Galactic Observer

John J. McCarthy Observatory

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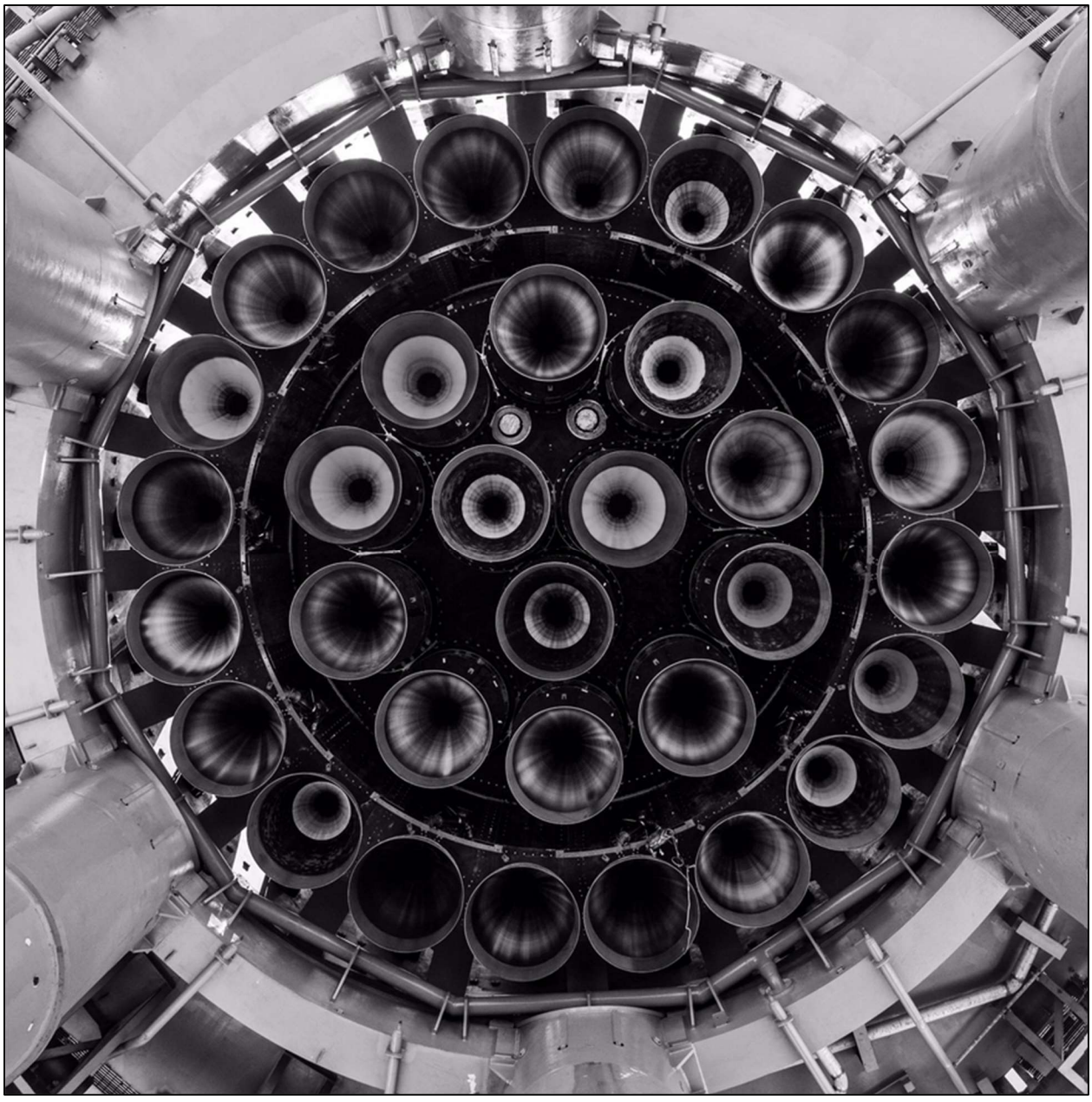
Pliva Vallis, an outflow channel on the east side of Jezero Crater, Mars
Credit: Image: HiRISE/CTX/HRSC

March Astronomy Calendar and Space Exploration Almanac



Looking up at the engine compartment of SpaceX's Super Heavy Booster and its 33 Raptor 2 methane-powered engines. The booster underwent a critical all-engine test-firing at Starbase in Boca Chica, Texas, on February 9th in preparation for its first orbital flight. Photos of the test-firing can be found on page 11.

Credit: SpaceX

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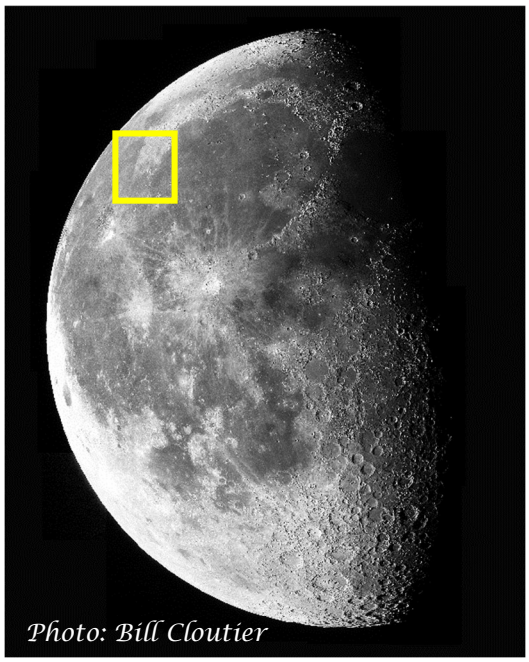
"Out the Window on Your Left"

It's been more than 50 years since Apollo astronaut Gene Cernan left the last boot print on the Moon's surface. As a nation founded on exploration and the conquest of new frontiers, today's commitment to return to the Moon has been as fleeting as the funding. But what if the average citizen had the means to visit our only natural satellite; what would they see out the window of their spacecraft as they entered orbit around the Moon? This column may provide some thoughts to ponder when planning your visit (if only in your imagination).

November's flight of the Space Launch System marked NASA's first major milestone in its Artemis program and a return to the Moon. In contrast to the Apollo program, this time, NASA is partnering with other countries and commercial enterprises for services related to its lunar ambitions.



Location of the Gruithuisen Domes

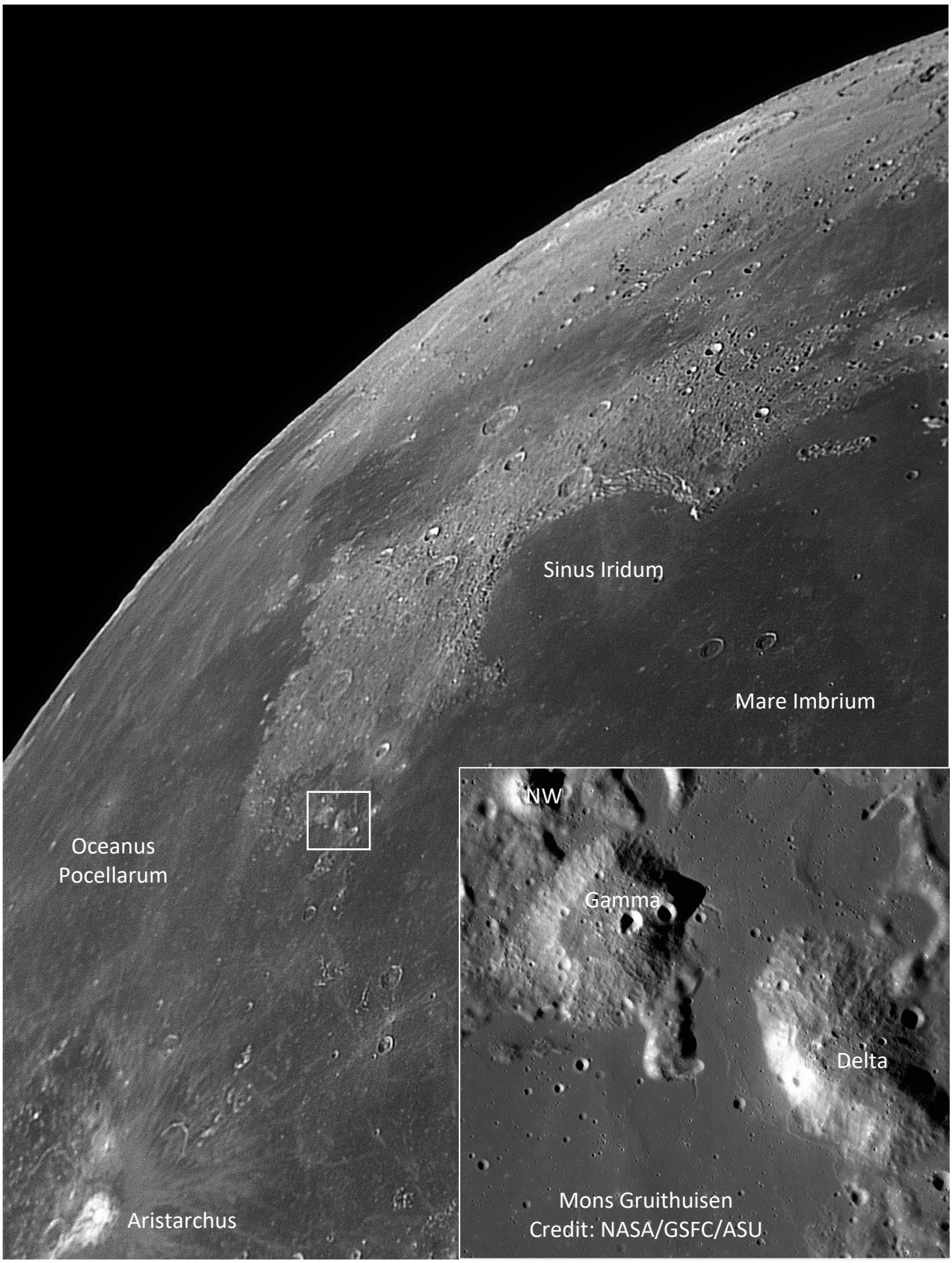
NASA's Commercial Lunar Payload Services program enables the agency to solicit lunar delivery assistance from pre-qualified American companies. Today there are 14 eligible providers for services that include payload integration, mission operations, launch from Earth and landing on the surface of the Moon.

