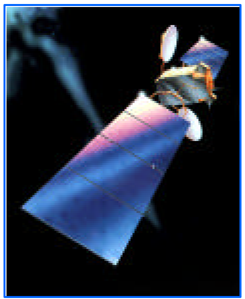

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Commercial Space Transportation Advisory Committee (COMSTAC)

Report of the COMSTAC Technology & Innovation Working Group

Commercial Spacecraft Mission Model Update

May 1998

Associate Administrator for Commercial Space Transportation
Federal Aviation Administration
U.S. Department of Transportation

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Report of the
COMSTAC Technology & Innovation Working Group

COMMERCIAL SPACECRAFT MISSION MODEL UPDATE

May 1998

Paul M. Fuller

Paul Fuller, Chairman
Technology & Innovation Working Group

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

TABLE OF CONTENTS

COMMERCIAL MISSION MODEL UPDATE

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. 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 1998 update of the worldwide commercial geosynchronous transfer orbit (GTO) satellite mission model for the period 1998 through 2010. It is based on market forecasts obtained in early 1998 from major spacecraft manufacturers, satellite operators and launch service providers. The mission model is limited to "addressable" payloads only (i.e., payloads open to internationally competed launch service procurements). Payloads captive to any launch systems are excluded from the mission model. Note that the number of projected *vehicle* launches per year is a subset of this *payload* launch demand forecast due to the potential for multiple manifesting of satellites on launch vehicles. Also, low-earth orbit (LEO) and medium-earth orbit (MEO) payloads are not included in this mission model. The FAA/AST develops the LEO/MEO market forecasts in a separate report using a different forecast methodology (Reference 1).

2. 1998 MISSION MODEL UPDATE METHODOLOGY

Through a process used since 1993, 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 1998 - 2010. Respondents completed a table that segregated payloads into categories of "Medium," "Intermediate" and "Heavy" based on separated mass inserted into a nominal transfer orbit, assuming launch at 28° north latitude. 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 (907-1,814 kg)	Medium	Dual Ariane 4/5, dual H-IIA, Delta II, Long March 3 or 3A
4,000-9,000 lb (1,814-4,083 kg)	Intermediate	Dual Ariane 4/5, Atlas IIA, IIAS, Atlas IIIA, Delta III, HII-A, Long March 2E or 3C, Sea Launch, Proton D1e
>9,000 lb (>4,083 kg)	Heavy	Dedicated Ariane 4/5, H-IIA, Delta IV, Atlas IIIB, Proton M, Sea Launch, Long March 3B

In 1998, the following organizations responded with data used in the development of this report:

American Mobile Radio Corp.
Arianespace, Inc.*
Asia Satellite Telecommunications, Ltd.
The Boeing Company*
COMSAT
GE American Communications, Inc.
Hughes Space & Communications*
ICO Global Communications
INTELSAT/ICO & INC
Lockheed Martin Telecomm. (LMT)*
International Launch Services*
Japan Satellite Systems, Inc.
Loral Skynet
Motorola/Celestri
Optus Communications
PanAmSat
PT Satellite Palapa Indonesia
Rocket System Corporation*
Societe Europeene Des Satellites
Space Systems/Loral*
TRW

Comprehensive mission model forecasts (of the total addressable market of payloads seeking GTO launch services) were received from those organizations marked by an asterisk (*). Other responses provided partial market or company specific payload launch demand information. Market demand data were received from foreign as well as domestic organizations. The Technology and Innovation Working Group expresses their sincere appreciation for the inputs provided by the international organizations.

3. CONCLUSIONS

The following conclusions are based on the results of this 1998 update of the worldwide commercial GTO mission model:

- The 1998 COMSTAC Commercial Mission Model (Figure 1.0) indicates the average demand for commercial GTO payload launch services will be 33 spacecraft per year in the period 1998-2010. This is the same average value (33 payloads per year) obtained in the 1997 mission model update. However, the high-low dispersions, which represent the highest and lowest data point in any given year, are large and underscore the uncertainty in predicting the market.

- The 1998 forecast closely matches the 1997 forecast in the out-years, but the near-term forecast shows a “flattening” of the demand (Figure 2.0). In addition, the 1999 forecast shows a sizable reduction from last year’s report; from 40 payloads to 29 payloads, a drop of 11 satellites. The Working Group attributed this to a short-term response to the Asian economic crisis (the majority of the 11 payloads removed from the 1997 forecast are Asian launch opportunities). Many of these appear to have been delayed or deferred into the 2000-2001 timeframe. Other factors contributing to the decline in 1999 include continuing disappointments in project financing for several GEO regional mobile satellite programs and unanticipated delays in start-up financing for the emerging Ka-band market.

- The forecast mass distribution of commercial payloads reflects a trend toward heavier satellites (Figure 3.1), continuing the trend identified in the 1997 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), the increasing spacecraft power requirements, larger antennae requirements, and increased orbital congestion.

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

- The *vehicle* launch demand forecast is presented in Figure 4.0 and Table 3.0. It was derived from the *payload* launch demand forecast by taking into account the growing trend in dual manifesting of commercial satellites. Note that this conversion from payload to vehicle launch demand is based on the market capture assumptions noted in Table 3.0.

Complete tabular data are contained in Tables 1.0, 2.0, and 3.0. The data analysis and market projection results are contained in Appendix A. The detailed 1998-2000 Near-Term Mission Model is contained in Appendix B. The 1988-1997 Payload Launch History is contained in Appendix C.

4. RECOMMENDATIONS

It is recommended that this 1998 COMSTAC Commercial Spacecraft Mission Model Update be provided to appropriate US Government agencies for their use, and that it be released to the general public. Also, it is recommended that the COMSTAC Technology & Innovation Working Group prepare and provide briefings on the interpretation and implications of the 1998 Mission Model update to the appropriate US Government agencies.

