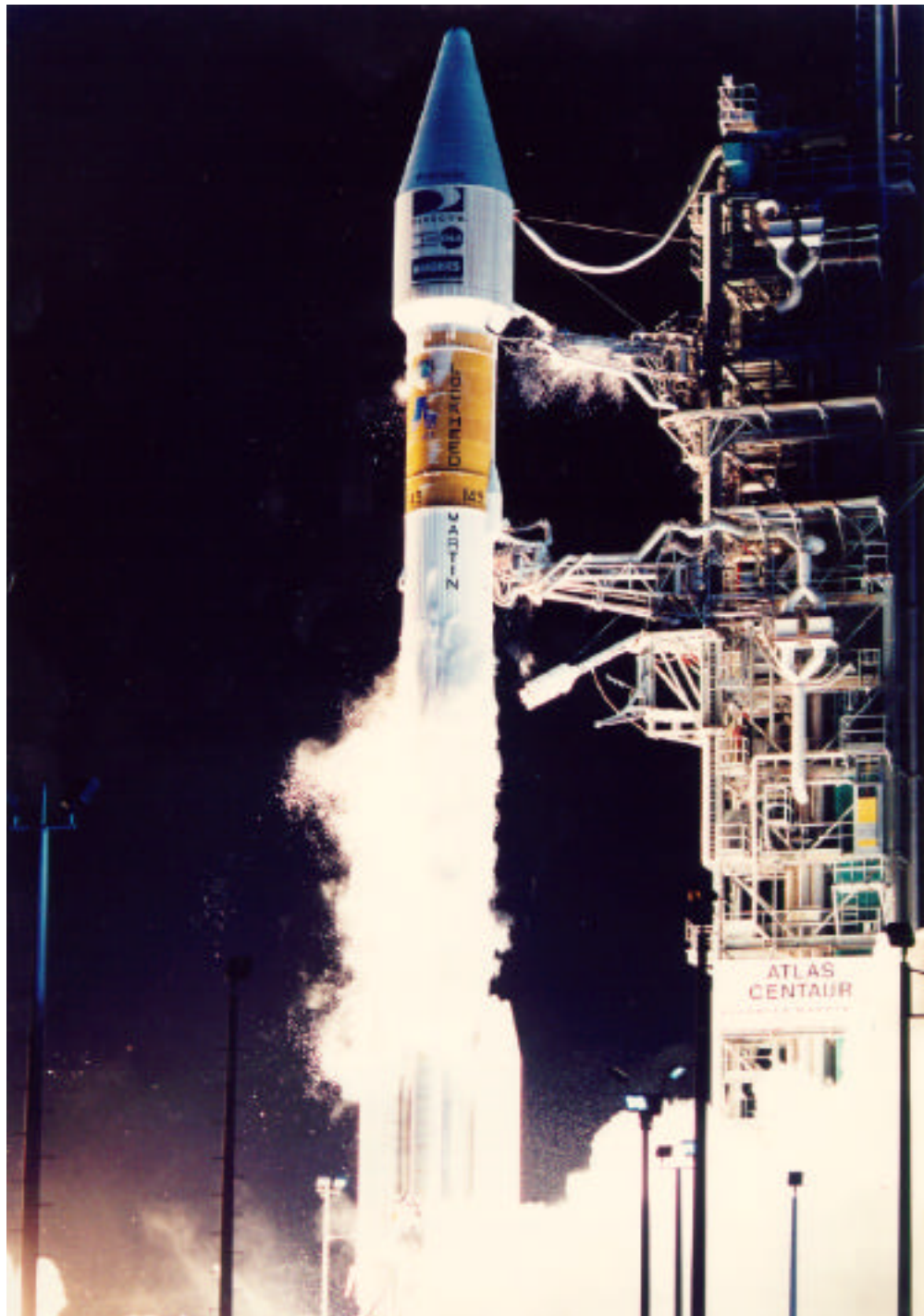


Commercial Space Transportation

QUARTERLY LAUNCH REPORT

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



1st Quarter 1998

United States Department of Transportation • Federal Aviation Administration
Associate Administrator for Commercial Space Transportation



1ST 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: International Launch Services (1997). Image is of the Atlas 2AS launch on December 8, 1997, from Cape Canaveral Air Station. It successfully orbited the Galaxy 8I direct broadcast satellite for PanAmSat Corporation.

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This document was released on January 31, 1998.

SUMMARY

**Fourth Quarter 1997
Launch Events**

- In the fourth quarter of 1997, the United States launched 12 vehicles. Five of these were commercial (two Atlas, two Delta, and one Pegasus) and seven were non-commercial (one each on Pegasus, Delta, Atlas, and Shuttle, as well as three Titan 4 launches). All of these launches were successful.
- There were ten Russian launches (three commercial and seven non-commercial). The commercial launches were on two Proton and one START 1. The non-commercial launches were on a Proton, a Cyclone, and five Soyuz. One of the commercial Proton launches was a failure, but all other Russian launches were successful.
- Three successful, commercial Ariane 4 launches also took place, and Europe's Ariane 5 returned to flight in a successful, non-commercial flight.
- China made two successful launches of the Long March.
- Japan conducted a successful, non-commercial launch of its H2 launch vehicle.
- Brazil's VLS failed in its first ever launch attempt.

**First and Second Quarter 1998
Scheduled Launch Events**

-
- United States vehicles are to make 32 launches in the next two quarters. Of these, 21 launches will be commercial. Commercial launches will include five Atlas, eight Delta, three Athena, four Pegasus, and a Taurus. Planned non-commercial launches are two Atlas, one Delta, and one Pegasus launch as well as three Shuttle, one Taurus, one Titan 2 and two Titan 4 launches.
 - Russia plans 9 launches. Four of these launches are to be commercial. The commercial launches are two Proton, one START-1, and one Zenit (this launch was sold through Ukraine). Non-commercial events will include three Soyuz and two Proton launches.
 - Europe plans six Ariane launches carrying nine satellites. Seven commercial GEO communication satellites will be launched on four Ariane 4 flights and one non-commercial remote sensing satellite will also be launched on an Ariane 4. The Ariane 5's first commercial launch will carry the commercial Hot Bird 5 communication satellite.
 - China intends to make six Long March launches, of which three will be commercial. Two of the three commercial launches will carry Iridium LEO communication satellites (two sets of two) and the other a GEO communication satellite. One of the three non-commercial launches will carry a pair of remote sensing satellites and the other two will carry a single GEO communications satellite each.
 - Japan intends to make one non-commercial launch on the H2 carrying a non-commercial technology development satellite.

SUMMARY

Commercial Products and Services

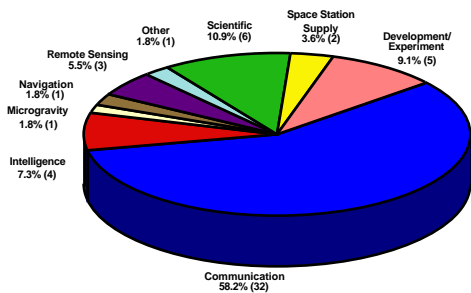
First and Second Quarter 1998

First Flight of the Delta 3

The first flight of the new Delta 3 launch vehicle is scheduled for June 1998 and will deploy Galaxy 10, a Hughes HS-601 satellite, for PanAmSat. Boeing inherited the Delta 3 program following its merger with McDonnell Douglas, and the vehicle was designed specifically to address the intermediate commercial GEO launch market. In May 1995, McDonnell Douglas announced it would develop the Delta 3 with a GTO capacity of 8,360 lb., more than twice the 4,060 lb. capacity of the Delta 2 7925. The development of the Delta 3 was enabled by a firm commitment for ten launches from Hughes between 1998 and 2002. Hughes has since purchased three more launches, and Space Systems/Loral has purchased five Delta 3 launches. The Delta 3 uses the same first stage engines as the Delta 2 and uses much of the same infrastructure as the Delta 2. New additions to the Delta 3 include a more powerful upper stage, larger strap-on motors, and a larger composite payload fairing.

Payload Use Analysis

Fourth Quarter 1997



Fifty-five payloads were launched in the fourth quarter of 1997. They were divided between communication (58.2 percent), intelligence (7.3 percent), microgravity (1.8 percent), navigation (1.8 percent), remote sensing (5.5 percent), scientific (10.9 percent), space station supply (3.6 percent), development/experimental (9.1 percent), and other (1.8 percent).

Communication payloads constituted all but one (95 percent) of the 22 internationally competed payloads on commercial launches. The remaining internationally competed payload was a remote sensing satellite.

LAUNCH SCHEDULE

Scheduled Launch Events

Vehicle	Payload	Site
JANUARY 1998		
Ariane 44LP	Brazilsat B3 Inmarsat 3 F5	Kourou
Athena 2	Lunar Prospector	CCAS
Atlas 2A	SM II 98-01	CCAS
Delta 2 7925	Skynet 4D	CCAS
Delta 2 7920	Iridium 49-53	VAFB
Long March 3B	Sinosat 1	Xichang
Shuttle Endeavour	STS 89	KSC
Soyuz	Soyuz TM-27	Baikonur
FEBRUARY 1998		
Ariane 42L	BSAT 1 B Hot Bird Plus 4	Kourou
Athena 2	IKONOS 1	VAFB
Atlas 2	GBS 8	CCAS
Delta 2 7420	Globalstar 1-4	CCAS
H 2	COMETS 1	Tanegashima
Long March 3B	ChinaStar 1A	Xichang
START 1	Odin	Svobodny
MARCH 1998		
Ariane 4-TBA	SPOT 4	Kourou
Athena 1	Clark	VAFB
Atlas 2AS	Sky 2	CCAS
Atlas 2AS	Intelsat 8A F6	CCAS
Proton (SL-12)	Astra 2A	Baikonur
Proton (SL-12)	EchoStar 4	Baikonur
Soyuz	Progress M-38	Baikonur

LAUNCH SCHEDULE

Scheduled Launch Events

(Continued)

Vehicle	Payload	Site
APRIL 1998		
Ariane 44L	Insat 2E Nilesat 1	Kourou
Atlas 2AS	Eutelsat 3 F 1	CCAS
Delta 2 7920	Iridium 58-62	VAFB
Delta 2 7420	Globalstar 5-8	CCAS
Shuttle Columbia	STS 90	KSC
MAY 1998		
Ariane 4-TBA	PAS 7	Kourou
Delta 2 7920	Argos Oersted Sunsat	VAFB
Long March 4	CBERS/Ziyuan 1 SACI 1	Taiyuan
Shuttle Discovery	STS 91	KSC
Titan 4B/Centaur	USA 1998-05	CCAS
Titan 2	NOAA K	VAFB
JUNE 1998		
Ariane 5	Hot Bird Plus 5	Kourou
Atlas 2AS	Intelsat 8A F5	CCAS
Atlas 2AS	EOS AM 1	VAFB
Delta 3	Galaxy 10	CCAS
Delta 2 7920	Iridium R1 - R5	VAFB
Proton (SL-13)	FGB	Baikonur
Titan 4/Centaur	USA 1998-06	CCAS

