National Aeronautics and
Space Administration

Launch Services Program

Earth's Bridge to Space

2012
Rev: Basic

Earth's Bridge to Space

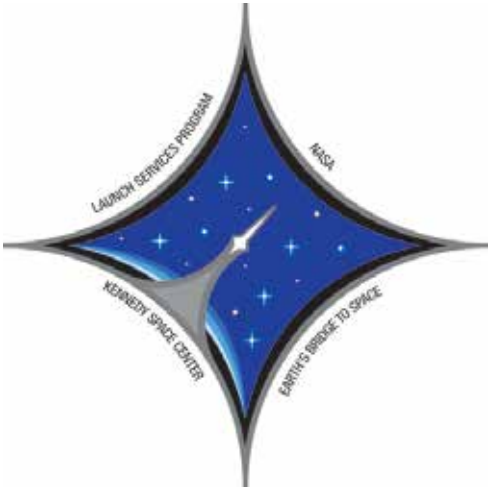
Over the past several decades, NASA's policy has been to have contractors carry out many important tasks. Private companies and consortia have been playing vital roles, getting rockets and satellites ready for flight, on their way, and all the way to orbit.

Established in 1998, the Launch Services Program is a superior collection of state-of-the-art technology, business, procurement, engineering best-practices, strategic planning, studies, and techniques – all absolutely instrumental for the United States to have access to a dependable and secure Earth-to-space bridge, launching spacecraft to orbit our planet, or fly much further into the cosmic deep.

Capitalizing on a half-century of expertise and collaboration with NASA, LSP is striving to facilitate and reinvigorate America's space effort broadening the unmanned rocket and satellite market by providing reliable, competitive and user-friendly services.

Starting in the late 90's, as the Space Shuttle program was still in full swing, private aerospace companies developed and eventually built powerful rockets to ensure the United States would have uninterrupted access to space.

In recent years, these new rockets have launched NASA's spacecraft into Earth orbit as well as distant cosmic destinations such as Mercury, Mars, Jupiter and Pluto. The Delta II and Atlas V have delivered satellites into orbit for government agencies other than NASA, including the military and private companies.



Launch Services Program @ Work

It goes without saying that a successful liftoff is only the first, yet fundamental step in the climb to Earth orbit, or to escape from its gravity.

Just as vital, however, are the services preceding, supporting and following every launch – all the way through rocket-spacecraft separation through the end of its useful life.

The Launch Services Program takes care of important and sensitive matters and it is no exaggeration calling it a bridge to space – a bridge standing on four pillars representing the 4 LSP Goals:

Goal 1: Maximize Mission Success
Maximize mission success and achieve mission excellence for all missions.

Goal 2: Assure Long-Term Launch Services
Assure services by providing end-to-end and advisory service expertise for NASA science, Exploration, U.S. Government, and Government sponsored missions.

Goal 3: Promote Evolution of a U.S. Commercial Space Launch Market
Promote the evolution of a U.S. Commercial Space Launch Market through continued relationship development with customers and stakeholders as well as the continual enhancement of policy, contracts, and launch service products and services.

Goal 4: Continually Enhance LSP's Core Capabilities
Enhance the Launch Services Program Core Capabilities by monitoring the Program's performance assessment tools and measures, relationships with customer and stakeholders, workforce, LSP policy and contracts, and products and services.

Besides describing some of NASA's most significant unmanned missions, this brochure was conceived to illustrate the contribution and role played in those achievements by the Launch Services Program.

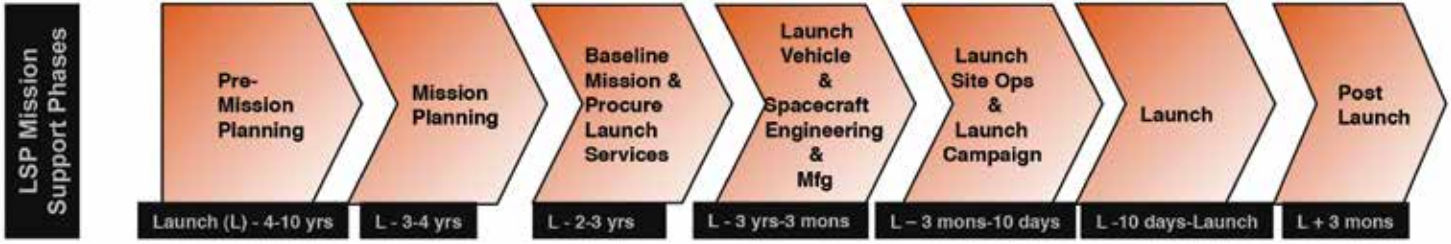
In essence, LSP was born from a straightforward idea: having one entity taking care of all needs a customer may have when making decisions and choices about a specific satellite, its architecture, size and weight, and to ensure the spacecraft is delivered to orbit on budget and on schedule.