Three companies were originally scheduled to deliver payloads to the Moon in 2023: Astrobotic, Intuitive Machines, and Masten Space Systems (acquired by Astrobotic in September 2022). In NASA's original 2019 order, Astrobotic was tasked with delivering its payload to Lacus Mortis ("Lake of Death"), a basaltic plain located south of the elongated Mare Frigoris ("Sea of Cold") on the eastern limb of the near side of the Moon. In February, NASA announced that it was retargeting the mission to the Gruithuisen Domes, located on the northeast edge of Oceanus Procellarum or "Ocean of Storms." Astrobotic's Peregrine lander will carry a diverse suite of scientific instruments, a rover, and other equipment from six different countries and dozens of science teams to the lunar surface. The lander will launch on the inaugural flight of United Launch Alliance's Vulcan Centaur rocket, tentatively in the first quarter of 2023.

The Gruithuisen Domes are a lunar geologic conundrum. They appear to have a high silicic content, much higher than the surrounding basaltic plains, as well as most of the Moon. On Earth. silicic volcanoes like Mount St. Helens are typically formed in the presence of two ingredients – water and plate tectonics. The Moon has neither (no significant water), raising the question: how did the Gruithuisen Domes form?

The domes, designated Gamma, Delta and Northwest are approximately 3.8 billion years old and are bounded by plains with ages varying from 2.3 to 3.6 billion years. While low-lying domes are common on the Moon, the larger Gruithuisen massifs rise about a mile (1.5 km) above their surroundings and are an order-of-magnitude larger than their mare counterparts.

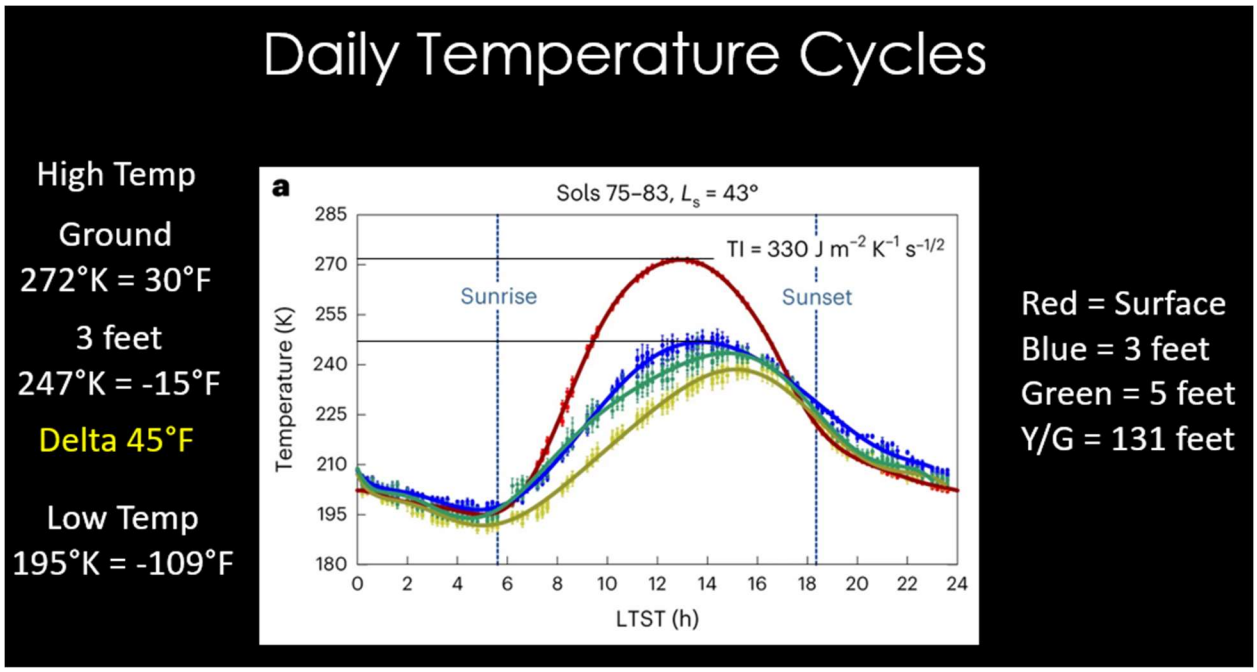
Gruithuisen Domes



Weather Report from Jezero

NASA's Perseverance rover was sent to Mars with a comprehensive suite of weather instruments. The sensors in the package, called the Mars Environmental Dynamics Analyzer or MEDA, are providing researchers information on the local environment in unparalleled detail. Data from MEDA is being transmitted on pressure, air and surface temperature, relative humidity, wind, aerosol (dust) concentrations, and solar radiative forcing (a measurement of the energy balance between incoming solar radiation energy and outgoing thermal infrared emission). Researchers have used the MEDA data to characterize daily, as well as seasonal, changes in the crater.

The Perseverance rover landed inside Jezero crater on February 18, 2021, near the northwest rim, in the early Martian spring. Researchers have now published weather data on the first 250 sols (Martian days) of the mission, encompassing the northern hemisphere spring to early summer.

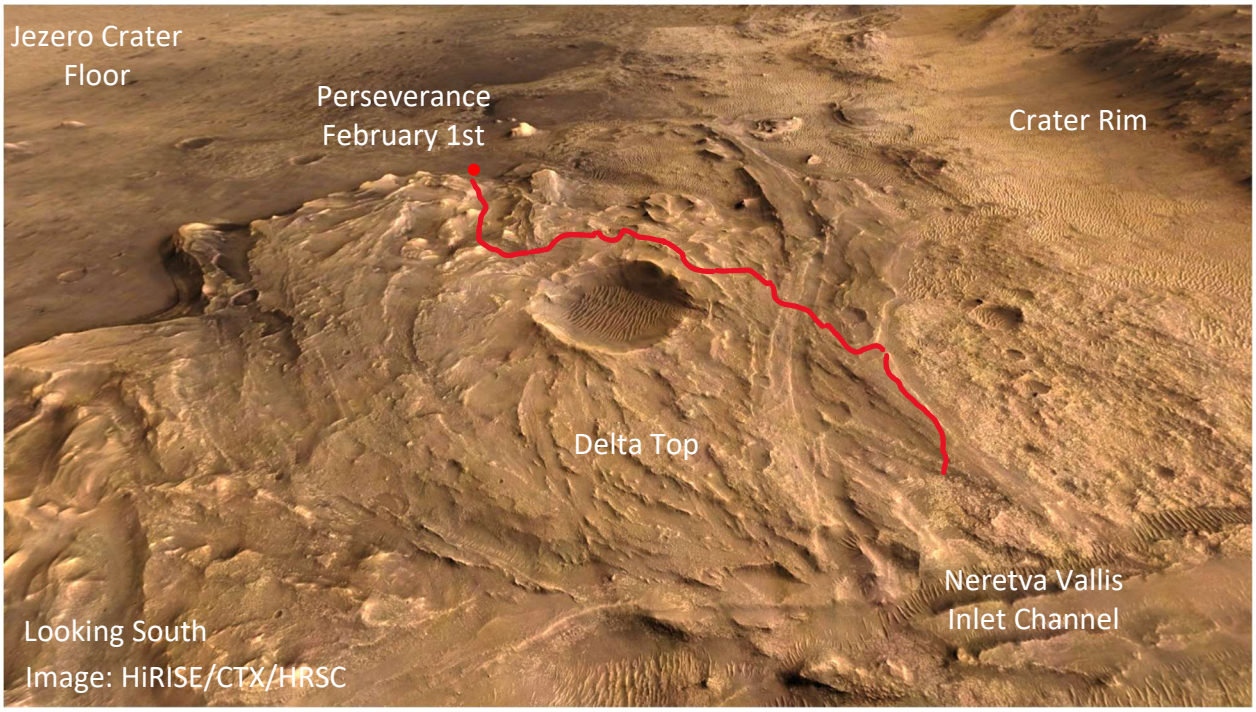


Rodriguez-Manfredi, J.A., de la Torre Juarez, M., Sanchez-Lavega, A. et al. The diverse meteorology of Jezero Crater over the first 250 sols of Perseverance on Mars. Nat. Geosci. (2023)

