Galactic Observer

John J. McCarthy Observatory

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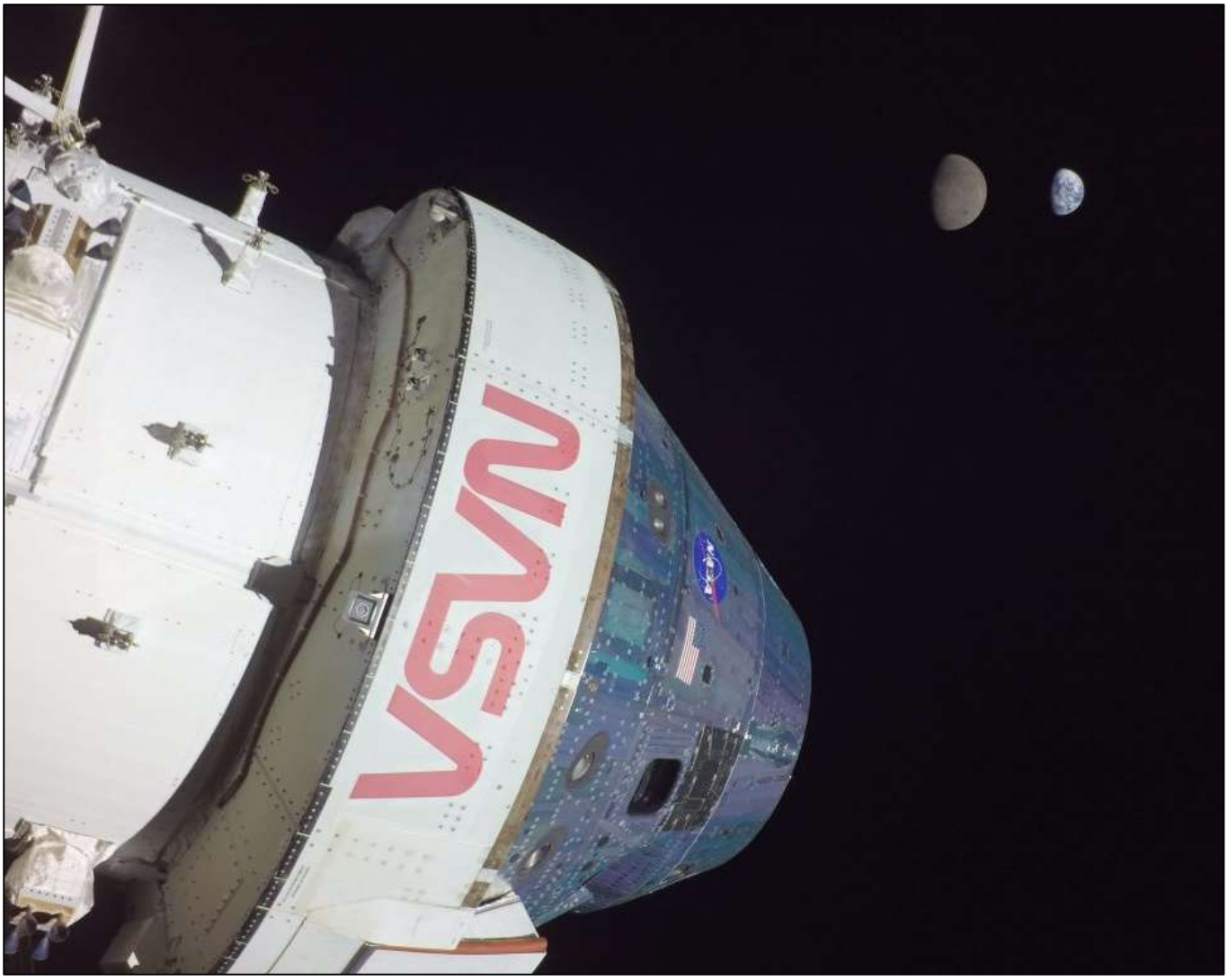
Photos: Marc Polansky

A close conjunction of Mars and the Moon on Wednesday December 7th. The Full Moon was captured by McCarthy Observatory astrophotographer Marc Polansky around 11 pm with a Canon T6i DSLR and a Sigma 600 mm lens. The insert, with Mars enlarged, was also taken by Marc through a Celestron C8 telescope.

January Astronomy Calendar and Space Exploration Almanac



NASA's Artemis I mission concluded its 25.5-day mission on December 11th, gently splashing down in the Pacific Ocean off the Baja peninsula under the canopies of four large parachutes. The Orion spacecraft traveled out beyond the Moon into deep space, farther than any other human-rated spacecraft. Orion reached is maximum distance from Earth on November 28th, day thirteen of the mission, when it was 268,457 miles (166,811 km) away from the Blue Marble (and 43,138 miles or 26,805 km from the Moon), while traveling at 1,679 miles per hour (1,043 kph). The image of the Earth and Moon was captured by one of the cameras mounted at the tip of each of the spacecraft's four solar panels.

Credit: NASA

In This Issue

"Out the Window on Your Left"

It's been 50 years since 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).

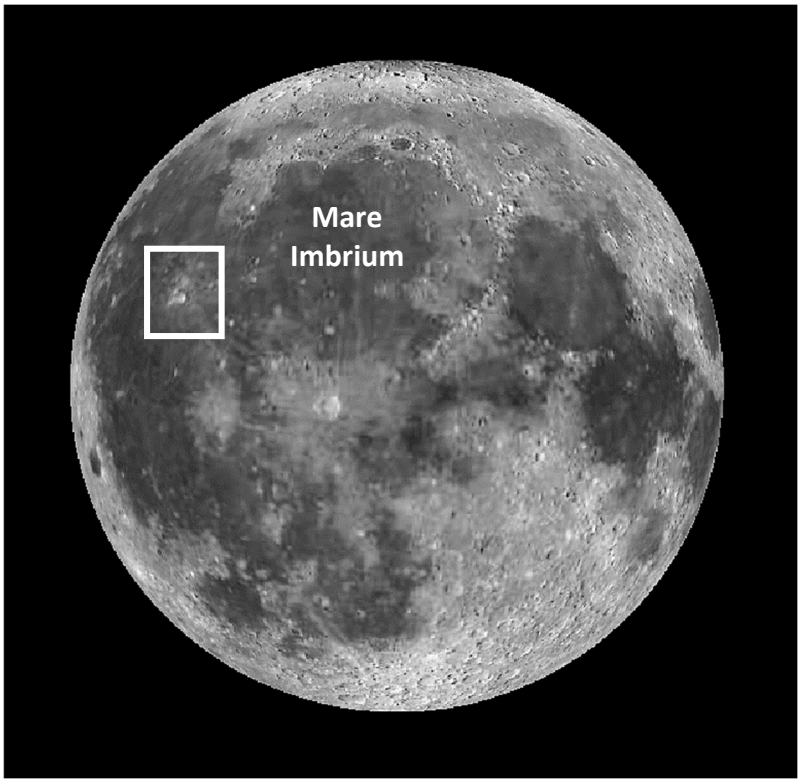
The Aristarchus Plateau is a rectangular-shaped upheaval of the Moon's crust, likely created in the aftermath of the impact that formed the adjacent Imbrium Basin approximately 3.85 billion years ago. Subsequent volcanic activity flooded the Imbrium Basin (creating the lunar mare) and burying the lower-lying portions of the plateau.

The Plateau is dominated by one of the brightest craters on the Moon, Aristarchus, and the largest sinuous rille or lava channel, Vallis Schröteri.