5. REFERENCES

1. Department of Transportation Report, “LEO Commercial Market Projections,” April 1997.

2. Depart of Transportation Letter, dated 3/12/98, Patricia Smith.

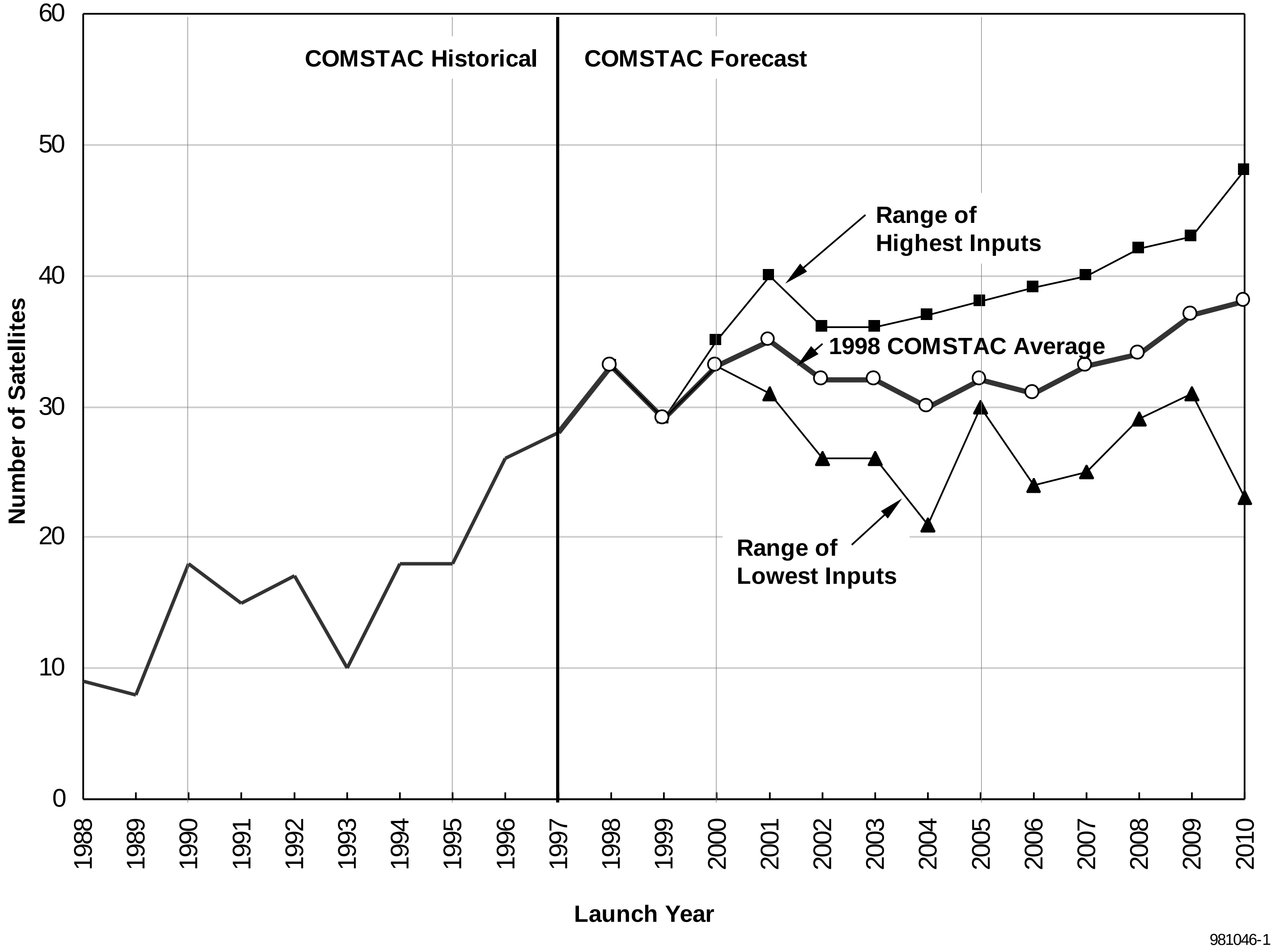

Figure 1.0. 1998 COMSTAC Commercial GTO Mission Model

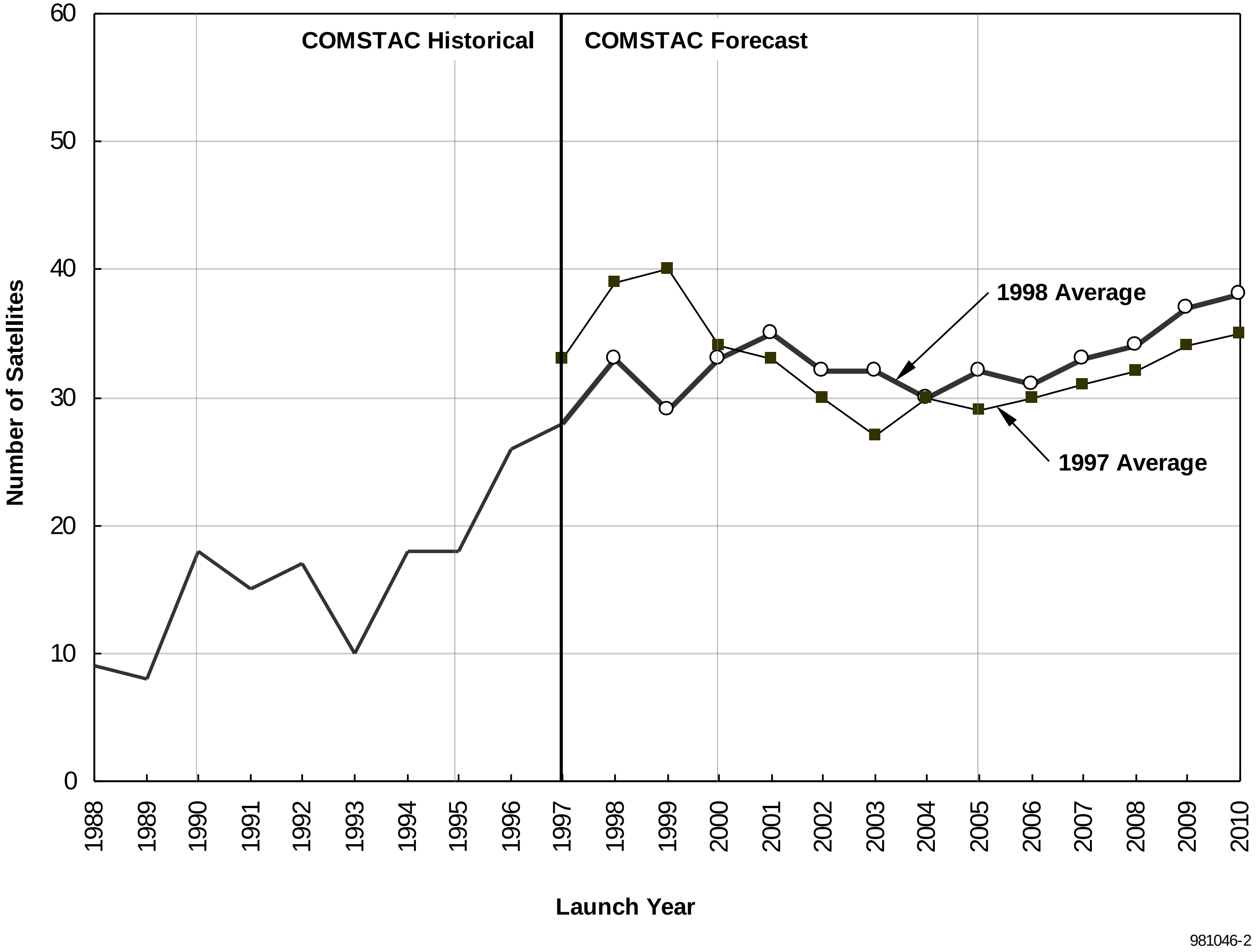

Figure 2.0. 1998 COMSTAC Mission Model Comparison

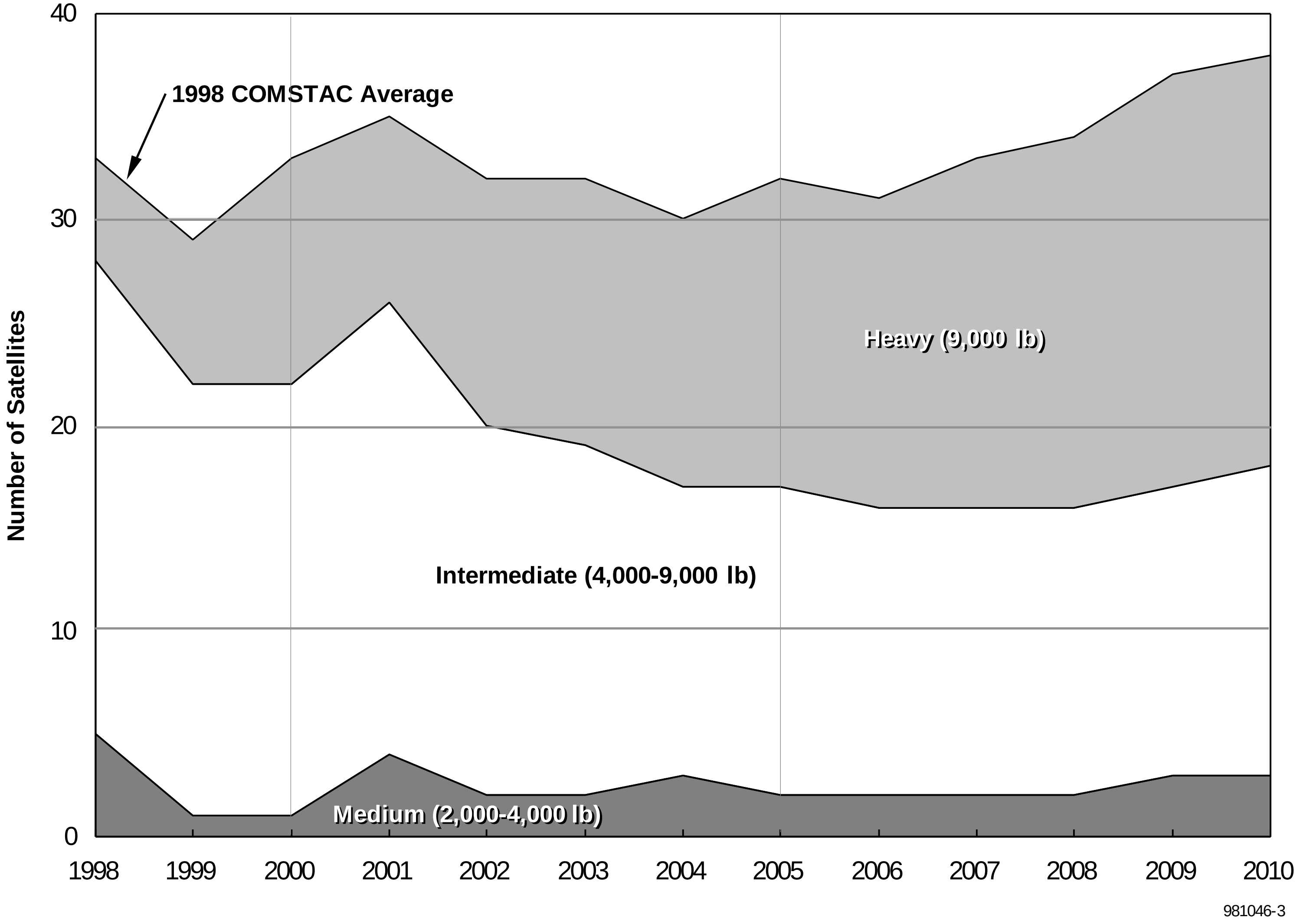

Figure 3.1. Forecast Trends in Commercial GTO Payload Mass Distribution

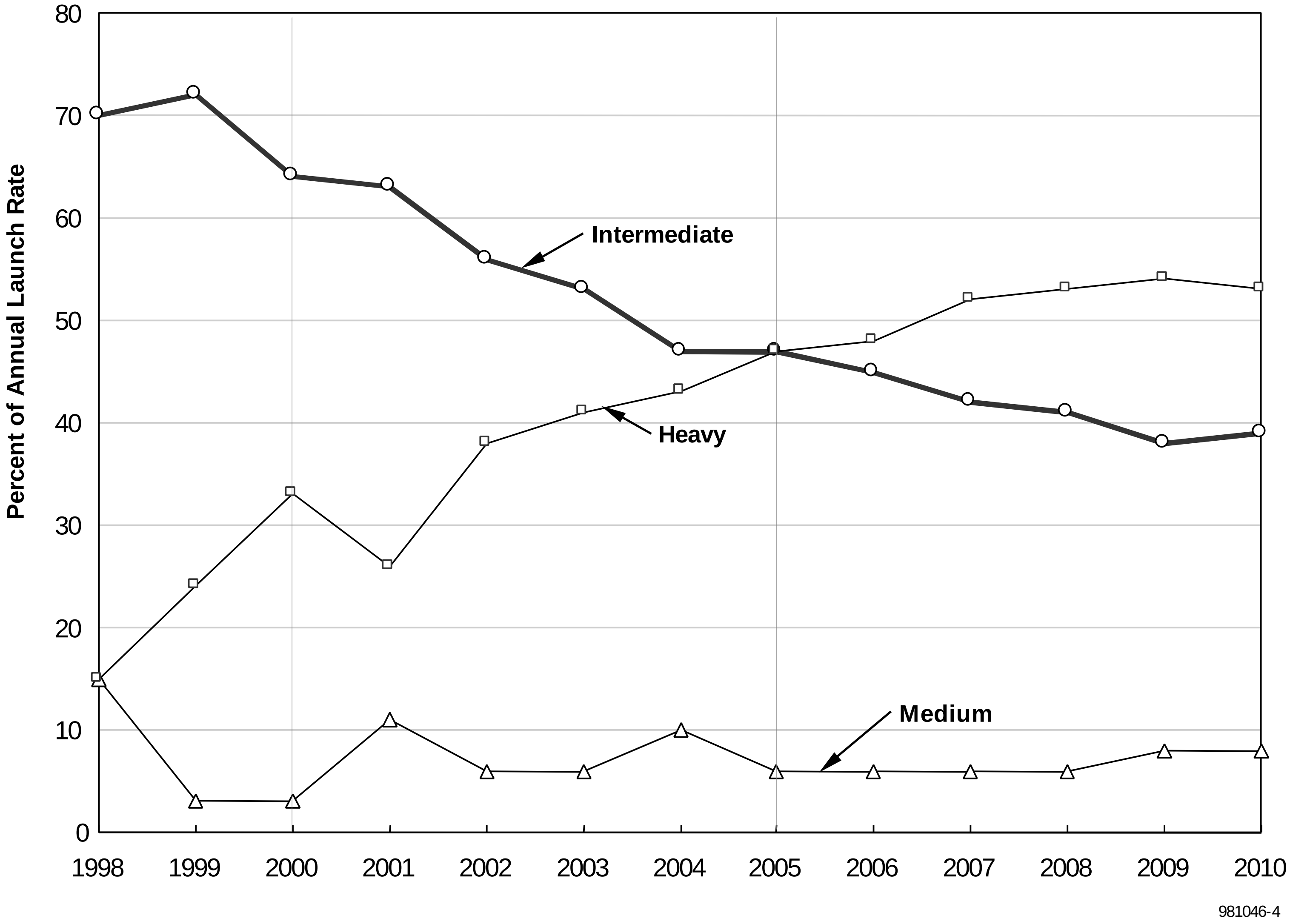

Figure 3.2. Forecast Average Mass Trends as a Percentage of Total Market

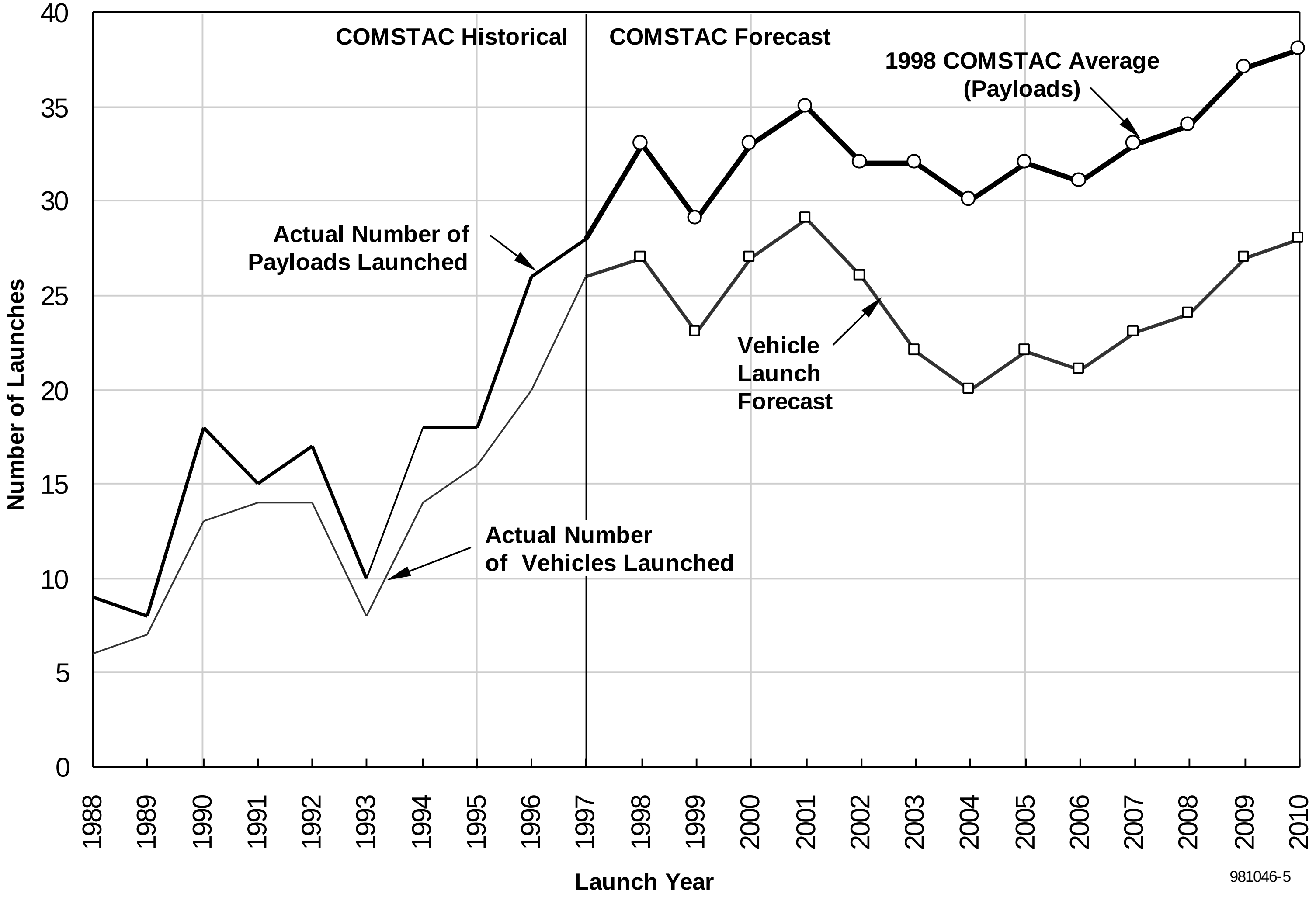

Figure 4.0. COMSTAC Launch Demand Forecast

Table 1.0 1998 COMSTAC Commercial GTO Mission Model Summary

COMSTAC 1998 Summary	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Total 1998-2010**	**Avg 1998-2010**
Highest Input	33	29	35	40	36	36	37	38	39	40	42	43	48		
Average Rate	**33**	**29**	**33**	**35**	**32**	**32**	**30**	**32**	**31**	**33**	**34**	**37**	**38**	**429**	**33**
Lowest Input	33	29	33	31	26	26	21	30	24	25	29	31	23		

Notes:

1) The “Highest” and “Lowest” inputs are the maximum and minimum individual estimates provided for any one year in the comprehensive US forecasts provided. No single forecast was consistently higher or lower than the “Average Rate” throughout the forecast period.

2) The highest comprehensive forecast was 483 addressable payloads to be launched from 1998 through 2010. The lowest was 383 and the average was 429.

3) The yearly “Average Rate” forecast numbers represent the sum of all yearly forecast-payload launch rates divided by the number of all comprehensive US Forecasts provided.

4) The 1998-2000 figures reflect the consensus forecast developed by the Working Group members and is presented in Appendix B, “1998-2000 Near-Term Mission Model.”

Table 2.0 Forecast Trends in Payload Mass Distribution

Payload Mass	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total 1998-2010	Avg 1998-2010	Percent of Total 1998-2010
MLV 2,000-4,000 lb	5	1	1	4	2	2	3	2	2	2	2	3	3	32	2.5	7%
ILV 4,000-9,000 lb	23	21	21	22	18	17	14	15	14	14	14	14	15	222	17.1	52%
HLV >9,000	5	7	11	9	12	13	13	15	15	17	18	20	20	175	13.5	41%
Total Market	**33**	**29**	**33**	**35**	**32**	**32**	**30**	**32**	**31**	**33**	**34**	**37**	**38**	**429**	**33.0**	**100%**

Notes:

1) MLV: Medium Class

2) ILV: Intermediate Class

3) HLV: Heavy Class

4) Computational Note: Microsoft Office 97 Excel 8.0 was used for the data analyses. The AVERAGE function was used to average the industry inputs. The ROUND, followed by the TRUNC, functions were then used to convert to integer values. Finally, the SUM function was used to obtain totals and the AVERAGE function applied to obtain overall averages.

Table 3.0 COMSTAC Launch Demand Forecast Summary

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total 1998-2010	Avg 1998-2010
Payload Launch Demand	33	29	33	35	32	32	30	32	31	33	34	37	38	429	33
Assumed Dual Launches	6	6	6	6	6	10	10	10	10	10	10	10	10	110	8
Vehicle Launch Demand	**27**	**23**	**27**	**29**	**26**	**22**	**20**	**22**	**21**	**23**	**24**	**27**	**28**	**319**	**25**

Notes:

1) Payload Launch Demand is the annual Average Rate forecast per Table 1.0.

2) Assumed Dual Launches is the annual number of dual payload launches assumed to occur from 1998 – 2010. This represents the market share captured by unspecified dual payload launch vehicles: six (6) per year from 1998 – 2002, and ten (10) per year from 2003 – 2010 (see A.6, Appendix A).

3) Vehicle Launch Demand is the derived annual demand for launch vehicles based on the assumptions of Note 2.

Report of the
COMSTAC Technology & Innovation Working Group

COMMERCIAL SPACECRAFT MISSION MODEL UPDATE

May 1998

APPENDIX A
1998 DISCUSSION AND RESULTS

Commercial Space Transportation Advisory Committee (COMSTAC)
Office of Commercial Space Transportation
Federal Aviation Administration
US Department of Transportation

A. 1998 DISCUSSION AND RESULTS

A.1 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 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.

<u>1993</u>: 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.

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

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

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

<u>1996</u>: The 1996 annual update expanded the request for input data to a greater number of companies and satellite operators. The resulting forecast (Reference A4) represented a consensus on the size of the market, which was close to the 1995 "Higher Growth" case, with average annual demand of 31 payloads per year. However, in the case of mass

distribution, the group agreed to portray two cases: "Stable Mass Growth" and "Continued Mass Growth." The "Stable Mass Growth" scenario predicted that Intermediate payloads would represent 70% of the market over the forecast period, while the "Continued Mass Growth" case reflected the emergence of a segment of Heavy payloads, representing 42% of the total market.

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

A.2 1998 MISSION MODEL

The 1998 COMSTAC mission model consists of 3 elements. The first is a forecast of demand for internationally competed launches of commercial payloads to geostationary transfer orbit (GTO) from 1998 to 2010. The second is an estimate of the mass distribution of these payloads. The third element is a launch vehicle demand projection derived from the payload launch demand forecast. The results of 1998's assessment of these elements are discussed below.

A.3 FORECAST OF DEMAND FOR PAYLOAD LAUNCHES

A.3.1 1998 Payload Launch Demand. Figure 1.0 shows the COMSTAC Technology and Innovation Working Group's forecast demand for commercial launch services to GTO. The figure plots the actual number of payloads launched from 1988 through 1997 ("COMSTAC Historical"). It then displays the range of the individual comprehensive estimates provided by Working Group members from 1998 onward and compares them with the average of the comprehensive estimates combined ("COMSTAC Forecast").

