



LSP

LAUNCH SERVICES PROGRAM

EARTH'S BRIDGE TO SPACE

Your established provider of a commercial launch experience and targeted services, LSP guides your team to mission success by procuring a unique and customized ride to space, allowing you to focus on what matters most...

Your spacecraft, the science, your precious cargo!

TABLE OF CONTENTS

Introduction and Objective	3
Rocket Science 411	4
LSP Strategy.....	6
Launch Services	8
Launch Sites	10
Spacecraft Customers.....	12
Mission Life Cycle.....	14
Contracts.....	16
Launch Vehicle Providers and Capabilities.....	18
Small Satellite Missions	26
Advisory Role Missions	28
Partnerships and Collaboration	30
Historical Mission Highlights	32
In the Launch Queue for 2022-2023	44
Knowledge Launch	52
Staying Connected to LSP	54

INTRODUCTION

NASA's Launch Services Program (LSP) unites scientific and robotic spacecraft customers' needs with the appropriate rocket, managing the process to ensure the spacecraft is placed in orbit around the Earth, the Sun, or powered to destinations deeper into the solar system. LSP assists customers who need specialized, highly technical support worldwide, and enables some of NASA's greatest scientific missions and technical achievements.

Let's take three minutes to explore LSP as "Earth's Bridge to Space."

NASA's Launch Services Program: The Common Thread



Watch this introductory video here:

<https://www.youtube.com/watch?v=9GwU808wfpQ>

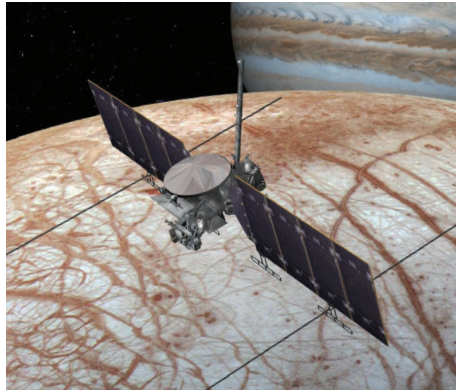
OBJECTIVE

This portfolio is intended to educate and connect you to some of NASA's most significant science-based missions, and to highlight the contributions made by LSP. By increasing your understanding of LSP's contributions to NASA's mission success, you may also realize the benefits to you and all of humankind.

ROCKET SCIENCE 411

What is a Spacecraft?

A spacecraft, also referred to as a payload, is a machine designed to fly in space. Generally a type of satellite, spacecraft are used for a variety of purposes, including communications, Earth observation, meteorology, navigation, planetary exploration, and transport of humans and cargo. Every spacecraft is unique to the specific mission and has different destination requirements. To carry out its scientific mission, a spacecraft relies on a launch vehicle to transport it to the proper orbit.



What is a Launch Vehicle?

A launch vehicle is a rocket-propelled vehicle used to carry a spacecraft from Earth's surface to space, usually to Earth orbit or beyond. Although launch vehicles may appear similar, no two are alike because they are extremely complex devices with millions of pieces and systems that must be calculated and constructed to work together. A launch vehicle is chosen based on the spacecraft's mission requirements. For example, the farther away from Earth the spacecraft needs to go, the bigger and more powerful the launch vehicle needs to be.



The spacecraft and launch vehicle must be compatible. Every mission presents its own set of unique complexities. The energy required to reach orbit and the unforgiving nature of small errors is the reason we refer to challenging endeavors as “rocket science.”

- ◆ **Each spacecraft has a specific destination in space**, which could be a unique orbit or even another planet. There could even be a specific time the satellite must reach its orbital destination, as is the case for planetary missions since planets are moving targets. This could be compared to a quarterback in a football game, who has to analyze and calculate how to throw a ball to a moving receiver. The quarterback must account for the speed of the ball, the arc of the throw, and the timing of the throw in order to reach the moving target at the right time and place. In this comparison, LSP and the commercial launch vehicle provider are the quarterback, the spacecraft is the football, and the destination requirement is the receiver.
- ◆ **The launch vehicle and spacecraft must also survive ground handling and launch environments.** This includes stressful environments such as vibration, contamination, electromagnetism, extreme temperatures, and structural loads along the way. For example, consider the vibration felt during takeoff when flying in an airplane. It's also important for the launch vehicle and spacecraft to be controlled in a clean environment at the proper temperatures, and to be protected from external environments such as lightning. During flight, rockets are subjected to additional forces of weight, thrust, and aerodynamics, which each bring their own challenges.

Choosing a launch vehicle depends on three things:
how much the spacecraft weighs; how far away it's going;
and what it's going to do.

Watch “What is the Right Rocket to Launch a Robot?”
[youtube.com/watch?v=JcmjW6mTV64](https://www.youtube.com/watch?v=JcmjW6mTV64)

LSP STRATEGY

Origin and Purpose

In 1998, NASA's Launch Services Program (LSP) was established to support NASA's science and robotic missions by procuring commercial launch vehicles. The program was established at NASA's Kennedy Space Center to centralize technical and management support to spacecraft customers. LSP brings together people, procurement, engineering best practices, strategic planning, studies, and cutting-edge techniques—all instrumental components for the United States to have a dependable and secure Earth-to-Space bridge that is dedicated to launching all types of spacecraft.

The principal objectives of LSP are to provide **safe, reliable, cost-effective** and **on-schedule** launch services to including mission analysis, spacecraft integration, and processing for payloads seeking transportation to space on commercial launch vehicles. LSP acts as a broker, matching spacecraft with optimal launch vehicles. Once the correct vehicle is selected, LSP buys that spacecraft a ride to space. LSP then works to ensure mission success by managing the overall process and assuring the rocket will work correctly to deliver a healthy spacecraft to the correct orbit or destination. LSP provides support throughout the journey, **from pre-mission planning to the post-launch phase** of the spacecraft.

As such, LSP provides NASA's acquisition and program management of commercial launch vehicle missions. This is accomplished through a skillful NASA/contractor team providing leadership, expertise, and cost-effective services in the commercial launch arena to satisfy space transportation requirements and maximize the probability of mission success.

Launch Services Program has launched nearly 100 missions to date. The work of LSP is considered **Earth's Bridge to Space!**

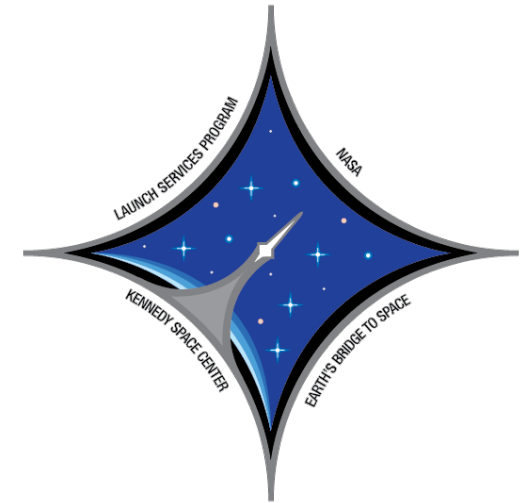
Vision and Mission

Vision:

Science and discovery through unlimited access to the universe

Mission:

Uniting customers, capabilities, and culture to explore space through unparalleled launch services



FUN FACT:

Did you know LSP's establishment year of '98 is written in the stars? Much is revealed in the LSP logo, which depicts the following:

- ◆ There are nine stars to the left of the rocket and eight stars to the right of the rocket, which represents 1998, the year the program began.
- ◆ The compass star represents LSP's direction and leadership in launch services.
- ◆ The four points represent LSP's four strategic goals.
- ◆ The rocket in the center represents the fleet of vehicles used for launch services.
- ◆ The trail connecting the rocket to Earth is representative of the LSP motto "Earth's Bridge to Space."

LAUNCH SERVICES

There are many pieces that make up the “big picture” of the Launch Services Program. The services that LSP provides are based on the spacecraft customer’s mission requirements. Represented here are LSP’s primary “end-to-end” services, from advanced planning through post launch. LSP also offers tailored approaches to serve a wide variety of customers, including one-of-a-kind launch contracts and advisory services.

Advanced Planning

- ◆ Supports spacecraft design
- ◆ Conducts launch vehicle trade studies



Business

- ◆ Procures commercial launch services, payload processing facilities, and support contractors
- ◆ Manages multi-year budgets from the spacecraft customer for specific missions, and from NASA’s Space Operations Mission Directorate for infrastructure aspects of LSP

Technical

- ◆ Provides insight and approval of launch vehicle fleets
- ◆ Verifies and validates mission engineering and analysis
- ◆ Certifies launch systems
- ◆ Integrates spacecraft to launch vehicles



Launch Site Operations

- ◆ Supports spacecraft standalone testing, propellant loading, payload encapsulation, and integrated testing in a clean facility
- ◆ Provides infrastructure to communicate with spacecraft

Launch Operations

- ◆ Provides communications and telemetry data
- ◆ Participates in countdown
- ◆ Gives “go for launch”
- ◆ Ensures liftoff and orbital insertion through separation



Post Launch

- ◆ Determines mission success
- ◆ Reviews and assesses data

LAUNCH SITES

Location, Location, Location

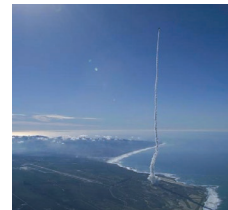
The physical location of the launch facility is another important consideration in space science. The decision on the proper launch site location is based on the **type of science**, and what **orbital destination** the satellite needs to reach to gather the science.