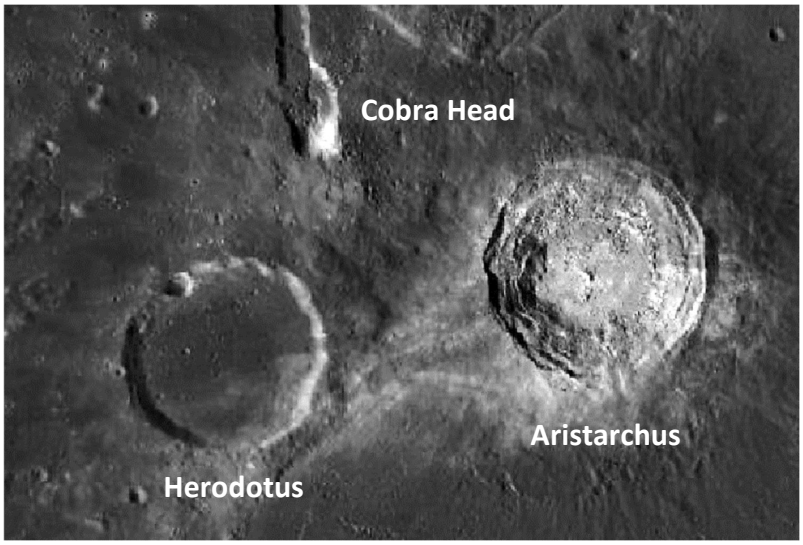
The Aristarchus crater is 25 miles (40 km) in diameter and almost 2 miles in depth (2.7 km), with a central peak that rises 1,000 feet (300 meters) above the crater floor.

Vallis Schröteri, the 106-mile (170-km) long rille, begins at a volcanic vent located just north of the craters Aristarchus and Herodotus – at a feature known as "Cobra Head."

The plateau slopes downward to the north. While the southeastern portion sits about 2.2 miles (3.5 km) above the surrounding mare, the northern region, covered with pyroclastic deposits, rises to a height of only 3,300 feet (1 km).

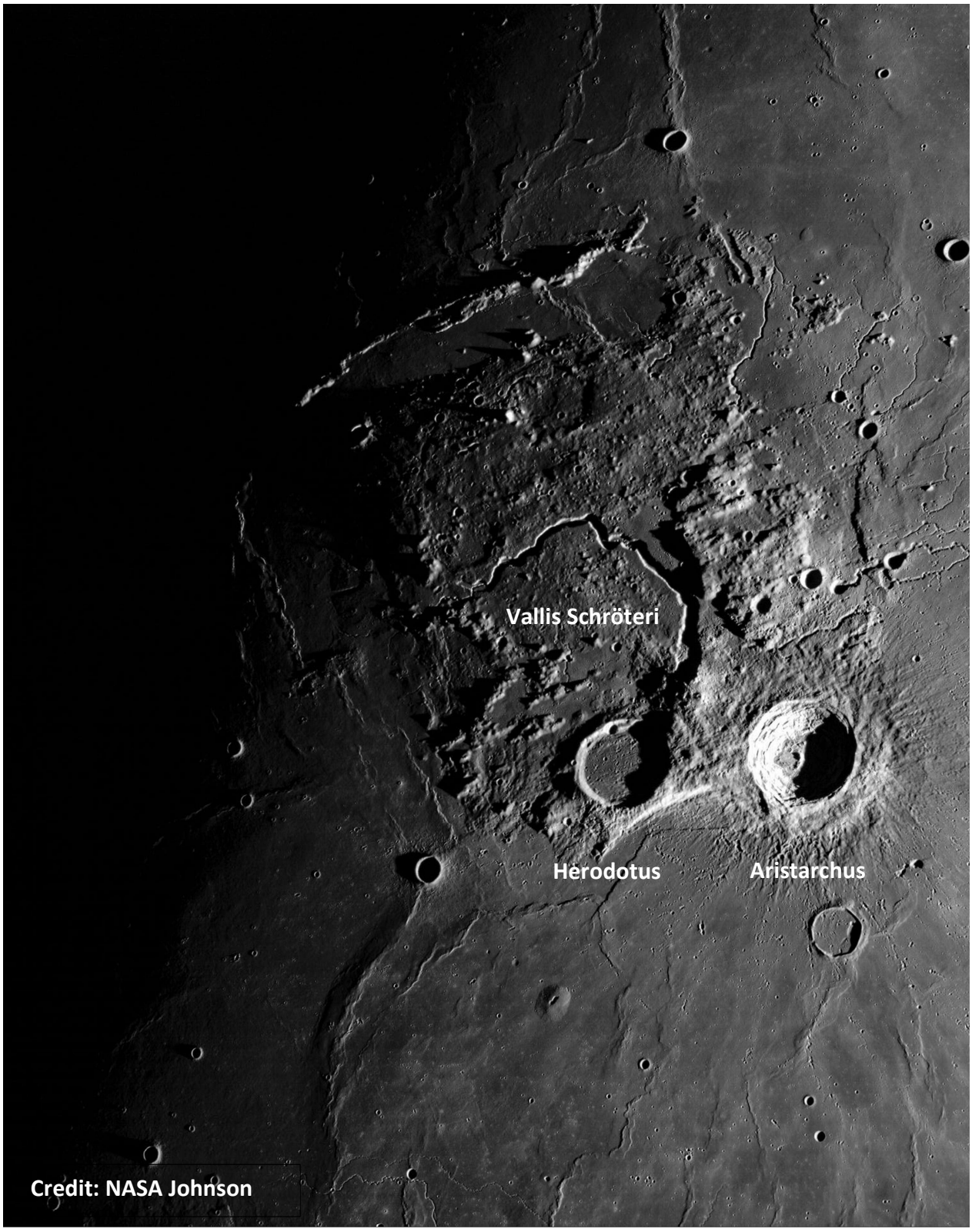


Location of the Aristarchus Plateau (above) and a closeup of the southern portion (below) Source: LROC QuickMap



Aristarchus Plateau

Captured by the optical navigation camera aboard the Orion spacecraft on Flight Day 20 of the Artemis I mission during the spacecraft's second and final close approach to the Moon



Planets in 2023

The superior planets (those that orbit further from the Sun than the Earth) return to the evening sky in the latter half of 2023, appearing at their brightest when they are at, or near, Opposition (when a planet is opposite the Sun in our sky). At Opposition, a planet will rise around sunset and is highest in our sky (crosses the meridian) around or just after midnight.

Saturn reaches Opposition on August 27th, 13 days later than in 2022. The ringed planet can be found in the constellation Aquarius the Water Carrier, shinning at an apparent magnitude of +0.4 at its brightest. It will be 8.76 AU from Earth at that time (approximately 815 million miles or 1.311 billion km). Saturn has an axial tilt of 27°, so our view of the gas giant changes from year to year. In the coming year, the planet's rings will be tilted at an angle of only +9° to our line of sight.

As seen from Earth, Saturn's ring tilt (the ring plane opening angle to the Earth) has been decreasing since 2017 when it was near maximum at 26°. The rings will be edge-on in March 2025 (as seen from Earth) and not at their full splendor again until May 2032 when the rings will be tilted at their maximum (27°). While we have been enjoying views of Saturn's north pole, after 2025, the planet's south pole will slowly come into view.

Neptune reaches Opposition on September 19th. The blue ice giant can be found in the constellation Pisces the Fish. At an apparent magnitude of +7.8, you will need binoculars or a small telescope to locate the eighth planet against the background stars. At its closest, Neptune will be a distant 28.90 AUs from the Earth (approximately 2.69 billion miles or 4.32 billion km).

Jupiter reaches Opposition, on average, every 399 days or about 33 days later each successive year. In 2023, Opposition is on November 3rd when the gas giant will be 3.98 astronomical units (AU) from Earth (approximately 370 million miles or 596 million km). Jupiter will shine at an apparent magnitude of -2.9 at its brightest (only surpassed by Venus for planetary luminosity) and can be found in the constellation Ares the Ram, not too far from the planet Uranus.

Uranus reaches Opposition on November 13th. The first planet to be discovered with the telescope can also be found in the constellation Aries the Ram. At an apparent magnitude of +5.7, you will need perfect viewing conditions (dark, clear skies) to spot the seventh planet. Uranus will be almost a billion miles closer than Neptune, but still a distant 18.63 AUs from the Earth (approximately 1.73 billion miles or 2.79 billion km). Only with the aid of a telescope will you be able to see the blue-green disk of this sideways-spinning planet.

