time frame shows an unprecedented demand of up to 40 payload launches per year. A cyclical dip centered around 2003 is still apparent in the mission model, consistent with the 1995 and 1996 mission models. This is followed by a resurgence in demand thereafter, fueled by replenishment requirements of satellites recently launched or under construction and by varying estimates of out year growth.

The forecast from 1997 through 1999 clusters tightly around the average. This is due to the fact that many of these payloads are identified and are manifested on launch vehicles. Also, a concerted effort by the working group to reach consensus was made on those payloads that have not been formally identified nor manifested. The forecast from 2000 onward varies more widely. Nevertheless, this year's forecasts were more consistent with one another than they were in either of the last two years.

The 1997 mission model (Figure 1.0) plots the actual number of payloads launched from 1988 through 1996 (COMSTAC Historical). It also displays the range of independent estimates provided by working group members from 1997 onward and compares them with an average of all estimates combined (COMSTAC Forecast).

The ranges of these estimates are plotted as high-low lines above and below the average. Each high-low line represents the highest and lowest individual estimate provided in any one year. The dashed lines that link the series of highest and lowest estimates were added to show the range of inputs. They do not represent any one member's consistently higher or lower input and are therefore not additive. All members' estimates were either higher or lower than the average one or more times during the forecast period.

Comparison with 1996 report -- Figure 2.0 compares this year's forecast with last year's forecast. The 1997 mission model predicts an average of 33 satellites to be launched per year. Last year's mission model predicted an average of 31 satellites to be launched per year over the same 1997-2010 period. There is little difference between the two forecasts.

This year's estimate is slightly higher than last year's estimate, especially over the 1999-2003 time frame. This may be due to increasing confidence in the number of launch opportunities that may appear over that period. Beyond 2003, the 1996 and 1997 forecasts are very consistent.

Approach to Demand Modeling -- The approach used by industry to forecast commercial satellite demand includes: evaluating firm contracted missions, current satellite operator planned and replenishment missions, projected operator growth and growth replenishment missions, and some estimate of "unidentified growth." Finally an attrition rate of 10 percent of annual launch demand is also assumed. It includes on-orbit satellite and launch vehicle failures, with the replacement accomplished within two years of failure. Unidentified growth estimates include proprietary, company specific information on future market demand. Differing assessments of unidentified growth play a key role in the variance in the data in the last several years of the mission model.

As in years previous, the near-term COMSTAC mission model serves as a useful indicator of scheduled launch service demand. The forecast, however, does not account for unanticipated launch failures or delays in the launch vehicle or satellite supply chain. For example, the working group forecast that 30 commercial satellites would be launched into GTO in 1996. The actual number launched was 26, for a difference of four satellites. This was due to five launch services that were scheduled but postponed from 1996 into 1997 (due to later than planned satellite delivery). In addition, one launch service was accelerated from 1997 into 1996 at the customer's request. This pattern of firm schedule commitments followed by modest delays has appeared consistently in previous editions of this report. Customer preference and launch failures have also contributed to this phenomenon.

Forecast uncertainties -- A key issue raised by the working group involved the difficulty and uncertainty in forecasting the commercial launch market beyond a five year planning horizon. Most members felt confident in their forecasts over the next several years. Beyond five years, however, there was a problem with visibility into new commercial programs that may occur, but for which satellite operators have not made or announced serious plans. This stems from the fact that it can take three years, and often less, to start a commercial satellite system, including financing, frequency coordination, satellite construction and launch.

In the 2005-2010 time frame, most working group members had less confidence in their forecasts. The long-term growth shown in most forecasts is the result of two key variables. The first variable is the replenishment of existing satellites and satellites about to be launched over the next several years. The second variable involves differing assessments of planned and unidentified missions and forecast operator growth.

Most working group members felt strongly that today's existing C and Ku-band infrastructure will be replaced. On the other hand, the long term potential of emerging new applications, (such as new Ka-band "internet in the sky" systems) while potentially very large, was very difficult to quantify at this point in time.

Methodology and calculations -- The average launch rate from 1997 through 2010 was calculated by adding all the working group forecasts together and dividing them by the number of forecasts (Figure 1.0 and Table 1.0). Estimates for 1997 and 1998 reflect the consensus forecast developed by the working group and are provided in detail in Appendix B, "1997-1999 Near Term Mission Model."

Varying estimates for 1999 reflect independent assessments of the likelihood or timing of the unassigned or "spacecraft not ordered" programs annotated in Appendix B. While the group neared consensus on the number (40) of payloads expected to be available for launch in 1999, they arrived at this consensus using various subsets of 44 different programs.

The highest and lowest inputs (shown in Figure 1.0 and Table 1.0) represent the single highest or lowest estimated number of payloads to be launched in that year. No working group member's forecast was consistently higher or lower than the average throughout the forecast period. Therefore, the maximum inputs and minimum inputs are not additive. Accordingly, the highest single cumulative estimate across the 1997-2010 forecast period was 499 addressable commercial payloads to be launched. The lowest cumulative estimate was 399 and the average was 457.

Trends in Payload Launch Mass

Figures 3.1 and 3.2 reflect a significant evolution from 1996 in the working group's opinion regarding how far and how fast trends in commercial satellite payload mass will

evolve. They suggest a broad consensus that commercial payload launch mass would probably continue to gradually increase in the future.

How many medium, intermediate and heavy launches will there be? -- The COMSTAC Technology and Innovation Working Group explored this question in detail. Last year, the working group maintained two positions on this subject. One part of the group maintained that payload mass growth may have peaked or could stabilize over the next few years. The other part of the group maintained that commercial communications payloads were likely to grow, generally in line with their historical track record.

This year, however, the working group reached a broad consensus that commercial payload launch mass would probably continue to grow gradually in the future. Moreover, in an attempt to display what each member saw as important underlying trends in this area, the working group sought to show their individual estimates as a collective average over time.

Like last year, Figure 3.1 shows these trends quantitatively as their payload-by-payload contribution to the total COMSTAC mission model from 1997 through 2010. Figure 3.2 shows these same trends as a year-by-year percentage of each member's respective mission model over the same period. This figure is perhaps the most representative of the group's collective view points regarding mass growth.

As indicated, the number of intermediate launches is forecast to decrease gradually from about 80% of the market to about 40% of the market in 2010. The number of heavy launches is forecast to increase correspondingly. The number of medium GTO launches, however, is forecast to remain relatively constant at about 2-4 a year (about 10% of the market) as small countries and new operators continue to enter the market.

Payload Mass Definitions -- The payload mass class definitions have been further refined since 1996. The new HLV mass class definition adopted in 1996 for payloads heavier than 9,000 pounds now applies to payloads to be launched in 1998 and beyond, consistent with the planned first launches of U.S. vehicles whose performance will greatly exceed the previous 8,000 pound threshold. This definition has also been clarified to refer specifically to launch vehicle *performance* (vs. launch mass) greater than or equal to 9,000 pounds to a nominal geosynchronous transfer orbit of 200 nm x GEO at an inclination of 28° north.

In practice, this keeps the HLV mass category definition consistent with a performance greater than that available from a U.S. launchers from a U.S. launch site without a degradation in required satellite lifetime. This definition is also consistent with the less than 8,000 pound performance historically available from U.S. launchers since 1988, as reflected in the historical tables in previous COMSTAC commercial spacecraft mission models.