The Launch Services Program has helped turn into reality some of NASA's greatest scientific missions and technical achievements. Moreover, LSP assists customers who need specialized, high-technology support worldwide.

LSP 101

The NASA Launch Services Program's job is to act as a broker, matching spacecraft with launch vehicles. Once the right vehicle is selected, LSP buys that spacecraft a ride to space and works diligently to ensure mission success. This process from mission selection to launch can take anywhere from 7 to 20 years. The depiction below shows the support that LSP provides from years before the spacecraft is even created, all the way through, until well after the spacecraft is launched. That is end-to-end full service.

LSP is able to evaluate spacecraft customer needs and pair the requirements of the customer with an appropriate launch vehicle and provide technical guidance through the entire process from the pre-mission planning all the way to the post-launch phase of their spacecraft.



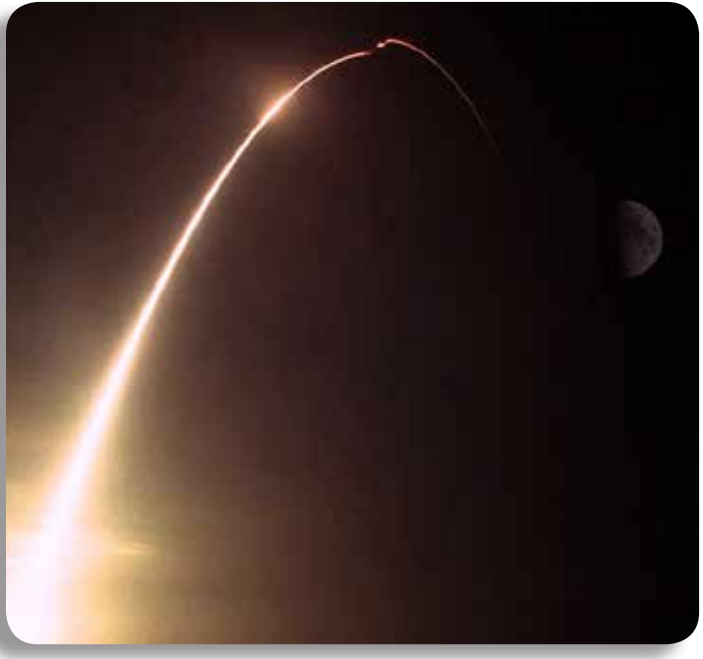
Factoid:

Geosynchronous Orbit (GEO)- From 22,236 miles (35,786 km) and above the earth.

LSP 101 cont.

Spacecraft destination requirements, coupled with the mass and volume of the spacecraft determine the launch vehicle required. The destination may be an orbit or even another planet. Additionally, spacecraft must survive ground handling and launch environments such as vibration, contamination, electromagnetic, thermal, and structural loads along the way. Engineers and Analysts with LSP ensure the optimal launch vehicle is used to deliver a healthy spacecraft to the correct orbit or destination. If not for LSP, customers would be required to provide their own commercial launch license, vehicle provider, research and development, payload processing facility, as well as airspace coordination and monitoring capability. Additionally, LSP maintains continuous insight into the commercial launch vehicle industry, tracking lessons learned to efficiently identify and mitigate risks for future managed launches.

Currently Working



Currently, the Launch Services Program assists national and international companies opting for American rockets to launch their satellites. Hundreds of active U.S. spacecraft are orbiting Earth and five other celestial bodies: Mercury, the Moon, Mars, Saturn, and asteroid Vesta.

Two spacecraft are currently in transit: in August 2011 the Juno space probe began its long cruise toward Jupiter, while another craft, New Horizons, is racing toward Pluto. This fly-by mission will culminate in 2015 with a closest approach to the distant planetoid and its moons.

Continuing on its flight path, New Horizons will sail toward the remotest reaches of the Solar System and an immense ocean of icy bodies known as the Oort Cloud. Scientists just can't wait until that happens but may have to wait until the following decade to fulfill their dream.

Currently Working cont.