LAUNCH SCHEDULE

Additional Launch Events to be Announced[†]

For the First and Second Quarter 1998

Vehicle	Payload	Site
FIRST QUARTER OF 1998		
Long March 2C	Iridium 54 Iridium 55	Taiyuan
Long March 3B	APMT 1	Xichang
Pegasus XL	Orbcomm 13-20	VAFB
Pegasus XL	TRACE	VAFB
Pegasus XL	SNOE	VAFB
	BATSAT	
Proton (SL-12)	Glonass-M R1 - R3	Baikonur
Proton (SL-12)	Gorizont 33	Baikonur
Taurus 1	STEX 1	VAFB
Taurus 1	Geosat Follow-On 1	VAFB
	Orbcomm 3	
	Orbcomm 4	
	Celestis 2	

SECOND QUARTER OF 1998

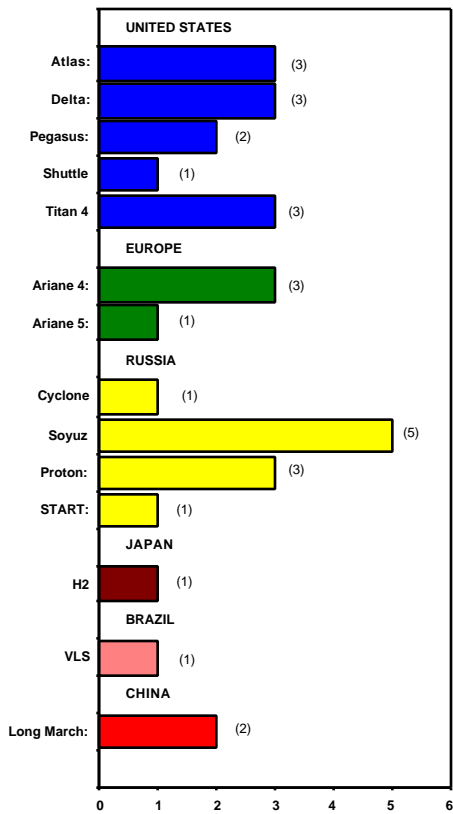
Delta 2 7925	Thor 3	CCAS
Long March 2C	Iridium 56 Iridium 57	Taiyuan
Pegasus XL/HAPS	Orbcomm 21-28	Wallop's Island
Pegasus XL	SCD 2	CCAS
Zenit 2	Globalstar 9-20	Baikonur

[†] 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

LAUNCH REPORT

Launch Events

Fourth Quarter 1997



Number of Launches
October - December 1997

In the fourth quarter, the U.S. launch vehicles made 12 of the 30 launches worldwide. Five of these launches were commercial; two sets of five Iridium payloads on Delta, two GEO communication satellites on Atlas, and a set of eight Orbcomm LEO communication satellites on Pegasus. The United States also made seven non-commercial launches. Three of these were Titan 4s (two intelligence and one science payload), with one each for Delta (a GPS satellite), Atlas (a military communication satellite), the Shuttle, and Pegasus (DoD's STEP 4). STEP 4's solar panels failed to deploy after launch and the satellite was declared lost.

Europe's Ariane 4 launch vehicle made three launches orbiting four commercial communication satellites and a scientific satellite. The Ariane 5 also flew successfully in a non-commercial test flight.

There were ten Russian launches, of which three were commercial (two Protons with GEO communication satellites and a START 1 with the EarlyBird 1 remote sensing satellite). The commercial AsiaSat 3 was stranded in a low orbit when its Proton's Block DM upper stage failed to operate properly. Contact was lost with the EarlyBird after a successful launch and its fate is unclear at this time. Five of the seven non-commercial launches were made by Soyuz launch vehicles (two Progress payloads and one intelligence, one remote sensing, and one microgravity payload). The remaining two payloads were a non-commercial communication satellite on a Proton and an intelligence satellite on a Cyclone.

Japan launched the ETS-7 technology development payload on an H2 along with the TRMM remote sensing satellite.

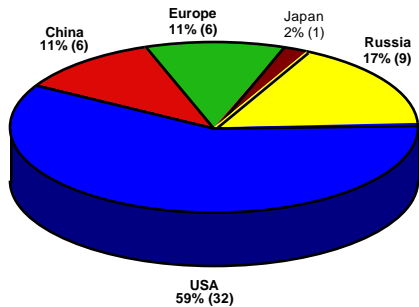
Brazil made its first launch of the VLS, but only three of the vehicle's four solid rocket boosters ignited leading to a failed launch.

China successfully launched a GEO communication satellite and two Iridium satellites on two commercial Long March vehicles.

LAUNCH REPORT

Scheduled Launch Events

First and Second Quarter 1998



Scheduled Launch Events, by Region
January - June 1998

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

In the first and second quarter of 1998, 54 launch events are planned. The United States plans to conduct 32 of these. Seven launches will be on Atlas vehicles, five will carry communication payloads in addition to launches carrying one intelligence and one remote sensing payload. Eight are on Delta 2 with seven communication and one development payload (launched with two small scientific satellites). One Delta 3 will carry a communications satellite. An Athena 1 will launch a remote sensing satellite, and two Athena 2 flights will carry a remote sensing and a scientific payload. Pegasus will launch five times with three communication and two scientific payloads. Taurus will be used twice, launching a technology development payload and another multiple payload launch with an intelligence, two communication, and a funerary payload. There will also be three Shuttle missions, one Titan 2 with a meteorological satellite, and two Titan 4s with classified payloads.

Russia anticipates nine launches. Five are on Proton with three communication satellites, the first International Space Station module, and a set of three Glonass navigation satellites. Soyuz will make two launches to Mir (one crewed Soyuz and one Progress supply mission). A Zenit will launch a set of 12 Globalstar LEO communication satellites under a contract negotiated by Ukraine. Finally, a START 1 will launch a Swedish scientific payload.

Europe's Ariane 5 will make its first commercial flight launching the Hot Bird Plus 5 commercial communication satellite. There will also be four Ariane 4 launches with seven communication satellites and one Ariane 4 launch of a remote sensing payload.

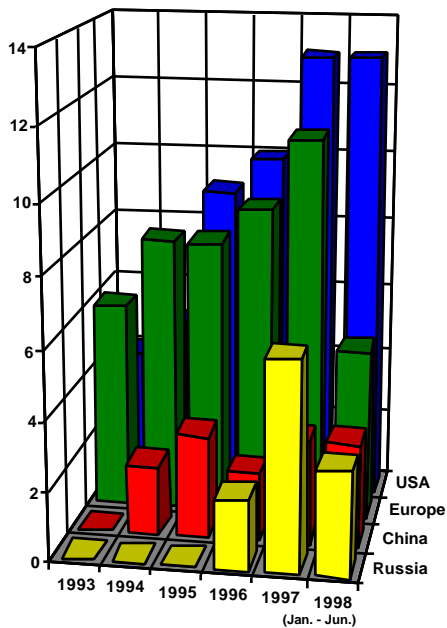
China intends to launch six Long March vehicles. Five will have communication payloads and one will carry a pair of remote sensing satellites.

Japan will launch a technology development payload on an H 2 launch vehicle.

LAUNCH REPORT

Scheduled Commercial Launch Events

First and Second Quarter 1998



Commercial Launch Events
January 1993 - June 1998
(Small Vehicles Excluded)

Of the 43 worldwide launches (excluding small launch vehicles) anticipated for the next two quarters, 24 will be commercial. The United States will have more than half of these, with 13 commercial launches. Delta 2 vehicles will launch seven times with communication payloads (five launches will carry multiple-manifested communication satellites to LEO). One Delta 3 will launch a GEO communication payload. Five Atlas launches will carry GEO communication satellites. If U.S. small commercial launches are considered, the United States' share becomes 21 of 33 commercial launches. Including three Pegasus vehicles to be launched with communication payloads and a fourth to launch a scientific payload. Three more of these commercial launches will be on Athena launch vehicles; two are remote sensing satellite launches while the third will carry a scientific spacecraft (Lunar Prospector). Also, a single Taurus will launch an intelligence, two LEO communications, and a funerary satellite.

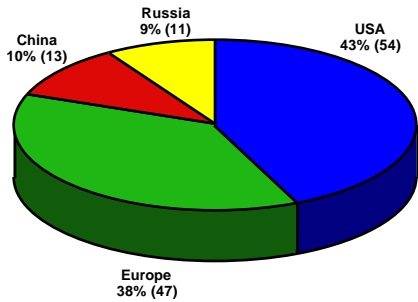
Europe plans four commercial launches of the Ariane 4, placing seven communication satellites in GEO. The Ariane 5 will make its first commercial launch, carrying a GEO communications payload.

Russia intends to conduct three commercial launches (excluding small launch vehicles). Two of these launches are on Proton launch vehicles with GEO communication satellites as payloads and one is on a Ukrainian-marketed Zenit launch with 12 Globalstar satellites. One additional Russian launch (of a small launch vehicle) is a START 1 launch vehicle which will loft the Swedish Odin scientific satellite. This launch brings the Russian total to four commercial launches.

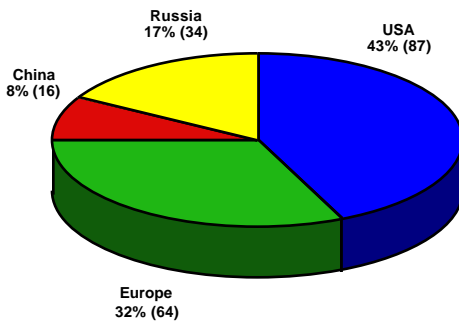
China's three commercial launches will be divided between GEO and LEO payloads with one GEO communication satellite launch and two launches of Iridium LEO communication satellites (two satellites per launch).

LAUNCH REPORT

Commercial Launch Trends



Commercial Launch Market Trend
January 1993 - June 1998
(Small Vehicles Excluded)



Internationally Competed Payloads Market Trend
January 1993 - June 1998
(Small Vehicles Excluded)

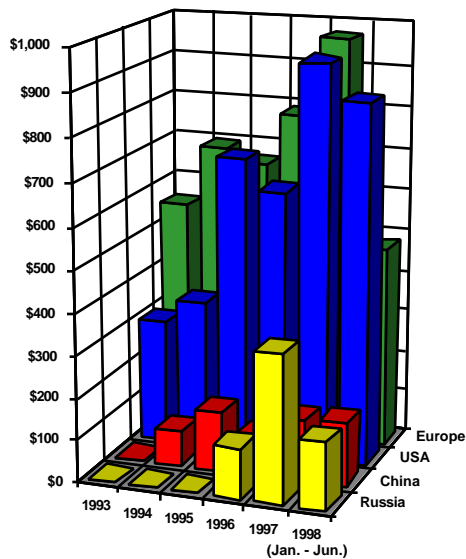
Between January 1993 and June 1998, 125 commercial launch events are planned or have occurred (excluding small launch vehicles). The United States plans to make 54 of these (a 43-percent share of the total). In internationally competed payloads, the United States will have launched 87 of 201 payloads for a 43-percent share.