The ranges of the independent 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.

This year's mission model predicts an average demand of 33 payloads per year over the period from 1998–2010. 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. This is followed by a resurgence in demand thereafter, fueled by replenishment requirements for existing telecommunications satellites and varying estimates of out-year growth.

The near-term forecast from 1998 to 2000 was established by the Working Group by detail review of current launch manifests from the launch service providers and spacecraft manufacturers and operators. This results in a single consensus demand projection for the years 1998 and 1999. However, from the year 2000 and beyond, the majority of the projected payloads have not been manifested on specific launch vehicles, and a single consensus demand projection could not be established.

A.3.2 Comparison with 1997 Report -- Figure 2.0 compares this year's forecast with last year's forecast. The 1998 mission model predicts an average of 33 satellites per year will be launched into geostationary transfer orbit (GTO) over the period 1998–2010. Last year's mission model also predicted an average demand of 33 payloads per year over the period 1997–2010. Thus, there is a consistency in the overall payload launch demand forecast over the past two years.

However, the 1998 near-term forecasts varied significantly from the 1997 near-term projections. Specifically, the 1999 launch forecast made this year shows a sizable reduction from last year's mission model: from 40 payload to about 29 payloads (a drop of 11 payloads). The Working Group attributed this mainly to a short-term response to the Asian economic crisis. A majority of the 11 payloads removed from the forecast for 1999 are Asian launch opportunities that have been delayed or deferred into the 2000–2001 timeframe. Other factors contributing to the decline include continued disappointments in project financing for several GEO regional mobile satellite programs, and unanticipated delays in start-up financing for the emerging Ka-frequency band satellite market. Recognition must also be made of the dynamic nature of the near-term launch manifest caused by administrative, technical, and programmatic changes.

A.3.3 Approach to Demand Modeling -- The approach used to forecast commercial satellite demand included evaluation of:

- Firm contracted missions
- Current satellite operator planned and replenishment missions
- Projected operator growth and growth replenishment missions
- An estimate of "unidentified growth."

In addition to these considerations, an attrition rate factor of 10% of annual launch demand was also assumed. This factor includes on-orbit satellite and launch vehicle failures, with the replacement assumed to occur 2 years following the failure. The "unidentified growth" estimates include proprietary, company-specific information, and assumptions on future markets. Differing assessments of "unidentified growth" were the major factor in the high-low variance range in the mission model forecast data.

The near-term COMSTAC mission model (1998-2000) is based on an assessment of the currently manifested launches and payloads soon to be assigned to launch vehicles. Since these missions are identified by name, the near-term forecast does not account for unanticipated launch failures from previous years, nor delays in the launch vehicle or satellite supply chain. For example, last year the Working Group forecast that 33 addressable commercial satellites would be launched into GTO in 1997. The actual number was 28, for a difference of 5 satellites. This was because five scheduled payload launches were postponed from 1997 into 1998. This pattern of firm schedule commitments, followed by modest delays has appeared consistently in previous editions of our mission model forecasts.

A.3.4 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 only 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.

A.3.5 Methodology and Calculations -- The average launch rate from 1998 through 2010 was calculated by adding the five (5) domestic comprehensive forecasts together and dividing them by five (5) (Figure 1.0 and Table 1.0).

Estimates for 1998 and 1999 reflect the consensus forecast developed by the Working Group based on currently manifest payloads. These are provided in detail in Appendix B, "1998-2000 Near-Term Mission Model." However, in the year 2000, consensus could not be reached on a single forecast number of payload launches. The estimates varied between 33 and 35 payloads. The variation in estimates for 2000 reflect independent assessments of the likelihood or timing of the unassigned or "Spacecraft Not Ordered (NO)" programs annotated in Appendix B.

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 submitted in any of the forecasts. No single comprehensive forecast was consistently higher or lower than the average throughout the forecast period. Therefore, the maximum inputs and minimum inputs are not additive. Accordingly, the highest single cumulative estimate across the 1998-2010 forecast period was 483 addressable commercial payloads to be launched. The lowest cumulative estimate was 383 and the average was 429.

A.4 TRENDS IN PAYLOAD LAUNCH MASS

Figures 3.1 and 3.2 reflect the Working Group's consensus forecast on how commercial satellite payload mass will evolve. This year, as in 1997, the Working Group reached a broad consensus that commercial payload launch mass would probably continue to gradually increase in the future.

Figure 3.1 shows the annual number of payloads in each of the Medium (2,000 – 4,000 lb), Intermediate (4,000 – 9,000 lb) and Heavy (> 9,000 lb) payload categories from 1998 – 2010. Figure 3.2 shows these same data as a year-by-year percentage of each mass category over the same period. This figure is perhaps the most representative of the group's collective viewpoints regarding mass growth.