Mercury is best seen when farthest from the Sun in Earth's sky. The finest evening views (Greatest Eastern Elongation) will occur on April 11th, August 9th, and December 4th, with the August apparition the best as it will be relatively close to Mars and therefore easier to locate. The best morning prospects (Greatest Western Elongation) are on January 30th, May 29th, and September 22nd, with the September apparition being the brightest at magnitude -0.4.

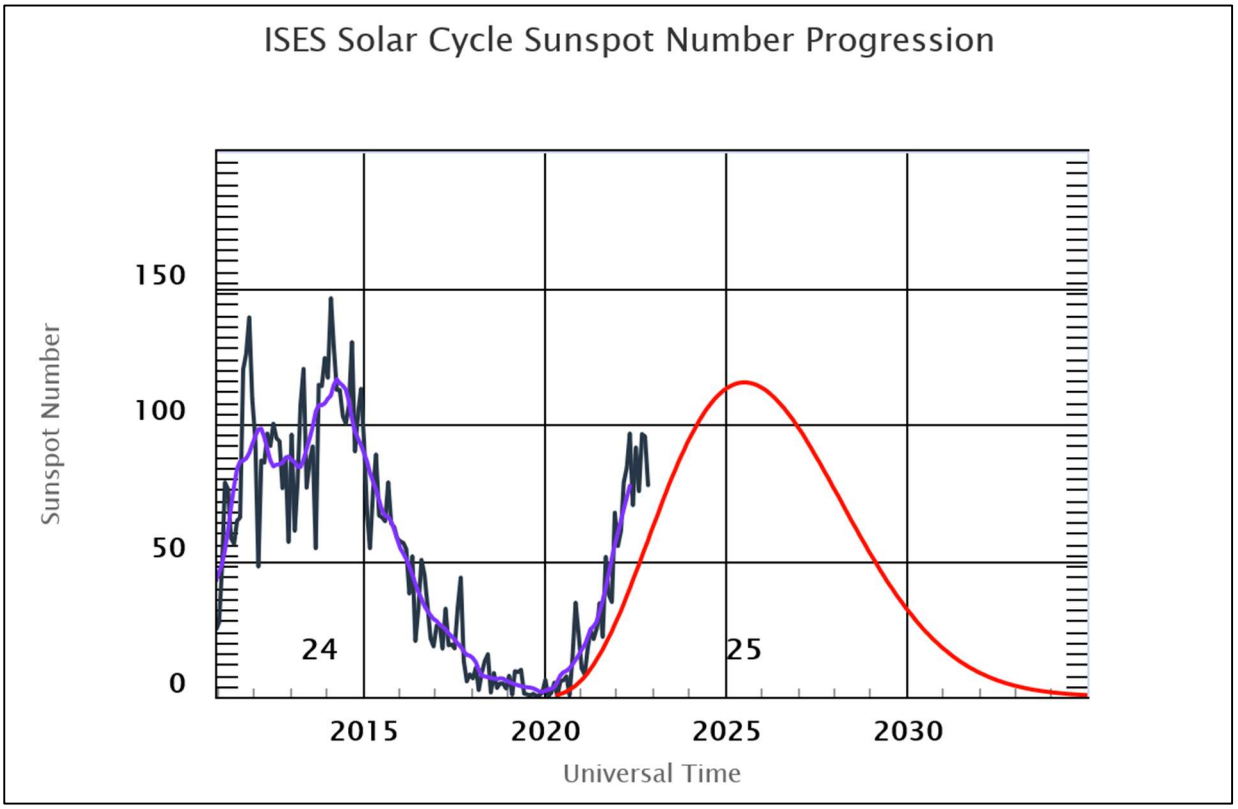
Venus is brightest when closest to Earth (crescent phase) and its separation greatest from the Sun. The planet reaches Greatest Eastern Elongation on June 4th, when it is 45° from the Sun in the evening sky and sets almost 3 hours after sunset. Its Greatest Western Elongation occurs on October 23rd, when it appears in the morning sky not far from the bright star Regulus in Leo.

Mars reaches Opposition every 26 months. In 2022, the planets aligned on December 8th. However, while Mars will be in the evening sky for the first half of 2023, the next Opposition won't be until January 15, 2025.

The Sun

The Sun's magnetic field changes polarity approximately every 11 years: north becomes south, and south becomes north. The number of sunspots (dark areas on the photosphere) wax and wane over a similar period of time, known as the solar cycle. During the peak (number of sunspots), the Sun is more active with frequent outbursts that can produce significant space weather events, energize Earth's magnetic field and heat up its highest atmospheric layers. The heating of the thermosphere causes it to expand as it absorbs much of the X-ray and ultraviolet radiation from the Sun. While extremely diffuse, it still can increase the drag on satellites (and the International Space Station) that orbit within this layer, potentially shortening their operational life.

Solar cycles have been numbered since 1755, starting with "Cycle 1." We are currently in the Cycle 25, which began in December 2019 (solar minimum). The Sun's activity is expected to ramp up to a predicted maximum level in July 2025, although it could happen sooner based on the current trend (while 11 years is the average, cycles can be as short as 9 years and as long as 14 years).



International Space Environmental Services (ISES) Space Weather Prediction Center
National Oceanic and Atmospheric Administration

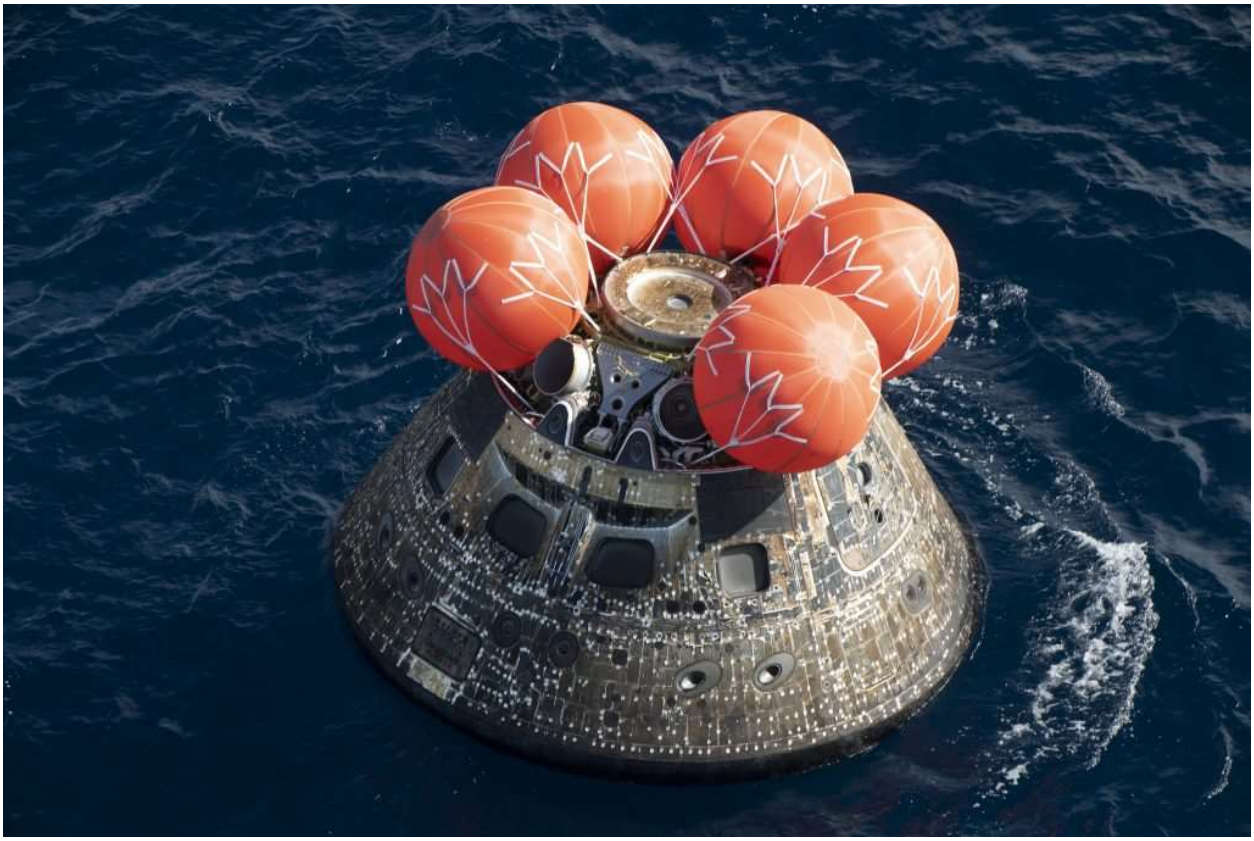
Development Money for a Lunar Construction System

NASA awarded ICON Technology (ICON), a Texas-based company, $57.2 million for the maturation of its Project Olympus lunar construction system. The company has been developing the tools and techniques to fabricate outposts on the Moon (and Mars), using locally available materials.