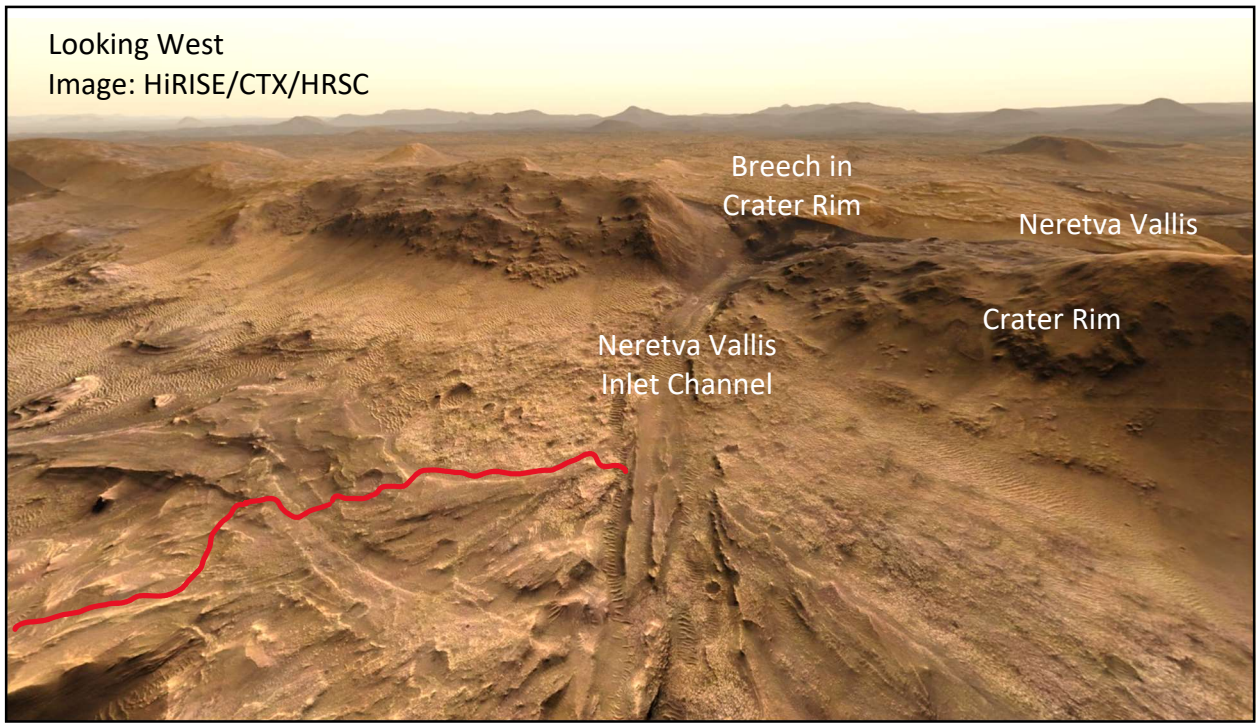
MEDA sensors on the rover's mast and body provide continuous tracking of temperature at four heights in the lower part of the atmosphere in direct interaction with the surface. In this layer, most of the atmospheric dynamics is driven by radiative processes (from the heating of the surface). Temperature measurements are taken at the surface and at heights around 3 feet (0.85 meters), 5 feet (1.45 meters), and about 130 feet (40 meters).

The graph (above) plots the average temperature at the surface and the three elevated points throughout a Martian day for nine sols in late spring. Temperatures peak shortly after noon before quickly collapsing in the afternoon. Because Mars has a very thin atmosphere, roughly 100 times less dense than Earth's atmosphere, there is a steep temperature gradient between the surface and the elevated measurements. For example, the temperature at noon on the surface is about 45°F (7°C) higher than that measured only 3 feet (0.85 meters) above the surface.

Delta Top



Perseverance's prime mission concluded on January 6, 2023, one Martian year after its landing in February 2021. The caching of ten of its rock and soil samples for future retrieval at a location called “Three Forks” in January marked the end of the rover’s “Delta Front” operation and the beginning of its extended mission and the “Delta Top” campaign. This next phase, expected to last eight months, will provide scientists a look at the upper surface of the ancient river delta as they search for material delivered by the inlet waterway from surrounding areas of the planet.



Leading the Way to the Top

Image of the delta ascent acquired by NASA's Mars Helicopter's high-resolution color camera
Credits: NASA/JPL-Caltech

A Martian winter is almost twice as long as on Earth. With the extreme cold and dust-laden skies, NASA's Ingenuity helicopter struggled to survive, running out of power each night to keep itself warm. The recurring "near-death" experience wasn't fatal, but it did cause the helicopter's clock to reset, disrupting its communication link with the rover. With the batteries never fully charged, any energy accumulated during those short winter days was used to keep warm rather than flying.

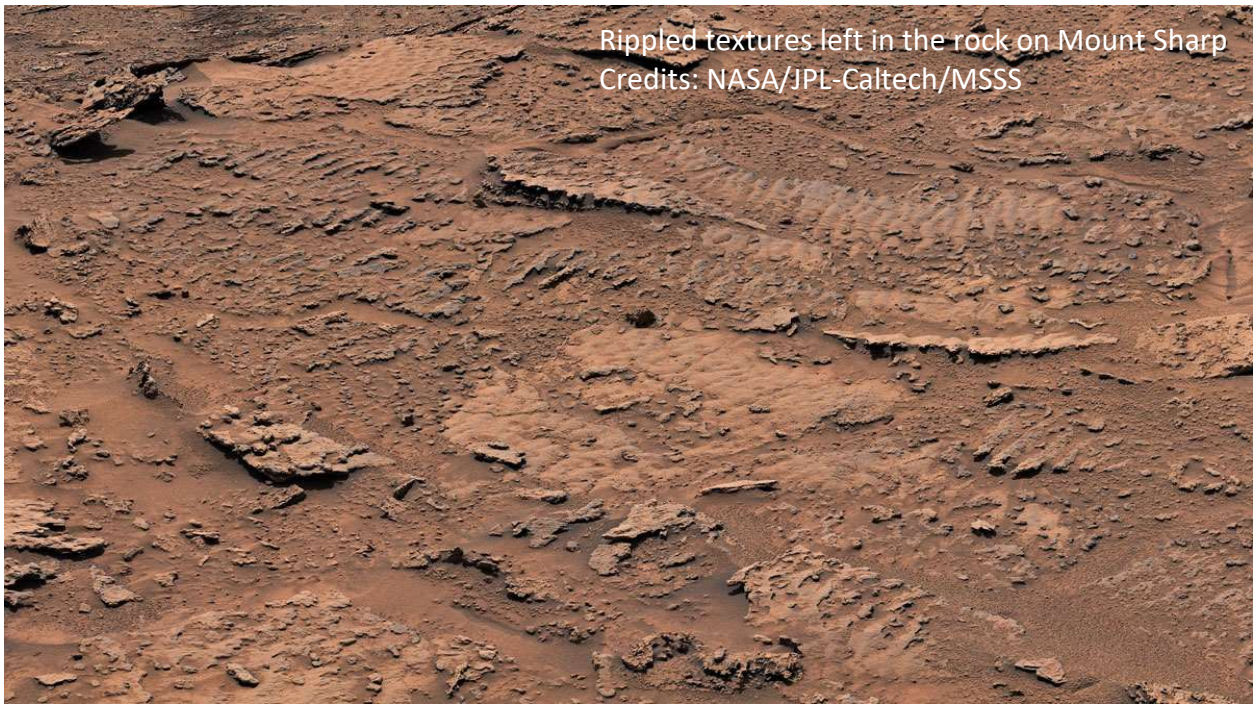
With the arrival of Spring at the end of December (on Earth), the Ingenuity team has been able to get back to the business of exploring Jezero crater and conducting scouting sorties for the Perseverance rover. NASA is currently using Ingenuity to scout the route for the rover to the top of the delta, about 130 feet (40 meters) above the crater floor. Designed for a 30-day demonstration on level ground, repurposing the helicopter has required several modifications and upgrades to its software for extended flight, hazard avoidance and landing on rugged terrain.