As indicated, the number of Intermediate mass payload launches is forecast to decrease gradually from about 70% of the market to about 40% of the market during the forecast period. The number of Heavy launches is forecast to increase correspondingly. The number of Medium mass payload launches, however, is expected to remain relatively constant at about 2-3 a year (or 10% of the market) as small countries and new operators continue to enter the GEO satellite market.

A.4.1 Payload Mass Definitions. The payload mass class definitions were refined in 1997 to reflect new market entrants like Delta III and Atlas III. The Heavy HLV mass class, defined as payloads heavier than 9,000 lb, 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 lb threshold used in forecasts for 1996 and prior years. The definition has also been clarified to refer specifically to launch vehicle *performance* (vs. launch mass) greater than or equal to 9,000 lb 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. launch site without degradation in required satellite lifetime. This definition is also consistent with the less than 8,000 lb performance historically available from U.S. launchers since 1988, as reflected in the historical tables in previous COMSTAC commercial spacecraft mission models.

A.4.2 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. 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 12 heavy-class payloads."

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 12 heavy-class payloads, plus or minus 4-7 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 2004-2005. 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.

A.4.3 How Heavy Is "Heavy?" One frequently asked question to the COMSTAC Working Group is: 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 agrees that the next generation of commercial satellites currently under development will 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 A6), 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.

A.4.4 Why are Commercial Payloads Getting Bigger? -- US government satellites are getting smaller for several reasons: 1) funding limitations, 2) technological progress in miniaturization and 3) reduced heavy-lift launch costs. In contrast, commercial communication satellites are enjoying similar technological progress, but are growing larger in both volume and total launch mass. There is probably no single reason why this is happening, but is probably due to a series of technical and financial factors that continue to favor larger commercial satellites over time. Moreover, commercial satellites operate in a burgeoning telecommunications environment that is not subject to fixed and declining Government budgets, but to commercial opportunity. Some of the factors affecting continued or stabilization of commercial satellite mass growth are listed 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 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 orpower hungry phased arrays
  - Onboard processing and satellite cross links drive mass growth in some cases
  - Higher frequency use such as Ka and V-band requires more power

- 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 launch price advantage for mid-range satellite

A.4.5 Methodology and Calculations:

A.4.5.1 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 the five (5) 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: (3+3+2+2+1)/5=2. 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.

A.4.5.2 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 E across the forecast period. The results are then added together and divided by 5 to form the working group's average.

A.5 INTERNATIONAL PARTICIPATION

As part of COMSTAC's expanded efforts to include as many industry participants as possible in developing the mission model, the Working Group received complete and partial mission model forecasts from various foreign organizations. One comprehensive forecast (1998 – 2010) from a foreign launch provider was received, and 8 partial forecasts were received from various satellite operators. These inputs were used to validate the domestic industry comprehensive inputs, but could not be published because of confidentiality constraints.

A.6 DERIVATION OF LAUNCH DEMAND

A.6.1 Purpose -- Since inception, the COMSTAC mission model has provided launch demand forecasts in terms of the number of payloads to be launched. In the fall of 1997, an approach was developed by the Working Group to estimate the demand for *vehicle* launches from the payload launch forecasts by consideration of dual manifesting of a portion of the payload mission model. This section summarizes the methodology, assumptions, and results of describing the same demand forecast in terms of actual or projected *launches* through the 1988-2010 time frame. The data for 1988-1997 are based on actual dual-manifest historic information. Projections from 1998-2010 are based on assumed dual-manifest factors.

A.6.2 Methodology and Assumptions

Historical -- The actual number of commercial GTO launches recorded from 1988 through 1997 is lower than the number of payloads launched due to dual manifesting on Ariane 4 and Titan 3 rockets. This is reflected in Figure 4.0.

In cases where two internationally competed GTO payloads were carried on the same launch vehicle, one "payload equivalent" was subtracted from the payload count in the mission model.

In cases where one commercial GTO payload was launched with another non-commercial or non-GTO payload, that commercial payload was counted as a single commercial launch.

Forecast – The highest publicly announced commercially available dual launch capability is approximately 8 flights per year, for a theoretical maximum of 16 commercial payloads per year. This is scheduled to become fully available by the year 2000.

This 8 flight maximum is discounted to an average of 6 dual commercial flights per year, based on two factors. First, history has shown a steady rate of about 2 captive launches co-manifested with a commercial payload per year. Second, trends in payload mass growth may preclude the easy accommodation of 2 average sized commercial spacecraft on a single launcher.

A second dual launch capability is postulated to become commercially available beginning in 2003. The working group estimated that this would result in 4 more commercial launches per year. Factors governing the success of such an outcome include the performance of the launch vehicle in question and the relative cost of a dual manifest launch compared to a single manifest launch.

The forecast launches are also shown in Figure 4.0.

A.6.3 Results

There were 115 internationally competed launches from 1988 through end-of-year 1996 (Reference A5, Table D-1.0). This represents an average of 12.8 actual launches per year, or approximately 5.4 dual manifested commercial payloads per year. This translates to a net reduction of 24 payload equivalents, or about 2.7 launches per year (Reference A5, Table C-1, 1988-1996 Mission Model History).

These adjustments to the COMSTAC Mission Model derive almost entirely from the Arianespace launch experience. From 1988-1996, Arianespace launched 44 dual commercial payloads on 23 separate launches. Accordingly, 23 payload equivalents were subtracted from the 1988-1996 historical plot in Figure 4. Arianespace also conducted 17 "hybrid" launches of one commercial GTO payload and another non-commercial or non-GTO payload. Those launches were counted as 14 "single" commercial launches and not subtracted from the mission model.

The Titan 3 launched two commercial payloads on one launch during this period, resulting in one additional payload equivalent being subtracted from the historical plot.

Adjustments to the 1998-2010 COMSTAC Mission Model forecast stem from an increase in the possible number of dual commercial launches. This increase derives from the phased introduction of the Ariane 5 launch vehicle through 2000 and the possible gradual introduction of a multiple launch capability on the Evolved Expendable Launch Vehicle beginning in the year 2003. Taken together, the introduction of such dual manifesting capabilities may represent a potential of about 20 co-manifested commercial payloads, or about 10 dual commercial launches per year.

A.7 REFERENCES

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

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

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

A4. COMSTAC Report, “Commercial Spacecraft Mission Model Update - 22 July 1996,” Office of Commercial Space Transportation, US Department of Transportation/Federal Aviation Administration, Washington, D.C.

A5. COMSTAC Report, “Commercial Spacecraft Mission Model Update – May 1997,” US Department of Transportation/Federal Aviation Administration, Washington, D.C.

A6. COMSTAC Report, “Commercial Space Launch System Requirements – 1996,” Office of Commercial Space Transportation, US Department of Transportation, Washington, D.C.

Report of the

COMSTAC Technology & Innovation Working Group

COMMERCIAL SPACECRAFT MISSION MODEL UPDATE

May 1998

APPENDIX B
1998 - 2000 NEAR-TERM MISSION MODEL

Commercial Space Transportation Advisory Committee (COMSTAC)
Office Of Commercial Space Transportation
Federal Aviation Administration
U. S. Department of Transportation

B. 1998-2000 NEAR TERM MISSION MODEL

Near-Term Payload Launch Demand Forecast 1998 through 2000. A summary of the near-term 1998-2000 mission model individually identified by name is presented in Appendix B. The mission model is divided into addressable commercial GTO spacecraft and non-commercial spacecraft that will potentially utilize the same commercial launch systems and launch sites. The non-commercial spacecraft forecast includes payloads captive to specific launch systems. US 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 US competition as well, perhaps beyond 2000. In the period through 1999, 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 Boeing representative could modify the published manifest data for the Delta II, or a spacecraft manufacturer with knowledge of launch dates on a non-US launch system could provide the most up-to-date information on that system.
- Where the spacecraft has been ordered, but the launch company has not been selected, the date the operator contracted for satellite readiness was used.
- Plans of existing satellite service operators were used as available.
- Plans of new or potential operators (i.e., growth in demand) were subject to the judgment of the individual subgroup members. It is this factor that led to the dispersions around the average forecast beginning in the year 2000.

Payload Mass Definitions. The payload mass class definitions were refined in 1997 to reflect new market entrants like Delta III and Atlas III. The new HLV mass class defines payloads heavier than 9,000 lb and 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 lb threshold. The definition has also been clarified to refer specifically to launch vehicle *performance* (vs. launch mass) greater than or equal to 9,000 lb to a nominal geosynchronous transfer orbit of 200 nm x GEO at an inclination of 28^0 north.

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

This Appendix contains the following tables:

> **Table B.1. 1998-2000 COMSTAC Commercial GTO Mission Model –** This is the consensus near-term mission model of the worldwide addressable commercial spacecraft launch demand GTO. The mission model is provided annually by specific launch system, if known. Actual data for 1997 is also included.
>
> **Table B.2. 1998-2000 Missions Not Included in COMSTAC Commercial GTO Mission Model – Uses GTO Launch Sites –** This is the near-term mission model of the 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. Actual data for 1997 is included, as is a summary table of total traffic at GTO launch sites.
>
> **Table B.3. 1998-2000 Missions Not Included in COMSTAC Commercial GTO Mission Model – Uses Non-GTO Launch Sites –** This is the near-term mission model of the 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. Actual data for 1997 is also included.
>
> **Table B.4. 1998-2000 Missions Not Included in COMSTAC Commercial GTO Mission Model – Uses FOREIGN Non-GTO Launch Sites –** This is the near-term mission model of the non-addressable launch demand that utilize foreign launch systems from launch sites not used for addressable commercial launches to GTO. Actual data for 1997 is included.

Table B.1. 1998-2000 COMSTAC Commercial GTO Mission Model (May 1998)

