Delta II

Outlook

- Production of Delta II completed
- Flights of surplus Delta II vehicles currently in storage could continue
- NASA added Delta II to NLS II contract, allowing the agency to use the surplus launch vehicles

Orientation

Description. Delta II is a medium-lift expendable launch vehicle.

Sponsor. The U.S. Air Force Space and Missiles Systems Center, Los Angeles, California, sponsors Department of Defense launches of Delta vehicles, with Boeing Integrated Defense Systems, Delta Government Launch Services, providing interface for U.S. government customers. Boeing Integrated Defense Systems, Boeing Launch Services, markets commercial launches.

Status. Delta II launch vehicles are in production and operational.

Total Produced. Over 160 Delta II boosters have been produced.

Application. Delta II expendable launch vehicles can carry medium-size payloads up to 5,800 kilograms into low-Earth orbit (LEO), or up to 2,000 kilograms into geosynchronous transfer orbit (GTO).

Price Range. Commercial customers are charged about $55 million to $65 million for a Delta II launch.

Contractors

Prime

Boeing	http://www.boeing.com, 100 N Riverside, Chicago, IL 60606 United States, Tel: + 1 (312) 544-2000, Fax: + 1 (312) 544-2082, Prime

Subcontractor

Alliant Techsystems - Aerospace Systems, Aerospace Structures	http://www.atk.com, 1700 N Research Park Way, Logan, UT 84341 United States, Tel: + 1 (435) 753-8565 (Composite Thermal Shields; RS-68 Nozzle; Interstages, Centerbodies, Aeroskirts, Payload Adapters & Fairings, Nose Cones, Centaur Interstage A)
Alliant Techsystems - Aerospace Systems	http://www.psi-pci.com, 6033 E Bandini Blvd, Commerce, CA 90040 United States, Tel: + 1 (213) 722-0222, Fax: + 1 (213) 721-6002 (Second Stage Titanium Fuel Tank)
Eaton Aerospace	http://www.aerospace.eaton.com, 9650 Jeronimo Rd, Irvine, CA 92618 United States, Tel: + 1 (949) 452-9500, Fax: + 1 (949) 452-9555 (Thruster Module)

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Honeywell Aerospace, Defense Avionics Systems	http://www.honeywell.com/sites/aero/Avionics_Electronics.htm, 699 Route 46, Teterboro, NJ 07068 United States, Tel: + 1 (201) 393-3924 (Redundant Inertial Flight Control Assembly)
Pratt & Whitney Rocketdyne	http://www.pratt-whitney.com, 6633 Canoga Ave, Canoga Park, CA 91309 United States, Tel: + 1 (818) 586-1000 (First Stage Main Engine)
Pratt & Whitney Rocketdyne, West Palm Beach Operations	http://www.pratt-whitney.com, PO Box 109600, West Palm Beach, FL 33410-9600 United States, Tel: + 1 (561) 796-2000, Fax: + 1 (561) 796-7285 (Delta III Rl10B-2 Cryogenic Upper Stage Engine)
Thales Alenia Space	http://www.thalesgroup.com/Markets/Space/Home/, 100 boulevard du Midi, BP99, Cannes la Bocca, 06156 France, Tel: + 33 4 92 92 70 00, Fax: + 33 4 92 92 31 40 (Delta II Upperstage Tanks)

Comprehensive information on Contractors can be found in Forecast International's "International Contractors" series. For a detailed description, go to www.forecastinternational.com (see Products & Samples/Governments & Industries) or call + 1 (203) 426-0800.

Contractors are invited to submit updated information to Editor, International Contractors, Forecast International, 22 Commerce Road, Newtown, CT 06470, USA; rich.pettibone@forecast1.com

Technical Data

Design Features. The Delta II expendable launch vehicle is offered in a variety of models, depending on the payload and its intended orbit. Boeing uses four-digit nomenclature. Typical Delta II configurations include the 7326-10, 7425-10, 7925-10, 7925, and 7925H-10.

The first digit (7) indicates that the rocket uses Alliant Techsystems 40-inch-diameter (1,106mm) Graphite Epoxy Motor (GEM) strap-on boosters.