As of the end of February, Ingenuity has flown 45 times, over a distance of almost 31,700 feet (9,660 meters) with a total flight time of 77 minutes. The highest altitude achieved by the little rotorcraft has been about 46 feet (14 meters), with the fastest ground speed 12.3 mph (5.5 m/s).

An Unexpected Find

NASA's Curiosity rover has been exploring Gale crater since it landed on Mars in August of 2012. The mobile laboratory was designed to assess the planet's "habitability" and whether Mars ever had an environment able to support life. Shortly after arrival, the rover found evidence of ancient streams and lake beds around the lower elevations of a central 3-mile-tall (5-km-tall) mountain (informally called Mount Sharp).

Since 2014, the rover has been climbing the mountain, with its many layers providing a geologic timeline of Martian history. Its lowest layers of clay-bearing minerals have confirmed that early Mars was warmer and wetter. Upper layers are consistent with a transition to a dryer and colder environment.



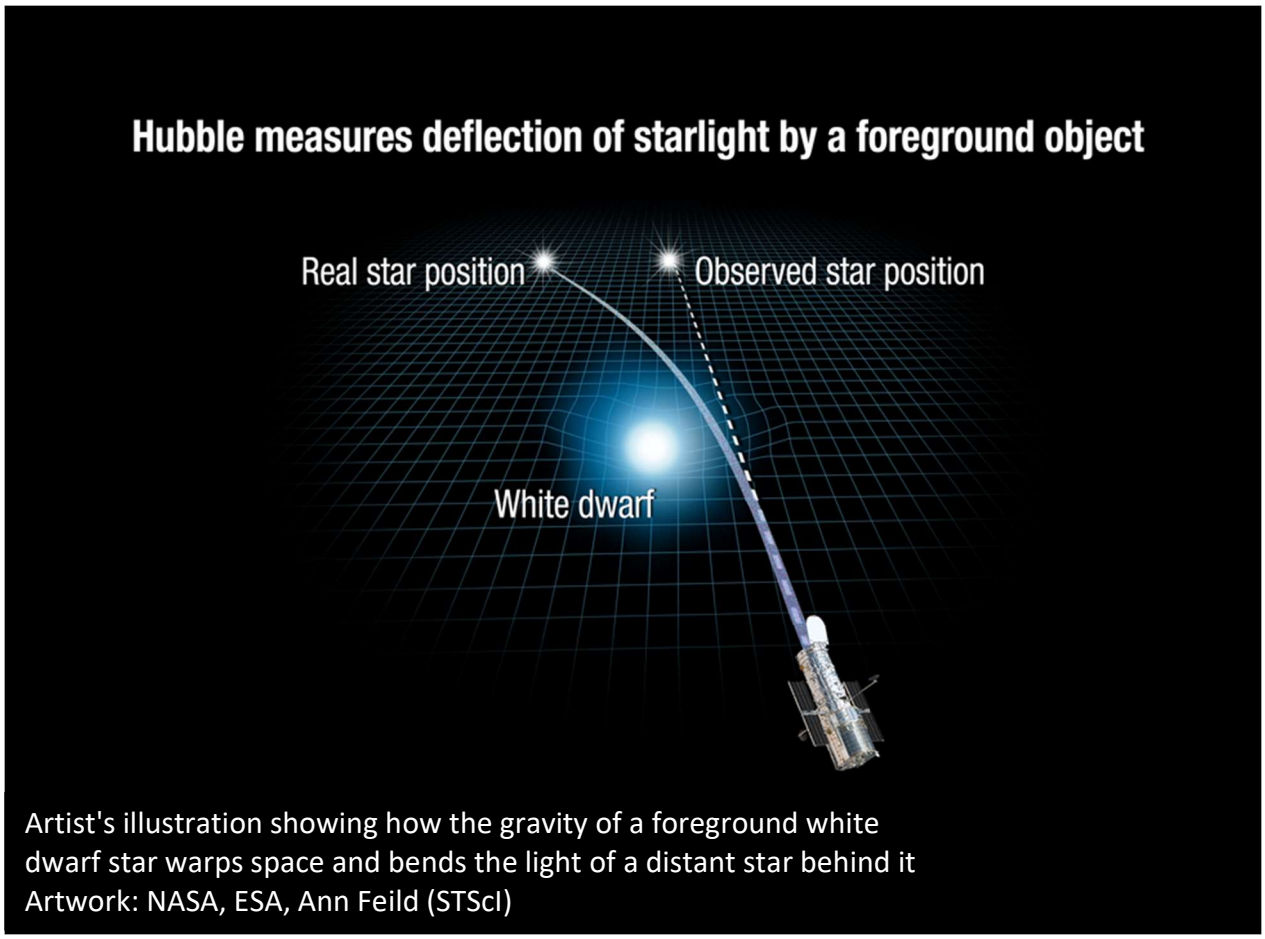
Rippled textures left in the rock on Mount Sharp
Credits: NASA/JPL-Caltech/MSSS

When Curiosity rover arrived at the "sulfate-bearing unit" last fall, scientists expected that they had seen the last of the water-rich layers. However, after having climbed nearly a half-mile above the mountain's base, the rover came across a thin band of dark rock (called the Marker Band). Within that rock band was the clearest evidence yet of a shallow lake.

Billions of years ago, surface waves created undulating bands in the sediment on the bottom of the lake. Over time, as the water disappears, the patterns were preserved in the deposits and manifested today by the ripples in the rock found by Curiosity. Sampling the hard rock found in the Marker Band has proved difficult, as several drilling attempts have not been successful.

Up ahead is another potential water-related feature. At the end of the wind-carved valley (called Gediz Vallis) though which the rover is traveling is a debris field containing large boulders. The material appears to have been deposited by a small river that originated higher up on Mount Sharp and ran down through the valley. The rover has only seen the debris pile from a distance, but scientists are hoping to get a better view later this year. Since the material likely originated from higher elevations, it would be much younger than anything that Curiosity has seen.

Measuring the Mass of Single, Isolated Star



Artist's illustration showing how the gravity of a foreground white dwarf star warps space and bends the light of a distant star behind it
Artwork: NASA, ESA, Ann Feild (STScI)

Astronomers have, for the first time, directly measured the mass of a single, isolated white dwarf star. The measurement was made with NASA's Hubble Space Telescope using a technique called gravitational lensing (first predicted by Einstein's theory of general relativity).

White dwarfs are the collapsed remnants of stars, much like our own Sun, after they have exhausted their fuel and cast off the outer layers. The remaining, extremely hot, stellar core has a density 200,000 times that of Earth. The first white dwarf discovered was in the triple star system of 40 Eridani, about 16.3 light-years from the Sun (although many references identify Sirius' companion to be the first).

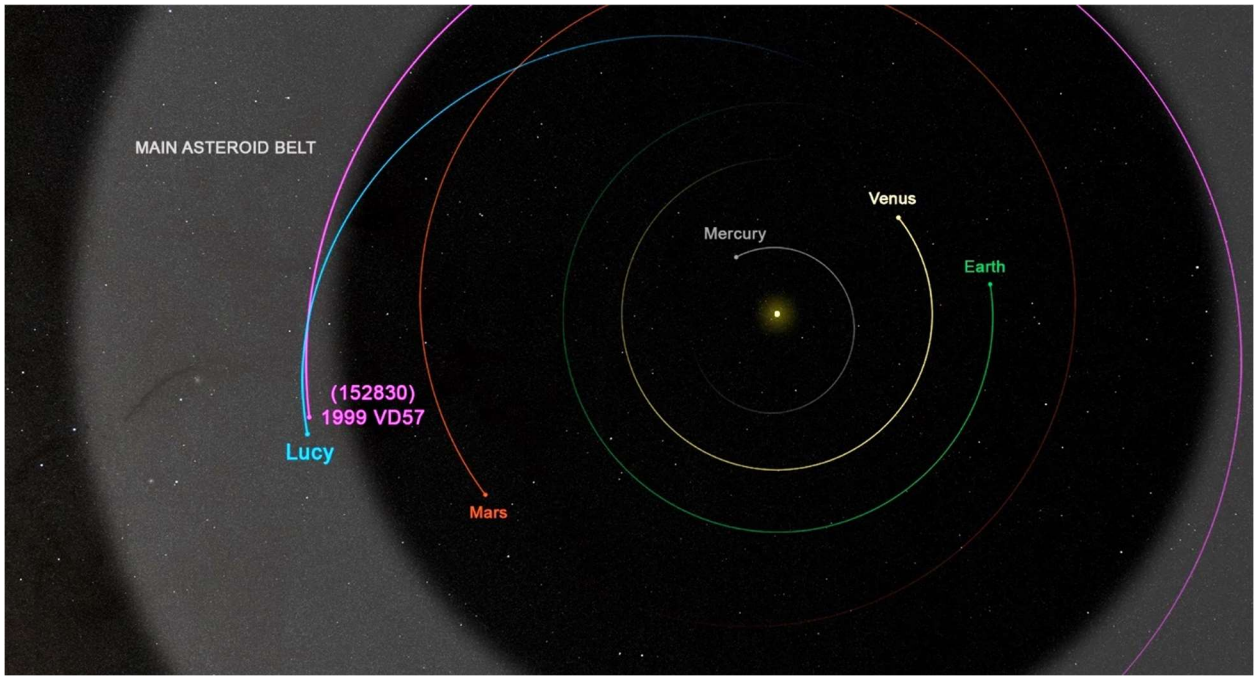
Until now, white dwarf mass measurements have been confined to those in binary systems. Masses of binary stars can be determined by observing the motion of the two co-orbiting stars and applying Isaac Newton's Universal Law of Gravitation. For a single star, astronomers relied upon a central idea in Einstein's theory that massive objects curve the structure of spacetime, affecting the motion of anything, including light, passing close by.

