ORIGINAL

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Secretary Copy

July 8, 2002

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Satellite Policy Branch
International Bureau

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

BY HAND

Mr. Don Abelson
Chief, International Bureau
Federal Communications Commission
445 Twelfth Street, S.W.
Room 6-C750
Washington, D.C. 20554

Re: Loral Space & Communications Ltd. Authorization for a Ku- and Ka-band Satellite at 47° W.L. (FCC File Nos. CSS-83-002-P-(M) and SAT-MOD-20000104-00045)

Columbia Communications Corporation Application for Authority to Construct, Launch And Operate a Trans-Atlantic Satellite System (FCC File Nos. SAT-LOA-19870331-00061; SAT-AMD-19990511-00052; and SAT-MOD-19990511-00051)

Dear Mr. Abelson:

We are writing on behalf of our client, Orbital Resources, LLC ("Orbital Resources"), to notify the International Bureau that the above-referenced license authorizing Loral Space & Communications Ltd. ("Loral") to operate both Ku-band and Ka-band capacity at 47° W.L. is now *null and void* pursuant to its self-effectuating terms. As a result, the orbital and spectrum resources that Loral has so long withheld from service – in the case of Ku-band for nearly two decades – are now available for immediate reassignment.

In addition to nullifying its own license, Loral's failure to bring a satellite into service at 47° W.L. also has a direct impact on the application of Columbia Communications Corporation ("Columbia") to provide Ku-band service in the Atlantic Ocean Region. The existence of the Loral authorization for a hybrid satellite at 47° W.L. was the sole basis for the International Bureau's May 2001 rejection of Columbia's application. *See Columbia Communications Corp.*, 16 FCC Rcd 10867, 10875-76 (¶ 26) (IB 2001) ("*Order*"). A Petition for Reconsideration of the *Order* is pending, and the nullification of the Loral license is a crucial change of circumstances that requires reversal of the Bureau's denial of Columbia's application. There is now no valid license for operation of Ku-band space segment at 47° W.L. that precludes the grant of these rights to Columbia. Accordingly, the Bureau should promptly grant Columbia's long-pending Atlantic region Ku-band application, and permit Columbia to modify its current license to operate a C-band satellite at this location to include Ku-band authority as well.

The principals of Orbital Resources, Clifford Laughton and Kenneth Gross, were the sole shareholders of Columbia prior to its transfer to GE American Communications, Inc. in September 2000 and GE Americom's subsequent acquisition by SES Global S.A. Pursuant to the agreements implementing the transfer of control, Mr. Laughton and Mr. Gross have each retained rights to future payments in the event that additional authority is granted to Columbia as a result of the applications that were pending in September 2000, including the request for Atlantic Ku-band authority. Orbital Resources' principals thus have a continuing financial interest in the processing of Columbia's above-referenced applications seeking this authority.

The History of the 47° W.L. Orbital Location Through May 2001

On September 5, 1985, the Commission granted Loral's predecessor-in-interest, Orion Network Systems, Inc. ("Orion"), a conditional authorization to construct, launch and operate two Ku-band satellites in the Atlantic Ocean Region. *See Orion Satellite Corp.*, File No. CSS-83-002-P, Mimeo No. 6871 (rel. September 6, 1985). Subsequently, in June 1991, Orion was granted final authority to operate at two orbital locations – 37.5° W.L. and 47° W.L. *See Orion Satellite Corp.*, 6 FCC Rcd 4201 (1991).

In March 1987, Columbia refiled an application originally submitted in November 1983 seeking authority to operate its own Atlantic Ocean Region Ku-band satellite at 49° W.L., two degrees from the location licensed to Orion. *See* Application of Columbia Communications Corporation for a Trans-Atlantic Satellite System, FCC File No. SAT-LOA-19870331-00061 (filed March 31, 1987). Recognizing that the Commission had by that time initiated a temporary freeze on new applications in the Atlantic region of the orbital arc, Columbia specifically requested that processing of the application be held in abeyance until the application freeze was lifted. *See id.* at 4-5.* Apparently heeding this request, the Commission did not immediately place the application on Public Notice.

More than seven years later, and nearly a decade after receiving its initial conditional license, Orion launched a single Atlantic region satellite at 37.5° W.L. in November 1994, commencing service in January 1995. Later in 1995, Orion filed an application to modify its authority for the remaining Atlantic orbital location at 47° W.L., seeking to add authority to operate Ka-band frequencies on the same spacecraft. *See* FCC File No. 204-SAT-ML-95.

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* The Commission did not officially terminate the Atlantic region filing freeze until August 2001. *See Amendment to the Commission's Regulatory Policies Governing Domestic Fixed Satellites and Separate International Satellite Systems*, 16 FCC Rcd 15579, 15597-98 (¶¶ 33-34) (2001).

Meanwhile, Columbia had begun providing satellite space segment services three years before Orion using the commercial C-band payload on the TDRS-4 satellite at 41° W.L., as well as capacity on the TDRS-5 satellite in the Pacific region. Desiring to expand its existing trans-Atlantic service, Columbia filed an application in late 1995 to launch a new C-band satellite at 47° W.L.

Shortly after filing its application, in response to the availability of unused C-band capacity on the TDRS-6 satellite at 47° W.L., Columbia sought and obtained temporary authority to operate the TDRS-6 C-band transponders at this orbital location. It has now been operating C-band space segment at this location for nearly six years.

On May 9, 1997, the International Bureau granted Orion authority to add Ka-band capacity to its existing Ku-band authorization for 47° W.L. *See Orion Atlantic, L.P.*, 13 FCC Rcd 1416 (IB 1997). Under the modified authorization, Orion was given its first performance milestones, requiring it to commence construction no later than May 1998, to complete construction by April 2002, and to launch the satellite by May 2002. *Id.* at 1426 (¶ 32). Just a few months after the initial Ka-band licenses were granted, Orion agreed to be acquired by Loral, a transaction that the Bureau approved on February 26, 1998 and which was consummated shortly thereafter. *See Loral Space & Communications and Orion Network Systems, Inc.*, 13 FCC Rcd 4592 (IB 1998).

In January 1999, the Bureau granted the Columbia application to launch and operate its planned 47° W.L. C-band satellite. Five months after the 47° W.L. application was granted, Columbia sought to amend its long deferred 49° W.L. Ku-band application by converting it to specify operation at 47° W.L., and modifying its existing single-band authorization at this location to include both C- and Ku-band capacity. The application was premised on the company's observation that Loral/Orion, which had at that time held its Ku-band license for nearly fourteen years, had not proceeded with construction as required under its license, and had thus rendered its authorization null and void. The Commission quickly placed these applications on Public Notice.

While these applications were pending, Loral filed on January 4, 2000 an application seeking once again to modify its 47° W.L. license, this time to permit the use of inter-satellite links ("ISLs"), and to delay performance under its milestone schedule. *See* FCC File No. SAT-MOD-20000104-00045 ("Loral Modification Application"). Despite the fact that two years had elapsed since the merger of Loral and Orion, the company asserted that use of ISLs was now necessary to interconnect Ka-band satellites licensed to Loral's CyberStar subsidiary with those originally licensed to Orion entities. *See* Loral Modification Application, Exhibit 1 at 1. Based on the fact that the CyberStar authorizations did not have system construction milestones, Loral also asked the Bureau to defer the remaining milestones associated with the licenses granted nearly three years earlier to Orion. The request was nothing more than a transparent effort to bootstrap its then open-ended CyberStar authorizations into additional time to construct at 47° W.L., using ISLs as a pretext for further delay.

A few weeks later, on January 21, 2000, the Bureau issued an initial *MO&O* denying Columbia's applications to modify its 47° W.L. authorization and to amend its 49° W.L. application, as well as a separately filed petition to revoke the Orion 47° W.L. authorization due to Loral's failure to proceed with construction. The Bureau accepted at face value Loral's statement that it had commenced construction of a satellite for 47° W.L. As a consequence of this acceptance, the Bureau rejected Columbia's application in a single two-sentence paragraph –

> *Because we conclude that Loral's authorization for a Ku-band satellite at 47° W.L. is valid*, we deny Columbia's application to add Ku-band capability to its authorized C-band satellite at 47° W.L. To do otherwise would cause harmful interference to Loral's authorized system in clear contravention of Commission rules.

Columbia Communications Corporation, 15 FCC Rcd 15566, 15571 (¶ 10) (IB 2000) (emphasis added). Columbia filed a timely Petition for Reconsideration of this decision on February 22, 2000.[†]

On May 22, 2001, the Bureau released the *MO&O* that is subject to the still pending Petition for Reconsideration. Although it noted "Loral's failure to build and launch a satellite that was authorized ten years ago," the Bureau continued to maintain, "Loral has not violated any of the terms of its licenses." *Columbia Communications Corporation*, 16 FCC Rcd 10867,10870 (¶ 7) (IB 2001). Despite the absence of any evidence in the record showing that Loral was actually proceeding with construction, the Bureau relied on the existence of a satellite construction contract between Loral and its affiliated manufacturing arm as sufficient under the FCC's prevailing policies to satisfy the commencement of construction milestone.

Just three days after upholding the Loral license against Columbia's challenge, however, the International Bureau denied Loral's separate request to extend its system construction milestones in connection with its request for ISL authority. The Bureau found that Loral's request to delay construction and launch of its 47° W.L. satellite, as well as other Ka-band satellites, "is not due to circumstances beyond its control, nor to any other factor that would

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[†] *See* Petition for Partial Reconsideration, FCC File Nos. CSS-83-002-P-(M) *et al.* (filed February 22, 2000). Among the issues raised in the Petition was the grant to Orion in 1995 of an additional Atlantic region orbital assignment at 15° W.L. in the absence of any demonstration that the single satellite it had them launched was near its capacity– a step that was itself in *clear contravention* of the Commission's rules limiting orbital assignments to two per region until there is a demonstration that in-orbit capacity is nearly filed. *See id.* at 10-11 and 47 C.F.R. § 25.140(f). Columbia has also noted that the Bureau's focus solely on the 47° W.L. orbital location without considering other options for implementation of its proposed service was contrary to its well-settled policy that orbital locations are fungible, and that "an applicant's request for a particular orbital position is not dispositive of the orbital location that will actually be assigned." *See* Petition for Reconsideration, File No. SAT-LOA-19870331-00061, at 7-8 (filed June 21, 2001); *Pan American Satellite Corp.*, 60 R.R.2d 398, 409 (1986).

justify providing it with more time to hold these scarce orbital resources to the exclusion of others." *Loral Space & Communications Corporation*, 16 FCC Rcd 11044 (¶ 1) (IB 2001). The Bureau further admonished that "[f]ailure to meet the remaining milestones . . . will automatically render authorizations for these satellites null and void without further Commission action." *Id.* at 11048 (¶ 8).

Developments Since May 2001

In rejecting Columbia's Petition for Reconsideration of its modification application seeking to operate in Ku-band frequencies at 47° W.L., the International Bureau stated, "regardless of the merits of Columbia's application, the Ku-band capacity at the 47° W.L. [orbital location] is not available for assignment to Columbia or any other applicant *at this time*." *Columbia Communications Corporation*, 16 FCC Rcd at 10876 (¶ 26) (emphasis added). Thus, based entirely on this presumed unavailability of Ku-band operating authority at 47° W.L., the Bureau denied Columbia's application without reaching its merits.

The Bureau relied heavily on its determination that none of the significant public information provided by Columbia indicating that Loral no longer intended to deploy a Ku-/Ka-band satellite at 47° W.L. by May 2002 provided definitive "evidence that Loral is *not* proceeding with construction of the satellite." *Id.* at 10873 (¶ 18). The Bureau nonetheless emphasized that Loral's next milestone date, for satellite completion in April 2002, would afford a more definitive opportunity to assess the company's compliance with its license. Specifically, the Bureau announced that "[a]t that time, we will evaluate Loral's compliance with this license condition." *Id.*

The day of reckoning has now finally arrived. Indeed, as of the end of May 2002, all of the milestones for Loral's 47° W.L. authorization have passed, including both completion of construction and launch. Unlike satisfaction of the satellite commencement and completion milestones, fulfillment of the satellite launch benchmark is relatively easy to evaluate because launching a commercial satellite necessarily creates not only a public record but places a facility in Earth orbit, permitting the presence (or absence) of a spacecraft at a particular orbital slot to be verified with relative ease.

From a practical standpoint, the easiest means of determining whether a particular satellite has been launched is to consult the Quarterly Launch Reports prepared under contract by Futron Corporation ("Futron") for the Federal Aviation Administration's Office of Commercial Space Transportation ("OCST"). These government reports, which are typically released during the latter half of January, April, July and October, contain a comprehensive listing based on numerous information sources of the launches that occurred during the preceding quarter, as well as projected launches for the current and immediately following quarters.

As is evident from Loral's request to extend its milestones for completion and launch for an indefinite period beyond April/May 2002, Loral did not have any near-term plans for timely satisfaction of its milestones as of June/July 2001, when it sought reconsideration of the Bureau's denial of its milestone extension request. The OCST Quarterly Launch Reports released from September 2001 through April 2002 reveal that, since the conclusion of the pleading cycle in that proceeding on July 17, 2001, Loral has not actually launched any satellites into any orbital location, nor was a launch compliant with its 47° W.L. milestones projected in any such report. *See* Attachment 1, Commercial Space Transportation Quarterly Launch Report (2nd Quarter 2002) (six launches including commercial payloads during the First Quarter of 2002, none launching a Loral spacecraft); Attachment 2, Commercial Space Transportation Quarterly Launch Report (1st Quarter 2002) (three launches including commercial payloads during the Fourth Quarter of 2001, none launching a Loral spacecraft); and Attachment 3, Commercial Space Transportation Quarterly Launch Report (4th Quarter 2001) (four launches including commercial payloads during the Third Quarter of 2001, none launching a Loral spacecraft).

Although the next Quarterly Launch Report will not be available until later this month, Futron issues its own monthly reports on recent and near-term projected launches in advance of the quarterly reports. Monthly reports have been issued for April, May, June and July of 2002, covering actual satellite launches from April 1 through July 2, 2002, and none indicates a completed, or even planned, launch by Loral. *See* Attachment 4, April, May, June and July 2002 Futron Launch Reports (four launches including commercial payloads from April 1 through July 2, none launching a Loral spacecraft).

Accordingly, based on the reports prepared for the FAA through March 2002, and on additional data made publicly available by Futron, it is evident that no satellite has been launched into the 47° W.L. orbital location during the period from July 1, 2001 through June 4, 2002. This period covers the entire possible launch window for the Loral satellite from the time it sought extension of its construction milestones through the May 2002 expiration of the launch milestone.

The Consequences of Loral's Failure to Launch at 47° W.L.

As the International Bureau has very recently reemphasized, "[t]he milestone schedule included in each [satellite] authorization is designed to ensure that licensed entities are proceeding with construction *and will launch their satellites in a timely manner*." *EchoStar Satellite Corporation,* DA 02-1534, slip op. at 2 (¶ 5) (IB, released July 1, 2002) ("*EchoStar*") (emphasis added). Consistent with this well-established policy, the Order modifying Orion's 47° W.L. license to allow construction of a Ku-/Ka-band hybrid satellite stated unambiguously that "unless extended by the Commission for good cause shown, each of the authorizations shall become NULL AND VOID in the event the space station is not constructed, *launched, and successfully placed into operation* in accordance with the technical parameters and terms and conditions of the authorizations" by the milestone dates established – May 1998 (Construction Commenced), April 2002 (Construction Completed), and May 2002 (Launch). *Orion Atlantic, L.P.*, 12 FCC Rcd at 1426 (¶ 32) (CAPITALIZED EMPHASIS IN ORIGINAL, *italicized emphasis added)*. The Bureau has declined to modify these terms, there being no good cause to do so, and the May 2002 launch deadline has now passed without the milestone being met. Accordingly, Loral's authority to operate both Ku-band and Ka-band space segment capacity at 47° W.L. is now null and void pursuant to the explicit terms of its license.

The terms of Loral's license have divested it of Ku-band authority at 47° W.L., so that there is now no impediment to granting Columbia the Atlantic region Ku-band authority it has sought for nearly two decades.[‡] Indeed, as the Bureau has recently made clear, "requiring licensees to adhere strictly to a milestone schedule prevents orbital locations from being warehoused by licensees to the exclusion of qualified entities that are prepared to implement systems immediately." *EchoStar*, DA 02-1534, slip op. at 2 (¶ 5). Because Columbia is already licensed to provide C-band space segment at this location, the addition of Ku-band authority would promote efficient use of the spectrum and speed the availability of new space segment capacity.

Orbital Resources is aware that Columbia has recently filed applications seeking to re-order the timing of its satellite launches in the Atlantic region, accelerating launch of a new satellite into the 37.5° W.L. orbital slot to meet an immediate need for follow-on capacity at that location and recommencing procurement for a replacement satellite at 47° W.L., which will not be required to provide continuity of service for several more years. The plan submitted by Columbia projects a November 2002 milestone for commencement of construction on the new 47° W.L. satellite. Prompt grant of Columbia's previously rejected modification request would thus allow it to contract for construction of a hybrid C-/Ku-band satellite in advance of this milestone, consistent with the Commission's policies recognizing the technical and operational benefits of hybrid satellites. *See Hughes Communications Galaxy, Inc. et al.*, 6 FCC Rcd 72, 73 (¶ 8)(1991).

Since November 1983, Columbia consistently has sought but a single Atlantic Ku-band orbital location in order to compete on more equal footing with its competitors in the market for international satellite services, all of which have such capability. Columbia's expeditious authorization to operate in Ku-band at the 47° W.L. orbital location at this time would not cause harmful interference to any operational or licensed system, and grant of the requested authority would serve the public interest by providing long-promised but never developed Ku-band service.

Accordingly, the International Bureau should complete action in this proceeding (now pending for a year) as soon as possible – and, in any event, no later than November 1, 2002. Such action will promote the fastest possible introduction of long-delayed Ku-band service at 47°

[‡] Because it has been pending for fifteen years, Columbia's application may be processed without initiating a processing round, as the Commission has established that all applications filed prior to January 19, 1996 are to be processed under the procedures applicable to international satellite applications prior to that date. *See Amendment to the Commission's Regulatory Policies Governing Domestic Fixed Satellites and Separate International Satellite Systems*, 11 FCC Rcd 2429, 2436 (¶ 44) (1996) ("applications filed after the adoption date" of the order to "be considered in future 'consolidated' FSS rounds" *after action "on all pending separate system applications ... "*) (emphasis added).

W.L. As the Bureau stated in the recent *EchoStar* order, "[t]he policy objective of the milestone requirement is to ensure that unused spectrum is reassigned as quickly as possible to another qualified entity" once it is evident that the original licensee has failed to comply with its milestones. *EchoStar*, DA 02-1534, slip op, at 3 (¶ 7). The Bureau should therefore vacate the portion of its *Order* denying Columbia's request to operate Atlantic region Ku-band capacity, reinstate its application for consideration on its merits, and expeditiously grant Columbia authority to operate Ku-band capacity at 47° W.L. as part of a C-/Ku-band hybrid spacecraft, consistent with its 1999 modification application.

Respectfully submitted,

Raul R. Rodriguez
David S. Keir
Counsel to Orbital Resources, LLC

Attachments

cc: Stephen Bell
John Stern
Philip Spector
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ATTACHMENT 1

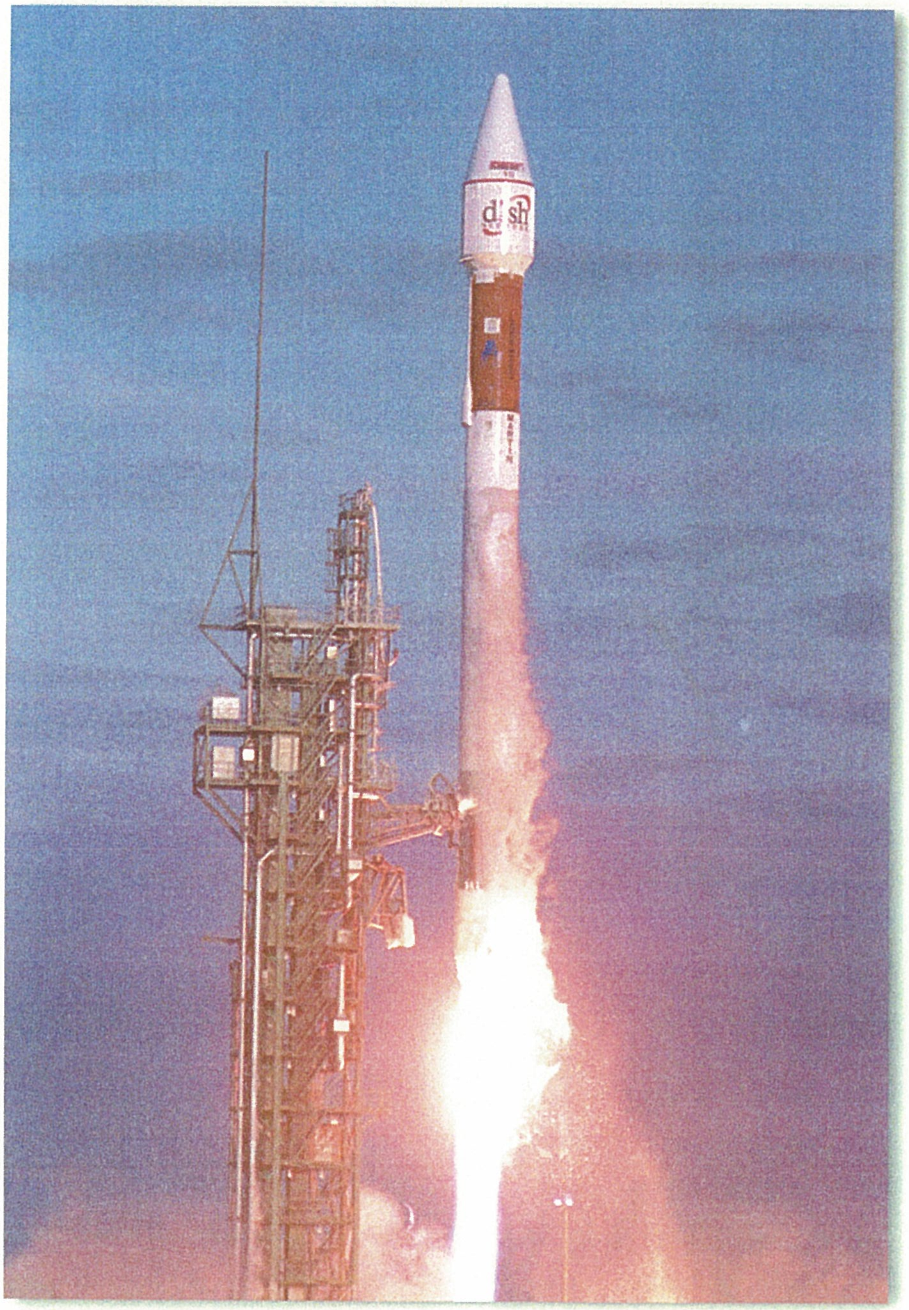
Commercial Space Transportation

QUARTERLY LAUNCH REPORT

Featuring the launch results from the 1st quarter 2002 and forecasts for the 2nd and 3rd quarters 2002

Quarterly Report Topic:

Launch Activity and Orbital Debris Mitigation



2nd Quarter 2002

United States Department of Transportation • Federal Aviation Administration
Associate Administrator for Commercial Space Transportation
800 Independence Ave. SW • Room 331
Washington, D.C. 20591

Introduction

The Second Quarter 2002 Quarterly Launch Report features launch results from the first quarter of 2002 (January-March 2002) and launch forecasts for the second quarter of 2002 (April-June 2002) and the third quarter of 2002 (July-September 2002). This report contains information on worldwide commercial, civil, and military orbital space launch events. Projected launches have been identified from open sources, including industry references, company manifests, periodicals, and government sources.
Projected launches 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)

Contents

Cover: Cape Canaveral Air Force Station, Fla., Feb. 21, 2002 - An Atlas 3B launch vehicle successfully delivers its EchoStar 7 payload into orbit for EchoStar Communications Corporation. Courtesy of International Launch Services.

First Quarter 2002 Highlights

In the first quarter of 2002, two new vehicle variants made their first launches. These vehicles were International Launch Services' (ILS) Atlas 3B and Rocket System Corporation's H-2A. In addition, Arianespace's Ariane 5G launch vehicle returned to flight after a failed launch in July 2001.

The first launch of the ILS Atlas 3B occurred on February 21 from Cape Canaveral Air Force Station in Florida. The vehicle used the two-engine Centaur upper stage to place the EchoStar 7 communications satellite successfully into geosynchronous orbit. The Atlas 3B is an upgraded version of the recently-debuted Atlas 3A launch vehicle. While the Atlas 3A can lift a maximum of 4,060 kilograms (8,951 pounds) to geosynchronous transfer orbit (GTO), the Atlas 3B is capable of lifting 4,500 kilograms (9,921 pounds) to GTO. A replacement for the Atlas 2, the Atlas 3 will eventually be replaced by the Atlas 5 Evolved Expendable Launch Vehicle.