The second digit indicates the number of strap-on boosters used (3, 4, or 9), the third digit relates to the second-stage model (currently 2 for the Aerojet AJ-10-118K), and the fourth digit represents the type of upper stage (0 for none; 0H for no third stage – heavy configuration with 46-inch-diameter [1,168mm] GEM 46 solid rocket motor; 5 for Thiokol Star 48B; 5H for Star-48B – heavy configuration with GEM 46 motors; and 6 for Star-37 FM solid motor). No dash after the number indicates the 2.9-meter-diameter, 8.5-meter-long fairing is used. A -10 indicates a 3.0-meter-diameter, 8.9-meter-long fairing, and a -10L represents the 3.0-meter-diameter, 9.2-meter-long fairing.

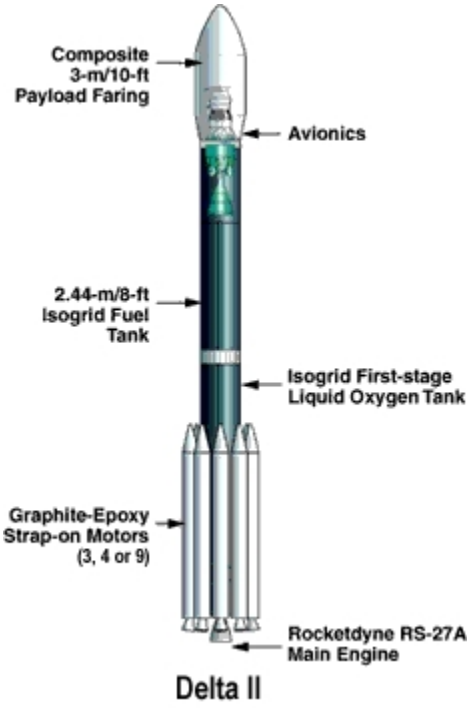
	Metric	**U.S.**
Delta II		
Dimensions		
Rocket Overall Length	39.0 m	128 ft
Stage 0 Length (GEM 40/GEM 46)	10.0 m/11.2 m	32.9 ft/36.8 ft
Stage 1 Length	26.1 m	85.9 ft
Stage 2 Length	5.8 m	19.3 ft
Stage 3 Length	2.1 m	7.2 ft
Stage 0 Diameter	1.01 m/1.1 m	3.3 ft/3.8 ft
Stage 1 Diameter	2.4 m	8.0 ft
Stage 2 Diameter	2.4 m	8.0 ft
Stage 3 Diameter	1.2 m	4.0 ft
Fairing Diameter	2.8 m	9.3 ft
Weight		
Rocket Launch Weight	219,088 kg	483,000 lb
Solid Propellant Weight (GEM 40/GEM 46)	11,767 kg/16,864 kg	25,942 lb/37,180 lb
Performance		
Delta 7326-10 to LEO	2,731 kg	6,020 lb
Delta 7326-10 to GEO	898 kg	1,980 lb
Delta 7425-10 to LEO	3,094 kg	6,820 lb
Delta 7426-10 to GEO	1,102 kg	2,430 lb
Delta 7925-10 to LEO	4,971 kg	10,960 lb

	Metric	U.S.
Delta 7925-10 to GEO	1,799 kg	3,966 lb
Delta 7925 to LEO	5,139 kg	11,330 lb
Delta 7925 to GEO	1,869 kg	4,120 lb
Delta 7925-H10L to LEO	5,815 kg	12,826 lb
Delta 7925-H10L to GEO	2,064 kg	4,550 lb

Propulsion

Delta 7925

Stage 0	(9)	Alliant Techsystems stretched Graphite Epoxy Motor (GEM) strap-on solid rocket boosters, 439.7 kN (98,844 lbst) each
Stage 1	(1)	Rocketdyne RS-27 liquid rocket engine (121 expansion ratio), 890 kN (200,000 lbst)
Stage 2	(1)	Aerojet AJ10-118K liquid rocket engine, 44.5 kN (10,000 lbst)
Stage 3	(1)	Thiokol Star 48 solid rocket engine, 66.7 kN (15,000 lbst)



Cutaway View Showing Delta II Components

Source: Boeing

Launch of a Delta II

Source: Boeing

Variants/Upgrades

Delta II. Currently in production, the model is the workhorse of the Delta family. Boeing expects to retire the vehicle in 2010 or 2011.

Delta III. More powerful than the Delta II, this rocket suffered back-to-back failures in its first two missions. Boeing has phased out this model.