Europe has 47 of the launches in this period, a 38-percent share. It has 64 internationally competed payloads, for 32 percent of the total. China is expected to have launched 13 times with 16 payloads for an eight percent share of internationally competed payloads and a ten percent share of commercial launches. Russia should have conducted 11 commercial launches for a nine-percent share and deployed 34 internationally competed payloads (17 percent of the total).

In the three quarters covered by this report, October 1997 through June 1998, a total of 35 commercial launches are expected (excluding small vehicles) with 77 internationally competed payloads. The United States will have made 17 commercial launches in this period (or 49 percent of the total) carrying 42 internationally competed payloads (55 percent of the total). Europe plans eight commercial launches (23 percent) with 11 internationally competed payloads (14 percent). China's share of commercial launches is five launches (14 percent) and eight payloads (ten percent). Russia's anticipates 16 payloads on five vehicles for 21 percent of internationally competed payloads and 14 percent of commercial launches.

LAUNCH REPORT

Commercial Launch Revenues



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

January 1993 - June 1998

* 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.

In the first half of 1998, revenues for commercial launch events are expected to total \$1.6 billion worldwide. Including these projected figures, the total revenues for the period between January 1993 and June 1998 are projected to be \$10.1 billion. Of this total, the United States will have a 41 percent share of world revenues with a total of \$4.1 billion. Europe will have a 46 percent share, with \$4.7 billion. Russia holds an estimated six percent share with \$0.63 billion and China will have a seven percent share with \$0.68 billion.

Over the past two years and into the second quarter of 1998, U.S. revenues have been stable at approximately 40 percent of world commercial launch revenues. For the five-and-a-half-year period between January 1993 and June 1998, the United States has a 41 percent share of these revenues. Chinese and Russian revenues have increased over this period at the expense of Europe's Arianespace. In this quarter, however, the Russian portion of world launch revenues has dropped from a projected nine-percent share last quarter (for the January 1993 through March 1998 period) to a six-percent share this quarter (for the January 1993 through June 1998 period). Europe's share of 1993 through second quarter 1998 launch revenues is 46 percent, up from 44 percent for the previous quarter's January 1993 through March 1998 period. Such small fluctuations do not constitute major market trends, but they do demonstrate the uncertainties involved in launch market predictions.

U.S. & INTERNATIONAL SMALL LAUNCH VEHICLES

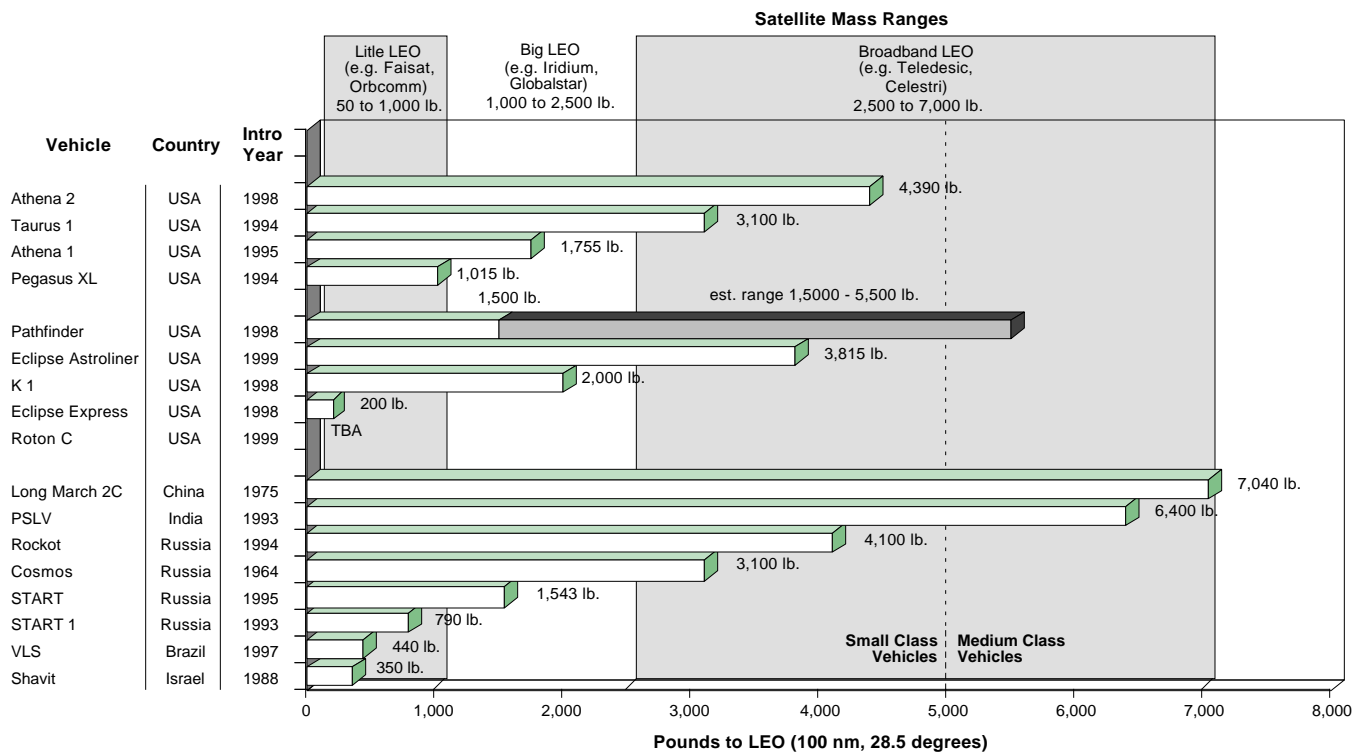
Since the 1980s, there have been expectations that a substantial commercial market for launch services using small launch vehicles¹ would develop. In fact, commercial launches of small launch vehicles have, in theory, been available since the mid-1980s. However, the first commercial launch of a small vehicle did not occur until 1993. Since then, the market has been small, about one or two commercial launches annually, and until recently, only U.S. firms have served the market (the first non-U.S. commercial launch of a small vehicle occurred in December 1997).

There are now revitalized expectations that the market will become much larger in the next few years. These expectations are driven by the

emergence of new commercial applications for small satellites in low Earth orbit – ideal payloads for small vehicles – and are fueling the development of new commercial vehicles by launch service providers around the world.

Constellations of small, commercial satellites will be used in low Earth orbit (LEO) to provide global wireless data and telephone services as well as international data networks; these constellations are sometimes called “big LEO” systems and use dozens and sometimes hundreds of satellites. The first of these systems to be deployed is the mobile satellite communication system Iridium, owned by Motorola and its international partners, which is currently in its

Figure 1. Worldwide Small Launch Vehicle Capabilities



¹ By FAA’s definition, small launch vehicles are defined as being able to deliver no more than 5,000 lb. to low Earth orbit (LEO). For this report, a LEO orbit is defined as an orbit at 28.5 degrees and 100 nm altitude.

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launch phase. The initial deployment of these massive constellations will generally not use small launch vehicles; they will be deployed in groups on larger launch vehicles, to minimize deployment costs. For example, in 1997, 46 Iridium satellites were launched on seven medium- and two heavy-class launch vehicles²; similar vehicles will launch the remaining 26 satellites in 1998. Group launches will not be feasible, however, for maintenance of these large constellations. Maintenance flights will be needed on a quick-turnaround basis to replace single satellite failures and for planned system replenishment in smaller numbers. It is expected that these operations and maintenance flights will primarily use small launch vehicles.

Small satellites will also provide many niche services such as store and forward e-mail, fleet tracking, and utility monitoring; these satellites and constellations are sometimes called “little LEOs” and may use a single satellite or several dozen. It is likely that these systems will use small launch vehicles. In fact, Orbital Sciences began full-scale deployment of the Orbcomm satellite system with the launch of eight Orbcomm satellites on a Pegasus this past December. Orbcomm is a little LEO system which will provide two-way data communications worldwide for e-mail, non-voice messaging, and fleet tracking.

The precise timing and size of the market for small launch vehicle services is uncertain, because of the recent emergence of commercial LEO satellite applications. However, many firms are offering commercial small launch vehicle services in anticipation of the success of these LEO applications. New firms in the United States and in other countries continue to enter the market. In

addition to the conventional U.S. and foreign small launch vehicles, there has also been renewed interest in and pursuit of reusable launch vehicle (RLV) concepts. Several of these concepts are also targeting small satellites.

This report profiles each of the current U.S. and international small launch systems and the markets their operators are targeting. It includes an overview of the various reusable launch vehicle concepts in development and how their proponents hope they will become a competitive alternative to traditional expendable launch vehicles. Figure 1, on page 1 above, shows current and planned launch vehicle systems and their capacities.

U.S. EXPENDABLE SMALL LAUNCH VEHICLES

There are currently two U.S. small launch vehicle families in commercial operation: Lockheed Martin’s Athena and Orbital Sciences Corporation’s Pegasus and Taurus vehicles.

Athena

Lockheed Martin’s Athena 1 launch vehicle, formerly the Lockheed Martin Launch Vehicle 1 (LMLV-1), is a two-stage solid propellant vehicle based on the Thiokol Castor 120 solid rocket motor. Since its initial demonstration flight which ended in failure, it has been redesigned and its management and manufacturing approach restructured. It is capable of putting 1,755 lb. into a LEO orbit. The Athena 2 (formerly the LMLV-2) is essentially an Athena 1 with an additional Castor 120 solid rocket motor. Its LEO capacity is 4,390 lb.

The Athena 1’s first successful flight was the commercial launch of NASA’s Lewis remote sensing spacecraft on August 23, 1997 (Lewis

² Medium class vehicles have maximum lift capacities between 5,001 lb. and 12,000 lb. to LEO, intermediate vehicles between 12,001 and 25,000 lb., and heavy vehicles greater than 25,000 lb. to LEO.

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failed shortly after launch and was eventually lost). Lockheed Martin's earlier demonstration flight of the LMLV-1 on August 15, 1995, failed to deploy the GEMstar 1 payload for Volunteers in Technical Assistance (VITA).

The first launch of the larger Athena 2 deployed NASA's Lunar Prospector on January 6, 1998. The price for this commercial launch was approximately \$28 million (the launch price for an Athena 1 is about \$16 million).