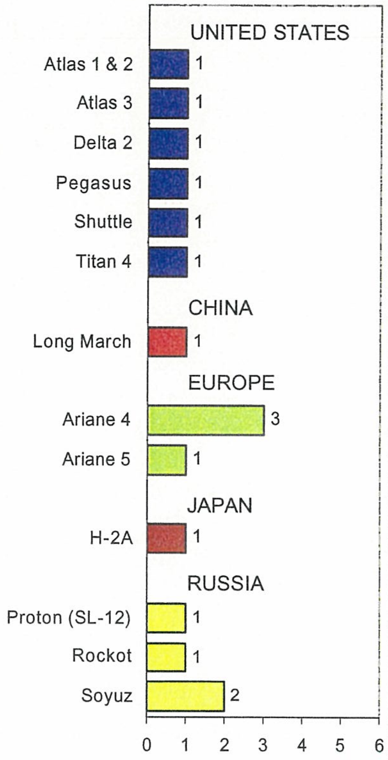
On February 4, Japan's first H-2A, with additional solid rocket strap-on boosters, carried the Mission Demonstration Satellite 1 (MDS-1), Vehicle Evaluation Payload 3 (VEP-3), and the Demonstration of Atmospheric Reentry Systems with Hyper Velocity (DASH) into Earth orbit. After the launch, however, DASH failed to separate from the H-2A 202 booster and was lost. The two other payloads functioned properly and reached their proper orbits.

On February 28, Arianespace successfully launched an Ariane 5G from its launch site at Kourou, carrying the European Space Agency's (ESA) Envisat 1 satellite, part of ESA's Earth Observation Program. This launch was the first of an Ariane 5 since the failed launch on July 12, 2001, when an Ariane 5G suffered a second-stage failure resulting in the loss of the ESA's Artemis and Japan's Broadcasting Satellite System Corporation's Bsat 2B.

Vehicle Use

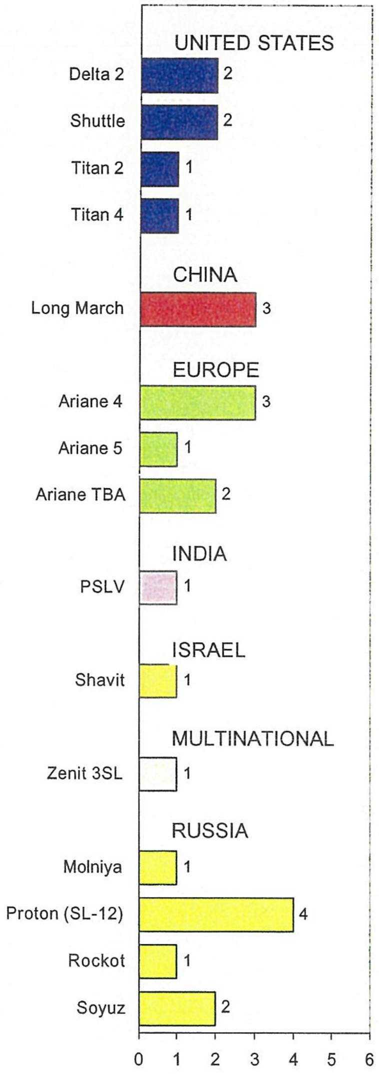
(January 2002 – September 2002)

Figure 1: First Quarter 2002 Total Launch Vehicle Use



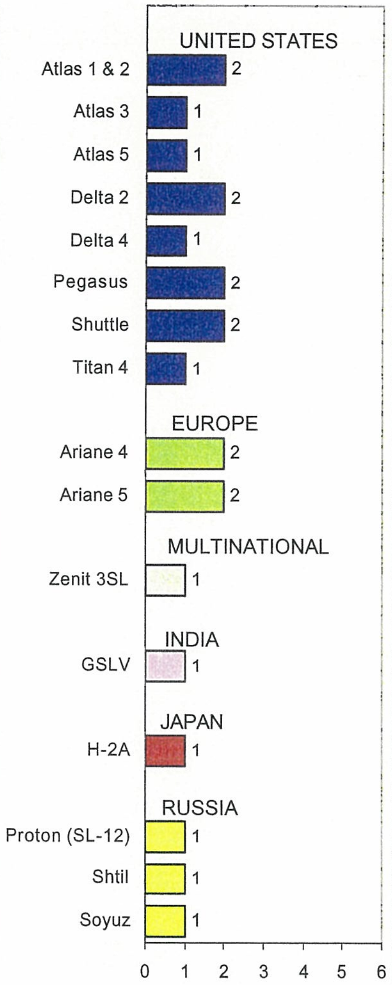
Total = 16

Figure 2: Second Quarter 2002 Total Projected Launch Vehicle Use



Total = 26

Figure 3: Third Quarter 2002 Total Projected Launch Vehicle Use

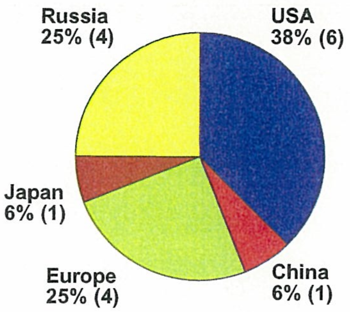


Total = 22

Figures 1-3 show the total number of orbital launches (commercial and government) of each launch vehicle that occurred in the first quarter of 2002 and that are projected for the second and third quarters of 2002. These launches are grouped by the country in which the primary vehicle manufacturer is based. Exceptions to this grouping are launches performed by Sea Launch, which are designated as multinational.

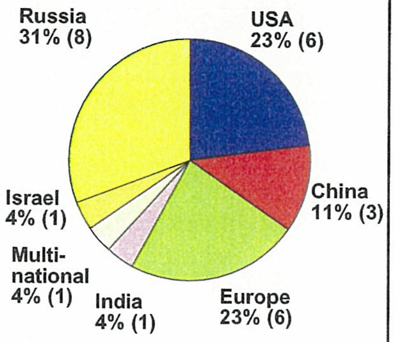
Total Launch Events by Country
(January 2002 – September 2002)

Figure 4: First Quarter 2002 Total Launch Events by Country



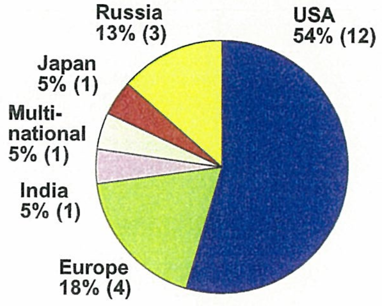
Total = 16

Figure 5: Second Quarter 2002 Total Projected Launch Events by Country



Total = 26

Figure 6: Third Quarter 2002 Total Projected Launch Events by Country

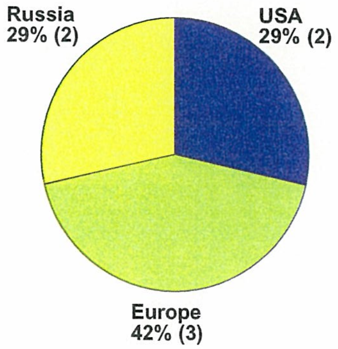


Total = 22

Figures 4-6 show all orbital launch events (commercial and government) that occurred in the first quarter of 2002 and that are projected for the second and third quarters of 2002.

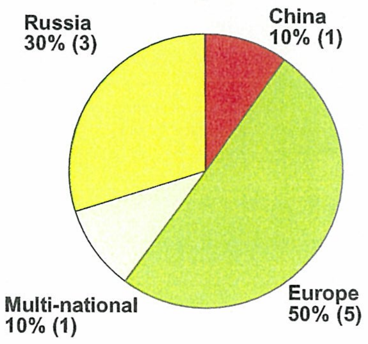
Commercial Launch Events by Country
(January 2002 – September 2002)

Figure 7: First Quarter 2002 Commercial Launch Events by Country



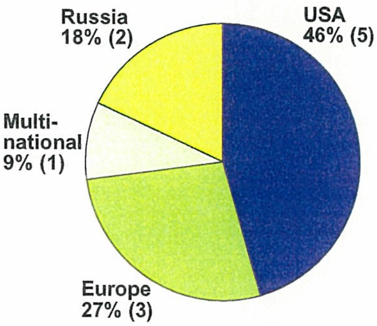
Total = 7

Figure 8: Second Quarter 2002 Projected Commercial Launch Events by Country



Total = 10

Figure 9: Third Quarter 2002 Projected Commercial Launch Events by Country



Total = 11

Figures 7-9 show all *commercial* orbital launch events that occurred in the first quarter of 2002 and that are projected for the second and third quarters of 2002.

Commercial vs. Non-commercial Launch Events
(January 2002 – September 2002)

Figure 10: First Quarter 2002 Commercial vs. Non-commercial Launch Events

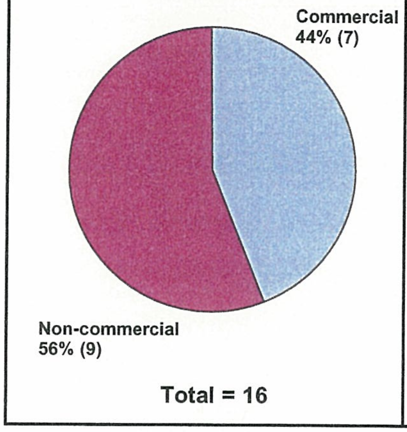


Figure 11: Second Quarter 2002 Commercial vs. Non-commercial Projected Launch Events

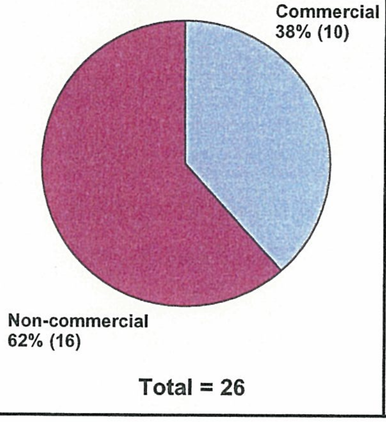
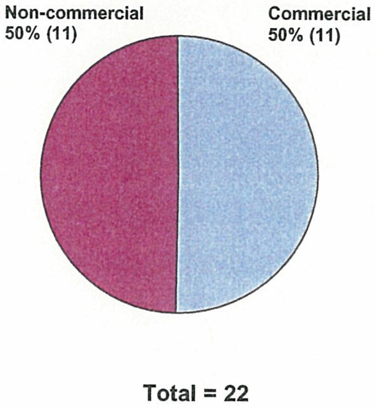


Figure 12: Third Quarter 2002 Commercial vs. Non-commercial Projected Launch Events



Figures 10-12 show commercial vs. non-commercial orbital launch events that occurred in the first quarter of 2002 and that are projected for the second and third quarters of 2002.

First Quarter 2002 Launch Successes vs. Failures
(January 2002 – March 2002)

Figure 13: Total Launch Successes vs. Failures

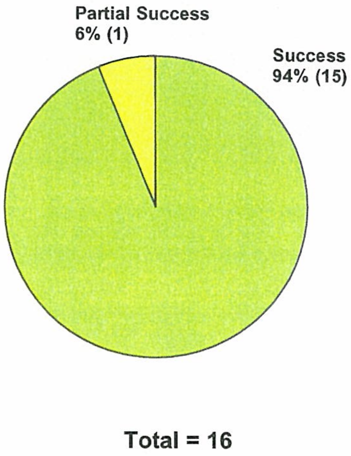


Figure 13 shows successful vs. failed orbital launch events that occurred in the first quarter of 2002. Partially-successful orbital launch events are those in which the launch vehicle fails to deploy its payload to the appropriate orbit but the payload is able to reach a useable orbit by using its own propulsion systems. Cases in which the payload is unable to reach a useable orbit or would use all of its fuel to do so are considered failures. The partially-successful launch was of NASA's TDRS I spacecraft, which did not reach its proper orbit. It is antipicated that it will be able to achieve this orbit by using its on-board thrusters.

Payload Use
(January 2002 – September 2002)

Figure 14: First Quarter 2002 Payload Use

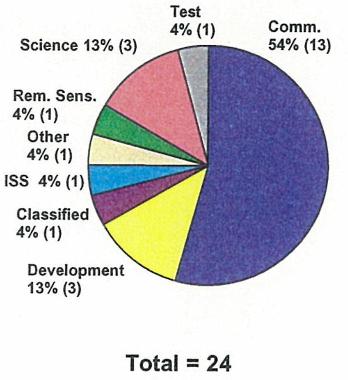


Figure 15: Second Quarter 2002 Projected Payload Use

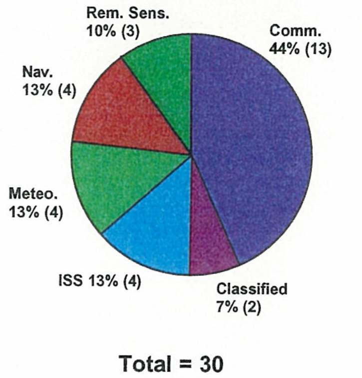
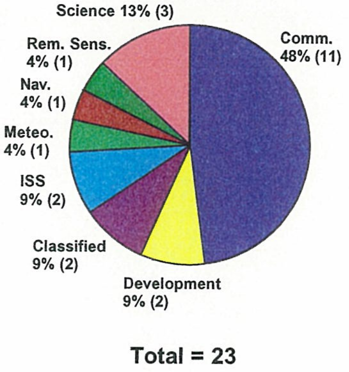


Figure 16: Third Quarter 2002 Projected Payload Use



Figures 14-16 show total payload use (commercial and government), actual for the first quarter of 2002 and that are projected for the second and third quarters of 2002. The total number of payloads launched may not equal the total number of launches due to multi-manifesting, i.e., the launching of more than one payload by a single launch vehicle.

Payload Mass Class
(January 2002 – September 2002)

Figure 17: First Quarter 2002 Payload Mass Class

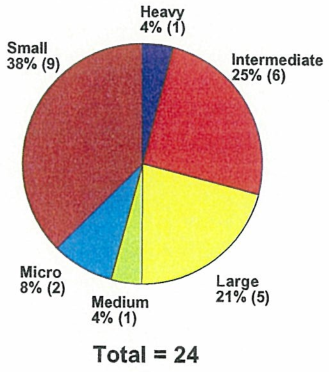


Figure 18: Second Quarter 2002 Projected Payload Mass Class

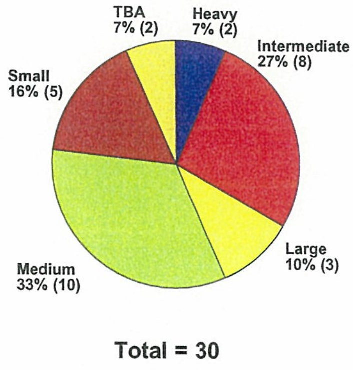
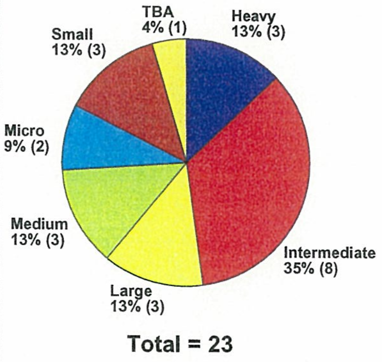


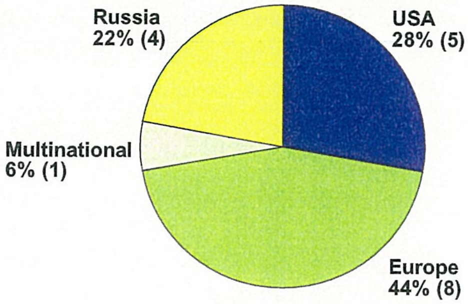
Figure 19: Third Quarter 2002 Projected Payload Mass Class



Figures 17-19 show total payloads by mass class (commercial and government), actual for the first quarter of 2002 and projected for the second and third quarters of 2002. The total number of payloads launched may not equal the total number of launches due to multi-manifesting, i.e., the launching of more than one payload by a single launch vehicle. Payload mass classes are defined as Micro: 0 to 91 kilograms (0 to 200 lbs.); Small: 92 to 907 kilograms (201 to 2,000 lbs.); Medium: 908 to 2,268 kilograms (2,001 to 5,000 lbs.); Intermediate: 2,269 to 4,536 kilograms (5,001 to 10,000 lbs.); Large: 4,537 to 9,072 kilograms (10,001 to 20,000 lbs.); and Heavy: over 9,073 kilograms (20,000 lbs.).

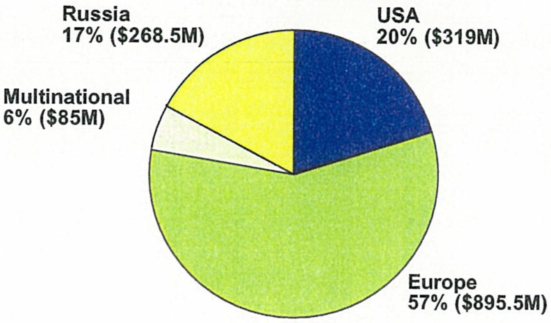
Commercial Launch Trends
(April 2001 – March 2002)

Figure 20: Commercial Launch Events, Last 12 Months



Total = 18

Figure 21: Commercial Launch Revenue, Last 12 Months



Total = $1568M

Figure 20 shows commercial launch events for the period April 2001 to March 2002 by country.

Figure 21 shows commercial launch revenue for the period April 2001 to March 2002 by country.

Figure 22: Commercial Launch Events by Country, Last Five Years

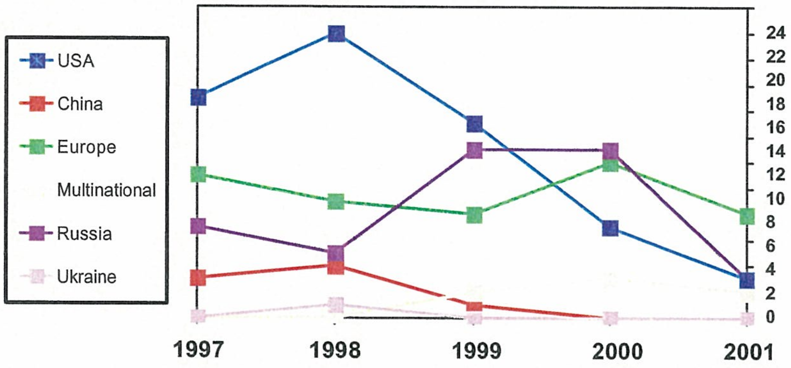


Figure 22 shows commercial launch events by country for the last five full years.

Figure 23: Commercial Launch Revenue (in $ million) by Country, Last Five Years

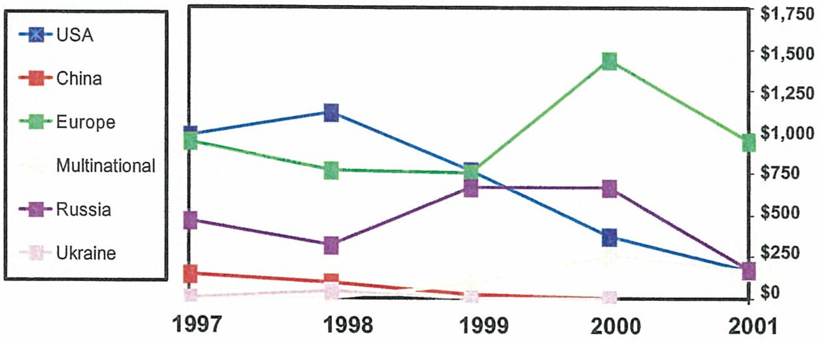


Figure 23 shows commercial launch revenue by country for the last five full years.

Launch Activity and Orbital Debris Mitigation

INTRODUCTION

Since the start of human space activity, the number of orbital debris, or artificial objects orbiting Earth that are no longer functional, has steadily increased. These debris make up 95 percent of all orbiting space objects and consist of spent satellites and upper stages, separation devices, bolts, paint chips, and still other spacecraft components. U.S. Space Command tracks more than 9,000 objects larger than ten centimeters wide with ground-based optical and radar telescopes; another 100,000 objects between one and ten centimeters are estimated to be orbiting Earth. Figure 1 shows computer-generated views of catalogued space objects, including debris, distributed in various Earth orbits.

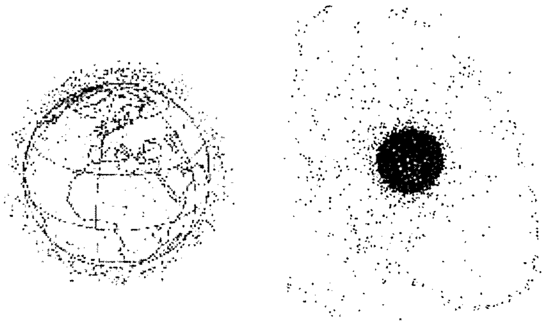


Figure 1: Space objects distributed in low-Earth (left) and geostationary, medium-Earth, and Molniya (right) orbits

While the risk of an orbital debris impact to an operational spacecraft is low, the debris population continues to grow at 175 metric tons per year and has caused damage to active spacecraft. Indeed, orbital debris' presence is apparent in the dings and dents observed on spacecraft such as the Space Shuttle, the Russian Mir space station, and the Hubble Space Telescope. As a result, efforts are underway in both the government and industry to mitigate orbital debris.

As indicated above, launch vehicle upper stages and their mechanisms and components have proven to be a considerable contributor to the orbital debris population. This report shows how launch vehicles and launch activity can create orbital debris and explains what the U.S. and foreign governments and the aerospace industry are doing to minimize the amount of orbital debris generated by launch activity.

LAUNCH ACTIVITY AND ORBITAL DEBRIS CREATION

Along with derelict spacecraft, upper stages comprise the greatest concentration of mass in Earth orbit. More than 1500 rocket bodies launched by the spacefaring nations of the world currently circle Earth, with nearly half of these in low orbits. The orbital stages of launch vehicles can create hazards to operational spacecraft in two main ways: through collisions and explosions.

Collisions involving launch vehicle orbital stages can occur if spent upper stages and their components remain in operational orbits after directly injecting their payloads. While rare, collisions can cause devastation to active spacecraft, as occurred when the Japanese ECS-1 (Ayame-1) satellite was incapacitated after colliding with the third stage of its own launch vehicle.

Accidental explosions of upper stages are the primary source of the approximately 2200 rocket body debris now in Earth orbit. Upper stages may explode when, after the upper stage successfully delivers satellites to orbit, stored energy, such as residual propellants and pressurants, undergoes thermal cycling or is over-pressurized due to solar heating. Such explosions can generate hundreds of fragments of orbital debris and, along with spacecraft explosions, account for almost 40 per-

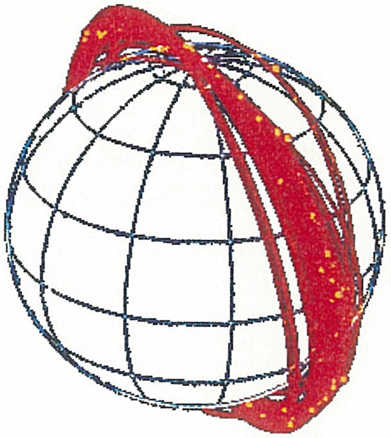


Figure 2: Notional spread of orbital debris after a spacecraft or upper stage explosion

cent of all orbiting objects tracked from the ground. Figures 2 and 3 depict how orbital debris can spread over time.

Upper stage explosions are considered to be the greatest source of the most hazardous debris in Earth orbit. The creation of more debris adds to the risk of collision with an active satellite. While Space Shuttle Discovery successfully avoided debris from an exploded Pegasus upper stage with an in-orbit maneuver in 1997, the less fortunate French military satellite CERISE was struck by a fragment of an exploded Ariane upper stage in 1996. Three upper stages and two upper stage components exploded in 2001.

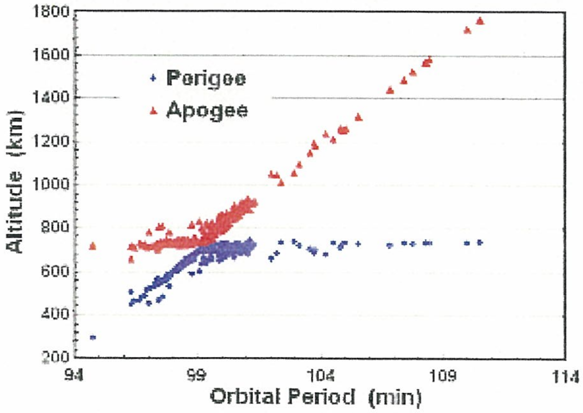


Figure 3: Gabbard diagram of the orbital debris distribution from a Long March upper stage explosion in March 2000

The launch industry and U.S. government, along with governments around the world, have recognized the risks associated with upper stage collisions and explosions. The next section shares the efforts the U.S. government, international organizations, and the launch industry have made to minimize on-orbit collisions and explosions involving launch hardware, in turn mitigating orbital debris.

LAUNCH ACTIVITY AND ORBITAL DEBRIS MITIGATION

Recognizing that keeping the space environment clean is a common responsibility and desire, spacefaring governments and companies have worked to develop procedures and standards for minimizing the amount of orbital debris they produce in their launch activities. While some of the government procedures and standards developed pertain specifically to launch hardware, many are generally applicable to space activity. Though described in separate sections below, U.S. government, foreign and international, and launch industry orbital debris mitigation efforts have coincided in time and have influenced one another.

U.S. Government Efforts

In 1988, the Reagan Administration released the first national space policy that called for agencies to "seek to minimize the creation of orbital debris." The following year, the U.S. government issued a report on orbital debris. Noting the lack of good measurements on the orbital debris environment, the report called for the National Aeronautics and Space Administration (NASA) and the Department of Defense (DoD) to develop a plan to monitor the debris environment. As a result, these agencies embarked on programs to address this recommendation. Figure 4 shows the Haystack radar, a facility operated by the

Massachusetts Institute of Technology's Lincoln Laboratory that NASA and the Air Force have used since 1990 to track small orbital debris.