Delta IV. Medium- and heavy-lift vehicle developed for the U.S. Air Force, this rocket was previously directed at the commercial satellite launch market as well. However, Boeing decided in 2003 to focus the Delta IV exclusively on military launches. (For further information on the Delta IV, see the "EELV" report in this tab.)

Delta II

Program Review

Background. The Delta expendable launch vehicle is one of the oldest and most successful U.S. rockets in production. Since 1960, when NASA first used it to place the earliest, primitive, passive communications satellites in orbit, Delta has launched hundreds of scientific, meteorological, Earth resource, and communications spacecraft.

Delta development began in the late 1950s as part of a U.S. Air Force launch vehicle program. McDonnell Douglas (now part of The Boeing Co) built the initial Delta by placing second- and third-stage Vanguard rocket motors on top of a modified Thor intermediate-range ballistic missile first stage. The Delta launch vehicle has since evolved through a series of models to the current Delta II model 7925, which is distinguishable by its nine strap-on solid rocket motors.

Delta production came to a halt in 1984 in line with NASA's dream of total dependence on manned space flight vehicles (i.e., the Space Shuttle). After the Challenger accident in 1986, however, it was apparent to NASA and the Pentagon that a mix of manned and unmanned launch systems was necessary to ensure continued access to space. Within months of the disaster, the space agency ordered three additional Delta launch vehicles.

One military program particularly hard hit by the shuttle flight hiatus was the U.S. Air Force's Navstar Global Positioning System. The many satellites that form the system were originally slated for launch aboard the Space Shuttle. Following the Challenger accident, the service announced a competition for a new medium-lift vehicle (MLV) to launch the milsats. McDonnell Douglas got the nod in 1987 to supply an initial batch of seven Delta IIs. The contract included options for 13 MLVs, which brought the total number of Delta IIs on order with the Air Force in the late 1980s to 20.

Delta II Chosen for MLV III Rocket

In 1993, the U.S. Air Force selected McDonnell Douglas for the Medium Launch Vehicle III contract. The MLV III is used to launch Air Force Navstar GPS Block IIR replenishment satellites. Under terms of the contract, McDonnell Douglas was selected to supply up to 25 launches over a seven-year period. The Delta II 7925 used for the MLV III contract is nearly identical to the one used to launch the current Navstar GPS Block II satellites.

Hughes Space and Communications International (now part of Boeing) awarded McDonnell Douglas a contract in 1995 to launch as many as 13 commercial communications satellites, prompting the go-ahead for development of the Delta III.

In 1998, the first Delta III mission ended about one minute after liftoff when the booster exploded over the Atlantic Ocean, destroying the Galaxy X satellite owned by PanAmSat Corporation. An investigation traced the failure to a problem with the rocket's control system.

The second Delta III launch attempt also ended in failure when the upper stage stopped prematurely during its burn profile, stranding an Orion 3 satcom in a useless orbit. Investigators traced the failure to a Pratt & Whitney manufacturing process that had created voids in the RL10B-2's combustion chamber seams.

Boeing launched its third Delta III in 2000 with a payload designed to follow a trajectory similar to that of the Orion 3 launch. Boeing officials judged the launch a success; however, insurance industry officials said the launch constituted a partial claim, as the Delta III placed the payload approximately 3,400 kilometers lower than its expected orbit. Fuel on the spacecraft would have to be used to raise the orbit, thus decreasing the spacecraft's design life. Boeing commented that it was within the "contractually specified tolerance." One year later, Boeing said it would discontinue Delta III production.

Green Light for Lockheed-Boeing Deal

The Federal Trade Commission (FTC) agreed to allow the formation of the United Launch Alliance (ULA), the merger of the government launch operations of Boeing and Lockheed Martin – but with conditions. In a statement released September 3, 2006, the FTC said that it would allow Boeing and Lockheed to proceed with the ULA, but only under the terms of a consent decree that requires the companies to cooperate equally with all manufacturers of government payloads and to protect sensitive information provided by those payload manufacturers.

Proponents of the ULA argued that the joint venture would save the government money, whereas satellite manufacturers and other launch vehicle developers expressed concern that the ULA would give the two companies an unfair advantage for government launch and satellite work.

First Cosmo-SkyMed Launched

The Cosmo-SkyMed satellite, developed for the Italian Space Agency and Italian Ministry of Defense, was boosted into orbit in June 2007 after being launched aboard a Boeing Delta II from the Vandenberg Air

Force Base in California. The satellite, which carries a radar imager, is the first part of a constellation of four orbiting probes that will collect data on floods, droughts, earthquakes, and landslides. The second Cosmo-SkyMed launched in December 2007, and the third launched in October 2008. The fourth is expected to launch in 2010.