Using data from ESA's Gaia space observatory, astronomers were able to accurately predict the passing of a nearby white dwarf star ("LAWD 37") in front of a distant background star. Hubble was then able to measure the degree to which light from the distant star was deflected during the passage. The precision measurement yielded a mass estimate of 56 percent the mass of our Sun.

And Then There Were Ten

The number of targets for NASA's Lucy mission continues to grow. The spacecraft was launched on a twelve-year mission on October 16, 2021, originally intending to conduct flybys of six Jupiter Trojan asteroids and one main belt asteroid (7 total). However, before the spacecraft had left the launch pad, a moon was discovered orbiting one of the Trojans (Eurybates), increasing the target count to eight. Eurybates, and its moon Queta, will be the first Trojans encountered by Lucy after flying through the main asteroid belt in August 2027.

In March of 2022, astronomers observing an occultation of a star by one of Lucy's other target Trojan asteroids (Polymele) detected an additional object about 124 miles (200 km) away from the minor planet. Likely a mini-moon approximately 3 miles (5 km) across, it brought the number of mission targets to nine.



Trajectory of the Lucy spacecraft prior to its encounter with asteroid (152830) 1999 VD57
Credits: NASA's Goddard Space Flight Center

While the spacecraft has been cruising through the inner solar system, mission personnel have been combing the data on thousands of known asteroids for additional intercept opportunities. Most recently, a very small main-belt asteroid (0.4 miles or 700 meters in size) was identified as being within range of the spacecraft as it transits the inner region of the belt later this year. The Lucy team is planning on conducting a series of maneuvers starting in early May 2023 to close the distance between the spacecraft and asteroid to approximately 280 miles (450 km) for a November 1st encounter. The tenth mission target, originally designated (152830) 1999 VD57, has now received the formal name of (152830) Dinkinesh by the International Astronomical Union. Dinkinesh is the Ethiopian name for the human-ancestor fossil, also known as Lucy.

The fortuitous location of this small body provides the Lucy team with the opportunity to conduct an engineering test of the spacecraft's innovative asteroid-tracking navigation system well before it reaches its main scientific targets.

Starship Static Fire

SpaceX conducted a full-duration static fire of its Starship Super Heavy booster. Thirty-one of 33 Raptor engines ignited for 6 to 7 seconds, producing 7.9 million pounds of thrust, less than half of the booster's capability. It surpassed the Soviet Moon rocket (N1) for the greatest number of engines (30) on a single rocket, but the N1 still holds the thrust record at about 10.5 million pounds. At full power, with all 33 engines firing, the Super Heavy booster is expected to produce more than 16 million pounds of thrust during launch. By comparison, NASA's new Moon rocket, the Space Launch System, generated 8.8 million pounds of thrust on liftoff of the Artemis 1 mission.

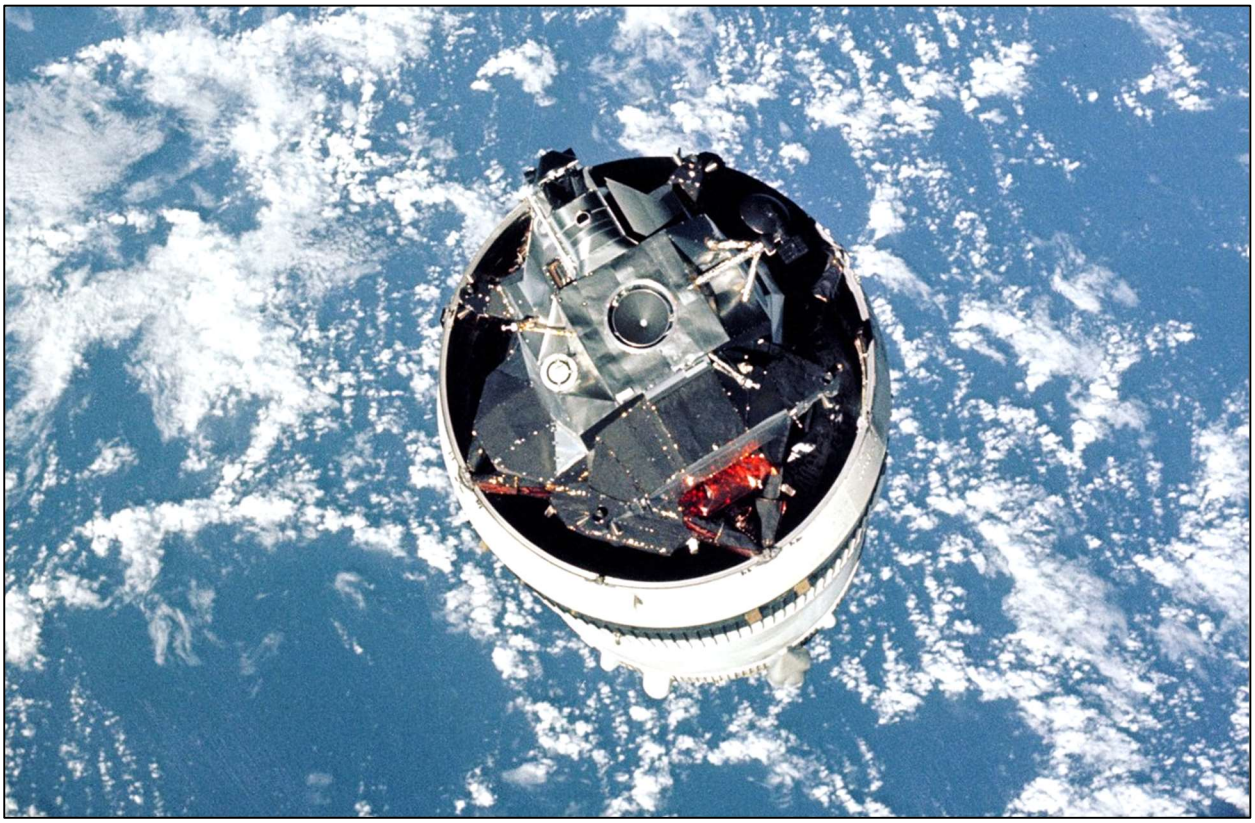
Flight of the Spider

The Apollo 9 mission was the first manned test flight of all the hardware needed for a lunar landing, including the lunar module. The Saturn V launched from the Kennedy Space Center on March 3, 1969 carried the record setting payload into low-Earth orbit. The mission was commanded by James McDivitt, with David Scott as the Command Service Module (CSM) Pilot and Russell Schweickart as the Lunar Module (LM) Pilot.

The Apollo 9 CSM taken from the window of the LM

Image: NASA

The crew would complete 152 orbits of the Earth, challenging the human physiology in ten days of weightlessness. During the first day on orbit, the CSM separated from the Saturn V's third stage. Turning around to face the rocket booster, the CSM docked with the LM nested inside. Using the CSM's thrusters, the joined pair moved a safe distance away. The third stage engine was then restarted to simulate a maneuver required for a deep space mission. It was eventually placed in a heliocentric orbit.



