Commercial Space Transportation

QUARTERLY LAUNCH REPORT

Featuring the launch results from the previous quarter and forecasts for the next two quarters

4th Quarter 1998

United States Department of Transportation • Federal Aviation Administration

Associate Administrator for Commercial Space Transportation

4TH QUARTER 1998 REPORT

Objectives

This report summarizes recent and scheduled worldwide commercial, civil, and military orbital space launch events. Scheduled launches listed in this report are vehicle/payload combinations that have been identified in open sources, including industry references, company manifests, periodicals, and government documents. Note that such dates are subject to change.

This report highlights commercial launch activities, classifying commercial launches as one or more of the following:

- ***Internationally competed launch events (i.e., launch opportunities considered available in principle to competitors in the international launch services market),***
- ***Any launches licensed by the Office of the Associate Administrator for Commercial Space Transportation of the Federal Aviation Administration under U.S. Code Title 49, Section 701, Subsection 9 (previously known as the Commercial Space Launch Act), and***
- ***Certain European launches of post, telegraph and telecommunications payloads on Ariane vehicles.***

Photo credit: Boeing (1998). Image is of the Delta 2 7920 launch on September 8, 1998 from Vandenberg Air Force Base. The commercial launch successfully deployed five Iridium satellites to low Earth orbit in the tenth Delta 2 launch for the Iridium system.

CONTENTS

This document was released on October 20, 1998.

SUMMARY

Third Quarter 1998 Launch Events

- In the third quarter of 1998, the United States conducted five launches. Four launches were commercial (one Delta 2, one Delta 3, and two Pegasus) and one was non-commercial (a Titan 4). Of these launches, two were failures (the Delta 3 and the Titan 4). The Delta 3 failed to deploy the Galaxy 10 communications satellite due to a guidance system failure, and the Titan 4 failed to deploy a classified payload due to a power loss to a guidance system.
- There were seven Russian launches in this period, two of which were commercial. The two commercial launches were of one Proton and one Shtil. The remaining five non-commercial launches consisted of two Molniya, one Soyuz, and two Zenit launches. All launches were successful.
- Europe conducted two successful commercial launches of Ariane vehicles with no failures.
- China launched two Long March vehicles, one commercial and one non-commercial, with both launches successful.
- Japan launched one successful non-commercial launch of the M 5 launch vehicle.
- One Ukrainian commercial Zenit 2 failed to deploy 12 Globalstar satellites due to a second stage malfunction.
- North Korea attempted one non-commercial launch of Taepo Dong 1 which failed to orbit its payload.

Fourth Quarter 1998 and First Quarter 1999 Scheduled Launch Events

- The United States plans to make 31 launches in the next two quarters. Of these, 16 launches will be commercial: one Athena 1 and two Athena 2, five Atlas 2 and one Atlas 3, three Delta 2 and one Delta 3, two Pegasus and one Sea Launch. Non-commercial launches will consist of five Delta 2, two Pegasus, three Shuttle launches, one Taurus, one Titan 2, and three Titan 4 launches.
- Russian launch vehicles are scheduled to make 15 launches, 11 of which are commercial. These commercial launches are on six Proton, four Soyuz, and one START. Non-commercial launches will include two Soyuz, one Proton, and one Cosmos.
- One Ukrainian non-commercial Zenit will be launched.
- Europe plans six commercial Ariane 4 launches and two launches of the Ariane 5, one commercial and one non-commercial.
- China intends to launch three Long March vehicles, one of which will be commercial.
- India will conduct a non-commercial launch of the PSLV.

SUMMARY

Commercial Products and Services

Fourth Quarter 1998
and First Quarter 1999

Three More Launch Systems to Make Commercial Debut

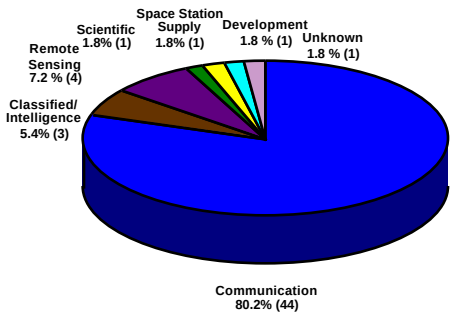
Three major launch systems will make their commercial debut during the next two quarters. The Lockheed Martin Atlas 3A will make its first flight in March 1999. The vehicle is capable of lifting 8,940 pounds to geosynchronous transfer orbit and has a first stage powered by the Russian-designed RD-180 engine. The RD-180 engine is co-produced by RD AMROSS, a joint venture formed by NPO Energomash and Pratt & Whitney. The first flight of the Atlas 3A will launch Loral Skynet's Telstar 7 satellite.

The first flight of the Sea Launch vehicle is also scheduled for March. Sea Launch, a multi-national partnership led by Boeing, will launch the Ukrainian-manufactured Zenit vehicle from on ocean platform south of Hawaii. Sea Launch is capable of lofting 11,050 pounds into geosynchronous transfer orbit. The first flight is scheduled to deploy the Galaxy 11 satellite for PanAmSat, although press reports suggest a flight of a dummy test payload may be substituted for the inaugural launch.

The Ariane 5 vehicle is scheduled to make its final developmental flight in late October, followed by its first commercial launch in January. The first commercial launch is expected to carry Asiastar 1 for Worldspace, Inc., and Telkom 1 for PT Telekom of Indonesia. The Ariane 5 is capable of placing 15,000 pounds into geosynchronous transfer orbit.

Payload Use Analysis

Third Quarter 1998



In the third quarter of 1998, there were 55 payloads launched worldwide. These payloads were divided between communications (80.2 percent), intelligence/classified (5.4 percent), remote sensing (7.2 percent), scientific (1.8 percent), development (1.8 percent), space station supply (1.8 percent), and unknown (1.8 percent).

Communications payloads constituted all of the 25 internationally competed payloads on commercial launches.

LAUNCH SCHEDULE

Scheduled Launch Events

Vehicle	Payload	Site
OCTOBER 1998		
Ariane 44L	Eutelsat W2 Sirius 3	Kourou
Ariane 44L	Afristar 1 GE 5	Kourou
Ariane 5	ARD Maqsat 3	Kourou
Atlas 2AS	Hot Bird 5	CCAS
Atlas 2A	GBS 9	CCAS
Delta 2 7920	Iridiums 83-87	VAFB
Delta 2 7326	Deep Space 1 Sedsat-1	CCAS
Long March 4	FY-1C	Taiyuan
Shuttle Discovery	STS 95 PANSAT 1 Spartan 201-04R	KSC
Taurus 1	STEX	VAFB
NOVEMBER 1998		
Ariane 42L	SatMex 5	Kourou
Athena 2	IKONOS 1	VAFB
Delta 2 7925	Bonum 1	CCAS
Proton (SL-13)	Zarya	Baikonur
Proton (SL-12)	PAS 8	Baikonur
Soyuz	Globalstars 21-24	Baikonur
Titan 2	QuickSCAT	VAFB
Zenit 2	Okean O1	Baikonur
DECEMBER 1998		
Ariane 42L	PAS 6B	Kourou
Athena 1	Rocsat 1	Spaceport Florida
Atlas 2AS	JCSAT 6	CCAS
Delta 2 7425	Mars Climate Orbiter	CCAS
Delta 2 7925	Argos Oersted Sunsat	VAFB
Proton (SL-12)	Tempo 1	Baikonur
Shuttle Discovery	STS 88 Unity MightySat 1 Press. Mating A 1&2 SAC A	KSC
Titan 4B/IUS	DSP 19	CCAS

LAUNCH SCHEDULE

Scheduled Launch Events

(Continued)

Vehicle	Payload	Site
JANUARY 1999		
Ariane 5	AsiaStar 1 Telkom 1	Kourou
Atlas 2AS	ICO 1	CCAS
Cosmos	Abrixas MegSat 0	Kapustin Yar
Delta 2 7425	Mars Polar Lander Deep Space 2	CCAS
Long March 3B	Chinasat 8	Xichang
Shuttle Columbia	STS 93 AXAF	KSC
Soyuz	Globalstars 29-32	Baikonur
Titan 4B/Centaur	Milstar II-F1	CCAS
FEBRUARY 1999		
Ariane 44L	Arabsat 3A Skynet 4E	Kourou
Athena 2	IKONOS 2	VAFB
Delta 2 7426	Stardust	CCAS
Delta 3	Orion F3	CCAS
Proton (SL-12)	Sesat	Baikonur
Proton (SL-12)	Nimiq 1	Baikonur
Soyuz	Soyuz TM-29	Baikonur
MARCH 1999		
Atlas 2AS	Eutelsat W3	CCAS
Atlas 3A	Telstar 7	CCAS
Delta 2 7920	Iridiums 88-92	VAFB
Sea Launch	Galaxy 11	Sea Launch Platform
START 1	Odin	Svobodny
Titan 4B	USA 1999-03	VAFB

LAUNCH SCHEDULE

Additional Launch Events to be Announced*

* This section summarizes launches and payloads that are expected to occur during the next two quarters. Exact launch dates were not available prior to publication of this report

For the Fourth Quarter 1998 and First Quarter 1999

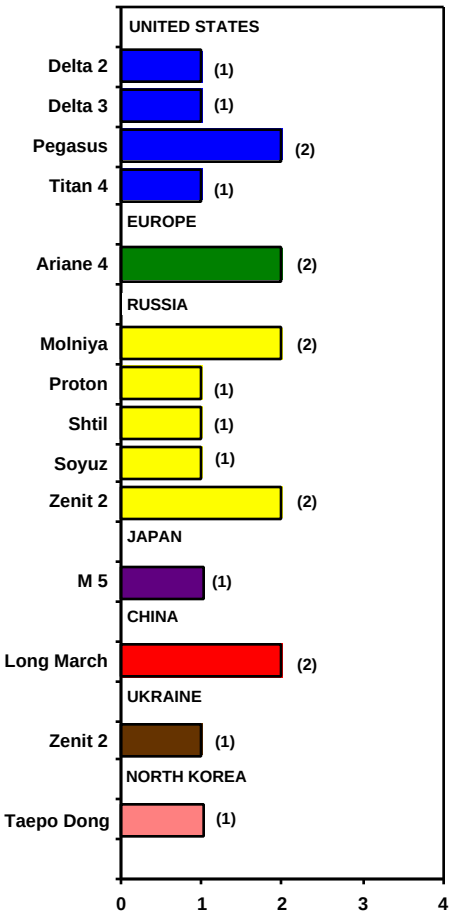
Vehicle	Payload	Site
FOURTH QUARTER OF 1998		
Pegasus XL	SCD 2	CCAS
Pegasus XL	SWAS	VAFB
Proton (SL-12)	Telstar 6	Baikonur
Soyuz	Progress M-40	Baikonur
TR 1A**	JEM Microgravity Test	Tanegashima
FIRST QUARTER OF 1999		
Ariane 4-TBA	Insat 2E	Kourou
Long March 2C	Iridium 93 Iridium 94	Taiyuan
Pegasus XL	TERRIERS Celestis 3 MUBLCOM	VAFB
Pegasus XL	WIRE	VAFB
Proton (SL-12)	Astra 1H	Baikonur
PSLV	IRS P4 Kitsat 3 Tubsat C-DLR	Sriharikota
Soyuz	Globalstars 33-36	Baikonur

** Denotes a suborbital launch

LAUNCH REPORT

Launch Events

Third Quarter 1998



Number of Launches
July - September 1998

In the third quarter, United States launch vehicles made five of the 19 total launches worldwide.