Last, but not least, there is the Mars Science Laboratory – an automobile-sized robotic rover that has successfully landed on the Red Planet to look for traces or the actual presence of organic matter. A pair of robotic explorers that visited Mars in 1976 found no evidence of organic matter. That made scientists dispute the results and reliability of chemical reactions obtained from soil samples.

In summary, LSP constantly strives to meet the needs of a pool of diverse customers comprising NASA's mission directorates and Education Office, National Security Community, National Oceanic and Atmospheric Administration (NOAA), as well as projects with international partners.

Factoid:

In January 2006, during the launch of the New Horizons mission, Atlas V set a new world record for the fastest spacecraft leaving Earth-- 35,800 miles per hour.

LSP Mixed Fleet Approach

Expendable Launch Vehicles (ELVs) On NLS II Contract

Current Launch Vehicle Capabilities

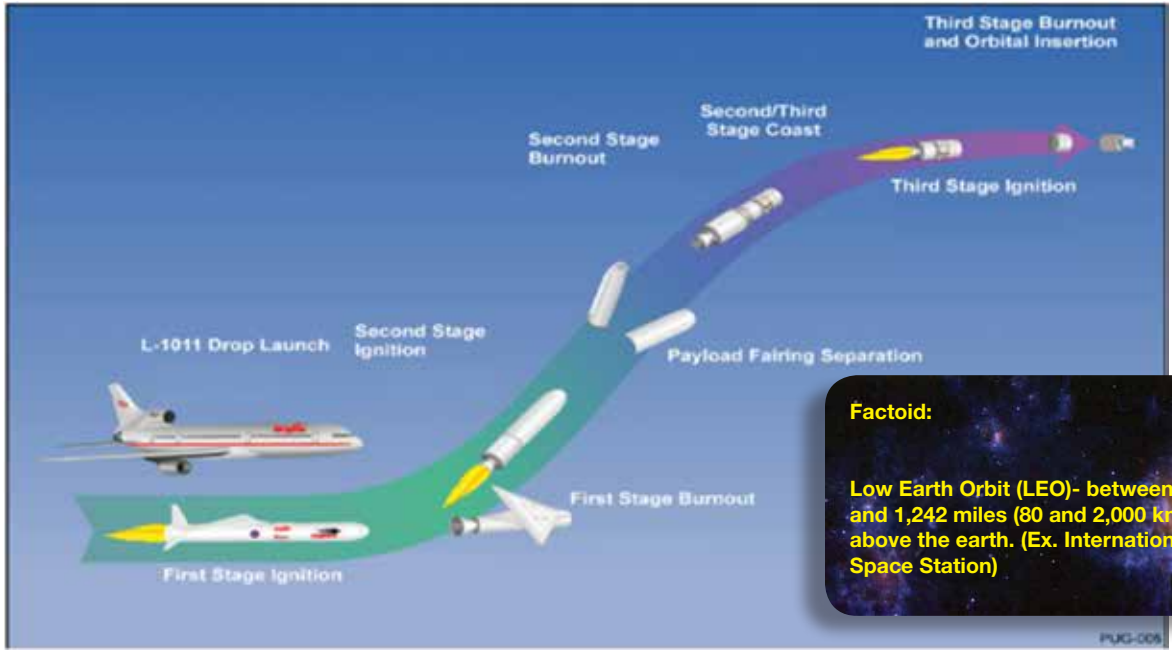
Pegasus XL- Orbital Sciences Corporation produces the Pegasus XL, a small commercial vehicle launched from the company's L-1011 Stargazer aircraft. The air-launch increases the rocket's capability by eliminating the first 39,000 feet of ascent. Launches are possible from anywhere with an appropriate airfield. The Pegasus XL can carry a payload up to 977 lbs (443kg) to Low Earth Orbit.

World's first privately developed space launch vehicle, first launched in 1990.

Factoid:

After a five-second free fall in a horizontal position, the Pegasus first stage ignites. The aerodynamic lift, generated by the rocket's triangle-shaped wing, delivers the payload into orbit in about 10 minutes!

Typical Pegasus XL Flight Profile



Factoid:

Low Earth Orbit (LEO)- between 49 and 1,242 miles (80 and 2,000 km) above the earth. (Ex. International Space Station)

Current Launch Vehicle Capabilities

Atlas V- United Launch Alliance offers multiple configurations available to carry a range of payloads from the 4 meter diameter fairing to the 5 meter diameter fairing. That is more volume than an average single family home! Solid rocket boosters are available to increase performance. The Atlas can carry a payload up to 45,239 lbs (20,520 kg) to Low Earth Orbit.