ULA Restructures Delta II Program

Facing the loss of one of its biggest customers, the United Launch Alliance announced in January 2008 that it was restructuring its Delta II launch vehicle program in an attempt to continue operations at lower launch rates while maintaining "competitive" prices. The medium-lift Delta II – used primarily by the U.S. Air Force and NASA – is being phased out by the Air Force in favor of the larger Delta IV and Atlas V EELV rockets. According to ULA, the restructuring involves reducing the number of facilities used by the Delta II program and taking advantage of unspecified synergies with the larger EELV programs.

As part of the plan, ULA appointed Rick Navarro as its Delta II program director. Navarro was tasked with implementing the restructure, executing the manifest, and ensuring ULA remains at the forefront of the medium-lift market. Navarro previously served as Delta director of launch operations at Cape Canaveral Air Force Station (CCAFS), Florida, and Vandenberg Air Force Base, California.

Despite the restructuring, Delta II production has ceased. Launches of surplus vehicles will continue. However, without the U.S. Air Force, NASA could not afford to maintain Delta II infrastructure by itself.

Funding

Pentagon Delta II procurement funding was provided by the Medium Launch Vehicle (MLV) line of the USAF budget, Budget Activity 5, Missile Procurement appropriation account. All numbers are based on the FY11 Department of Defense Budget Request issued in February 2010. Figures for FY12 are unavailable.

U.S. FUNDING

	Prior AMT	FY09 AMT	FY10 AMT	FY11 AMT	FY12 AMT
MLV Procurement	2,746.49	37.74	-	-	-
Qty	58				

All $ are in millions.

Timetable

Month	Year	Major Development
	1959	Development of first Delta launch vehicle begins
May	1960	First Delta launch attempt ends in failure
Feb	1989	Navstar GPS Block II-1 launches on Delta 6925; first Delta II launch
Aug	1998	Delta III with Galaxy X explodes after launch from Cape Canaveral
May	1999	Orion 3 launched on Delta III (upper-stage failure leaves satellite in useless orbit)
Aug	2000	Demonstration flight of Delta III with USAF payload
Jan	2001	Navstar GPS IIR-7 launches on Delta II 7925
Apr	2001	2001 Mars Odyssey launches on Delta II 7925
May	2001	GeoLITE launches on Delta II 7925
Jun	2001	MAP launches on Delta II 7925
Aug	2001	Genesis launches on Delta II 7425-10C
Oct	2001	QuickBird 2 launches on Delta II 7320-10C
Dec	2001	Jason-1, TIMED launches on Delta II 7920-10
Feb	2002	Iridium Mission 12 launches on Delta II 7920 (five satellites)
May	2002	Aqua launches on Delta II 7920-10L
Jul	2002	Contour launches on Delta II 7425
Nov	2002	Eutelsat W5 launches on Delta IV (inaugural launch)
Jan	2003	Icesat/CHIPSAT launches on Delta II 7320
Jan	2003	GPS-IIR8 launches on Delta II 7925
Mar	2003	GPS IIR-9 launches on Delta II 7925