Variation between estimates -- It is important to note that there was still a wide variety of opinion as to how far and how fast trends in commercial satellite payload mass may evolve. In other words, on face value, both Figures 3.1 and 3.2 may overstate the apparently inexorable or linear nature of payload mass growth. They should *not* be read as, "In the year 2002 there will be exactly 18 intermediate and 9 heavy-class payloads." For example, Figures 3.1 and 3.2 (and corresponding Table 2.0) may be better interpreted as, "Within five years, we could see as many as 18 intermediate and 9 heavy-class payloads, plus or minus 5-6 payloads either way."

Alternatively, based on our consensus estimate, the number of intermediate payloads launched per year will equal the number of heavy payloads launched some time between 2005-2006. Based on the variation between working group member inputs, however, one might read Figure 3.2 as indicating this might occur as early as 2003 or perhaps at some point beyond the year 2007.

How heavy is "heavy"? -- One frequently asked question of the COMSTAC working group was: How heavy will the next generation of "heavy" commercial satellites be? Is there a limit to payload mass growth and how much over the 9,000 lb. threshold will commercial satellites weigh?

The working group did not develop an estimate independent of last year's COMSTAC Commercial Space Launch System Requirements document (Reference A5). However, it was broadly suggested that the next generation of commercial satellites currently under development would probably take full advantage of the lift capacity available for sale on the commercial market. In other words, demand for heavy commercial satellites could grow to meet the supply of heavy lift launchers, but not beyond.

Consistent, therefore, with the 1996 COMSTAC Commercial Space Launch Systems Requirements document (Reference A1), this would imply "heavy" commercial satellites could weigh as much as 11,000 lb. by 1998-2000, and as much as 15,000 lb. or more in the future.

Why are commercial payloads getting bigger? -- In contrast to U.S. government-funded satellites, commercial communication satellites are getting bigger, both volumetrically and in total launch mass.

U.S. government satellites may be getting smaller for several reasons: Funding limitations, technological progress, and heavy-lift launch costs. In contrast, commercial communication satellites are enjoying similar technological progress, but are still growing. There is probably no one black-or-white reason why this is happening. However, it is perhaps due to a preponderance of technical and financial factors that may continue to favor larger satellites over time. Moreover, commercial satellites operate in a burgeoning telecommunications environment that is not subject to a fixed and declining budget. A summary of various factors concerning commercial satellite mass growth as discussed by the working group are outlined below:

- Factors Favoring Continued Mass Growth
  - New heavy-lift launch vehicles are becoming commercially available
  - Larger satellites are more cost effective on a dollars per transponder basis
  - Commercial end user requirements are:
    -- Pushing satellites into the 10-20 kW power range, thus increasing mass of batteries, power conditioners, and thermal radiators
    -- Increasing the size of deployable reflectors
  - Orbital congestion and frequency reuse are leading to heavier multiple spot beam antennas or power hungry phased arrays
  - Onboard processing and satellite cross links may drive mass growth in some cases
- Factors Favoring Mass Growth Stabilization
  - Larger satellites cost more and expose operators, insurers and financiers to more risk
  - Satellite manufacturers compete to provide the lowest cost solution to their customer's requirements, often at lowest possible satellite mass

- Electric propulsion for orbit raising could reduce launch mass significantly
- Availability of dual launch capability may create a price advantage for mid-range satellites

Methodology and Calculations

Basis of Figure 3.1 -- The forecasts for each payload market segment (MLV, ILV and HLV) shown in Figure 3.1 are based on the average of all six comprehensive forecasts supplied for each segment. This results in three separate payload mass distribution forecasts for each payload mass category. The three separate forecasts are then added together to form the comprehensive payload mass distribution model.

For example, in 2002, estimates of the number of MLV payloads to be launched in that year are calculated accordingly: (4 +3+3+1+4+3)/6 = 3. The ILV and HLV forecasts are calculated in the same way for each year and then all three forecasts are added together to complete the total mission model.

Basis of Figure 3.2 -- The forecasts involving average mass distribution as a percent of total market are based on a year-by-year percentage of each member's respective mission model for each market segment. The resulting estimates are then averaged together and plotted as a percentage of the total market.

For example, in 2002, working group member A predicts there will be 3 medium, 20 intermediate, and 12 heavy payloads launched that year for a total of 35 payloads. These respectively represent 9%, 57% and 34% of member A's total market forecast for that year. This process is repeated for members B through F across the forecast period. The results are then added together and divided by 6 to form the working group's average.

New Inputs

As part of COMSTAC's expanded efforts to include as many industrial participants as possible in developing this mission model, the working group received two new important forecasts. Both came from outside the U.S. One was from a satellite manufacturer, the other from a satellite operator.

The Technology & Innovation Working Group hereby summarizes and incorporates their forecasts for reference as follows:

Table A.1. International Inputs to 1997 COMSTAC Commercial GTO Mission Model

GTO Forecast A

	1999	2000	2001	2002	2003	2004
ILV	100%	80%	60%	40%	20%	20%
HLV	0%	20%	40%	60%	80%	80%

GTO Forecast B

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
MLV	0%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
ILV	94%	88%	83%	81%	78%	78%	78%	78%	80%	81%	81%	81%
HLV	6%	9%	13%	16%	19%	19%	19%	19%	17%	16%	16%	16%

In terms of mass growth, Forecast A was somewhat more aggressive than the most aggressive U.S. estimate. Likewise, Forecast B was somewhat less aggressive than the least aggressive U.S. estimate, but very close to the U.S. average in terms of total number of payloads to be launched.

As is our practice, the individual names associated with each forecast are kept confidential. Perhaps as additional forecasts are received in future years, we can include them as a separate and more comprehensive supplement in the report.

References

A1. COMSTAC Report, "Commercial Space Launch Systems Requirements - 28 April 1993", Office of Commercial Space Transportation, U.S. Department of Transportation, Washington, D.C.

A2. COMSTAC Report, "Commercial Spacecraft Mission Model Update - February 1994", Office of Commercial Space Transportation, U.S. Department of Transportation, Washington, D.C.

A3. COMSTAC Report, "Commercial Spacecraft Mission Model Update - 18 May 1995", Office of Commercial Space Transportation, U.S. Department of Transportation, Washington, D.C.

A4. COMSTAC Report, "Commercial Spacecraft Mission Model Update - 25 July 1996", Office of Commercial Space Transportation, U.S. Department of Transportation/Federal Aviation Administration, Washington, D.C.

A5. COMSTAC Report, "Commercial Space Launch System Requirements - 25 July 1996", U.S. Department of Transportation/Federal Aviation Administration, Washington, D.C.

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MAY 1997

APPENDIX B
1997 - 1999 NEAR TERM MISSION MODEL

Commercial Space Transportation Advisory Committee (COMSTAC)
Office of the Associate Administrator for Commercial Space Transportation
Federal Aviation Administration
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1997 Mission Model - Near Term

Near Term Payload Launch Demand Forecast 1997 through 1999: A summary of the near-term 1997-1999 mission model individually identified by name is presented in Appendix B. The table is divided into addressable commercial GTO spacecraft and non-commercial spacecraft that will potentially utilize the same commercial launch systems. The non-commercial spacecraft forecast includes payloads captive to specific launch systems. U.S. spacecraft manufacturers have recently started to enter this market, and there is speculation that the launch service segment of this market may eventually open to U.S. competition as well, perhaps beyond 2000. In the period through 1998, most launch procurement decisions have been made and the launch vehicle manifests have been established. Over this time period, satellite lead times are striving for 12-18 month delivery cycles, while launch vehicles deliveries remain closer to 24 months. Therefore, pressure continues for launch vehicle manufacturers to compress production and/or cycle times.