★ The primary launch sites for NASA are **Cape Canaveral Space Force Station** in Florida, and **Vandenberg Space Force Base** in California.



Cape Canaveral Space Force Station & Kennedy Space Center, Florida

- ◆ Missions requiring **equatorial orbits** are typically launched from here due to its closer proximity to the equator. They are also ideal for a west-east orbit.



Vandenberg Space Force Base, California

- ◆ This launch site is preferred for spacecraft requiring a north-south orbit, and is also best for missions with a **polar orbit** destination.



Wallops Island Flight Facility, Virginia

- ◆ NASA's premier location for conducting research using **suborbital vehicles**. This site also supports International Space Station resupply missions.



Reagan Test Site, Kwajalein Atoll, Republic of the Marshall Islands

- ◆ Located between Hawaii and Australia, Kwajalein is the world's largest coral atoll. This site is used for missions requiring **equatorial orbits** and low inclinations.



Kodiak Island, Alaska

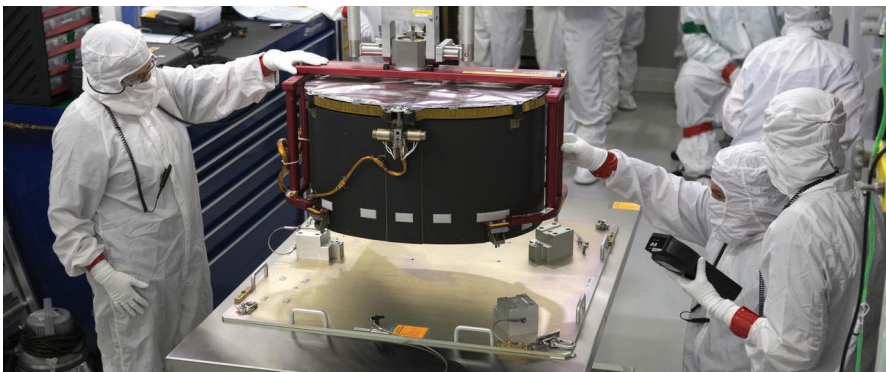
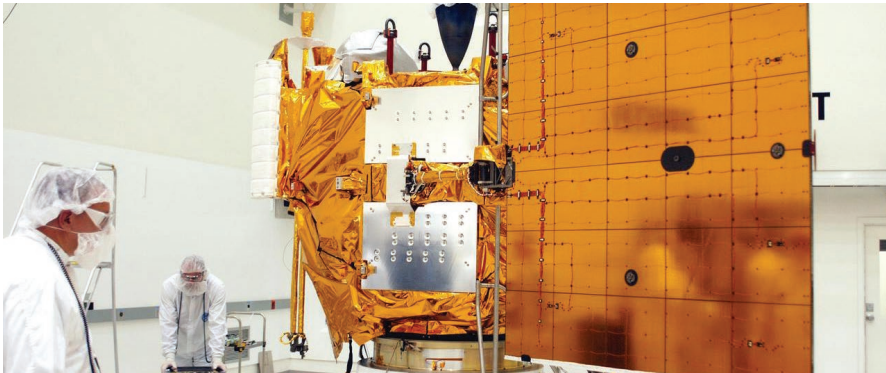
- ◆ One of the best locations in the world for **polar launch operations** due to its wide launch azimuth and unobstructed downrange flight path.

Additional launch sites specific to LSP's Venture-Class Acquisition of Dedicated and Rideshare (VADR) launch services contract are:

- ✈ **Rocket Lab Launch Complex 1 in Mahia, New Zealand**
- ✈ **Mojave Air and Space Port in Mojave, California**
- ✈ **Starbase in Boca Chica, Texas**

SPACECRAFT CUSTOMERS

The work performed by NASA's Launch Services Program (LSP) is entirely focused on the spacecraft customer's mission needs. In other words, the work of LSP benefits the customer's goals, which ultimately **benefits society through the legacy of scientific discovery!** Listed on the right are just some of LSP's spacecraft customers.



◆ NASA Centers

- ◁ Ames Research Center in Silicon Valley, California
- ◁ Goddard Space Flight Center in Greenbelt, Maryland
- ◁ Glenn Research Center in Cleveland, Ohio
- ◁ Jet Propulsion Laboratory at the California Institute of Technology
- ◁ Johnson Space Center in Houston, Texas
- ◁ Langley Research Center in Hampton, Virginia
- ◁ Marshall Space Flight Center in Huntsville, Alabama

◆ Applied Physics Laboratory in Laurel, Maryland

◆ MIT Lincoln Laboratory in Lexington, Massachusetts

◆ Southwest Research Institute in San Antonio, Texas

◆ Universities and High Schools across the United States launching small research satellites (CubeSats)

◆ International Partners

- ◁ European Space Agency (ESA)
- ◁ Indian Space Research Organization (ISRO)
- ◁ Japan Aerospace Exploration Agency (JAXA)

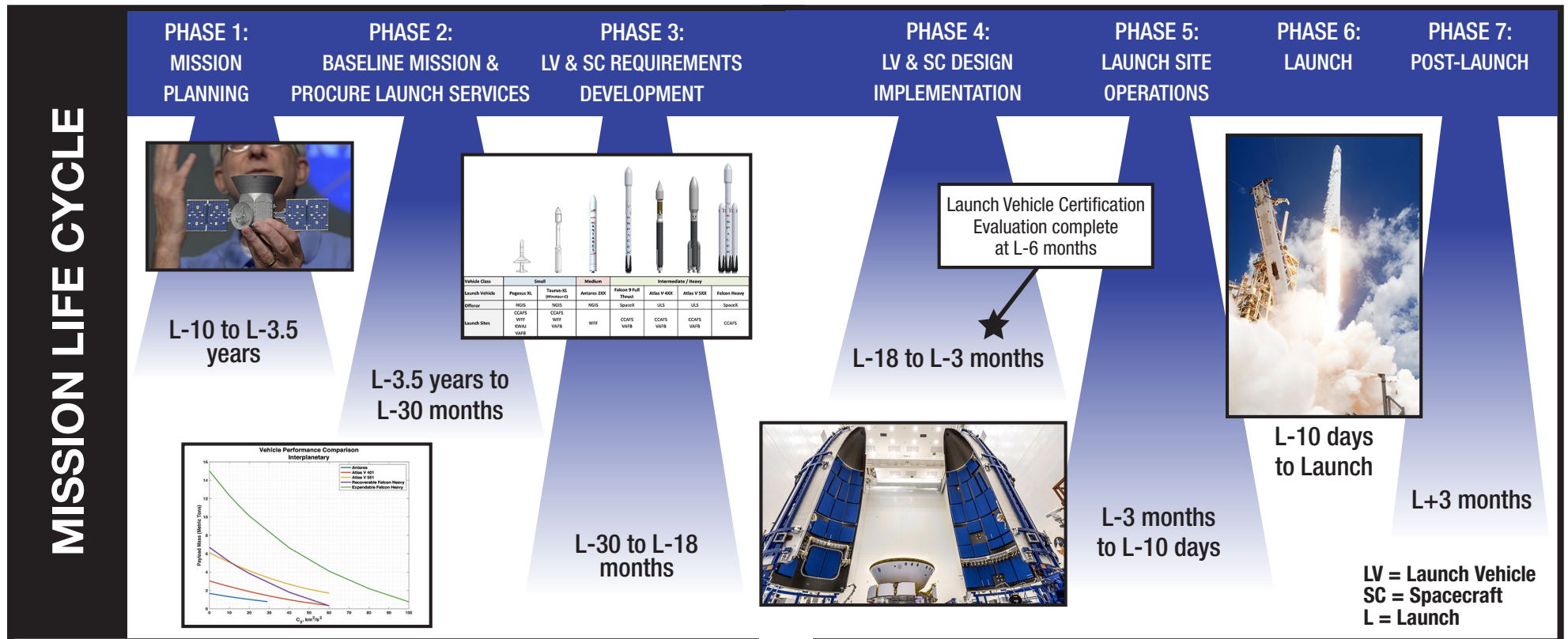
◆ Other Government Agencies (customers and collaborators):

- ◁ United States Space Force (USSF)
- ◁ National Reconnaissance Organization (NRO)
- ◁ National Oceanic and Atmospheric Administration (NOAA)

MISSION LIFE CYCLE

For traditional primary satellites to be launched, the process from mission selection to launch can take anywhere from 4-10 years. The reason for this is primarily due to the vast complexities and risk levels of developing the specific spacecraft. The depiction below shows the support that LSP provides as the spacecraft is being conceived until well after the spacecraft has launched. This is what comprises end-to-end full service.

LSP also offers tailored approaches for a wide variety of customers, including one-of-a-kind contracts and advisory services. These services vary in scope, complexity, and duration based on the spacecraft customer's needs. Generally, lower complexity and higher risk tolerance would warrant a reduction in time and cost. An example of this tailored approach would be awarding a launch service customized to mission specific requirements under the VADR contract.