		1997	1998	1999	2000	TOTAL	3 Year Average Rate
TOTAL =		28	33	29	33	95	31.7
Arianespace		15	15	14	4	33	11.0
	HLV	1 Intelsat 801 1 Intelsat 802 1 Intelsat 803 1 Intelsat 804 1 US-GE Americom GE2 1 US-PAS 6		1 Laos-LStar 1	1 Canada-Anik F1 1 Intelsat 902 1 LStar 2		
	ILV	1 Argentina-Nahuel 3 1 Eutelsat-Hotbird 3 1 India-Insat 2D 1 Inmarsat 304 1 Japan-JCSat 5 (1R) 1 Sweden-Sirius 2 1 Thailand-Thaicom 3	1 Brazil-Brazilsat B3 1 Egypt-Nilesat 1 1 Eutelsat W2 1 Eutelsat-Hotbird 4 1 Eutelsat-Hotbird 5 1 India-Insat 2E 1 Inmarsat 305 1 SatMex 5 (Morelos 3) 1 US-GE Americom GE5 1 US-PAS 6B 1 US-PAS 7 1 US-Worldspace-Afristar	1 Arabsat 3A 1 Eutelsat W3 1 Indonesia-Satelit Telkom 1 1 Intelsat KTV 1 1 Korea-Koreasat 3 1 Luxembourg-SES Astra 2B 1 Singapore-ST 1 1 US-CD Radio 1 1 US-CD Radio 2 1 US-Telstar 7 1 US-Worldspace-Ameristar 1 US-Worldspace-Asiastar	1 Japan-Superbird D		
	MLV	1 Indonesia-Indostar 1 1 Japan-BSat 1A	1 Japan-BSat 1B 1 Sweden-Sirius 3 1 UK-Skynet 4E	1 UK-Skynet 4F			
Atlas		6	4	3	1	8	2.7
	HLV	1 Japan-SCC-Superbird C					
	ILV	1 Japan-JSat 4 1 US-Echostar 3/DBSC 1 1 US-GE Americom GE 3 1 US-PAS Galaxy 8I 1 US-TCI Tempo FM 2	1 Eutelsat W1 1 Intelsat 805A 1 Intelsat 806A 1 Japan-JCSat 6	1 Eutelsat W4 1 US-Loral Orion 2 1 US-MCI ASkyB 1	1 Spain-Hispasat 1C		
Delta		1	5	0	0	5	1.7
	ILV		1 US-PAS Galaxy 10 1 US-Loral Orion 3 AP				
	MLV	1 Norway-Thor 2A	1 UK-Skynet 4D 1 Norway-Thor III 1 Russia-Bonum 1				
H-IIA		0	0	0	0	0	0.0
	HLV						
	ILV						
	MLV						
Long March		2	1	0	0	1	0.3
	HLV	1 Philippine-Mabuhay 1	1 China-Chinasat 8				
	ILV	1 China-APStar 2R					
	MLV						
Proton		4	6	4	1	11	3.7
	HLV	1 China-Asiasat 3 1 Luxembourg-SES Astra 1G 1 US-PAS 5 1 US-Loral Telstar 5	1 US-PAS 8	1 China-Asiasat 3S 1 Indonesia-Garuda (ACes) 1	1 Intelsat 901		
	ILV		1 Canada-Nimiq 1 1 Luxembourg-SES Astra 2A 1 US-Echostar 4 1 US-Loral Telstar 6 1 US-TCI Temposat 1	1 Russia-LMI #01 1 US-GE Americom GE4			
Zenit 3SL		0	1	0	1	2	0.7
	HLV		1 US-PAS Galaxy 11		1 •US-Unnamed		
	ILV						
TBD		0	1	8	26	35	11.7
	HLV		1 Luxembourg-SES Astra 1H	1 US-PAS 1R 1 US-PAS 9	RFP 1 Australia-Optus C1 RFP 1 Japan-JCSat 07 1 Luxembourg-SES Astra 1K 1 ME-Thuraya 1 NO 1 zAttrition-1998/9 Relaunches NO 1 Indonesia-M2A 1		
	ILV			1 Turkey-Eurasiasat 1 1 US-GE Americom GE1A 1 US-LMT-unnamed NO 1 US-Loral X 1 US-MCI ASkyB 2 NO 1 Attrition-1998 Relaunches	NO 1 Brazil-Brazilsat 4 NO 1 China-Asiasat 4 NO 1 Egypt-Nilesat 2 1 Eutelsat-EuropeSat 1 1 India-Insat 3A RFP 1 Norway-Thor IV NO 1 Russia-LMI #02 NO 1 Spain-Hispasat 1D 1 US-AMRC 01 1 US-AMRC 02 1 US-Echostar 5 1 US-Europe*Star 1 1 US-GE Americom GE2B 1 US-GE Americom GE7 NO 1 US-PAS NO 1 US-PAS 1 US-Telstar 08 NO 2 zAttrition-1998/9 Relaunches NO •Celstar 1 NO •Celstar 2		
	MLV				1 Chinasat 9		

LEGEND

NO = Spacecraft not ordered

• = No concensus

Table B.2. 1998-2000 Missions Not Included in COMSTAC Commercial Mission Model - Uses GTO Launch Sites (May 1998)

	1997	1998	1999		TOTAL	3 Year Average Rate
TOTAL =	15	20	25	23	68	22.7
Ariane	1	2	3	3	8	2.7
	1 Eumetsat-Meteosat(MOP 4) 7	1 ESA-Recovery Module 1 France-Spot 4	1 ESA-Envisat 1 France-Helios 1B 1 France-XMM	1 France-Stentor 1 Italy-Sicral 1 1 Meteosat SG1	8	
Atlas	2	4	5	3	12	4.0
	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-NRO-Call UP MLV-07	1 US-AF-Call UP MLV-10 1 US-AF-DSCS 3-07 1 US-N-UHF/EHF F10 1 US-NASA-TDRSS I 1 US-NASA/NOAA-Goes L	1 US-AF-Call UP MLV-12 1 US-AF-Call UP MLV-13 1 US-AF-DSCS 3-08	12	
Delta	4	4	8	8	20	6.7
	1 US-AF-GPS 2-Block 2-28 1 US-AF-GPS 2R-01 1 US-AF-GPS 2R-02 1 US-NASA-ACE	1 ***GlobalStar 1 - 04*** 1 ***GlobalStar 2 - 04*** 1 US-NASA-DeepSpace 1 1 US-NASA-Mars Orbiter-2	1 ***ICO 04*** 1 ***ICO 05*** 1 US-AF-GPS 2R-03 1 US-AF-GPS 2R-04 1 US-AF-SMTS/SBIRS 1 US-NASA-FUSE 1 US-NASA-Mars Lander-1 1 US-NASA-Stardust	1 ***ICO 07*** 1 ***ICO 10*** 1 ***ICO 12*** 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-AF-GPS 2R-09	20	
Japan	1	1	2	2	5	1.7
	1 Japan-ETS-7/TRMM	1 Japan-Comets	1 Japan-ETS 9 1 Japan-MutiFunctTrans Sat	1 ESA-Artimis 1 Japan-DRTS 1A		
Long March	2	3	1	2	6	2.0
	1 China-DFH 302 1 China-Fen Yun 2	1 China-DFH 303 1 China-Sinosat 1 1 China-Zhongwei 1	1 China-Zhongwei 2	1 China-DFH 401 1 China-Sinosat 2		
Proton	5	6	6	5	17	5.7
	1 ***Iridium 01 - 7*** 1 ***Iridium 02 - 7*** 1 Russia-Cosmos 2344 1 Russia-Cosmos 2345 1 ***Russia-Coupon 01 - 1***	1 ***Iridium 03 - 7*** 1 Russia-Cosmos 2350 1 Russia-Express 1 Russia-FGB 1 Russia-Raduga 1 Russia-Service Module	1 ***ICO #02*** 1 ***ICO #03*** 1 Russia-Express 1 Russia-Express 2 Domestic Requirements	1 ***ICO #09*** 1 Russia-Express 1 Russia-Express 2 Domestic Requirements		
TBD						

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

Legend:

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.**

	1997	1998	1999	2000	TOTAL	3 Year Average Rate
TOTAL SPACECRAFT LAUNCHED =	43	53	54	56	163	54.3
Additional Spacecraft in Leo Constelation clusters counted as one	12	12	0	0	12	4.0

Table B.3. 1998-2000 Missions Not Included in COMSTAC Commercial GTO Mission Model - Uses Non-GTO Launch Sites (May 1998)

United States Ranges

		1997	1998	1999	2000	TOTAL	3 Year Average Rate
TOTAL =		**28**	**32**	**18**	**27**	**77**	**25.7**

Eastern Ranges

		1997	1998	1999	2000	TOTAL	3 Year Average Rate
STS		**8**	**7**	**8**	**9**	**24**	**8.0**
	RLV	1 US-STS081-Atlantis 1 US-STS082-Discovery 1 US-STS083-Columbia 1 US-STS084-Atlantis 1 US-STS085-Discovery 1 US-STS086-Atlantis 1 US-STS087-Columbia 1 US-STS094-Columbia	1 US-STS089-Endeavour 1 US-STS090-Columbia 1 US-STS091-Discovery 1 US-STS088-Endeavour 1 US-STS093-Columbia 1 US-STS095-Discovery 1 US-STS096-Endeavour	1 US-STS092-Atlantis 1 US-STS097-Discovery 1 US-STS098-Endeavour 1 US-STS099-Atlantis 1 US-STS100-Columbia 1 US-STS101-Columbia 1 US-STS102-Atlantis 1 US-STS103-Endeavour	1 US-STS104-Discovery 1 US-STS105-Endeavour 1 US-STS106-Atlantis 1 US-STS107-Columbia 1 US-STS108-Endeavour 1 US-STS109-Atlantis 1 US-STS110-Columbia 1 US-STS111-Endeavour 1 US-STS112-Atlantis		
Athena		**0**	**2**	**0**	**0**	**2**	**0.7**
	Small		1 Taiwan-ROCSAT 1 US-NASA-Lunar Prospector				
Pegasus		**3**	**3**	**0**	**0**	**3**	**1.0**
	Small	1 Spain-Minisat 1 US-Orbcomm 1-8 1 US-Step 4	1 Brazil-SCD 2 1 US-Orbcomm 2-8 1 US-Orbcomm 3-8				
Taurus		**0**	**0**	**0**	**0**	**0**	**0.0**
	Small						
Titan		**3**	**4**	**1**	**2**	**7**	**2.3**
	HLV	1 US-AF T4 DSP 18 1 US-NASA T4 Cassini 1 US-NRO T4 Trumpet	1 US-NRO T4 1 US-NRO T4 1 US-AF T4 DSP 19 1 US-AF T4 DSP 20	1 US-AF T4 Milstar 3	1 US-AF T4 DSP 21 1 US-AF T4 Milstar 4		

Vandenberg Test Center

		1997	1998	1999	2000	TOTAL	3 Year Average Rate
Athena		**1**	**2**	**0**	**0**	**2**	**0.7**
	Small	1 US-NASA-Lewis	1 US-Ikonos 1 1 US-Ikonos 2				
Atlas		**0**	**1**	**0**	**1**	**2**	**0.7**
	ILV		1 US-NASA-EOS AM		1 US-AF-MLV 11		
Delta		**6**	**6**	**2**	**5**	**13**	**4.3**
	MLV	1 ***Iridium 01 - 05*** 1 ***Iridium 02 - 05*** 1 ***Iridium 03 - 05*** 1 ***Iridium 04 - 05*** 1 ***Iridium 05 - 05*** 1 ***Iridium 06 - 05***	1 ***Iridium 07 - 05*** 1 ***Iridium 08 - 05*** 1 ***Iridium 09 - 05*** 1 ***Iridium 10 - 03*** 1 US-AF-Argos P91 1 US-NASA-Landsat 7	1 ***Iridium 11 - 03*** 1 US-AF-EO-1/SAC C	1 ***Iridium 12 - 03*** 1 ***Iridium 13 - 03*** 1 US-NASA-GP B 1 US-NASA-Image 1 US-NASA-Jason/TIMED		
Pegasus		**4**	**1**	**2**	**2**	**5**	**1.7**
	Small	1 US-Orbview 1 US-FORTE 1 US-Orbcomm 01-2 1 US-Orbcomm 02-2	1 US-NASA-Trace	1 US-NASA-SWAS 1 US-NASA-Wire	1 US-NASA-Deepspace 3 1 US-NASA-VCL		
Taurus		**0**	**4**	**2**	**2**	**8**	**2.7**
	Small		1 US-AF-GEOSat F/O 1 US-AF-STEX 1 US-NASA-SNOE/Batsat 1 US-RA-Terrier	1 US-NASA-Catsat 1 US-NASA-UNEX 01	1 US-NASA-SMEX 1 US-NASA-UNEX 02		
Titan		**3**	**2**	**3**	**3**	**8**	**2.7**
	HLV	1 US-Lacrosse K18		1 US-NRO III	1 US-NRO III 1 US-NRO III		
	MLV	1 US-AF (DMSP 38) 1 US-NASA-TIROS	1 US-NASA-Quikscat 1 US-NOAA K	1 US-AF (DMSP 15) 1 US-NOAA L	1 US-AF (DMSP 16)		
TBD			**0**	**0**	**3**	**3**	**1.0**
					1 US-NASA-EOS-PM 1 1 US-NASA-MAP 1 US-NASA-Genesis		

Table B.4. 1998-2000 Missions Not Included in COMSTAC Commercial GTO Mission Model - Uses FOREIGN Non-GTO Launch Sites