There are five launches planned for Athena through 1999. Three of these are commercial launches of small remote sensing payloads: NASA's Clark satellite and Space Imaging's IKONOS 1 and 2. The remaining two launches are the commercial launch of the Taiwanese ROCSat and the non-commercial U.S. Air Force SBIRS LADS satellite.

Industry analysts believe Lockheed Martin could launch 12 or more Athena vehicles per year if demand warranted.³

Pegasus

Orbital Science Corporation's Pegasus XL is a three-stage, solid propellant, winged rocket that is air launched by an L-1011 carrier aircraft. It can place a 1,015 lb. payload into a low Earth orbit. It is currently the most active U.S. small launch vehicle with five launches in 1997, placing 13 payloads in orbit.

In the past, Pegasus has been primarily used to launch small engineering test satellites for the Department of Defense as well as scientific satellites for U.S. and international customers at about \$12 million to \$14 million per launch. Pegasus has launched a number of OSC's own

payloads, including the Orbview 2 remote sensing satellite and the initial launch of satellites for OSC's Orbcomm LEO communication satellite constellation. Pegasus has been launched 19 times since its maiden flight in 1990: eight of the standard Pegasus and 11 of the current Pegasus XL. Of these launches, six have been commercial and 13 non-commercial.

Ten Pegasus launches are planned over the next two years. These include six commercial launches, two of which are Orbcomm satellites (in sets of eight), three scientific, and one communication satellite. Four non-commercial government launches are also planned, carrying three scientific and one experimental payload.

Pegasus has had a historical maximum launch rate of five per year in 1997 and industry analysts consider the maximum expected Pegasus build and launch rate to be about eight per year.⁴

Taurus

Orbital Sciences Corporation's Taurus is essentially a three-stage solid propellant Pegasus vehicle stacked on a solid propellant Thiokol Castor 120 solid rocket motor (called stage 0). Its LEO capacity is 3,100 lb.

Taurus was successfully launched on March 13, 1994 and deployed the ARPAsat satellite as well as the STEP 0/TAOS 1 payload for the Department of Defense. This vehicle differed from the current Taurus configuration; it used a Peacekeeper ICBM first stage instead of the Thiokol Castor 120 stage, which will be used by future Taurus vehicles.

Taurus is expected to make two commercial and two non-commercial launches before the end of

³ "United States/LAUNCHERS," *Jane's Space Directory, 1995-1996*, pg. 275.

⁴ "United States/LAUNCHERS," *Jane's Space Directory, 1996-1997*, pg. 262.

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1999. The first commercial launch will take place early in 1998. This launch will carry the Geosat Follow-On (GFO) spacecraft, along with two Orbcomm satellites and the second Celestis funerary payload. The second commercial launch will carry the Korean Kompsat remote sensing payload in 1999.

Non-commercial payloads manifested for Taurus include the STEX 1 and TSX 5 satellites for the Department of Defense. Both of these are intended for launch in 1998. STEX 1, or the Sensor Technology Experiment, will demonstrate radiation measurement technology. TSX 5, the Tri-Service Experiment Mission, will support technology development for the Ballistic Missile Defense Organization.

A Taurus launch costs approximately \$18 million to \$20 million.

INTERNATIONAL VEHICLES

Following its first commercial Pegasus launch in 1993, the United States has made eight of nine small commercial launches worldwide. Until the 1997 launch of EarlyBird on a START-1 launch vehicle, the United States was the only nation whose firms provided commercial small launch services. With the former Soviet launch industry now providing commercial services, the United States no longer holds this exclusive position. The commercial small launch vehicle market became truly international on December 24, 1997 with the successful launch of a Russian START-1 vehicle.

Other emerging players in the small launch vehicle market include Brazil and possibly Israel. Although the first flight of the Brazilian VLS ended in failure in 1997, it will be offered commercially some time in the next few years.

The Israeli Next vehicle, based on the Shavit, may launch payloads commercially if an international partner can be found to provide a launch site outside of Israel, which is limited by overflight restrictions.

Meanwhile, other countries, such as China and India, have begun offering commercial services on medium launch vehicles which compete with the small launch vehicle market. China's Long March 2C, for example, successfully placed two Iridium satellites in orbit on December 8, 1997. The Chinese Long March 2C is a medium lift launch vehicle by FAA's definition but is small enough to compete directly against small-class vehicles. India's PSLV, another medium-class vehicle, will carry a South Korean satellite as a secondary payload in the third quarter of 1998.

Russia

Russia currently markets three small launch vehicles to both commercial and non-commercial customers: Cosmos, Rockot, and START. Russia is the largest provider of commercial small launch vehicles outside of the United States. It is the only other country, besides the United States, to have conducted a commercial small launch. This launch took place on December 24, 1997 from the Russia launch site at Svobodny when EarthWatch, Inc.'s EarlyBird remote sensing satellite was deployed on the START-1 launch vehicle. Russia has also launched several foreign small satellites as secondary payloads on other Russian vehicles.

Cosmos

The Cosmos launch vehicle is a two-stage liquid fueled launch vehicle with a LEO capacity of 3,100 lb.

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Cosmos has been launched over 400 times since its introduction in 1964. Two developmental flights of the Faisat satellite system, Faisat 1 and Faisat 2v, were launched aboard Cosmos vehicles in 1995 and 1997.⁵ Cosmos launch services are now sold in the United States through Cosmos USA, a partnership between Assured Space Access of Arlington, Virginia, and EDB Polyot of Omsk, Russia.

In May 1996, Final Analysis, Inc. announced it would buy four Cosmos launches to deploy 26 operational satellites, plus spares. The first dedicated commercial launch of the Cosmos vehicle will be in 1999 when it will carry the first seven Faisat satellites. The entire constellation will be deployed by 2000. A Cosmos launch is reported to cost between \$10 million and \$14 million.

Rockot

Rockot is a three-stage liquid-fueled vehicle based on the SS-19 ICBM with a LEO capacity of 4,100 lb. Daimler Benz of Bremen, Germany and Russian Rockot manufacturer Khrunichev formed a joint venture known as Eurocket in March 1995 to market a commercial variant of the vehicle.

Rockot made its first orbital launch in December 1994 when it launched Radio Rosto, an amateur radio satellite, for the Russian Defense, Sports, and Technical Organization.

The next launch of Rockot is expected in 1998, carrying the UoSat-12 satellite for Surrey Satellite and Technology on a non-commercial launch. The launch will be a development flight for a new minisatellite platform and which will carry collaborative payloads from Nanyang

Technological University in Singapore and the European Space Agency.⁶ The E-sat data-messaging system is a "little-LEO" constellation of six 210 kg satellites planned by Echostar and DBS Industries. The system is currently undergoing mass trade-off studies and will be deployed on either two Rockot launches (carrying three satellites each) or three Rockot launches (of two satellites each) beginning in late 1998. The launch of this little LEO system will mark the first dedicated commercial launch of the Rockot.

START

The START launch vehicle family consists of the four-stage START-1 with a LEO capacity of 790 lb. and the five-stage START with a LEO capacity of 1,543 lb. These vehicles are based on the solid-fuel SS-20 and SS-25 ballistic missiles.

START-1 first flew on March 25, 1993 and placed a small test satellite in orbit. The first flight of the five-stage START ended in failure on March 28, 1995, resulting in the loss of Israel's Gurwin satellite and Unamsat for the Autonomous University of Mexico. The second flight of the START-1 successfully launched Zeya on March 4, 1997, a small experimental satellite carrying a communications and geodesy payload. The Zeya launch was the first launch from Russia's new far Eastern launch site at Svobodny.

The most recent and perhaps most significant flight of a START-1 launch vehicle was EarthWatch's EarlyBird remote sensing spacecraft on December 24, 1997. This flight was the first dedicated commercial launch of a non-U.S. small launch vehicle.

⁵ "Final Analysis/VITA Launch Falls Victim to Red Tape," *Satellite News*, April 28, 1997, p. 1.

⁶ Surrey Small Satellite Homepage (http://www.ee.surrey.ac.uk/CSER/UOSAT/SSHP/future_minis.html)

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SR-6

The next commercial flight is expected to be the Swedish Odin satellite in 1998. A LEO store-and-forward system known as Courier has been proposed by START manufacturer MTT and STC Complex and would be launched sometime after 1999 if the program is carried through. STC Complex of Russia is handling all contracts for the START vehicle.

A deal between Akjuit Aerospace and STC Complex, signed in October 1996, will allow START launches from Canada beginning in late 1998. The new commercial launch site, called SpacePort Canada, is located near Churchill, Manitoba on the shore of Hudson Bay. The agreement will provide a turn-key launch service package aimed at servicing the small satellite industry and will be ideal for launching into polar, high-inclination, and sun-synchronous orbits.⁷

China

China is active in the commercial LEO market using the Long March 2C. Although defined as a medium-lift launch vehicle, it competes in the small payload launch market because of its rather low capacity (7,040 pounds to LEO). On September 1, 1997, a Chinese Long March 2C was used to launch two, inert "Mass Frequency Simulators" to test the vehicle's capability to launch Iridium satellites. The Long March 2C later successfully orbited two actual Iridium satellites on December 8, 1997. Several additional Long March 2C Iridium launches are planned for 1998. To date, no other commercial payloads are known to be manifested for Long March 2C, which costs about \$15 million to \$20 million per launch.

⁷ "Spaceport Deal Signed/Canadians Will Launch Russian START Rockets," *Space News*, October 14, 1996, p. 1.

Brazil

Brazil has spent many years developing its own orbital launch capability, which culminated last year in the first launch attempt of the Veiculo Lancador de Satellites (VLS). VLS has a LEO capacity of 440 lb. It failed in its first launch attempt on November 2, 1997 when one of its four solid rocket motors failed to ignite. Developed from technology used in Brazil's Sonda sounding rockets, VLS launch vehicles use the launch complex at Alcântara, Brazil. Located less than three degrees south of the equator, Alcântara is an excellent site for equatorial launches. Brazil plans to launch one VLS rocket per year for the next several years and intends to eventually sell VLS launch services commercially. The recent inaugural flight of the VLS was a non-commercial launch and reportedly cost about \$6.5 million.

India

India developed its Polar Satellite Launch Vehicle (PSLV) to launch its series of earth resource remote sensing satellites. The PSLV is technically a medium-lift launch vehicle but could, in principal, be used commercially for a variety of commercial LEO missions. It can put 6,400 lb. into LEO. The PSLV has been launched four times since 1993, failing on its first launch attempt due to a problem with the separation of the second stage. The PSLV flew successfully in 1994 and 1996 but, on September 29, 1997, it placed the IRS 1D satellite into a lower-than intended orbit (onboard propulsion managed to raise the orbit of IRS 1D to the intended location). There are five more PSLV launches currently planned by the Indian government at the rate of about one per year. The unit cost of a PSLV vehicle is reported to be between \$11 million and

\$12 million. The next launch, in 1998, is expected to carry a small South Korean satellite as a secondary payload with the IRS P4 satellite.⁸ No dedicated commercial launches are planned at this time.