Note, however, that even in this near-term period complete unanimity was not reached due to differences in opinions on outcomes of expected demand including effects of double booking, program delays, etc. Therefore, the ground rules that were adopted to arrive at the forecast presented are stated below:

- Published manifests of the launch service providers were used unless a failure event or other recognizable event has caused a delay.
- Where manifests do not exist, or where an event which caused a delay has occurred, the subgroup relied on the data source within the subgroup that most likely had the superior knowledge. For example, the McDonnell Douglas representative could modify the published manifest data for the Delta II, or a spacecraft manufacturer with knowledge of launch dates on a non-U.S. launch system could provide the most up-to-date information on that system.
- Where the spacecraft has been ordered, but the launch company has not been selected, the date the operator contracted for satellite readiness was used.
- Plans of existing satellite service operators were used as available.
- Plans of new or potential operators (i.e. growth in demand) were subject to the judgment of the individual subgroup members. It is this factor that led to the dispersions around the average forecast beginning in the year 1999.

Payload Mass Definitions: The payload mass class definitions have been further refined since 1996. The new HLV mass class definition adopted in 1996 for payloads heavier than 9,000 pounds now applies to payloads to be launched in 1998 and beyond, consistent with the planned first launches of U.S. vehicles whose performance will greatly exceed the previous 8,000 pound threshold. This definition has also been clarified to refer specifically to launch vehicle *performance* (vs. launch mass) greater than or equal to 9,000 pounds to a nominal geosynchronous transfer orbit of 200 nm x GEO at an inclination of 28° north.

In practice, this keeps the HLV mass category definition consistent with a performance greater than that available from a U.S. launchers from a U.S. launch site without a degradation in required satellite lifetime. This definition is also consistent with the less than 8,000 pound performance historically available from U.S. launchers since 1988, as reflected in the historical tables in previous COMSTAC commercial spacecraft mission models (References A2, A3, and A4).

This appendix contains the following tables:

Table B.1. 1997-1999 COMSTAC Commercial GTO Mission Model - This is the consensus near-term mission model of the worldwide addressable commercial spacecraft launch demand to GTO. The mission model is provided annually by specific launch system, if known.

Table B.2. 1997-1999 Mission Not Included in COMSTAC Commercial GTO Mission Model - Uses GTO Launch Sites - This is the consensus near-term mission model of worldwide non-addressable launch demand that utilize the same launch systems and launch sites used for addressable commercial GTO mission model of Table B.1.

Table B.3. 1997-1999 Missions Not Included in COMSTAC Commercial GTO Mission Model - Uses Non-GTO Launch Site - This is the consensus near-term mission model of worldwide non-addressable launch demand that utilize the same launch systems used for addressable commercial GTO mission model of Table B.1, but at launch sites not used for addressable commercial launches to GTO.

Table B.1. 1997-1999 COMSTAC Commercial GTO Missio

		1996	1997	1998	1999	TOTAL	3 Year Average Rate
TOTAL =		26	33	39	44	116	38.7
Arianespace		14	16	17	6	39	13.0
	HLV	1 Intelsat 707A 1 Intelsat 709	1 Intelsat 801 1 Intelsat 802 1 Intelsat 803 1 US-GE Americom GE2 1 US-PAS 6	1 Laos-LStar 1 1 Laos-LStar 2			
	ILV	1 Arabsat 2A 1 Arabsat 2B 1 Canada-TMI MSat M1 1 Indonesia-Palapa C2 1 Italy-Italsat 2 1 Japan-NStar CS-B 1 Turkey-Turksat 1C 1 US-Echo Star 2 1 US-PAS 3R 0 Argentina-Nahuel 3 0 India-Insat 2D 0 Thailand-Thaicom 3 0 US-PAS DTH 6	1 Argentina-Nahuel 3 1 Brazil-Brazilsat B3 1 Egypt-Nilesat 1 1 Eutelsat-Hotbird 3 1 Eutelsat-Hotbird 4 1 India-Insat 2D 1 Inmarsat 304 1 Sweden-Sirius 2 1 Thailand-Thaicom 3	1 Eutelsat W2 1 Eutelsat-Hotbird 5 1 HSC Mfg-Unnamed 1 HSC Mfg-Unnamed 1 India-Insat 2E 1 Inmarsat 305 1 Luxembourg-SES Astra 2B 1 Singapore-ST 1 1 Intelsat 804 1 US-World Space 1 1 US-World Space 2 1 US-PAS 7 1 Japan-JCSat 5 (1R)	1 HSC Mfg-Unnamed 1 US-World Space 3 1 Korea-Koreasat 3 1 Intelsat KTV 1 1 Eutelsat W3		
	MLV	1 Israel-Amos 1 1 Malaysia-MeaSat 1 1 Malaysia-MeaSat 2	1 Indonesia-Indostar 1 1 Japan-BSat 1A	1 Japan-BSat 1B 1 UK-Skynet 4E	1 UK-Skynet 4F		
Atlas		5	6	5	0	11	3.7
	HLV	1 Indonesia-Palapa C1	1 Japan-SCC-Superbird C				
	ILV	1 Eutelsat-Hotbird 2 1 Inmarsat 301 1 Inmarsat 303 1 US-GE Americom GE1	1 US-TCI Tempo FM 2 1 Japan-JSat 4 1 US-Echostar 3/DBSC 1 1 US-GE Americom GE 3 1 Hughes-Galaxy 8I	1 Japan-JCSat 6 1 US-Sky 2 1 Eutelsat W1 1 Intelsat 805A 1 Intelsat 806A			
Delta		2	2	2	0	4	1.3
	ILV			1 US-Hughes Galaxy 10 1 US-Hughes Orion 3			
	MLV	1 KoreaSat 2 1 US-Hughes Galaxy 9	1 Norway-Thor 2A 1 UK-Skynet 4D				
Long March		3	2	1	0	3	1.0
	HLV	1 Intelsat 708A	1 Philippine-Mabuhay 1				
	ILV		1 China-APStar 2R	1 Argentina-Nahuel 4			
	MLV	1 China-APStar 1A 1 China-Chinasat 7					
Proton		2	5	4	1	10	3.3
	HLV		1 China-Asiasat 3 1 Luxembourg-SES Astra 1G 1 US-PAS 5 1 US-AT&T Telstar 5	1 Indonesia-ACes 1	1 US-GE Americom GE4		
	ILV	1 Inmarsat 302 1 Luxembourg-SES Astra 1F 0 US-TMI TempoSat 1	1 US-Sky 1	1 US-Echostar 4 1 US-PAS 8 1 US-TCI Tempo FM 1			
Zenit		0	0	1	1	2	0.7
	HLV			1 US-Hughes Galaxy 11	1 US-Hughes Spaceway 01		
	ILV						
TBD		0	2	9	36	47	15.7
	HLV		1 Luxembourg-SES Astra 2A	1 Luxembourg-SES Astra 1H	NO 1 Indonesia-ACes 2 1 Indonesia-M2A 1 NO 1 Indonesia-M2A 2 1 US-Hughes Galaxy 13 1 US-Hughes Galaxy 14 NO 1 US-PAS 9 1 •Saudi Arabia-Satphone 1		
	ILV		1 Thailand-Thaicom 4	1 Arabsat 2C 1 Canada-Telesat DTH 1 1 China-Chinasat 8 1 Indonesia-Palapa X 1 Indonesia-Satelit Telkom 1 1 US-AT&T Telstar 6 1 US-Loral Mfg-Unnamed 1 •Pakistan-Paksat 1	NO 1 Canada-Anik F1 NO 1 Canada-Telesat DTH 2 NO 1 China-APStar 3 NO 1 China-Asiasat 4 NO 1 Eutelsat W4 NO 1 Germany-DFS FO NO 1 Indonesia-Palapa DTH NO 1 Insat 3A NO 1 Intelsat KTV 2 NO 1 Japan-JCSat 07 NO 1 Japan-Superbird B2R NO 1 Norway-Thor 2B NO 1 Spain-Hispasat 1C NO 1 Sweden-Sirius 3 NO 1 Thailand-Thaicom 5 NO 1 US-AT&T Telstar 7 NO 1 US-Echostar FSS 1 NO 1 US-Hughes DBS 4 NO 1 US-Hughes Galaxy 12 1 US-Orion 2 NO 3 zAttrition-1997 Relaunches NO 1 •Egypt-Nilesat 2 NO 1 •Eutelsat Hotbird 06 NO 1 •Turkey-Turksat 2A NO 1 •US-SAT CD Radio 1		
	MLV				NO 1 Indonesia-Palapa B6 1 •Israel-Amos 1B		