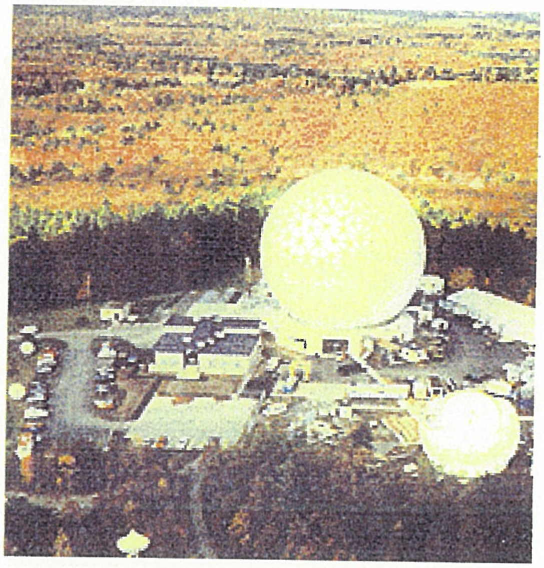


Figure 4: The Haystack radar

The Bush Administration took up orbital debris mitigation as a formal goal in its 1989 national space policy, adding that the United States would also encourage other nations to adopt debris mitigation policies and practices. Following the approval of that directive, NASA and DoD adopted policies concerning the mitigation of orbital debris in all of their space activities.

The government updated its orbital debris report in 1995, issuing five recommendations. These recommendations were to: (1) continue and enhance debris measurement, modeling, and monitoring capabilities; (2) conduct a focused study on debris and emerging low-Earth orbit (LEO) systems; (3) develop government/industry design guidelines on orbital debris; (4) develop a strategy for international discussion; and (5) review and update U.S. policy on debris. These recommendations have guided U.S. government activity regarding orbital debris mitigation since that time. Just one year after the issuance of this report, President Clinton's national space policy reaffirmed the earlier policy by calling for U.S. government agencies to minimize space debris. The 1996 policy also required NASA, DoD, the intelligence community and the private sector to develop design guidelines for U.S. government space hardware procurements and stressed a U.S. leadership role in urging other nations to adopt debris minimization practices and policies.

Shortly after the issuance of the report, a U.S. interagency working group led by NASA and DoD developed a work plan to study the debris environment and to work with U.S. government agencies and other spacefaring nations and international organizations to design and adopt guidelines to minimize orbital debris. In 1997, the working group created a set of "U.S. Government Orbital Debris Mitigation Standard Practices." Based on a NASA safety standard of procedures for limiting debris, the Standard Practices are intended for government-operated or -procured space systems, including satellites as well as launch vehicles. The interagency group has shared the guidelines with the aerospace industry to encourage voluntary compliance.

Now forming the foundation of U.S. government protocol regarding orbital debris, the Standard Practices support four objectives, presented below. All of the practices apply to launch vehicle components and upper stages.

1. *Control of debris released during normal operations.* Spacecraft as well as upper stages are to be designed to eliminate or minimize debris released under normal circumstances. Any planned release of debris larger than five millimeters that remain on orbit for over 25 years should be evaluated and justified on the basis of cost effectiveness and mission requirements.

2. *Minimization of debris generated by accidental explosions, during and after mission operations.* During missions, spacecraft

and upper stages should not have any credible failure modes for accidental explosions, or the probability of a failure mode's occurrence should be limited. After missions, on-board stored energy should be depleted or safed.

3. *Selection of safe flight profile and operational configuration.* Spacecraft and upper stage design and mission profiles should estimate and limit the probability of collision with known objects during orbital lifetime. Tether systems should be analyzed for intact and severed conditions.

4. *Post-mission disposal of space structures.* Launch vehicle components, upper stages, spacecraft, and other payloads should be disposed of at the end of mission life by one of three methods: atmospheric re-entry, maneuver to a designated storage orbit, or direct retrieval. Tether systems should be analyzed for intact and severed conditions when performing trade-offs between various disposal strategies.

Several U.S. government agencies have worked in recent years to develop guidelines and regulations on orbital debris production and mitigation for their activities and the industries they oversee. NASA, DoD, and Air Force Space Command orbital debris directives and guidelines have applied broadly to their launch as well as on-orbit activities. Air Force Space Command's Eastern and Western Range Requirement 127-1, for example, states that launches from federal ranges must have completed collision avoidance analyses. Regulatory agencies such as the Federal Communications Commission and the National Oceanic and Atmospheric Administration have proposed and published rules, respectively, pertaining to orbital debris mitigation for communications and remote sensing satellites, respectively.

The Federal Aviation Administration (FAA) has developed orbital debris-related regulations for the U.S. launch industry. The FAA attempts to mitigate orbital debris generated by space transportation in several ways. In 14 Code of Federal Regulations (CFR) part 415.39, the FAA requires expendable launch vehicle (ELV) launch license applicants to demonstrate that: (1) there will be no unplanned contact between the vehicle, its components, and payload after payload separation; (2) no debris will be generated from the conversion of chemical, pressure, and kinetic energy sources into energy that fragments the vehicle or its components; and (3) stored energy must be removed by depleting residual fuel and leaving all fuel line valves open, venting any pressurized system, leaving all batteries in permanent discharge state, and removing any remaining source of stored energy.

While part 415.39 applies to ELVs, 14 CFR part 431.43 specifies that the first two of the above stipulations apply to reusable launch and re-entry vehicles. The latter regulation also requires a reusable vehicle operator to perform a collision avoidance analysis to ensure a 200-kilometer separation between the vehicle and an inhabitable orbiting object during launch and re-entry. Finally, 14 CFR part 440, Appendix A, requires launch license applicants seeking a maximum probable loss determination for their activities to share with the FAA an analysis of risks posed by launch vehicles to operational satellites on orbit.

Foreign and International Efforts

As Table 1 shows, all major spacefaring nations have been responsible for adding to the number of space objects and debris in Earth orbit. Several foreign space agencies and organizations have recognized the risks associated with orbital debris and have issued or are currently developing orbital debris mitigation guidelines that apply to launch as well as all types of space activities. Many of these standards bear strong similarities to U.S. standards and have been patterned after them. The Japanese, European, French, and Russian space agencies have all developed orbital debris mitigation standards.

Country/ organization	Payloads	Rocket bodies	Debris	Total
China	32	20	285	337
CIS	1336	820	1687	3843
ESA	32	100	185	317
India	22	6	226	254
Japan	71	30	16	117
USA	966	570	2226	3762
Total	2459	1546	4625	8630

Table 1: Orbiting space objects and debris by origin

The subject of orbital debris has been and is currently being addressed in international fora. In 1993, several of the world's space agencies formed the Inter-Agency Space Debris Coordinating Committee (IADC) to facilitate the exchange of technical research and information related to orbital debris, to facilitate opportunities for space debris research cooperation, and to identify debris mitigation options. The IADC has compiled orbital debris mitigation guidelines for the world's spacefaring governments to follow that draw heavily from standards the space-faring nations have developed. In 2003, the IADC will present its guidelines to the Scientific and Technical Subcommittee of the United Nations' Committee for the Peaceful Uses of Outer Space (COPUOS), which since 1994 has included orbital debris as an annual agenda item.

Industry Efforts

Even before governments began to develop orbital debris-related policies and guidelines, launch vehicle developers became aware of the risks associated with orbital debris and began to explore ways to mitigate this hazard. One of the earliest procedures U.S. vehicle manufacturers adopted was the passivation, or depletion of on-board energy sources, of upper stages to prevent them from exploding and fragmenting. Passivation includes the burning or venting of residual propellants, the release of pressurants, the discharge of batteries, and the spinning down of momentum wheels and devices with rotational energy. It is believed that more than 80 percent of all upper stage explosions could have been prevented by passivation. Moreover, no passivated upper stages are known to have exploded.

The passivation of U.S. launch vehicles started in the early 1960s, when Thor-Ablestar upper stages vented leftover fuels. Over time, as upper stages of U.S. and non-U.S. upper stages experienced explosions and fragmented, passivation caught on among the world's launch vehicle developers. By the 1980s and 1990s, passivation became a standard procedure on Delta, Pegasus, Atlas, and Titan orbital stages. Foreign upper stages, such as those of the Ariane, Long March, and Zenit, now also employ passivation measures. The cost of passivation can be relatively small if it is planned in a vehicle's design phase.

U.S. launch vehicle manufacturers also have modified vehicle designs to reduce the amount of debris that upper stages can create. Catchers are now attached to explosive bolts to prevent these components from becoming orbital debris when they are used to separate launch vehicle stages from each other or from their payloads. In addition, spring-loaded payload release mechanisms and payload hold-down clamps are now retained with their upper stages.

Finally, some launch vehicle upper stages are now being removed from useful orbits at the end of their missions in order to avoid collisions with operational spacecraft. Although the FAA does not require post-mission disposal, several techniques can be and are being used to dispose of upper stages. Post-delivery burns can remove upper stages from payload delivery orbits and into lower orbits to accelerate re-entry. The Delta 2 and Long March upper stages both performed post-delivery maneuvers to lower their perigees after deploying Iridium satellites, accelerating their decay periods to under two years; the Russian Proton upper stages immediately performed de-orbit burns. The Pegasus Hydrazine

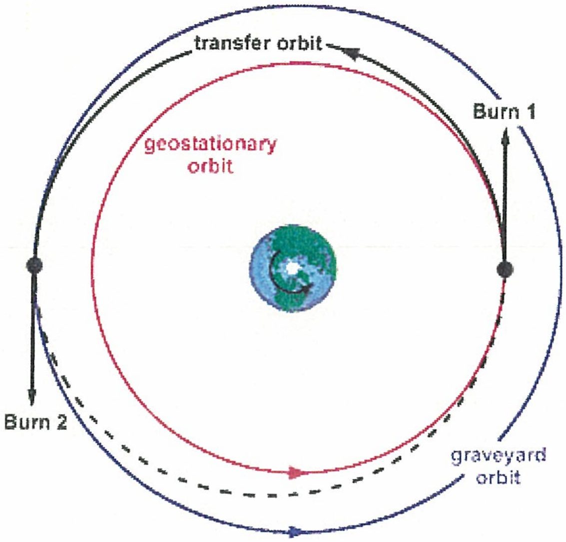


Figure 5: Movement of a space object from geostationary orbit to a graveyard orbit

Auxiliary Propulsion System (HAPS) also generally performs a depletion burn to move to a lower orbit shortly after payload delivery.

Extra burns can also remove upper stages from operational orbits and place them into "graveyard" orbits (see figure 5). In addition, upper stages can release their payloads early and leave the payloads to reach their final orbits using on-board thrusters. The U.S. Air Force is considering these various options for disposal of spent upper stages of the two Evolved Expendable Launch Vehicles, the Atlas 5 and Delta 4, from operational orbits after these vehicles deploy payloads into high-altitude orbits.

CONCLUSION

Although launch activity historically has been a major generator of orbital debris, the U.S. government, foreign governments, and the launch industry have become increasingly responsive to this issue over the decades since the beginning of the Space Age. The measures being taken by the launch industry, combined with the present creation of orbital debris mitigation standards and guidelines by national governments and international organizations, will help ensure that Earth orbit remains usable by the world's current and future spacecraft with minimal risk.

First Quarter 2002 Orbital Launch Events

Date	Vehicle	Site	Payload or Mission	Operator	Use	Vehicle Price	L	M
1/15/2002	Titan 4B/Centaur	CCAFS	Milstar F5	DoD	Communications	$350-450M	S	S
1/24/2002	√ Ariane 42L	Kourou	* Insat 3C	Indian Space Research Organization	Communications	$80-100M	S	S
2/4/2002	H-2A 202	Tanegashima	MDS-1	National Space Development Agency	Development	$75-95M	S	S
			DASH	Institute of Space and Astronautical Science	Development			F
			VEP-3	National Space Development Agency	Test			S
2/5/2002	Pegasus XL	CCAFS	HESSI	NASA	Scientific	$12-15M	S	S
2/11/2002	√ + Delta 2 7920	VAFB	* Iridium 90	Iridium Satellite LLC	Communications	$50-60M	S	S
			* Iridium 91	Iridium Satellite LLC	Communications			S
			* Iridium 94	Iridium Satellite LLC	Communications			S
			* Iridium 95	Iridium Satellite LLC	Communications			S
			* Iridium 96	Iridium Satellite LLC	Communications			S
2/21/2002	√ +	CCAFS	* EchoStar 7	Echostar Communications Corporation	Communications	$90-105M	S	S
2/23/2002	√ Ariane 44L	Kourou	* Intelsat 904	Intelsat	Communications	$100-125M	S	S
2/25/2002	Soyuz	Plesetsk	Kosmos 2387	Russian Ministry of Defense	Classified	$30-40M	S	S
2/28/2002	Ariane 5G	Kourou	Envisat 1	European Space Agency	Remote Sensing	$150-180M	S	S
3/1/2002	Shuttle Columbia	KSC	STS 109	NASA	Crewed	$300M	S	S
			Hubble Servicing Mission 3B	NASA	Other			S
3/8/2002	Atlas 2A	CCAFS	TDRS I	NASA	Communications	$90-105M	P	S
3/17/2002	√ Rockot	Plesetsk	GRACE 1	NASA/Deutschen Zentrum für Luft und Raumfahrt	Scientific	$12-15M	S	S
			GRACE 2	NASA/GeoForschungs Zentrum	Scientific			S
3/21/2002	Soyuz	Baikonur	Progress ISS 7P	Rosaviakosmos/NASA	ISS	$30-40M	S	S

√ Denotes commercial launch, defined as a launch that is internationally-competed or FAA-licensed.

+ Denotes FAA-licensed launch.

* Denotes a commercial payload, defined as a spacecraft that serves a commercial function or is operated by a commercial entity.

L and M refer to the outcome of the Launch and Mission (immediate status of the payload upon reaching orbit): S = success,
P = partial success, F = failure

Note: All launch dates are based on local time at the launch site at the time of launch.

First Quarter 2002 Orbital Launch Events

Date	Vehicle	Site	Payload or Mission	Operator	Use	Vehicle Price	L	M
3/25/2002	Long March 2F	Jiuquan	Shenzhou 3	China National Space Administration	Development	N/A	S	S
3/28/2002	√ Ariane 44L	Kourou	* JCSAT 8	Japan Satellite Systems (JSAT)	Communications	$100-125M	S	S
			* Astra 3A	SES Global	Communications			S
3/30/2002	√ Proton (SL-12)	Baikonur	* Intelsat 903	Intelsat	Communications	$75-95M	S	S

√ Denotes commercial launch, defined as a launch that is internationally-competed or FAA-licensed.

+ Denotes FAA-licensed launch.

* Denotes a commercial payload, defined as a spacecraft that serves a commercial function or is operated by a commercial entity.

L and M refer to the outcome of the Launch and Mission (immediate status of the payload upon reaching orbit): S = success, P = partial success, F = failure

Note: All launch dates are based on local time at the launch site at the time of launch.

Second Quarter 2002 Projected Orbital Launch Events

Date	Vehicle	Site	Payload or Mission	Operator	Use	Vehicle Price
4/2/2002	Molniya	Plesetsk	Kosmos 2388	Russian Ministry of Defense	Communications	$30-40M
4/8/2002	Shuttle Atlantis	KSC	STS 110	NASA		$300M
			ISS 8A	NASA	ISS	
4/16/2002 √	Ariane 4 TBA	Kourou	* NSS 7	New Skies Satellites N.V.	Communications	N/A
4/25/2002	Soyuz	Baikonur	Soyuz ISS 4S	Rosaviakosmos/NASA	ISS	$30-40M
4/26/2002	Delta 2 7920	VAFB	Aqua	NASA	Remote Sensing	$50-60M
5/4/2002	Ariane 42P	Kourou	SPOT 5	SPOT Image	Remote Sensing	$65-85M
5/6/2002 √	Proton (SL-12)	Baikonur	* DirecTV 5	DirecTV, Inc.	Communications	$75-95M
5/8/2002	Delta 2 7925-10	CCAFS	Navstar GPS 2R-8	DoD	Navigation	
5/14/2002	Soyuz	Baikonur	Progress ISS 8P	Rosaviakosmos/NASA	ISS	$30-40M
5/31/2002	Shuttle Endeavour	KSC	STS 111	NASA		$300M
			ISS UF-2	NASA	ISS	
5/2002 √	+ Zenit 3SL	Sea Launch Platform	* Galaxy 3C	Pan American Satellite Corp.	Communications	$75-95M
5/2002	Proton (SL-12)	Baikonur	Glonass M R4	Russian Ministry of Defense	Navigation	$75-95M
			Glonass M R5	Russian Ministry of Defense	Navigation	
			Glonass M R6	Russian Ministry of Defense	Navigation	
5/2002	Proton (SL-12)	Baikonur	* Express A1R	Russian Satellite Communciation Co.	Communications	$75-95M
5/2002	Long March 4B	Taiyuan	CBERS/Ziyuan 2	China/Brazil	Remote Sensing	$25-35M
6/3/2002	Titan 4B/Centaur	CCAFS	NRO T4	NRO	Classified	$350-450M
6/24/2002	Titan 2	VAFB	NOAA M	NOAA	Meteorological	$30-40M
6/2002 √	Long March 3A	Xichang	* Atlantic Bird 1	Eutelsat	Communications	$45-55M
6/2002 √	Ariane TBA	Kourou	* N-Star C	NTT Mobile Communications Network	Communications	N/A
6/2002 √	Rockot		* Iridium 97	Iridium Satellite LLC	Communications	$12-15M
			* Iridium 98	Iridium Satellite LLC	Communications	

√ Denotes commercial launch, defined as a launch that is internationally-competed or FAA-licensed.
+ Denotes FAA-licensed launch.
* Denotes a commercial payload, defined as a spacecraft that serves a commercial function or is operated by a commercial entity.

Second Quarter 2002 Projected Orbital Launch Events

Date	Vehicle	Site	Payload or Mission	Operator	Use	Vehicle Price
6/2002	V Proton (SL-12)	Baikonur	* EchoStar 8	Echostar Communications Corporation	Communications	$75-95M
6/2002	Long March 4B	Taiyuan	Fengyun 1D	China Meteorological Administration	Meteorological	$25-35M
			Haiyang 1	China Meteorological Administration	Meteorological	
6/2002	V Ariane TBA	Kourou	* Stellat 5	France Telecom	Communications	N/A
2Q/2002	PSLV	Sriharikota Range	Metsat	Indian Space Research Organization	Meteorological	$15-25M
2Q/2002	V Ariane 5G	Kourou	* eBird 1	Eutelsat	Communications	$150-180M
2Q/2002	V Ariane 44L	Kourou	* Intelsat 905	Intelsat	Communications	$100-125M
2Q/2002	Shavit 1	Palmachim AFB	Ofeq 5	Israel Space Agency	Classified	$10-15M

V Denotes commercial launch, defined as a launch that is internationally-competed or FAA-licensed.

+ Denotes FAA-licensed launch.

* Denotes a commercial payload, defined as a spacecraft that serves a commercial function or is operated by a commercial entity.

Third Quarter 2002 Projected Orbital Launch Events

Date		Vehicle	Site	Payload or Mission	Operator	Use	Vehicle Price
7/1/2002		Delta 2 7425-10	CCAFS	Contour	NASA	Scientific	$45-55M
7/8/2002	√ +	Atlas 5 401	CCAFS	* Hot Bird 6	Eutelsat	Communications	$85-110M
7/11/2002		Shuttle Columbia	KSC	STS 107 SpaceHab	NASA NASA	Scientific	$300M
7/15/2002	√ +	Delta 4 Medium	CCAFS	* Eutelsat W5	Eutelsat	Communications	$75-90M
7/20/2002		Soyuz	Baikonur	Progress ISS 9P	Rosaviakosmos/NASA	ISS	$30-40M
7/21/2002		Pegasus XL	CCAFS	GALEX	NASA	Scientific	$12-15M
7/25/2002		Delta 2 7925-10	CCAFS	Navstar GPS 2R-9 ProSEDS 2	DoD NASA	Navigation Development	$45-55M
7/2002	√	Ariane 5G	Kourou	* Insat 3A	Indian Space Research Organization	Communications	$150-180M
7/2002		Ariane 4 TBA	Kourou	MSG 1	Eumetsat	Meteorological	N/A
8/1/2002		H-2A 202	Tanegashima	DRTS W	National Space Development Agency	Communications	$75-95M
8/14/2002	√ +	Atlas 2AS	CCAFS	* Hispasat 1D	Hispasat	Communications	$90-105M
8/15/2002		Shuttle Atlantis	KSC	STS 112 ISS 9A	NASA NASA	ISS	$300M
9/22/2002	√ +	Pegasus XL	VAFB	* OrbView 3	ORBIMAGE	Remote Sensing	$12-15M
9/2002		Atlas 2AS	VAFB	NRO A3	NRO	Classified	$90-105M
9/2002		GSLV	Sriharikota Range	Gsat 2	Indian Space Research Organization	Communications	$25-45M
9/2002	√	Shtil	Barents Sea	Cosmos 1	The Planetary Society	Development	$0.1-0.3M
3Q/2002	√	Ariane 5 ESC-A	Kourou	* Hot Bird 7	Eutelsat	Communications	$150-180M
3Q/2002	√	Zenit 3SL	Sea Launch Platform	* Telstar 8	Loral Skynet	Communications	$75-95M
3Q/2002	√	Proton (SL-12)	Baikonur	* Astra 1K	SES Global	Communications	$75-95M
3Q/2002		Titan 4B	VAFB	NRO T1	NRO	Classified	$350-450M
3Q/2002	√	Ariane 44L	Kourou	* Intelsat 906	Intelsat	Communications	$100-125M
3Q/2002	√ +	Atlas 3B	CCAFS	* AsiaSat 4	Asia Satellite Telecommunications Co.	Communications	$90-105M

√ Denotes commercial launch, defined as a launch that is internationally-competed or FAA-licensed.
+ Denotes FAA-licensed launch.
* Denotes a commercial payload, defined as a spacecraft that serves a commercial function or is operated by a commercial entity.

ATTACHMENT 2

Commercial Space Transportation

QUARTERLY LAUNCH REPORT

Featuring the
launch results from
the 4th quarter 2001
and forecasts for
the 1st and 2nd
quarters 2002

Quarterly Report Topic:

EELV Reliability:
Building On Experience

1st Quarter 2002

United States Department of Transportation • Federal Aviation Administration
Associate Administrator for Commercial Space Transportation
800 Independence Ave. SW • Room 331
Washington, D.C. 20591

Introduction

The First Quarter 2002 Quarterly Launch Report features launch results from the fourth quarter of 2001 (October-December 2001) and launch forecasts for the first quarter of 2002 (January-March 2002) and the second quarter of 2002 (April-June 2002). This report contains information on worldwide commercial, civil, and military orbital space launch events. Projected launches have been identified from open sources, including industry references, company manifests, periodicals, and government sources. Projected launches 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)

Contents

Cover: Vandenberg Air Force Base, Calif., Oct. 18, 2001 - A Delta 2 7320-10 launch vehicle successfully carries the QuickBird imaging satellite into low-Earth orbit for DigitalGlobe. Courtesy of The Boeing Company.

Fourth Quarter 2001 Highlights

EELV Engine Testing Completed

In the fourth quarter of 2001, both Evolved Expendable Launch Vehicle (EELV) engine programs completed ground testing. Boeing's Rocketdyne division completed testing of the new RS-68 engine slated for use on the Delta 4 launch vehicle family, whose first launch is scheduled for July 15, 2002. The 2.9-million-newton (651,000-pound-force) thrust engine has been test fired 183 times for a total of 18,645 seconds of use. Boeing has also completed five hot fire tests of the engine installed in the Delta 4's Common Booster Core stage for a total of 55 seconds.

Firing tests of the RD AMROSS (Pratt & Whitney-NPO Energomash) RD-180 engine were also completed in the fourth quarter with a 350-second burn at at both the 47-percent and 100-percent power levels. The RD-180 is now fully qualified for use on the Atlas 5 Common Core Booster (which is expected to enter service in May 9, 2002). The five-year development of the RD-180 started in November 1996 and involved 135 test firings lasting 25,450 seconds. The engine is also used on Atlas 3, which has made one launch so far.

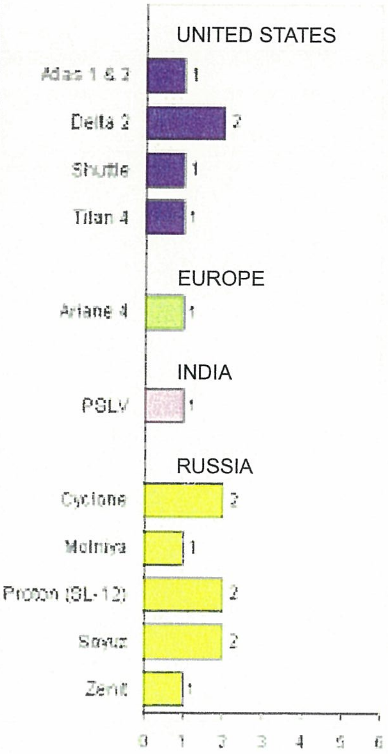
100th Delta 2 Launch

The 100th launch of a Boeing Delta 2 took place on December 7 from Vandenberg Air Force Base in California. The vehicle carried NASA's TIMED and NASA-CNES Jason satellites. TIMED (Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics) will study a little-known region of Earth's atmosphere, the area between 60 kilometers (37 miles) and 180 kilometers (112 miles) altitude. Jason 1 is a joint U.S.-French oceanographic satellite, which is working together with TOPEX/Poseidon (another U.S.-French satellite launched in 1992) to study the global climate.