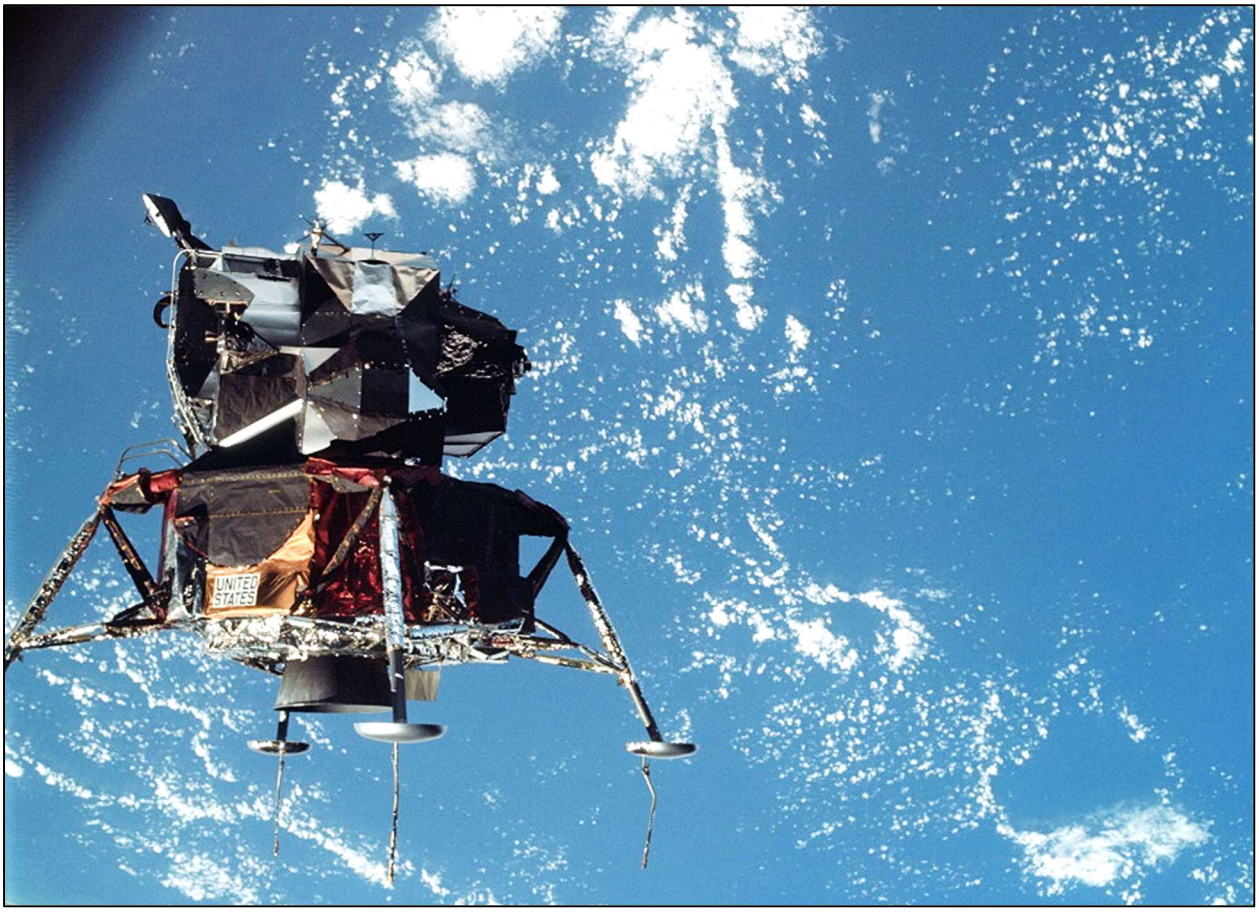
The Apollo 9 LM, nicknamed 'Spider,' shown in its launch position atop the Saturn V S-IVB third stage, its legs folded underneath. The image was taken from the CSM, nicknamed 'Gumdrop,' as it turned to face the LM. The conical drogue docking unit is visible at the top of the LM.

Image: NASA

The crew of Apollo 9 used the CSM's propulsion system to change orbit and test the structural integrity of the joined CSM and LM under load. On Flight Day 3, McDivitt and Schweickart entered the LM through a tunnel connecting the two vehicles to test fire the LM's descent engine before returning to the CSM. Schweickart's spacewalk scheduled for Flight Day 4 was cut short because of nausea. He did spend a short time outside the LM to check out the life support system backpack which the moonwalkers would use.

McDivitt and Schweickart would enter the LM again on Flight Day 5. This time the two vehicles separated, with the LM moving 113 miles away and 12 miles above the CSM. The descent stage of the LM was then jettisoned and the ascent stage engine fired for the first time. The ascent engine was used to lower the LM's altitude and rendezvous with the CSM. With docking and the transfer of McDivitt and Schweickart back into the CSM, the LM was jettisoned, its mission complete.

The crew of Apollo 9 accomplished all of the primary mission objectives, including rendezvous and docking of the two spacecraft, LM operations as a separate and independent spacecraft, transfer of the crew between the two spacecraft, a simulated rescue operation assuming a lunar landing abort, multiple restarts of the CSM's propulsion system (seven burns), and a full checkout of the CSM and LM systems. On Flight Day 10, the Command Module separated from the Service



A view of the free flying LM with its landing legs extended captured by David Scott who remained in the CSM while McDivitt and Schweickart checked out the LM. The Apollo 9 mission was the only time the LM flew in Earth orbit and would be photographed against a vibrant and colorful background rather than the stark lunar landscape.

Image: NASA

Module and reentered the Earth's atmosphere, splashing down in the Atlantic Ocean within three miles of the recovery ship, the USS Guadalcanal.

The near-Earth success of Apollo 9 would be repeated in lunar orbit by Apollo 10 in May of 1969, the precursor to the first Moon landing by the crew of Apollo 11 in July. Apollo 9 would also play a role in determining which astronaut would take that first step on Moon. McDivitt was originally selected to command Apollo 8, with the same mission objectives (full check out of the CSM and LM). However, the LM was behind schedule and wouldn't be ready, so NASA decided to send the Apollo 8 CM to the Moon without the LM.

McDivitt declined the command of Apollo 8's new mission (believing it was a publicity stunt), electing to trade places with the Apollo 9 crew, commanded by Frank Borman, in anticipation that the LM would be available for that flight. McDivitt's decision resulted in the swap of the backup crews for the two missions with Pete Conrad moving to command Apollo 12 rather than 11. Had McDivitt agreed to remain with Apollo 8, it's likely that Conrad would have taken the first step.

"The Times regrets the error"

Dr. Goddard with his liquid oxygen-gasoline rocket "Nell" in its launching frame on his aunt's farm in Auburn, MA NASA photo

On March 16, 1926, in Auburn, Massachusetts, Robert Goddard launched the first liquid-fueled rocket on a flight that would last only 2½ seconds. A graduate of Worcester Polytechnic Institute, despite discharging a powder rocket from the basement of the physics building, the significance of Goddard's feat is compared by space flight historians to the first aircraft flight at Kitty Hawk. Among his achievements, Goddard was first to prove that rockets would work in a vacuum and to mathematically explore the practicality of using rocket propulsion to reach high altitudes and even the Moon (1912).

His revolutionary ideas on spaceflight were treated harshly by the press (a New York Times 1920 editorial suggested that "he only seems to lack the knowledge ladled out daily in high schools."). As such, Goddard retreated from the public eye, eventually moving his research on rockets to the New Mexico desert (he had been banished in 1929 from the farm fields of Auburn by the local fire marshal).

Between 1926 and 1941, Goddard and his team, launched 34 rockets, achieving altitudes as high as 1.6 miles (2.6 km). He developed methods to control a rocket in flight using gyroscopes and steerable thrust. His patented inventions on multi-stage rockets and a liquid-fuel rocket in 1914 (Goddard is credited with 214 inventions) and his work as a theorist and engineer are considered significant to the advancement of spaceflight and Goddard is counted one of the founding fathers of modern rocketry. Before his death in 1945, he worked for the U.S. government on rocket research. NASA's Goddard Space Flight Center was named in his honor in 1959.

The location of the first liquid-fueled rocket flight is commemorated by granite markers erected on, what is now the Pakachoag Golf Course, not far from where the Massachusetts Turnpike passes by the Auburn Mall heading east.

Forty-nine years after their mocking editorial, on July 17, 1969, the day after the launch of Apollo 11, the New York Times issued a correction stating that "Further investigation and experimentation have confirmed …it is now definitely established that a rocket can function in a vacuum as well as in an atmosphere," adding "The Times regrets the error."

Zodiacal Light

The solar system is a dusty place – the source of the dust was thought to be from passing comets and collisions of asteroids. However, an accidental discovery by the Juno spacecraft on its journey to Jupiter suggests that Mars may be the source of the interplanetary dust in the orbital plane, although a clear mechanism for the dust escaping the Red Planet hasn't been identified.

Shortly before sunrise and just after sunset, sunlight can be seen reflecting off this disk of debris. Called the zodiacal light, it is best observed when the ecliptic (the apparent path of the Sun and planets) is nearly perpendicular to the horizon (on spring evenings and autumn mornings). The best time to glimpse the zodiacal light is when the Moon is absent from the evening sky (for example, during the fourth week of March and around the New Moon on the 21st).

Sunrise and Sunset (New Milford, CT)

March, the month named for the planet Mars, denotes the end of the long winter nights. The Sun crosses the celestial equator at 5:24 PM (EDT) on the 20th marking the Vernal Equinox and the beginning of the spring season in the northern hemisphere.