LEGEND

NO = Spacecraft not ordered

• = No concensus

Table B.2. 1997-1999 Missions Not Included in COMSTAC Commercial GTO Mission Model - Uses GTO Launch Sites

	1996	1997	1998	1999	TOTAL	3 Year Average Rate
TOTAL =	20	25	25	34	84	28.0
Ariane	5	2	0	4	6	2.0
	4 ESA-European Cluster 0 ESA-Recovery Module 1 France-Telecom 2D	1 Eumetsat-Meteosat(MOP 4) 7 1 ESA-Recovery Module		1 ESA-Envisat 1 France-Helios 1B 1 France-Spot 4 1 Italy-Sicral 1	6	
Atlas	2	2	3	6	11	3.7
	1 ESA-SAX-Astronomy 1 US-N-UHF/EHF F07	1 US-AF-DSCS 3-06 1 US-NASA/NOAA-Goes K	1 ICO #01 1 US-N-UHF/EHF F08 1 US-N-UHF/EHF F09	1 US-AF-Call UP MLV-10 1 US-AF-Call UP MLV-11 1 US-AF-DSCS 3-07 1 US-N-UHF/EHF F10 1 US-NASA-TDRSS 1 US-NASA/NOAA-Goes L	11	
Delta	6	7	9	11	27	9.0
	1 US-AF-GPS 2-Block 2-07 1 US-AF-GPS 2-Block 2-08 1 US-AF-GPS 2-Block 2-10 1 US-NASA-Mars Global Surv 1 US-NASA-MESUR Pathfinder 1 US-NASA-NEAR	1 GlobalStar 1 - 04 1 GlobalStar 2 - 04 1 US-AF-GPS 2-Block 2-09 1 US-AF-GPS 2R-01 1 US-AF-GPS 2R-02 1 US-AF-GPS 2R-03 1 US-NASA-ACE	1 ICO 04 1 ICO 05 1 US-AF-GPS 2R-04 1 US-AF-GPS 2R-05 1 US-AF-GPS 2R-06 1 US-AF-GPS 2R-07 1 US-AF-GPS 2R-08 1 US-NASA-FUSE 1 US-NASA-Mars Orbiter-2	1 ICO 07 1 ICO 10 1 ICO 12 1 US-AF-GPS 2R-09 1 US-AF-GPS 2R-10 1 US-AF-GPS 2R-11 1 US-AF-GPS 2R-12 1 US-AF-EO-1/SAC C 1 US-NASA-Jason/TIMED 1 US-NASA-Mars Lander-1 1 US-NASA-Stardust	27	
Japan	1	3	0	2	5	1.7
	1 Japan-ADEOS	1 Japan-Comets 1 Japan-ETS-7 1 Japan-TRMM		1 Japan-ETS 9 1 Japan-MutiFunctTrans Sat		
Long March	0	4	4	4	12	4.0
	0 China-DFH 302 0 China-Fengyun 2A	1 China-DFH 302 1 China-Sinosat 1 1 China-Fen Yun 2 1 China-Chinastar	1 China-DFH 303 1 China-DFH 401 1 China-Sinosat 2 1 China-Zhongwei 1	1 China-APMT 1 1 China-APMT 2 1 China-DFH 402 1 China-Zhongwei 2		
Proton	6	7	9	7	23	7.7
	1 Russia-Express 02 1 Russia-Gorizont 31 1 Russia-Gorizont 32 1 Russia-Raduga 0 Russia-Ekran 1 Russia-Mir.Priorda 1 Mars Mission	1 Iridium 01 - 7 1 Iridium 02 - 7 1 Russia-Express 03 1 Russia-Gorizont 33 1 Russia-Gorizont 34 2 Domestic Requirements	1 Iridium 03 - 7 1 Russia-Express 04 1 Russia-Express 05 1 Russia-Gorizont 35 2 Russia-Yamal 1 Russia-GALS-3 2 Domestic Requirements	1 ICO #02 1 ICO #03 1 Russia-Express 06 1 Russia-Express 07 1 Russia-Express 08 2 Domestic Requirements		
TBD						

Note: LEO/MEO Missions count multiple spacecraft as single requirement missions.

Legend:

Arabsat 2 — Launch Services accellerated from 1997 to 1996

1996 — Launch Services postponed from 1996 to 1997 or cancelled

Name — Launch Mission Failed

Name — Commercial LEO or MEO Launch Mission - Usually involves multiple spacecraft

•Name — Spacecraft not included in all members models

1 — Spacecraft provides commercial communication services, possibly involves western manufacturer, captive launch today.

	1996	1997	1998	1999	TOTAL	3 Year Average Rate
TOTAL SPACECRAFT LAUNCHED=	46	58	64	78	200	66.7
Additional Spacecraft in Leo Constelation clusters counted as one	0	18	6	26	50	16.7

Table B.3. 1997-1999 Missions Not Included in COMSTAC Commercial GTO Mission Model - Uses Non-GTO Launch Site