Vehicle Use

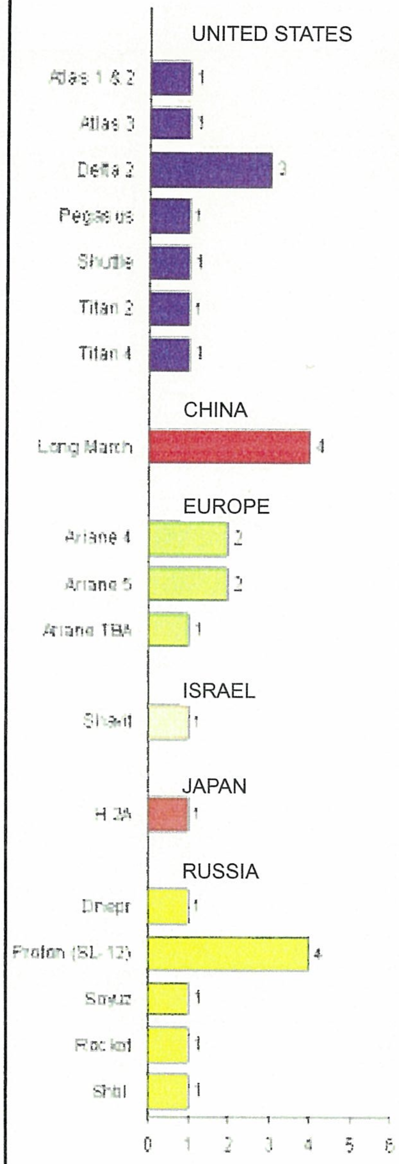
(October 2001 – June 2002)

Figure 1: Fourth Quarter 2001 Total Launch Vehicle Use



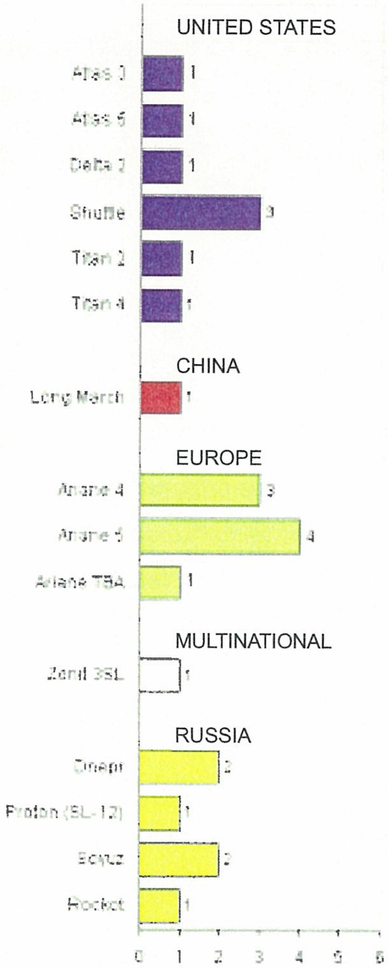
Total = 15

Figure 2: First Quarter 2002 Total Projected Launch Vehicle Use



Total = 28

Figure 3: Second Quarter 2002 Total Projected Launch Vehicle Use



Total = 24

Figures 1-3 show the total number of orbital launches (commercial and government) of each launch vehicle that occurred in the fourth quarter of 2001 and that are projected for the first and second quarters of 2002. These launches are grouped by the country in which the primary vehicle manufacturer is based. Exceptions to this grouping are launches performed by Sea Launch, which are designated as multinational.

Total Launch Events by Country
(October 2001 – June 2002)

Figure 4: Fourth Quarter 2001 Total Launch Events by Country

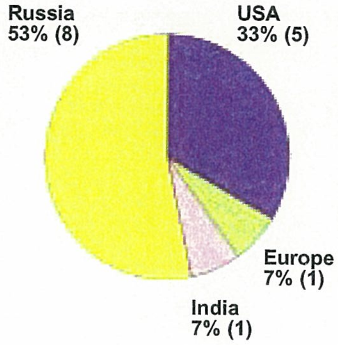


Figure 5: First Quarter 2002 Total Projected Launch Events by Country

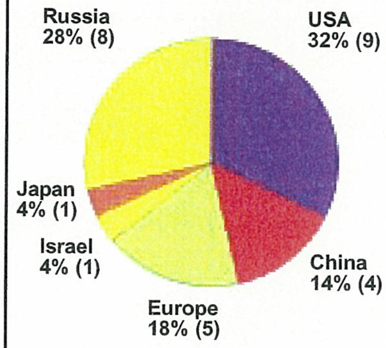
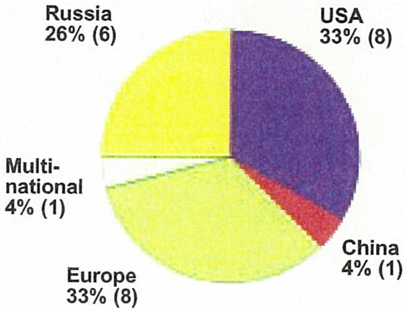


Figure 6: Second Quarter 2002 Total Projected Launch Events by Country



Figures 4-6 show all orbital launch events (commercial and government) that occurred in the fourth quarter of 2001 and that are projected for the first and second quarters of 2002.

Commercial Launch Events by Country
(October 2001 – June 2002)

Figure 7: Fourth Quarter 2001 Commercial Launch Events by Country

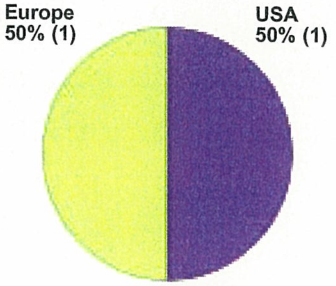


Figure 8: First Quarter 2002 Projected Commercial Launch Events by Country

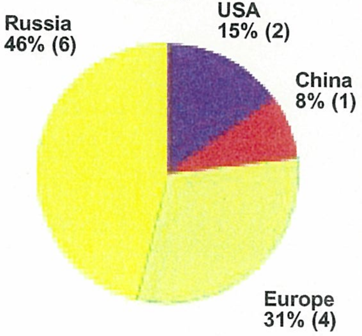
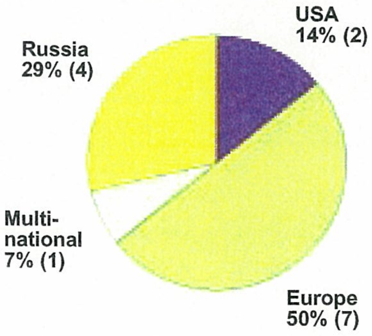


Figure 9: Second Quarter 2002 Projected Commercial Launch Events by Country



Figures 7-9 show all *commercial* orbital launch events that occurred in the fourth quarter of 2001 and that are projected for the first and second quarters of 2002.

Commercial vs. Non-commercial Launch Events
(October 2001 – June 2002)

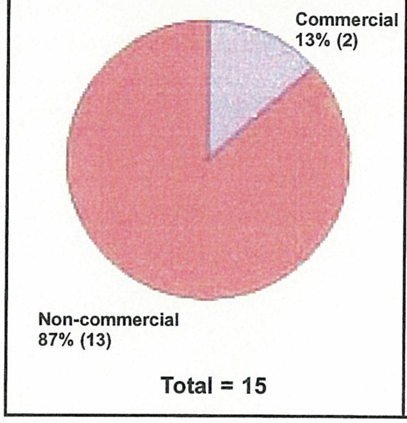


Figure 10: Fourth Quarter 2001 2001 Commercial vs. Non-commercial Launch Events

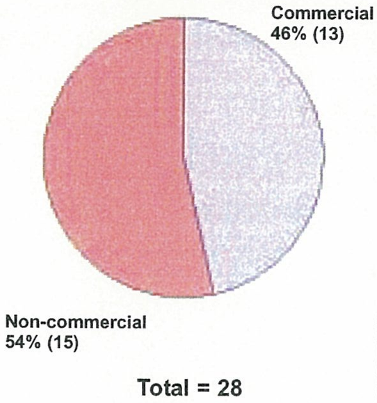


Figure 11: First Quarter 2002 Commercial vs. Non-commercial Projected Launch Events

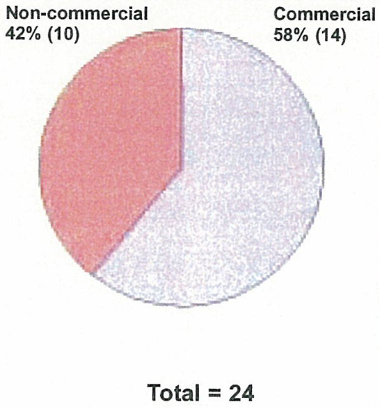


Figure 12: Second Quarter 2002 Commercial vs. Non-commercial Projected Launch Events

Figures 10-12 show commercial vs. non-commercial orbital launch events that occurred in the fourth quarter of 2001 and that are projected for the first and second quarters of 2002.

Fourth Quarter 2001 Launch Successes vs. Failures
(October 2001 – June 2002)

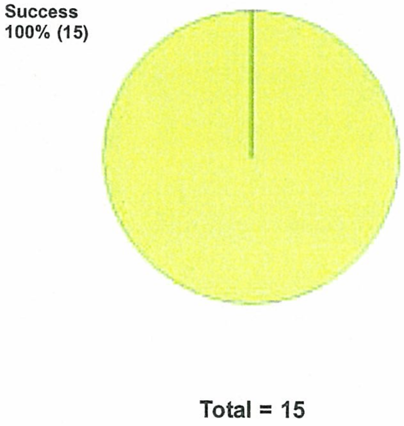
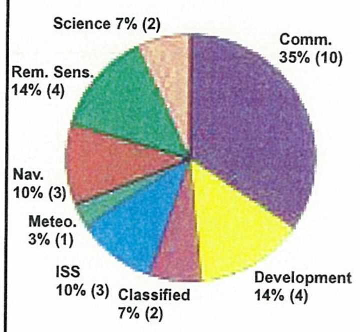


Figure 13: Total Launch Successes vs. Failures

Figure 13 shows successful vs. failed orbital launch events that occurred in the fourth quarter of 2001.

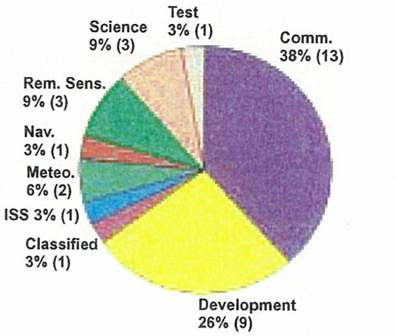
Payload Use
(October 2001 – June 2002)

Figure 14: Fourth Quarter 2001 Payload Use



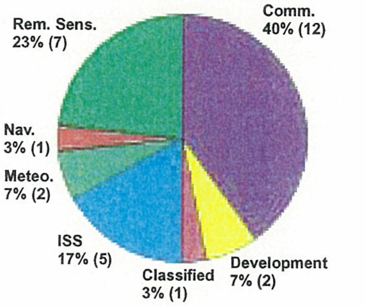
Total = 29

Figure 15: First Quarter 2002 Projected Payload Use



Total = 34

Figure 16: Second Quarter 2002 Projected Payload Use

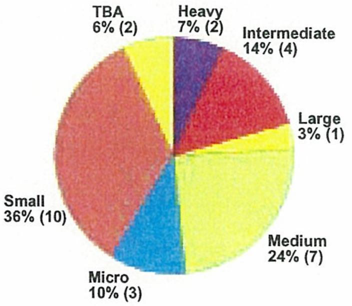


Total = 30

Figures 14-16 show total payload use (commercial and government), actual for the fourth quarter of 2001 and that are projected for the first and second quarters of 2002. The total number of payloads launched may not equal the total number of launches due to multi-manifesting, i.e., the launching of more than one payload by a single launch vehicle.

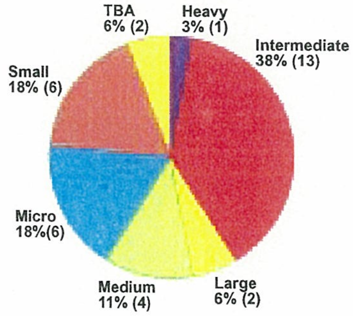
Payload Mass Class
(October 2001 – June 2002)

Figure 17: Fourth Quarter 2001 Payload Mass Class



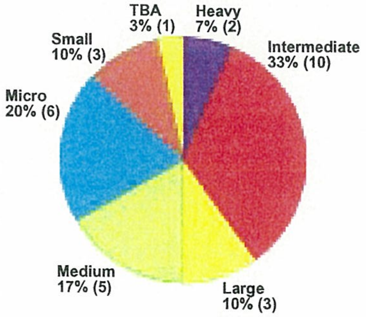
Total = 29

Figure 18: First Quarter 2002 Projected Payload Mass Class



Total = 34

Figure 19: Second Quarter 2002 Projected Payload Mass Class

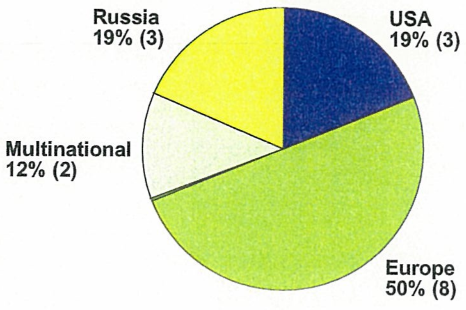


Total = 30

Figures 17-19 show total payloads by mass class (commercial and government), actual for the fourth quarter of 2001 and projected for the first and second quarters of 2002. The total number of payloads launched may not equal the total number of launches due to multi-manifesting, i.e., the launching of more than one payload by a single launch vehicle. Payload mass classes are defined as Micro: 0 to 91 kilograms (0 to 200 lbs.); Small: 92 to 907 kilograms (201 to 2,000 lbs.); Medium: 908 to 2,268 kilograms (2,001 to 5,000 lbs.); Intermediate: 2,269 to 4,536 kilograms (5,001 to 10,000 lbs.); Large: 4,537 to 9,072 kilograms (10,001 to 20,000 lbs.); and Heavy: over 9,073 kilograms (20,000 lbs.).

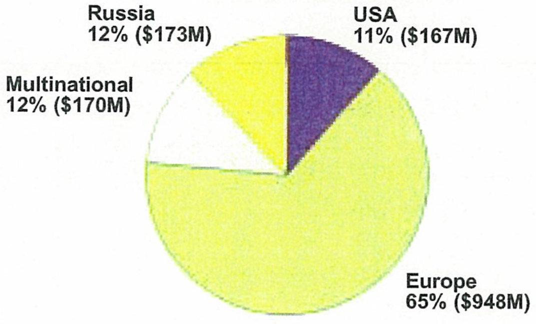
Commercial Launch Trends
(January 2001 – December 2001)

Figure 20: Commercial Launch Events, Last 12 Months



Total = 16

Figure 21: Commercial Launch Revenue, Last 12 Months



Total = $1458M

Figures 20 shows commercial launch events for the period January 2001 to December 2001 by country.

Figures 21 shows commercial launch revenue for the period January 2001 to December 2001 by country.

Figure 22: Commercial Launch Events by Country, Last Five Years

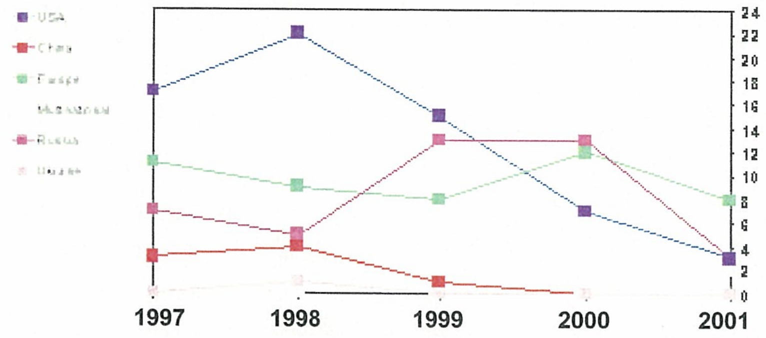


Figure 22 shows commercial launch events by country for the last five full years.

Figure 23: Commercial Launch Revenue (in $ million) by Country, Last Five Years

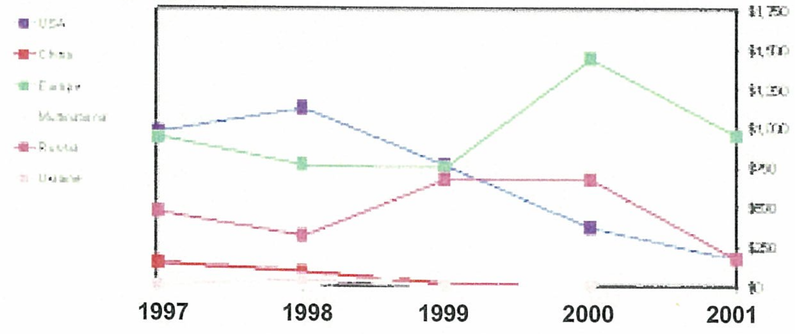


Figure 23 shows commercial launch revenue by country for the last five full years.

EELV Reliability: Building on Experience

The National Space Transportation Policy, signed by President Clinton on August 5, 1994, gave the National Aeronautics and Space Administration (NASA) responsibility for reusable launch vehicle development, while tasking the Department of Defense (DoD) with improving expendable launch vehicles (ELV) and the nation's existing launch infrastructure. This goal resulted in the initiation of the Evolved Expendable Launch Vehicle (EELV) program. Under this program DoD was to partner with industry to develop a national launch capability to satisfy both government and commercial payload requirements and reduce the cost of space access by at least 25 percent. Four companies initially competed for DoD contracts to develop these vehicles and ultimately, Lockheed Martin Corporation and The Boeing Company were awarded EELV production and service contracts for their respective Atlas 5 and Delta 4 vehicles.

With a focus on the Atlas and Delta families, the Fourth Quarter 2001 Quarterly Launch Report special report addressed the process by which launch vehicles become more reliable and capable over time. The present report augments the prior one, examining in greater depth the EELV program's effort to produce highly reliable vehicles in a relatively short period of time. The first part of this report shows that vehicle reliability tends to increase with testing and flight experience, and that later variants within a launch vehicle family tend to be more reliable than earlier ones. The second part of the report describes the approaches, many of which were taken to improve earlier vehicles' reliability that Boeing and Lockheed Martin are now using to bolster reliability and reduce technical risk of their respective EELVs. The report suggests that if past is prologue, the Atlas 5 and Delta 4 EELVs are on track to exceed the initial reliability of their predecessors in the short term, with a good chance of achieving superior reliability over the long term.

LAUNCH VEHICLE RELIABILITY AND THE IMPACT OF EXPERIENCE

Launch vehicles are complex devices, and like any complex device, it takes time to refine them. The ideal way to "wring out" a design's flaws and thus bolster a vehicle's reliability is to follow a thorough testing process. Vehicle developers routinely conduct ground tests of vehicle components and systems before a complete vehicle ever flies. While these tests certainly are critical to increasing a vehicle's chances of flight success, they do not guarantee that a vehicle will fly flawlessly. Optimally, ground tests would be followed by many dedicated test flights of the vehicle carrying a mass simulator or dummy payload. Repeat numbers of test flights would allow vehicle engineers to analyze the vehicle's performance, make modifications to enhance performance, and fly the vehicle to test the performance with design alterations.

For early ballistic missiles, the testing process did involve a large number of flights: the Atlas Intercontinental Ballistic Missile (ICBM), for

Vehicle	Number of Test Flights
Ariane 1	1
Ariane 2	0
Ariane 3	0
Ariane 4	1
Ariane 5	3
Space Shuttle	4
Atlas 1 & 2	0
Delta 3	1
Zenit 3SL	1

Table 1: Numbers of Test Launches for Launch Vehicles

one, made 82 test flights between 1957 and 1962, while the Titan ICBM made around 100 test flights. In contrast to missiles, launch vehicles generally make far fewer test flights (see Table 1). While this, in part, is because many launch vehicles are based on ballistic missiles and benefit from the testing carried out on the missiles, it is also because numerous test flights can be cost- and schedule-prohibitive for vehicle manufacturers. As a result, it is not uncommon for the first flight of a launch vehicle to carry a functional payload, as opposed to a mass simulator or test equipment. Regardless of whether or not a vehicle is formally in test status, however, continuous operations, analysis of performance, and subsequent design improvements are key to raising a design's reliability[1].

Moreover, constant monitoring of vehicle performance is necessary to maintain a high degree of reliability once it has been achieved: even proven systems may lose reliability as a result of changes in manufacturing or operating procedures. For example, both the Pratt and Whitney RL-10 engine, used on the Delta 3 and the Centaur upper stage, and the Proton's NPO Energomash 11D58M have caused launch failures because changes in manufacturing procedures resulted in flawed engines. Once these failures occurred, the problems were identified and corrected, but these cases serve to illustrate that launch vehicles require constant attention to keep them reliable.

THE CASES OF ARIANE, ATLAS, AND PROTON

To explore the development of vehicle reliability over time, this report considers members of three vehicle families: Ariane 1-4, pre-Atlas-3 Atlas vehicles, and pre-Proton-M Proton vehicles (Proton M and Atlas 3 vehicles differ too much from there respective predecessors to make their inclusion meaningful). These vehicles were chosen to compare the development histories of three representative vehicles of major spacefaring nations. Although other vehicles, such as the Delta and Soyuz, also have lengthy development histories, the three vehicles chosen are all similar in mass class and compete for the same basic market.

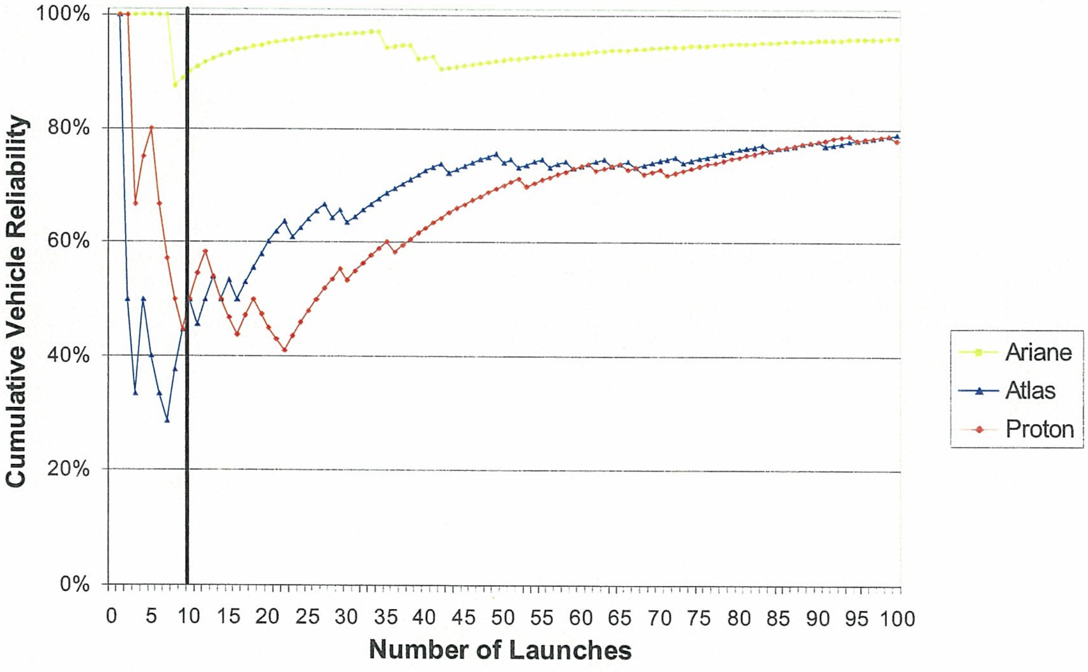


Figure 1: Cumulative Vehicle Reliability for the First 100 Launches

	Ariane 1-4			Atlas			Proton		
	Launch Number	Success Rate (for Interval)	Change	Launch Number	Success Rate (for Interval)	Change	Launch Number	Success Rate (for Interval)	Change
1	1-50	88%	N/A	1-50	74%	N/A	1-50	70%	N/A
2	51-100	94%	6%	51-100	84%	10%	51-100	86%	16%
3	101-136	100%	6%	101-150	88%	4%	101-150	96%	10%
4				151-200	90%	2%	151-200	96%	0%
5				201-250	88%	-2%	201-250	92%	-4%
6				251-300	100%	12%	251-284	94%	2%
7				301-306	100%	0%			

Table 2: Vehicle Reliability by Chronological Intervals of Fifty

As can be seen in Figure 1, a vehicle's first ten launches are generally the most problematic. For both Ariane and Atlas, the worst cumulative reliability occurred during the first ten launches. The Russian Proton deviates from this pattern, having made 22 flights before its reliability began to improve. This late turning point reflects the Russian design methodology, which calls for flight testing earlier in the design process than would be considered appropriate by a Western designer. Despite this testing process, the Proton still begins to improve early in its lifetime. By the 100th launch, Atlas and Proton achieved nearly identical cumulative reliabilities.

In order to portray early reliability gains in a different light, Table 2 and Figure 2 show vehicle success rates by increments of 50. The success rate of each set of 50 launches is based on the experience in that set of launches; it is not cumulative. As such, Table 2 and Figure 2 provide vehicle reliability data for distinct 50-launch increments and illustrate differences in reliability among different periods (for instance, the difference between the reliability of launches 1 through 50 as compared to launches 51 through 100). Note that the size of the final interval varies among the vehicles, as none of them have been launched an even multiple of fifty times.