Factoid:

One Atlas V solid rocket booster produces more thrust at launch than 5 Boeing 747 airplanes on takeoff and the Atlas V can accommodate up to 5 solid rocket boosters!

Current Launch Vehicle Capabilities cont.

Delta II- United Launch Alliance offers multiple configurations of the Delta II with the 10-foot diameter fairing. The number of solid rocket boosters varies between 3 and 9 dependent on the weight of the payload. The Delta II can carry a payload up to 11,150 lbs (5,058 kg) to Low Earth Orbit.

Factoid:

A Delta II can launch a satellite to Low Earth Orbit (LEO) that is the equivalent weight of a Mercedes S500 sedan, approximately 1,905 kilograms (4,200 pounds).

Current Launch Vehicle Capabilities cont.

Falcon 9- The SpaceX Falcon 9 is offered with a 5.2 meter fairing capable of carrying 23,038 lbs (10,450 kg) to Low Earth Orbit from Cape Canaveral Air Force Station. SpaceX has broken ground at Vandenberg Air Force Base in order to convert Launch Complex 4 East to accommodate the Falcon 9 for launch.

Factoid:

Did you know that a satellite must travel at approximately 17,000 miles per hour to stay in Low Earth Orbit? At that speed, you could get from Kennedy Space Center to Orlando in about 13 seconds.

Current Launch Vehicle Capabilities cont.

Falcon 9 Version 1.1- The SpaceX Falcon 9 Version 1.1 will be offered with the same fairing and a more powerful and efficient engine capable of delivering 29,000 lbs (13,150 kg) to Low Earth Orbit from Cape Canaveral Air Force Station. Falcon 9 v1.1 is an upgraded version of the Falcon 9 rocket with more powerful Merlin 1D engines and lengthened propellant tanks. The Version 1.1 will be the core for SpaceX's Falcon Heavy, a powerful booster formed from three first stages strapped together.

Two companies have funded Commercial Orbital Transportation Services (COTS) agreements with NASA: Space Exploration Technologies (SpaceX) and Orbital Sciences Corporation. Since their competitive selection, both have been working vigorously to develop technologies and capabilities to complete orbital space flight demonstrations. The International Space Station Program has already purchased future cargo delivery services from both companies to resupply the space station through 2015.

Current Launch Vehicle Capabilities cont.

Athena Ic- The Athena Ic, produced by Lockheed Martin Space Systems Company and ATK, consists of a Castor 120 first stage and an upgraded Castor 30 second stage. The Athena Ic is capable of carrying a payload weighing up to 1,750 lbs (794 kg) to Low Earth Orbit. That's the weight of a small car!

Factoid:

On a 4,400 HP locomotive, the maximum torque would be about 25,700 ft-lb. Maximum take-off thrust produced by this Athena IIc is more than 14 times more at 360,500 ft-lb for just the first stage!

Current Launch Vehicle Capabilities cont.

The heritage Athena II rocket sits on the pad.

Athena IIc- The Athena IIc is produced by Lockheed Martin Space Systems Company and ATK and consists of a Castor 120 first stage, Castor 120 second stage, and an upgraded Castor 30 third stage. The Athena IIc is capable of carrying a payload of 4,171 lbs (1,896 kg) to Low Earth Orbit.

Factoid:

In September 2010, the Athena Ic and IIc were added to NASA's Launch Services II (NLS II) contract.