		1996	1997	1998	1999	TOTAL	3 Year Average Rate
United States-Florida							
TOTAL =		24	42	40	40	122	40.7
STS							
	RLV						
Taurus							
	Small						
Titan							
	HLV		1 US-AF T4 (DoD) 1 US-AF T4 (DoD) 1 US-AF T4 (DoD)	1 US-AF T4 (DoD) 1 US-AF T4 (DoD)	1 US-AF T4 (DoD) 1 US-AF T4 (DoD) 1 US-AF T4 (DoD)		
United States-Vandenberg Test Center							
Atlas							
	ILV		1 US-AF (DMSP)	1 US-NASA-EOS AM	1 US-AF (DMSP)		
Delta							
	MLV	0 Iridium 01 - 3 1 US-AF-Midcourse Space Exp 1 US-NASA-Polar	1 Iridium 01 - 3 1 Iridium 02 - 5 1 Iridium 03 - 5 1 Iridium 04 - 5 1 Iridium 05 - 5 1 Iridium 06 - 5 1 US-AF-Argos P91	1 Iridium 07 - 5 1 Iridium 08 - 5 1 Iridium 09 - 03 1 US-NASA-Landsat 7	1 Iridium 10 - 03 1 Iridium 11 - 03 1 Iridium 12 - 03		
LMLV							
	Small						
Taurus							
	Small						
Titan							
	HLV		1 US-NOAA K	1 US-NOAA L 1 US-AF T4 (DoD)	1 US-NOAA M 1 US-AF T4 (DoD)		
China-Taiyuan/Jiyuan							
Long March							
	ILV	1 China-FSW 2-03					
	MLV		1 China-FSW 1C 1 Iridium 01 - 2 1 Iridium 01 - 3	1 Brazil-CBERS 1 1 Iridium 02 - 2 1 Iridium 03 - 2	1 Iridium 04 - 2 1 Iridium 05 - 2 1 Iridium 06 - 2 1 Iridium 07 - 2 1 Iridium 08 - 2		
Russia-Baikonur							
Molniya							
	MLV						
Tskylon							
	MLV	1 Russia-Domestic	1 Russia-Domestic	1 Russia-Domestic	1 Russia-Domestic		
Soyuz							
	HLV	2 Russia-MIR Manned 3 Russia-MIR Supply 1 Russia-Domestic	1 GlobalStar 01 - 3 1 GlobalStar 02 - 3 2 Russia-MIR Manned 4 Russia-MIR Supply 2 Russia-Domestic	1 GlobalStar 03 - 3 2 Russia-MIR Manned 4 Russia-MIR Supply 2 Russia-Domestic	2 Russia-MIR Manned 4 Russia-MIR Supply 2 Russia-Domestic		
Zenit							
	HLV	1 Russia-Domestic	1 Russia-Domestic	1 GlobalStar 01 - 12 1 GlobalStar 02 - 12 1 GlobalStar 03 - 12 1 Russia-Domestic	1 Russia-Domestic b Russia-Domestic		
Russia-Plesetsk							
Cosmos							
	MLV	4 Russia-Domestic	4 Russia-Domestic	3 Russia-Domestic	3 Russia-Domestic		
Molniya							
	MLV	1 Czech-Magion 5 4 Russia-Domestic	4 Russia-Domestic	4 Russia-Domestic	4 Russia-Domestic		
Soyuz							
	HLV	2 Russia-Domestic 1 Russia-Domestic	3 Russia-Domestic	2 Russia-Domestic	2 Russia-Domestic		
Start							
	Small		1 Russia-Domestic	2 Foreign-Commercial 1 Russia-Domestic	3 Foreign-Commercial 1 Russia-Domestic		
Tskylon							
	MLV		1 Russia-Domestic		1 Russia-Domestic		
INDIA							
PSLV/GSLV							
		1 India-IRS P3	2 India-Domestic	2 India-Domestic	2 India-Domestic		
Commercial GTO COMSTAC =		26	33	39	44	116	38.7
Non COMSTAC GTO Site =		20	25	25	34	84	28.0
Non GTO Sites =		24	42	40	40	122	40.7
TOTAL =		70	100	104	118	322	107.3

Report of the
COMSTAC Technology & Innovation Working Group

COMMERCIAL SPACECRAFT MISSION MODEL UPDATE

MAY 1997

APPENDIX C
1988 - 1996 MISSION MODEL - HISTORY

Commercial Space Transportation Advisory Committee (COMSTAC)
Office of the Associate Administrator for Commercial Space Transportation
Federal Aviation Administration
U.S. Department of Transportation

1988-1996 Mission Model - History

This appendix contains the following tables:

Table C.1. 1997 Mission Model History - Commercial GTO Mission Model - This is the history of the worldwide addressable commercial spacecraft launches to GTO during the period 1988 to 1996.

Table C.2. 1997 Mission Model History - Not Included in Commercial GTO Mission Model - Utilized Commercial Launch Service Vehicles/Sites - This is the history of the worldwide non-addressable launches during the period 1988 to 1996 that used same vehicles and launch sites as addressable commercial GTO mission of Table C.1.

Table C.3. 1997 Mission Model History - Not Included in COMSTAC Commercial GTO Mission Model - Used United States Non-GTO Launch Sites - This is the history of the worldwide non-addressable launches during the period 1988 to 1996 that used domestic launch sites not used for addressable commercial launches to GTO.

Table C.4. 1997 Mission Model History - Not Included in COMSTAC Commercial GTO Mission Model - Used Foreign Non-GTO Launch Sites - This is the history of the worldwide non-addressable launches during the period 1988 to 1996 that used foreign launch sites not used for addressable commercial launches to GTO.

Table C.5. 1997 Mission Model History - Summary - This table summarizes the history of commercial and non-commercial launches from 1988 to 1996 as presented in Tables C.1 to C.4.

Table C.1. 1997 Mission Model History - Commercial GTO Mission Model

	1988	1989	1990	1991	1992
TOTAL =	9	8	18	15	17
Arianespace	9	7	9	9	9
HLV		1 Intelsat 602 1 Japan-JSSI JCSat1 1 Japan-SCC Superbird A	1 Japan-SCC Superbird B 1 US-Comsat SBS 6	1 Canada-Telesat Anik B1 1 Canada-Telesat Anik B2 1 Intelsat 601 1 Intelsat 605 1 Luxembourg-SES Astra 1B	1 US-Hughes Galaxy 7 1 1 Japan-SCC Superbird B 1 1 Japan-SCC Superbird A 1 1 1
ILV	1 Intelsat 513A 1 Luxembourg-SES Astra 1	1 Germany-DBP TVSat 2 1 Intelsat 515A 1 Sweden-SSC Tele X	1 Eutelsat 201	1 Eutelsat 202 1 Italy-Italsat 1	1 Eutelsat 204 1 1 India-Insat 2A 1 1 Spain-Hispasat 1A
MLV	1 Eutelsat 105 1 India-Insat 1C 1 UK-Skynet 4B 1 US-Comsat SBS 5 1 US-GTE GStar 3 1 US-GTE Spacenet 3R 1 US-Panamsat 1	1 Germany-DBP DFS 1	1 Germany-DBP DFS 2 1 Japan-Nasda BS 2X 1 UK-Skynet 4C 1 US-GE Satcom C1 1 US-GTE GStar 4 1 US-Hughes Galaxy 6	1 Inmarsat 2 F3 1 US-OSC-Orbcom	1 US-GE Satcom C3 1 1 Arabsat 1C 1 Inmarsat 2 F4
Atlas	0	0	0	2	3
HLV					
ILV				1 Eutelsat 203	1 Intelsat K1 1
MLV				1 Japan-NHK BS 3H	1 US-Hughes Galaxy 1R 1 US-Hughes Galaxy 5
Delta	0	1	4	4	3
MLV		1 UK-BSB/Marcopolo 1	1 India-Insat 1D 1 Indonesia-Palapa B03 1 Inmarsat 2 F1 1 UK-BSB/Marcopolo 2	1 Inmarsat 2 F2 1 NATO 4A 1 US-GE Satcom(Aurora) C5 1 US-GTE Spacenet (ACS 2) 4	1 Germany-DBP DFS 3 1 1 Indonesia-Palapa B4 5 US-GE Satcom C4
Titan 3	0	0	4	0	0
HLV			1 Intelsat 603 1 Intelsat 604		
ILV			1 Japan-JCSat 2		
MLV			1 UK-Skynet 4A		
Long March	0	0	1	0	2
HLV					
ILV					1 Australia-Optus B1 Australia-Optus B2 1
MLV			1 China-Asiasat 1		
Proton	0	0	0	0	0
HLV					
ILV					
MLV					