Table 2 and Figure 2 show that these vehicles continue to improve for at least the first 100 to 150 launches, with reliability reaching the 90- to 100-percent range. As long as a vehicle's reliability is under 100 percent, however, there is the possibility of further improvement. This

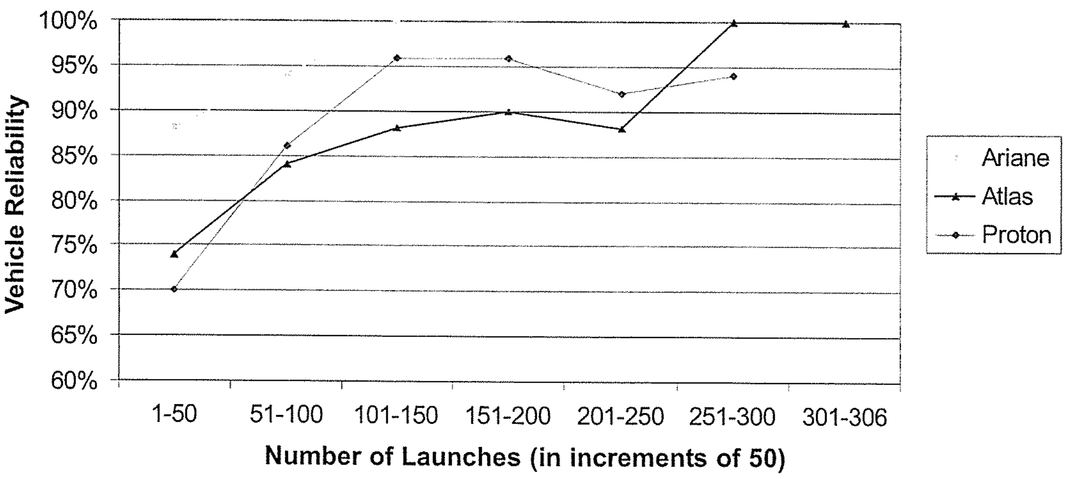


Figure 2: Vehicle Reliability by Chronological Intervals of Fifty

is demonstrated by the improvement shown by the Atlas vehicle in its final two increments (flights 251 through 306).

For Ariane, reliability improvement ceased when it achieved a perfect record in its last interval of 36 launches. This achievement is even more striking considering that the actual number of successful consecutive Ariane launches was 65, from 1995 to the present. As of the first quarter of 2002, Ariane vehicles (excluding the Ariane 5) have cumulative reliability of 94 percent.

Proton improved throughout its first 150 launches, then showed no improvement during its fourth increment and declined by two percent in its fifth increment. The sixth set of launches is promising, returning to the third and fourth increments' 96 percent success rate. Improvement in Proton's reliability already may be occurring, but this will not be clear for another 20 or 30 launches. Proton's lifetime cumulative reliability is 89 percent.

The Atlas reliability development pattern shows similarities to the histories of both Ariane and Proton. Atlas vehicle reliability improved up through the third 50-launch increment, then declined slightly, and then leveled off for the next three periods. In the sixth period, Atlas had a perfect record, which has continued into the first nine launches of the seventh 50-launch period. The total number of consecutive successful launches for Atlas is now 60, for a cumulative reliability of 88 percent.

This analysis intends not to determine which vehicle is superior, but instead to outline the developmental patterns of launch vehicles gained over many launches. Judging from the sample vehicles, it appears that most launch vehicles experience the greatest improvements in reliability over their first 150 launches. Improvement may continue to occur, but the technical innovations resulting in the greatest immediate increases in reliability will have already been made; thus, reliability gains will be harder to achieve.

There is also the possibility that a vehicle may manifest new problems and suffer a decrease in reliability as it ages. In some cases, this occurs because components become obsolete or unavailable, forcing changes in a vehicle that may cause failures. In other cases, design or manufacturing changes in proven components and systems may result in new bugs to replace the old ones that had been carefully removed from the launch vehicle system. Still, even in cases where reliability does decline, the vehicle's reliability remains better than during its initial period of operation: single or even multiple, failures later in a vehicle's life have less of an impact as the number of successful launches grows.

In effect, when launches are successful, reliability improves. When a failure occurs, reliability declines; in correcting the problems revealed by the failure, however, the vehicle becomes more reliable in the long term. Figure 2 shows that both Atlas and Proton have endured declines in reliability. Although it is not possible to go into the details of every launch failure of Ariane, Atlas, and Proton some failures can be chosen for closer examination because they exemplify the process by which launch vehicle reliability improves.

In Proton's last 34 launches, there have been two launch failures (flights 263 and 266). These failures were similar and were caused by the same problem: debris left inside their second-stage engines during assembly at the Voronezh Mechanical Plant in Russia. Design changes have been made in current production engines, and controls have been developed to prevent such problems in the future. These controls include better quality control processes during manufacturing and special examinations of all flight motors. Following these changes and increased scrutiny of older engines, there have been no more Proton launch failures.

There have only been three failures of the Atlas launch vehicle since its commercialization following the Challenger disaster. All three of these failures occurred in Atlas' fifth launch increment (launch numbers 236, 246, and 247). These failures are further examples of why even well-proven vehicles fail. Flight numbers 236 and 246 failed when their Centaur upper stages' engines malfunctioned. Investigations of both failures revealed that the Centaur engines could be frozen during a chill-down procedure used prior to liftoff to ensure proper liquid oxygen (LOX) flow. In order to mitigate this flaw in the Atlas vehicle, General Dynamics (who then produced the Atlas launch vehicle) introduced hardware and launch procedure changes that have prevented the recurrence of this problem.

Atlas' flight number 247 was lost because an improperly tightened set-screw caused the vehicle's first stage to produce only two thirds of its nominal thrust. This shortfall caused the payload to be deployed into an improper orbit. Once this problem was identified and it was determined not to be a design or hardware problem, launches quickly resumed. The problem has not recurred.

Even when a failure is not fully understood useful information can be gained from it. In the case of the most recent failure of an Ariane 4 launch vehicle (an Ariane 42P), the vehicle achieved only 70 percent of its nominal third-stage thrust and failed to place its payload into a proper geostationary transfer orbit. The investigating board concluded that insufficient amounts of LOX had reached the turbopump gas generator. Two causes seemed likely. One was a partial blockage of one of the supplier components by a foreign particle or ice; the other was a leak in the LOX feed, possibly due to a bad seal. Simulations indicated that an obstruction was the most likely cause of the accident.

Despite the uncertainty concerning the cause of the failure, the board recommended a series of steps to improve the Ariane 4's reliability. Six of the board's 13 recommendations covered contamination risks, while five related to improved testing and leak prevention, while the final two concerned the study of overall failure options. Even though the exact cause of the failure was not proven, the chances of a similar failure were reduced and the Ariane 4 has since flown without a failure.

The discussion of vehicle reliability thus far has largely revolved around the accumulation of experience with, and a growing understanding of, launch vehicles by their builders and operators. As can be seen in the previous examples, failures occur for many reasons. Some of these are as simple as an inadequately-torqued screw while others can be traced back to the drawing board. The important point is that failures not caused by wholly random events (for instance, a lightning strike) can generally be prevented once the hardware or procedural flaw that caused them is discovered. With each such discovery-many of which are discovered without the loss of a vehicle-the vehicle grows more reliable. The availability of and desire to conserve this knowledge base is why launch vehicle manufacturers prefer to make improvements in an incremental fashion as opposed to creating new systems from scratch.

Because the knowledge gained through the experiences with one variant is imparted in the next, a new variant within a given vehicle family starts higher on the learning curve than an entirely new vehicle. Table 3 shows the development of the Ariane 1-4 family. It can be seen that the earliest two Ariane variants, Ariane 1 and Ariane 3, have the lowest reliability records of all of the variants considered here. These two variants have the lowest initial reliabilities as well as the lowest lifetime reliabilities. Note that both initial and lifetime reliabilities generally increased as new Ariane variants were introduced.

		First Ten Launches			All Launches		
Vehicle Variant	Introduction Year	Success	Failure	Reliability	Success	Failure	Reliability
Ariane 1 (all)	1979	8	2	80%	9	2	82%
Ariane 3 (all)	1984	8	2	80%	9	2	82%
Ariane 2 (all)	1986	5	1	83%	5	1	83%
Ariane 44LP	1988	9	1	90%	25	1	96%
Ariane 44L	1989	9	1	90%	32	1	97%
Ariane 40	1990	7	0	100%	7	0	100%
Ariane 42P	1990	9	1	90%	13	1	93%
Ariane 44P	1991	10	0	100%	17	0	100%
Ariane 42L	1993	9	1	90%	10	1	91%
Totals		74	9		127	9	

Table 3: Ariane 1-4 Variant Launch Reliability

Unfortunately, an analysis of the reliability differences among variants in a family cannot be applied to Proton or Atlas. The major distinction among various Proton vehicles is the upper stage; Proton vehicles do not vary in the same way as Ariane vehicles, whose variants use different combinations of strap-on boosters and were introduced at different times. The large number of Atlas variants, many of which have made only two or three launches, prevents the Atlas from being useful as an example of the effects of variation on launch vehicle reliability. Nonetheless, the analyses in this section suggest that, in general, the most reliable launch vehicle is one whose history is extensive and replete with incremental developments.

EELV RELIABILITY

The products of the EELV program, the Lockheed Martin Atlas 5 and the Boeing Delta 4, represent an effort to create new vehicles that achieve high reliabilities but with fewer launches than the vehicles discussed above. The EELV manufacturers hope their vehicles will not undergo the initial failures of their predecessors and will capture many of the reliability improvements developed during their predecessor's operational lifetimes. The manufacturers hope to achieve high reliability using a combination of their predecessors' heritage and experience, incremental innovation, and simplification of various systems.

Despite embracing quite different design choices, the developers of both the Delta 4 and the Atlas 5 are using the same approach to maintain the experience gained by previous launch vehicles. Both Delta 4 and Atlas 5 have been preceded by intermediate vehicles serving as transitions between them and their proven ancestors. These "bridge" vehicles are the Atlas 3 and the Delta 3, both of which have a large degree of commonality with the older Delta and Atlas designs while pioneering various innovations for the follow-on Delta 4 and Atlas 5.

The Atlas 3 is an initial effort to reduce vehicle complexity while increasing vehicle performance. It uses improved first-stage fuel tank construction and simplified components, while replacing the original Atlas's stage-and-a-half staging concept with a more conventional single stage. It also replaces the original design's three Rocketdyne engines with a single, more powerful, NPO Energomash/Pratt & Whitney RD-180 engine. As a result, the Atlas 3's first-stage thrust section undergoes only one staging event and has only seven fluid interfaces, as opposed to previous Atlas models with six staging events and 17 fluid interfaces.

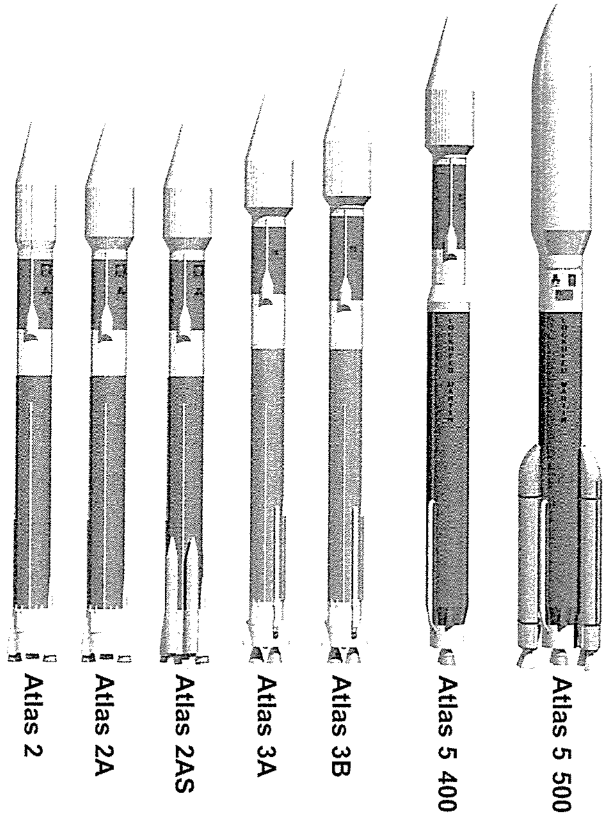


Figure 3: Atlas Vehicle Lineage

The Atlas 3 family also introduces two improved versions of the Centaur upper stage: the Atlas 3A uses a single-engine Centaur, removing one RL10A-4-1 engine and centering the other along the Centaur's axis, while the Atlas 3B uses a lengthened version of the improved Centaur with two RL10A-4-2 engines. The improved Centaur engines include upgrades, such as chiller modifications and a health monitoring system designed to increase reliability and operational standards. Both the single- and dual-engine Centaurs will continue to be used on the Atlas 5 series after the Atlas 3 is retired (see Figure 3 for the Atlas lineage).

Unlike the Atlas 3 program, Boeing did not improve the Delta 3's engines for use on the Delta 4, but it does introduce a number of new features that will be used on the Delta 4. The upper stage introduced on the Delta 3 will be used in an expanded form (using the same RL10B-2 engine as the previous version with larger fuel and oxidizer tanks) on the Delta 4, along with the Redundant Inertial Flight Control Assembly avionics system that debuted on the Delta 3.

By introducing a limited number of new components to the EELVs, and doing so as much as possible through transitional vehicles, Boeing and Lockheed Martin are attempting to increase EELV reliability while reducing their development risk. Lockheed Martin is confident, for instance, that the success of the Atlas 3 has proven 80 percent of Atlas 5's technologies.[2]

In addition to reducing risk and thereby improving reliability by incrementally introducing new systems and better designs, both the Atlas 5 and Delta 4 are designed with

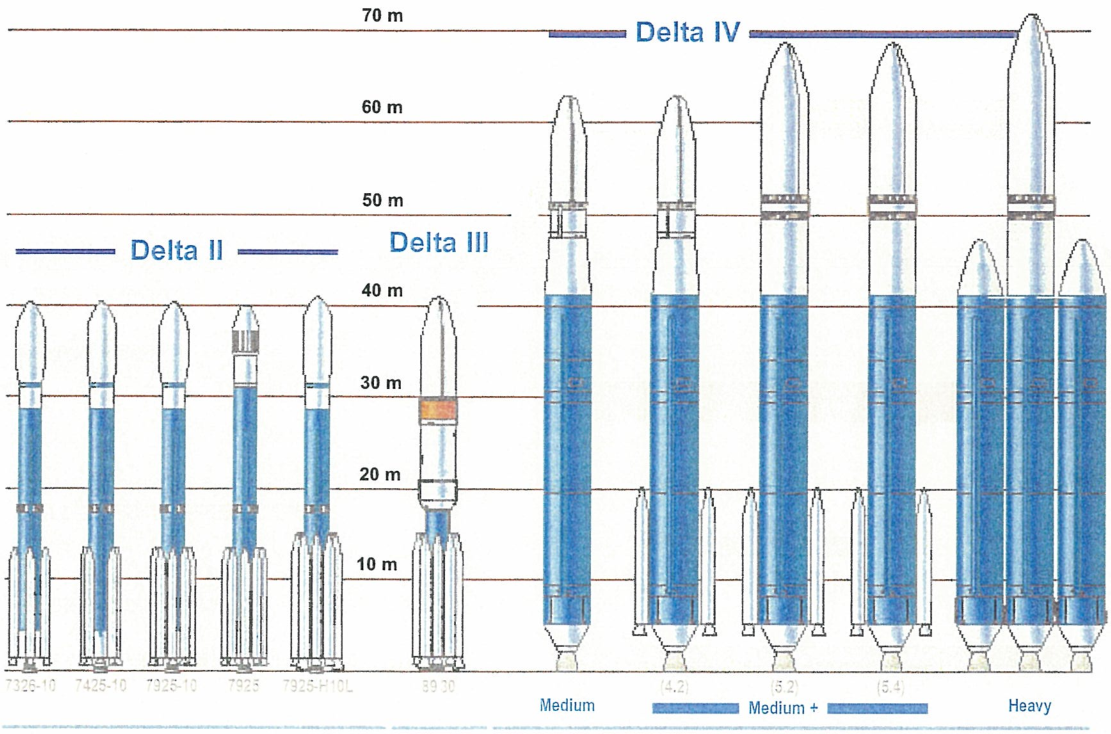


Figure 4: Delta Vehicle Lineage

fewer possible failure modes than their predecessors. The Atlas 5, for example, is estimated to have approximately 125 potential single-point failures as opposed to over 250 for the Atlas 2AS.[3] Lockheed Martin will also replace the pressure-stabilized fuel tanks used on all previous Atlas vehicles with structurally-stable propellant tanks. These tanks will support the weight of the vehicle's payload without being fueled, in contrast to previous Atlas vehicles, which required the pressure of the fuel in their tanks to bear the weight of their payloads. The new Atlas 5 Common Core Booster™ (CCB) will be much more robust than its pressure-stabilized predecessor, while still using many systems proven on the Atlas 3.

The Delta 4 involves further improvements on the components pioneered by the Delta 3. It introduces a new first-stage common booster core (CBC), which will use the Rocketdyne RS-68 engine developed specifically for the Delta 4. This engine has 95 percent fewer parts than the comparable Space Shuttle Main Engine (SSME) and requires only 8,000 hours of touch labor, compared with 171,000 hours for the SSME.[4]

The heavy version of the Delta 4 will use three CBC stages in parallel. It will resemble the current Titan 4 in appearance, but instead of using two entirely different engine systems (a liquid-fueled core stage and strap-on solid fuel boosters) it will have a single design repeated three times. Only after the CBC has been tested in single core launches will it be used in this triplex arrangement-an approach aimed at reducing the risk of vehicle failure (see the Delta vehicle lineage in Figure 4).

CONCLUSION

If the strategies of using incremental innovation and simplified components and systems are successful, the overall reliability of the Boeing and Lockheed Martin EELVs should be higher than that of earlier variants in their respective vehicle lineages at a corresponding point in their development. As the name *Evolved* Expendable Launch Vehicle suggests, these vehicles are intended to build on success and limit new risk, while introducing capabilities equivalent to those of a new vehicle. If experience provides any guidance, to the extent that launch vehicle development is successfully managed, the EELVs will have higher initial reliabilities than those of a clean-slate design. Such a success will improve U.S. launch assets while maintaining current capabilities.

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[1] It should be noted that every launch of an expendable launch vehicle (ELV) is actually an inaugural flight of that particular vehicle (if not that particular design). ELV reliability is thus not easily or fairly comparable with that, for example, of a certified commercial aircraft.

[2] http://www.ilslaunch.com/missionplanner

[3] Ibid.

[4] http://lean.mit.edu/Events/workshops/files_public/EBRT_eelv.pdf

Fourth Quarter 2001 Orbital Launch Events

Date	Vehicle	Site	Payload or Mission	Operator	Use	Vehicle Price	L	M
10/5/01	Titan 4B	VAFB	NRO T3	National Reconnaissance Office	Classified	$350-450M	S	S
10/6/01	Proton	Baikonur	Raduga 1-06	Russian Ministry of Defense	Communications	$75-95M	S	S
10/11/01	Atlas 2AS	CCAFS	NRO A2	National Reconnaissance Office	Communications	$90-105M	S	S
10/18/01	√ + Delta 2 7320	VAFB	* QuickBird 2	DigitalGlobe	Remote Sensing	$45-55M	S	S
10/21/01	Soyuz	Baikonur	Soyuz ISS 3S	Rosaviakosmos/ NASA	ISS	$30-40M	S	S
10/22/01	PSLV	Sriharikota Range	PROBA	European Space Agency	Development	$15-25M	S	S
			TES	Indian Space Research Organization	Remote Sensing			
			BIRD	Deutschen Zentrum für Luft und Raumfahrt	Development			
10/25/01	Molniya	Plesetsk	Molniya 3-51	Russian Ministry of Defense	Communications	$30-40M	S	S
11/26/01	Soyuz	Baikonur	Progress ISS 6P	Rosaviakosmos/ NASA	ISS	$30-40M	S	S
11/26/01	√ Ariane 44LP	Kourou	* DirecTV 4S	DirecTV, Inc.	Communications	$90-110M	S	S
12/1/01	Proton	Baikonur	Kosmos 2380	Russian Ministry of Defense	Navigation	$75-95M	S	S
			Kosmos 2381	Russian Ministry of Defense	Navigation			
			Kosmos 2382	Russian Ministry of Defense	Navigation			
12/5/01	Shuttle Endeavour	KSC	STS 108	NASA	Crewed	$300M	S	S
			ISS UF-1	NASA	ISS			
12/7/01	Delta 2 7920	VAFB	Jason 1	NASA/Centre National d'Etudes Spatiales	Remote Sensing	$50-60M	S	S
			TIMED	NASA	Scientific			
12/10/01	Zenit 2	Baikonur	Meteor 3M N1	Rosaviakosmos/NASA	Meteorological	$35-50M	S	S
			Badr 2	Space and Upper Atmosphere Research Commission	Development			
			Kompass	Izmiran	Scientific			
			Maroc-Tubsat	Royal Center for Remote Sensing	Remote Sensing			
			Reflektor	Scientific Research Institute for Precision Device Engineering	Development			
12/21/01	Cyclone 2	Baikonur	Kosmos 2383	Russian Ministry of Defense	Classified	$20-25M	S	S
12/28/01	Cyclone 3	Plesetsk	* Gonets D1 7	Smolsat (NPO PM, et. al)	Communications	$20-25M	S	S
			* Gonets D1 8	Smolsat (NPO PM, et. al)	Communications			
			* Gonets D1 9	Smolsat (NPO PM, et. al)	Communications			
			Kosmos 2384	Russian Ministry of Defense	Communications			
			Kosmos 2385	Russian Ministry of Defense	Communications			
			Kosmos 2386	Russian Ministry of Defense	Communications			

√ Denotes commercial launch, defined as a launch that is internationally competed or FAA licensed.

\+ Denotes FAA-licensed launch.

* Denotes a commercial payload, defined as a spacecraft that serves a commercial function or is operated by a commercial entity.

L and M refer to the outcome of the Launch and Mission: S = success, P = partial success, F = failure

Note: All launch dates are based on local time at the launch site at the time of launch.

First Quarter 2002 Projected Orbital Launch Events

Date	Vehicle	Site	Payload or Misson	Operator	Use	Vehicle Price
1/15/02	Titan 4B/Centaur	CCAFS	Milstar F5	Department of Defense	Communications	$350-450M
1/23/02	V Ariane 42L	Kourou	* Insat 3C	Indian Space Research Organization	Communications	$80-100M
1/XX/02	Shavit 1	Palmachim	Ofeq 5	Israel Space Agency	Classified	$10-15M
1/XX/02	Long March 2F	Jiuquan	Shenzhou 3	China National Space Administration	Development	N/A
2/1/02	Pegasus XL	CCAFS	HESSI	NASA	Scientific	$12-15M
2/3/02	H 2A 202	Tanegashima	MDS 1	National Space Development Agency	Development	$75-95M
			Vehicle Evaluation Payload 3	National Space Development Agency	Test	
			DASH	Institute of Space and Astronautical Science	Development	
2/8/02	V + Delta 2 7920	VAFB	* Iridium MS-12	Iridium Satellite LLC	Communications	$50-60M
2/14/02	V Ariane 44L	Kourou	* Intelsat 904	Intelsat	Communications	$100-125M
2/21/02	V + Atlas 3B	CCAFS	* EchoStar 7	EchoStar Satellite Corp.	Communications	$90-105M
2/28/02	Shuttle Columbia	KSC	STS 109	NASA	Crewed	$300M
			Hubble Servicing Mission 3B	NASA	Development	
2/28/02	Soyuz	Baikonur	Progress ISS 7P	Rosaviakosmos/ NASA	ISS	$30-40M
2/XX/02	Titan 2	VAFB	DMSP 5D-3-F16	Department of Defense (USA)	Meteorological	$30-40M
2/XX/02	V Dnepr 1	Svobodny	Unisat 2	Italian Space Agency	Development	$10-20M
			Tropnet 1	Russia	Development	
			Tropnet 2	Russia	Development	
			Tropnet 3	Russia	Development	
3/1/02	Ariane 5G	Kourou	ENVISAT 1	European Space Agency	Remote Sensing	$150-180M
3/4/02	V Proton	Baikonur	* Intelsat 903	Intelsat	Communications	$75-95M
3/5/02	V Rockot	Plesetsk	GRACE 1	NASA/Deutschen Zentrum für Luft und Raumfahrt	Scientific	$12-15M
			GRACE 2	NASA/GeoForschungs Zentrum	Scientific	
3/6/02	Delta 2 7925-10	CCAFS	Navstar GPS 2R-8	Department of Defense	Navigation	$45-55M
3/8/02	Atlas 2A	CCAFS	TDRS F9	NASA	Communications	$90-105M
3/20/02	V Shtil	Barents Sea	Cosmos 1 Deployment Test 2	The Planetary Society	Development	$0.1-0.3M
3/24/02	Delta 2 7920	VAFB	Aqua	NASA	Remote Sensing	$50-60M
3/XX/02	V Ariane 5G	Kourou	* Insat 3A	Indian Space Research Organization	Communications	$150-180M
3/XX/02	Proton	Baikonur	* Express A1A	Russian Satellite Communciation Co.	Communications	$75-95M
1Q/2002	Long March 4B	Taiyuan	FSW 18	China	Meterological	$25-35M
1Q/2002	V Proton	Baikonur	* EchoStar 8	EchoStar Satellite Corp.	Communications	$75-95M
1Q/2002	Long March 4B	Taiyuan	CBERS/Ziyuan 2	China/Brazil	Remote Sensing	$25-35M
1Q/2002	V Long March 3A	Xichang	* Atlantic Bird 1	Eutelsat	Communications	$45-55M
1Q/2002	V Ariane	Kourou	* N-Star C	NTT Mobile Communications Network	Communications	N/A
1Q/2002	V Proton	Baikonur	* DirecTV 5	DirecTV, Inc.	Communications	$75-95M

V Denotes commercial launch, defined as a launch that is internationally competed or FAA licensed.
+ Denotes FAA-licensed launch.
* Denotes a commercial payload, defined as a spacecraft that serves a commercial function or is operated by a commercial entity.
L and M refer to the outcome of the Launch and Mission: S = success, P = partial success, F = failure
Note: All launch dates are based on local time at the launch site.