Artist's illustration of ICON's envisioned Project Olympus lunar construction system in action on the Moon. (Image credit: ICON)

ICON has pioneered the use of advanced and innovative construction techniques that include using 3D printers, to build homes in the U.S. and in Mexico. Its Project Olympus is intended to demonstrate that its processes can be adapted to build critical infrastructure like landing pads, roads and habitats with simulated lunar materials, and under the Moons' harsh environment conditions and lower gravity field.

Orion Returns Home



NASA's Artemis I wrapped up a 25.5 day, 1.4 million mile journey on a Sunday afternoon with the Orion spacecraft splashing down in the Pacific Ocean. The crew module, the only component of the agency's Space Launch System designed to be recovered, entered the Earth's atmosphere at 25,000 mph (40,000 km/h) before deploying a series of parachutes and slowing down to a speed of just 25 mph (11 km/h) before it hit the water.

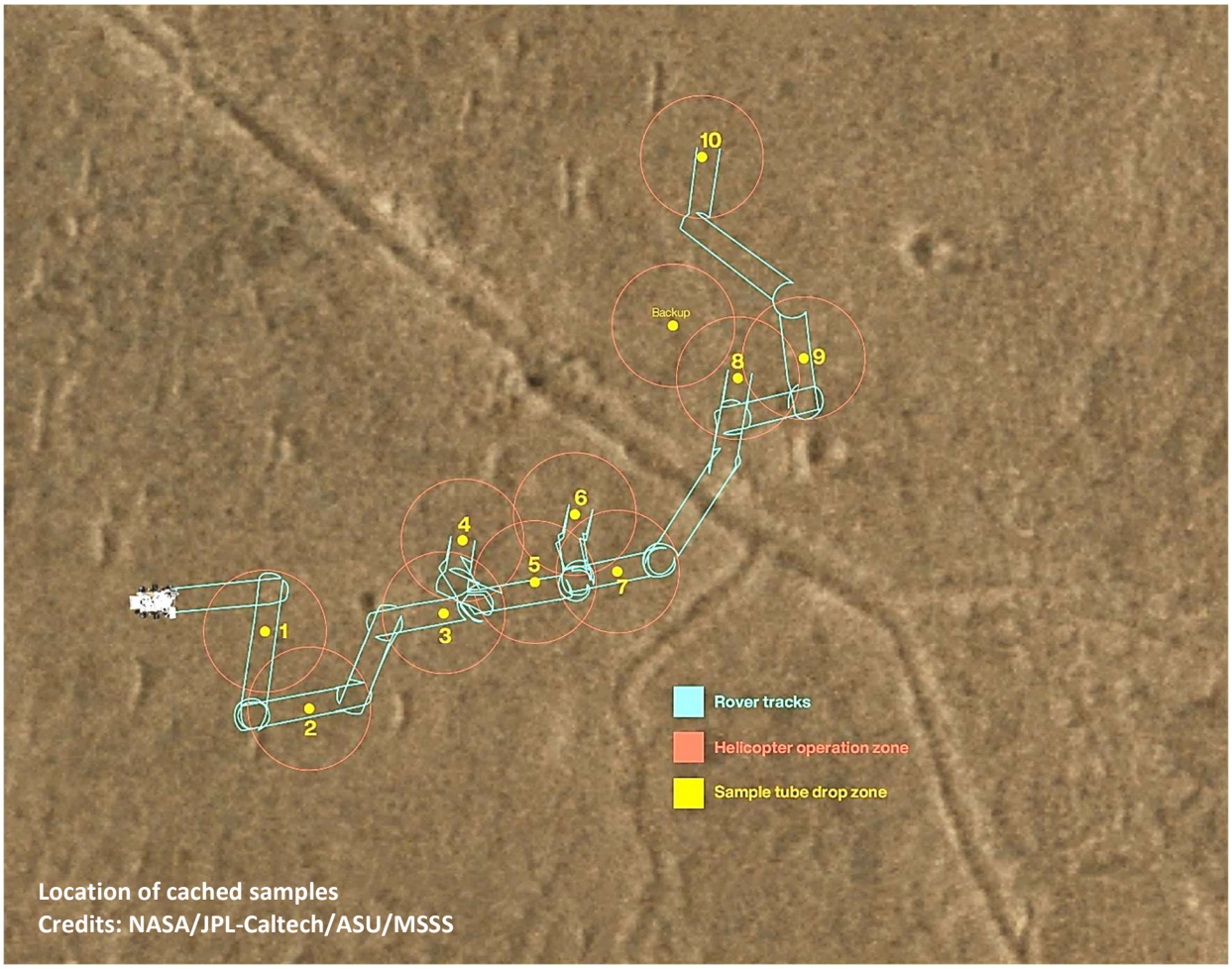
The splashdown of the Orion spacecraft on December 11th occurred exactly 50 years from the day the Apollo 17 lunar lander Challenger set down in the Moon's Taurus-Littrow valley. NASA had originally targeted a landing site near San Diego, but a less than favorable forecast pushed the recovery zone about 300 miles (480 km) south, off the coast of the Baja peninsula.

Shortly after separating from the Service Module, Orion performed a "skip entry," dipping into the upper layers of the Earth's atmosphere and "skipping" back out before reentering a second time. It was the first time this maneuver has been used for a human-rated spacecraft. Skip-entries have several advantages. As compared to the direct entry method used by Apollo, the technique extends the range of returning spacecraft and allows Orion to splashdown with more precision (targeting the same area regardless of when the spacecraft returns from the Moon). It also lowers the g-forces that the astronauts will experience and the heating by the spacecraft (with two reentry events rather than one). Orion splashed down within 2.1 nautical miles (4 km) of target.

The returning spacecraft was retrieved by USS Portland. It will be returned to the Kennedy Space Center for a detailed inspection, and where several components will be removed and refurbished for future flights.

Martian Cache Established

Over the next month, NASA's Perseverance rover will deposit ten of its sealed titanium sample tubes onto the ground at an area within Jezero Crater referred to as "Three Forks." The tubes, containing a diverse sample of chalk-size cores of rock or regolith, will be positioned to facilitate future retrieval and the return to Earth for analysis.



Since the sampling campaign began in September 2021, the rover has been collecting duplicate samples from several of its rock targets, with half designated for the Three Forks sample depot. Perseverance will retain the other half of paired samples along with those collected in the future.