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Month	Year	Major Development
Jun	2003	Mars Rover A launches on Delta II 7925 (first launch)
Jul	2003	Mars Rover B launches on Delta II Heavy (second launch)
Aug	2003	SIRTF launches on Delta II 7920-Heavy
Dec	2003	GPS IIR-10 launches on Delta II 7925
Mar	2004	GPS IIR-11 launches on Delta II 7925
Apr	2004	Gravity Probe-B launches on Delta II
Jun	2004	GPS IIR-12 launches on Delta II 7925
Jul	2004	AURA launches on Delta II 7925
Aug	2004	MESSENGER launches on Delta II 7925-Heavy
Nov	2004	GPS IIR-13 launches on Delta II 7925
Nov	2004	SWIFT launches on Delta II 7420
Jan	2005	Deep Impact launches on Delta II 7925
May	2005	NOAA-N launches on Delta II
Sep	2005	GPS IIR-M1 launches on Delta II
Apr	2006	Cloudsat and CALIPSO launch on Delta II
Jun	2006	USA 187, USA 188, USA 189 launch on Delta II
Sep	2006	GPS IIR-M2 launches on Delta II
Oct	2006	STEREO 1 and STEREO 2 launch on Delta II
Nov	2006	GPS IIR-M3 launches on Delta II
Dec	2006	USA-193 (NROL-21) launches on Delta II
Feb	2007	THEMIS (5) launches on Delta II
Jun	2007	Cosmo-SkyMed launches on Delta II
Aug	2007	Mars Scout Phoenix launches on Delta II
Sep	2007	WorldView 1 launches on Delta II
Sep	2007	DAWN launches on Delta II
Oct	2007	GPS IIR-M4 launches on Delta II
Dec	2007	Cosmo-SkyMed 2 launches on Delta II
Dec	2007	GPS IIR-M5 launches on Delta II
Mar	2008	GPS IIR-M6 launches on Delta II
Jun	2008	GLAST launches on Delta II 7920
Jun	2008	OSTM/Jason-2 launches on Delta II
Sep	2008	GeoEye-1 launches on Delta II
Oct	2008	Cosmo-SkyMed 3 launches on Delta II
Feb	2009	NOAA-19 launches on Delta 7320
Mar	2009	Kepler launches on Delta II
Mar	2009	GPS IIR-20 launches on Delta II
May	2009	STSS ATRR launches on Delta II
Aug	2009	GPS IIR-21 launches on Delta II
Sep	2009	STSS Demo 1 and Demo 2 launch on Delta II
Oct	2009	WorldView 2 launches on Delta II
Dec	2009	WISE launches on Delta II
Nov	2010	Fourth Cosmo-SkyMed launched on Delta II
Jun	2011	SAC-D/Acquarius launched on Delta II
Sep	2011	Grail-A/-B launched on Delta II

Forecast Rationale

No Delta II launch vehicles are forecast to be produced over the next 10 years. NASA and the U.S. Air Force, the primary customers of the Delta II, plan to launch future spacecraft on board newer launch vehicles such as the Delta IV and Atlas V. However, Delta IIs that have already been produced will continue their operations during the next few years.

While the Delta II has a strong record of success and is well suited to launching medium-sized satellites into low-Earth and geosynchronous orbits, NASA and the Pentagon are shifting away from the launch vehicle due to increased prices and a preference for larger vehicles. In recent years, the cost of a single Delta II launch rose to $65 million. In addition, the Department of Defense requires the use of larger launch vehicles to accommodate the larger satellites it is using. NASA could not afford to maintain Delta II infrastructure and manufacturing expenses by itself. Together with the Delta II's rising costs and the Pentagon's decision to stop

using the launch vehicle, NASA also shifted from the Delta II toward larger launch vehicles.

The Delta II will continue operations in the near term. Since November 2010, Delta II rockets lifted the COSMO-SkyMed 4, SAC-D, and the twin Grail-A and Grail-B spacecraft into orbit. In September 2011, NASA added the Delta II to its NASA Launch Services (NLS) II contracting vehicle with United Launch Alliance (ULA). This will allow NASA to utilize Delta IIs that have already been manufactured and are currently in storage. Medium-class launch vehicles are important to NASA's goals. The agency typically launches many medium-weight science satellites, making it impractical to rely entirely on Atlas V and Delta IV EELVs. By adding the Delta II to its NLS II contract, NASA will buy time until new medium-class launch vehicles such as the Falcon 9 are certified to carry NASA payloads into orbit.

Now that the Delta II has ceased production, ULA needs to decide how it will compete in the medium-lift market. The company does not expect demand in this market to be strong and believes that the five Delta IIs currently in storage will be enough to meet demand through 2015. However, if demand proves to be stronger than expected, the company has a number of options. One strategy, albeit expensive, would be to restart Delta II production, although this would pit the more costly Delta II against cheaper options such as the SpaceX Falcon 9, and Soyuz, operated by Arianespace.

Another scenario for the company could be to modify its larger EELVs to accommodate multiple payloads. This would mitigate the higher cost of the Delta IV and Atlas V compared to the Delta II. In fact, ULA has already begun work that would allow the Atlas V to carry two payloads.

Because of the high cost of restarting production as well as the increased global competition, it is unlikely that Delta II production will resume over the next 10 years. In addition, the U.S. government, long the primary customer of the Delta II, seems to favor the newer and larger Delta IV and Atlas V launch vehicles. Even though Delta II will not restart production, ULA expects units that have already been produced will continue operations through 2015.

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