Second Quarter 2002 Projected Orbital Launch Events

Date		Vehicle	Site	Payload or Mission	Operator	Use	Vehicle Price
4/4/2002		Shuttle Atlantis	KSC	STS 110	NASA	Crewed	$300M
				ISS 8A	NASA	ISS	
4/10/2002		Ariane 42P	Kourou	SPOT 5	SPOT Image	Remote Sensing	$65-85M
4/XX/02	√	Ariane TBA	Kourou	* Stellat 5	France Telecom	Communications	N/A
4/XX/02	√	Dnepr 1	Baikonur	Alsat	Algerian Remote Sensing Council	Remote Sensing	$10-20M
				Kina	Surrey Satellite Technology Ltd.	Remote Sensing	
				DMC 5	Government of Thailand	Remote Sensing	
				NigeriaSat 1	Government of Nigeria	Remote Sensing	
				BNSCSat	Surrey Satellite Technology Ltd.	Remote Sensing	
4/XX/02	√	Ariane 4 TBA	Kourou	* NSS 7	New Skies Satellites N.V.	Communications	N/A
4/XX/2002		Soyuz	Baikonur	Soyuz ISS 4S	Rosaviakosmos/NASA	Crewed	$30-40M
5/2/2002		Shuttle Endeavour	KSC	STS 111	NASA	Crewed	$300M
				ISS UF-2	NASA	ISS	
5/9/2002	√ +	Atlas 5 300	CCAFS	* Hot Bird 6	Eutelsat	Communications	$85-110M
5/14/2002		Soyuz	Baikonur	Progress ISS 8P	RKK Energia/NASA	ISS	$30-40M
5/28/2002	√ +	Atlas 3A	CCAFS	* AsiaSat 4	Asia Satellite Telecommunications Co. (Asiasat)	Communications	$90-105M
5/XX/02	√	Dnepr 1	Baikonur	Yamsat 1	National Space Program Office (NSPO)	Development	$10-20M
5/XX/02	√	Ariane 5G	Kourou	* eBird 1	Eutelsat	Communications	$150-180M
5/XX/02	√ +	Zenit 3SL	Sea Launch Platform	* Galaxy 3C	Pan American Satellite Corp.	Communications	$75-95M
6/3/2002		Titan 4B/Centaur	CCAFS	NRO T4	NRO	Classified	$350-450M
6/25/2002		Titan 2	VAFB	NOAA M	NOAA	Meteorological	$30-40M
6/27/2002		Shuttle Columbia	KSC	STS 107	NASA	Crewed	$300M
				SpaceHab Research Double Module	NASA	ISS	
6/XX/02		Long March 4B	Taiyuan	Haiyang 1	State Oceanic Administration (SOA)	Remote Sensing	$25-35M
				Fengyun 1D	China Meteorological Administration	Meterological	
6/XX/02	√	Rockot	Plesetsk	* Iridium MS-TBA	Iridium LLC	Communications	$12-15M
6/XX/02	√	Ariane 5 ESC-A	Kourou	* Hot Bird 7	Eutelsat	Communications	$150-180M
6/XX/02		Delta 2 7925-10	CCAFS	Navstar GPS 2R-9	DoD	Navigation	$45-55M
				ProSEDS 2	NASA	Development	
2Q/2002	√	Ariane 5G	Kourou	* WildBlue 1	WildBlue	Communications	$150-180M
2Q/2002	√	Ariane 44L	Kourou	* Intelsat 905	Intelsat	Communications	$100-125M
2Q/2002	√	Ariane 5G	Kourou	* Astra 3A	SES Astra	Communications	$150-180M
2Q/2002	√	Proton	Baikonur	* Astra 1K	SES Astra	Communications	$75-95M

√ Denotes commercial launch, defined as a launch that is internationally competed or FAA licensed.

+ Denotes FAA-licensed launch.

* Denotes a commercial payload, defined as a spacecraft that serves a commercial function or is operated by a commercial entity.

ATTACHMENT 3

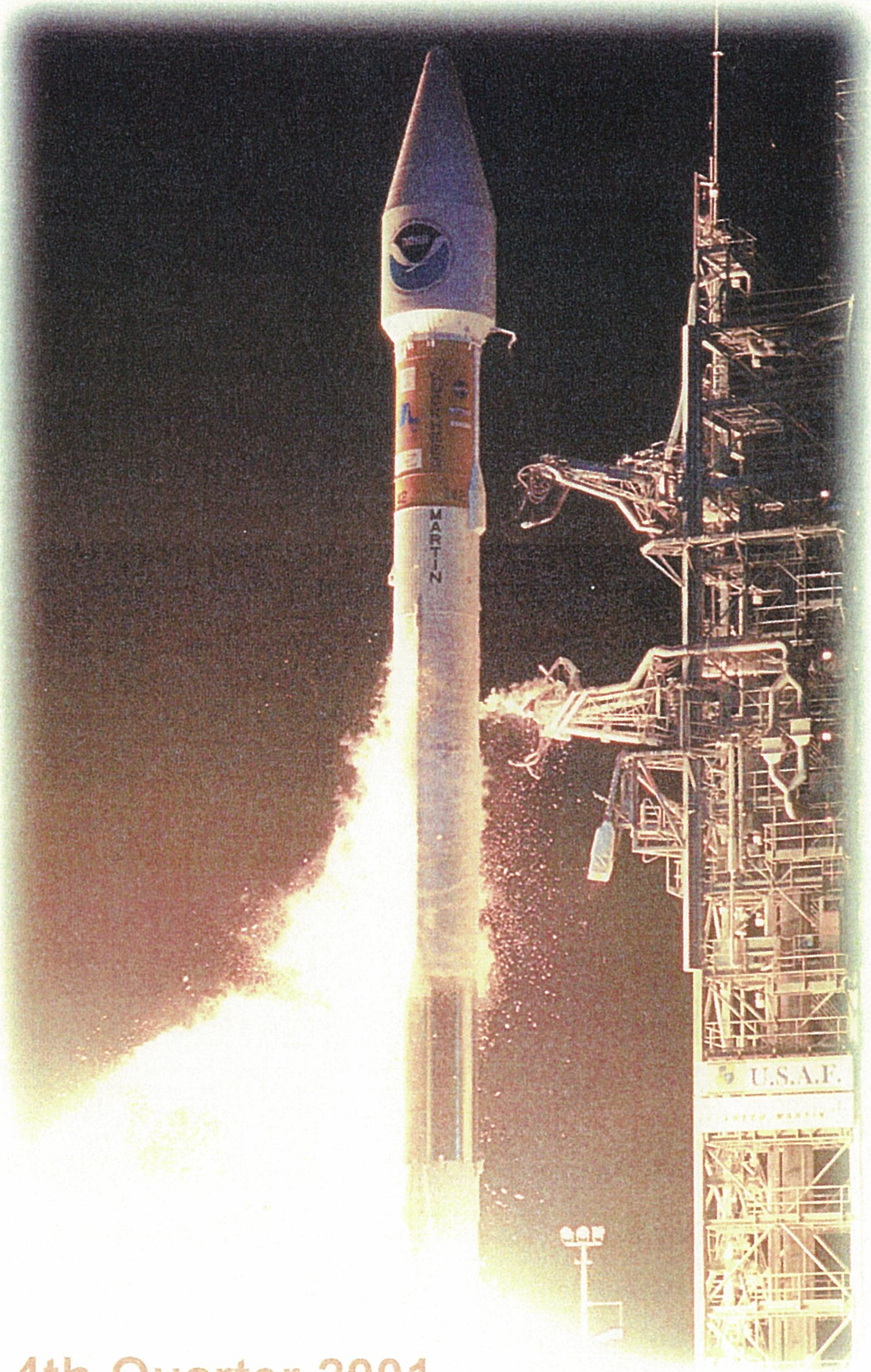
Commercial Space Transportation

QUARTERLY LAUNCH REPORT

Featuring the
launch results from
the 3rd quarter 2001
and forecasts for the
4th quarter 2001 and
1st quarter 2002

Quarterly Report Topic:

The Evolution of Commercial Launch Vehicles



4th Quarter 2001

United States Department of Transportation • Federal Aviation Administration
Associate Administrator for Commercial Space Transportation
800 Independence Ave. SW • Room 331
Washington, D.C. 20591

Introduction

The Fourth Quarter 2001 Quarterly Launch Report features launch results from the third quarter of 2001 (July-September 2001) and launch forecasts for the fourth quarter of 2001 (October-December 2001) and the first quarter of 2002 (January-March 2002). This report contains information on worldwide commercial, civil, and military orbital space launch events. Projected launches have been identified from open sources, including industry references, company manifests, periodicals, and government sources. Projected launches 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)

Contents

* Fourth quarter launch events include all launches projected for the fourth quarter as well as those projected to occur at some point in 2001 but not assigned to a specific month or quarter.

Cover: Cape Canaveral Air Force Station, Florida, July 23, 2001 - An Atlas 2A rocket successfully carries the GOES-M weather satellite into space for the National Oceanic and Atmospheric Administration. Courtesy of International Launch Services.

Third Quarter 2001 Highlights

Ariane 5 Launch Failure

On July 12, the launch of the European Space Agency's Artemis communications and navigation technology satellite and Japan's BSAT-2B commercial communications satellite failed when the Ariane 5 launch vehicle was unable to deliver them into the proper orbits. The failure was due to a malfunction in the upper stage of the booster. Arianespace officials say that a "combustion instability" during the upper stage engine's ignition reduced thrust and also led to the premature shutdown of the engine when it exhausted its propellants. BSAT-2B has been declared a loss while efforts are continuing to use Artemis' on-board thrusters to achieve a proper orbit.

Japanese Launch Vehicle Completes Successful Maiden Voyage

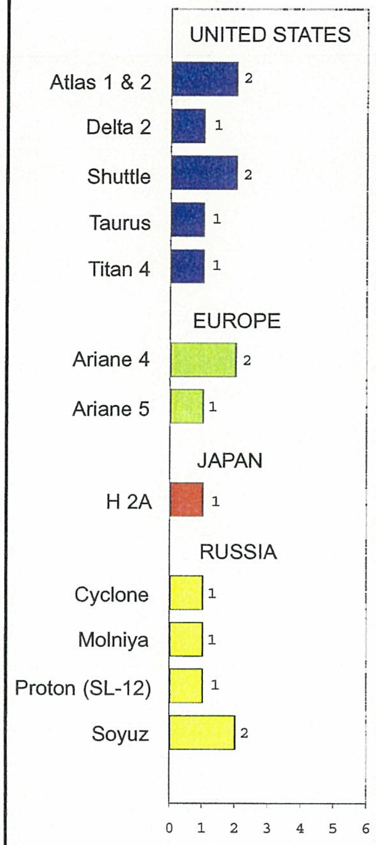
Japan's H-2A launch vehicle completed its initial flight in an August 29 launch from the Tanegashima launch site. The vehicle successfully carried the 3,000 kilogram Vehicle Evaluation Payload-2 (VEP-2), which contained sensors to measure launch vibrations and thermal conditions during flight.

Satellites Lost Due To Taurus Failure

A Taurus launch vehicle built by Orbital Sciences Corporation failed in a September 21 launch from Vandenberg AFB in California. NASA's QuikTOMS and Orbimage's OrbView 4 satellites, as well as a Celestis funerary payload, were lost when the vehicle's second stage veered off course at T+83 seconds. Though the rocket was soon brought under control, the change in course caused payload separation at an altitude too low for recovery and the launch and missions were failures.

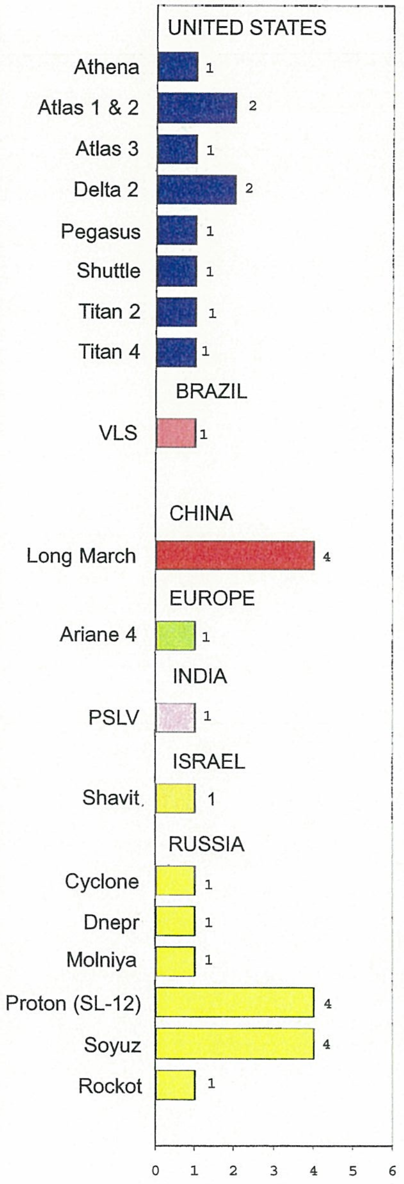
Vehicle Use
(July 2001 – March 2002)

Figure 1: Third Quarter 2001 Total Launch Vehicle Use



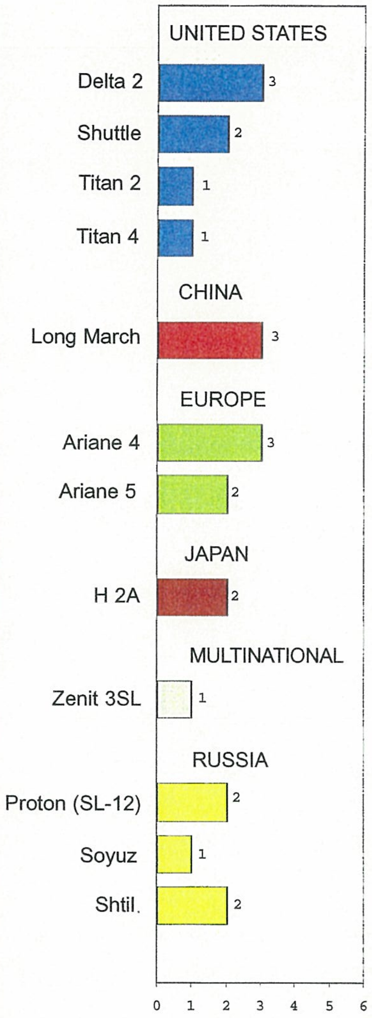
Total = 16

Figure 2: Fourth Quarter 2001 Total Projected Launch Vehicle Use



Total = 30

Figure 3: First Quarter 2002 Total Projected Launch Vehicle Use



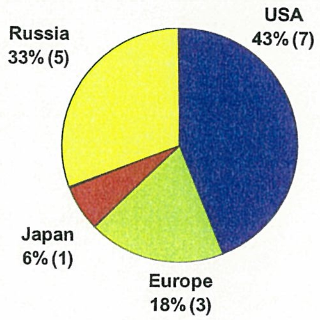
Total = 23

Figures 1-3 show the total number of orbital launches (commercial and government) of each launch vehicle that occurred in the third quarter of 2001 and that are projected for the fourth quarter of 2001 and first quarter of 2002. These launches are grouped by the country in which the primary vehicle manufacturer is based. Exceptions to this grouping are launches performed by Sea Launch, which are designated as multinational.

Total Launch Events by Country

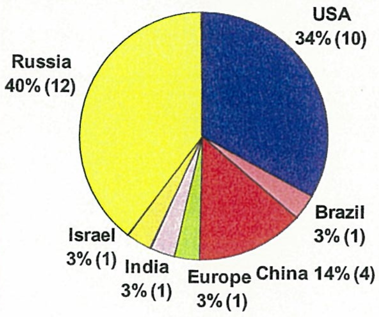
(July 2001 – March 2002)

Figure 4: Third Quarter 2001 Total Launch Events by Country



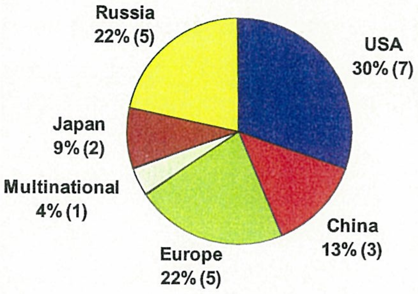
Total = 16

Figure 5: Fourth Quarter 2001 Total Projected Launch Events by Country



Total = 30

Figure 6: First Quarter 2002 Total Projected Launch Events by Country



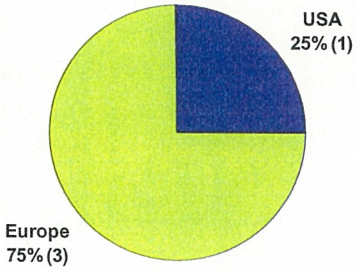
Total = 23

Figures 4-6 show all orbital launch events (commercial and government) that occurred in the third quarter of 2001 and that are projected for the fourth quarter of 2001 and first quarter of 2002.

Commercial Launch Events by Country

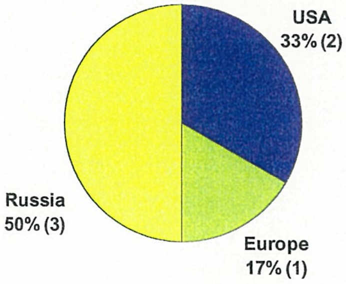
(July 2001 – March 2002)

Figure 7: Third Quarter 2001 Commercial Launch Events by Country



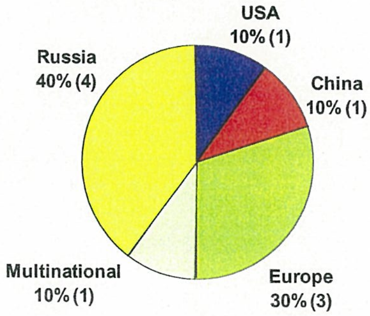
Total = 4

Figure 8: Fourth Quarter 2001 Projected Commercial Launch Events by Country



Total = 6

Figure 9: First Quarter 2002 Projected Commercial Launch Events by Country

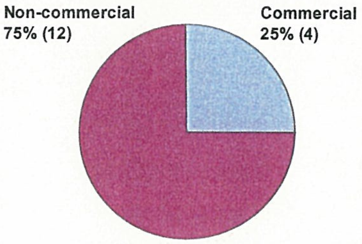


Total = 10

Figures 7-9 show all *commercial* orbital launch events that occurred in the third quarter of 2001 and that are projected for the fourth quarter of 2001 and first quarter of 2002.

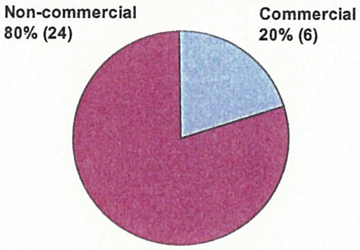
Commercial vs. Non-commercial Launch Events
(July 2001 – March 2002)

Figure 10: Third Quarter 2001 2001 Commercial vs. Non-commercial Launch Events



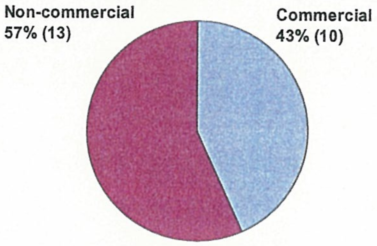
Total = 16

Figure 11: Fourth Quarter 2001 Commercial vs. Non-commercial Projected Launch Events



Total = 30

Figure 12: First Quarter 2002 Commercial vs. Non-commercial Projected Launch Events

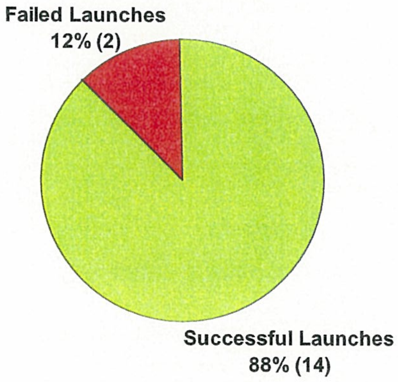


Total = 23

Figures 10-12 show commercial vs. non-commercial orbital launch events that occurred in the third quarter of 2001 and that are projected for the fourth quarter of 2001 and first quarter of 2002.

Third Quarter 2001 Launch Successes vs. Failures
(July 2001 – September 2001)

Figure 13: Total Launch Successes vs. Failures

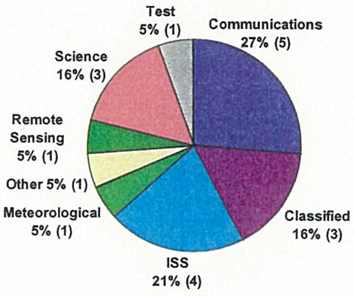


Total = 16

Figure 13 shows successful vs. failed orbital launch events that occurred in the third quarter of 2001.

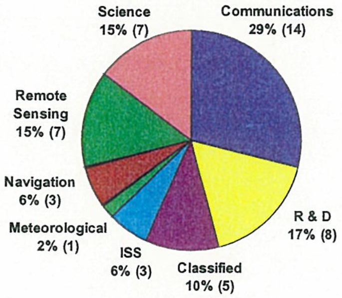
Payload Use
(July 2001 – March 2002)

Figure 14: Third Quarter 2001 Payload Use



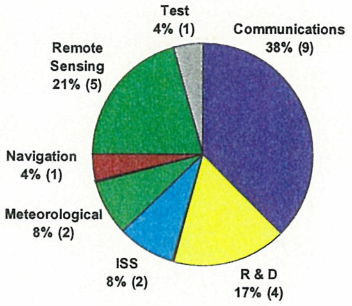
Total = 19

Figure 15: Fourth Quarter 2001 Projected Payload Use



Total = 48

Figure 16: First Quarter 2002 Projected Payload Use

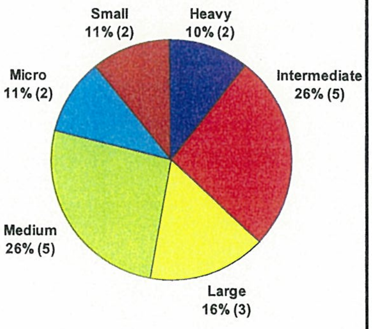


Total = 24

Figures 14-16 show total payload use (commercial and government), actual for the third quarter of 2001 and that are projected for the fourth quarter of 2001 and first quarter of 2002. The total number of payloads launched may not equal the total number of launches due to multi-manifesting, i.e., the launching of more than one payload by a single launch vehicle.

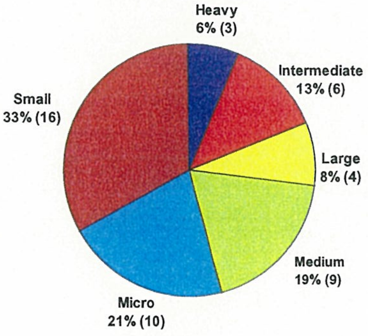
Payload Mass Class
(July 2001 – March 2002)

Figure 17: Third Quarter 2001 Payload Mass Class



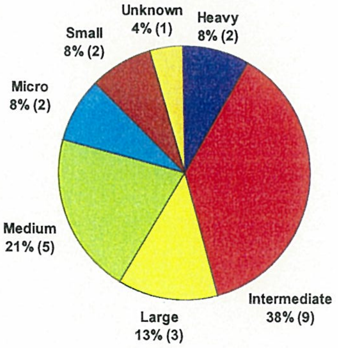
Total = 19

Figure 18: Fourth Quarter 2001 Projected Payload Mass Class



Total = 48

Figure 19: First Quarter 2002 Projected Payload Mass Class

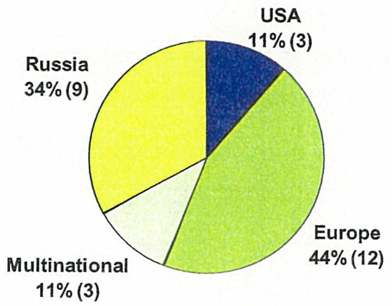


Total = 24

Figures 17-19 show total payloads by mass class (commercial and government), actual for the third quarter of 2001 and projected for the fourth quarter of 2001 and first quarter of 2002. The total number of payloads launched may not equal the total number of launches due to multi-manifesting, i.e., the launching of more than one payload by a single launch vehicle. Payload mass classes are defined as Micro: 0 to 91 kilograms (0 to 200 lbs.); Small: 92 to 907 kilograms (201 to 2,000 lbs.); Medium: 908 to 2,268 kilograms (2,001 to 5,000 lbs.); Intermediate: 2,269 to 4,536 kilograms (5,001 to 10,000 lbs.); Large: 4,537 to 9,072 kilograms (10,001 to 20,000 lbs.); and Heavy: over 9,073 kilograms (20,000 lbs.).

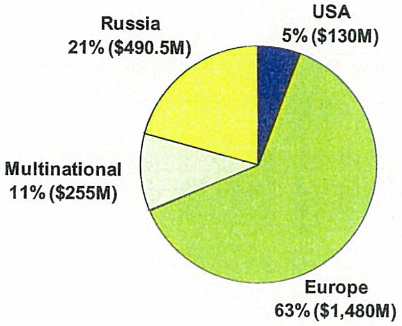
Commercial Launch Trends
(October 2000 – September 2001)

Figure 20: Commercial Launch Events, Last 12 Months



Total = 27

Figure 21: Commercial Launch Revenue, Last 12 Months



Total = $2355.5M

Figures 20 shows commercial launch events for the period October 2000 to September 2001 by country.

Figures 21 shows commercial launch revenue for the period October 2000 to September 2001 by country.