PHASE 1
Support the SC mission design with launch service information. Refine SC customer requirements.

PHASE 2
Establish/initiate a launch service contract. Identify all funding and resources required.

PHASE 3
Develop launch services requirements and preliminary design. Support SC build and integration.

PHASE 4
Implement launch services requirements. Support SC build, integration, and test phase.

PHASE 5
Final test and check out of LV and SC systems.

PHASE 6
Integrate SC to LV and test. Launch to place SC in proper orbit.

PHASE 7
Mission Success! Verify LV performance and identify issues to be resolved.

CONTRACTS

LSP offers a **mixed-fleet approach** to support science, Earth-orbit, and interplanetary missions under the contractual mechanisms known as the NASA Launch Services II (NLS II) contract and the Venture-Class Acquisition of Dedicated and Rideshare (VADR) launch services contract. This provides multiple types of vehicles, ensures the optimal one is chosen to support the spacecraft's mission requirements, and ensures competitive prices prevail among the providers.

The NLS II contract is LSP's **primary method** to acquire NASA-managed launch services for low risk-tolerant missions. NLS II is a multiple-supplier, multiple-award, indefinite-delivery/indefinite-quantity contract mechanism with an ordering period through June 2025 and an overall period of performance through December 2027. NLS II enables **higher levels of mission assurance through additional insight and approvals** to the launch vehicle readiness. NLS II offers the option to on-ramp new launch vehicles each year. LSP also offers unique "one-off" contracting for customers that need additional options that are not offered with NLS II.

Pictured below is the current LSP fleet of launch vehicles on the NLS II contract.



The path to VADR has been an exciting journey. It started with our first round of Venture Class Launch Services (VCLS) contracts (Rocket Lab, Virgin Orbit, Firefly Space Systems), then CAPSTONE (Rocket Lab), VCLS Demo 2 (Astra Space, Relativity Space, Firefly Black), and TROPICS (Astra Space). These were all done as one-off contracts prior to the award of the VADR contract and LSP learned a lot from these acquisitions. Between the spacecraft customer needs and the launch vehicle market maturity, there was a demand for an easier, more streamlined process to procure launch services for Class D, high risk-tolerant payloads. This is what has led us to VADR.

The VADR launch services contract embraces a commercial approach that utilizes a lower level of mission assurance and more commercial practices to achieve **lower launch costs** through Federal Aviation Administration (FAA)-licensed commercial launches. VADR provides a broad range of FAA-licensed commercial launch services capable of delivering payloads ranging from CubeSats to Class D missions that can tolerate **relatively high risk** to a variety of orbits. VADR is a multiple-supplier, multiple-award, fixed-price, indefinite-delivery/indefinite-quantity contract mechanism with a period of performance through January 2027. The acquisition also includes a special on-ramp provision to enable new providers to submit proposals introducing launch services for new capabilities not available or identified at the time of the initial contract award.

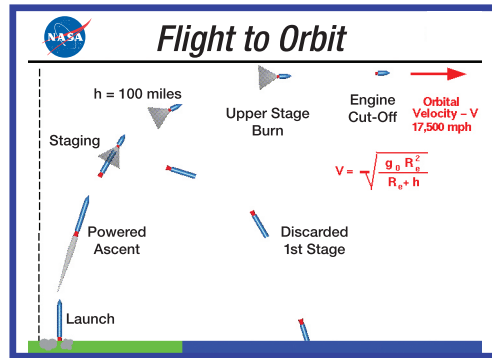
Below are the 12 companies selected to provide launch services for VADR.

- ✈️ **ABL Space Systems**
- ✈️ **Relativity Space**
- ✈️ **Astra Space**
- ✈️ **Rocket Lab USA**
- ✈️ **Blue Origin**
- ✈️ **Spaceflight**
- ✈️ **L2 Solutions**
- ✈️ **SpaceX**
- ✈️ **Northrop Grumman**
- ✈️ **United Launch Alliance**
- ✈️ **Phantom Space**
- ✈️ **Virgin Orbit**

LAUNCH VEHICLE PROVIDERS AND CAPABILITIES

Different Launch Vehicles for Different Orbits

Expendable launch vehicles all use the same basic technology to get off the pad and into space: two or more rocket-powered stages, which fall away when their engine burns complete, as pictured to the right. Reusable launch vehicles allow for recovery of part of the launch system for later use. Whatever the customer puts on top of the final discarded stage is considered the payload or spacecraft. There are multiple orbits to choose from, and different launch vehicles to get them there - all determined by the purpose and requirements of the mission.



- ◆ **Low-Earth Orbit** is between 100 and 1,242 miles (160 and 2,000 km) above the earth. This is the lowest-energy orbit to reach, and is where the International Space Station resides. Satellites travel approximately 17,000 miles per hour to stay in low-Earth Orbit. At that speed, you could get from NASA's Kennedy Space Center to Orlando in about 13 seconds. Satellites with an orbital path over or near the poles maintain a polar orbit, which is usually in low-Earth Orbit.
- ◆ **Medium-Earth Orbit** is between 1,242 and 22,236 miles (2,000 and 35,786 km) above Earth.
- ◆ **Geosynchronous Orbit** is from 22,236 miles (35,786 km) above the earth. Satellites headed for GEO first go to an elliptical orbit with an apogee of about 23,000 miles (37,015 km). Firing of the spacecraft's engines at apogee then makes the orbit round.

New Glenn

Blue Origin's New Glenn rocket is a single configuration heavy-lift launch vehicle capable of carrying people and payloads routinely to Earth orbit and beyond. New Glenn's fully reusable first stage is designed for a minimum of 25 flights. The seven meter fairing has two times the payload volume of any existing launch vehicle and is also able to launch and land in 95% of weather conditions. The Blue Engine 4 (BE-4) will enable New Glenn to launch payloads weighing 45 metric tons to low-Earth orbit and 13 metric tons to geostationary transfer orbit.

Learn more about New Glenn:
blueorigin.com/new-glenn



Artist Rendering:
Blue Origin

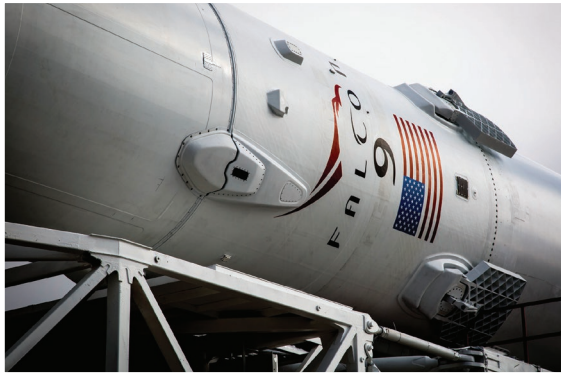
LAUNCH VEHICLE PROVIDERS AND CAPABILITIES

Falcon 9

SpaceX produces multiple configurations of their Falcon launch vehicles. Falcon 9, the world's first commercial orbital class reusable rocket, is a two-stage rocket designed and manufactured by SpaceX for the reliable and safe transport of people and payloads. Reusability allows SpaceX to reflly the most expensive parts of the rocket, which in turn drives down the cost of space access. Falcon 9 is capable of carrying payloads weighing up to 50,265 lbs (22,800 kg) into low-Earth orbit, up to 18,300 lbs (8,300 kg) into geostationary transfer orbit, and up to 8,860 lbs (4,020 kg) to Mars.

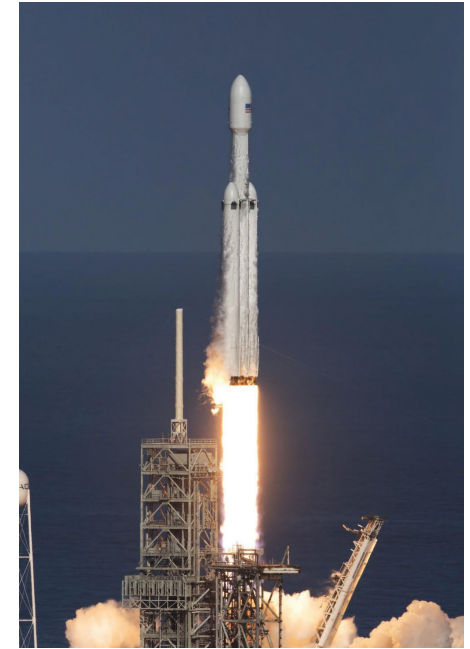


Learn more about Falcon 9: [spacex.com/vehicles/falcon-9](https://www.spacex.com/vehicles/falcon-9)



Falcon Heavy

Falcon Heavy is the most powerful operational rocket in the world by a factor of two. Falcon Heavy is composed of three Falcon 9 nine-engine cores whose 27 Merlin engines together generate more than 5 million pounds of thrust at liftoff, equal to approximately eighteen 747 aircraft. Falcon Heavy is capable of carrying payloads weighing up to 140,660 lbs (63,800 kg) into low-Earth orbit, up to 58,860 lbs (26,700 kg) into geostationary transfer orbit, and up to 37,040 lbs (16,800 kg) to Mars.