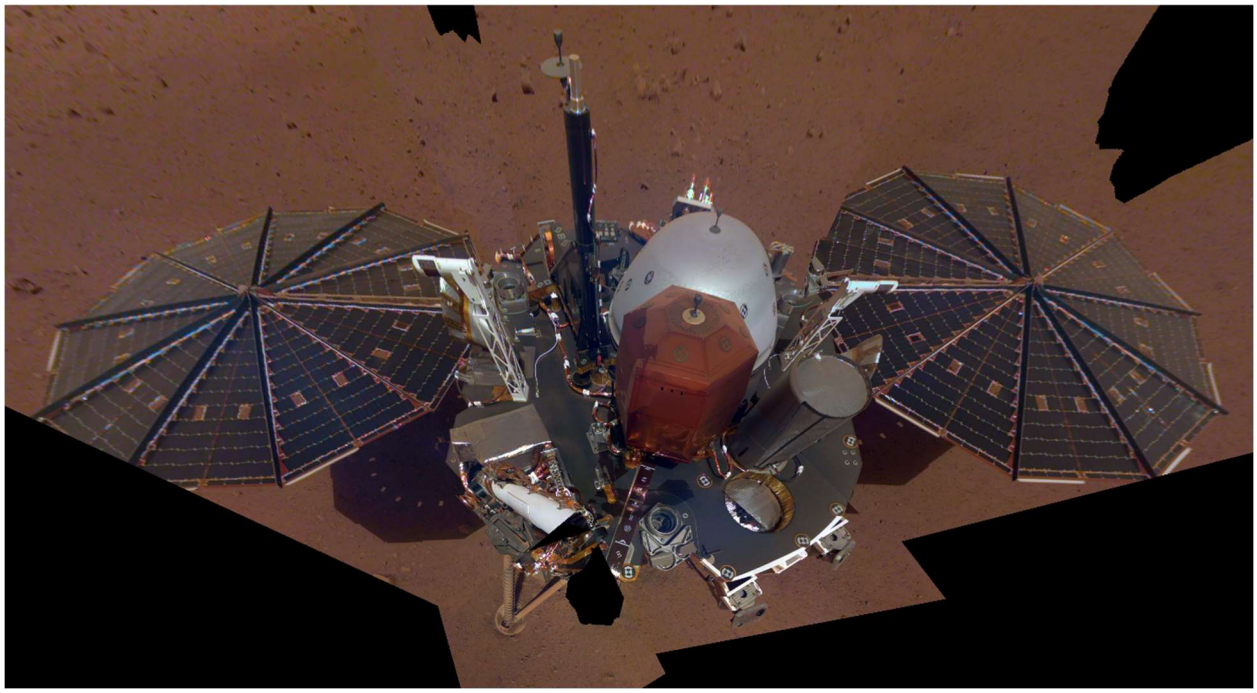
The depot was created as a contingency. NASA and its partner, the European Space Agency, are currently in discussions on a sample return mission. Tentative plans include the launch of an orbiter in 2027 and a lander in 2028, with samples expected to be returned to Earth in 2033. The organizations fully expect that Perseverance will be operational in that timeframe and capable of delivering its collection of samples to the lander. However, should that not be possible, the lander could deploy two helicopters to retrieve the sample tubes from the Three Forks cache.

The helicopters would be designed to work with only one tube at a time, therefore, the tubes are being dropped far enough from one another so that retrieval of one would not impact the others. As shown in the annotated photo (above) the zigzag drop pattern ensures that each sample location had sufficient separation and an "area of operation" at least 18 feet (5.5 meters) in diameter.

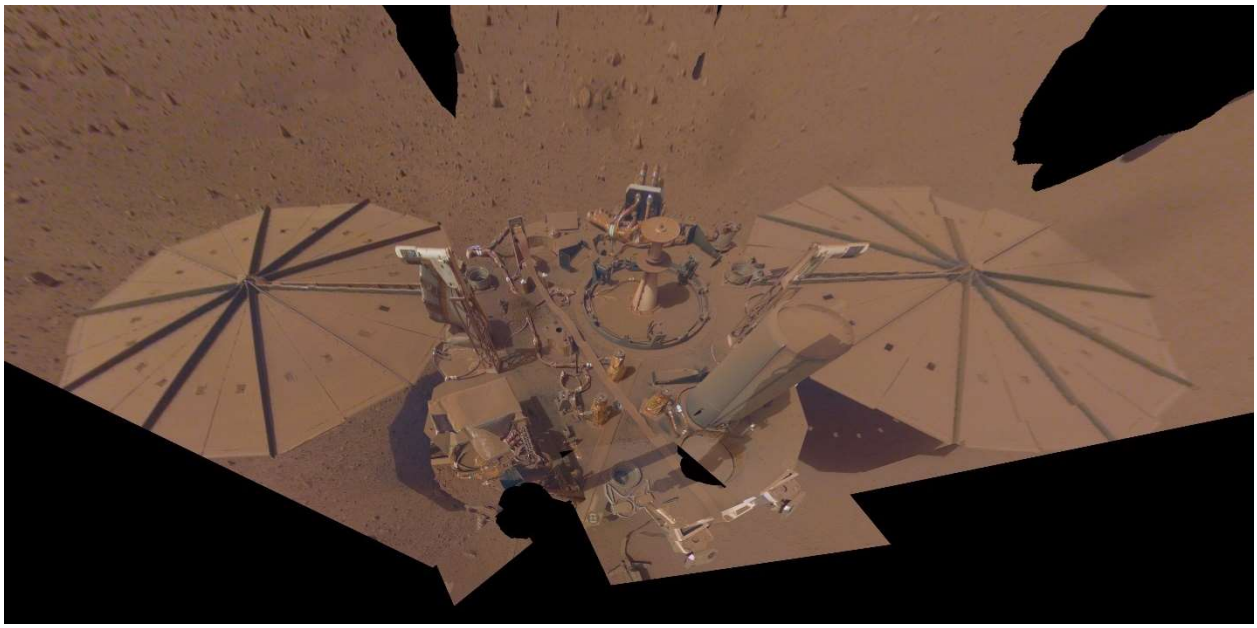
First sample dropped onto the surface on December 21, 2022 - Sol 653 of the mission
Credits: NASA/JPL-Caltech/MSSS

InSight's Mission Comes to an End

After four years on the Martian surface, the accumulation of dust on NASA's InSight lander has become so profuse so as to prevent its solar panels from generating enough power to support surface operations. On December 18th, the lander failed to respond to communications from Earth.



When InSight landed on November 26, 2018, the solar arrays produced around 5,000 watt-hours each Martian day, or Sol. As of December 12, 2022, the arrays were generating an average of only 285 watt-hours of energy. As a result, NASA has recently announced the end of mission.



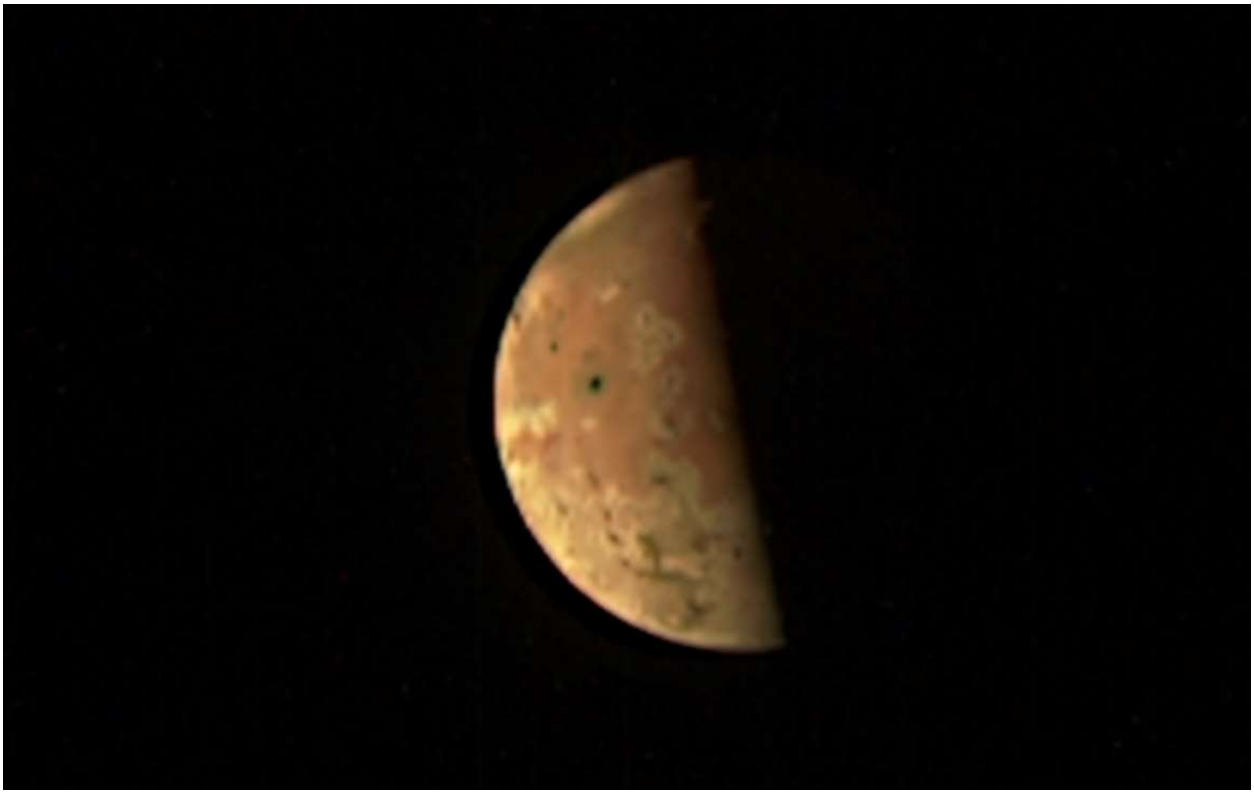
The last selfie taken by InSight's robotic arm before it was parked as an energy-saving measure shows the two dust-laden solar arrays, each about 7 feet (2.2 meters) in diameter
Images Credit: NASA/JPL-Caltech