The first flight of the Delta 3 failed to deploy the Galaxy 10 satellite. A roll instability on the Delta 3 led to an oscillation too severe for the vector control systems on the three air-lit solid rocket motors to compensate before running out of hydraulic fluid. The vehicle then began to yaw 25 to 35 degrees and break apart at which point the vehicle self-destructed. Boeing has said that it believes the problem can be corrected by changing the control software.

A Titan 4A failed to deploy a classified satellite for the National Reconnaissance Office. A momentary loss of electrical power to the guidance system was related to the vehicle pitching sharply downward followed by the auto-destruct of the vehicle. It is not clear what caused the loss of electrical power.

A Russian Shtil vehicle deployed Tubsat N and Tubsat N1, two small LEO communications satellites built by the Technical University of Berlin. This was the first space launch from a submarine. Since the early 1990s, various marketing agencies have been trying to sell space launch vehicles based on the variety of existing and proposed sea-launched ballistics missiles built by Makeyev Design Bureau. The first launch of Shtil proves the market potential for future commercial sea-based launches to LEO.

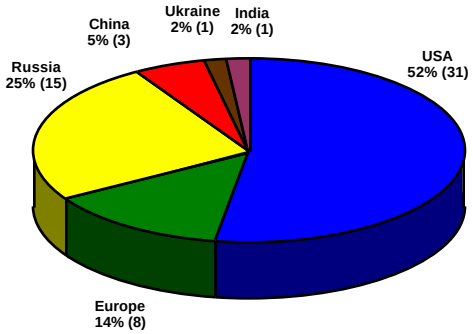
Japan successfully launched one M 5 vehicle carrying a planetary probe. The Nozomi probe (known as Planet-B before launch) will enter into orbit around Mars, making it the first planetary probe to be launched by Japan.

Ukraine's first commercial Zenit launch failed to deploy 12 Globalstar satellites when a computer failure caused the second stage engine to shut down early.

North Korea attempted its first orbital launch using a Taepo Dong 1 vehicle to deploy a small payload which North Korean officials claimed was intended to broadcast patriotic music via a short-wave transmitter. The Taepo Dong 1 uses the first stage of the Nadong 1 medium ballistic missile and a Scud-C derivative as a second stage. No payload has been detected in orbit by a source outside North Korea and is thus considered a failed launch, and the nature of the payload cannot be confirmed.

Scheduled Launch Events

Fourth Quarter 1998
and First Quarter 1999



Scheduled Launch Events, by Region
October 1998 - March 1999

(includes small launch vehicles, excludes sub-orbital launch events)

Fifty-nine orbital launch events are scheduled in the fourth quarter of 1998 and the first quarter of 1999. The United States share of these is 31 launches. Five launches will be on variants of Atlas 2 vehicles each carrying a communications satellite. Of these, four will go to GEO and one to MEO. The first launch of the Atlas 3 will deploy a GEO communications payload. Eight Delta 2 vehicles will carry 11 communications satellites, seven scientific spacecrafts, one experimental satellite, and one developmental satellite. One flight of the Delta 3 will launch a GEO communications satellite. Sea Launch is expected to deploy its first GEO communications satellite. Two Athena 2 vehicles will carry a single remote sensing satellite each, and an Athena 1 will carry a developmental satellite. One Taurus flight will deploy a developmental payload. Two Pegasus launches will carry a single scientific satellite each, a third will deploy a scientific satellite with a small communications satellite and a funerary payload, while a fourth will carry a single communications satellite. There will also be three Shuttle missions. One of these will carry International Space Station (ISS) components and two developmental satellites, another a deployable science satellite and a small communications satellite, and a third shuttle flight will deploy a scientific spacecraft. There will also be one Titan 2 launch with a science satellite and three Titan 4 launches carrying a classified payload, an intelligence payload, and a communications satellite.

Russia plans to launch 15 vehicles. Seven will be Proton rockets, six with communications satellites and one with an ISS component. Six are Soyuz vehicles lofting one crew capsule, one supply flight to Mir, and four flights carrying four Globalstar satellites each. The remaining two launches will be of a Cosmos carrying a communications and a scientific satellite as well as a START carrying a scientific satellite.

Ukraine plans to launch one remote sensing satellite from Russia's Baikonur site.

Europe's Ariane 4 is scheduled to orbit nine GEO communications satellites on six Ariane 4 vehicles. One Ariane 5 developmental launch will carry a dummy satellite and a developmental payload, while a second Ariane 5 will carry two communications satellites.

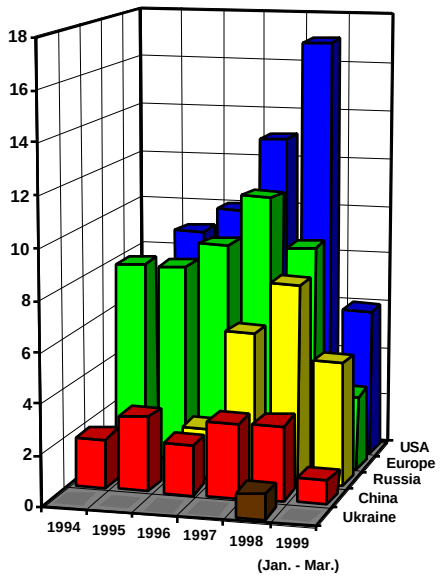
China intends to launch three Long March vehicles, two with communications payloads and one with a meteorological payload.

India is scheduled to launch an IRS remote sensing satellite and two small foreign satellites on a PSLV.

LAUNCH REPORT

Scheduled Commercial Launch Events

Fourth Quarter 1998
and First Quarter 1999



Commercial Launch Events
January 1994 - March 1999
(Small Vehicles Excluded)

Excluding small launch vehicles, 48 launches are planned for the next two quarters. Of these, 29 will be commercial launches. When small launch vehicles are included, this total increases to 59, of which 35 are expected to be commercial. The United States plans to conduct 11 commercial launches (excluding small vehicles). These will consist of five flights of the Atlas 2 family of vehicles launching GEO communications satellites and the first launch of an Atlas 3 also with a GEO communications satellite. The Delta 2 will launch three times commercially, including two launches with five Iridium satellites each and one GEO communications satellite. The Delta 3 is expected to deploy one commercial GEO communications satellite. The first flight of the Sea Launch Zenit 3 from its ocean platform with a GEO communications satellite is also expected. Commercial small vehicle launches will include two launches of Athena 2 vehicles, each of which is to loft a remote sensing satellite, and one Athena 1 which is to carry a developmental payload. One Pegasus vehicle will launch a single communications satellite, and a second Pegasus will carry a scientific satellite along with a small communications satellite and a funerary payload.

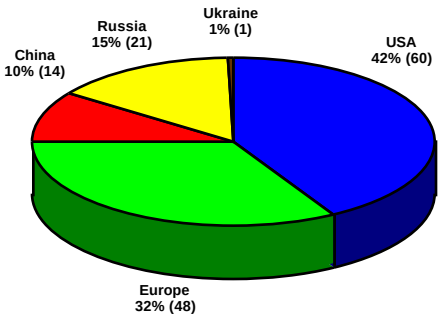
All but one of Europe's eight scheduled launches are commercial. Six commercial launches will be on Ariane 4 vehicles carrying a total of nine GEO communications satellites. One commercial flight of an Ariane 5 will also deploy two GEO communications satellites.

Russia intends to conduct six commercial Proton launches of GEO communications satellites. Four Soyuz vehicles will carry four Globalstar LEO communications satellites each, and one commercial small vehicle launch will deploy a scientific satellite on a START vehicle for a total of 11 commercial launches.

China's one commercial launch will carry two Iridium communications satellites to LEO.

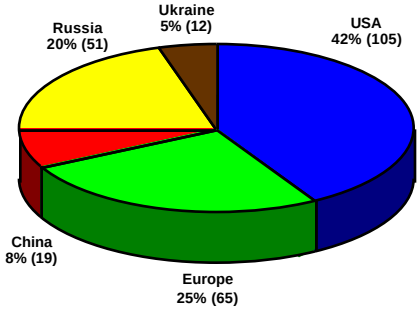
LAUNCH REPORT

Commercial Launch Trends



Commercial Launch Market Trend
January 1994 - March 1999

(Small Vehicles Excluded)



Internationally Competed Payloads
Market Trend
January 1994 - March 1999

(Small Vehicles Excluded)

One hundred forty-four commercial launch events (excluding small launch vehicles) are projected for the period between January 1994 and March 1999. The United States has a 42-percent share, or 60, of these launches. In terms of internationally competed payloads on commercial launches (excluding small launches), the United States will have launched 105 of 252 payloads, for a 42-percent share of payloads.

Europe's portion of the total is 48 launches, for a 32-percent share of launches, and 65 payloads or 25 percent of total payloads.

China will have 14 launches for ten percent of launches, and 19 payloads for 8 percent of the total.

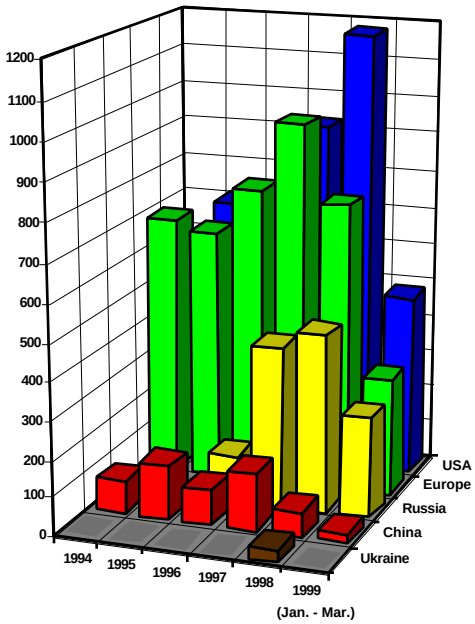
Russia will have conducted 21 commercial launches for a 15-percent share and deployed 51 internationally competed payloads or 20 percent of the total.

Ukraine will have made one commercial launch from Russia's launch site at Baikonur representing just under one percent of launches, to deploy 12 payloads or five percent of total payloads.

In the period covered by this report, July 1998 through March 1999, 36 commercial launches (excluding small launch vehicles) are planned worldwide. It is expected that there will be 73 internationally competed payloads (excluding small launch vehicles). The United States plans 13 launches for 36 percent of these launches and will loft 23 internationally competed payloads for 32 percent of such payloads. Europe plans nine launches (25 percent) and 11 payloads (15 percent). China's share is two launches (five percent) and four payloads (five percent), while Russia's plans include 23 payloads on 11 vehicles for 32 percent of payloads and 31 percent of launches. Ukraine's single launch will account for three percent of commercial launches and their 12 payloads will constitute 16 percent of total internationally competed payloads in the last two quarters of 1998 and the first quarter of 1999.

LAUNCH REPORT

Commercial Launch Revenues



Commercial Launch Revenues by Region
(in US $ Millions)*

January 1994 - March 1999

* Graph reflects approximate revenues based on actual price quotes and historical price averages. Launch vehicle pricing data is currently being verified for historical accuracy, which may affect figures, shown in future quarterly launch reports. Figures here are shown in constant 1994 dollars. Includes small vehicles.