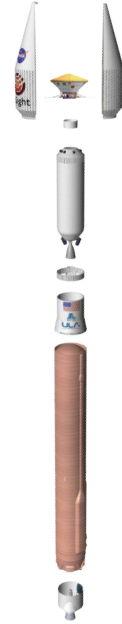
Learn more about Falcon Heavy: [spacex.com/vehicles/falcon-heavy](https://www.spacex.com/vehicles/falcon-heavy)

FUN FACT: To put payload weights into perspective, the average U.S. car weighs 4,000 lbs and a school bus weighs 29,000 lbs. Our launch vehicle providers are doing some heavy lifting!

LAUNCH VEHICLE PROVIDERS AND CAPABILITIES

Atlas V

United Launch Alliance (ULA) offers multiple configurations of the Atlas V rocket. To carry payloads, the 400 series has a fairing of four meters in diameter (which is available in three different lengths), and up to three solid rocket boosters can be added to increase its performance. The Atlas V 400 series can carry a payload weighing up to 33,660 lbs (15,260 kg) to low-Earth orbit, and up to 6,210 lbs (2,820 kg) into Geosynchronous Earth Orbit. The 500 series has a fairing of five meters in diameter (which also comes in three different lengths) to carry much larger payloads into orbit. The Atlas V 500 series can carry a payload weighing up to 41,570 lbs (18,850 kg) to low-Earth orbit, and up to 8,500 lbs (3,850 kg) into Geosynchronous Earth Orbit. Up to five solid rocket boosters can be added to increase its performance.



Learn more about Atlas V and its many configurations:

ulalaunch.com/rockets/atlas-v

Vulcan

ULA's newest launch vehicle, the Vulcan rocket has a fairing of 5.4 meters in diameter (available in two different lengths) and can carry a payload weighing up to 60,000 lbs (27,200 kg) to low-Earth orbit, and up to 15,400 lbs (7,000 kg) into Geosynchronous Earth Orbit. Up to six solid rocket boosters can be added to increase its performance.

Learn more about Vulcan: ulalaunch.com/rockets/vulcan-centaur



To identify the specific configuration of the Atlas V 400 and 500 series, a three-digit (XYZ) naming convention is used to identify (1) the payload fairing size; (2) the number of solid rocket boosters; and (3) the number of Centaur engines.

RELEASED - Printed documents may be obsolete; validate prior to use.



Artist Rendering:
United Launch Alliance

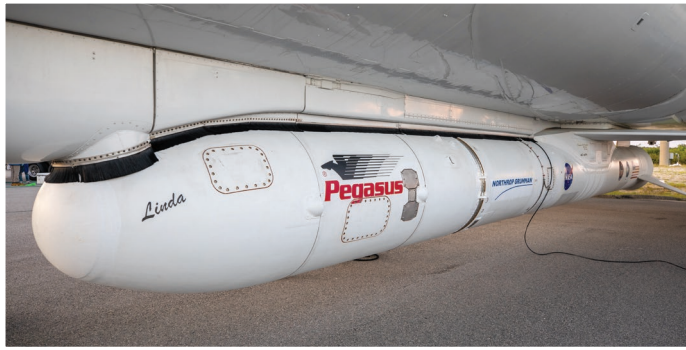
LAUNCH VEHICLE PROVIDERS AND CAPABILITIES

Pegasus XL

Northrop Grumman Space Systems produces the Pegasus XL, a small expendable rocket that attaches beneath the company's Stargazer L-1011 aircraft. Approximately 40,000 feet over open ocean the Pegasus XL is released and free-falls for five seconds before igniting its first stage rocket motor. It is the only airborne-launched rocket. The three-stage Pegasus rocket is used to deploy small satellites weighing up to 1,000 lbs (453.59 kg) into low-Earth orbit. This patented air-launch system provides customers flexibility in launch location and requires minimal ground support.

Learn more about Pegasus XL:

northropgrumman.com/space/pegasus-rocket



Antares

Northrop Grumman's Antares rocket is a two-stage vehicle that provides low-Earth orbit launch capability for payloads weighing up to 17,636 lbs (8,000 kg). An optional third stage allows for higher orbits and planetary missions. The Antares design utilizes powerful RD-181 first stage engines and is primarily used to support the company's Commercial Resupply Services contract with NASA.

Learn more about Antares:

northropgrumman.com/space/antares-rocket

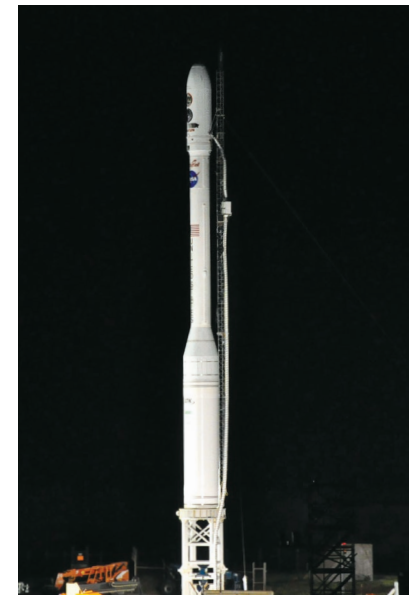


Minotaur-C (Taurus XL)

Minotaur Commercial (Minotaur-C), formerly known as Taurus XL, is a four-stage solid fueled launch vehicle built by Northrop Grumman. Minotaur-C is based on the air-launched Pegasus rocket, substituting the carrier aircraft for a powerful solid rocket motor to carry the vehicle away from the ground. Minotaur-C is able to carry a maximum payload of 3,214 lbs (1,458 kg) into a low-Earth orbit.

Learn more about Minotaur-C:

northropgrumman.com/space/minotaur-rocket



SMALL SATELLITE MISSIONS

As part of the mixed-fleet approach supporting the spacecraft customer's mission requirements, Launch Services Program also manages the launch of small satellite missions, known as CubeSats, which are selected by **NASA's CubeSat Launch Initiative (CSLI)**.

- ◆ CSLI provides access to space for small satellites developed by the NASA Centers and programs, educational institutions, and non-profit organizations. This gives CubeSat developers access to a low-cost pathway to conduct research in the areas of science, exploration, technology development, education, or operations.
- ◆ By providing a progression of educational opportunities including CSLI for students, teachers, and faculty, NASA assists the nation in attracting and retaining students in Science, Technology, Engineering, and Mathematics (STEM) disciplines.
- ◆ CSLI also promotes and develops innovative technology partnerships among NASA, U.S. industry, and other sectors for the benefit of agency programs and projects. NASA thus gains a mechanism to use CubeSats for low-cost technology development or pathfinders.
- ◆ CubeSats, also called nanosatellites, come in several sizes and are based on the standard CubeSat "unit," measuring 10x10x10cm or 1U (small enough to fit in the palm of your hand). CSLI launches CubeSats as small as 1U and as large as 12U.

- ◆ Due to the small size of CubeSats and the amount of research they can complete once in orbit, NASA can make room for them on the same rockets that take much larger payloads into space. In these instances, the CubeSats are essentially "hitchhiking" to space and are considered secondary payloads to the primary satellites being launched.
- ◆ Launch Services Program finds these rides to space for CSLI selected CubeSats by manifesting them on NASA, military, or commercial launch vehicles going to the right orbit in the right timeframe. The complement of CSLI CubeSats on a given flight is referred to as an **Educational Launch of Nanosatellites (ELaNa) mission**.
- ◆ Once manifested, LSP works with both the CubeSat developer and the launch service provider to ensure that technical, safety, and regulatory requirements are satisfied before launch.

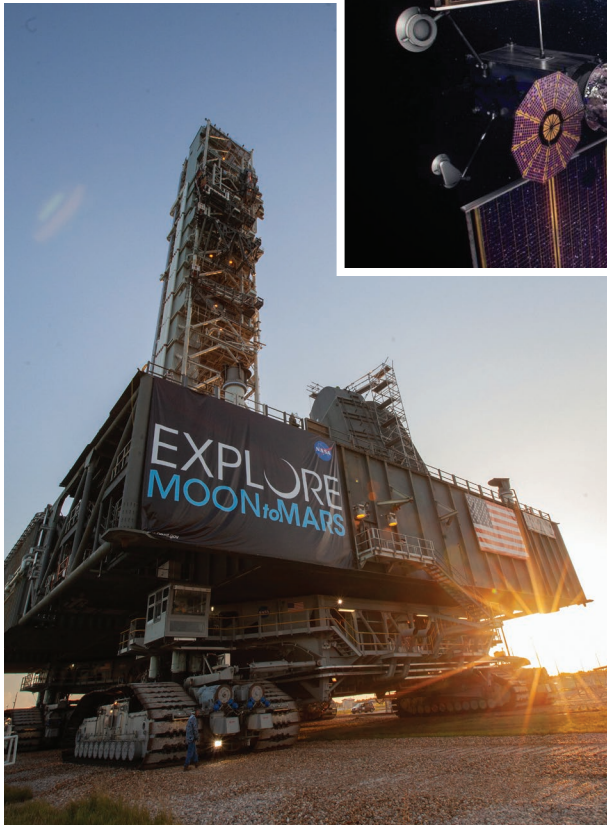
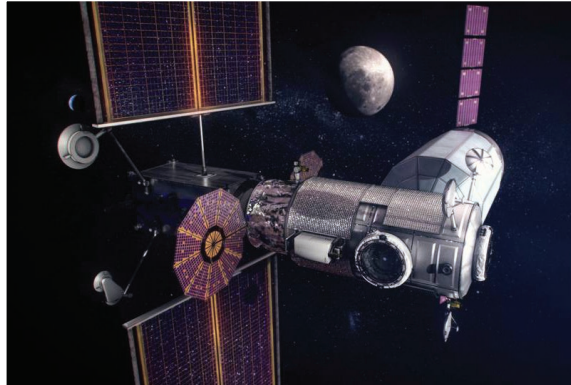