Io Flyby

NASA's Juno spacecraft completed its 47th flyby of Jupiter on December 14th. The cloud top passage also set up the first of a series of close encounters with Jupiter's closest Galilean moon, Io, the most volcanic place in the solar system.

The region around Jupiter is treacherous, with the planet's radiation-intensive magnetosphere and huge doughnut-shaped radiation belts around its equatorial region that extend out past the moon Europa. Juno's highly elliptical orbit minimizes the time spent within the radiation field, but ultimately, cumulative radiation damage to the spacecraft's electronics will bring the mission to an end. In an effort to prolong its operating life, the engineers at Lockheed Martin Space Systems designed and built a titanium vault to enclose and shield the spacecraft's most sensitive components. While the spacecraft's electronics would have been completely fried without the 500 pound (200 kg) vault, its control circuits and hardware are still exposed to lower levels of radiation that, with each pass, shorten their life. Even relatively mild radiation can degrade circuitry, introduce errors, impact communications or navigations systems, and cause computer crashes.

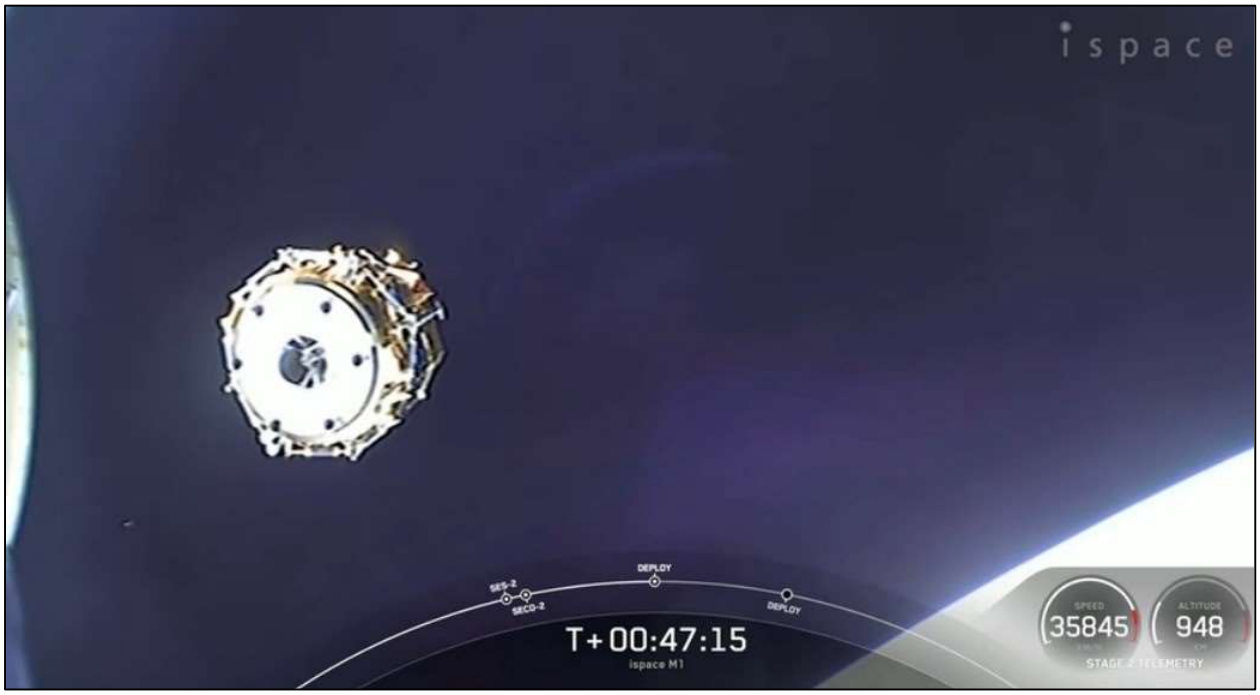
The 47th pass was not without incident. Most likely caused by a radiation spike as the spacecraft flew through the magnetosphere, Juno's downlink of science data was disrupted. Mission controllers were able reboot the spacecraft's computer and recover the science data from the flyby, including that from Io.



The first image of Io downloaded from the December 14th flyby. The image was captured from a distance of about 40,000 miles (64,000 km). Credit: NASA/JPL-Caltech/SwRI/MSSS

Korean Moon Probe and Lunar Flashlight in Transit

A SpaceX Falcon 9 rocket, launched in December from the Cape Canaveral Space Force Station in Florida, carried two payloads into orbit around the Earth before being sent on their way to the Moon. About 47 minutes into the mission, the Korean Hakuto-R spacecraft was deployed from the rocket's second stage. About 6 minutes later, NASA's Lunar Flashlight spacecraft was released. The two spacecraft were placed on a fuel-efficient trajectory that will take them a million miles from Earth before being captured by the Moon's gravity in April 2023.



Deployment of the Hakuto-R spacecraft

Credit: SpaceX

The Hakuto-R spacecraft, about the size of a compact car and weighing about 2,200 pounds (one metric ton fully fueled), is a Moon lander. Developed by a Japanese company called ispace, the company will attempt to be the first private venture to successfully execute a soft landing on the lunar surface. Once in lunar orbit, Hakuto-R will fire its main engine to autonomously descend into Atlas crater, located near the Moon's northern limb, east of Mare Frigoris.

Hakuto-R is carrying about 24 pounds (11 kgs) of customer payloads, the largest being a rover from the United Arab Emirates developed by the Mohammed Bin Rashid Space Center. The 22 pound (10 kg) rover is designed to operate for one lunar day (14 Earth days) during which it will study the properties of the lunar soil, dust conveyance, and the surface plasma environment. Also onboard is the Japanese Lunar Excursion Vehicle. This tiny robot, weighing a half of pound (.25 kg), transforms from a small sphere into a rolling cylinder. The robot is equipped with a camera for scouting the interior of the crater.

The Lunar Flashlight will eventually settle into an orbit that will take it as close as 9 miles (15 km) above the Moon's south pole. Equipped with four colored lasers that emit near-infrared light in wavelengths that are readily absorbed by surface water ice, the spacecraft will scan the interiors of those craters that sit in perpetual darkness. If the presence of water ice is confirmed, it could be used by future astronauts for drinking water, breathing air, and rocket propellant.