For the year 1998, revenues from commercial launch events are projected to be around $2.5 billion, and approximately $1.1 billion for the first quarter of 1999. Revenues for the period between January 1994 and March 1999 are expected to be approximately $10.4 billion. United States launch providers will have a 42-percent share of these revenues with about $4.3 billion, and European launch providers will have 41 percent with about $4.2 billion. Russian launch providers hold an estimated 12-percent share with about $1.3 billion, and launch services from China will have a five-percent share of about $565 million. Ukraine's single launch will account for less than one percent of revenues at roughly $33 million.

In 1998, United States launch service providers will have about $1.2 billion (47 percent) of the total $2.5 billion. This position reflects the strength of the United States' larger launch vehicles and the growing importance of its small launch vehicles. Russian launch services continue to see an increase in revenue into 1999 with $267 million for the first quarter alone compared to $472 million for all of 1998. This growth is due to the first Soyuz launches of Globalstar LEO satellites in addition to the GEO Proton launches.

Special Report

Update of the Space and Launch Insurance Industry

INTRODUCTION

Insurance is a basic requirement for the maintenance of a commercial space industry. Space activity mishaps can result in hundreds of millions of dollars of expenses. Two recent launch vehicles that failed (a Titan 4A and the initial Delta 3) were valued at $1.3 billion and $225 million respectively (inclusive of payload). The replacement cost of the recently failed Galaxy 4 satellite, for example, was in the range of $200 to $250 million. In addition, consequences of mishaps will typically extend beyond the cost of a satellite and launch vehicle. Business operations can be delayed, possibly resulting in the deferral of a satellite venture's vital revenue streams. With such valuable assets at risk, insurance is essential to mitigate the high cost of a failure.

Certain types of space insurance, such as third party liability insurance, protect the general public from the hazards of space activity. The U.S. Federal Aviation Administration, through the Commercial Space Launch Act Amendments of 1988, requires third party liability insurance as a condition for the issuance of a commercial launch license. Under the 1972 United Nations Convention on International Liability for Damage Caused by Space Objects, governments are liable for injury or damage to third parties, caused by launch vehicles or payloads launched under their jurisdiction.

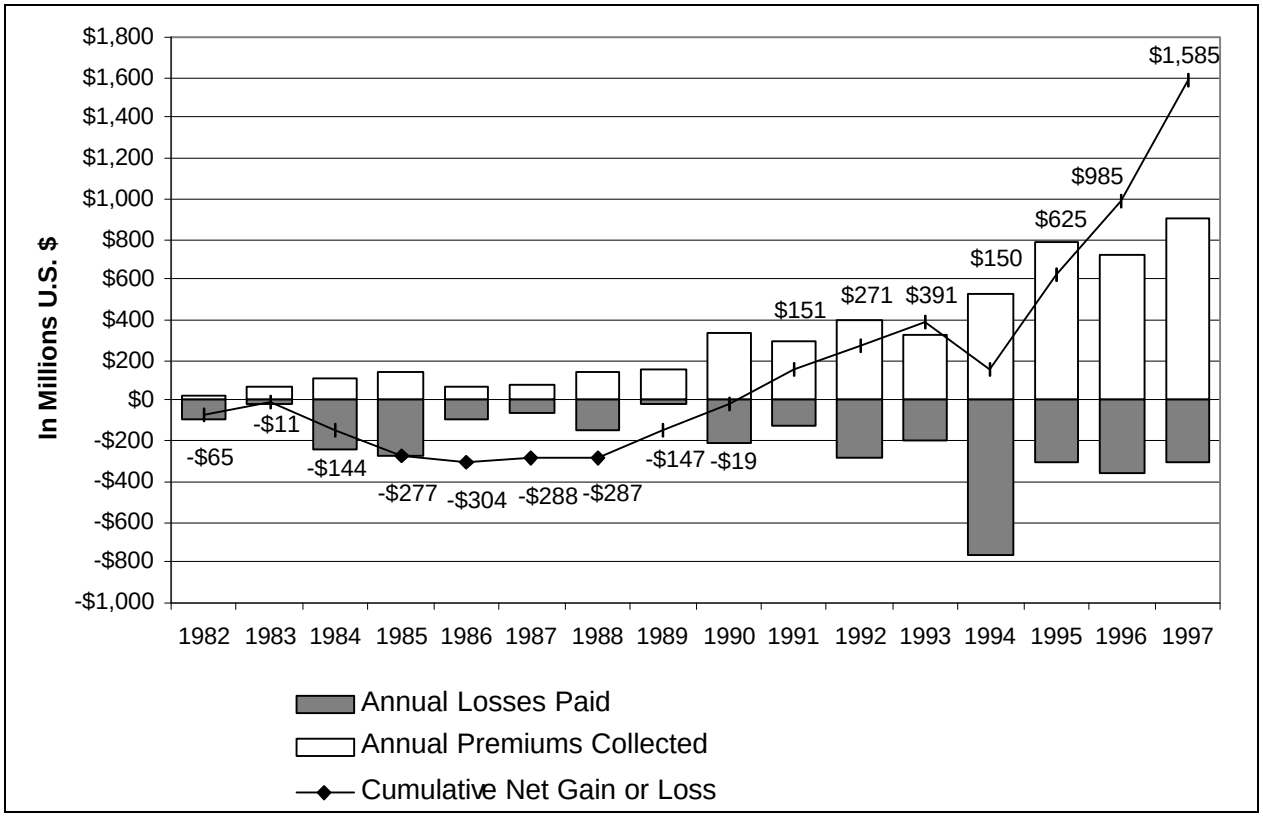


Figure 1. Approximate Launch Premiums Collected and Claims (1982-1997) (Source: International Technology Underwriters, International Space Brokers, and International Space Industry Report)

Table 1. Types of Space Insurance

Launch Insurance Pays the owner of a satellite for a failed launch or for a satellite damaged on that launch.
Government Property Insurance Pays the government for the loss of any government property due to launch operations.
Third Party or Liability Insurance Pays a third party for loss from a failed launch (e.g., debris falling on private property). It is required for a launch license.
Re-Launch Insurance Guarantees a second launch if the first launch results in failure.
Business Interruption Insurance Makes payment for revenue losses by organizations using a satellite.
On-Orbit Insurance This refers to insurance applicable during the on-orbit operations time period.
Constellation Insurance This covers the services provided by a LEO constellation, not the individual satellites in the constellation.

As a whole, space insurance comes in many different forms. It can help compensate for the failure of a launch or the partial or total loss of an on-orbit satellite, for losses suffered by third parties, and even for losses due to canceled government funding. Table 1 above summarizes the principal types of space insurance (see also Appendix 1).

Launch insurance indemnifies the owner of a satellite for a failed launch, failed vehicle, and/or failed satellite. Typically, $250 million to $300 million of coverage is provided, with the average premium for launch insurance currently ranging from around 15 percent to 25 percent. Third-party liability insurance indemnifies a third party from loss or damage caused by a satellite or launch vehicle. Usually, only $150 million to $200 million coverage is required (which typically sells for a 0.1 percent to 0.2 percent premium) for large vehicles.

THE SPACE INSURANCE MARKET – HISTORICAL

The space insurance industry dates from the 1960s, when it appeared as a response to the development of commercial communications satellites. Aviation insurance specialists issued the first policies, which featured low premiums and compensation that was paid on the provision of a minimum of evidence. In the late 1960s and the early 1970s, space insurance markets changed dramatically when a substantially larger number of insured launches failed, causing underwriters to suffer heavy losses. Brokers began to specialize in space insurance, and some of them hired space experts as consultants or staff members in an attempt to better understand and predict the space industry. This technical approach to underwriting was by no means universally accepted, however, and many underwriters continued to use more traditional actuarial methods to make underwriting decisions.

When a second wave of launch failures occurred in the mid-1980s, the space insurance industry's cumulative losses (total premiums collected less total claims paid out) reached close to $300 million by 1986. Underwriters raised premiums above 30 percent to cover previous losses and to restore industry profitability. Some satellite operators decided to self-insure rather than pay premiums at these levels, and high insurance cost was regarded as a barrier to entry into the market. By the end of the 1980s, the industry was nearing restored profitability with launch insurance premiums in the early 1990s falling to the 15 percent to 20 percent rate.

THE SPACE INSURANCE MARKET – RECENT

The space insurance industry has been profitable since 1991. The industry's cumulative profitability for the 1982-1997 period is approximately $1.6 billion[1] (see also Figure 1). The 1990s have seen an expansion in the number of insured launches following a period of slow growth in the 1980s. In 1997, there were 35 major insured launches, nearly double the 18 in 1990 (see Figure 2).

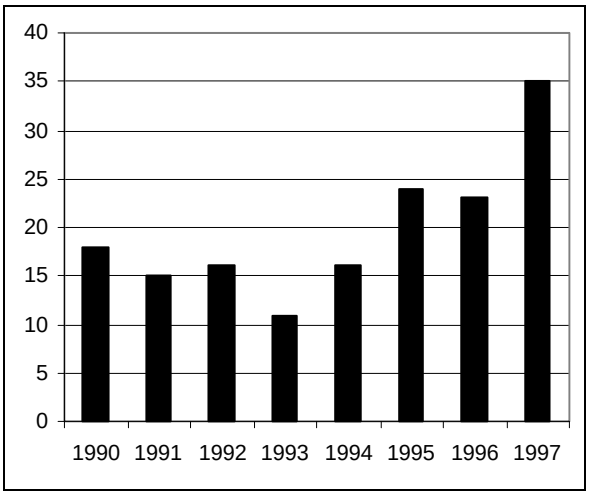


Figure 2. Insured Launches 1990-1997 (Source: International Space Brokers Group)

The increasing profitability of the space insurance market has drawn ever-increasing amounts of money into space insurance. As a result, insurance premiums in 1998 are quite low and the market soft (a soft market is one in which more money is available for insurance than is needed to cover demand). Although premiums are difficult to estimate precisely, a series of recent interviews by the Satellite Industry Association produced the list of approximate launch insurance rates in Table 2.

This year has seen two commercial launch failures thus far. The launch failure of the first Delta 3 resulted in the loss of PanAmSat's Galaxy 10 communications satellite. The cost of the Delta 3 launch and satellite were covered under a $4 billion insurance package, the largest such package to date (further discussion of this is provided below). However, lost revenues associated with the destruction of this satellite and the on-orbit failure of the Galaxy 4 satellite in May 1998 were not covered under the insurance deal.

The second failure, that of the Zenit 2 in September, will delay the deployment of the Globalstar LEO constellation, which will enter service with 12 fewer satellites than were initially planned. Globalstar's new launch plan will cost an additional $85 million (beyond what it will receive from insurance for the Zenit 2 failure).

Table 2. Launch Insurance Rates as of June 1998

USA	Atlas	15 – 17%
USA	Delta	15 – 17%
Europe	Ariane 4	15 – 17%
Russia	Proton	20%
China	Long March 3B	25%

(Source: Satellite Industry Association)

[1] This cumulative profitability does not take into account the time-value of money.

PROFITS AND VOLATILITY IN SPACE INSURANCE MARKETS

Almost every launch, launch vehicle, and payload has its own unique characteristics. This uniqueness (and the small number of launches in general) reduces the information that can be drawn from individual launches so that launch insurance has a relatively small actuarial base. An actuarial base may become larger with large constellation

deployments like Navstar/GPS, in which many identical payloads are launched on multiple identical launch vehicles, or Iridium, which used many similar launch vehicles, mainly Delta and Long March vehicles.