		1997	1998	1999	2000	TOTAL	3 Year Average Rate
Non-United States Ranges							
TOTAL =		24	27	25	16	68	22.7
China-Taiyuan/Jiyuan							
Long March							
	ILV						
	MLV	1 China-FSW 1C 1 ***Iridium Sim-02*** 1 ***Iridium 01 - 2***	1 Brazil-CBERS 1 1 China-Fengyun 1C 1 ***Iridium 02 - 2*** 1 ***Iridium 03 - 2*** 1 Ziyuan 1	1 ***Iridium 04 - 2*** 1 ***Iridium 05 - 2*** 1 ***Iridium 06 - 2*** 1 ***Iridium 07 - 2*** 1 ***Iridium 08 - 2***	1 Brazil-CBERS 2 1 ***Iridium 09 - 2*** 1 ***Iridium 10 - 2*** 1 ***Iridium 11 - 2***		
Russia-Baikonur							
Molniya							
	MLV						
Tskylon							
	MLV	1 Russia-Cosmos 2347					
Soyuz							
	HLV	1 Russia-Cosmos 2343 1 Russia-Photon 1 Russia-Progress M34 1 Russia-Progress M35 1 Russia-Progress M36 1 Russia-Progress M37 1 Russia-Soyuz TM 25 1 Russia-Soyuz TM 26	1 Russia-Cosmos 2349 1 Russia-Progress M38 1 Russia-Progress M39 1 Russia-Progress M40 1 Russia-Soyuz TM 27 1 Russia-Soyuz TM 28 1 Russia-Soyuz TM 29 1 Russia-Soyuz TM 30	1 ***GlobalStar 01 - 3*** 1 ***GlobalStar 02 - 3*** 1 ***GlobalStar 03 - 3*** 1 Russia-Cosmos 1 Russia-Progress M41 1 Russia-Progress M42 1 Russia-Progress M43 1 Russia-Soyuz TM 31 1 Russia-Soyuz TM 32 1 Russia-Soyuz TM 33	1 Russia-Cosmos 1 Russia-Progress M44 1 Russia-Progress M45 1 Russia-Progress M46 1 Russia-Soyuz TM 34 1 Russia-Soyuz TM 35 1 Russia-Soyuz TM 36		
Zenit							
	HLV	1 Russia-Cosmos	1 ***GlobalStar 01 - 12*** 1 ***GlobalStar 02 - 12*** 1 Russia-Resurs	1 ***GlobalStar 03 - 12*** 1 Russia-Meteor 3M	1 Russia-Okean O-N1		
Russia-Plesetsk/Svobodny							
Cosmos							
	MLV	1 Russia-Cosmos 2341 1 Russia-Cosmos 2346	1 Russia-Cosmos 1 Russia-Cosmos	1 Russia-Cosmos 1 Russia-Cosmos	1 Russia-Cosmos		
Molniya							
	MLV	1 Russia-Cosmos 2340 1 Russia-Cosmos 2342 1 Russia-Molniya	2 Russia-Cosmos	2 Russia-Cosmos			
Soyuz							
	HLV	1 Russia-Cosmos 2337-9/3 Gonets 1 Russia-Cosmos 2348	1 Russia-Cosmos	1 Russia-Cosmos			
Start							
	Small	1 Russia-Zeya 1 US-Early Bird 1	1 Sweden-Odin 1 US-Early Bird 2				
Tskylon							
	MLV						
INDIA							
PSLV/GSLV							
		1 India-IRS 1D	1 India-IRS P4 1 India-Domestic	2 India-Domestic	1 India-Domestic		
ISRAEL-Palmahim							
Shavit							
			1 Israel-Ofeg 4		1 Israel-Domestic		
Japan							
M-5							
		1 Japan-Test Launch	1 Japan-Luna A	1 Japan-Domestic	1 Japan-Domestic		

TOTAL LAUNCHES

	1997	1998	1999	2000	TOTAL	3 Year Average Rate
Commercial GTO COMSTAC =	28	33	29	33	95	31.7
Non COMSTAC GTO Site =	15	20	25	23	68	22.7
United States Non GTO Ranges =	28	32	18	27	77	25.7
NON-United States Non GTO Ranges =	24	27	25	16	68	22.7
TOTAL =	95	112	97	99	308	102.7

Report of the
COMSTAC Technology & Innovation Working Group

COMMERCIAL SPACECRAFT MISSION MODEL UPDATE

May 1998

APPENDIX C
1988 - 1997 MISSION MODEL - HISTORY

Commercial Space Transportation Advisory Committee (COMSTAC)
Office Of Commercial Space Transportation
Federal Aviation Administration
U. S. Department of Transportation

C. 1988 –1997 MISSION MODEL HISTORY

This Appendix contains the following figure and tables:

> **Figure C.1. Summary of Total Launches –** This figure plots the total number of vehicle launches in the various spacecraft categories defined in Tables C.1 through C.5 that were performed in the period 1988 through 1997.
>
> **Table C.1. 1998 Mission Model History – Commercial GTO Mission Model -** This is the history of the worldwide addressable commercial spacecraft launch demand to GTO during the period 1988 to 1997.
>
> **Table C.2. 1988-1997 Missions Not Included in the COMSTAC Commercial GTO Mission Model – Used GTO Launch Site** - This is the history of the worldwide non-addressable spacecraft launch demand that utilized the same launch systems and launch sites that are used for the addressable Commercial GTO Mission Model, Table C.1.
>
> **Table C.3. 1988-1997 Missions Not Included in the COMSTAC Commercial GTO Mission Model – Used United States Non-GTO Launch Sites** – This is the history of the worldwide non-addressable spacecraft launch demand that utilized domestic launch sites not used for the addressable commercial launches to GTO in Table C.1
>
> **Table C.4. 1988-1997 Missions Not Included in the COMSTAC Commercial GTO Mission Model – Used Foreign Launch Sites** – This is the history of the worldwide non-addressable spacecraft launch demand that utilized foreign launch sites not used for the addressable commercial launches to GTO in Table C.1.
>
> **Table C.5. 1988-1997 Spacecraft Summary (All Launch Sites) –** This table summarizes the history of commercial and non-commercial spacecraft launches from 1988 to 1997 as presented in Tables C.1 through C.4.

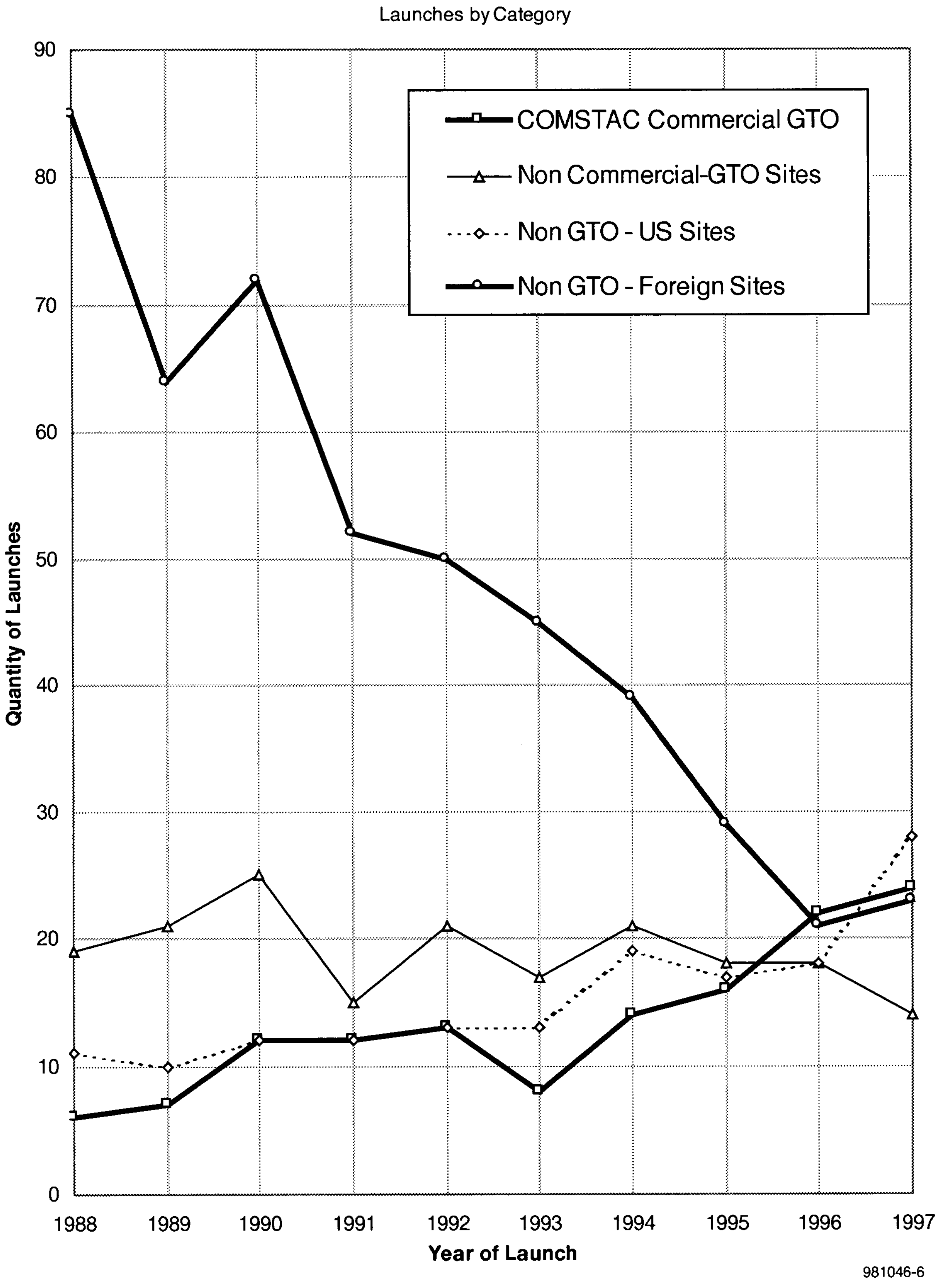

Figure C.1. Summary of Total Launches (1988-1997)