1993	1994	1995	1996	TOTAL	Average Rate
10	18	18	26	139	15.4
8	12	9	14	86	9.6
Intelsat 701	1 Intelsat 702	1 Intelsat 706A	1 Intelsat 707A		
Luxembourg-SES Astra 1C		1 Japan-NStar CS-4A	1 Intelsat 709		
Mexico-Solidaridad 1					
US-Hughes DBS 1					
US-Hughes Galaxy 4					
India-Insat 2B	1 Brazil-Brazilsat B1	1 Brazil-Brazilsat B2	1 Arabsat 2A		
Spain-Hispasat 1B	1 Eutelsat-II F5	1 Eutelsat 206 Hotbird 1	1 Arabsat 2B		
	1 Luxembourg-SES Astra 1D	India-Insat 2C	1 Canada-TMI MSat M1		
	1 Mexico-Solidaridad 2	1 Luxembourg-SES Astra 1E	Indonesia-Palapa C2		
	1 Turkey-Turksat 1A	1 US-AT&T Telstar 402R	1 Italy-Italsat 2		
	1 Turkey-Turksat 1B	1 US-Hughes DBS 3	1 Japan-NStar CS-B		
	1 US-AT&T Telstar 402	1 US-PAS 4	1 Turkey-Turksat 1C		
	1 US-Panamsat 2		1 US-Echo Star 2		
	1 US-Panamsat 3		1 US-PAS 3R		
Thailand-Thaicom 1	1 Thailand-Thaicom 2		1 Israel-Amos 1		
	1 Japan-NHK BS 3N		1 Malaysia-MeaSat 1		
			1 Malaysia-MeaSat 2		
1	3	5	5	19	2.1
	1 Intelsat 703	1 Intelsat 704			
		1 Intelsat 705			
US-AT&T Telstar 401	1 US-Hughes DBS 2	1 US-Hughes Galaxy 3R	1 Eutelsat-Hotbird 2		
	1 US-Orion 1	1 Japan-JSat 3	1 Indonesia-Palapa C1		
			1 Inmarsat 301		
			1 Inmarsat 303		
		1 US-AMSC MSat M2	1 US-GE Americom GE1		
1	1	1	2	17	1.9
NATO 4B	1 US-Hughes Galaxy1R/2	1 KoreaSat 1	1 KoreaSat 2		
			1 US-Hughes Galaxy 9		
0	0	0	0	4	0.4
0	2	3	3	11	1.2
			1 Intelsat 708A		
	1 Australia-Optus B3	1 China-APStar 2			
		1 China-Asiasat 2			
		1 US-Echo Star 1			
			1 China-APStar 1A		
	1 China-APStar 1		1 China-Chinasat 7		
0	0	0	2	2	0.2
			1 Inmarsat 302		
			1 Luxembourg-SES Astra 1F		

Table C.2. 1997 Mission Model History - Not Included in Commercial GTO Mission M

	1988	1989	1990	1991	1992
TOTAL =	21	23	25	15	19
Arianespace	3	3	2	3	2
	1 ESA-Meteosat 3	1 ESA-Olympus 1	1 France-Spot 2	1 ESA-ERS 1	1 France-Telecom 2B 1
	1 France-TDF 1	1 ESA-Hipparcos	1 France-TDF 2	1 ESA-Meteosat 5	1 NASA-TOPEX 1
	1 France-Telecom 1C	1 ESA-Meteosat 4		1 France-Telecom 2A	
Atlas	0	1	1	0	2
		1 US Navy Fltsatcom 8	1 US-NASA/AF CRESS		1 USAF-DSCS 3 B01 1
					1 USAF-DSCS 3 B02 1
					1
					1
Delta	1	7	7	1	6
	1 US-AF DM43-ThrustVe	1 US-AF Cos Bkgnd Exp	1 Germany-Rosat-X Ray	1 US-AF GPS-Navstar 11	1 US-AF GPS Navstar 121
		1 US-AF Delta Star	1 US-AF GPS Navstar 06		1 US-AF GPS Navstar 131
		1 US-AF GPS Navstar 01	1 US-AF GPS Navstar 07		1 US-AF GPS Navstar 141
		1 US-AF GPS Navstar 02	1 US-AF GPS Navstar 08		1 US-AF GPS Navstar 151
		1 US-AF GPS Navstar 03	1 US-AF GPS Navstar 09		1 US-AF GPS Navstar 161
		1 US-AF GPS Navstar 04	1 US-AF GPS Navstar 10		1 US-AF GPS Navstar 171
		1 US-AF GPS Navstar 05	1 US-AF RelayMirrorExp		
Japan	2	1	2	1	1
	1 Japan-CS 3A	1 Japan-GMS 4	1 Japan-BS 3A	1 Japan-BS 3B	1 Japan-JERS
	1 Japan-CS 3B		1 Japan-MOS 1B		
Long March	2	0	2	1	0
	1 China-DDH 201		1 China-DFH 203	1 China-DFH 204	
	1 China-DFH 202		1 Pakistan-Badar 1		
Proton	13	11	11	9	8
Glonass launches counted as 1	1 Ekran 18	1 Gorizont 17	1 Ekran	1 Gorizont 23	1 Ekran 20 1
	1 Ekran 19	1 Gorizont 18	1 Gorizont 20	1 Gorizont 24	1 Gorizont 25 1
	1 Gorizont	1 Gorizont 19	1 Gorizont 21	1 Raduga 27	1 Gorizont 26 1
	1 Gorizont 15	1 Raduga 1-1	1 Gorizont 22	1 Raduga 28	1 Gorizont 27 1
	1 Gorizont 16	1 Raduga 23	1 Raduga 1-2		1
	1 Raduga 11	1 Raduga 24	1 Raduga 25		
	1 Russia-Cosmos/Glonass		1 Raduga 26		
	6 Russia-Mil/Science	5 Russia-Mil/Science	4 Russia-Mil/Science	5 Russia-Mil/Science	4 Russia-Mil/Science 1