Webb Sets Its Sights on Titan

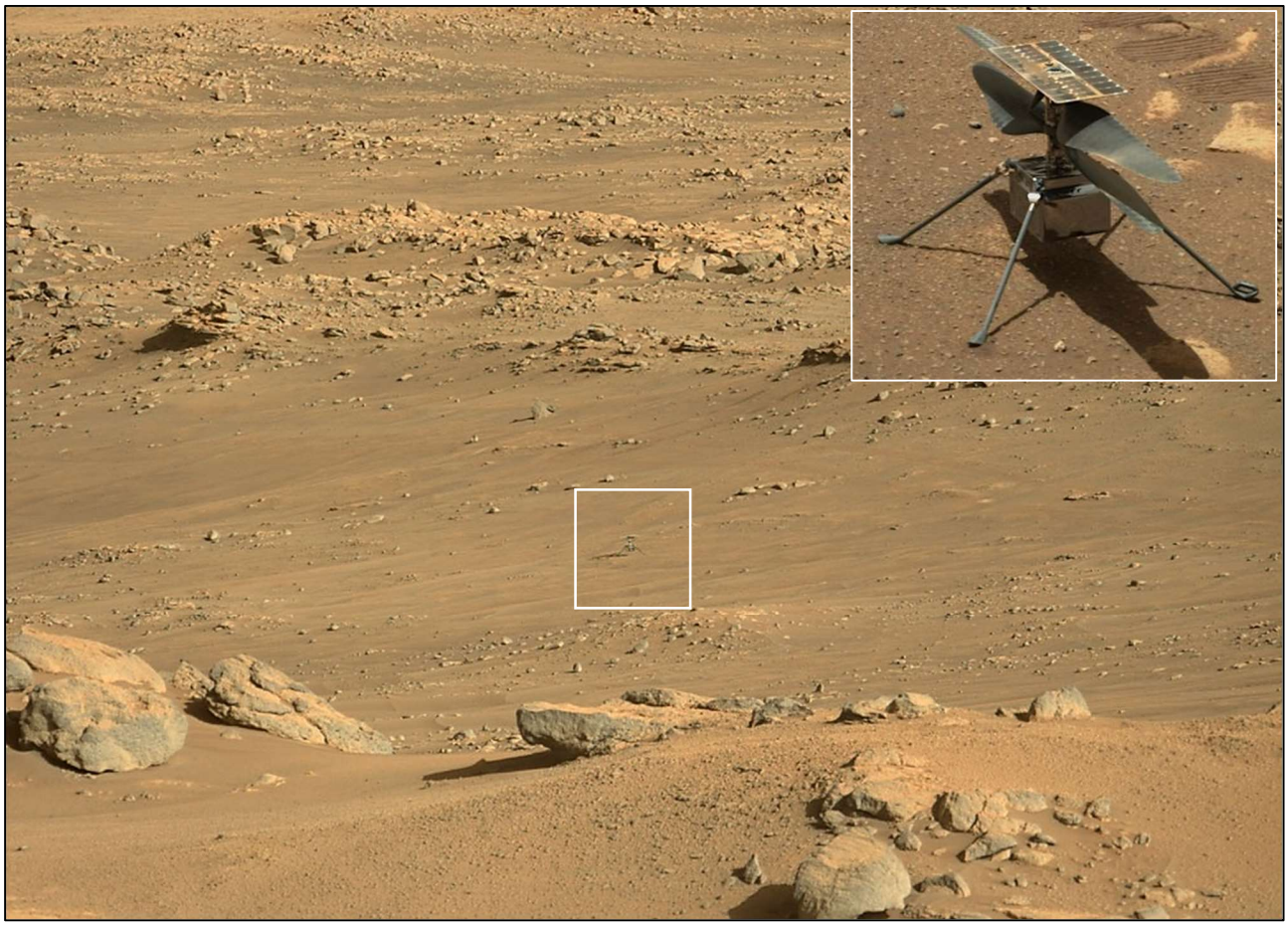
Two views of Saturn's moon Titan captured by the James Webb Space Telescope's NIRCam instrument. (Image credit: NASA, ESA, CSA, Webb Titan GTO Team/Alyssa Pagan (STScI))

The James Webb Space Telescope recently turned its sights on Saturn's largest moon Titan. Using its Near-Infrared Camera (NIRCam), researchers detected several clouds in the moon's atmosphere. Clouds can provide researchers essential information on the wind flow at different altitudes, global jet streams, and other atmospheric conditions on the moon. Since the Cassini mission ended in 2017, the Saturnian system has been monitored almost exclusively by Earth-based telescopes.

Other than Earth, Titan is the only body in the solar system with a dense atmosphere, as well as rivers, lakes and seas. Instead of a water cycle, Titan's is a world of hydrocarbons (like methane and ethane) which rain down upon the surface, run off into reservoirs, before evaporating and repeating the cycle. The hydrocarbons also contribute to the dense haze or orange smog in the primarily nitrogen atmosphere that hides details of the moon's surface from most optical instruments. At temperatures of -290°F, or -179°C, water ice plays the role of rock on this world that is larger than the planet Mercury. Our best views of the surface were provided by the Huygens probe as its descended through the cloud layer after being dropped off by Cassini in 2005.

Titan is the target of NASA's Dragonfly mission, scheduled to launch in 2026 and arrive in 2034. The nuclear powered craft, equipped with eight rotors, is expected to fly its science payload through Titan's dense atmosphere to dozens of sites over its 2.7-year baseline mission. With a chemical make-up that is similar to Earth's primordial atmosphere, Dragonfly will be looking for signs that life that may have developed on this extraordinary world.

New Mission for Ingenuity



The Ingenuity helicopter captured by the Perseverance rover's Mastcam-Z camera when the rotorcraft was about 970 feet (295 meters) away. The closeup was taken shortly after Ingenuity was deployed on the surface. Credits: NASA/JPL-Caltech/ASU/MSSS

NASA's Ingenuity helicopter, which rode to Mars attached to the Perseverance rover, took its first flight on April 19, 2021. That flight lasted just 39 seconds, with the rotorcraft rising to an altitude of 10 feet (3 meters) before settling back down. It was the first of 5 flights that NASA hoped to conduct within a 30-day window allotted for this technology demonstration.

Fast forward 591 Sols (Martian days) and what was once a test vehicle, has become an integral member of the mission to explore Jezero crater. NASA now intends to fly the diminutive aircraft up to the top of the ancient river delta, accompanying Perseverance and providing the rover a second pair of "eyes" along the route. Designed for a level "test bed," JPL engineers have been testing and uploading changes to Ingenuity's software so that the helicopter can fly higher, further, and land on more rugged surfaces with its new hazard avoidance capabilities.

In early December, as the JPL team worked to reposition the helicopter along the front of the delta, Ingenuity set a new altitude record, gaining 46 feet (14 meters) of altitude as compared to its previous maximum of 33 feet (10 meters). As of December 17th, the 4 Earth-pound (1.8 kg) rotorcraft has flown 37 times, covering a total distance of 24,867 feet (7,579 meters), with just over an hour of cumulative flight time.