For more information and videos on NASA's historical and upcoming small satellite missions visit:
nasa.gov/directorates/heo/home/CubeSats_initiative

ADVISORY ROLE MISSIONS

Artemis Program & The Gateway

The Launch Services Program supports NASA's return to the Moon. For NASA's Artemis architecture, LSP is serving in a major consulting role for the Gateway Logistics Element, the Human Landing System, the Habitation and Logistics Outpost, and the Power and Propulsion Element, as well as providing mission management to deliver the Canadian Deep Space Exploration Robotic System to the Gateway. LSP is also leveraging expertise in Venture Class Launch Services and has contracted for the launch of CAPSTONE, a precursor lunar CubeSat mission, to reduce technical risk in advance of crewed Artemis campaigns.



Commercial Crew Program & Commercial Resupply Services

LSP also provides advisory expertise for Commercial Crew Program (CCP) missions and Commercial Resupply Services (CRS) program missions in support of the International Space Station. LSP supports CCP and CRS on an as-needed basis by giving insight into the launch vehicles and assessments on certain aspects by request depending on the details of the mission. So far, LSP has provided advisory services for more than 40 CRS missions launched on SpaceX's Falcon 9 and Northrop Grumman's Antares rockets. LSP also provides advisory services for SpaceX and Boeing CCP current and future missions.



PARTNERSHIPS AND COLLABORATION

The reach of Launch Services Program is far and wide. LSP is able to successfully carry out its mission with the support of numerous NASA programs/centers, Department of Defense, commercial providers, foreign governments, start-ups, and more.

Space exploration and scientific discovery is a team effort.

LSP is partnered with innovative aerospace and technology companies from all over the world. Below are all of the companies currently awarded LSP-managed contracts.



New Horizons

New Horizons launched on a ULA Atlas V rocket from Space Launch Complex 41 at Cape Canaveral Air Force Station on January 19, 2006. It swung past Jupiter for a gravity boost and scientific studies in February 2007, and conducted a six-month-long reconnaissance flyby study of Pluto and its moons in the summer of 2015. **The New Horizons mission was to examine Pluto's and Charon's global geology and geomorphology, map their surface compositions and temperatures, and examine Pluto's complex atmosphere.** As part of an extended mission in 2019, the spacecraft headed further into the Kuiper Belt to examine another of the ancient, icy mini-worlds in that vast region, at least a billion miles beyond Neptune's orbit. The mission is currently extended through 2021 to explore additional Kuiper Belt objects.

The Johns Hopkins University Applied Physics Laboratory (APL) designed, built, and operates the New Horizons spacecraft and manages the mission for NASA's Science Mission Directorate. A close-up look at these worlds from a spacecraft promises to tell an incredible story about the origins and outskirts of our solar system. New Horizons is exploring – for the first time – how ice dwarf planets like Pluto and Kuiper Belt bodies have evolved over time.



To see more of the incredible images captured by New Horizons, visit:

[nasa.gov/mission
pages/newhorizons
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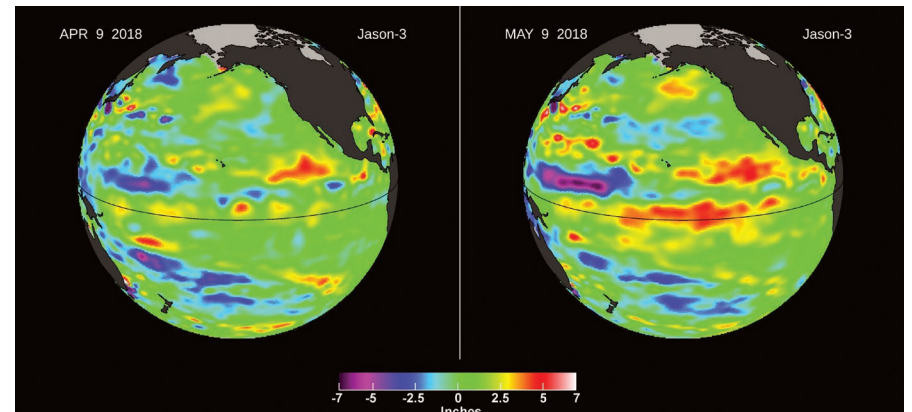
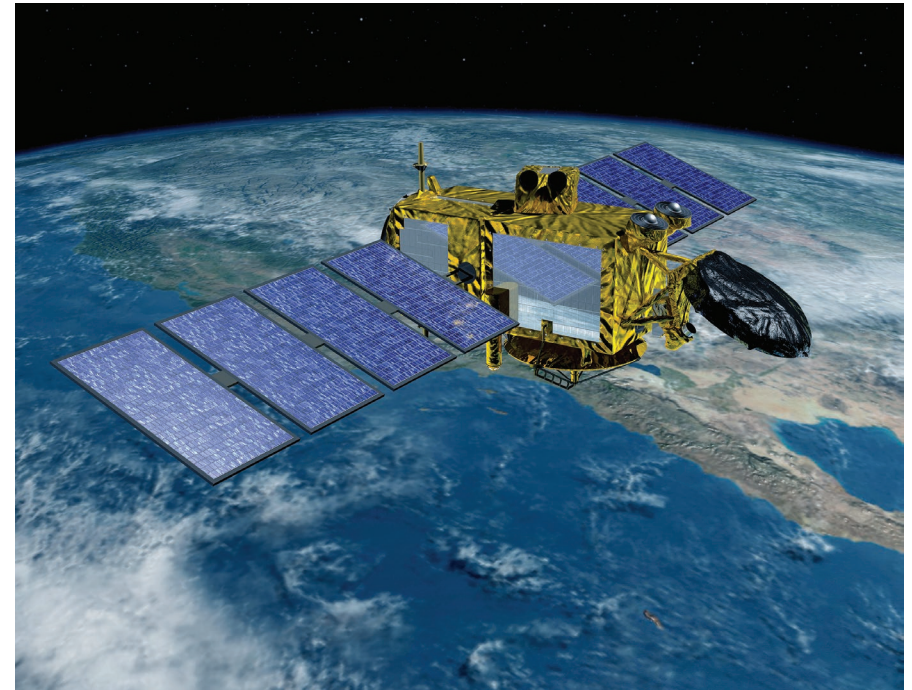
HISTORICAL MISSION HIGHLIGHTS

January 17
2016

Joint Altimetry Satellite Oceanography Network-3 (Jason-3)

Jason-3 lifted off from Space Launch Complex 4E at Vandenberg Air Force Base in California on January 17, 2016 aboard a SpaceX Falcon 9 rocket. It is the fourth mission in the U.S.-European series of satellites that measure the height of the ocean surface. The mission will **improve weather, climate, and ocean forecasts**, including helping NOAA's National Weather Service and other global weather and environmental agencies more **accurately forecast the strength of tropical cyclones**.

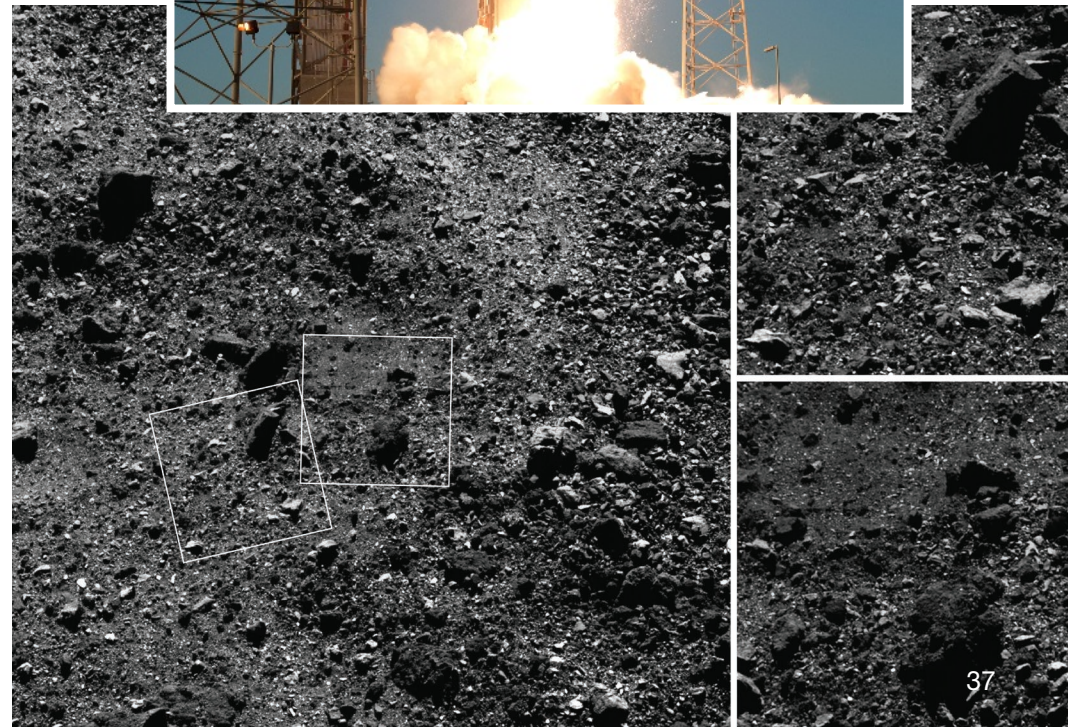
The mission extended the time series of ocean surface topography measurements begun by the TOPEX/Poseidon satellite mission in 1992, continuing through the Jason-1 mission launched in 2001 to the currently operations OSTM/Jason-2 mission launched in 2008.