Generally, insurance spreads risk over either multiple events or long periods of time. The predictability of events increases as the number of occurrences grows. The total number of orbital launches is small and each launch is different enough that insurance rates are difficult to determine. Space insurance rates (particularly launch insurance rates) are, therefore, as much a matter of market forces as a matter of actuarial tables.

In addition to the lack of a strong actuarial basis, space insurance differs from most other forms of insurance in that it has short time lines for large dollar amounts of coverage. The lifetime of most launch policies, even with extended on-orbit coverage, is no more than five years and the riskiest portion of this is a launch that takes place in under half an hour. For a launch-plus-five-year policy (in which the payload is covered for five years of on-orbit service after its launch) about 75 percent of the premium goes to cover the launch while only 25 percent is left for the remaining five years. The brief duration of an actual launch event makes launch insurance potentially very profitable. When a launch succeeds, the launch portion of the premium immediately becomes profit (after expenses). Conversely, a series of launch failures in a short period of time will have a severe effect on underwriters' financial reserves. The large increase in premiums following a series of launch failures in the mid-1980s illustrates this effect.

A great deal of volatility remains in the industry even in the most profitable of times. The increasing reliability and stable price of launch vehicles, along with the growing pool of available underwriting money, help cushion the market against potential shocks, but the increasing value of some satellites (and, hence, higher possible claims for those launches, if they fail) provides a countervailing force. As an example, consider Intelsat satellite prices. The Intelsat 5 series (first launched in 1980) were built for approximately $60 million per satellite. Intelsat 7 A8 (lost in a 1996 Long March launch failure) cost $140 million, 2.3 times the price of the earlier Intelsat 5. Such increases in the price of satellites greatly increase the size of underwriters' exposure to losses, exacerbating insurance market volatility.

The year 1996 is an example of how thin the margin between success and failure can be. Although underwriters saw a net profit of $246 million,[2] this profit could easily have been erased had one or two more launches resulted in failure.

THE LAUNCH UNDERWRITING PROCESS

The current success of the space insurance market has brought in a considerable amount of new investment. With greater financial resources, insurers have been increasingly willing to underwrite higher totals on satellite launches. The maximum amount of coverage available for a single launch (an estimate often used as an indicator of industry health) has risen each year for the past 12 years. Underwriters worldwide have increased this amount from $150 million in 1987 to $300 to $350 million in the early

[2] Ignores operating costs; in 1996, worldwide premiums totaled $811 million and losses amounted to $565 million.

Table 3. Top Six Individual Underwriter Single Launch Maximums (March 1998)

Assicurazioni Generali S.p.A. (Italy)	$120 million
AGF/AGA (France)	$95 million
La Reunion Spatiale (France)	$95 million
Marham Space Consortium of London (Lloyd's of London)	$80 million
BIS/Brockbank (USA)	$75 million
INTEC/AXA (USA)	$65 million

(Source: International Space Industry Report)

1990s. In the latter 1990s, the available amount has risen from an estimated $555 million in 1995 to $650 million in 1996 and as much as $800 million to $1 billion in early 1998. These amounts may reflect an increase in underwriters' confidence in launch vehicles, the increased availability of capital and, in general, a better understanding of the commercial space transportation and satellite industries.

While the theoretical maximum represents the collective wisdom of the market as to what the maximum coverage for any single launch should be, it does not reflect the amount of coverage a single underwriter is willing to underwrite on a regular basis for a single launch. The amounts that some major space launch insurance underwriters were willing to underwrite for single launches (as of March 1998) are given in Table 3.

Currently, the world's four largest insurance-providing countries are the United States, France, the United Kingdom, and Italy. Insurance capacity is spread worldwide and insurance packages are almost always international. Figure 3 shows the division of world underwriting capacity[3] in March 1998.

[3] "Capacity" is the measure of an insurer's financial strength to issue contracts of insurance, usually determined by the largest amount acceptable on a given risk or, in certain other situations, by the maximum volume of business it is prepared to accept.

LARGE UNDERWRITING PACKAGES

The large sums involved in space insurance require that multiple insurers work together to underwrite individual policies. These policies will frequently cover multiple launches as well. Such arrangements allow individual underwriters to underwrite coverage much greater than that possible for any single launch, insured individually. Multiple-launch packages allow underwriters to offer lower rates for launches that are good risks and higher rates for launches that are bad risks. A multiple launch package allows actuarial tools to be applied, helping to limit overall uncertainty. As a result, multiple-launch insurance deals are a common form of underwriting.

The largest single space insurance package assembled to date is the $4 billion deal arranged for PanAmSat in January 1998. Space Machine Advisors of Greenwich, Connecticut was the primary insurer and three other major players participated in the deal: Aon of London, Gras Savoye of Paris, and Triangle Brokerage of Bermuda.

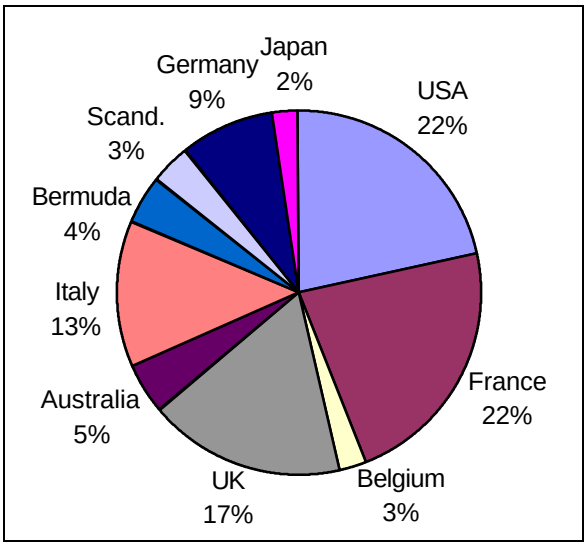


Figure 3. World Space Insurance Capacity (Approximate Total $1.2 B; as of March 1998) (Source: International Space Industry Report)

Table 4. Launches Covered in PanAmSat Space Insurance Package

Payload	Launch Vehicle	Satellite Bus	Status
Galaxy 10	Delta 3	HS-601 HP	Launch Failed
PAS 8	Proton	FS 1300	Future
PAS 6B	Ariane 42L	HS 601 HP	Future
Galaxy 11	Ariane 4	HS 702	Future
PAS 1R	Ariane 5	HS 702	Future
Galaxy 4R	H 2A	HS 601 HP	Future
Galaxy 10R	Ariane 5	HS 601 HP	Future
Galaxy 3C	Proton	HS 702	Future

Under this arrangement, PanAmSat extended its on-orbit insurance to three years for its 18 satellites currently on orbit and insured the launches of eight new satellites (on eight different launch vehicles, see Table 4) to be conducted over the same period. PanAmSat received a rate of approximately 14.5 percent for the entire package.

This package is notable not only for its high value but also for the number of new payloads and vehicles that it covers. In addition to the Sea Launch vehicle, the policy covered the Delta 3, Japan's H 2A, and the European Ariane 5. None of these vehicles have a long history. Neither the Delta 3 nor the H 2A had been launched when PanAmSat's insurance package was negotiated and the Ariane 5 has not yet had a fully successful launch.

The first three Hughes 702 satellites to be deployed are also covered by this contract. The first Hughes 702 satellite (Galaxy 11) is to be launched on an Ariane 4 vehicle. The second (PAS 1R) and third (Galaxy 3C) are to be launched on a Proton and an Ariane 5 respectively.

Another example of a large insurance package is the 1995 policy under which Intelsat insured ten launches for a cost of $2 billion. This coverage was arranged through International Space Brokers (ISB) of Rosslyn, Virginia, but underwriting was divided among insurance companies in four countries: the United States, France, the United Kingdom, and Germany. Although launch insurance premium rates for Arianespace had been running at about 17 percent of insured value, ISB was able to secure a rate below nine percent for each of the seven Ariane missions and a rate of somewhat over 11 percent for the Long March 3B flights.

UNDERWRITING & LAUNCH VEHICLE RELIABILITY

In addition to market forces and available capital (discussed previously), a very important issue in underwriting decisions is the availability of information about the systems involved. Both technical detail and operational history are used to predict the chance of success for a launch or the on-orbit lifetime of a satellite. See Table 5 for some examples of current vehicle family reliability.

Table 5. Lifetime Vehicle Reliability Rates

Vehicle	Launch Attempts	Reliability
Atlas 1 & 2	49	95.9%
Delta 2	73	98.6%
Delta 3	1	0.0%
Ariane 4	81	96.3%
Ariane 5	2	50.0%
Proton	254	89.4%
Soyuz	958	99.3%
Long March	54	90.7%

(Source: STAR Database, October 14, 1998)

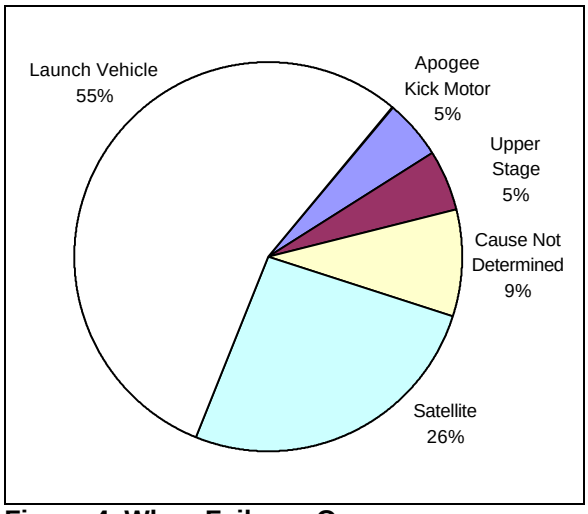


Figure 4. When Failures Occur
(Source: Assicurazioni Generali, 1995)

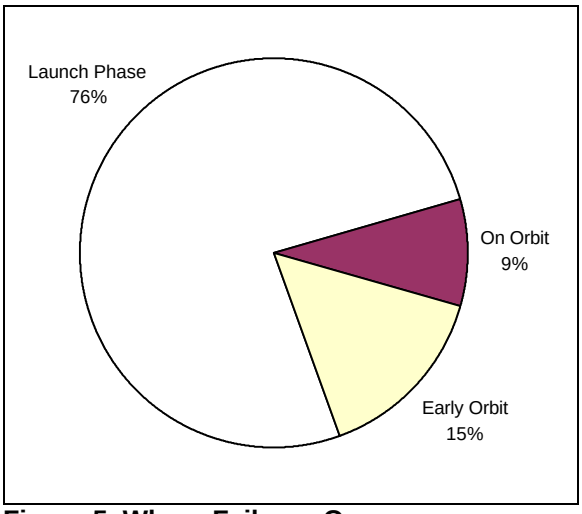


Figure 5. Where Failures Occur
(Source: Assicurazioni Generali, 1995)

Because the first flight of a launch vehicle is a more uncertain event than the fortieth, insurance is likely to cost more for the first launch of a new vehicle than for an older vehicle with a record of successful flights. Ten launches are generally considered an adequate number to prove a vehicle if they have been successful. All else being equal, as a launch vehicle's record improves, its user's insurance premiums will decline as underwriters place more trust in the vehicle. Since the majority of failures and mishaps take place during the launch phase, trust in the reliability of a launch vehicle is important (see Figures 4 and 5).