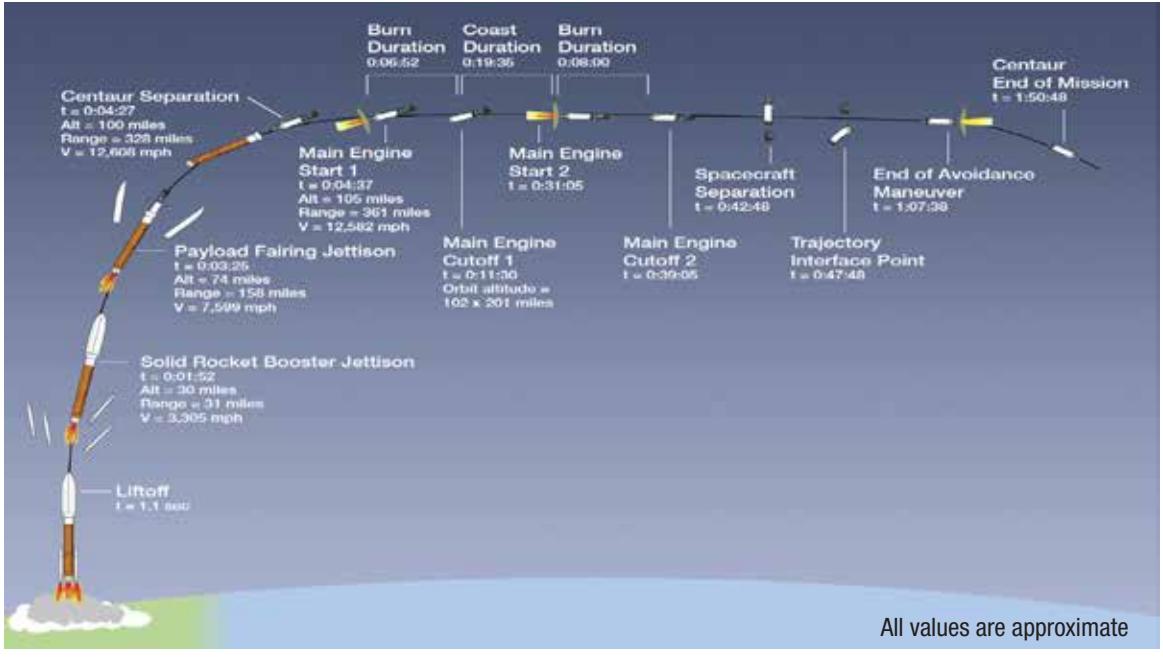
Current Launch Vehicle Capabilities cont.

Antares- Orbital Sciences Corporation produces the Antares, a medium commercial vehicle. The Antares can carry payloads in excess of 11,000 lbs (4,989 kg) to Low Earth Orbit. Antares will leverage Orbital's industry-leading experience in developing, building and operating launch vehicles. Internally funded by Orbital, Antares is currently under development with a total of 10 missions planned between 2012 and 2015: a risk reduction mission, a demonstration of commercial re-supply services for the International Space Station under a NASA Commercial Orbital Transportation Services agreement, and eight Commercial Resupply Missions to deliver cargo to the ISS.

Factoid:

The amount of helium used to launch a single Antares vehicle is enough to fill 250,000 balloons - enough to cover 5 football fields.

Typical ELV with Solid Rocket Boosters (SRBs) Flight Profile



LSP Launch Sites

Primary launch sites are Cape Canaveral Air Force Station (CCAFS) in Florida and Vandenberg Air Force Base (VAFB) in California. Other launch locations are NASA's Wallops Flight Facility in Virginia, the Kwajalein Atoll in the South Pacific's Republic of the Marshall Islands, and Kodiak Island in Alaska.

LSP Spacecraft Customers

- **Goddard Space Flight Center** in Greenbelt, Maryland.
- **Jet Propulsion Laboratory**, located at the California Institute of Technology.
- **Ames Research Center** at Moffett Field, in California's Silicon Valley.
- **Marshall Space Flight Center** at Redstone Arsenal in Huntsville, Alabama.
- **Langley Research Center** in Hampton, Virginia.
- **Applied Physics Laboratory** in Laurel, Maryland.
- Several U.S. Universities, launching small research satellites (CubeSats).
- International partners
- Other Government Agencies:
  - National Oceanic and Atmospheric Administration (NOAA)
  - Missile Defense Agency (MDA)
  - National Reconnaissance Organization (NRO)

CALIPSO Spacecraft

Historic Launches

Mars Exploration Rovers (MER-A & B)

NASA's Mars Exploration Rovers launched aboard Delta II vehicles from CCAFS. MER-A "Spirit" launched June of 2003, and MER-B "Opportunity" launched July 7 that same year. Both rovers reached Mars in January 2004. Information sent back to Earth from the rovers revealed the existence of water in the Red Planet's past (now ice). Previous missions to Mars include the 2001 Mars Odyssey spacecraft that launched in 2001.

The Mars Pathfinder began its journey as NASA's first return to Mars after the Viking mission began with the launch of the Mars Global Surveyor in 1996, scheduled to last two years. The Surveyor traveled to the Red Planet and spent about two years mapping the Martian surface to achieve a global portrait then continued to work, so NASA extended its mission and used it as a communications satellite to relay data from the Mars Odyssey as well as the Spirit and Opportunity twins back to Earth.