Israel

Israel will offer commercial launch services on Next, an upgraded version of its domestic Shavit launch vehicle. Shavit, built by Israeli Aircraft Industries, has conducted three non-commercial launches to date. These launches placed three Israeli Ofteq remote sensing satellites in orbit in 1988, 1990, and 1995. When launched from Israel's domestic launch site in the Negev Desert, Shavit is constrained in terms of orbital inclination because of overflight restrictions imposed by neighboring Arab countries. It has a LEO capacity of 350 lb.

Israeli Aircraft Industries has been trying to get permission to use the Wallops Island, Virginia launch site for the Next vehicle. TRW had campaigned for the use of Next to launch the TSX 5 satellite (now scheduled to be launched on Taurus). If the Israelis are successful in finding an international launch site, Next could join the commercial launch market.⁹

REUSABLE SMALL LAUNCH VEHICLE CONCEPTS

There are currently a number of different reusable launch vehicle (RLV) systems under development by private industry. They are mostly focused on the emerging market for the replacement of

satellite in the new LEO telecommunications constellations. The combination of a large potential market and relatively small satellites at low orbits combine to make this an attractive point of entry for new launch systems.

General concepts range from the launch of satellites from a vehicle in a suborbital ballistic trajectory, exemplified by the Rocketplane Pathfinder and Eclipse concepts, to Kistler's design for a relatively conventional but fully-reusable two-stage launch vehicle. Other ideas include the one-stage Roton vehicle that will autogyro back to its launch site. Several of the commercial RLVs in development plan to make their first flights within the next two years, including Kistler's K-1, Kelly Space & Technology's Eclipse, and Rotary Rocket Company's Roton. More specific descriptions of some of these RLV concepts follow, although these do not constitute an exhaustive listing of all current private RLV efforts.

Pioneer Rocketplane's Pathfinder

Drawing on the heritage of the proposed Black Horse military spaceplane of 1993, Pathfinder was proposed by Pioneer Rocketplane of Lakewood, Colorado as a potential design for the X-34. While not selected for the X-34 contract, Pioneer Rocketplane has nevertheless continued development of the Pathfinder vehicle as a commercial concept. In June 1997, NASA awarded one of four \$2 million contracts to Pioneer Rocketplane for the Pathfinder. These awards were conducted under the Bantam program, which is intended to develop preliminary designs and conduct wind tunnel tests for concepts to launch small satellites.¹⁰

⁸ Florida Today SpaceOnline (<http://www.flatoday.com/space/today/index.htm>), September 29, 1997.

⁹ "Long Way From Home," *Aviation Week*, February 3, 1997, p.21.

¹⁰ The other three awards went to Universal Space Lines, Inc. of Newport Beach, Summa Technology, Inc. of Huntsville, and Aerojet-General Corp. of Sacramento.

Using in-air fueling, the Pathfinder rocketplane would take on liquid oxygen (LOX) to power several Russian-designed RD-120 engines and then fly to an altitude of 130 km to deploy its payload with an expendable upper stage. Pioneer Rocketplane envisions using Pathfinder as a fast package delivery system or as a vehicle to carry passengers to the edge of space as tourists. The liquid oxygen in-air fueling systems remains the largest technical challenge for their spaceplane, and Pioneer Rocketplane expects it will require about \$100 million in investment to develop Pathfinder.¹¹

Kelly Space and Technology's Eclipse

Kelly Space and Technology (KST) is developing a family of tow-launched suborbital rocketplanes which would place satellites into orbit using an expendable upper stage. In October 1996, Motorola signed a contract to launch 20 Iridium satellites in ten launches on an as-needed basis, beginning possibly as early as 1999.¹² Three versions of the Eclipse vehicle are planned. In order of capacity from smallest to largest they are: the Sprint, the Express, and the Astroliner. The Sprint will launch only suborbital payloads, while the Express will launch suborbital and microsat orbital missions. The Astroliner would be capable of launching small payloads into LEO. KST is currently conducting ground and flight tests of the Eclipse tow-launch technique using modified U.S. Air Force supplied QF-106 aircraft, along with the USAF Flight Test Center-supplied C-141A tow aircraft at Edwards Air Force Base.

¹¹ Pioneer Rocketplane *Initial Product/Design* (<http://www.rocketplane.com/inprod.htm>)

¹² "Motorola Signs Up For Eclipse Launcher," *Space News*, October 7, 1996, p. 1.

Kistler Aerospace Corporation's K-1

Kistler Aerospace Corporation is developing the K-1, a two-stage fully reusable launch vehicle. It will be a vertical take-off vehicle much like traditional ELVs, but both stages are recovered following air-bag landings. Initial test flights of the K-1 are scheduled for 1998. Kistler plans to offer its K-1 vehicle for \$17 million per launch. In August 1997, the U.S. Department of Energy signed an agreement with the Nevada Test Site Development Corporation that will allow Kistler to develop launch operations at that site. Kistler also plans to construct a launch facility at the Woomera site in northern Australia for both test and launch operations.

Rotary Rocket Company's Roton-C

The current design of the Roton was unveiled at the Cheap Access To Space (CATS) Symposium in July 1997. Rotary Rocket plans to use a vertical take-off-and-landing vehicle utilizing a rocket powered ascent and a helicopter-like, unpowered rotor for the descent and landing. The Roton-C concept is based on using centrifugal pumping of propellant by spinning the combustion chambers and using a rotor to land the vehicle instead of engine thrust, parachutes, or fixed wings. Earlier Roton concepts would have employed the rotors during the ascent as well. The first test flights are planned for 1999, with operations beginning in 2000. Rotary Rocket Company will initially offer launch services themselves but hopes to build a fleet of vehicles to be sold to other companies to provide launch, cargo delivery, and space tourism services. The company is still seeking investors after an initial round of fundraising raised about \$6 million.¹³

¹³ Rotary Rocket Company (<http://www.rotaryrocket.com>)

Special Report

UNITED STATES GOVERNMENT RLV EFFORTS

The U.S. government is also sponsoring technology development for reusable vehicles through the X-33 and X-34 programs as well as a number of advanced concepts efforts.

The X-33, built by Lockheed Martin, is intended to demonstrate the feasibility of various RLV technologies. It is also intended to enable the private development of a commercial RLV. This vehicle would most likely be the proposed Lockheed Martin VentureStar reusable heavy launch vehicle. It is hoped that such a vehicle could perform many of the missions the space shuttle performs today, including carrying humans into space.

The X-34 will serve as a testbed for various RLV technologies to be used on the X-33. Built by Orbital Sciences Corporation, it is intended to reach speeds up to Mach 8 and altitudes of 80 km. A second X-34 vehicle was recently ordered to reduce the risks to the program in case of the loss of a vehicle.

Other NASA efforts include the Future X program and the X-38/Crew Return Vehicle (CRV). The Future X program deals with aspects of low cost access to space not covered by the X-33 and X-34 programs, and the X-38/CRV is intended to develop a "lifeboat" for the International Space Station. As such, the X-38 is not designed for a crewed launch but will certainly be able to return crews to the Earth.

Another U.S. Government RLV development program is the Military Spaceplane. This program is intended to provide quick access to space to perform a variety of military missions in the second quarter of the next century.

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

APMT	Asia Pacific Mobile Telecommunications
BSAT	Broadcast Satellite System Corp. Satellite
CBERS	China/Brazil Earth Resources Satellite
CCAS	Cape Canaveral Air Station

COMETS	Communications and Broadcasting and Tech Satellite
DARA	German Space Agency
DASA	Deutsche Aerospace
DFH	Dong Fang Hong
DMSP	Defense Meteorological Satellite Program
DoD	Department of Defense
DoT	Department of Transportation
DSCS	Defense Satellite Communications System
ELI	Elliptical
ELINTS	Electronic intelligence satellites
ELV	Expendable Launch Vehicle
EOS	Earth Observation System
ESA	European Space Agency
ETS	Engineering Test Satellite
EXT	Extra-Orbital
FAA	Federal Aviation Administration
FGB	Functional Cargo Block
GBS	Global Broadcast System
GEO	Geosynchronous Orbit
GOES	Geostationary Operational Environmental Satellite
GTO	Geosynchronous Transfer Orbit
IAE	Institute of Aeronautics and Space
INMARSAT	International Maritime Satellite Organization
INPE	National Institute for Space Research
INTA	Instituto Nacional de Tecnica Aeroespacial
INTELSAT	International 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	Middle Earth Orbit
MoD	Ministry of Defense
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
OCST	Office of Commercial Space Transportation
OSC	Orbital Sciences Corporation
PAS	Pan American Satellite
PSLV	Polar Satellite Launch Vehicle
PTT	Post Telegraph and Telecommunications
RKK Energia	Rocket and Space Company Energia
SACI	Satellite Cientifico
SCD	Satellite de Coleta de Dados
SES	Societe Europeene des Satellites
SLV	Satellite Launch vehicle
SSTI	Small Spacecraft Technology Initiative
STEP	Space Test Experiments Platform
STEX	Sensor Test Experiement
STS	Space Transportation System
SNOE	Student Nitric Oxide Explorer
TRACE	Transition Region and Coronal Explorer
TRMM	Tropical Rainfall Measuring Mission
USMP	United States Microgravity Payload
VAFB	Vandenberg Air Force Base
VLS	Veiculo Lancador de Satellites
XL	Extra Long