The recent loss of the first Delta 3 launch vehicle is an example of the uncertainties inherent in the use of a new vehicle. Although it drew from the proven design of the Delta 2, the Delta 3 still experienced unforeseen problems which resulted in its failure. Because of this failure, it will likely cost more to insure future Delta 3 launches until the vehicle is proven.

Similarly, Sea Launch must deal with the perceived uncertainties of both a new launch vehicle (the untested Zenit 3/SL) and of its novel ocean-going launch platform (a converted oil drilling platform). Boeing plans to test the Zenit 3/SL by conducting its initial launch with a dummy payload instead of the originally manifested Galaxy 11. This test will hopefully please underwriters who have been concerned about the risk of launching commercial spacecraft on the initial launch of commercial vehicles, but it will cost Sea Launch in both time and money.

Concerns about vehicle reliability appear any time that a launch vehicle fails. One recent example is the Air Force's investigation of the 1997 Delta 2/GPS launch failure. In this case, there were concerns that the restriction of information would reduce underwriters' ability to make informed judgments. This concern caused notable complaints about the Air Force's investigation and reiterated the point that information about launch vehicles and satellites is essential to the space insurance industry today.

CONCLUSIONS

When asked, many underwriters state that the introduction of new and changed launch and satellite systems is one of the most important issues for the future of the space industry. As the industry builds larger, more powerful satellites and launch vehicles, underwriting challenges will increase. Underwriters feel that only time and experience will bring these new systems to the levels of maturity that will provide satisfactory reliability.

The issues surrounding the introduction of new technology issue are already evident. Both of this year's commercial failures, the Delta 3 and the Zenit 2, are new vehicles to the commercial launch industry. As a result of these launch failures and of other claims, insurance claims for 1998 will total close to $1 billion.

Appendix 1. Types of Space Transportation Insurance

Launch Insurance

Launch insurance indemnifies the owner of a satellite for a failed launch, failed vehicle, and/or failed satellite. Typically, $250 million to $300 million coverage is provided, with the average premium for launch insurance currently ranging from around 15 to 25 percent (although premiums have been as high as 26 to 30 percent). Cross-waivers by co-launching parties are agreements not to sue each other in the event of failure. There is no government requirement for this type of insurance for commercial launches, but NASA may require it for its payloads. This type of insurance now often includes coverage for the first three to five years of on-orbit operation as well as the launch itself.

Government Property Insurance

Government property insurance indemnifies the government for loss of any government property due to launch operations. FAA/AST typically requires $75 million to $80 million coverage for large vehicles with lesser amounts for smaller vehicles. Such insurance typically requires a 1.5 percent to 2.0 percent premium.

Third Party or Liability Insurance

Liability insurance indemnifies a third party from loss related to hardware or mission failure (e.g., debris falling on private property). FAA/AST can demand up to $500 million coverage but usually requires only $150 to $200 million coverage (which typically sells for 0.1% to 0.2% premium) for large vehicles. Third party insurance is required for a launch license because governments are liable for injury or damage to third parties under the 1972 United Nations Convention on International Liability for Damage Caused by Space Objects. This convention obligates the launching country to assume liability for damage done by either a launcher or a satellite. Other launch providers, around the world, also require liability insurance for commercial launches. Arianespace requires 400 million French francs in liability insurance, which is currently included in Ariane's launch price. Long March also requires third-party liability insurance. No claims have been filed under these policies to date.

Re-Launch Insurance

Re-launch insurance is a form of first-party insurance begun by Arianespace, which is now regularly offered by many launch service providers. With re-launch insurance, the launch service provider guarantees a second launch if the first launch results in failure. In this case, the launch provider acts as the insurance company. Re-launch insurance began as an enticement to payload owners who could not get a commitment from insurance underwriters sufficiently in advance to schedule a launch and begin manufacture of the spacecraft. A launch provider will typically offer one rate if the customer requires a cash payment in the event of failure and another rate if the customer will accept a re-launch.

Business Insurance

This type of insurance involves indemnification for revenue loss typically for satellite owners if the satellite fails to attain operational status. In recent years, premiums for this insurance have become too costly and very few satellite life insurance policies are sold.

On-Orbit Insurance

On-orbit insurance is becoming more commonplace and refers to insurance applicable during the on-orbit operations time period. It encompasses coverage for satellite owners and satellite manufacturers and includes satellite life insurance, manufacturer incentive insurance, and insurance of satellites during on-orbit testing. Premiums from these policies have increased from less than $50 million a year in the 1980s to more than $100 million expected in 1996. Note that this type of insurance is for on-orbit operations only and is not related to the performance of the launch vehicle.

Constellation Insurance

While on-orbit insurance is coverage of individual satellites, constellation insurance is the coverage of a constellation or part of a constellation. In the case of Iridium, the operation of an orbital plane (there are six such planes in the Iridium system) but not the individual satellite that make up the plane might be covered. These satellites are easy to replace and, to some degree, are interchangeable. It is the service provided by the constellation or plane itself, not the individual satellites, that is insured.

GLOSSARY

For proper interpretation of the data in this report, the following definitions should be understood:

Commercial Launch Events: A commercial launch event is an internationally competed launch event, as defined below, and/or any launch licensed by the Department of Transportation/Office of Commercial Space Transportation (DoT/OCST), under the Commercial Space Launch Act (CSLA), or certain Post, Telegraph and Telecommunications launches.

Commercial Launch Revenue: Commercial launch revenues are generated from launch services provided by private and government licensed entities. It is understood that commercial launch providers of different countries operate within different economic, policy, and procedural contexts which affect the respective prices for a launch contract, however, this report does not attempt to adjust its data for these factors.

Geosynchronous Orbit (GEO): An orbit approximately 22,300 miles above the equator in which a payload completes one orbit around the Earth every 24 hours.

Geosynchronous Transfer Orbit (GTO): A temporary orbit used to later place payloads in a geosynchronous orbit.

Internationally-Competed Launch Events: An internationally competed launch event results from a launch opportunity which is available in principle to competitors in the international launch services market.

Low Earth Orbit (LEO): An orbit range on the order of 100-1000 nautical miles.

Market Share: That segment of a commercial market which is captured by a specified entity.

Microgravity: An environment in which gravitational forces are essentially nonexistent. Microgravity is used for materials processing, life-sciences, and other experiments. Suborbital flights generally are conducted to expose experimental payloads to a brief microgravity environment. Microgravity is also utilized for orbiting payloads.

Orbital Insertion: The point of a launch event at which a payload has attained planned orbital velocity and finally separates from its launch vehicle.

Payload: Cargo to be jettisoned or released which may include attached kick motors.

Payload Mass Class: Payloads are categorized in the following mass classes:

Microsat	0 - 200 lbs	Small	201 - 2,000 lbs
Medium	2,001 - 5,000 lbs	Intermediate	5,001 - 10,000 lbs
Large	10,001 - 20,000 lbs	Heavy	over 20,000 lbs

Scheduled Launch Events: Future launch events associated with specific dates as reported in open sources.

Secondary Payload: A payload of lesser dimensions and weight than the primary payload(s). These payloads are launched along with primary payload(s) due to excess launch capacity.

Suborbital: A term used to describe a launch event or payload that does not achieve a full earth orbit.

ACRONYMS

ARD Atmospheric Re-entry Demonstrator
AXAF Advanced X-Ray Astrophysics Facility
CCAS Cape Canaveral Air Station
DARA German Space Agency
DASA Deutsche Aerospace
DoD Department of Defense
DoT Department of Transportation
DSP Defense Support Program
ELI Elliptical
ELINTS Electronic intelligence satellites
ELV Expendable Launch Vehicle
ESA European Space Agency
ETS Engineering Test Satellite
EXT Extra-Orbital
FAA Federal Aviation Administration
FY Fen Yung
GBS Global Broadcast System
GEO Geosynchronous Orbit
GTO Geosynchronous Transfer Orbit
INMARSAT - International Maritime Satellite Organization
INPE National Institute for Space Research
INTA Instituto Nacional de Tecnica Aeroespacial

Telecommunications Satellite Organization
IRS Indian Resource Satellite
ISAS Institute of Space and Astronautical Science
ISRO Indian Space Research Organization
JCSAT Japan Communications Satellite Co. Satellite
JPL Jet Propulsion Laboratory
JSAT Japan Satellite Systems, Inc.
KB Design Bureau
KSC Kennedy Space Center
LEO Low Earth Orbit
MEO Medium Earth Orbit
MoD Ministry of Defens
MUBLCOM - Multiple Beam Beyond Line-of-Sight Communications
NASA National Aeronautics and Space Administration
NASDA National Space Development Agency (Japan)
NEC Nippon Electric Corp.
nMI Nautical Mile
NOAA National Oceanic and Atmospheric Administration
NPO Scientific Production Organization
NSAB Nordiska Satellit AB
OSC Orbital Sciences Corporation
PAS Pan American Satellite
PSLV Polar Satellite Launch Vehicle
PTT Post Telegraph and Telecommunications
QuickSCAT - Quick Scatterometer
RKK Energia - Rocket and Space Company Energia
SAC Satellite de Aplicaciones Cientificas
SACI Satellite Cientifico
SCD Satellite de Coleta de Dados
SES Societe Europeene des Satellites
SLV Satellite Launch vehicle
STEX Sensor Test Experiement
STS Space Transportation System
SWAS Submillimeter Wave Astronomy Satellite
TERRIERS - Tomographic Experiment using Radiative Recombinative Ionospheric EUV and Radio Sources
TRACE Transition Region and Coronal Explorer
USMP United States Microgravity Payload
VAFB Vandenberg Air Force Base
WIRE Wide-Field Infrared Explorer
XL Extra Long