Jason-3 has begun mapping the ocean! This shows sea surface height (blue/magenta indicates lower-than-normal sea levels, while yellow/red indicates higher-than-normal sea levels). Data from Jason-3 will be used to monitor climate change and track phenomena like El Niños.

Origins, Spectral Interpretation, Resource Identification, and Security-Regolith Explorer (OSIRIS-REx)

OSIRIS-REx, NASA's first asteroid sampling mission, launched from Space Launch Complex 41 at Cape Canaveral Air Force Station atop a ULA Atlas V rocket on September 8, 2016, for a seven-year mission to and from near-Earth asteroid Bennu. This was the beginning of a journey that could revolutionize our understanding of the early solar system. **The OSIRIS-REx mission is to map Bennu's surface using 3D laser imaging, retrieve samples from the surface, and return to Earth.** The mission will help scientists investigate how planets formed and how life began, as well as improve our understanding of asteroids that could impact Earth. The spacecraft completed its 1.2 billion-mile journey and arrived at asteroid Bennu in December of 2018. OSIRIS-REx is scheduled to return the sample to Earth in 2023.



Transitioning Exoplanet Survey Satellite (TESS)

NASA's newest planet hunter, TESS, is the next step in the search for planets outside of our solar system, including those that could support life. The mission will survey the entire sky over the course of two years and will **analyze 200,000 of the brightest stars near the Sun to search for transiting exoplanets.**

TESS launched on April 18, 2018, aboard a SpaceX Falcon 9 rocket from Cape Canaveral Air Force Station. During its first year of science, TESS discovered 21 planets outside of our solar system.

TESS scientists expect the mission will catalog more than 2,000 planet candidates and vastly increase the current number of known exoplanets. Of these, approximately 300 are expected to be Earth-sized and super-Earth-sized exoplanets, which are worlds no larger than twice the size of Earth. TESS will find the most promising exoplanets orbiting our nearest and brightest stars, **giving future researchers a rich set of new targets for more comprehensive follow-up studies.** The prime mission ended July 2020, with an extended mission following shortly after.



FUN FACT: 100 light-years away, in our own Milky Way galaxy, in the constellation Dorado, sits a planetary system named TOI 700. It is home to TOI 700 d, the first Earth-size habitable-zone planet discovered by TESS.

To keep up with the latest TESS stories, visit:
nasa.gov/content/latest-tess-stories

HISTORICAL MISSION HIGHLIGHTS

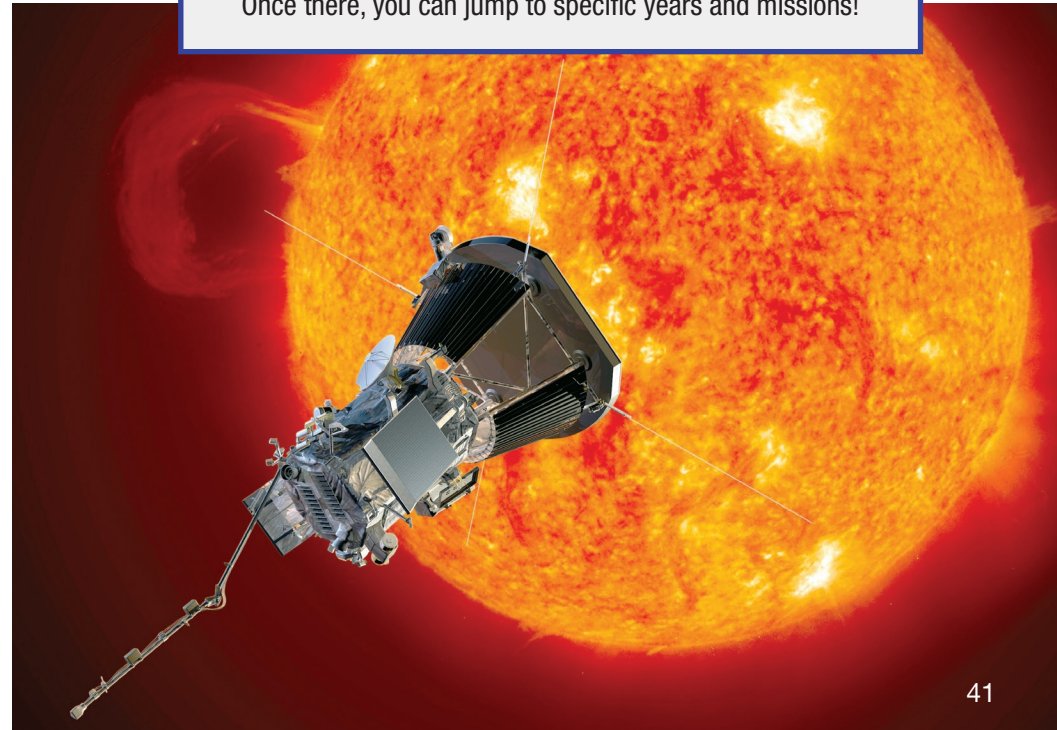
Parker Solar Probe

NASA's Parker Solar Probe launched aboard a ULA Delta IV Heavy rocket on August 12, 2018, from Space Launch Complex 37 at Cape Canaveral Air Force Station and will be the **first-ever mission to “touch” the Sun**. The spacecraft will travel directly into the Sun's atmosphere about 4 million miles from our star's surface. NASA's historic Parker Solar Probe mission will revolutionize our understanding of the Sun, where changing conditions can propagate out into the solar system, affecting Earth and other worlds. Parker Solar Probe will travel closer to the Sun's surface than any spacecraft before it, **facing brutal heat and radiation conditions**—and ultimately providing humanity with the closest-ever observations of a star.

On June 9, 2020, NASA's Parker Solar Probe signaled the success of its fifth close pass by the Sun, called a perihelion, with a radio beacon tone. The spacecraft completed the fifth perihelion flying within 11.6 million miles from the Sun's surface and reaching a top speed of about 244,225 miles per hour. **This sets the record for closest human-made object to the Sun and fastest human-made object.**



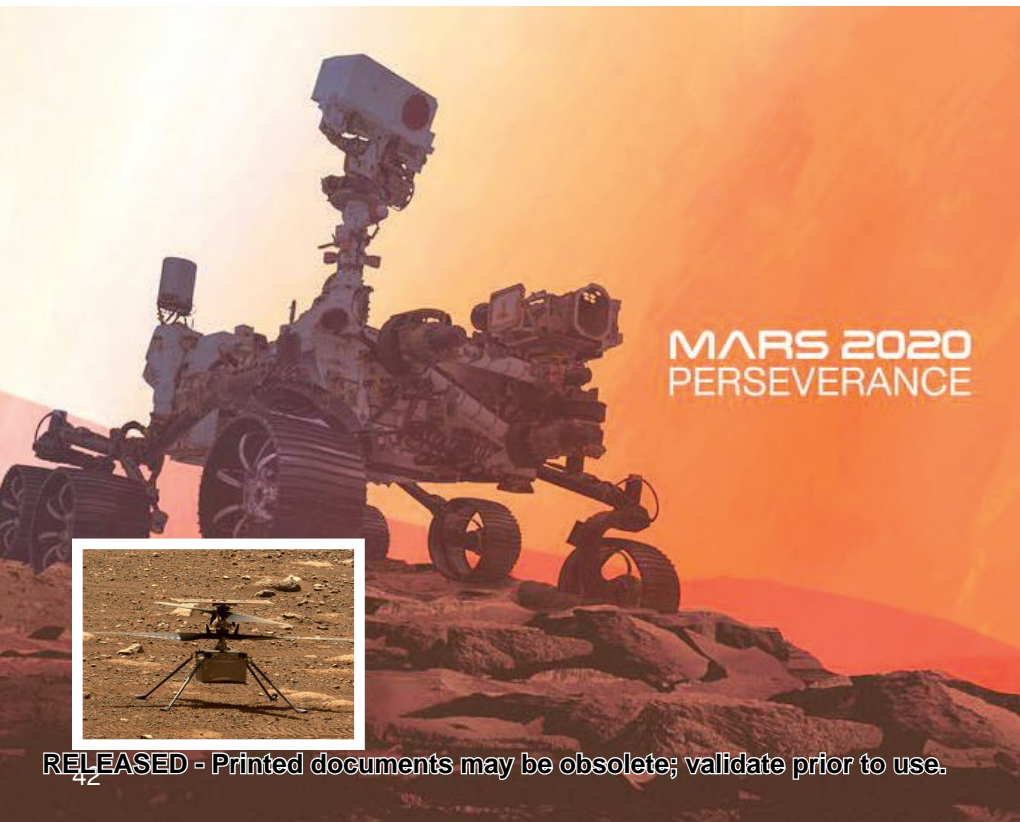
To learn more about LSP's historical launches, visit:
public.ksc.nasa.gov/lsp/history
Once there, you can jump to specific years and missions!