Mars Exploration Rover

Historic Launches cont.

Kepler, Deep Impact, MESSENGER

The Kepler mission, the 10th in NASA's Discovery missions, launched on a Delta II rocket, in 2009. The Kepler telescope was specifically designed to survey a portion of the region of the Milky Way galaxy for about three-and-a-half years to discover dozens of Earth-size planets in or near the habitable zone and determine how many of the billions of stars in the galaxy have such planets. The mission could be extended to six years. With continuous discoveries, check the most recent findings here.

The Deep Impact mission launched in 2005 and reached Comet Tempel 1 in July 2005. The "fly-by" spacecraft collected images of the comet before its "impactor" spacecraft reached the comet, and after the impact to study the pristine interior of one of its craters.

NASA's Mercury Surface, Space, Environment, Geochemistry, and Ranging (MESSENGER) spacecraft launched aboard a Delta II rocket in August of 2004. The spacecraft made the 4.9-billion-mile trek to Mercury, with 15 trips around the sun and flybys of the Earth and Venus along the way. The spacecraft reached Mercury in 2008, with flybys of that planet in January and October, and again in September 2009. MESSENGER is only the second spacecraft sent to mercury, but the first one to orbit mercury.

Factoid:

NASA's Kepler mission has discovered 11 new planetary systems hosting 26 confirmed planets!

Kepler

Historic Launches cont.

New Horizons

In 2006, NASA dispatched an ambassador to the planetary frontier. The New Horizons spacecraft is now halfway between Earth and Pluto, on approach for a dramatic flight past the icy planet and its moons in July 2015. After 10 years and more than 3 billion miles, on a historic voyage that has already taken it over the storms and around the moons of Jupiter, New Horizons will shed light on new kinds of worlds we've only just discovered on the outskirts of the solar system. Pluto gets closer by the day, and New Horizons continues into rare territory, as just the fifth probe to traverse interplanetary space so far from the Sun. And the first to travel so far, to reach a new planet for exploration.

New Horizons

Historic Launches cont.

GOES and TDRS Fleet of Satellites

NASA used the Atlas II to launch the NOAA GOES weather satellites, [left], and some of the TDRS communications series of satellites into orbit. GOES-M lifted off in 2001 aboard an Atlas IIA. It was the fifth spacecraft to be launched in the current advanced series of environmental satellites for NOAA and the first to have a solar X-ray imager. The most recent TDRS launch was in 2002.

GOES-M satellite

TDRS-J satellite

Historic Launches cont.

Kodiak Star

Lunar Prospector

Kodiak Star (Athena I) & Lunar Prospector (Athena II)

The Athena I vehicle carried NASA's Kodiak Star mission into orbit Sept. 29, 2001, from the Kodiak Launch Complex in Alaska. NASA's Starshine 3 and three U.S. Department of Defense satellites were launched into different orbits. Starshine 3 provided data on satellite orbit decay. The first successful launch of an Athena II carried NASA's Lunar Prospector spacecraft on a mission to search for traces of water or ice on the moon.

Historic Launches cont.

Terra

NASA launched the Earth Observing System's flagship satellite "Terra," named for Earth, in 1999. Terra has been collecting data about Earth's changing climate. Terra carries five state-of-the-art sensors that have been studying the interactions among the Earth's atmosphere, lands, oceans, and radiant energy. Each sensor has unique design features that will enable scientists to meet a wide range of science objectives.

Terra

2011 LSP Managed Launches

Aquarius

Aquarius will make NASA's first space observations of the salinity, or concentration of salt, at the ocean surface, a key variable in satellite studies of Earth. Variations in salinity influence the ocean's deep circulation, outline the path freshwater takes around our planet and help drive Earth's climate.

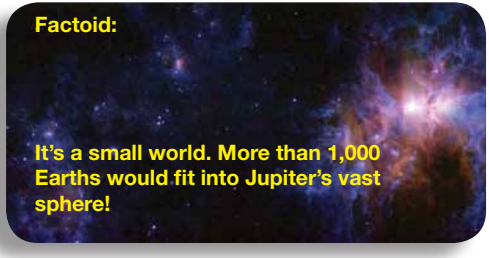
Aquarius

2011 LSP Managed Launches cont.

Juno

Juno's principal goal is to understand the origin and evolution of Jupiter. Underneath its dense cloud cover, Jupiter safeguards secrets to the fundamental processes and conditions that governed our solar system during its formation. As our primary example of a giant planet, Jupiter can also provide critical knowledge for understanding the planetary systems being discovered around other stars.