Legend: Spacecraft failed to reach operating status as planned

Spacecraft partially failed after achieving operating status

TOTAL SPACECRAFT LAUNCHED=	30	31	43	30	36
FAILURES	3	1	4	2	2
	10.0%	3.2%	9.3%	6.7%	5.6%

odel - Utilized Commercial Launch Service Vehicles/Sites

1993	1994	1995	1996	TOTAL	Average Rate
18	21	20	20	182	20.2
2	0	4	5	24	2.7
Eumetsat-Meteosat 6		1 ESA-ERS 2	4 ESA-European Cluster		
France-Spot 3		1 ESA-ISO	1 France-Telecom 2D		
		1 France-Helios 1			
		1 France-Telecom 2C			
4	2	6	2	18	2.0
US-AF DSCS 3-03	1 US-Navy UHF F03	1 ESA-SOHO	1 ESA-SAX-Astronomy		
US-AF DSCS 3-04	1 US-NOAA Goes 8	1 US-AF DSCS 3-05	1 US-N-UHF/EHF F07		
USN-UHF F01		1 US-NASA/NOAA Goes J			
USN-UHF F02		1 US-Navy UHF/EHF F04			
		1 US-Navy UHF/EHF F05			
		1 US-Navy UHF/EHF F06			
6	2	1	6	37	4.1
US-AF GPS 2 Blk 2 01	1 NASA-Wind	1 US-NASA XTE	1 US-AF-GPS 2-Block 2-07		
US-AF GPS 2 Blk 2 02	1 US-AF GPS 2 Block 2 06		1 US-AF-GPS 2-Block 2-08		
US-AF GPS 2 Blk 2 03			1 US-AF-GPS 2-Block 2-10		
US-AF GPS 2 Blk 2 04			1 US-NASA-Mars Global Surv		
US-AF GPS 2 Blk 2 05			1 US-NASA-MESUR Pathfinder		
US-AF GPS Navstar 18			1 US-NASA-NEAR		
0	2	2	1	12	1.3
	1 Japan-ETS 6	1 Japan-GMS	1 Japan-ADEOS		
	1 Japan-OREX	1 Japan-SFU			
0	2	0	0	7	0.8
	1 China-DFH 301				
	1 China-SJ 4				
6	13	7	6	84	9.3
Gorizont	1 Express 01	1 GALS 2	1 Russia-Express 02		
Gorizont 28	1 GALS 1	1 Luch 1-1	1 Russia-Gorizont 31		
Gorizont 29-Rimsat	1 Gorizont 30-Rimsat		1 Russia-Gorizont 32		
Raduga 29	1 Luch 1		1 Russia-Raduga 33		
Raduga 30	1 Raduga 1-3				
	1 Raduga 31				
	1 Raduga 32		1 Russia-Mil/Science		
Russia-Mil/Science	6 Russia-Mil/Science	5 Russia-Mil/Science	1 Mars Mission		
28	39	38	46	321	35.7
4	5	1	5	27	3.0
14.3%	12.8%	2.6%	10.9%	8.4%	8.4%

Table C.3. 1997 Mission Model History - Not Included in COMSTAC Commercial GTO

	1988	1989	1990	1991	1992
TOTAL =	9	16	22	23	18
United States-Florida					
STS	4	11	11	10	13
RLV	1 US-STS-026 Discovery 1 US-NASA TDRS C 1 US-STS-027 Atlantis 1 US-DoD (Lacrosse)	1 US-STS-029 Discovery 1 US-NASA TDRS D 1 US-STS-030 Atlantis 1 US-NASA Magellan 1 US-STS-028 Columbia 1 US-DoD (Jumpseat) 1 US-DoD (Jumpseat) 1 US-STS-034 Atlantis 1 US-NASA Galileo 1 US-STS-033 Discovery 1 US-DoD (Magnum)	1 US-STS-032 Columbia 1 US-Navy Syncom IV-51 1 US-STS-036 Atlantis 1 US-DoD (KH-11A) 1 US-STS-031 Discovery 1 US-NASA Hubble 1 US-STS-041 Discovery 1 US-NASA Ulysses 1 US-STS-038 Atlantis 1 US-DoD (Magnum) 1 US-STS-035 Columbia	1 US-STS-037 Atlantis 1 US-NASA GRO 1 US-STS-039 Discovery 1 US-STS-040 Columbia 1 US-STS-043 Atlantis 1 US-NASA TDRS E 1 US-STS-048 Discovery 1 US-NASA UARS 1 US-STS-044 Atlantis 1 US-DoD (DSP)	1 US-STS-042 Discovery 1 US-STS-045 Atlantis 1 US-STS-049 Endeavour 1 US-STS-050 Columbia 1 US-STS-046 Atlantis 1 ESA-Eureka 1 US-NASA/Italy TSS 1 US-STS-047 Endeavour 1 US-STS-052 Columbia 1 US-NASA Lageos II 1 US-STS-053 Discovery 1 US-DoD (Jumpseat) 1 US-DoD (DSP)
Taurus	0	0	0	0	0
Small					
Titan	1	4	5	0	1
HLV	1 US-AF Titan 34D (Chatle	1 US-AF Titan 34D (Chatle 1 US-AF Titan 34D (DSCS) 1 US-AF Titan 34D (DSCS) 1 US-AF Titan 4 (DSP 14)	1 US-AF Titan 4 (DSP 15) 4 US-AF Titan 4 (NOSS)		1 US-NASA T3 Mars Observer
United States-Vandenberg Test Center					
Atlas	2	0	4	2	0
MLV	1 US-AF DMSP F09 1 US-NOAA 11		1 US-AF DMSP F10 3 US-AF Stacksat	1 US-AF DMSP F11 1 US-NOAA 12	1
Delta	0	0	0	0	2
MLV					1 Japan-Geotail 1 US-NASA EUVE
LMLV	0	0	0	0	0
Small					
Pegasus	0	0	2	7	0
Small			1 US-Pegsat 1 US-SECS	1 US-SARA 6 US-DARPA Sats	1 1 1
Taurus	0	0	0	0	0
Small					
Titan	2	1	0	4	2
HLV	1 US-AF T34D (KH-11)			1 US-AF T4 (Lacrosse) 3 US-AF T4 (NOSS)	1 US-AF T4 (KH-12) 2
MLV	1 US-AF T2 (Ferrett)	1 US-AF T2 (Ferrett)			1 US-AF T2 (DoD) 1 1

Legend:

- Spacecraft failed to reach operating status as planned
- Spacecraft partially failed after achieving operating status