Table C.1. 1998 Mission Model History - Commercial GTO Mission Model

		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	TOTAL	Average Rate
TOTAL =		9	8	18	14	17	10	18	18	26	28	166	16.6
Arianespace		9	7	9	8	9	8	12	9	14	15	100	10.0
	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 E1 1 Canada-Telesat Anik E2 1 Intelsat 601 1 Intelsat 605 1 Luxembourg-SES Astra 1B	1 US-Hughes Galaxy 7 1 Japan-SCC Superbird B1 1 Japan-SCC Superbird A1	1 Intelsat 701 1 Luxembourg-SES Astra 1C 1 Mexico-Solidaridad 1 1 US-Hughes DBS 1 1 US-Hughes Galaxy 4	1 Intelsat 702	1 Intelsat 706A 1 Japan-NStar CS-4A	1 Intelsat 707A 1 Intelsat 709	1 Intelsat 801 1 Intelsat 802 1 Intelsat 803 1 Intelsat 804 1 US-GE Americom GE2 1 US-PAS 6		
	ILV	1 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 India-Insat 2A 1 Spain-Hispasat 1A	1 India-Insat 2B 1 Spain-Hispasat 1B	1 Brazil-Brazilsat B1 1 Eutelsat-II F5 1 Luxembourg-SES Astra 1 1 Mexico-Solidaridad 2 1 Turkey-Turksat 1A 1 Turkey-Turksat 1B 1 US-AT&T Telstar 402 1 US-Panamsat 2 1 US-Panamsat 3	1 Brazil-Brazilsat B2 1 Eutelsat 206 Hotbird 1 1 India-Insat 2C 1 Luxembourg-SES Astra 1E 1 US-AT&T Telstar 402R 1 US-Hughes DBS 3 1 US-PAS 4	1 Arabsat 2A 1 Arabsat 2B 1 Canada-TMI MSat M1 1 Indonesia-Palapa C2 1 Italy-Italsat 2 1 Japan-NStar CS-B 1 Turkey-Turksat 1C 1 US-Echo Star 2 1 US-PAS 3R	1 Argentina-Nahuel 3 1 Eutelsat-Hotbird 3 1 India-Insat 2D 1 Inmarsat 304 1 Japan-JCSat 5 (1R) 1 Sweden-Sirius 2 1 Thailand-Thaicom 3		
	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-GE Satcom C3 1 Arabsat 1C 1 Inmarsat 2 F4	1 Thailand-Thaicom 1	1 Thailand-Thaicom 2 1 Japan-NHK BS 3N		1 Israel-Amos 1 1 Malaysia-MeaSat 1 1 Malaysia-MeaSat 2	1 Indonesia-Indostar 1 1 Japan-BSat 1A		
Atlas		0	0	0	2	3	1	3	5	5	6	25	2.5
	HLV							1 Intelsat 703	1 Intelsat 704 1 Intelsat 705		1 Japan-SCC- Superbird C		
	ILV				1 Eutelsat 203	1 Intelsat K1	1 US-AT&T Telstar 401	1 US-Hughes DBS 2 1 US-Orion 1	1 Japan-JSat 3 1 US-AMSC MSat M2 1 US-Hughes Galaxy 3R	1 Eutelsat-Hotbird 2 1 Indonesia-Palapa C1 1 Inmarsat 301 1 Inmarsat 303 1 US-GE Americom GE1	1 Japan-JSat 4 1 US-Echostar 3/DBSC 1 1 US-GE Americom GE 3 1 US-PAS Galaxy 8I 1 US-TCI Tempo FM 2		
	MLV				1 Japan-NHK BS 3H	1 US-Hughes Galaxy 1R 1 US-Hughes Galaxy 5							
Delta		0	1	4	4	3	1	1	1	2	1	18	1.8
	ILV												
	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) (1 US-GTE Spacenet (ACS 2) 4	1 Germany-DBP DFS 3 1 Indonesia-Palapa B4 1 US-GE Satcom C4	1 NATO 4B	1 US-Hughes Galaxy1R/2	1 KoreaSat 1	1 KoreaSat 2 1 US-Hughes Galaxy 9	1 Norway-Thor 2A		
H-IIA		0	0	0	0	0	0	0	0	0	0	0	0.0
	HLV												
	ILV												
	MLV												
Long March		0	0	1	0	2	0	2	3	3	2	13	1.3
	HLV									1 Intelsat 708A	1 Philippine-Mabuhay 1		
	ILV					1 Australia-Optus B1 1 Australia-Optus B2		1 Australia-Optus B3	1 China-APStar 2 1 China-Asiasat 2 1 US-Echo Star 1				
	MLV			1 China-Asiasat 1				1 China-APStar 1		1 China-APStar 1A 1 China-Chinasat 7	1 China-APStar 2R		
Proton		0	0	0	0	0	0	0	0	2	4	6	0.6
	HLV										1 China-Asiasat 3 1 Luxembourg-SES Astra 1G 1 US-PAS 5 1 US-Loral Telstar 5		
	ILV									1 Inmarsat 302 1 Luxembourg-SES Astra 1F			
Zenit 3 SL		0	0	0	0	0	0	0	0	0	0	0	0.0
	HLV												
	ILV												
Titan 3		0	0	4.001	0	0	0	0	0	0	0	4.001	0.4
	HLV			1 Intelsat 603 1 Intelsat 604									
	ILV			1 Japan-JCSat 2									
	MLV			1 UK-Skynet 4A									

Legend:

▭	Spacecraft failed to reach operating status as planned
⬚	Spacecraft partially failed after achieving operating status

Table C.2.   1988-1997 Missions Not Included in the COMSTAC Commercial GTO Mission Model - Used GTO Launch Sites

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	TOTAL	Average Rate
TOTAL =	**27**	**27**	**30**	**20**	**25**	**20**	**29**	**25**	**22**	**27**	**252**	**25.2**
Ariane	**3**	**3**	**2**	**4**	**2**	**2**	**0**	**4**	**5**	**1**	**26**	**2.6**
	1 ESA-Meteosat 3 1 France-TDF 1 1 France-Telecom 1C	1 ESA-Olympus 1 1 ESA-Hipparcos 1 ESA-Meteosat 4	1 France-Spot 2 1 France-TDF 2	1 ESA-ERS 1 1 ESA-Meteosat 5 1 France-Telecom 2A 1 US-OSC-Orbcom	1 France-Telecom 2B 1 NASA-TOPEX	1 Eumetsat-Meteosat 6 1 France-Spot 3		1 ESA-ERS 2 1 ESA-ISO 1 France-Helios 1 1 France-Telecom 2C	4 ESA-European Cluster 1 France-Telecom 2D	1 Eumetsat-Meteosat(MOP4) 7		
Atlas	**0**	**1**	**1**	**0**	**2**	**4**	**2**	**6**	**2**	**2**	**20**	**2.0**
		1 US Navy Fltsatcom 8	1 US-NASA/AF CRESS		1 USAF-DSCS 3 B01 1 USAF-DSCS 3 B02	1 US-AF DSCS 3-03 1 US-AF DSCS 3-04 1 USN-UHF F01 1 USN-UHF F02	1 US-Navy UHF F03 1 US-NOAA Goes 8	1 ESA-SOHO 1 US-AF DSCS 3-05 1 US-NASA/NOAA Goes J 1 US-Navy UHF/EHF F04 1 US-Navy UHF/EHF F05 1 US-Navy UHF/EHF F06	1 ESA-SAX-Astronomy 1 US-N-UHF/EHF F07	1 US-AF-DSCS 3-06 1 US-NASA/NOAA-Goes K		
Delta	**1**	**6**	**8**	**2**	**8**	**6**	**3**	**0**	**6**	**4**	**44**	**4.4**
	1 US-AF DM43-ThrustVec	1 US-AF Delta Star 1 US-AF GPS Navstar 01 1 US-AF GPS Navstar 02 1 US-AF GPS Navstar 03 1 US-AF GPS Navstar 04 1 US-AF GPS Navstar 05	1 Germany-Rosat-X Ray 1 US-AF GPS Navstar 06 1 US-AF GPS Navstar 07 1 US-AF GPS Navstar 08 1 US-AF GPS Navstar 09 1 US-AF GPS Navstar 10 1 US-AF LowPwrAtmosCom 1 US-AF RelayMirrorExp	1 US-AF GPS-Navstar 11 1 US-AF LOSAT (SDI)	1 Japan-Geotail 1 US-AF GPS Navstar 12 1 US-AF GPS Navstar 13 1 US-AF GPS Navstar 14 1 US-AF GPS Navstar 15 1 US-AF GPS Navstar 16 1 US-AF GPS Navstar 17 1 US-NASA EUVE	1 US-AF GPS 2 Blk 2 01 1 US-AF GPS 2 Blk 2 02 1 US-AF GPS 2 Blk 2 03 1 US-AF GPS 2 Blk 2 04 1 US-AF GPS 2 Blk 2 05 1 US-AF GPS Navstar 18	1 NASA-Wind 1 US-AF GPS 2 Block 2 06 1 US-AF SEDS		1 US-AF-GPS 2-Block 2-0 1 US-AF-GPS 2-Block 2-0 1 US-AF-GPS 2-Block 2-1 1 US-NASA-Mars Global 1 US-NASA-MESUR Pathfinder 1 US-NASA-NEAR	1 US-AF-GPS 2-Block 2-28 1 US-AF-GPS 2R-01 1 US-AF-GPS 2R-02 1 US-NASA-ACE		
Japan	**2**	**1**	**2**	**1**	**1**	**0**	**2**	**2**	**1**	**1**	**13**	**1.3**
	1 Japan-CS 3A 1 Japan-CS 3B	1 Japan-GMS 4	1 Japan-BS 3A 1 Japan-MOS 1B	1 Japan-BS 3B	1 Japan-JERS		1 Japan-ETS 6 1 Japan-OREX	1 Japan-GMS 1 Japan-SFU	1 Japan-ADEOS	1 Japan-ETS-7/TRMM		
Long March	**2**	**0**	**2**	**1**	**0**	**0**	**3**	**0**	**0**	**2**	**10**	**1.0**
	1 China-DDH 201 1 China-DFH 202		1 China-DFH 203 1 Pakistan-Badar 1	1 China-DFH 204			1 China-DFH 301 2 China-SJ 4			1 China-DFH 302 1 China-Fen Yun 2		
Proton	**19**	**16**	**15**	**12**	**12**	**8**	**19**	**13**	**8**	**17**	**139**	**13.9**
	1 Ekran 18 1 Ekran 19 1 Gorizont 1 Gorizont 15 1 Gorizont 16 1 Raduga 11 3 Russia-Cosmos/Glonass 10 Russia-Mil/Science	1 Gorizont 17 1 Gorizont 18 1 Gorizont 19 1 Raduga 1-1 1 Raduga 23 1 Raduga 24 10 Russia-Mil/Science	1 Ekran 1 Gorizont 20 1 Gorizont 21 1 Gorizont 22 1 Raduga 1-2 1 Raduga 25 1 Raduga 26 8 Russia-Mil/Science	1 Gorizont 23 1 Gorizont 24 1 Raduga 27 1 Raduga 28 8 Russia-Mil/Science	1 Ekran 20 1 Gorizont 25 1 Gorizont 26 1 Gorizont 27 8 Russia-Mil/Science	1 Gorizont 1 Gorizont 28 1 Gorizont 29-Rimsat 1 Raduga 29 1 Raduga 30 3 Russia-Mil/Science	1 Express 01 1 GALS 1 1 Gorizont 30-Rimsat 1 Luch 1 1 Raduga 1-3 1 Raduga 31 1 Raduga 32 12 Russia-Mil/Science	1 GALS 2 1 Luch 1-1 11 Russia-Mil/Science	1 Russia-Express 02 1 Russia-Gorizont 31 1 Russia-Gorizont 32 1 Russia-Raduga 33 3 Russia-Mil/Science 1 Mars Mission	7 ***Iridium 01 - 7*** 7 ***Iridium 02 - 7*** 1 Russia-Cosmos 2344 1 Russia-Cosmos 2345 1 ***Russia-Coupon 01 - 1***		

Legend: ☐ **Spacecraft failed to reach operating status as planned**

⬚ **Spacecraft partially failed after achieving operating status**

Table C.3. 1988-1997 Missions Not Included in the COMSTAC Commercial GTO Mission Model - Used UNITED STATES Non-GTO Launch Sites