Juno

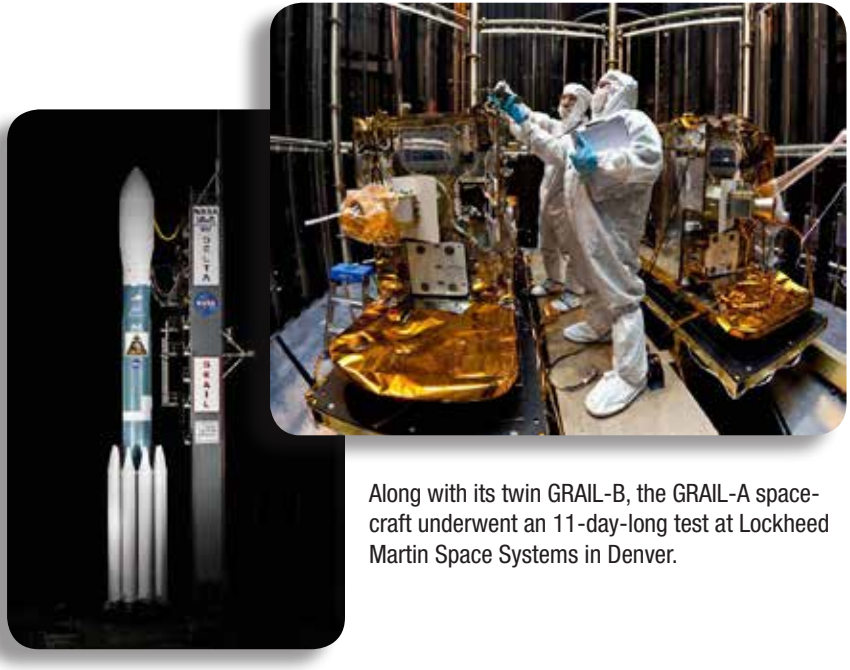


2011 LSP Managed Launches cont.

GRAIL

The Gravity Recovery and Interior Laboratory (GRAIL) mission was competitively selected through the Discovery Program. GRAIL launched on a Delta II launch vehicle and will use high-quality gravity field mapping of the moon to determine the moon's interior structure.

GRAIL



Along with its twin GRAIL-B, the GRAIL-A spacecraft underwent an 11-day-long test at Lockheed Martin Space Systems in Denver.

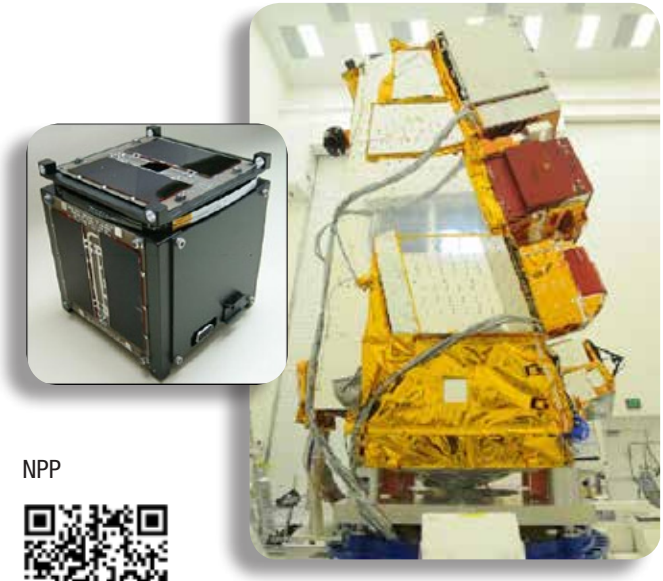
2011 LSP Managed Launches cont.

NPP

The Suomi National Polar-orbiting Partnership (Suomi NPP) mission represents a critical first step in building the next-generation Earth-observing satellite system that will collect data on both long-term climate change and short-term weather conditions. Suomi NPP is the result of a partnership between NASA, the National Oceanic and Atmospheric Administration, and the Department of Defense.

For the NPP mission, there were three Poly Picosatellite Orbital Deployers (P-PODs) aboard the Delta II rocket that ferried NPP into space. Several Universities built research CubeSats that were chosen by NASA and manifested as auxiliary payloads on the Delta II launch vehicle for NASA's NPOESS Preparatory Project (NPP) Mission.