Characteristics of Cited Vehicles

Vehicle	(Success + Partial) / 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	2/3 66.7%	29900 lb. 13600 kg	9900 lb. 4500 kg	4950 lb. 2250 kg	N/A	\$60-70 M	Xichang
Proton (SL-12)	196/219 89.5%	46297 lb. 21000 kg	12100 lb. 5500 kg	4850 lb. 2200 kg	N/A	\$50-70 M	Baikonur
Proton (SL-13)	24/27 88.9%	46000 lb. 20900 kg	16535 lb. 7500 kg	N/A	N/A	\$50-70 M	Baikonur
Shuttle Columbia	24/24 100%	47300 lb. 21455 kg	13007 lb. 5900 kg	5203 lb. 2360 kg	N/A	\$161-215 M	KSC
Shuttle Discovery	25/25 100%	47300 lb. 21455 kg	13007 lb. 5900 kg	5203 lb. 2360 kg	N/A	\$161-215 M	KSC
Titan 4	11/12 91.7%	39100 lb. 17736 kg	14000 lb. 6350 kg	N/A	N/A	\$160-180 M	CCAS, VAFB
Titan 4/Centaur	8/8 100%	39100 lb. 17736 kg	14000 lb. 6350 kg	10200 lb. 4627 kg	N/A	\$240-270 M	CCAS
Titan 4B/Centaur	1/1 100%	N/A	N/A	N/A	N/A	N/A	CCAS, VAFB
Zenit 2	23/28 82.1%	30300 lb. 13740 kg	N/A	N/A	N/A	\$25-40 M	Baikonur
Intermediate							
Ariane 4-TBA	N/A	N/A	N/A	N/A	N/A	\$85 M	Kourou
Ariane 42L	5/5 100%	16300 lb. 7400 kg	7450 lb. 3380 kg	N/A	N/A	\$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	16/17 94.1%	18300 lb. 8300 kg	8950 lb. 4060 kg	N/A	N/A	\$80-95 M	Kourou
Ariane 44P	12/12 100%	15200 lb. 6900 kg	7320 lb. 3320 kg	N/A	N/A	\$75-90 M	Kourou
Atlas 2	9/9 100%	14500 lb. 6580 kg	6200 lb. 2810 kg	3086 lb. 1400 kg	N/A	\$60-70 M	CCAS
Atlas 2A	12/12 100%	16050 lb. 7280 kg	6700 lb. 3039 kg	3307 lb. 1500 kg	N/A	\$65-80 M	CCAS
Atlas 2AS	12/12 100%	19050 lb. 8640 kg	7950 lb. 3606 kg	4604 lb. 2090 kg	N/A	\$90-100 M	CCAS, VAFB
Delta 3	N/A	18408 lb. 8350 kg	8360 lb. 3800 kg	N/A	N/A	N/A	CCAS
H 2	5/5 100%	23000 lb. 10500 kg	8800 lb. 4000 kg	4800 lb. 2200 kg	N/A	\$182-201 M	Tanegashima
Soyuz	944/951 99.3%	15400 lb. 7000 kg	N/A	N/A	N/A	\$12-25 M	Baikonur, Plesetsk

Characteristics of Cited Vehicles

Vehicle	(Success + Partial) / Attempts	LEO 28 Degrees	GTO	GEO	SUB	Price per Launch (Approx.)	Launch Sites
Medium							
Cyclone 3	125/127 98.4%	8818 lb. 4000 kg	N/A	N/A	N/A	\$10-15 M	Baikonur
Delta 2 7920	10/10 100%	11109 lb. 5039 kg	2800 lb. 1270 kg	N/A	N/A	\$45-50 M	CCAS, VAFB
Delta 2 7925	37/38 97.4%	11220 lb. 5089 kg	4060 lb. 1840 kg	2000 lb. 907 kg	N/A	\$45-50 M	CCAS, VAFB
Delta 2 7420	N/A	N/A	N/A	N/A	N/A	\$45-50 M	CCAS
Long March 2C	16/16 100%	7040 lb. 3200 kg	2200 lb. 1000 kg	860 lb. 390 kg	N/A	\$15-20 M	Jiuquan
Long March 4	2/2 100%	8818 lb. 4000 kg	2430 lb. 1100 kg	1220 lb. 550 kg	N/A	\$20-30 M	Taiyuan
Titan 2	18/18 100%	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	CCAS, VAFB
Athena 2	1/1 100%	4390 lb. 1990 kg	N/A	N/A	N/A	\$19-21 M	CCAS, VAFB
Pegasus XL	7/11 63.6%	1015 lb. 460 kg	322 lb. 146 kg	181 lb. 82 kg	N/A	\$12-14 M	VAFB, Wallops Island
Pegasus XL/HAPS	1/1 100%	N/A	N/A	N/A	N/A	N/A	Wallops Island
START 1	3/3 100%	790 lb. 360 kg	N/A	N/A	N/A	\$5-10 M	Plesetsk, Svobodny
Taurus 1	1/1 100%	3100 lb. 1400 kg	990 lb. 450 kg	N/A	N/A	\$17-25 M	VAFB
VLS	0/1 0%	440 lb. 200 kg	N/A	N/A	N/A	N/A	Alcantara

Characteristics of Cited Payloads

Payload	Use	Price	Orbit	Apogee	Perigee	Launch Mass	Mass in Orbit	Freq. Bands & Trans.	Stab.	Power
Classified										
USA 1998-05	Classified	N/A	Unknown	N/A	N/A	N/A	N/A		N/A	N/A
USA 1998-06	Classified	N/A	Unknown	N/A	N/A	N/A	N/A		N/A	N/A
Communication										
APMT 1	Communication	N/A	GEO	N/A	N/A	N/A	N/A		N/A	N/A
APStar 2R	Communication	N/A	GEO 76.5E	N/A	N/A	8140 lb. / 3700 kg	N/A	15 Ku, 1 Ku	N/A	N/A
Asiasat 3	Communication	N/A	GEO 105.5E	N/A	N/A	7656 lb. / 3480 kg	N/A	16 Ku, 28 C	N/A	N/A
Astra 1G	Communication	N/A	GEO 19.2E	19305 nMi	19305 nMi	7260 lb. / 3300 kg	N/A	32 Ku	3-axis	N/A
Astra 2A	Communication	N/A	GEO 28.2E	N/A	N/A	7260 lb. / 3300 kg	N/A	32 Ku	N/A	N/A
BrazilSat B3	Communication	N/A	GEO 293E	19330 nMi	19305 nMi	3850 lb. / 1750 kg	N/A	27 C, 1 C,	Spin	N/A
BSAT 1 B	Communication	N/A	GEO 110E	19330 nMi	19305 nMi	2750 lb. / 1250 kg	N/A	4 Ku	Spin	N/A
ChinaStar 1A	Communication	\$ 87 M	GEO 87.5E	N/A	N/A	6600 lb. / 3000 kg	N/A	16 Ku, 4 Ku	N/A	N/A
Coupon/Bankir 1	Communication	N/A	GEO 55E	N/A	N/A	N/A	N/A		N/A	N/A
DSCS III 3-10	Communication	N/A	GEO	19326 nMi	19323 nMi	2475 lb. / 1125 kg	N/A	6 SHF	3-axis	1240 W
EchoStar 3	Communication	N/A	GEO 298.5E	N/A	N/A	6600 lb. / 3000 kg	N/A	16 Ku	3-axis	N/A
EchoStar 4	Communication	N/A	GEO 185E	N/A	N/A	6600 lb. / 3000 kg	N/A	16 Ku	3-axis	N/A
Eutelsat 3 F 1	Communication	N/A	GEO 10E	19332 nMi	19305 nMi	6599 lb. / 3000 kg	N/A	24 Ku	N/A	N/A
Galaxy 10	Communication	N/A	GEO 237E	19330 nMi	19322 nMi	7683 lb. / 3492 kg	3730 lb. / 1692 kg	16 Ku, 8 Ku	N/A	4700 W
Galaxy 8I	Communication	N/A	GEO 265E	19330 nMi	19322 nMi	6572 lb. / 2987 kg	N/A	24 Ku, 24 C	N/A	N/A
GBS 8	Communication	N/A	GEO	N/A	N/A	6305 lb. / 2866 kg	N/A	EHF, UHF	N/A	2500 W
Globalstar 1-20	Communication	N/A	LEO	764 nMi	764 nMi	988 lb. / 449 kg	N/A	1 L	N/A	875 W
Gorizont 33	Communication	N/A	GEO	N/A	N/A	N/A	N/A		N/A	N/A
Hot Bird Plus 4	Communication	N/A	GEO 13E	N/A	N/A	6380 lb. / 2900 kg	N/A	17 Ku, 2 Ku	N/A	N/A
Hot Bird Plus 5	Communication	N/A	GEO 13E	N/A	N/A	6380 lb. / 2900 kg	N/A	19 Ku, 2 Ku	N/A	N/A
IndoStar 1	Communication	N/A	GEO 106.1E	N/A	N/A	2442 lb. / 1110 kg	N/A	5 S	N/A	N/A
Inmarsat 3 F5	Communication	N/A	GEO	N/A	N/A	4352 lb. / 1978 kg	N/A	2 C, 1 L,	N/A	N/A
Insat 2E	Communication	N/A	GEO 83E	N/A	N/A	5500 lb. / 2500 kg	N/A	16 C, 1 C	N/A	N/A
Intelsat 8 F4	Communication	N/A	GEO 64E	N/A	N/A	8122 lb. / 3692 kg	N/A	6 Ku, 18 C,	N/A	N/A
Intelsat 8A F5	Communication	N/A	GEO 110.5E	N/A	N/A	8122 lb. / 3692 kg	N/A	9 Ku, 28 C	N/A	N/A
Intelsat 8A F6	Communication	N/A	GEO 319.5E	N/A	N/A	8122 lb. / 3692 kg	N/A	9 Ku, 28 C	N/A	N/A
Iridium 25-62	Communication	N/A	LEO	419 nMi	419 nMi	1496 lb. / 680 kg	N/A	1 L, 1 Ka	N/A	N/A
Iridium R1 - R5	Communication	N/A	LEO	419 nMi	419 nMi	1496 lb. / 680 kg	N/A		N/A	N/A
JCSAT 5	Communication	N/A	GEO 150E	N/A	N/A	6820 lb. / 3100 kg	N/A		N/A	N/A
Nilesat 1	Communication	N/A	GEO 353E	N/A	N/A	3894 lb. / 1770 kg	N/A	12 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
Communication (Cont.)										
Orbcomm 03-28	Communication	N/A	LEO	419 nMi	411 nMi	95 lb. / 43 kg	N/A		N/A	N/A
PAS 7	Communication	N/A	GEO 291.5E	N/A	N/A	7524 lb. / 3420 kg	N/A	30 Ku, 14 C	N/A	N/A
SCD 2	Communication	N/A	LEO	427 nMi	392 nMi	253 lb. / 115 kg	N/A		N/A	N/A
SCD 2A	Communication	N/A	LEO	419 nMi	419 nMi	250 lb. / 114 kg	N/A		N/A	N/A
Sinosat 1	Communication	N/A	GEO	N/A	N/A	7683 lb. / 3492 kg	N/A	14 Ku, 24 C	N/A	N/A
Sirius 2	Communication	N/A	GEO 5.2E	21600 nMi	21600 nMi	6354 lb. / 2888 kg	N/A	26 Ku, 8 Ku	N/A	N/A
Sky 2	Communication	N/A	GEO	N/A	N/A	7683 lb. / 3492 kg	N/A	32 Ku	N/A	N/A
Skynet 4D	Communication	N/A	GEO 326E	N/A	N/A	3152 lb. / 1433 kg	N/A	3 X	3-axis	N/A
Thor 3	Communication	N/A	GEO	N/A	N/A	N/A	N/A		N/A	N/A
Crewed										
Soyuz TM-27	Crewed	N/A	LEO	221 nMi	213 nMi	15587 lb. / 7070 kg	14969 lb. / 6790 kg		N/A	N/A
Development										
Argos	Development	N/A	LEO	450 nMi	450 nMi	N/A	N/A		N/A	N/A
ETS 7	Development	\$ 37 M	LEO	297 nMi	297 nMi	6101 lb. / 2773 kg	N/A		3-axis	N/A
Inspector	Development	N/A	LEO	N/A	N/A	N/A	N/A		N/A	N/A
STEP 4	Development	N/A	LEO	324 nMi	324 nMi	396 lb. / 180 kg	N/A		N/A	N/A
STEX 1	Development	N/A	LEO	N/A	N/A	N/A	N/A		N/A	N/A
Experimental										
Falcon Gold	Experimental	N/A	ELI	N/A	N/A	N/A	N/A		N/A	N/A
Maqsat H	Experimental	N/A	ELI	N/A	N/A	5060 lb. / 2300 kg	N/A		N/A	N/A
Intelligence										
Geosat Follow-On 1	Intelligence	N/A	LEO	432 nMi	422 nMi	748 lb. / 340 kg	N/A		N/A	N/A
Kosmos 2347	Intelligence	N/A	LEO	232 nMi	221 nMi	6930 lb. / 3150 kg	N/A		N/A	N/A
Kosmos 2348	Intelligence	N/A	LEO	199 nMi	95 nMi	N/A	N/A		N/A	N/A
SM II 98-01	Intelligence	N/A	TBA	N/A	N/A	N/A	N/A		N/A	N/A
USA 133	Intelligence	N/A	LEO	363 nMi	230 nMi	N/A	N/A		N/A	N/A
USA 136	Intelligence	N/A	ELI	N/A	N/A	N/A	N/A		N/A	N/A
Meteorological										
NOAA K	Meteorological	N/A	LEO	473 nMi	459 nMi	4915 lb. / 2234 kg	3205 lb. / 1454 kg		N/A	1400 W
Microgravity										
Foton N-11	Microgravity	N/A	LEO	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
Navigation										
Glonass-M R- 1	Navigation	N/A	MEO	10338 nMi	10322 nMi	N/A	N/A	1 L	N/A	N/A
Glonass-M R- 2	Navigation	N/A	MEO	10338 nMi	10322 nMi	N/A	N/A	1 L	N/A	N/A
Glonass-M R- 3	Navigation	N/A	MEO	10338 nMi	10322 nMi	N/A	N/A	1 L	N/A	N/A
Navstar GPS 2-28	Navigation	N/A	MEO	10899 nMi	10899 nMi	4138 lb. / 1881 kg	N/A	1 L	N/A	N/A
Other										
Celestis 2	Other	N/A	LEO	N/A	N/A	N/A	N/A		N/A	N/A
Sputnik Replica	Other	N/A	LEO	N/A	N/A	N/A	N/A		N/A	N/A
Remote Sensing										
CBERS/Ziyuan 1	Remote Sensing	\$ 69 M	LEO	420 nMi	420 nMi	3190 lb. / 1450 kg	N/A		3-axis	985 W
Clark	Remote Sensing	\$ 45 M	LEO	268 nMi	268 nMi	612 lb. / 278 kg	N/A		N/A	N/A
Earlybird 1	Remote Sensing	N/A	LEO	254 nMi	254 nMi	682 lb. / 310 kg	N/A		N/A	N/A
EOS AM 1	Remote Sensing	N/A	LEO	381 nMi	381 nMi	N/A	N/A		N/A	N/A
IKONOS 1	Remote Sensing	N/A	LEO	367 nMi	367 nMi	1797 lb. / 817 kg	N/A		N/A	N/A
Resurs-F 1M	Remote Sensing	N/A	LEO	128 nMi	128 nMi	12600 lb. / 5727 kg	N/A		N/A	N/A
SACI 1	Remote Sensing	N/A	LEO	420 nMi	420 nMi	132 lb. / 60 kg	N/A		N/A	N/A
SPOT 4	Remote Sensing	N/A	LEO	446 nMi	443 nMi	5500 lb. / 2500 kg	N/A	1 X	N/A	N/A
TRMM	Remote Sensing	\$ 148 M	LEO	189 nMi	189 nMi	7964 lb. / 3620 kg	N/A		3-axis	N/A
Scientific										
Cassini	Scientific	\$ 1215 M	EXT	N/A	N/A	12773 lb. / 5806 kg	5100 lb. / 2313 kg	X	3-axis	700 W
COMETS 1	Scientific	N/A	GEO 121E	N/A	N/A	7583 lb. / 3447 kg	N/A	1 S, 2 Ka	N/A	N/A
Equator-S	Scientific	N/A	ELI	34398 nMi	270 nMi	550 lb. / 250 kg	N/A		N/A	N/A
Huygens	Scientific	\$ 239 M	EXT	N/A	N/A	N/A	N/A		N/A	N/A
Lunar Prospector	Scientific	N/A	EXT	N/A	N/A	513 lb. / 233 kg	N/A		N/A	N/A
Mirka	Scientific	N/A	LEO	N/A	N/A	330 lb. / 150 kg	N/A		N/A	N/A
Odin	Scientific	N/A	LEO	324 nMi	324 nMi	550 lb. / 250 kg	N/A		N/A	N/A
Oersted	Scientific	N/A	LEO	464 nMi	243 nMi	136 lb. / 62 kg	N/A		N/A	44 W
SNOE	Scientific	N/A	LEO	297 nMi	297 nMi	220 lb. / 100 kg	N/A		N/A	N/A
Spartan 201-04	Scientific	N/A	LEO	168 nMi	159 nMi	2800 lb. / 1270 kg	N/A		N/A	N/A
Sunsat	Scientific	N/A	LEO	464 nMi	243 nMi	132 lb. / 60 kg	N/A		N/A	N/A
Teamsat 1	Scientific	N/A	ELI	N/A	N/A	N/A	N/A		N/A	N/A
TRACE	Scientific	N/A	LEO	378 nMi	378 nMi	491 lb. / 223 kg	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
Space Staion										
FGB	Space Station	\$ 165 M	LEO	N/A	N/A	42500 lb. / 19278 kg	N/A		3-axis	N/A
Supply										
Progress M-36	Supply	N/A	LEO	N/A	N/A	15983 lb. / 7250 kg	N/A		N/A	N/A
Progress M-37	Supply	N/A	LEO	N/A	N/A	15983 lb. / 7250 kg	N/A		N/A	N/A
Progress M-38	Supply	N/A	LEO	N/A	N/A	15983 lb. / 7250 kg	N/A		N/A	N/A
Unknown										
BATSAT	Unknown	N/A	LEO	N/A	N/A	N/A	N/A		N/A	N/A