		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	TOTAL	Average Rate
United States Ranges													
TOTAL =		16	18	25	26	18	19	23	23	22	61	251	25.1
Eastern Ranges													
STS		4	11	11	11	13	11	10	11	10	8	100	10.0
	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-5 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-US AF MPEC-AF P6 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 14)	1 US-STS-042 Discovery 1 US-STS-045 Atlantis 1 US-STS-049 Endeavour 1 US-STS-050 Columbia 1 US-STS-046 Atlantis 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)	1 US-STS-054 Endeavour 1 US-NASA TDRS F 1 US-STS-056 Discovery 1 US-NASA Spartan 1 US-STS-055 Columbia 1 US-STS-057 Endeavour 1 US-STS-051 Discovery 1 US-NASA ACTS 1 German-Orgeus-Spas 1 US-STS-058 Columbia 1 US-STS-060 Discovery	1 US-STS-060 Discovery 1 US-STS-062 Columbia 1 US-STS-059 Endeavour 1 US-STS-065 Columbia 1 US-NASA-Intl Micrograv 1 US-STS-064 Discovery 1 US-NASA-Spartan 1 US-STS-068 Endeavour 1 US-STS-066 Atlantis 1 US-NASACrista-SPAS	1 US-STS-063 Discovery 1 US-NASA-Spartan 1 US-STS-067 Endeavour 1 US-STS-071 Atlantis 1 US-STS-070 Discovery 1 US-NASA TDRS G 1 US-STS-069 Endeavour 1 US-NASA-Spartan 1 US-NASA WSF 2 1 US-STS-073 Columbia 1 US-STS-074 Atlantis	1 US-STS-072 Endeavour 1 US-NASA-Spartan 1 US-STS-075 Columbia 1 US-NASA-Spartan 1 US-STS-076 Atlantis 1 US-STS-077 Endeavour 1 US-STS-078 Columbia 1 US-STS-079 Atlantis 1 US-STS-080 Columbia 1 US-NASA WSF 3	1 US-STS081-Atlantis 1 US-STS082-Discovery 1 US-STS083-Columbia 1 US-STS084-Atlantis 1 US-STS085-Discovery 1 US-STS086-Atlantis 1 US-STS087-Columbia 1 US-STS094-Columbia		
Athena		0	0	0	0	0	0	0	0	0	0	0	0.0
	Small												
Pegasus		0	0	0	0	0	2	0	0	2	10	14	1.4
	Small						1 US-Orbcomm/CDS 1 Brazil-SCD			1 Argentina-SAC-B 1 US-SAC-B/HETE	1 Spain-Minisat 8 US-Orbcomm 1-8 1 US-Step 4		
Taurus		0	0	0	0	0	0	0	0	0	0	0	0.0
	Small												
Titan		1	5	6	0	1	0	4	4	3	3	27	2.7
	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 13) 1 US-AF Titan 4 (DSP 16)	1 US-AF Titan 4 (DSP 15) 1 US-AF Titan 4 (DSP 17) 1 US-AF Titan 4 (NOSS) 3 US-AF Titan 4 (NOSS)		1 US-NASA T3 Mars Observer		1 US-AF T4 (Adv Jumpseat 1 US-AF T4 (DoD) 1 US-AF T4 (DSP 17) 1 US-AF T4 (Milstar 1)	1 US-AF T4 (Adv Jumpseat 1 US-AF T4 (DoD) 1 US-AF T4 (DoD) 1 US-AF T4 (Milstar 2)	1 US-AF T4 (Adv Jumpseat 1 US-AF T4 (DoD) 1 US-AF T4 (DoD)	1 US-AF T4 DSP 18 1 US-NASA T4 Cassini 1 US-NRO T4 Trumpet		
United States-Vandenberg Test Center													
Athena		0	0	0	0	0	0	0	1	0	1	2	0.2
	Small								1 US-GEMStar (Vita Sat)		1 US-NASA-Lewis		
Atlas		2	0	4	2	0	1	2	1	0	0	12	1.2
	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 US-NOAA 13	1 US-AF DMSP F12 1 US-NOAA 14	1 US-AF DMSP F13				
Delta		0	1	0	0	0	0	0	2	2	30	35	3.5
	MLV		1 US-AF Cos Bkgnd Exp						1 Canada-Radarsat 1 US-NASA-XTE	1 US-AF-Midcourse Space 1 US-NASA-Polar	5 ***Iridium 01 - 05*** 5 ***Iridium 02 - 05*** 5 ***Iridium 03 - 05*** 5 ***Iridium 04 - 05*** 5 ***Iridium 05 - 05*** 5 ***Iridium 06 - 05***		
Pegasus		0	0	2	7	0	1	3	4	4	6	27	2.7
	Small			1 US-Pegsat 1 US-SECS	1 US-SARA 6 US-DARPA Sats		1 US-Alexis	1 US-APEX 1 US-Step 1 1 US-Step 2 (P-91)	1 US-Orbcomm 2 US-Orbcomm 1 US-Step 3 (P92-2)	1 US-FAST 1 US-MSTI 3 1 US-REX II 1 US-TOMS CP	1 US-Orbview 1 US-FORTE 2 US-Orbcomm 01-2 2 US-Orbcomm 02-2		
Scout		6	0	2	1	2	1	1	0	0	0	13	1.3
	Small	5 Domestic 1 San Marcos		2 Domestic	1 Domestic	2 Domestic	1 Domestic	1 Domestic					
Taurus		0	0	0	0	0	0	2	0	0	0	2	0.2
	Small							1 US-STEP/TAOS 1 US-DarpaSat					
Titan		3	1	0	5	2	3	1	0	1	3	19	1.9
	HLV	2 US-AF T34D (KH-11)			1 US-AF T4 (Lacrosse) 4 US-AF T4 (NOSS)	1 US-AF T4 (KH-12)	2 US-AF T4 (NOSS)			1 US-AF T4	1 US-Lacrosse K18		
	MLV	1 US-AF T2 (Ferrett)	1 US-AF T2 (Ferrett)			1 US-AF T2 (DoD)	1 US-NASA T2 (Landsat 6)	1 US-NASA T2 (Clementine)			1 US-AF (DMSP 38) 1 US-NASA-TIROS		

Legend:

☐ **Spacecraft failed to reach operating status as planned**

⬚ **Spacecraft partially failed after achieving operating status**

Table C.4. 1988-1997 Missions Not Included in the COMSTAC Commercial GTO Mission Model - Used FOREIGN Launch Sites

		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	TOTAL	Average Rate
Non-United States Ranges													
TOTAL =		97	81	89	75	67	56	49	33	28	34	609	60.9
China-Taiyuan/Jiyuan													
Long March		2	0	2	0	2	1	1	0	1	5	14	1.4
	ILV												
	MLV	1 China-FSW 1-01 1 China-FenYun 1A		1 China-FenYun 2 1 China-FSW 1-02		1 China-FSW 1-03 1 China-FSW 1-04	1 China-FSW 2-01	1 China-FSW 2-02		1 China-FSW 2-03	1 China-FSW 1C 2 ***Iridium Sim-02*** 2 ***Iridium 01 - 2***		
India													
PSLV/GSLV		1	0	0	0	1	1	2	0	1	1	7	0.7
		1 India-SROSS 2				1 India-SROSS C	1 India-IRS 1E	1 India-IRS P2 1 India-SROSS C		1 India-IRS P3	1 India-IRS 1D		
Israel													
Shavit		1	0	1	0	0	0	0	1	0	0	3	0.3
	Small	1 Israel-Horizon		1 Israel-Ofeg 2					1 Israel-Ofeq 3				
Japan													
M-3S/M-5		0	1	1	1	0	1	0	1	0	1	6	0.6
	Small		1 Japan-Exos	1 Japan-Hagoromo	1 Japan-Solar		1 Japan-Asuka		1 Japan-Express		1 Japan-Test Launch		
Russia-Baikonur													
Energia		1	0	0	0	0	0	0	0	0	0	1	0.1
	HLV	1 Russia-Buran											
Molniya		1	0	0	1	0	0	0	2	0	0	4	0.4
	MLV	1 Russia-Domestic			1 Russia-Domestic				1 Russia-Domestic 1 Russia-Domestic				
Rockot		0	0	0	0	0	0	1	0	0	0	1	0.1
	Small							1 Russia-Domestic					
Soyuz		22	13	12	12	11	10	11	8	6	8	113	11.3
	HLV	3 Russia-MIR Manned 6 Russia-MIR Supply 13 Russia-Domestic	1 Russia-MIR Manned 4 Russia-MIR Supply 8 Russia-Domestic	3 Russia-MIR Manned 4 Russia-MIR Supply 5 Russia-Domestic	2 Russia-MIR Manned 5 Russia-MIR Supply 5 Russia-Domestic	2 Russia-MIR Manned 5 Russia-MIR Supply 4 Russia-Domestic	2 Russia-MIR Manned 5 Russia-MIR Supply 3 Russia-Domestic	3 Russia-MIR Manned 5 Russia-MIR Supply 3 Russia-Domestic	2 Russia-MIR Manned 5 Russia-MIR Supply 1 Russia-Domestic	2 Russia-MIR Manned 3 Russia-MIR Supply 1 Russia-Domestic	1 Russia-Cosmos 2343 1 Russia-Photon 1 Russia-Progress M34 1 Russia-Progress M35 1 Russia-Progress M36 1 Russia-Progress M37 1 Russia-Soyuz TM 25 1 Russia-Soyuz TM 26		
Tskylon		3	3	4	0	0	4	0	4	1	1	20	2.0
	MLV	3 Russia-Domestic	3 Russia-Domestic	4 Russia-Domestic			4 Russia-Domestic		2 Russia-Domestic 1 Chili-Fiasat 1 Russia-Domestic	1 Russia-Domestic	1 Russia-Cosmos 2347		
Vostok		2	0	0	0	0	0	0	0	0	0	2	0.2
	MLV	1 India-IRS 1A 1 Russia-Domestic											
Zenit		2	0	2	1	3	2	4	1	1	1	17	1.7
	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	1 Russia-Cosmos 2237 1 Russia-Cosmos 2263	1 Russia-Cosmos 2278 1 Russia-Cosmos 2290 1 Russia-Resurs 1 1 Russia-Cosmos 2297	1 Russia-Cosmos 2322	1 Russia-Cosmos 2333	1 Russia-Cosmos		
Russia-Plesetsk													
Cosmos		14	16	17	20	14	6	5	7	10	2	111	11.1
	MLV	14 Russia-Domestic	16 Russia-Domestic	17 Russia-Domestic	19 Russia-Domestic 1 Russia-Domestic	14 Russia-Domestic	6 Russia-Domestic	5 Russia-Domestic	7 Russia-Domestic	10 Russia-Domestic	1 Russia-Cosmos 2341 1 Russia-Cosmos 2346		
Molniya		10	5	12	4	8	8	3	4	5	3	62	6.2
	MLV	10 Russia-Domestic	5 Russia-Domestic	11 Russia-Domestic 1 India-IRS 1B	4 Russia-Domestic	8 Russia-Domestic	8 Russia-Domestic	3 Russia-Domestic	3 Russia-Domestic 1 Czech-Magion 4	4 Russia-Domestic 1 Czech-Magion 5	1 Russia-Cosmos 2340 1 Russia-Cosmos 2342 1 Russia-Molniya		
Soyuz		23	25	20	12	13	7	4	4	3	10	121	12.1
	HLV	20 Russia-Domestic 3 Russia-Domestic	25 Russia-Domestic	18 Russia-Domestic 2 Russia-Domestic	12 Russia-Domestic	13 Russia-Domestic	7 Russia-Domestic	4 Russia-Domestic	4 Russia-Domestic	2 Russia-Domestic 1 Russia-Domestic	9 Russia-Cosmos 2337-9/3 Gonets 1 Russia-Cosmos 2348		
Start		0	0	0	0	0	1	0	1	0	2	4	0.4
	Small						1 Russia-Domestic		1 Israel-Gurwin		1 Russia-Zeya 1 US-Early Bird 1		
Tskylon		15	18	18	24	15	15	18	0	0	0	123	12.3
	MLV	15 Russia-Domestic	18 Russia-Domestic	18 Russia-Domestic	23 Russia-Domestic 1 Czech-Magion 3	15 Russia-Domestic	15 Russia-Domestic	17 Russia-Domestic 1 Russia-Domestic					

Legend:

☐ **Spacecraft failed to reach operating status as planned**

⬚ **Spacecraft partially failed after achieving operating status**

Table C.5. 1988-1997 Spacecraft Summary (All Launch Sites)

All Launch Sites

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	TOTAL	Average Rate
COMSTAC Commercial GTO =	9	8	18	14	17	10	18	18	26	28	166	16.6
Non Commercial GTO Site =	27	27	30	20	25	20	29	25	22	27	252	25.2
Non GTO US Sites =	16	18	25	26	18	19	23	23	22	61	251	25.1
Non GTO Foreign Sites =	97	81	89	75	67	56	49	33	28	34	609	60.9
TOTAL =	149	134	162	135	127	105	119	99	98	150	1278	127.8