Figure 22: Commercial Launch Events by Country, Last Five Years

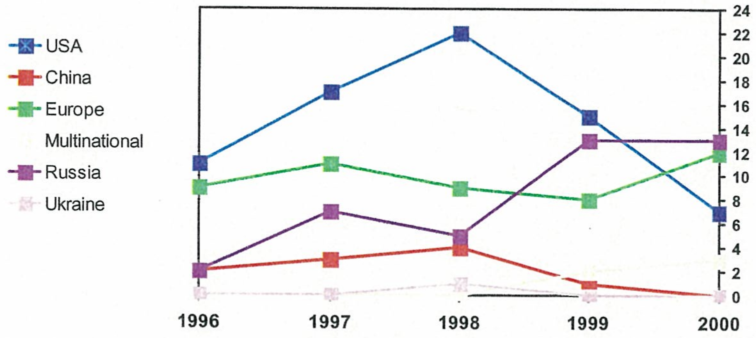


Figure 22 shows commercial launch events by country for the last five full years.

Figure 23: Commercial Launch Revenue (in $ million) by Country, Last Five Years

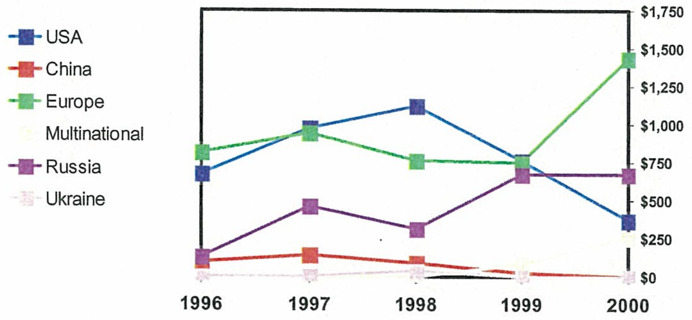


Figure 23 shows commercial launch revenue by country for the last five full years.

The Evolution of Commercial Launch Vehicles

INTRODUCTION

On February 14, 1963, a Delta launch vehicle placed the Syncom 1 communications satellite into geosynchronous orbit (GEO). Thirty-five years later, another Delta launched the Bonum 1 communications satellite to GEO. Both launches originated from Launch Complex 17, Pad B, at Cape Canaveral Air Force Station in Florida. Bonum 1 weighed 21 times as much as the earlier Syncom 1 and the Delta launch vehicle that carried it had a maximum geosynchronous transfer orbit (GTO) capacity 26.5 times greater than that of the earlier vehicle.

Launch vehicle performance continues to constantly improve, in large part to meet the demands of an increasing number of larger satellites. Current vehicles are very likely to be changed from last year's versions and are certainly not the same as ones from five years ago. In many cases this is true even though the commonly used name for a vehicle has not changed.

This report will detail vehicle performance improvements over the last four decades. Evolutionary paths will be traced for the Atlas and Delta launch vehicles. Patterns of growth and reliability of these vehicles are also examined.

Atlas and Delta vehicles, in particular, have been chosen because they were part of the original generation of U.S. launch vehicles and exhibit increased capacity with only moderate technical change from one generation to the next. Later vehicles, designed from the beginning as launch vehicles, (for instance the European Ariane series, or the Russian Proton) have not undergone the same degree of evolution and, hence, are less interesting for this study.

LAUNCH VEHICLE ORIGINS

The initial development of launch vehicles was an arduous and expensive process that occurred simultaneously with military weapons programs; launch vehicle and missile developers shared a large portion of the expenses and technology. The initial generation of operational launch vehicles in both the United States and the Soviet Union was derived and developed from the operating country's military ballistic missile programs. The Russian Soyuz launch vehicle is a derivative of the first Soviet intercontinental ballistic missile (ICBM) and the NATO-designated SS-6 Sapwood. The United States' Atlas and Titan launch vehicles were developed from U.S. Air Force's first two ICBMs of the same names, while the initial Delta (referred to in its earliest versions as Thor Delta) was developed from the Thor intermediate range ballistic missile (IRBM) coupled with the upper stages of the unsuccessful Vanguard launch vehicle (the first launch vehicle developed as a launch vehicle from the start).

This evolution followed the pattern set by the development of the atmospheric sounding rocket, the use of which was pioneered when the U.S. Army launched German-built V-2s after World War II. In this program, scientists were offered the chance to place scientific instruments in V-2s that were to be launched for weapons development reasons. As the explosive warheads had been removed from the missiles, increased room and lifting capacity allowed for scientific and weapons research on the same flights.

LAUNCH VEHICLES VS. BALLISTIC MISSILES

The most basic difference between launch vehicles and ballistic missiles is that launch vehicles have the ability to modify their trajectories once they achieve orbital velocities. While a ballistic missile may have the ability to achieve an orbital velocity, it cannot change its path to circle the Earth instead of following a parabola that returns it (regardless of its speed) to the Earth because it does not have the additional propulsion capacity to change its path once it reaches orbital speed and altitude (see Figure 1 for a visual depiction of the difference).

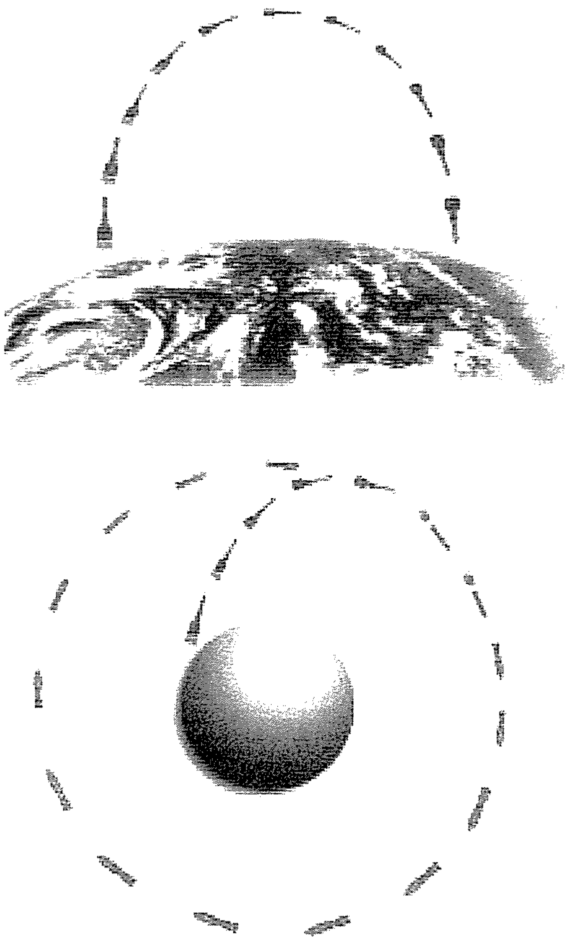


Figure 1. Ballistic Missile Parabola (top) vs. Launch Vehicle Orbital Path (bottom)

Due to these considerations, the first step in modifying a ballistic missile to fill a launch vehicle role is to give it an upper-stage maneuvering capability. In the case of the Thor Delta, this was achieved by the addition of the Vanguard launch vehicle's upper stages to the Thor IRBM that served as the Thor Delta launch vehicle's first stage. In the case of the Atlas, new hardware was developed to allow the payload to achieve a stable orbit (although the Atlas Able also used Vanguard stages).

These early launch vehicles had the capacity to lift a payload to low Earth orbit (LEO). As time progressed, however, the desire to place satellites into higher orbits such as GEO became more prevalent. Additional systems to increase capacity from that of a ballistic missile or a LEO-capable launcher became necessary. Launch vehicles were soon given an extra upper stage to place payloads into GEO orbits.

ATLAS VEHICLE EVOLUTION

As described in the previous section, the first step in the evolution of launch vehicles was the addition of stages that allowed missiles to perform a launch vehicle role. Following this basic modification, a continuing series of major and minor modifications occurred that increasingly optimized the vehicle for its role as a launch vehicle. First government and then industry (after the Challenger accident) incrementally increased the launch capacity of the Atlas launch vehicle (Figure 2 and Table 1show the evolution of Atlas GEO capable vehicles).

For the Atlas launch vehicle, the first major change following its introduction in 1958 (an Atlas B carrying the world's first communications satellite for Project SCORE) was the ability to release its payload. The initial SCORE payload remained attached to the launch vehicle while the Mercury capsule that was the Atlas' next payload was able to detach from the launch vehicle upon reaching orbit. The use of the Atlas as a crew-rated vehicle also involved structural enhancements to the Atlas D ICBM-based launch vehicle. The first Atlas capable of launches to GEO was the 1959 Atlas Able, which married the Atlas ICBM with an upper stage based on Vanguard's second stage. This combination was not a success, however, failing in four out of four launch attempts.

The Atlas D ICBM was the basis of almost all early Atlas launch vehicles. In its space launch version, the Atlas D was referred to as the Atlas LV-3 (standing for launch vehicle 3). The LV-3A was an Atlas D with an Agena upper stage, the LV-3B carried the Mercury spacecraft, and the LV-3C used the Centaur upper stage. Unfortunately, as each launch vehicle was individually converted from an ICBM, the LV-3 was not an optimal vehicle. Large-scale missile production was cheap but converting ICBMs to launch vehicles was a lengthy and cumbersome process. As a result, in 1962 the Air Force awarded General Dynamics a contract to resolve this problem and develop a standardized Atlas D-based launch vehicle. The SLV-3 (standardized launch vehicle, as this vehicle was designated) was a more reliable, standardized version of the Atlas D ICBM with three Rocketdyne MA-3 engines (with a total of 1725 kN thrust), replacing the original three Rocketdyne MA-2 engines (with a total of 1630 kN thrust).

In 1965 General Dynamics received a further Air Force contract to improve the Atlas SLV-3 by lengthening the vehicle to increase its fuel load, reducing overall vehicle weight, and replacing the engines with Rocketdyne MA-5 engines (1950 kN total thrust). This program resulted in the SLV-3A and SLV-3C. These versions differed in the method of engine cut-off and choice of upper stage. The Atlas SLV-3A used a radio-controlled engine cut-off and an Agena upper stage. The Atlas SLV-3C used a Centaur upper stage with engine cut-off caused by fuel depletion.

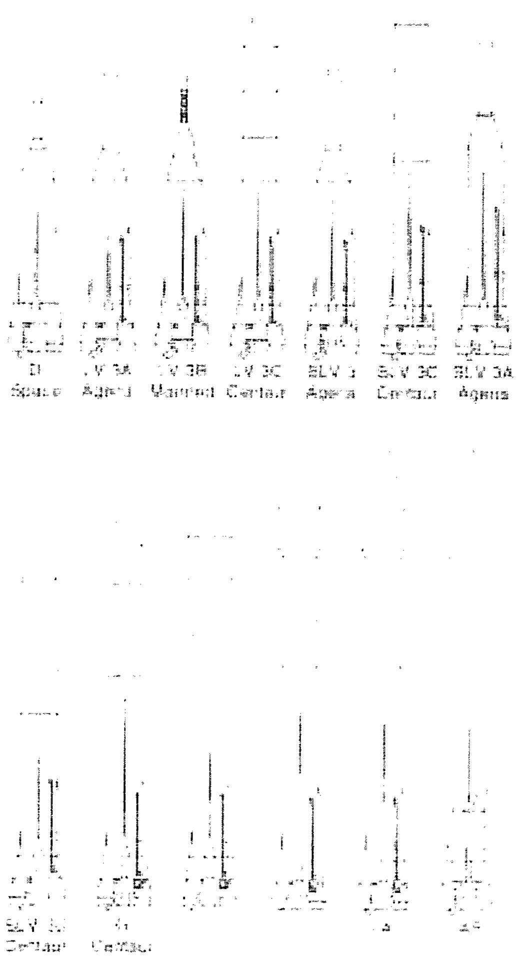


Figure 2. Atlas Launch Vehicle Evolution

The Agena upper stage's development ended with the SLV-3A, but the success of the SLV-3C with its Centaur upper stage led to an evolution into the SLV-3D. This vehicle used the Centaur's autopilot and guidance systems to control the entire vehicle unlike previous vehicles, which used Atlas-based control systems for the initial part of the launch and then transferred control to the Centaur upper stage to complete the mission.

The final government-initiated version of the Atlas was the Atlas G, which was first launched in 1984. As with the previous SLV-

3D, the Atlas was once again lengthened to increase fuel capacity and received improved versions of the MA-5 engines.

The Atlas G led directly to the commercial Atlas vehicle program initiated by General Dynamics in 1987 after the destruction of the Space Shuttle Challenger, previous to which government-funded production had been canceled. For the first time, Atlas vehicles were built with no assured government customer. These first commercial Atlas launch vehicles (dubbed Atlas 1) were very similar to the Atlas G but offered two new payload fairings and were entirely funded by General Dynamics. The first Atlas 1 was launched in 1990.

The Atlas 1 was followed in 1991 by the Atlas 2, which was originally developed to launch Air Force Defense Satellite Communications System satellites under the Medium Launch Vehicle (MLV) 2 contract. The Atlas 2 uses upgraded Rocketdyne MA-5A engines (2155 kN thrust), a lengthened booster for greater fuel capacity, improved structures, a new stabilization system, and a lengthened Centaur upper stage to provide more fuel and hence better upper-stage performance.

The final versions of the Atlas 2 series, the Atlas 2A (1992) and the Atlas 2AS (1993), differ from the Atlas 2 by having more powerful Pratt & Whitney RL-10 engines in the Centaur upper stage. In the case of the 2AS, four Thiokol Castor 4A solid rocket motors add an additional 173.6 kN of thrust to the first stage of the vehicle. Following these modifications, Lockheed Martin (the current owner of the Atlas line) replaced the three Rocketdyne engines with a single, more powerful, NPO Energomash / Pratt & Whitney RD-180 engine.

With the Atlas 3, the slow incremental process that characterized the development of previous Atlas vehicles was replaced by a more revolutionary approach. The Atlas 3 represents an initial effort to reduce vehicle complexity while increasing performance. This model uses improved first-stage fuel tank construction, contains less-complicated components and increases overall launch vehicle performance. As an example, the Atlas 3's first stage thrust section undergoes only one staging event and the engine is supplied by only seven fluid interfaces. By contrast, previous Atlas models had up to six staging events and 17 fluid interfaces.

New and improved versions of the Centaur Upper Stage were also introduced on the Atlas 3 series. The Centaur Upper Stage used by the Atlas 3A uses a single engine. The removal of one RL10A-4-1 engine and the centering of the remaining engine along the Centaur's axis differentiate it from earlier Centaur versions. The upper stage for the Atlas 3B is a lengthened version of the Centaur outfitted with two RL10A-4-2 engines. These engines include upgrades (such as chiller modifications and a health monitoring system) designed to increase reliability and operational standards. Both the single-engine Centaur and the lengthened Centaur with dual RL10A-4-2 engines will be used on the Atlas 3 series as well as on the Atlas 5 series.

Built under the U.S. Air Force's Evolved Expendable Launch Vehicle (EELV) program with funding from both the Air Force and Lockheed Martin, the Atlas 5 will continue the trend of radical change toward bigger, more capable launch vehicles initiated with the Atlas 3. The Atlas 3 will provide valuable experience needed for Atlas 5 production and operation and, once the Atlas 5 is operational, the Atlas 3 will be phased out. More than twice the weight of Atlas 3, Atlas 5 will be able to carry twice the payload mass. The Atlas 5 will have approximately 125 potential single point failures, as opposed to over 250 for the Atlas 2AS, will be able to launch in higher wind conditions,

Vehicle	Intro Year	Vehicle Weight (kg)	GTO Performance (kg)
Atlas B	1958	110740	N/A
Atlas Able	1959	120051	250
Atlas D	1959	117730	N/A
Atlas LV-3B Mercury	1959	116100	N/A
Atlas LV-3A/Agena	1960	123990	800
Atlas LV-3C/Centaur	1962	136124	1800
Atlas SLV-3/Agena	1964	N/A	N/A
Atlas SLV-3C/Centaur	1967	148404	1800
Atlas SLV-3A/Agena	1968	N/A	700
Atlas SLV-3D/Centaur	1972	148404	1900
Atlas G/Centaur	1984	166140	2255
Atlas 1	1990	164300	2255
Atlas 2	1991	187600	2810
Atlas 2A	1992	185427	3039
Atlas 2AS	1993	233750	3630
Atlas 3A	2000	220672	4055
Atlas 3B	2001	225392	4500
Atlas 5 (551)	2002	540340	8200

Table 1: Evolution of Atlas Mass and GTO Payload Capacity

and will dispense with the pressure-stabilized fuel tanks used on all previous Atlas vehicles. Unlike its predecessors, the Atlas 5 will be able to stand under the weight of its payload without being fully fueled because it will have structurally-stable booster propellant tanks. By contrast, previous Atlas vehicles used the pressure of the fuel in their tanks to bear part of the load of the payload.

DELTA VEHICLE EVOLUTION

The Delta launch vehicle was initially adapted from an IRBM by Douglas Aircraft Company for the U.S. Air Force. In April 1959, NASA's Goddard Space Flight Center contracted with Douglas to create a civilian launch vehicle based on the Air Force's Thor-Able vehicle. Douglas (later as McDonnell Douglas) continued to produce Delta vehicles for the U.S. Government until production was ended in 1984 due to the U.S. policy decision to launch all payloads on the Space Shuttle. Following the Challenger accident, production was restarted as a commercial venture with the vehicle called the Delta 2. McDonnell Douglas captured the U.S. Air Force's MLV-1 contract with this vehicle in 1987 and then offered the Delta 2 on the commercial market.

Between Delta's first flight in 1960 and today's Delta 2 vehicles the Delta launch vehicle has gone through a set of evolutions similar to that of the Atlas vehicle. Extensive changes have been made that have resulted in substantially greater capacity (see Figure 3 and Table 2). During this period, the Delta's first stage has received five different engines and has been lengthened twice to increase propellant mass. The second stage has had five different engines and has also been lengthened twice to increase propellant mass. The third stage has seen seven engine changes and overall, the Delta vehicle has received two avionics upgrades, four increasingly large fairings, and two sets of strap-on solid rocket motors.

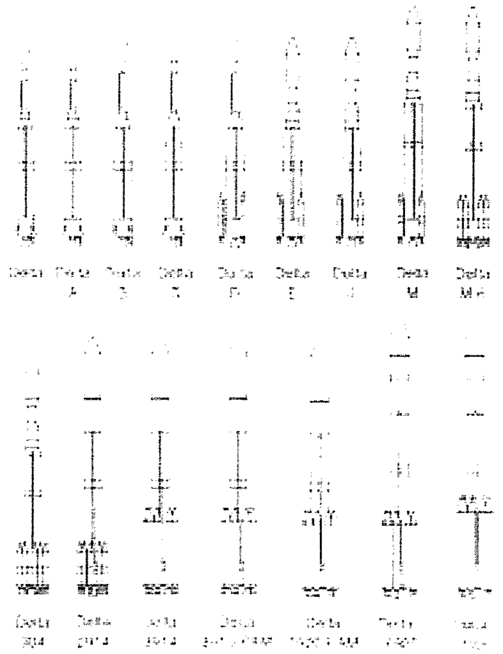


Figure 3. Delta Launch Vehicle Evolution

Following the slow evolution of the Thor to the Delta and then to the Delta 2, there has been a more radical improvement with the development of the Delta 3 and then the Delta 4 EELV. The Delta 3 has a larger diameter first-stage fuel tank than Delta 2 and uses nine solid fuel graphite-epoxy motors derived from those on Delta 2 but with 25 percent more thrust. The Delta 3's second stage carries more propellant than Delta 2 and burns cryogenic fuels, which produce more energy than those used by the Delta 2, allowing it to launch heavier payloads.

The Delta 4 involves even more improvements. It consists of a new "common booster core" first stage using the new Rocketdyne RS-68 engine. This engine has 95 percent fewer parts than the Space Shuttle Main Engine (which is a comparable engine in terms of thrust) and requires only 8,000 hours of touch labor, compared with 171,000 hours for the Shuttle engine. It is supplemented by solid fuel graphite-epoxy motors, two types of upper stages, and three payload fairings depending on customer needs. A heavy lift version will also be available and will involve a combination of three core boosters with an upper stage and larger fairing. Boeing offers five different versions of the Delta 4 addressing a broad range of payload mass classes. Like the Atlas 3 and Atlas 5, the Delta 4 will replace the Delta 3 once it is introduced into service over the next few years.

LAUNCH VEHICLE GROWTH TRENDS

As can be seen from the development of the Atlas and Delta launch vehicles, the tendency in launch vehicle development has been for vehicles to grow in capacity and, hence, in size. Although micro-satellites have been developed, the tendency has been to produce larger, more capable commercial satellites rather than to stabilize or reduce satellite size. Thus, there is a continuous interplay between satellite and launch vehicle size. Neither set of designers wishes to exceed the other's needs or capabilities, but both seek to use greater capacity as a selling point. No signs at this point indicate that either satellite or launch vehicle growth has reached its end (although it is possible to get too far ahead of the market and suffer accordingly, as the failure of the commercial Titan 3 demonstrated).

A case that proves this is that of the Delta Lite launch vehicle sought by NASA under its Med Lite launch vehicle contract in the mid-1990s. This program was intended to produce a lower-priced version of the Delta launch vehicle by reducing its payload size and payload capacity. Ultimately, McDonnell Douglas determined that there was insufficient market demand for such a vehicle and chose to provide NASA with launches on larger Delta variants rather than pay to develop the Delta Lite for the limited number of launches planned under the Med Lite launch procurement contract.

Vehicle	Intro Year	Vehicle Weight (kg)	GTO Performance (kg)
Thor	1957	49340	N/A
Thor Able	1958	51608	N/A
Thor Agena A	1959	53130	N/A
Thor Able-Star	1960	53000	N/A
Thor Agena B	1960	56507	N/A
Delta	1960	52442	45
Delta A	1962	51555	68
Delta B	1962	51984	68
Delta C	1963	52004	82
Delta D	1964	64679	104
Delta E	1965	69023	150
Delta J	1968	69497	263
Delta M	1968	89881	356
Delta M-6	1969	N/A	454
Delta 904	1971	N/A	635
Delta 2914	1972	130392	724
Delta 3914	1975	190799	954
Delta 3910/PAM	1980	191633	1156
Delta 3920/PAM	1982	190721	1270
Delta 4920	1989	200740	1270
Delta 5920	1989	201580	1360
Delta 2 6925	1990	217920	1447
Delta 2 7925	1990	229724	1820
Delta 3	1998	301450	3810
Delta 4 Medium	2002	249500	5845
Delta 4 Medium-Plus (4,2)	2002	N/A	4640
Delta 4 Medium-Plus (5,2)	2002	N/A	4640
Delta 4 Medium-Plus (5,4)	2002	N/A	6565
Delta 4 Heavy	2002	733400	13130

Table 2: Evolution of Delta Mass and GTO Payload Capacity

Also interesting to note is that this phenomenon of vehicle growth does not seem to be dependent on the country or company developing the vehicle. Table 3 shows the growth in payload capacity of selected Russian and European launch vehicle families over the course of their development.

VEHICLE RELIABILITY

Over time, reliability has improved for both the Delta and Atlas vehicles. The Atlas vehicle's cumulative reliability has ranged from a low of 29 percent after seven launches in 1960 to the current level of 87 percent first achieved in 1997 (see Figure 4). Delta's cumulative reliability has improved from a low of 91 percent after 23 launches in 1965 to 97 percent since 1998 (see Figure 5).

CONCLUSION

Launch vehicles are have tended to become increasingly capable over time. It is clear that both capacity and reliability can be increased considerably if the demand for greater capability remains and resources are directed towards those ends. The Delta 4

Initial Vehicle	GTO Capacity (kg)	Intro Year	Current Vehicle	GTO Capacity (kg)	Intro Year	Increase in GTO Capacity
Ariane 1	1,850	1979	Ariane 44L	4,520	1989	144%
Sputnik (LEO)	1,300	1957	Soyuz (LEO)	7,000	1963	438%
Proton (SL-8, LEO)	12,200	1965	Proton SL-12 (LEO is SL-13)	20,900	1967	71%

Table 3. Launch Capacity Growth in Vehicles Worldwide

and Atlas 5 are particular examples of how much vehicles can grow if their development is sustained. While the availability of resources and demand for launch services cannot be guaranteed at any given time in the future, one thing is clear: later versions of a launch vehicle, possessing the operational understanding and technological refinement that are developed over time, are likely to be far more capable and less risky than their familial predecessors.