Characteristics of Cited Vehicles

Vehicle	(Success + Partials) / Attempts	LEO 28 Degrees	GTO	GEO	SUB	Price per Launch (Approx.)	Launch Sites
Heavy							
Ariane 5	1/2|50%	39600 lb. 18000 kg	15000 lb. 6800 kg	N/A*	N/A	$115-143 M	Kourou
Long March 3B	4/5|80%	29900 lb. 13600 kg	9900 lb. 4500 kg	4950 lb. 2250 kg	N/A	$60-70 M	Xichang
Proton (SL-12)	197/220|89.6%	46297 lb. 21000 kg	12100 lb. 5500 kg	4850 lb. 2200 kg	N/A	$75-75 M	Baikonur
Proton (SL-13)	27/30|90%	46000 lb. 20900 kg	16535 lb. 7500 kg	N/A	N/A	$50-70 M	Baikonur
Sea Launch	N/A	35000 lb. 15876 kg	11050 lb. 5000 kg	N/A	N/A	$90-100 M	Sea Launch Platform
Shuttle Columbia	25/25|100%	47300 lb. 21455 kg	13007 lb. 5900 kg	5203 lb. 2360 kg	N/A	N/A	KSC
Shuttle Discovery	26/26|100%	47300 lb. 21455 kg	13007 lb. 5900 kg	5203 lb. 2360 kg	N/A	N/A	KSC
Shuttle Endeavour	12/12|100%	47300 lb. 21455 kg	13007 lb. 5900 kg	5203 lb. 2360 kg	N/A	N/A	KSC
Titan 4/Centaur	8/9|88.9%	39100 lb. 17736 kg	14000 lb. 6350 kg	10200 lb. 4627 kg	N/A	$250-350 M	CCAS
Titan 4B/Centaur	2/2|100%	N/A	N/A	N/A	N/A	$250-350 M	CCAS, VAFB
Titan 4B/IUS	1/1|100%	47800 lb. 21727 kg	N/A	12700 lb. 5773 kg	N/A	$250-350 M	CCAS, VAFB
Zenit 2	25/31|80.7%	30300 lb. 13740 kg	N/A	N/A	N/A	$25-40 M	Baikonur
Intermediate							
Ariane 42L	5/5|100%	16300 lb. 7400 kg	7450 lb. 3380 kg	N/A	N/A	$75-85 M	Kourou
Ariane 44L	24/25|96%	21100 lb. 9600 kg	9965 lb. 4520 kg	N/A	N/A	$90-110 M	Kourou
Ariane 44LP	18/19|94.7%	18300 lb. 8300 kg	8950 lb. 4060 kg	N/A	N/A	$80-95 M	Kourou
Ariane 44P	14/14|100%	15200 lb. 6900 kg	7320 lb. 3320 kg	N/A	N/A	$75-90 M	Kourou
Atlas 2A	13/13|100%	16050 lb. 7280 kg	6700 lb. 3039 kg	3307 lb. 1500 kg	N/A	$65-80 M	CCAS, VAFB
Atlas 2AS	14/14|100%	19050 lb. 8640 kg	8150 lb. 3688 kg	4604 lb. 2090 kg	N/A	$90-100 M	CCAS, VAFB
Atlas 3A	N/A	19097 lb. 8641 kg	8940 lb. 4055 kg	N/A	N/A	$45-80 M	CCAS, VAFB
Delta 3	0/1|0%	18408 lb. 8350 kg	8360 lb. 3800 kg	N/A	N/A	$55-60 M	CCAS
Soyuz	951/958|99.3%	15400 lb. 7000 kg	N/A	N/A	N/A	$12-25 M	Baikonur, Plesetsk
Medium							
Delta 2 7326	N/A	4370 lb. 1982 kg	2100 lb. 952 kg	N/A	N/A	$45-50 M	CCAS
Delta 2 7425	N/A	5160 lb. 2340 kg	2430 lb. 1102 kg	N/A	N/A	$45-50 M	CCAS, VAFB
Delta 2 7426	N/A	N/A	N/A	N/A	N/A	$45-50 M	CCAS, VAFB
Delta 2 7920	14/14|100%	11330 lb. 5139 kg	2800 lb. 1270 kg	N/A	N/A	$45-50 M	CCAS, VAFB
Delta 2 7925	39/40|97.5%	11330 lb. 5139 kg	3965 lb. 1799 kg	2000 lb. 907 kg	N/A	$45-50 M	CCAS, VAFB

*GEO capabale with kick motor

Characteristics of Cited Vehicles

Vehicle	(Success + Partials) / Attempts	LEO 28 Degrees	GTO	GEO	SUB	Price per Launch (Approx.)	Launch Sites
Medium (cont.)							
Long March 2C	19/19|100%	7040 lb. 3200 kg	2200 lb. 1000 kg	860 lb. 390 kg	N/A	$20-25 M	Jiuquan, Taiyuan
Long March 4	2/2|100%	8818 lb. 4000 kg	2430 lb. 1100 kg	1220 lb. 550 kg	N/A	$20-30 M	Taiyuan
M 5	2/2|100%	5500 lb. 2500 kg	2680 lb. 1215 kg	1080 lb. 490 kg	N/A	$41-47 M	Kagoshima
Molniya	295/310|95.2%	3970 lb. 1805 kg	N/A	N/A	N/A	$19-19 M	Baikonur, Plesetsk
PSLV	3/4|75%	6400 lb. 2900 kg	990 lb. 450 kg	N/A	N/A	$15-15 M	Sriharikota Range
Titan 2	19/19|100%	7900 lb. 3583 kg	N/A	N/A	N/A	$41-47 M	VAFB
Small							
Athena 1	1/2|50%	1755 lb. 800 kg	N/A	N/A	N/A	$14-16 M	Spaceport Florida, VAFB, Wallops (proposed)
Athena 2	1/1|100%	4390 lb. 1990 kg	N/A	N/A	N/A	$19-21 M	Spaceport Florida, VAFB, Wallops (proposed)
Cosmos	408/412|99%	3100 lb. 1400 kg	N/A	N/A	N/A	$10-10 M	Baikonur, Plestesk, Kapustin Yar
Pegasus XL	9/12|75%	1015 lb. 460 kg	322 lb. 146 kg	181 lb. 82 kg	N/A	$12-14 M	VAFB, Wallops
Pegasus XL/HAPS	3/3|100%	1015 lb. 460 kg	N/A	N/A	N/A	$12-14 M	VAFB, Wallops
Shtil	1/1|100%	1213 lb. 550 kg	N/A	N/A	N/A	N/A	Submarine Launch
START 1	3/3|100%	790 lb. 359 kg	N/A	N/A	N/A	$5-10 M	Plestesk, Svobodny
Taepo Dong 1	0/1|0%	N/A	N/A	N/A	N/A	N/A	Musudan-ri
Taurus 1	2/2|100%	3100 lb. 1400 kg	990 lb. 450 kg	N/A	N/A	$18-20 M	VAFB
Suborbital							
TR 1A	5/5|100%	N/A	N/A	N/A	1653 lb. 750 kg	N/A	Tanegashima

Characteristics of Cited Payloads

Payload	Use	Price	Orbit	Apogee	Perigee	Launch Mass	Mass in Orbit	Freq. Bands & Trans.	Stab.	Power
Classified										
USA 1998-08	Classified	Unknown	GEO	N/A	N/A	N/A	N/A	N/A	N/A	N/A
USA 1999-03	Classified	Unknown	Unknown	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Communications										
AfriStar 1	Communications	Unknown	GEO 21E	19305 nMi	19305 nMi	6155 lb. / 2785kg	2093 lb. / 947 kg	L, S, X	N/A	N/A
Arabsat 3A	Communications	Unknown	GEO	19400 nMi	19400 nMi	5967 lb. / 2700kg	N/A	20 Ku	N/A	N/A
AsiaStar 1	Communications	Unknown	GEO 105E	19305 nMi	19305 nMi	6155 lb. / 2785kg	2093 lb. / 947 kg	3L, 3X	N/A	N/A
Astra 1H	Communications	Unknown	GEO 19.2E	19400 nMi	19400 nMi	7260 lb. / 3300kg	N/A	32 Ku, 2 Ka	3-axis	N/A
Astra 2A	Communications	Unknown	GEO 28.2E	19400 nMi	19400 nMi	8033 lb. / 3635kg	N/A	32 Ku	N/A	N/A
Bonum 1	Communications	Unknown	GEO 36E	19400 nMi	19400 nMi	N/A	N/A	N/A	N/A	N/A
ChinaSat 8	Communications	$92.7 M	GEO 115.5E	19400 nMi	19400 nMi	N/A	N/A	36 C, 16 Ku	N/A	N/A
Eutelsat W2	Communications	Unknown	GEO 16E	19332 nMi	19305 nMi	6599 lb. / 3000kg	N/A	24 Ku	N/A	N/A
Eutelsat W3	Communications	Unknown	GEO 7E	19332 nMi	19305 nMi	6599 lb. / 3000kg	N/A	24 Ku	N/A	N/A
Galaxy 10	Communications	Unknown	GEO 237E	19321 nMi	19322 nMi	7683 lb. / 3492kg	3730 lb. / 1692 kg	24 C, 24 Ku	N/A	4700 W
Galaxy 11	Communications	Unknown	GEO 261E	19400 nMi	19400 nMi	7683 lb. / 3492kg	N/A	16 Ku, 8 Ku2	N/A	N/A
GBS 9	Communications	Unknown	GEO	19400 nMi	19400 nMi	6305 lb. / 2866kg	N/A	EHF, UHF	N/A	2500 W
GE 5	Communications	Unknown	GEO 281E	19400 nMi	19400 nMi	3890 lb. / 1760kg	N/A	16 Ku	N/A	N/A
Globalstars 5-36	Communications	$14.7 M	LEO	764 nMi	764 nMi	988 lb. / 449kg	N/A	L, C, S	N/A	875 W
Hot Bird 5	Communications	Unknown	GEO 13E	19400 nMi	19400 nMi	6380 lb. / 2900kg	N/A	19 Ku, 2 Ku2	N/A	N/A
ICO 1	Communications	Unknown	MEO	5592 nMi	5592 nMi	6050 lb. / 2750kg	N/A	1 C, 1 S	N/A	N/A
Insat 2E	Communications	Unknown	GEO 83E	19400 nMi	19400 nMi	5500 lb. / 2500kg	N/A	3 Ku, 18 C	N/A	N/A
Iridiums 3, 76-94	Communications	Unknown	LEO	419 nMi	419 nMi	1496 lb. / 680kg	N/A	1 L, 1 Ka	N/A	N/A
JCSAT 6	Communications	Unknown	GEO 150E	19400 nMi	19400 nMi	N/A	N/A	32 Ku	N/A	N/A
MegSat 0	Communications	Unknown	LEO	N/A	N/A	111 lb. / 50kg	N/A	N/A	N/A	N/A
Milstar II-F1	Communications	Unknown	GEO	19400 nMi	19400 nMi	N/A	N/A	N/A	N/A	N/A
Molniya 3	Communications	Unknown	ELI	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MUBLCOM	Communications	Unknown	LEO	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nimiq 1	Communications	$199.6 M	GEO 269E	19400 nMi	19400 nMi	7956 lb. / 3600kg	N/A	32 Ku	N/A	N/A
Orbcomms 13-28	Communications	Unknown	LEO	446 nMi	446 nMi	87 lb. / 40kg	N/A	N/A	N/A	N/A
Orion F3	Communications	Unknown	GEO	19400 nMi	19400 nMi	7072 lb. / 3200kg	N/A	33 Ku, 10 C	N/A	N/A
PANSAT 1	Communications	Unknown	LEO	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PAS 6B	Communications	Unknown	GEO 217E	19400 nMi	19400 nMi	7680 lb. / 3475kg	N/A	32 Ku	N/A	N/A
PAS 7	Communications	Unknown	GEO 68.5E	19400 nMi	19400 nMi	8482 lb. / 3838kg	N/A	40 Ku, 14 C	N/A	N/A
PAS 8	Communications	Unknown	GEO 166E	19400 nMi	19400 nMi	7920 lb. / 3600kg	N/A	24 Ku, 24 C	N/A	N/A
SAFIR 2	Communications	Unknown	LEO	367 nMi	367 nMi	N/A	N/A	N/A	N/A	N/A
SatMex 5	Communications	Unknown	GEO 215E	19400 nMi	19400 nMi	7183 lb. / 3250kg	N/A	N/A	N/A	N/A
SCD 2	Communications	Unknown	LEO	427 nMi	392 nMi	253 lb. / 115kg	N/A	N/A	N/A	N/A
Sesat	Communications	Unknown	GEO 36E	19400 nMi	19400 nMi	5720 lb. / 2600kg	N/A	18 Ku	N/A	N/A
Sinosat 1	Communications	Unknown	GEO 110.5E	19400 nMi	19400 nMi	6232 lb. / 2820kg	3536 lb. / 1600 kg	14 Ku, 24 C	3-axis	N/A
Sirius 3	Communications	Unknown	GEO 28.2E	19400 nMi	19400 nMi	3190 lb. / 1450kg	N/A	14 Ku	N/A	N/A