Launch Events October - December 1997

Launch Date	Vehicle	Payload	Operator	Manufacturer	Int'l Comp	Launch Type	Launch Outcome	Mission Outcome
Brazil								
VLS								
November 2, 1997	VLS	SCD 2A	IAE	IAE	No	Non-Commercial	Failure	Failure
China								
Long March								
October 17, 1997	Long March 3B	APStar 2R	APT Satellite Co., Ltd.	Space Systems/Loral	Yes	Commercial	Success	Success
December 8, 1997	Long March 2C	Iridiums 25-26	Iridium, Inc.	Lockheed Martin	Yes	Commercial	Success	Success
Europe (ESA)								
Ariane								
October 30, 1997	Ariane 5	Maqsat H Teamsat 1	Arianespace ESA	Arianespace ESA	No	Non-Commercial	Success	Success
November 12, 1997	Ariane 44L	IndoStar 1 Sirius 2	PT MediaCitra IndoStar NSAB	Orbcomm Aerospatiale	Yes	Commercial	Success	Success
December 2, 1997	Ariane 44P	JCSAT 5 Equator-S	JSAT NASA/DARA	Hughes Max Planck Institute	Yes	Commercial	Success	Success
December 21, 1997	Ariane 44P	Intelsat 8 F4	Intelsat	Lockheed Martin	Yes	Commercial	Success	Success

Launch Events October - December 1997

Launch Date	Vehicle	Payload	Operator	Manufacturer	Int'l Comp	Launch Type	Launch Outcome	Mission Outcome
Japan								
H 2								
November 28, 1997	H 2	TRMM ETS 7	NASDA/NASA NASDA	NASA Goddard Space Flight Center Toshiba	No	Non-Commercial	Success	Success
Russia								
Cyclone								
December 9, 1997	Cyclone 3	Kosmos 2347	Russia MoD	NPO Kometa	No	Non-Commercial	Success	Success
Proton								
November 12, 1997	Proton (SL-12)	Coupon/Bankir 1	Global Information Systems, Inc.	NPO Lavotchkin	No	Non-Commercial	Success	Success
December 3, 1997	Proton (SL-12)	Astra 1G	SES	Hughes	Yes	Commercial	Success	Success
December 23, 1997	Proton (SL-12)	Asiasat 3	Asia Sat Telecom Ltd.	Hughes	Yes	Commercial	Failure	Failure
Soyuz								
October 5, 1997	Soyuz	Progress M-36 Inspector Sputnik Replica	RKK Energia DARA/RKA RKA	RKK Energia Daimler Benz Russian amateur built	No	Non-Commercial	Success	Success
October 9, 1997	Soyuz	Foton N-11 Mirka	Space Research Institute (IKI) DLR	KB Photon Kayser-Threde	No	Non-Commercial	Success	Success
November 18, 1997	Soyuz	Resurs-F 1M	Russia MoD	Central Specialized Design Bureau (TsSKB)	No	Non-Commercial	Success	Success
December 16, 1997	Soyuz	Kosmos 2348	Russia MoD	Russia TBA	No	Non-Commercial	Success	Success
Russia (cont.)								
Soyuz (cont.)								
December 20, 1997	Soyuz	Progress M-37	RKK Energia	RKK Energia	No	Non-Commercial	Success	Success
START								
December 24, 1997	START 1	Earlybird 1	Earthwatch, Inc.	CTA (now OSC)	Yes	Commercial	Success	TBA
USA								
Atlas								

Launch Events October - December 1997

Launch Date	Vehicle	Payload	Operator	Manufacturer	Int'l Comp	Launch Type	Launch Outcome	Mission Outcome
October 5, 1997	Atlas 2AS	EchoStar 3	EchoStar Satellite Corp.	Lockheed Martin	Yes	Commercial	Success	Success
October 24, 1997	Atlas 2A	DSCS III 3-10 Falcon Gold	DoD Air Force Academy & Univ of Colorado	Lockheed Martin Air Force Academy & Univ of Colorado	No	Non-Commercial	Success	Success
December 8, 1997	Atlas 2AS	Galaxy 8I	PanAmSat	Hughes	Yes	Commercial	Success	Success
Delta								
November 5, 1997	Delta 2 7925	Navstar GPS 2-28	DoD	Rockwell International	No	Non-Commercial	Success	Success
November 8, 1997	Delta 2 7920	Iridiums 39-43	Iridium, Inc.	Lockheed Martin	Yes	Commercial	Success	Success
December 20, 1997	Delta 2 7920	Iridiums 44-48	Iridium, Inc.	Lockheed Martin	Yes	Commercial	Success	Success