Sun	Sunrise	Sunset
March 1st (EST)	06:28	17:43
March 15th (EDT)	07:05	18:59
March 31st (EDT)	06:38	19:17

Astronomical and Historical Events

1st Jupiter-Venus conjunction in the evening sky shortly after sunset
1st History: Launch of the space shuttle Columbia (STS-109) on an eleven-day mission to service the Hubble Space Telescope (4th servicing mission) (2002)
1st History: U.S. astronaut Scott Kelly and Russian cosmonaut Mikhail Kornienko return to Earth after a one-year stay on the International Space Station (2016)
1st History: Soviet spacecraft Venera 13 lands on Venus and records first color panoramic views of the surface (1982)
1st History: discovery of Saturn's moon *Helene* by Pierre Laques and Jean Lecacheux from the Pic du Midi Observatory in the French Pyrenees; named after Helen of Troy (1980)
1st History: Soviet spacecraft Venera 3 lands (crashes) on Venus, becoming first spacecraft to impact the surface of another planet (1966)
2nd Close approach of Apollo asteroid (2021 QW)
2nd History: launch of an unmanned SpaceX Crew Dragon spacecraft. First American spacecraft to autonomously dock with the International Space Station (2019)
2nd History: launch of the Rosetta spacecraft (2004); rendezvoused with *Comet 67 P/Churyumov-Gerasimenko* in May 2014, sending a lander to its surface in November 2014
2nd History: launch of Pioneer 10, a Jupiter flyby mission (1972)
3rd Moon at apogee (furthest distance from Earth)
3rd Close approach of Apollo asteroid (2017 BM123)
3rd Close approach of Apollo asteroid (2007 ED125)

Astronomical and Historical Events (continued)

3rd History: Chinese National Space Agency announces the Chang'e lunar exploration program (2003)
3rd History: launch of Apollo 9 with astronauts James McDivitt, David Scott and Russell Schweickart in the first manned flight test of the lunar module (1969)
3rd History: launch of the Pioneer 4 spacecraft towards the Moon; first U.S. spacecraft to escape the Earth's gravity (1959)
4th Close approach of Aten asteroid (2015 EG)
4th History: discovery of Jupiter's rings by the Voyager 1 spacecraft (1979)
5th Close approach of Apollo asteroid (2023 BK5)
5th History: discovery of Jupiter moon *Thebe* by Steve Synnott (1979)
5th History: Soviet spacecraft Venera 14 lands on Venus and uses a screw drill to obtain a surface sample that was determined to be similar to oceanic basalts on Earth (1982)
5th History: flyby of Jupiter by the Voyager 1 spacecraft (1979)
6th History: Valentina Tereshkova's birthday (1937), Soviet cosmonaut became the first woman to fly to space in 1963
6th History: Dawn spacecraft enters orbit around the dwarf planet *Ceres* (2015)
6th History: launch of the Kepler telescope from Cape Canaveral Air Force Station aboard a Delta II rocket (2009); designed to survey nearby stars for Earth-size and smaller planets; as of February 2019, Kepler discovered 2,414 confirmed planets with just as many yet to be confirmed3,255
6th History: flyby of Comet Halley by Vega 1, a Soviet spacecraft (1986)
7th Full Moon (Full Worm Moon)
7th Close approach of Apollo asteroid 535844 (2015 BY310)
7th History: John Herschel born, first astronomer to survey the southern hemisphere (1792)
8th Close approach of Apollo asteroid (2020 FQ)
8th History: maiden voyage of Europe's first unmanned cargo ship to the International Space Station; the Jules Verne was launched from Kourou, French Guiana aboard an Ariane 5 rocket; in addition to delivering supplies to the ISS, the cargo ship contained a manuscript by the 19th century French author and science fiction pioneer with computations of distances from Earth to several astronomical destinations, as well as to the center of the planet (2008)
8th History: flyby of *Comet Halley* by Susei, a Japanese spacecraft (1986)
8th History: discovery of rings around Uranus by NASA's airborne observatory (1977)
9th History: launch of Ivan Ivanovich on Sputnik 9, a mannequin used to test the Russian Vostok spacecraft in preparation for its crewed missions (1961)
9th History: Space Shuttle Discovery (STS-133) makes its final landing (2011)
9th History: flyby of *Comet Halley* by Vega 2, a Soviet spacecraft (1986)
9th History: launch of the Soviet spacecraft Sputnik 9, with dog Chernushka (1961)
9th History: Yuri Gagarin born; first person to orbit the Earth in 1961 (1934)
10th Scheduled launch of a SpaceX Dragon 2 spacecraft on a cargo resupply mission to the International Space Station aboard a Falcon 9 rocket from the Kennedy Space Center, Florida
10th History: Mars Reconnaissance Orbiter arrives at Mars (2006)
10th History: flyby of *Comet Halley* by Sakigake, a Japanese spacecraft (1986)

Astronomical and Historical Events (continued)

10th History: Uranus' rings discovered by astronomers James Elliot, Edward Dunham, and Jessica Mink using the Kuiper Airborne Observatory while observing a stellar occultation (1977)
11th **Second Saturday Stars - Open House at McCarthy Observatory**
11th History: launch of Pioneer 5 into solar orbit between the Earth and Venus; confirmed the existence of interplanetary magnetic fields (1965)
11th History: Urbain Leverrier born, mathematician and astronomer, predicted existence of Neptune (1811)
12th Daylight Saving - Set Clock Ahead 1 Hour (United States)
13th Close approach of Aten asteroid (2020 FV4)
13th History: flyby of *Comet Halley* by Giotto, a European Space Agency spacecraft (1986)
13th History: discovery of Saturn's moon *Calypso* by Dan Pascu, P.K. Seidelmann, William Baum and D. Currie (1980)
13th History: Percival Lowell born, established observatory in Flagstaff, AZ to observe Schiaparelli's Martian "canali" and look for other signs of life (1855)
13th History: William Herschel discovers the planet Uranus; originally named Georgium Sidus by Herschel in honor of his patron, King George III of England (1781)
13th History: Galileo Galilei publishes "Sidereus Nuncius" (Starry Messenger), the first scientific treatise based on observations made through a telescope; it described Galileo's early observations of the Moon, the stars, and the moons of Jupiter (1610)
14th Last Quarter Moon
14th Pi Day
14th Close approach of Apollo asteroid (2023 CM)
14th History: launch of ESA's ExoMars Trace Gas Orbiter and Schiaparelli lander aboard a Russian Proton rocket from the Baikonur Cosmodrome in Kazakhstan (2016)
14th History: Stardust passes within 112 miles (181 km) of the nucleus of *Comet Tempel 1* (2011)
14th History: John J. McCarthy Observatory issued Observatory Code Number 932 by the Minor Planet Center of the International Astronomical Union (2001)
14th History: first European launch of a liquid-fueled rocket by Johannes Winkler (1931)
14th History: Albert Einstein born, developed theories of mass to energy conversion and the curvature of space and time in large gravitational fields (1879)
14th History: Giovanni Schiaparelli born, director of the Milan Observatory and first to describe faint features on Mars as "canali" (1835)
15th Close approach of Apollo asteroid (2023 DM)
15th History: dedication of the Kitt Peak National Observatory (1960)
15th History: Alan Bean born; astronaut, moonwalker and artist (1932)
16th History: third and final flyby of Mercury by the Mariner 10 spacecraft (the last of the Mariner probes); Mariner 10 was also the first spacecraft to use solar radiation pressure on its solar panels and the antenna for attitude control during flight (1975)
16th History: launch of Gemini 8 with astronauts Neil Armstrong and David Scott; first docking with another space vehicle, an unmanned Agena stage (1966)
16th History: launch of the first Titan II Intercontinental Ballistic Missile, also used as the launch vehicle for the manned Gemini spacecraft in the early 1960's (1962)
16th History: Robert Goddard launches first liquid-fuel rocket in Auburn, MA (1926)
16th History: Caroline Herschel born (1750)

Astronomical and Historical Events (continued)