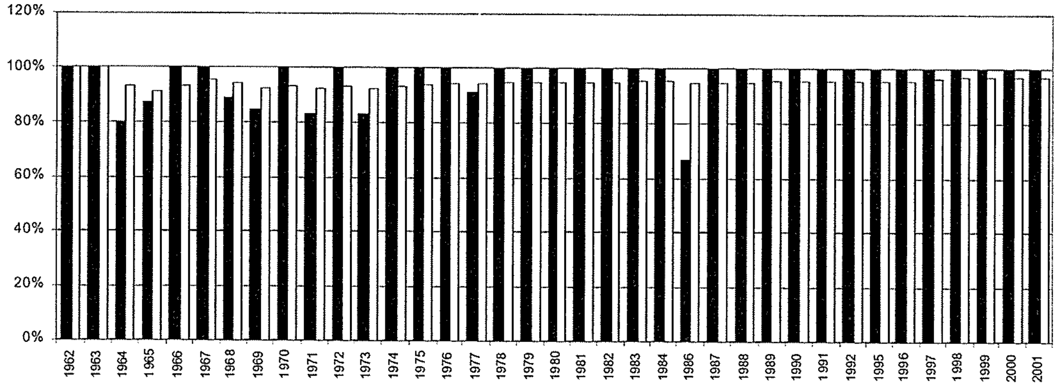


Figure 4. Atlas Launch Vehicle Reliability

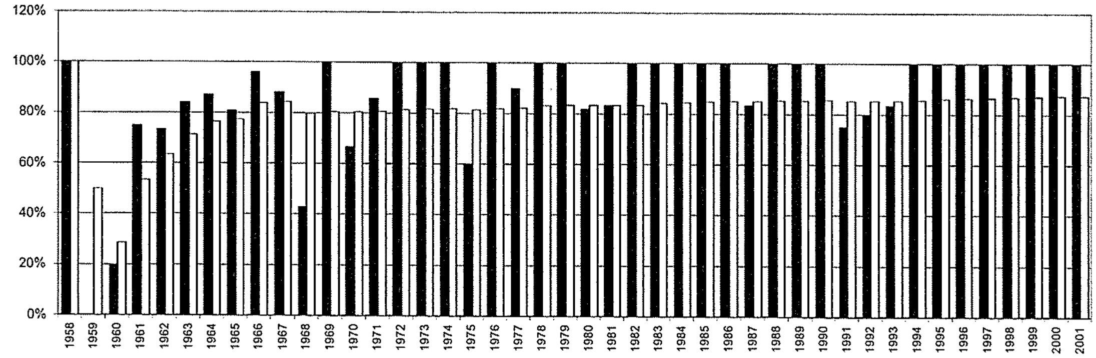


Figure 5. Delta Launch Vehicle Reliability

Third Quarter 2001 Orbital Launch Events

Date	Vehicle	Site	Payload or Mission	Operator	Use	Vehicle Price	L	M
7/12/01	Shuttle Atlantis	KSC	ISS 7A	NASA	ISS	$300M	S	S
			STS 104	NASA	Crewed			
7/12/01 √	Ariane 5 G	Kourou	* ARTEMIS	European Space Agency	Communications	$150-180M	F	P
			* BSat 2B	Broadcasting Satellite System Corp.	Communications			
7/20/01	Molniya	Plesetsk	Molniya 3K	Russian Ministry of Defense	Communications	$30-40M	S	S
7/23/01	Atlas 2AS	CCAFS	GOES 12	NOAA	Meteorological	$90-105M	S	S
7/31/01	Cyclone 3	Plesetsk	Coronas F	Izmiran and Lebedev Physical Institute	Scientific	$45-55M	S	S
8/6/01	Titan 4B/IUS	CCAFS	DSP 21	USAF	Classified	$350-450M	S	S
8/8/01	Delta 2 7326-10	CCAFS	Genesis	NASA/ JPL	Scientific	$45-55M	S	S
8/10/01	Shuttle Discovery	KSC	ISS 7A.1	NASA	ISS	$300M	S	S
			STS 105	NASA	Crewed			
8/21/01	Soyuz	Baikonur	Progress ISS 5P	Russian Space Agency	ISS	$30-40M	S	S
8/24/01	Proton (SL-12)	Baikonur	Kosmos 2379	Russian Ministry of Defense	Classified	$75-95M	S	S
8/29/01	H 2A 202	Tanegashima	Vehicle Evaluation Payload 2	Japanese National Space Development Agency	Test	$75-95M	S	S
8/30/01 √	Ariane 44L	Kourou	* Intelsat 902	Intelsat	Communications	$100-125M	S	S
9/8/01	Atlas 2AS	VAFB	NRO A1	NRO	Classified	$90-105M	S	S
9/15/01	Soyuz	Baikonur	Pirs	Russian Space Agency	ISS	$30-40M	S	S
9/21/01 √	+ Taurus 1	VAFB	* OrbView 4	Orbital Imaging Corp.	Remote Sensing	$18-20M	F	F
			QuikTOMS	NASA	Scientific			
			* Celestis 4	Celestis, Inc.	Other			
9/25/01 √	Ariane 44P	Kourou	* Atlantic Bird 2	Eutelsat	Communications	$80-100M	S	S

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L and M refer to the outcome of the Launch and Mission: S = success, P = partial success, F = failure

Fourth Quarter 2001 Projected Orbital Launch Events

Date	Vehicle	Site	Payload or Misson	Operator	Use	Vehicle Price
10/1/01	Athena 1	Kodiak Launch Complex	PICOSAT 1	USAF	Development	$16-17M
			PCSat	US Naval Academy	Communications	
			SAPPHIRE	Stanford University	Scientific	
			Starshine 3	NASA	Scientific	
10/5/01	Titan 4B	VAFB	NRO T3	NRO	Classified	$350-450M
10/6/01	Proton (SL-12)	Baikonur	Kosmos 2380	Russian Ministry of Defense	Classified	$75-95M
10/10/01	Atlas 2AS	CCAFS	NRO A2	NRO	Classified	$90-105M
10/11/01	Molniya	Plesetsk	Molniya TBA	Russian Ministry of Defense	Communications	$30-40M
10/18/01 √	+ Delta 2 7320	VAFB	* QuickBird 2	Digital Globe	Remote Sensing	$45-55M
10/21/01	Soyuz	Baikonur	Soyuz ISS 3S	NASA	ISS	$30-40M
10/XX/01	PSLV	Sriharikota Range (SHAR)	TES	Indian Space Research Organization	Remote Sensing	$15-25M
			PROBA	European Space Agency	Scientific	
			BIRD	Deutschen Zentrum für Luft- und Raumfahrt	Development	
10/XX/01	Long March 2F	Jiuquan	Shenzhou 3	Chinese National Space Administration	Development	N/A
10/XX/01	Soyuz	Baikonur	Kosmos 2381	Russian Ministry of Defense	Classified	$30-40M
11/13/01	Atlas 2A	CCAFS	TDRS F9	NASA	Communications	$90-105M
11/14/01	Soyuz	Baikonur	Progress ISS 6P	Russian Space Agency	ISS	$30-40M
11/14/01	Titan 2	VAFB	DMSP 5D-3-F16	USAF	Meteorological	$30-40M
11/15/01 √	Dnepr 1	Svobodny	Unisat 2	Agenzia Spaziale Italiana	Development	$10-20M
			Tropnet 1	One Stop Satellite Solutions	Development	
			Tropnet 2	One Stop Satellite Solutions	Development	
			Tropnet 3	One Stop Satellite Solutions	Development	
11/19/01	Proton (SL-12)	Baikonur	Glonass M R1	Russian Ministry of Defense	Navigation	$75-95M
			Glonass M R3	Russian Ministry of Defense	Navigation	
			Glonass M R2	Russian Ministry of Defense	Navigation	
11/26/01 √	Proton (SL-12)	Baikonur	* Intelsat 903	Intelsat	Communications	$75-95M
11/27/01 √	Ariane 4 TBA	Kourou	* DirecTV 4S	DirecTV, Inc.	Communications	N/A
11/29/01	Shuttle Endeavour	KSC	ISS UF-1	NASA	ISS	$300M
			STS 108	NASA	Crewed	
11/30/01	Rockot	Plesetsk	GRACE 1	NASA/Deutschen Zentrum für Luft- und Raumfahrt	Scientific	$12-15M
			GRACE 2	NASA/GFZ (Germany)	Scientific	

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Fourth Quarter 2001 Projected Orbital Launch Events

Date	Vehicle	Site	Payload or Misson	Operator	Use	Vehicle Price
11/XX/01	Pegasus XL	CCAFS	HESSI	NASA	Scientific	$12-15M
12/7/01	Delta 2 7920	VAFB	TIMED	NASA	Scientific	$50-60M
			Jason 1	NASA/Centre Nationale d' Etudes Saptiale	Remote Sensing	
12/19/01	√ + Atlas 3B	CCAFS	* EchoStar 7	EchoStar Satellite Corp.	Communications	$90-105M
4th Quarter	Long March TBA	TBA	OlympicSat 1	China	Development	N/A
			OlympicSat 2	China	Remote Sensing	
4th Quarter	Shavit 1	Palmachim AFB	Ofeq 5	Israel Space Agency	Classified	$10-15M
4th Quarter	Cyclone 3	Plesetsk	Gonets D1 7	Russian Space Agency	Communications	$45-55M
			Gonets D1 8	Russian Space Agency	Communications	
			Gonets D1 9	Russian Space Agency	Communications	
			Kosmos TBA 2	Russian Ministry of Defense	Communications	
			Kosmos TBA 3	Russian Ministry of Defense	Communications	
			Kosmos TBA 4	Russian Ministry of Defense	Communications	
2001	√ Proton (SL-12)	Baikonur	* DirecTV 5	DirecTV, Inc.	Communications	$75-95M
2001	VLS	Alcantara	SCD 3	Instituto Nacional de Pesquisas Espaciais	Remote Sensing	$6-7M
2001	Long March 1D	Jiuquan	Tansuo 1	China	Remote Sensing	$10-15M
2001	Long March TBA	Taiyuan	Chuang Xing 1	Chinese Academy of Sciences	Communications	$25-35M
2001	Soyuz	Plesetsk	Resurs F2	Russian Space Agency	Remote Sensing	$30-40M

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First Quarter 2002 Projected Orbital Launch Events

Date	Vehicle	Site	Payload or Mission	Operator	Use	Vehicle Price
1/14/02	Titan 4B/Centaur	CCAFS	Milstar F5	USAF	Communications	$350-450M
1/17/02	Shuttle Columbia	KSC	Hubble Servicing Mission 3B	NASA	Development	$300M
			STS 109	NASA	Crewed	
1/XX/02	√ Ariane 4 TBA	Kourou	* NSS 7	New Skies Satellites N.V.	Communications	N/A
1/XX/02	Ariane 5 G	Kourou	ENVISAT 1	European Space Agency	Remote Sensing	$150-180M
2/8/02	√ + Delta 2 7920	VAFB	* Iridium MS-12	Iridium LLC	Communications	$50-60M
2/15/02	Soyuz	Baikonur	Progress ISS 7P	Russian Space Agency	ISS	$30-40M
2/28/02	Shuttle Atlantis	KSC	ISS 8A	NASA	ISS	$300M
			STS 110	NASA	Crewed	
2/XX/02	√ Ariane 5 G	Kourou	* Astra 3A	SES Astra	Communications	$150-180M
3/6/02	Delta 2 7925-10	CCAFS	Navstar GPS 2R-8	USAF	Navigation	$45-55M
3/15/02	Ariane 42P	Kourou	SPOT 5	SPOT Image	Remote Sensing	$65-85M
3/21/02	Titan 2	VAFB	NOAA M	NOAA	Meteorological	$30-40M
3/24/02	Delta 2 7920	VAFB	Aqua	NASA	Remote Sensing	$50-60M
3/XX/02	√ Proton (SL-12)	Baikonur	Express A2A	Russian Satellite Communciation Co.	Communications	$75-95M
3/XX/02	√ Ariane 44L	Kourou	* Intelsat 904	Intelsat	Communications	$100-125M
1st Quarter	H 2A 202	Tanegashima	ADEOS 2	Japanese National Space Development Agency	Remote Sensing	$75-95M
1st Quarter	√ + Zenit 3SL	Sea Launch Platform	* Galaxy 3C	Pan American Satellite Corp.	Communications	$75-95M
1st Quarter	√ Shtil	Barents Sea	Cosmos 1 Deployment Test 2	The Planetary Society	Development	$0.1-0.3M
1st Quarter	√ Shtil	Barents Sea	Cosmos 1	The Planetary Society	Development	$0.1-0.3M
1st Quarter	Long March 4B	Taiyuan	FSW 18	China	Meteorological	$25-35M
1st Quarter	√ Proton (SL-12)	Baikonur	* EchoStar 8	EchoStar Satellite Corp.	Communications	$75-95M
1st Quarter	Long March 4B	Taiyuan	CBERS/Ziyuan 2	China/Instituto Nacional de Pesquisas Espaciais	Remote Sensing	$25-35M
1st Quarter	√ Long March 3A	Xichang	* Atlantic Bird 1	Eutelsat	Communications	$45-55M
1st Quarter	H 2A 202	Tanegashima	MDS 1	Japanese National Space Development Agency	Development	$75-95M
			Vehicle Evaluation Payload 3	Japanese National Space Development Agency	Test	

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ATTACHMENT 4

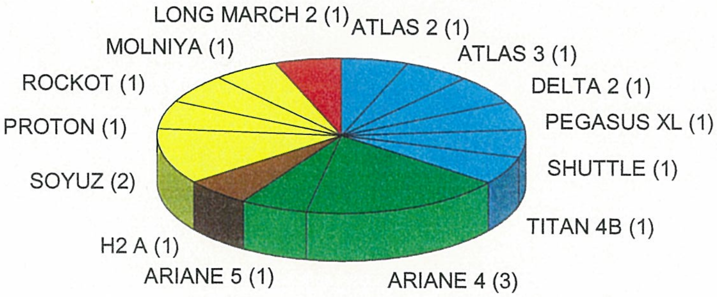
Futron Launch Report

April 2002

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
March 20 – May 1			20	21 🟨 Baikonur Progress ISS 7P (ISS) Soyuz ✓	22	23
24	25 🟥 Jiuquan Shenzhou 3 (Development) Long March 2F ✓	26	27	28 🟩 C Kourou Astra 3A, JCSAT 8 Ariane 44L ✓	29	30 🟨 C Baikonur Intelsat 903 (Comm.) Proton ✓
31	1	2 🟨 Plesetsk Kosmos 2388 (Military) Molniya ✓	3	4 🟦 KSC ISS 8A (ISS) Shuttle Atlantis	5	6
7	8	9	10	11	12	13
14	15	16 🟩 C Kourou NSS 7 (Comm.) Ariane 44L	17	18	19	20
21	22	23	24	25 🟨 Baikonur Soyuz ISS 4S (ISS) Soyuz	26 🟦 VAFB Aqua (Rem. Sens.) Delta 2 (7920)	27
28 🟨 C Baikonur DirecTV 5 (Comm.) Proton	29	30	1			

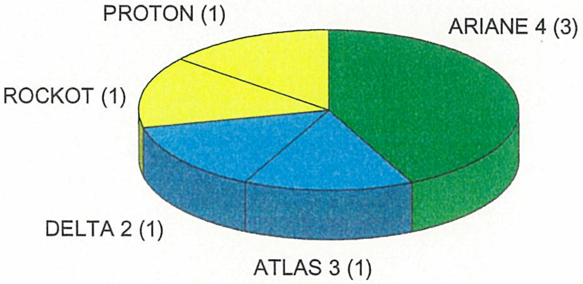
Legend: 🟦 USA 🟨 Russia 🟩 Europe 🟥 China ✓ Success ☒ Failure C Commercial

2002 Total Launches by Launch Vehicle Family



Total: 17

2002 Commercial Launches by Launch Vehicle Family



Total: 7

The definition of a "commercial" launch is any launch opportunity considered available in principle to competitors in the international launch services market or any launch licensed by the FAA Office of Commercial Space Transportation.

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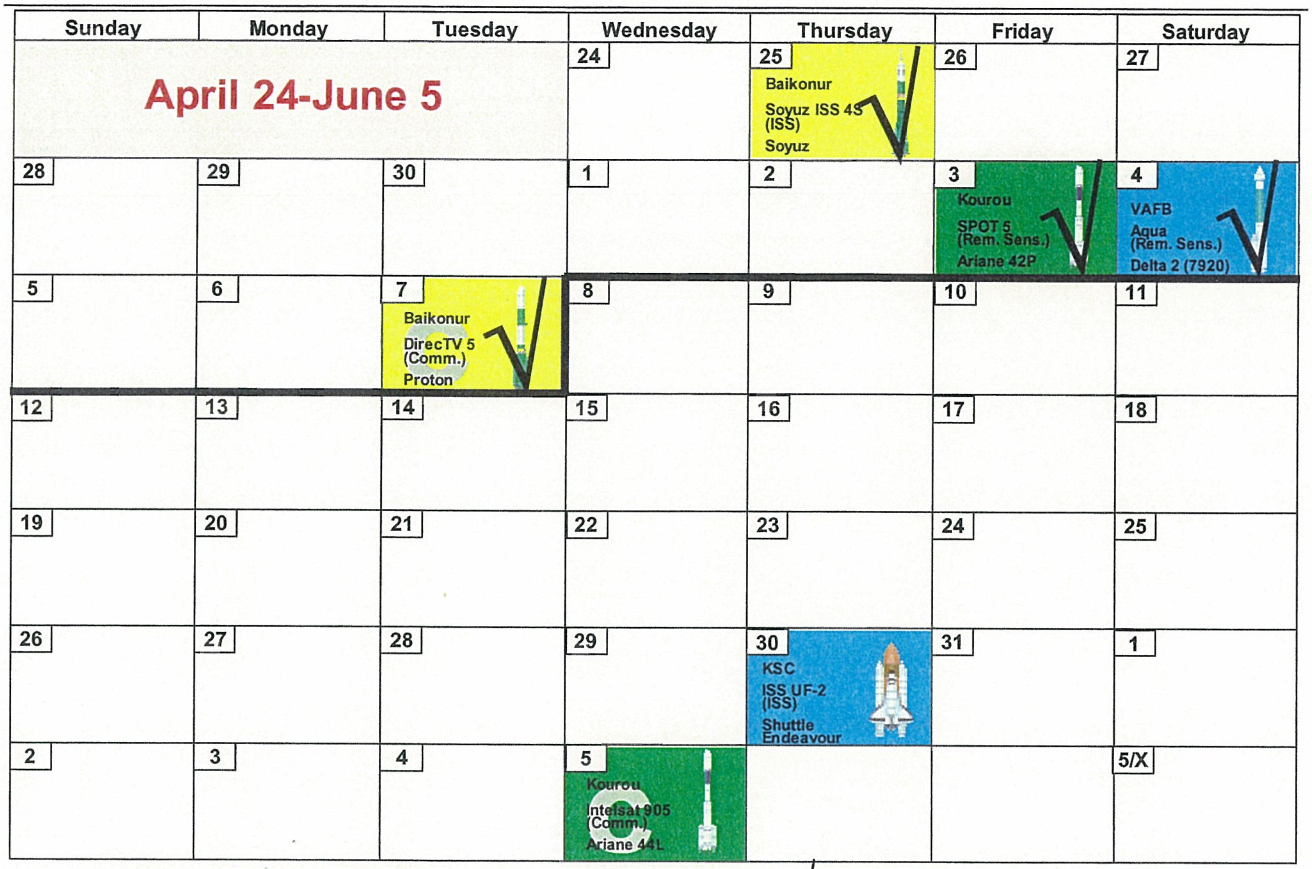
Futron Launch Report

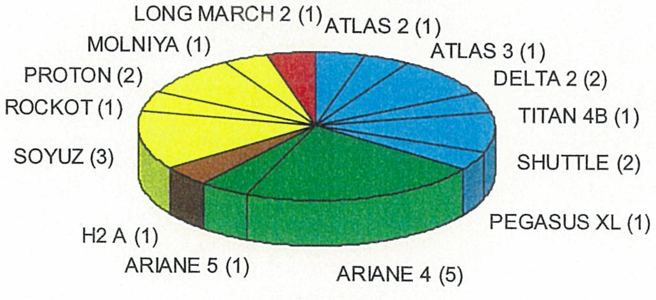
May 2002



Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
April 24-June 5			24	🟨 25 Baikonur Soyuz ISS 4S (ISS) Soyuz ✓	26	27
28	29	30	1	2	🟩 3 Kourou SPOT 5 (Rem. Sens.) Ariane 42P ✓	🟦 4 VAFB Aqua (Rem. Sens.) Delta 2 (7920) ✓
5	6	🟨 7 Baikonur C DirecTV 5 (Comm.) Proton ✓	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	🟦 30 KSC ISS UF-2 (ISS) Shuttle Endeavour	31	1
2	3	4	🟩 5 Kourou C Intelsat 905 (Comm.) Ariane 44L			5/X

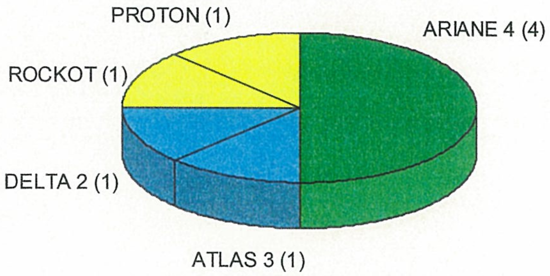
Legend: 🟦 USA 🟨 Russia 🟩 Europe ✓ Success ☒ Failure C Commercial

2002 Total Launches by Launch Vehicle Family



Total: 23

2002 Commercial Launches by Launch Vehicle Family



Total: 8

Legend: 🟦 USA 🟨 Russia 🟩 Europe 🟫 Japan 🟥 China

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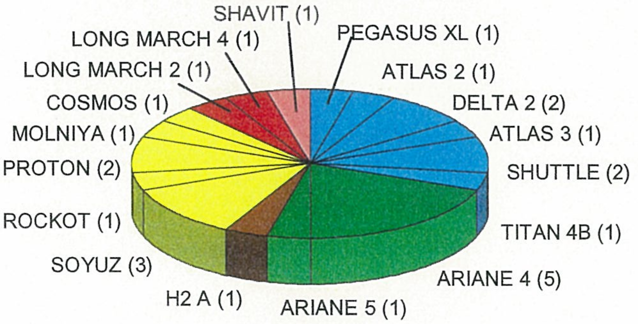
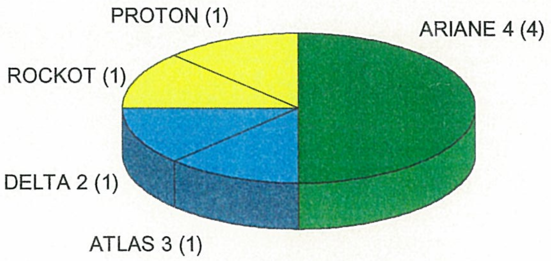
Futron Launch Report
June 2002

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
May 22-July 3			22	23	24	25
26	27	28 ✓ Plesetsk Kosmos 2389 (Military) Cosmos ✓ Palmachim Ofeq 5 (Military) Shavit	29	30	31	1
2	3	4	5 C Kourou Intelsat 905 (Comm.) Ariane 44L KSC ISS UF-2 (ISS) Shuttle Endeavour	6	7	8
9	10 Baikonur Express A1R (Comm.) Proton	11	12	13	14	15 C Sea Launch Galaxy 3C (Comm.) Zenit 3SL
16 C Baikonur Echostar 8 (Comm.) Proton	17	18	19 Plesetsk Iridium 97-98 (Comm.) Rockot	20	21	22
23	24 VAFB NOAA M (Rem. Sens.) Titan 2	25	26 Baikonur Progress 9P (ISS) Soyuz	27	28	29
30	1 CCAFS Contour (Science) Delta 2 7425-10	2	3			

Legend: ■ USA ■ Russia ■ Europe ■ Multinational ☑ Success ☒ Failure C Commercial ■ Israel


2002 Total Launches by Launch Vehicle Family

Total: 26


2002 Commercial Launches by Launch Vehicle Family

Total: 8

Legend: ■ USA ■ Russia ■ Europe ■ Japan ■ China ■ Israel

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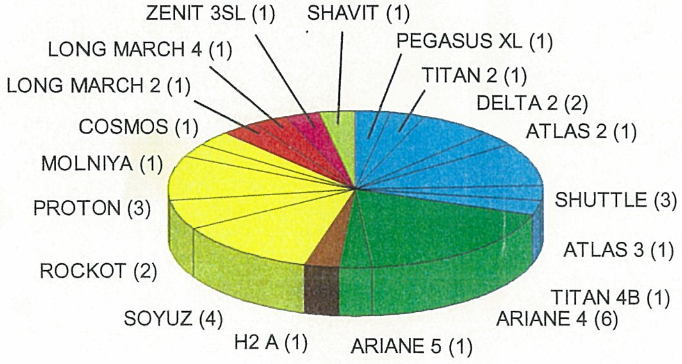
Futron Launch Report

July 2002

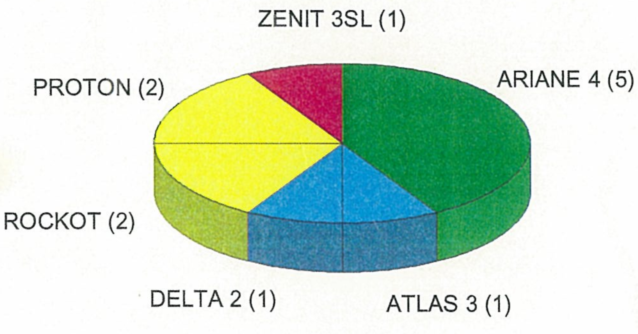
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
June 19 – July 31			19	🟨 20 C Plesetsk Iridium 97-98 (Comm.) Rockot ✓ 	21	22
23	🟦 24 VAFB NOAA M (Rem. Sens.) Titan 2 ✓ 	25	🟨 26 Baikonur Progress 9P (ISS) Soyuz ✓ 	27	28	29
30	1	2	🟦 3 CCAFS Contour (Science) Delta 2 7425-10 	4	🟩 5 C Kourou N-Star C, Stellat (Comm.) Ariane 5 ESC-A 	6
7	8	9	🟨 10 Plesetsk Kosmos TBA 10 (Military) Cosmos 	11	12	13
14	15	16	17	18	19	20
21	22	23	24	🟨 25 Baikonur Kosmos TBA 11 (Military) Proton 	26	27
28	29	30	31			🟥 7/X Taiyuan CBERS/Ziyuan 2 (Rem. Sens.) Long March 4B 

Legend: 🟦 USA 🟨 Russia 🟩 Europe 🟥 China ☑ Success ☒ Failure C Commercial



2002 Total Launches by Launch Vehicle Family

Total: 33



2002 Commercial Launches by Launch Vehicle Family

Total: 12

Legend: 🟦 USA 🟨 Russia 🟩 Europe 🟫 Japan 🟥 China 🟥 Israel

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