Mars 2020 - Perseverance and Ingenuity

The Mars 2020 mission launched aboard a ULA Atlas V rocket on July 30, 2020, from Launch Complex 41 at Cape Canaveral Space Force Station. Mars 2020 is part of NASA's Mars Exploration Program, a long-term effort of robotic exploration of the Red Planet. This mission addresses high-priority science goals, including **determining whether life ever existed on Mars, characterizing the planet's climate and geology, and preparing for future human exploration**. After a 7 month journey, the Perseverance rover landed on the Red Planet. The rover introduced a drill that has collected core samples of the most promising rocks and soils and set them aside for a future mission that could potentially return these samples to Earth. Perseverance was joined by Ingenuity, a small helicopter that became the first ever technological demonstration of powered flight on another planet.

The mission also provides opportunities to gather knowledge and demonstrate technologies that address the challenges of future human expeditions. These include testing a method for producing oxygen from the Martian atmosphere, identifying other resources (such as subsurface water), improving landing techniques, and characterizing weather, dust, and other potential environmental conditions that could affect **future astronauts living and working on Mars**.



Explore with Perseverance!

Check out the sites Perseverance is studying, view images taken by the rover, and more, in this interactive experience!

mars.nasa.gov/mars2020/surface-experience

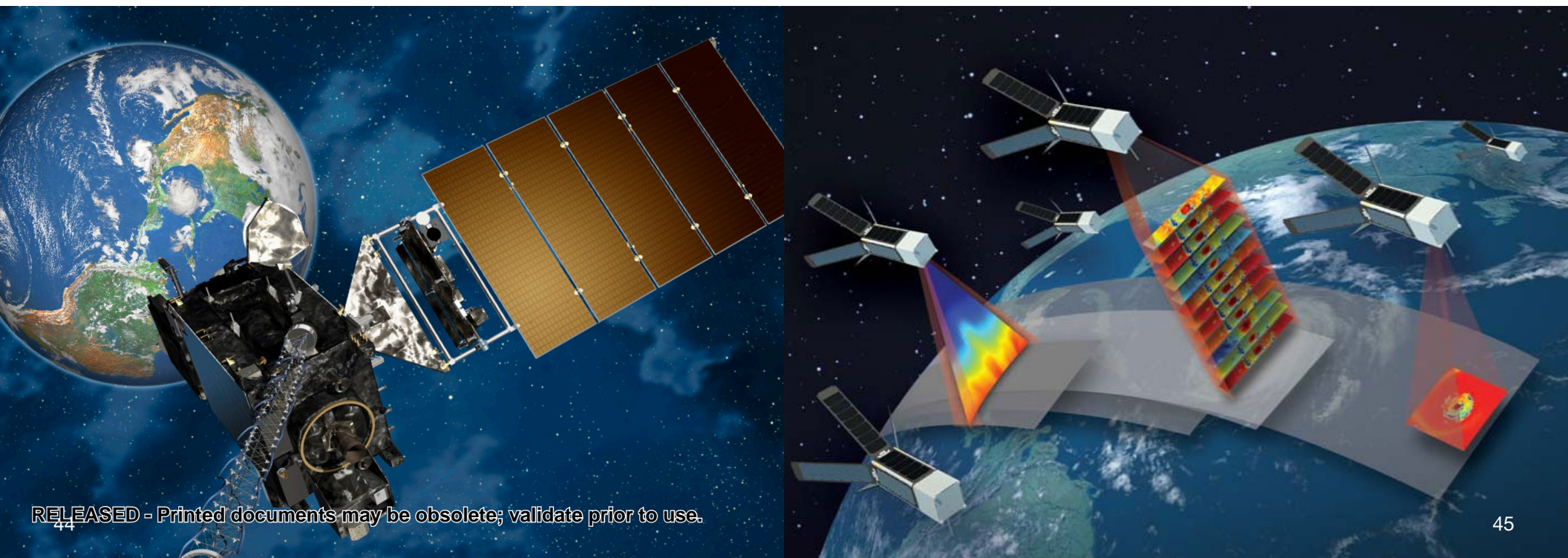
IN THE LAUNCH QUEUE FOR 2022-2023

Geostationary Operational Environmental Satellite-T (GOES-T)

The GOES-T mission will provide advanced imagery and atmospheric measurements of Earth's **weather, oceans, and environment**. The mission will also provide real-time mapping of lightning activity and improved monitoring of solar activity and space weather. GOES-T is the third spacecraft in NOAA's GOES-R Series, the Western Hemisphere's most sophisticated weather observing and environmental monitoring system. These satellites circle the Earth in a geosynchronous orbit, meaning they orbit Earth's equatorial plane at the same speed of Earth's rotation. This allows them to stay in a fixed position in the sky in respect to a point on the ground. Following a successful on-orbit checkout of its instruments and systems, NOAA will put GOES-T immediately into operational service, becoming GOES West. GOES-T will work in tandem with NOAA's operational GOES East satellite to **watch over more than half the globe** – from the west coast of Africa to New Zealand.

Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats (TROPICS)

The TROPICS mission comprises of a **constellation of six CubeSats** in three low-Earth orbital planes. TROPICS will provide rapid-refresh microwave measurements over the tropics that can be used to observe the thermodynamics of the troposphere and precipitation structure for storm systems over the entire storm lifecycle. This observing system offers an unprecedented combination of horizontal and temporal resolution to measure environmental and inner-core conditions for **tropical cyclones on a nearly global scale**. TROPICS hopes to demonstrate that a constellation approach to Earth science can provide improved resolution, configurable coverage (tropics, near global, or global), flexibility, reliability, and launch access at extremely low cost, thereby serving as a model for future missions.

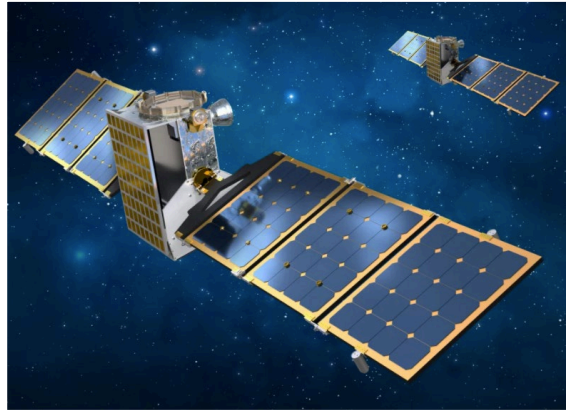


IN THE LAUNCH QUEUE FOR 2022-2023

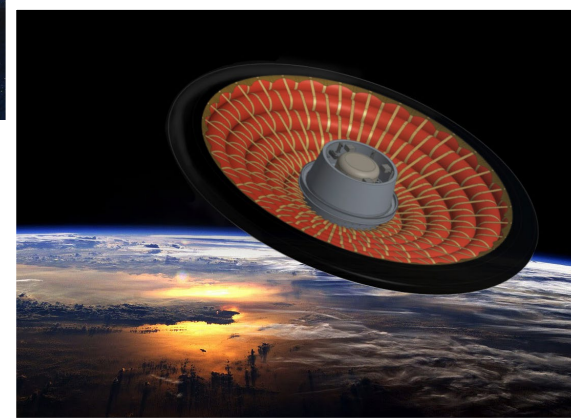
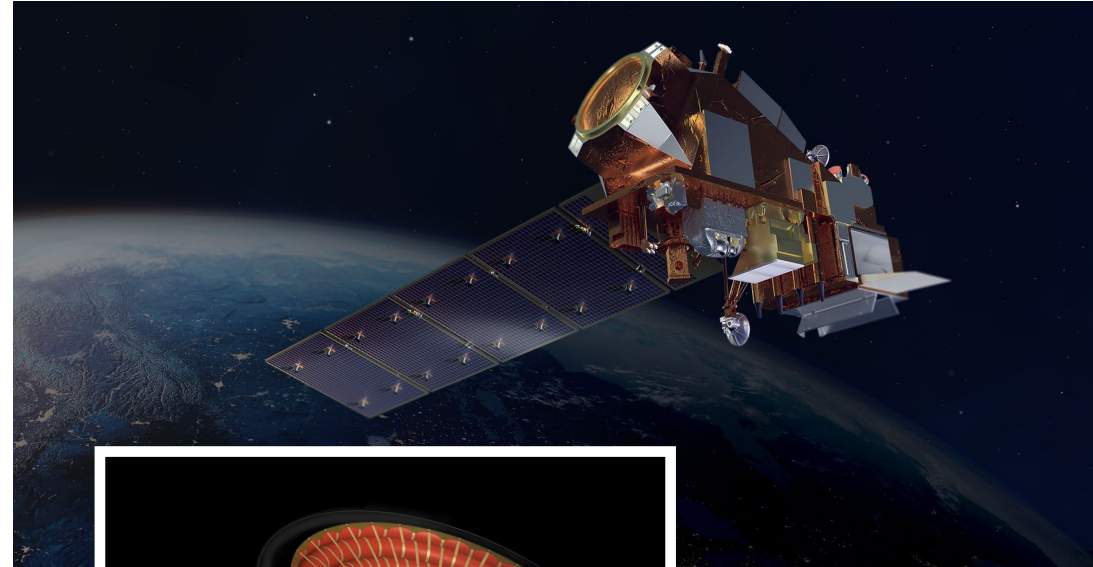
Psyche/Janus