CubeSats each measure about 4 inches cubed, with a volume of about 1 quart, and weigh in at less than 2.2 pounds. Each CubeSat must conform to standard aerospace materials requirements, orbital debris requirements and operate without the use of propulsion. During an expendable launch vehicle mission, the primary payload is launched first. After it has separated from the upper stage, a signal is sent from the launch vehicle to open the P-POD door, and a spring is used to push each CubeSat from the P-POD to begin their missions.



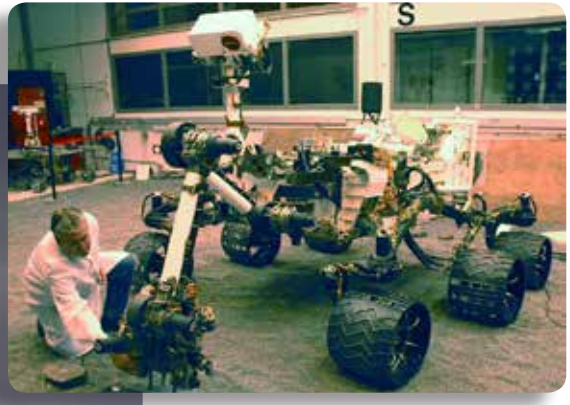
NPP

The NPP Satellite in the Ball Aerospace & Technologies Corp cleanroom

2011 LSP Managed Launches cont.

Mars Science Laboratory

Mars Science Laboratory is part of NASA's Mars Exploration Program, a long-term effort of robotic exploration of the red planet that was launched in November 2011 and has successfully landed and sent back its first pictures of Mars. Mars Science Laboratory is a rover that will assess whether Mars ever was, or is still today, an environment able to support microbial life. In other words, its mission is to determine the planet's "habitability."



Mars Science Laboratory

2011 LSP Managed Launches cont.

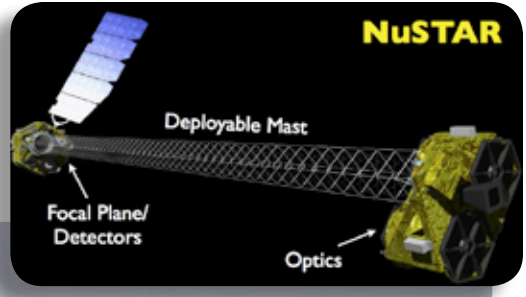
NuStar

The NuSTAR mission deployed the first focusing telescopes to image the sky in the high energy X-ray (6 - 79 keV) region of the electromagnetic spectrum. Our view of the universe in this spectral window has been limited because previous orbiting telescopes have not employed true focusing optics, but rather have used coded apertures that have intrinsically high backgrounds and limited sensitivity.

During a two-year primary mission phase, NuSTAR will map selected regions of the sky in order to:

- Take a census of collapsed stars and black holes of different sizes by surveying regions surrounding the center of own Milky Way Galaxy and performing deep observations of the extragalactic sky
- Map recently-synthesized material in young supernova remnants to understand how stars explode and how elements are created
- Understand what powers relativistic jets of particles from the most extreme active galaxies hosting supermassive black holes

NuStar



Technicians roll the Orbital Sciences Pegasus XL rocket with NASA's NuSTAR spacecraft to the waiting L-1011 carrier aircraft known as "Stargazer."

LSP Space Quiz

1. What is the only U.S. airborne launched rocket? What aircraft delivers it?
   Pegasus XL by Orbital / L-1011 "Stargazer"

2. How fast must a satellite go in order to remain in Low Earth Orbit?
   Approximately 17,000 miles per hour

3. How long did it take from launch for the "Curiosity" rover to land on Mars?
   9 months

4. How much is produced by one Atlas V solid rocket booster at launch?
   More than five 747 airplanes (380,000 lbf)

5. What year was the Launch Services Program developed?
   1998

6. How many Earths would fit into Jupiter's vast sphere?
   More than 1000

7. Can you name any spin-offs from the Space Program?
   There are more than 30,000, but just to name a few: Communications satellites (TV and cell phone), weather fore Resonance Imaging (MRI), cordless power tools, and much more

8. On average, how long does it take to go from mission selection to launch (end-to-end)?
   Between 7 and 20 years

9. What does LSP do?
   LSP manages all NASA satellite launches as well as other government satellites, end-to-end.

10. What rocket holds the world speed record for the fastest space craft at time of leaving Earth?
    35,800 miles per hour Atlas V

My Launch Pad

National Aeronautics and Space Administration

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