Launch Events October - December 1997

Launch Date	Vehicle	Payload	Operator	Manufacturer	Int'l Comp	Launch Type	Launch Outcome	Mission Outcome
USA (cont.)								
Pegasus								
October 22, 1997	Pegasus XL	STEP 4	DoD/USAF	TRW	No	Non-Commercial	Success	Failure
December 23, 1997	Pegasus XL/HAPS	Orbcomms 05-12	Orbcomm	OSC	No	Commercial	Success	Success
Shuttle								
November 19, 1997	Shuttle Columbia	STS 87 Spartan 201-04	NASA NASA	Rockwell International NASA	No	Non-Commercial	Success	Success
Titan								
October 15, 1997	Titan 4B/Centaur	Cassini Huygens	NASA European Space Agency (ESA)	Jet Propulsion Laboratory Aerospatiale	No	Non-Commercial	Success	Success
October 23, 1997	Titan 4	USA 133	NRO	Lockheed Martin	No	Non-Commercial	Success	Success
November 7, 1997	Titan 4/Centaur	USA 136	NRO	Boeing	No	Non-Commercial	Success	Success

Launch Events January - June 1998

Launch Date	Vehicle	Payload	Operator	Manufacturer	Launch Type	Int'l Comp	Site
China							
Long March							
January 25, 1998	Long March 3B	Sinosat 1	SINO-Sat Com Ltd	EuraSpace	Non-Commercial	No	Xichang
February 20, 1998	Long March 3B	ChinaStar 1A	Ministry of Posts and Telecommunications	Lockheed Martin	Non-Commercial	No	Xichang
1st Qtr 1998	Long March 2C	Iridiums 54-55	Iridium, Inc.	Lockheed Martin	Commercial	Yes	Taiyuan
1st Qtr 1998	Long March 3B	APMT 1	APMT	Hughes	Commercial	Yes	Xichang
May 1998	Long March 4	CBERS/Ziyuan 1 SACI 1	China/Brazil INPE	National Institute for Space Research (INPE) INPE	Non-Commercial	No	Taiyuan
2nd Qtr 1998	Long March 2C	Iridiums 56-57	Iridium, Inc.	Lockheed Martin	Commercial	Yes	Taiyuan
Europe (ESA)							
Ariane							
January 27, 1998	Ariane 44LP	Brazilsat B3 Inmarsat 3 F5	Embratel Inmarsat	Hughes Lockheed Martin	Commercial	Yes	Kourou
February 27, 1998	Ariane 42L	BSAT 1 B Hot Bird Plus 4	Telecommunications Advancement Org. Eutelsat	Hughes Matra Marconi	Commercial	Yes	Kourou
March 1998	Ariane 4-TBA	SPOT 4	CNES	Matra Marconi	Non-Commercial	No	Kourou

Launch Events January - June 1998

Launch Date	Vehicle	Payload	Operator	Manufacturer	Launch Type	Int'l Comp	Site
Europe (ESA) cont.							
Ariane (cont.)							
April 1998	Ariane 44L	Insat 2E Nilesat 1	ISRO Egyptian Radio and TV Union (ERTU)	ISRO Matra Marconi	Commercial	Yes	Kourou
May 1998	Ariane 4-TBA	PAS 7	PanAmSat	Space Systems/Loral	Commercial	Yes	Kourou
June 1998	Ariane 5	Hot Bird Plus 5	Eutelsat	Matra Marconi	Commercial	Yes	Kourou
Japan							
H 2							
February 13, 1998	H 2	COMETS 1	NASDA	Toshiba	Non-Commercial	No	Tanegashima
Russia							
Proton							
March 30, 1998	Proton (SL-12)	Astra 2A	SES	Hughes	Commercial	Yes	Baikonur
March 1998	Proton (SL-12)	EchoStar 4	EchoStar Satellite Corp.	Lockheed Martin Astro Space	Commercial	Yes	Baikonur
1st Qtr 1998	Proton (SL-12)	Glonass-M R1 - R3	Russia MoD	NPO Prikladnoi Mekhaniki	Non-Commercial	No	Baikonur
1st Qtr 1998	Proton (SL-12)	Gorizont 33	Russia	NPO Prikladnoi Mekhaniki	Non-Commercial	No	Baikonur

Launch Events January - June 1998

Launch Date	Vehicle	Payload	Operator	Manufacturer	Launch Type	Int'l Comp	Site
Russia cont.							
Proton (cont.)							
June 20, 1998	Proton (SL-13)	FGB	International	Krunichev/Salyut	Non-Commercial	No	Baikonur
Soyuz							
January 29, 1998	Soyuz	Soyuz TM-27	RKK Energia	RKK Energia	Non-Commercial	No	Baikonur
March 15, 1998	Soyuz	Progress M-38	RKK Energia	RKK Energia	Non-Commercial	No	Baikonur
START							
February 5, 1998	START 1	Odin	Swedish National Space Board	Swedish Space Corp.	Commercial	Yes	Svobodny
Zenit							
2nd Qtr 1998	Zenit 2	Globalstars 9-20	Globalstar, Inc.	Space Systems/Loral	Commercial	Yes	Baikonur
USA							
Athena							
January 6, 1998	Athena 2	Lunar Prospector	NASA	Lockheed Martin	Commercial	No	CCAS
February , 1998	Athena 2	IKONOS 1	Space Imaging Inc.	Lockheed Martin	Commercial	No	VAFB
March 25, 1998	Athena 1	Clark	NASA	CTA (now OSC), Inc.	Commercial	No	VAFB

Launch Events January - June 1998

Launch Date	Vehicle	Payload	Operator	Manufacturer	Launch Type	Int'l Comp	Site
USA cont.							
Atlas							
January 26, 1998	Atlas 2A	SM II 98-01	DoD	TBA	Non-Commercial	No	CCAS
February 13, 1998	Atlas 2	GBS 8	DoD	Hughes	Commercial	No	CCAS
March 3, 1998	Atlas 2AS	Sky 2	American Sky Broadcasting	Space Systems/Loral	Commercial	Yes	CCAS
March 16, 1998	Atlas 2AS	Intelsat 8A F6	Intelsat	Lockheed Martin	Commercial	Yes	CCAS
April 30, 1998	Atlas 2AS	Eutelsat 3 F 1	Eutelsat	Aerospatiale	Commercial	Yes	CCAS
June 4, 1998	Atlas 2AS	Intelsat 8A F5	Intelsat	Lockheed Martin	Commercial	Yes	CCAS
June 30, 1998	Atlas 2AS	EOS AM 1	NASA	Lockheed Martin	Non-Commercial	No	VAFB
Delta							
January 9, 1998	Delta 2 7925	Skynet 4D	British MoD	Matra Marconi	Commercial	Yes	CCAS
January 31, 1998	Delta 2 7920	Iridiums 49-53	Iridium, Inc.	Lockheed Martin	Commercial	Yes	VAFB
February 5, 1998	Delta 2 7420	Globalstars 1-4	Globalstar, Inc.	Space Systems/Loral	Commercial	Yes	CCAS

Launch Events January - June 1998

Launch Date	Vehicle	Payload	Operator	Manufacturer	Launch Type	Int'l Comp	Site
USA cont.							
Delta (cont.)							
April 18, 1998	Delta 2 7920	Iridiums 58-62	Iridium, Inc.	Lockheed Martin	Commercial	Yes	VAFB
April 24, 1998	Delta 2 7420	Globalstars 5-8	Globalstar, Inc.	Space Systems/Loral	Commercial	Yes	CCAS
May 29, 1998	Delta 2 7920	Argos Oersted Sunsat	Space Test Program Office, USAF NASA/Danish Space Research Council University of Stellenbosch	TRW University of Copenhagen Stellenbosch University	Non-Commercial	No	VAFB
June 9, 1998	Delta 3	Galaxy 10	PanAmSat	Hughes	Commercial	Yes	CCAS
June 1998	Delta 2 7920	Iridiums R1 - R5	Iridium, Inc.	Lockheed Martin	Commercial	Yes	VAFB
2nd Qtr 1998	Delta 2 7925	Thor 3	Telenor A.S.	Hughes	Commercial	Yes	CCAS
Pegasus							
1st Qtr 1998	Pegasus XL	SNOE BATSAT	U of Colorado/NASA Unknown	U of Colorado Unknown	Commercial	No	VAFB
1st Qtr 1998	Pegasus XL/HAPS	Orbcomms 13-20	Orbcomm	OSC	Commercial	No	VAFB
1st Qtr 1998	Pegasus XL	TRACE	NASA	NASA Goddard	Non-Commercial	No	VAFB

Launch Events January - June 1998

Launch Date	Vehicle	Payload	Operator	Manufacturer	Launch Type	Int'l Comp	Site
USA cont.							
Pegasus (cont.)							
2nd Qtr 1998	Pegasus XL/HAPS	Orbcomms 21-28	Orbcomm	OSC	Commercial	No	Wallops Island
2nd Qtr 1998	Pegasus XL	SCD 2	INPE	INPE	Commercial	Yes	CCAS
Shuttle							
January 22, 1998	Shuttle Endeavour	STS 89	NASA	Rockwell International	Non-Commercial	No	KSC
April 2, 1998	Shuttle Columbia	STS 90	NASA	Rockwell International	Non-Commercial	No	KSC
May 28, 1998	Shuttle Discovery	STS 91	NASA	Rockwell International	Non-Commercial	No	KSC
Taurus							
1st Qtr 1998	Taurus 1	Geosat Follow-On 1 Orbcomm 03 Orbcomm 04 Celestis 2	DoD Orbcomm Orbcomm Celestis	Ball Aerospace OSC OSC Celestis	Commercial	No	VAFB
1st Qtr 1998	Taurus 1	STEX 1	DoD	DoD	Non-Commercial	No	VAFB

**Launch Events
January - June 1998**

Launch Date	Vehicle	Payload	Operator	Manufacturer	Launch Type	Int'l Comp	Site
USA cont.							
Titan							
May 8, 1998	Titan 4B/Centaur	USA 1998-05	DoD	DoD	Non-Commercial	No	CCAS
May 18, 1998	Titan 2	NOAA K	NOAA	Lockheed Martin	Non-Commercial	No	VAFB
June 22, 1998	Titan 4/Centaur	USA 1998-06	DoD	DoD	Non-Commercial	No	CCAS