The Psyche mission is a journey to a **unique metal-rich asteroid** orbiting the Sun between Mars and Jupiter. What makes the asteroid Psyche unique is that it appears to be the exposed nickel-iron core of an early planet, one of the building blocks of our solar system. Deep within rocky, terrestrial planets - including Earth - scientists infer the presence of metallic cores, but these lie unreachably far below the planets' rocky mantles and crusts. Because we cannot see or measure Earth's core directly, Psyche offers a unique window into the violent history of collisions and accretion that created terrestrial planets.

Janus is a mission designed to send two small spacecraft into the main asteroid belt. Each spacecraft will **fly by a binary asteroid** and image it with visible and infrared cameras. The primary scientific objectives are to identify and understand the processes that lead to binary asteroid formation, and test and evaluate theories for binary asteroid evolution.



Joint Polar Satellite System 2 (JPSS-2)/Low-Earth Orbit Flight Test of an Inflatable Decelerator (LOFTID)



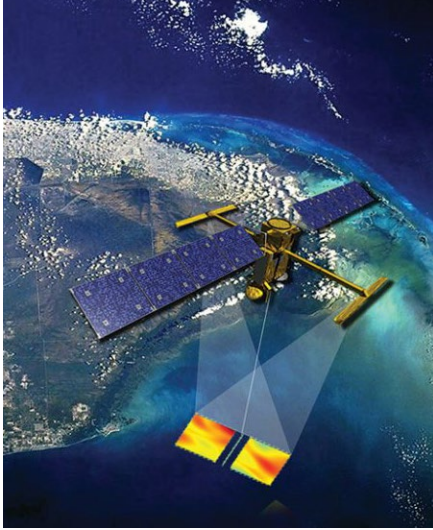
The second satellite in NOAA's JPSS series, JPSS-2 will circle the Earth from pole-to-pole and cross the equator 14 times daily, providing full global coverage twice a day. JPSS-2 will provide continuity

of meteorological data and observations of **atmosphere, ocean, and land** for monitoring and forecasting. NOAA's National Weather Service uses this data to increase accuracy of forecasts 3-7 days in advance of severe weather events.

The LOFTID mission will **demonstrate an inflatable aeroshell**, a type of heat shield, for atmospheric re-entry. For destinations with an atmosphere, one of the challenges faced is how to deliver heavy payloads (experiments, equipment, and people). After JPSS-2 reaches orbit, LOFTID will be put on a re-entry trajectory from low-Earth orbit to see if the heat shield can slow down and survive re-entry.

IN THE LAUNCH QUEUE FOR 2022-2023

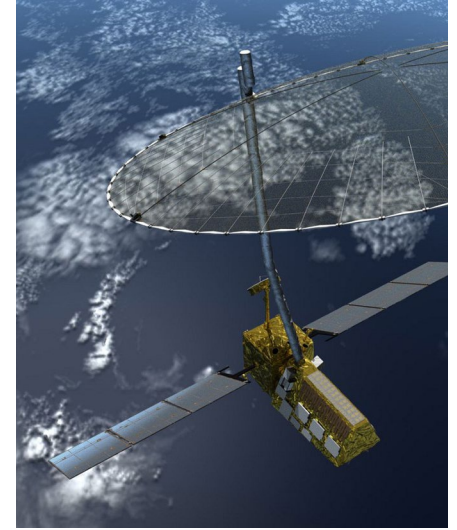
Surface Water and Ocean Topography (SWOT)



The SWOT satellite will collect detailed measurements of how Earth's bodies of water change over time and make the first-ever global survey of Earth's surface water. SWOT will survey at least 90 percent of the globe, studying Earth's **lakes, rivers, reservoirs, and oceans** at least twice every 21 days to improve ocean circulation models, weather and climate predictions, and aid in freshwater management around the world.

NASA-ISRO Synthetic Aperture Radar (NISAR)

NISAR will use advanced radar imaging to observe and take measurements of some of the planet's **most complex processes**. These include ecosystem disturbances, ice-sheet collapse, and natural hazards such as earthquakes, tsunamis, volcanoes and landslides. Data collected from NISAR will reveal information about the evolution and state of Earth's crust, our planet's changing climate, and aid future resource and hazard management.



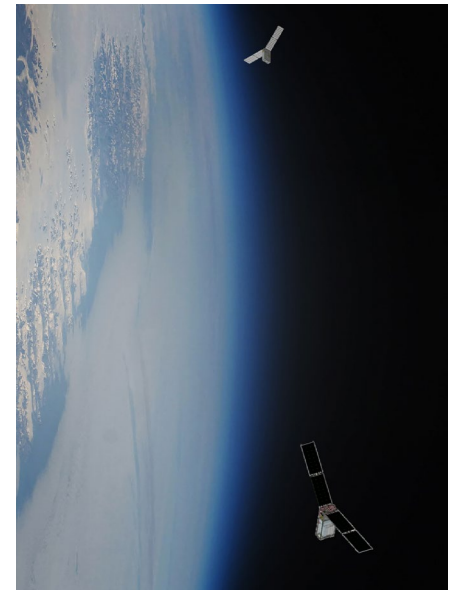
Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE)



CAPSTONE is a CubeSat weighing just 55 pounds that will serve as the first spacecraft to test a **unique, elliptical lunar orbit**. As a precursor for Gateway, a Moon-orbiting outpost that is part of NASA's Artemis program, CAPSTONE will help reduce risk for future spacecraft. Specifically, it will validate the power and propulsion requirements for maintaining this orbit and will demonstrate the reliability of innovative spacecraft-to-spacecraft navigation solutions and communication capabilities with Earth.

Polar Radiant Energy in the Far InfraRed Experiment (PREFIRE)

The PREFIRE mission will consist of two CubeSats in two different near-polar orbits to measure variations in Far Infrared Radiation (FIR) emissivity and greenhouse effect. PREFIRE will use thermal radiometric sampling of **Arctic and Antarctic surfaces and clouds** at the top of the polar atmosphere. These measurements are integrated with models to understand the role of FIR radiation in Arctic climate.



LSP

NASA's Launch Services Program 2022-2023



KNOWLEDGE LAUNCH

Now that you have broadened your knowledge of “rocket science” and the work of NASA’s Launch Services Program, here are some final questions to see just how much you’ve launched your learning. **Good luck!**

- 1) What year was the LSP established?
 - a. 2001
 - b. 1998
 - c. 1995
- 2) True or False: LSP’s job is to act like a broker, matching spacecraft with launch vehicles and manage the service to ensure mission success.
- 3) True or False: LSP’s two primary launch sites are Cape Canaveral Space Force Station (CCSFS) in Florida, and Vandenberg Space Force Base (VSFB) in California.
- 4) On average, how long does it take to go from mission selection to launch (end-to-end)?
 - a. Between 4-10 years
 - b. Between 1-5 years
 - c. Between 9-15 years
- 5) How long did it take from launch for the “Perseverance” rover to land on Mars?
 - a. 5 hours
 - b. 7 months
 - c. 2 years
- 6) True or False: A satellite must travel fast, at a speed of approximately 17,000 miles per hour, to remain in low-Earth Orbit.

- 7) How do small satellite missions, CubeSats, compare to traditional/primary satellite missions?
 - a. CubeSats are the same as primary satellites.
 - b. CubeSats are tiny in size, low in cost, and help engineers, researchers, and students conduct science in a host of fields. CubeSat missions also assume lower risk levels, and have lower insight and approval, and therefore are faster to launch.
- 8) What primary factors are considered when deciding the proper launch site location?
 - a. The decision is based on which launch site is available.
 - b. The decision is based on knowing the type of science needed, and where the orbital destination of the satellite will need to reach in order to accomplish the science.
- 9) True or False: LSP offers a mixed-fleet approach to support science, Earth-orbit, and interplanetary missions under the contractual mechanisms known as NLS II and VADR.
- 10) True or False: The Launch Services Program has launched nearly 100 missions to date.

Answers: 1. b; 2. True; 3. True; 4. a; 5. b; 6. True; 7. b; 8. b; 9. True; 10. True

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