17th Close approach of Apollo asteroid (2018 UQ1)
17th History: discovery of Asteroid 16 *Psyche* by Annibale de Gasparis (1852)
17th History: launch of the Gravity Recovery And Climate Experiment (GRACE) spacecraft (2002)
17th History: launch of Vanguard 1, 4th artificial satellite and oldest still orbiting Earth (1958)
17th History: discovery of Saturn's moon *Phoebe* by William Pickering (1899)
18th History: MESSENGER enters orbit around Mercury (2011)
18th History: New Horizons spacecraft (on its way to Pluto) crosses the orbit of Uranus (2011)
18th History: explosion during launch of a Vostok rocket carrying a military spy satellite kills 48 members of the Soviet Missile Troop; likely cause of explosion was an oxygen peroxide leak caused by the poor quality of the rocket's fuel filters (1980)
18th History: Alexei Leonov performs first spacewalk from Soviet Voskhod spacecraft (1965)
19th Moon at perigee (closest distance from Earth)
19th Close approach of Apollo asteroid (2016 WH)
19th History: Tenham meteorite fall; fragments of a large meteor rain down on a remote area of western Queensland, Australia (1879)
19th History: Moon flyby by the Hiten spacecraft; Japan's first lunar flyby, orbiter and surface impactor (1990)
20th Vernal Equinox (beginning of the Spring season in the northern hemisphere) at 5:24 PM EDT (21:24 UT)
20th Close approach of Aten asteroid (2018 FE3)
21st New Moon
21st History: launch of Ranger 9, Moon impact mission; transmitted the highest resolution imagery obtained to that date before impacting the floor of Alphonsus crater on the 24th (1965)
21st History: discovery of Saturn's moons *Tethys* and *Dione* by Giovanni Cassini (1684)
22nd History: launch of space shuttle Atlantis (STS-76), third mission to Russian space station Mir and transfer of the first American woman, Shannon Lucid, to the station (1996)
23rd History: launch of Gemini 3 with astronauts Virgil Grissom and John Young, first manned Gemini flight (1965)
23rd History: Wernher von Braun born, German rocket scientist and leader of the U.S. moon program (1912)
24th History: discovery of Comet Shoemaker-Levy 9 (1993)
25th History: launch of the IMAGE spacecraft, first mission dedicated to mapping the Earth's magnetosphere (2000)
25th History: close approach of Comet *Hyakutake* (0.10 AU) to Earth (1996)
25th History: launch of Soviet spacecraft Sputnik 10 with dog Zvezdochka (1961)
25th History: Christiaan Huygens discovers *Titan*, Saturn's largest moon (1655)
26th History: American astronomer J.W. Draper takes first photograph of the Moon (1840)
27th Amor Asteroid *5324 Lyapunov* closest approach to Earth (2.632 AU)
27th History: U.S. astronaut Scott Kelly and Russian cosmonaut Mikhail Kornienko arrive at the International Space Station for a year-long mission (2015)
27th History: launch of the Soviet atmospheric probe and lander Venera 8 to Venus (1972)
27th History: launch of Mariner 7, Mars flyby mission (1969)
27th History: President Eisenhower approves the military lunar program to be managed by the Advanced Research Projects Agency (1958)

Astronomical and Historical Events (continued)

28th First Quarter Moon
28th History: flyby of Comet Halley by the ICE spacecraft (1986)
28th History: Heinrich Olbers discovers the asteroid 2 *Pallas* (1802)
29th Close approach of Apollo asteroid (2022 YK4)
29th History: First flyby of Mercury by the Mariner 10 spacecraft (1974)
29th History: Heinrich Olbers discovers the asteroid 4 *Vesta* (1807)
30th Close approach of Apollo asteroid (2017 SE12)
30th Close approach of Apollo asteroid (2016 GH1)
31st Moon at apogee (furthest distance from Earth)
31st History: discovery of Dwarf Planet *Makemake* by Mike Brown, et al's (2005)
31st History: launch of Soviet spacecraft Luna 10, first man-made object to go into orbit around another planetary body; detected evidence of mass concentrations on the Moon called "mascons" (1966)

Commonly Used Terms

- Apollo: a group of near-Earth asteroids whose orbits also cross Earth's orbit; Apollo asteroids spend most of their time outside Earth orbit.
- Aten: a group of near-Earth asteroids whose orbits also cross Earth's orbit, but unlike Apollos, Atens spend most of their time inside Earth orbit.
- Atira: a group of near-Earth asteroids whose orbits are entirely within Earth's orbit
- Centaur: icy planetesimals with characteristics of both asteroids and comets
- Kuiper Belt: region of the solar system beyond the orbit of Neptune (30 AUs to 50 AUs) with a vast population of small bodies orbiting the Sun
- Opposition: celestial bodies on opposite sides of the sky, typically as viewed from Earth
- Plutino: an asteroid-sized body that orbits the Sun in a 2:3 resonance with Neptune
- Trojan: asteroids orbiting in the 4th and 5th Lagrange points (leading and trailing) of major planets in the Solar System

References on Distances

- the apparent width of the Moon (and Sun) is approximately one-half a degree (½°), less than the width of your little finger at arm's length which covers approximately one degree (1°); three fingers span approximately five degrees (5°)
- 1 astronomical unit (AU) is the distance from the Sun to the Earth or approximately 93 million miles

International Space Station and Starlink Satellites

- www.heavens-above.com for the times of visibility and detailed star charts for viewing the International Space Station and the bright flares from Iridium satellites.

Solar Activity

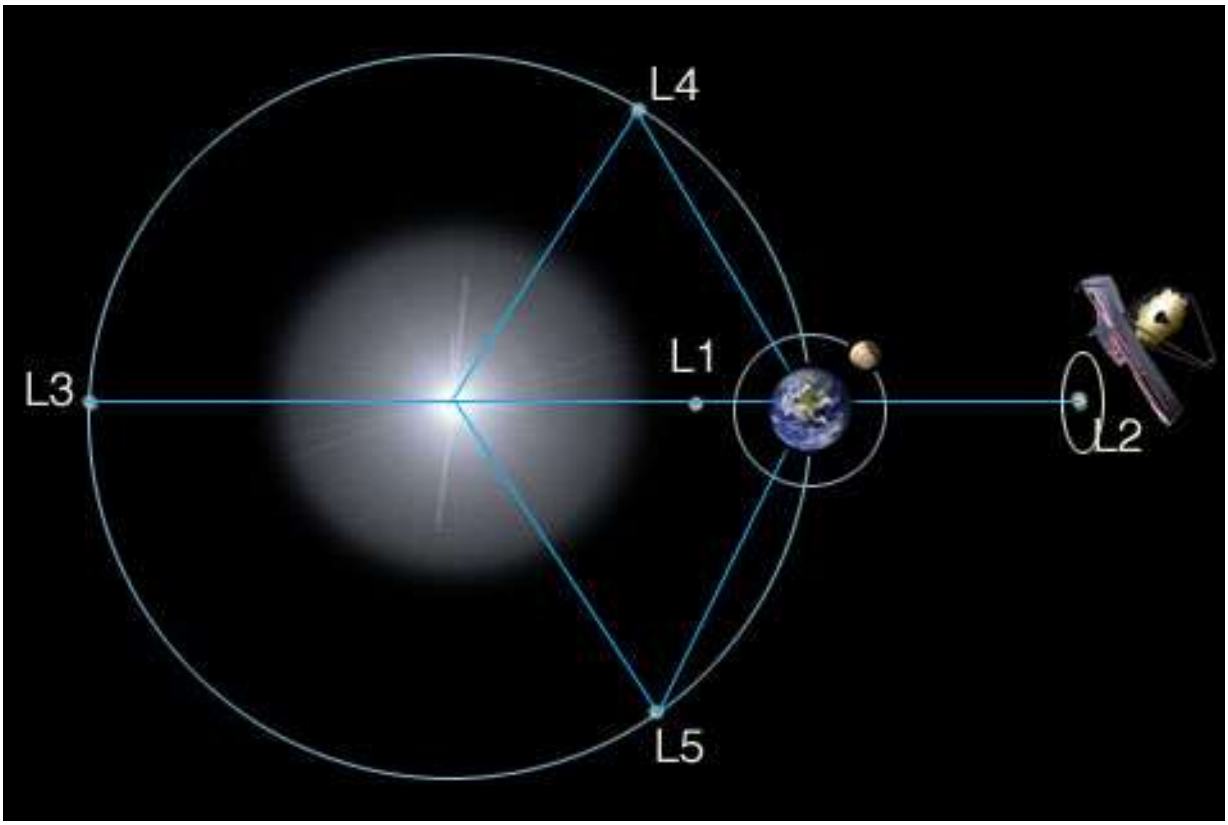
- For the latest on what's happening on the Sun and the current forecast for flares and aurora, check out www.spaceweather.com

NASA's Global Climate Change Resource

- Vital Signs of the Planet: https://climate.nasa.gov/

Lagrange Points

Five locations discovered by mathematician Joseph Lagrange where the gravitational forces of the Sun and Earth (or other large body) and the orbital motion of the spacecraft are balanced, allowing the spacecraft to hover or orbit around the point with minimal expenditure of energy. The L2 point (and location of the Webb telescope) is located 1 million miles (1.5 million km) beyond the Earth (as viewed from the Sun).



James Webb Space Telescope

- https://webb.nasa.gov/index.html

Mars – Mission Websites

- Mars 2020 (Perseverance rover): https://mars.nasa.gov/mars2020/
- Mars Helicopter (Ingenuity): https://mars.nasa.gov/technology/helicopter/
- Mars Science Laboratory (Curiosity rover): https://mars.nasa.gov/msl/home/

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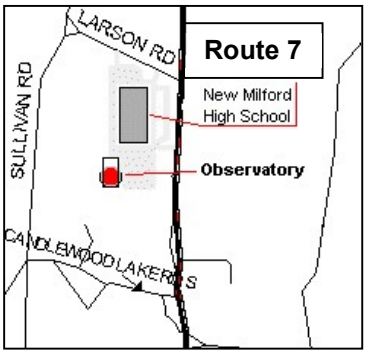

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