Characteristics of Cited Payloads

Payload	Use	Price	Orbit	Apogee	Perigee	Launch Mass	Mass in Orbit	Freq. Bands & Trans.	Stab.	Power
Communications (cont.)										
Skynet 4E	Communications	Unknown	GEO 53E	19400 nMi	19400 nMi	3321 lb. / 1510kg	N/A	3 X1	3-axis	N/A
ST 1	Communications	Unknown	GEO 88E	19400 nMi	19400 nMi	7127 lb. / 3225kg	3875 lb. / 1753 kg	16 Ku, 14 C	3-axis	N/A
Telkom 1	Communications	$78.4 M	GEO 108E	19400 nMi	19400 nMi	5525 lb. / 2500kg	N/A	36 C	N/A	N/A
Telstar 6	Communications	Unknown	GEO 267E	19400 nMi	19400 nMi	7683 lb. / 3492kg	N/A	28 Ku, 24 C	N/A	N/A
Telstar 7	Communications	Unknown	GEO 277E	19400 nMi	19400 nMi	7683 lb. / 3492kg	N/A	28 Ku, 24 C	N/A	N/A
Tempo 1	Communications	Unknown	GEO 241E	19400 nMi	19400 nMi	7683 lb. / 3492kg	N/A	32 Ku	N/A	N/A
Tubsat-N	Communications	Unknown	LEO	N/A	N/A	22 lb. / 10kg	N/A	N/A	N/A	N/A
Tubsat-N1	Communications	Unknown	LEO	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Crewed										
Soyuz TM-28	Crewed	Unknown	LEO	221 nMi	213 nMi	15587 lb. / 7070kg	14970 lb. / 6790 kg	N/A	N/A	N/A
Soyuz TM-29	Crewed	Unknown	LEO	221 nMi	213 nMi	15587 lb. / 7070kg	14970 lb. / 6790 kg	N/A	N/A	N/A
Development										
ARD	Development	Unknown	LEO	N/A	N/A	6002 lb. / 2716kg	N/A	N/A	N/A	N/A
Argos	Development	Unknown	LEO	450 nMi	450 nMi	N/A	N/A	N/A	N/A	N/A
MightySat 1	Development	Unknown	LEO	N/A	N/A	150 lb. / 68kg	N/A	N/A	N/A	N/A
Rocsat 1	Development	Unknown	LEO	N/A	N/A	878 lb. / 399kg	N/A	N/A	N/A	N/A
SAC A	Development	Unknown	LEO	N/A	N/A	N/A	N/A	N/A	N/A	N/A
STEX	Development	$85.6 M	LEO	N/A	N/A	1547 lb. / 700kg	N/A	N/A	N/A	N/A
Tech Sat 2	Development	Unknown	LEO	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tubsat C-DLR	Development	Unknown	LEO	540 nMi	540 nMi	N/A	N/A	N/A	N/A	N/A
Experimental										
Sedsat-1	Experimental	Unknown	LEO	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Intelligence										
DSP 19	Intelligence	Unknown	GEO	N/A	N/A	5171 lb. / 2340kg	N/A	N/A	N/A	N/A
Kosmos 2360	Intelligence	Unknown	LEO	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Kosmos 2361	Intelligence	Unknown	ELI	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Meteorological										
FY-1C	Meteorological	Unknown	LEO	470 nMi	470 nMi	1938 lb. / 881kg	N/A	N/A	N/A	N/A
Microgravity										
JEM Micrograv Test	Microgravity	Unknown	SUB	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Other										
Celestis 3	Other	Unknown	LEO	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Characteristics of Cited Payloads

Payload	Use	Price	Orbit	Apogee	Perigee	Launch Mass	Mass in Orbit	Freq. Bands & Trans.	Stab.	Power
Remote Sensing										
FASat-Bravo	Remote Sensing	Unknown	LEO	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IKONOS 1	Remote Sensing	Unknown	LEO	367 nMi	367 nMi	1797 lb. / 817kg	1215 lb. / 550 kg	N/A	3-axis	N/A
IKONOS 2	Remote Sensing	Unknown	LEO	367 nMi	367 nMi	1797 lb. / 817kg	N/A	N/A	N/A	N/A
IRS P4	Remote Sensing	Unknown	LEO	497 nMi	481 nMi	2970 lb. / 1350kg	N/A	N/A	N/A	N/A
Kitsat 3	Remote Sensing	Unknown	LEO	470 nMi	470 nMi	220 lb. / 100kg	N/A	N/A	N/A	N/A
Okean O1	Remote Sensing	Unknown	LEO	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Resurs-O1 N4	Remote Sensing	Unknown	LEO	451 nMi	451 nMi	6160 lb. / 2800kg	N/A	N/A	N/A	N/A
TMSAT 1	Remote Sensing	Unknown	LEO	451 nMi	451 nMi	110 lb. / 50kg	N/A	N/A	N/A	N/A
WestPac	Remote Sensing	Unknown	LEO	N/A	N/A	53 lb. / 24kg	N/A	N/A	N/A	N/A
Scientific										
Abrixas	Scientific	$32.4 M	LEO	324 nMi	324 nMi	990 lb. / 450kg	N/A	N/A	N/A	N/A
AXAF 1	Scientific	Unknown	ELI	756 nMi	540 nMi	11477 lb. / 5217kg	N/A	N/A	N/A	N/A
Deep Space 1	Scientific	$132.6 M	EXT	N/A	N/A	946 lb. / 430kg	N/A	N/A	N/A	N/A
Deep Space 2	Scientific	Unknown	EXT	N/A	N/A	9 lb. / 4kg	N/A	N/A	N/A	N/A
Mars Climate Orbiter	Scientific	Unknown	EXT	N/A	N/A	990 lb. / 450kg	N/A	N/A	N/A	N/A
Mars Polar Lander	Scientific	Unknown	EXT	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nozomi	Scientific	$76.9 M	EXT	N/A	N/A	N/A	1193 lb. / 540 kg	N/A	N/A	N/A
Odin	Scientific	Unknown	LEO	324 nMi	324 nMi	550 lb. / 250kg	N/A	N/A	N/A	N/A
Oersted	Scientific	Unknown	LEO	459 nMi	281 nMi	136 lb. / 62kg	N/A	N/A	N/A	44 W
QuickSCAT	Scientific	$36.1 M	LEO	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spartan 201-04R	Scientific	Unknown	LEO	168 nMi	159 nMi	2800 lb. / 1270kg	N/A	N/A	N/A	N/A
Stardust	Scientific	$75.1 M	EXT	N/A	N/A	840 lb. / 380kg	N/A	N/A	3-axis	N/A
Sunsat	Scientific	Unknown	LEO	464 nMi	243 nMi	132 lb. / 60kg	N/A	N/A	N/A	N/A
SWAS	Scientific	Unknown	LEO	324 nMi	324 nMi	623 lb. / 283kg	N/A	N/A	N/A	N/A
TERRIERS	Scientific	Unknown	LEO	297 nMi	297 nMi	268 lb. / 122kg	N/A	N/A	N/A	N/A
WIRE	Scientific	Unknown	LEO	270 nMi	270 nMi	649 lb. / 295kg	N/A	N/A	N/A	N/A
Space Station										
Pressurized Mating A 1&2	Space Station	Unknown	LEO	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Unity	Space Station	Unknown	LEO	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zarya	Space Station	$185.2 M	LEO	N/A	N/A	42500 lb. / 19278kg	N/A	N/A	N/A	3-axis
Supply										
Progress M-40	Supply	Unknown	LEO	N/A	N/A	15983 lb. / 7250kg	N/A	N/A	N/A	N/A
Test										
Maqsat 3	Test	Unknown	GEO	N/A	N/A	6019 lb. / 2730kg	N/A	N/A	N/A	N/A
Unknown										
Kwangmyongsong	Unknown	Unknown	ELI	3768 nMi	118 nMi	N/A	N/A	N/A	N/A	N/A

Launch Events
July - September 1998

Launch Date	Vehicle	Payload	Operator	Manufacturer	Int'l Comp	Launch Type	Launch Outcome	Mission Outcome
China								
			Long March					
July 18, 1998	Long March 3B	Sinosat 1	EuraSpace/Sinosatcom	Aerospatiale	No	Non-Commercial	Success	Success
August 20, 1998	Long March 2C	Iridium 3 Iridium 76	Iridium, Inc. Iridium, Inc.	Lockheed Martin Lockheed Martin	Yes	Commercial	Success	Success
Europe (ESA)								
			Ariane					
August 25, 1998	Ariane 44P	ST 1	Singapore Telecom	Matra Marconi	Yes	Commercial	Success	Success
September 16, 1998	Ariane 44LP	PAS 7	PanAmSat	Space Systems/Loral	Yes	Commercial	Success	Success
Japan								
			M 5					
July 4, 1998	M 5	Nozomi	ISAS	NEC	No	Non-Commercial	Success	Success
North Korea								
			Taepo Dong					
August 31, 1998	Taepo Dong 1	Kwangmyongsong	North Korea	Unknown	No	Non-Commercial	Failure	Failure
Russia								
			Molniya					
July 1, 1998	Molniya	Molniya 3	Russia/CIS PTT	NPO PM	No	Non-Commercial	Success	Success
September 29, 1998	Molniya	Kosmos 2361	Russian MoD	NPO Lavochkin	No	Non-Commercial	Success	Success
			Proton					
August 30, 1998	Proton	Astra 2A	SES	Hughes	Yes	Commercial	Success	Success

Launch Events
July - September 1998

Launch Date	Vehicle	Payload	Operator	Manufacturer	Int'l Comp	Launch Type	Launch Outcome	Mission Outcome
Russia (cont.)								
				Shtil				
July 7, 1998	Shtil	Tubsat-N Tubsat-N1	Tech. Univ. of Berlin Tech. Univ. of Berlin	Tech. Univ. of Berlin Tech. Univ. of Berlin	Yes	Commercial	Success	Success
				Soyuz				
August 13, 1998	Soyuz	Soyuz TM-28	RKK Energia	RKK Energia	No	Non-Commercial	Success	Success
				Zenit				
July 10, 1998	Zenit 2	Resurs-O1 N4 FASat-Bravo SAFIR 2 Tech Sat 2 TMSAT 1 WestPac	Russia Chilean Air Force OHB System Asher Space Rsrch. Inst. Thai MicroSatellite Co. ElectroOptics Systems/RKA	VNII Elektromekhaniki Surrey OHB System Technion Inst. of Tech. Surrey Unknown	No	Non-Commercial	Success	Success
July 28, 1998	Zenit 2	Kosmos 2360	Russian MoD	NPO Yuzhnoye	No	Non-Commercial	Success	Success
Ukraine								
				Zenit				
September 10, 1998	Zenit 2	Globalstars 5,7, 9-13,16-20	Globalstar, Inc.	Space Systems/Loral	Yes	Commercial	Failure	Failure