Mission Model - Used UNITED STATES Non-GTO Launch Sites

1993	1994	1995	1996	TOTAL	%	Average Rate
17	18	19	20	162		18.0
9	7	9	9	83		9.2
US-STS-054 Endeavour	1 US-STS-060 Discovery	1 US-STS-063 Discovery	1 US-STS-072 Endeavour			
US-NASA TDRS F	1 US-STS-062 Columbia	1 US-STS-067 Endeavour	1 US-STS-075 Columbia			
US-STS-056 Discovery	1 US-STS-059 Endeavour	1 US-STS-071 Atlantis	1 US-NASA/Italy TSS			
US-STS-055 Columbia	1 US-STS-065 Columbia	1 US-STS-070 Discovery	1 US-STS-076 Atlantis			
US-STS-057 Endeavour	1 US-STS-064 Discovery	1 US-NASA TDRS G	1 US-STS-077 Endeavour			
US-STS-051 Discovery	1 US-STS-068 Endeavour	1 US-STS-069 Endeavour	1 US-STS-078 Columbia			
US-NASA ACTS	1 US-STS-066 Atlantis	1 US-NASA WSF 2	1 US-STS-079 Atlantis			
US-STS-058 Columbia		1 US-STS-073 Columbia	1 US-STS-080 Columbia			
US-STS-060 Discovery		1 US-STS-074 Atlantis	1 US-NASA WSF 3			
0	0	0	0	0		0.0
0	4	4	3	22		2.4
	1 US-AF T4 (Adv Jumpseat)	1 US-AF T4 (Adv Jumpseat)	1 US-AF T4 (Adv Jumpseat)			
	1 US-AF T4 (DoD)	1 US-AF T4 (DoD)	1 US-AF T4 (DoD)			
	1 US-AF T4 (DSP 17)	1 US-AF T4 (DoD)	1 US-AF T4 (DoD)			
	1 US-AF T4 (Milstar 1)	1 US-AF T4 (Milstar 2)				
1	2	1	0	12		1.3
US-NOAA 13	1 US-AF DMSP F12	1 US-AF DMSP F13				
	1 US-NOAA 14					
0	0	1	2	5		0.6
		1 Canada-Radarsat	1 US-AF-Midcourse Space Exp			
			1 US-NASA-Polar			
0	0	1	0	1		0.1
		1 US-GEMStar (Vita Sat)				
3	3	3	5	23		2.6
Brazil-SCD	1 US-APEX	1 US-Orbcomm	1 US-FAST			
US-Alexis	1 US-Step 1	1 US-Orbcomm	1 US-MSTI 3			
US-Orbcomm/CDS	1 US-Step 2 (P-91)	1 US-Step 3 (P92-2)	1 US-REX II			
			1 US-TOMS CP			
			1 US-SAC-B/HETE			
0	1	0	0	1		0.1
	1 US-STEP/TAOS					
4	1	0	1	15		1.7
US-AF T4 (NOSS)			1 US-AF T4			
US-NASA T2 (Landsat 6)	1 US-NASA T2 (Clementine)					
US-NOAA 14						

Table C.4. 1997 Mission Model History - Not Included in COMSTAC Commercial GTO

		1988	1989	1990	1991	1992
TOTAL =		80	63	83	52	50
China-Taiyuan/Jiyuan						
Long March		2	0	2	0	2
	ILV					
	MLV	1 China-FSW 1-01 1 China-FenYun 1A		1 China-FenYun 2 1 China-FSW 1-02		1 China-FSW 1-03 1 China-FSW 1-04
Russia-Baikonur						
Molniya		1	1	0	0	0
	MLV	1 Russia-Domestic	1 Russia-Domestic			
Tskylon		3	3	5	1	0
	MLV	3 Russia-Domestic	3 Russia-Domestic	5 Russia-Domestic	1 Russia-Domestic	
Soyuz		22	12	14	13	11
	HLV	3 Russia-MIR Manned 6 Russia-MIR Supply 12 Russia-Domestic 1 Russia-Domestic	1 Russia-MIR Manned 4 Russia-MIR Supply 7 Russia-Domestic	3 Russia-MIR Manned 4 Russia-MIR Supply 7 Russia-Domestic	2 Russia-MIR Manned 5 Russia-MIR Supply 6 Russia-Domestic	2 Russia-MIR Manned 5 Russia-MIR Supply 4 Russia-Domestic
Zenit		2	0	2	1	3
	HLV	1 Russia-Cosmos 1943 1 Russia-Cosmos 1980		1 Russia-Cosmos 2082 1 Russia-Cosmos xxxx	1 Russia-Cosmos xxxx	1 Russia-Cosmos xxxx 1 Russia-Cosmos 2219 1 Russia-Cosmos 2227
Russia-Plesetsk						
Cosmos		7	9	9	12	7
	MLV	7 Russia-Domestic	9 Russia-Domestic	9 Russia-Domestic	11 Russia-Domestic 1 Russia-Domestic	7 Russia-Domestic
Molniya		10	5	23	5	8
	MLV	10 Russia-Domestic	5 Russia-Domestic	11 Russia-Domestic 11 India-IRS 1B 1 Russia-Domestic	5 Russia-Domestic	8 Russia-Domestic
Soyuz		20	26	20	11	13
	HLV	18 Russia-Domestic 2 Russia-Domestic	26 Russia-Domestic	18 Russia-Domestic 2 Russia-Domestic	11 Russia-Domestic	13 Russia-Domestic
Start		0	0	0	0	0
	Small					
Tskylon		10	7	8	9	5
	MLV	10 Russia-Domestic	7 Russia-Domestic	8 Russia-Domestic	8 Russia-Domestic 1 Czech-Magion 3	5 Russia-Domestic
Vostok		2	0	0	0	0
	MLV	1 India-IRS 1A 1 Russia-Domestic				
India						
PSLV/GSLV		1	0	0	0	1
		1 India-Domestic				1 India-SROSS C

		1997
		1
		1
		1
		4
		2 5 3
		1 1
		4
		7
		8
		1
		1

Legend: Spacecraft failed to reach operating status as planned

Spacecraft partially failed after achieving operating status

Mission Model - Used FOREIGN Non-GTO Launch Sites

1993	1994	1995	1996	TOTAL	%	Average Rate
44	39	28	22	461		51.2
1	1	0	1	9		1.0
China-FSW 2-01	1 China-FSW 2-02		1 China-FSW 2-03			
1	0	0	0	3		0.3
India-IRS 1C						
4	1	2	1	20		2.2
Russia-Domestic	1 Russia-Domestic	2 Russia-Domestic	1 Russia-Domestic			
10	11	8	6	107		11.9
Russia-MIR Manned Russia-MIR Supply Russia-Domestic	3 Russia-MIR Manned 5 Russia-MIR Supply 3 Russia-Domestic	2 Russia-MIR Manned 5 Russia-MIR Supply 1 Russia-Domestic	2 Russia-MIR Manned 3 Russia-MIR Supply 1 Russia-Domestic			
2	4	1	1	16		1.8
Russia-Cosmos 2237 Russia-Cosmos 2263	1 Russia-Cosmos 2278 1 Russia-Cosmos 2290 1 Russia-Resurs 1 1 Russia-Cosmos 2297	1 Russia-Cosmos 2322	1 Russia-Cosmos 2333			
4	5	5	4	62		6.9
Russia-Domestic	5 Russia-Domestic	5 Russia-Domestic	4 Russia-Domestic			
8	3	4	5	71		7.9
Russia-Domestic	3 Russia-Domestic	3 Russia-Domestic 1 Czech-Magion 4	4 Russia-Domestic 1 Czech-Magion 5			
7	4	4	3	108		12.0
Russia-Domestic	4 Russia-Domestic	4 Russia-Domestic	2 Russia-Domestic 1 Russia-Domestic			
1	0	1	0	2		0.2
Russia-Domestic		1 Israel-Gurwin				
5	8	3	0	55		6.1
Russia-Domestic Czech-Magion 2	7 Russia-Domestic 1 Russia-Domestic	1 Chili-Fiasat 1 Russia-Domestic 1 Russia-Domestic				
0	0	0	0	2		0.2
1	2	0	1	6		0.7
India-IRS 1E	1 India-IRS P2 1 India-SROSS C		1 India-IRS P3			

Table C.5. 1997 Mission Model History - Summary

	1988	1989	1990	1991	1992
Commercial GTO COMSTAC =	9	8	18	15	17
Non COMSTAC	0	0	0	0	0
Non GTO US Sites =	9	16	22	23	18
Non GTO Foreign	80	63	83	52	50
TOTAL =	98	87	123	90	85

1993	1994	1995	1996	TOTAL	%	Average Rate
10	18	18	26	89		29.7
0	0	0	0	0		0.0
17	18	19	20	92		30.7
44	39	28	22	183		61.0
71	75	65	68	364		121.3