Launch Events
July - September 1998

Launch Date	Vehicle	Payload	Operator	Manufacturer	Int'l Comp	Launch Type	Launch Outcome	Mission Outcome
USA								
				Delta 2				
September 8, 1998	Delta 2 7920	Iridiums 77,79-82	Iridium, Inc.	Lockheed Martin	Yes	Commercial	Success	Success
				Delta 3				
August 26, 1998	Delta 3	Galaxy 10	PanAmSat	Hughes	Yes	Commercial	Failure	Failure
				Pegasus				
August 2, 1998	Pegasus XL/HAPS	Orbcomms 13-20	Orbcomm	OSC	No	Commercial	Success	Success
September 23, 1998	Pegasus XL/HAPS	Orbcomms 21-28	Orbcomm	OSC	No	Commercial	Success	Success
				Titan 4				
August 12, 1998	Titan 4/Centaur	USA 1998-08	DoD	Unknown	No	Non-Commercial	Failure	Failure

Launch Events
October 1998 - March 1999

Launch Date	Vehicle	Payload	Operator	Manufacturer	Int'l Comp	Launch Type	Site
China							
			Long March				
October 1998	Long March 4	FY-1C	Chinese Academy of Space Tech.	Shanghai Inst. of Satellite Engineering	No	Non-Commercial	Taiyuan
January 1999	Long March 3B	ChinaSat 8	Chinese Broadcasting Satellite Corp.	Space Systems/Loral	No	Non-Commercial	Xichang
1st Qtr 1999	Long March 2C	Iridium 93 Iridium 94	Iridium, Inc. Iridium, Inc.	Lockheed Martin Lockheed Martin	Yes	Commercial	Taiyuan
Europe (ESA)							
			Ariane 4				
October 5, 1998	Ariane 44L	Eutelsat W2 Sirius 3	Eutelsat NSAB	Aerospatiale Hughes	Yes	Commercial	Kourou
October 28, 1998	Ariane 44L	AfriStar 1 GE 5	WorldSpace, Inc. GE Americom	Alcatel Espace Aerospatiale Espace & Defense	Yes	Commercial	Kourou
November 24, 1998	Ariane 42L	SatMex 5	Telecomm Mexico	Hughes	Yes	Commercial	Kourou
December 1998	Ariane 42L	PAS 6B	PanAmSat	Hughes	Yes	Commercial	Kourou
February 1999	Ariane 44L	Arabsat 3A Skynet 4E	Arabsat British Defense Ministry	DASA Matra Marconi	Yes	Commercial	Kourou
1st Qtr 1999	Ariane 4-TBA	Insat 2E	ISRO	ISRO	Yes	Commercial	Kourou
			Ariane 5				
October 20, 1998	Ariane 5	ARD Maqsat 3	ESA Kayser-Threde	Aerospatiale Kayser-Threde	Yes	Non-Commercial	Kourou
January 1999	Ariane 5	AsiaStar 1 Telkom 1	WorldSpace, Inc. PT Telekom	Alcatel Lockheed Martin	Yes	Commercial	Kourou

*High-profile suborbital launch events included.

Launch Events
October 1998 - March 1999

Launch Date	Vehicle	Payload	Operator	Manufacturer	Int'l Comp	Launch Type	Site
India							
			PSLV				
1st Qtr 1999	PSLV	IRS P4 Kitsat 3 Tubsat C-DLR	ISRO Korean Advncd Inst. of Science Tech. Univ. of Berlin	ISRO Surrey Tech. Univ. of Berlin	No	Non-Commercial	Sriharikota
Japan							
			TR 1A				
4th Qtr 1998	TR 1A*	JEM Micrograv Test	NASDA	Unknown	No	Non-Commercial	Tanegashima
Russia							
			Cosmos				
January 1999	Cosmos	Abrixas MegSat 0	DLR Meggiorin	OHB System Unknown	No	Non-Commercial	Kapustin Yar
			Proton				
November 20, 1998	Proton	Zarya	International	Krunichev/Salyut	No	Non-Commercial	Baikonur
November 1998	Proton	PAS 8	Pan American Satellite Corp.	Space Systems/Loral	Yes	Commercial	Baikonur
December 12, 1998	Proton	Tempo 1	Tempo Satellite, Inc.	Space Systems/Loral	Yes	Commercial	Baikonur
4th Qtr 1998	Proton	Telstar 6	Skynet	Space Systems/Loral	Yes	Commercial	Baikonur
February 1999	Proton	Sesat	Eutelsat	NPO PM	Yes	Commercial	Baikonur
February 1999	Proton	Nimiq 1	Telesat Canada	Lockheed Martin	Yes	Commercial	Baikonur
1st Qtr 1999	Proton	Astra 1H	SES	Hughes	Yes	Commercial	Baikonur

*High-profile suborbital launch events included.

Launch Events
October 1998 - March 1999

Launch Date	Vehicle	Payload	Operator	Manufacturer	Int'l Comp	Launch Type	Site
Russia (cont.)							
			Soyuz				
November 5, 1998	Soyuz	Globalstars 21-24	Globalstar, Inc.	Space Systems/Loral	Yes	Commercial	Baikonur
December 11, 1998	Soyuz	Globalstars 25-28	Globalstar, Inc.	Space Systems/Loral	Yes	Commercial	Baikonur
4th Qtr 1998	Soyuz	Progress M-40	RKK Energia	RKK Energia	No	Non-Commercial	Baikonur
January 28, 1999	Soyuz	Globalstars 29-32	Globalstar, Inc.	Space Systems/Loral	Yes	Commercial	Baikonur
February 22, 1999	Soyuz	Soyuz TM-29	RKK Energia	RKK Energia	No	Non-Commercial	Baikonur
1st Qtr 1999	Soyuz	Globalstars 33-36	Globalstar, Inc.	Space Systems/Loral	Yes	Commercial	Baikonur
			START				
March 1999	START 1	Odin	Swedish National Space Board	Swedish Space Corp.	Yes	Commercial	Svobodny
Ukraine							
			Zenit				
November 1998	Zenit 2	Okean O1	Russia	NPO Yuzhnoe	No	Non-Commercial	Baikonur
USA							
			Athena				
November 19, 1998	Athena 2	IKONOS 1	Space Imaging Inc.	Lockheed Martin Missiles & Space	No	Commercial	VAFB
December 15, 1998	Athena 1	Rocsat 1	NSPO	TRW	Yes	Commercial	Spaceport Florida
February 15, 1999	Athena 2	IKONOS 2	Space Imaging Inc.	Lockheed Martin	No	Commercial	VAFB

*High-profile suborbital launch events included.

Launch Events
October 1998 - March 1999

Launch Date	Vehicle	Payload	Operator	Manufacturer	Int'l Comp	Launch Type	Site
USA (cont.)							
			Atlas 2				
October 8, 1998	Atlas 2AS	Hot Bird 5	Eutelsat	Matra Marconi	Yes	Commercial	CCAS
October 19, 1998	Atlas 2A	GBS 9	DoD	Hughes	No	Commercial	CCAS
December 1998	Atlas 2AS	JCSAT 6	Japan Satellite Systems (JSAT)	Hughes	Yes	Commercial	CCAS
January 1999	Atlas 2AS	ICO 1	ICO Global Communications	Hughes	Yes	Commercial	CCAS
March 1999	Atlas 2AS	Eutelsat W3	Eutelsat	Aerospatiale	Yes	Commercial	CCAS
			Atlas 3				
March 1999	Atlas 3A	Telstar 7	Skynet	Space Systems/Loral	Yes	Commercial	CCAS
			Delta 2				
October 19, 1998	Delta 2 7920	Iridiums 83-87	Iridium, Inc.	Lockheed Martin	Yes	Commercial	VAFB
October 25, 1998	Delta 2 7326	Deep Space 1 Sedsat-1	NASA NASA	Spectrum Astro, Inc. University of Alabama in Huntsville	No	Non-Commercial	CCAS
November 12, 1998	Delta 2 7925	Bonum 1	Bonum	Hughes	Yes	Commercial	CCAS
December 10, 1998	Delta 2 7425	Mars Climate Orbiter	NASA	Lockheed Martin	No	Non-Commercial	CCAS
December 17, 1998	Delta 2 7925	Argos Oersted Sunsat	Space Test Program Office, USAF Danish Space Research Institute University of Stellenbosch	TRW Computer Resources International Stellenbosch University	No	Non-Commercial	VAFB
January 3, 1999	Delta 2 7425	Mars Polar Lander Deep Space 2	NASA NASA	Lockheed Martin JPL	No	Non-Commercial	CCAS
February 6, 1999	Delta 2 7426	Stardust	NASA	Lockheed Martin	No	Non-Commercial	CCAS
March 1, 1999	Delta 2 7920	Iridiums 88-92	Iridium, Inc.	Lockheed Martin	Yes	Commercial	VAFB

*High-profile suborbital launch events included.

Launch Events
October 1998 - March 1999

Launch Date	Vehicle	Payload	Operator	Manufacturer	Int'l Comp	Launch Type	Site
USA (cont.)							
			Delta 3				
February 18, 1999	Delta 3	Orion F3	Orion Network Systems	Hughes	Yes	Commercial	CCAS
			Pegasus				
4th Qtr 1998	Pegasus XL	SCD 2	INPE	INPE	Yes	Commercial	CCAS
4th Qtr 1998	Pegasus XL	SWAS	Smithsonian Astrophys. Obs.	NASA Goddard	No	Non-Commercial	VAFB
1st Qtr 1999	Pegasus XL	TERRIERS Celestis 3 MUBLCOM	Boston University/NASA Celestis ARPA	AeroAstro Celestis Orbital Sciences	Yes	Commercial	VAFB
1st Qtr 1999	Pegasus XL	WIRE	NASA	NASA Goddard	No	Non-Commercial	VAFB
			Sea Launch				
March 1999	Sea Launch	Galaxy 11	PanAmSat	Hughes	Yes	Commercial	Sea Launch Platform
			Shuttle				
October 29, 1998	Shuttle Discovery	STS 95 PANSAT 1 Spartan 201-04R	NASA Naval Postgraduate School NASA	Rockwell International Naval Postgraduate School NASA	No	Non-Commercial	KSC
December 3, 1998	Shuttle Endeavour	STS 88 Unity MightySat 1 Press. Mating A 1&2 SAC A	NASA NASA DoD NASA NASA	Rockwell International NASA CTA Space Systems NASA Bariloche Company Invap.	No	Non-Commercial	KSC
January 21, 1999	Shuttle Columbia	STS 93 AXAF 1	NASA NASA	Rockwell International TRW	No	Non-Commercial	KSC
			Taurus				
October 2, 1998	Taurus 1	STEX	NRO	Lockheed Martin	No	Non-Commercial	VAFB

*High-profile suborbital launch events included.

Launch Events
October 1998 - March 1999

Launch Date	Vehicle	Payload	Operator	Manufacturer	Int'l Comp	Launch Type	Site
USA (cont.)							
			Titan 2				
November 24, 1998	Titan 2	QuickSCAT	NASA	Ball Aerospace	No	Non-Commercial	VAFB
			Titan 4				
December 18, 1998	Titan 4B/IUS	DSP 19	DoD	TRW	No	Non-Commercial	CCAS
January 27, 1999	Titan 4B/Centaur	Milstar II-F1	DoD/USAF	Lockheed Martin	No	Non-Commercial	CCAS
March 15, 1999	Titan 4B	USA 1999-03	DoD	Unknown	No	Non-Commercial	VAFB

*High-profile suborbital launch events included.