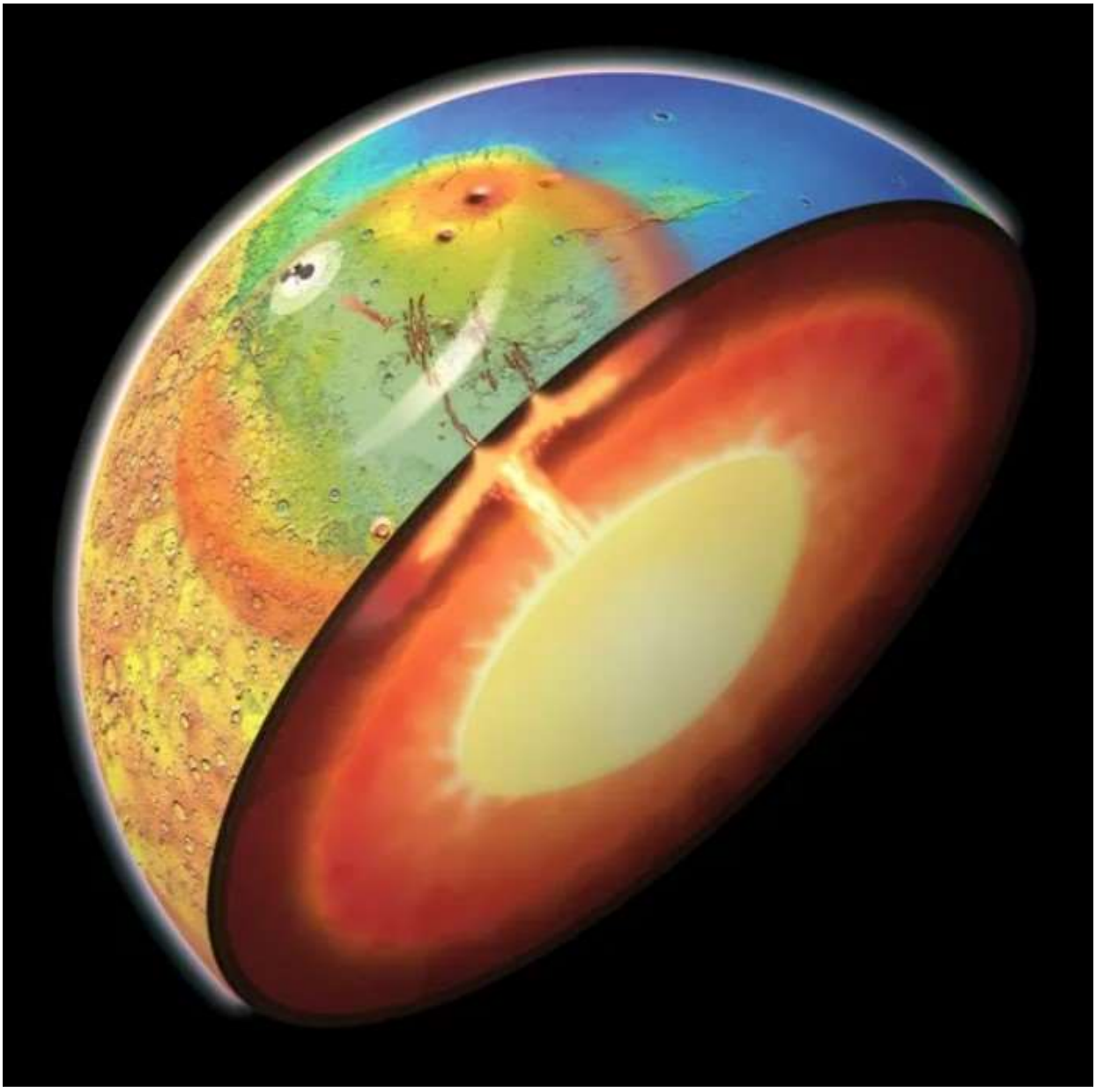
Above: A panorama of the ancient river delta at the western edge of Jezero crater from images taken by the Mastcam-Z system on NASA's Perseverance Mars rover
Credit: NASA/JPL-Caltech/ASU/MSSS

Below: A view of the delta from orbit captured by the European Space Agency's Mars Express Orbiter's High Resolution Stereo Camera, annotated with the helicopter's and rover's end-of-2022 location along the base of the delta
Credit: ESA/DLR/FU-Berlin

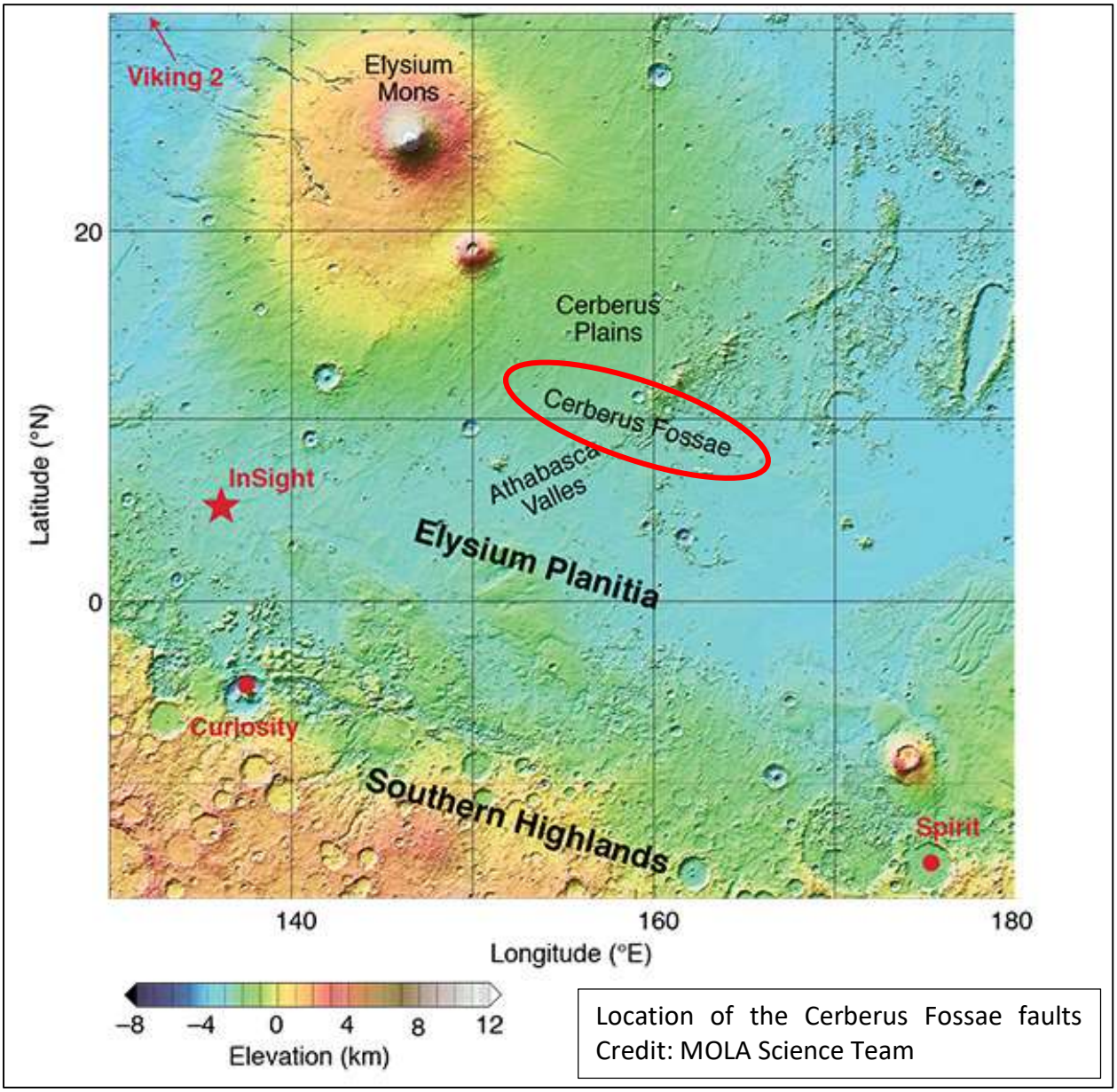
Hot Rock Rising

During InSight's four-year mission, the NASA lander's seismometer detected more than a thousand marsquakes. Almost all of the seismic activity was traced back to the Elysium Planitia region in the planet's northern lowlands, specifically, a series of young fissures that run along the surface for more than 800 miles (1,300 km) called Cerberus Fossae.

Scientists at the Lunar and Planetary Laboratory at the University of Arizona in Tucson, Arizona, have compiled multiple lines of evidence that the source of this seismic activity is likely a plume of molten rock rising from deep inside the planet.



Artist's impression of an active mantle plume under the Elysium Planitia region
Credit: Adrien Broquet & Audrey Lasbordes



Location of the Cerberus Fossae faults
Credit: MOLA Science Team

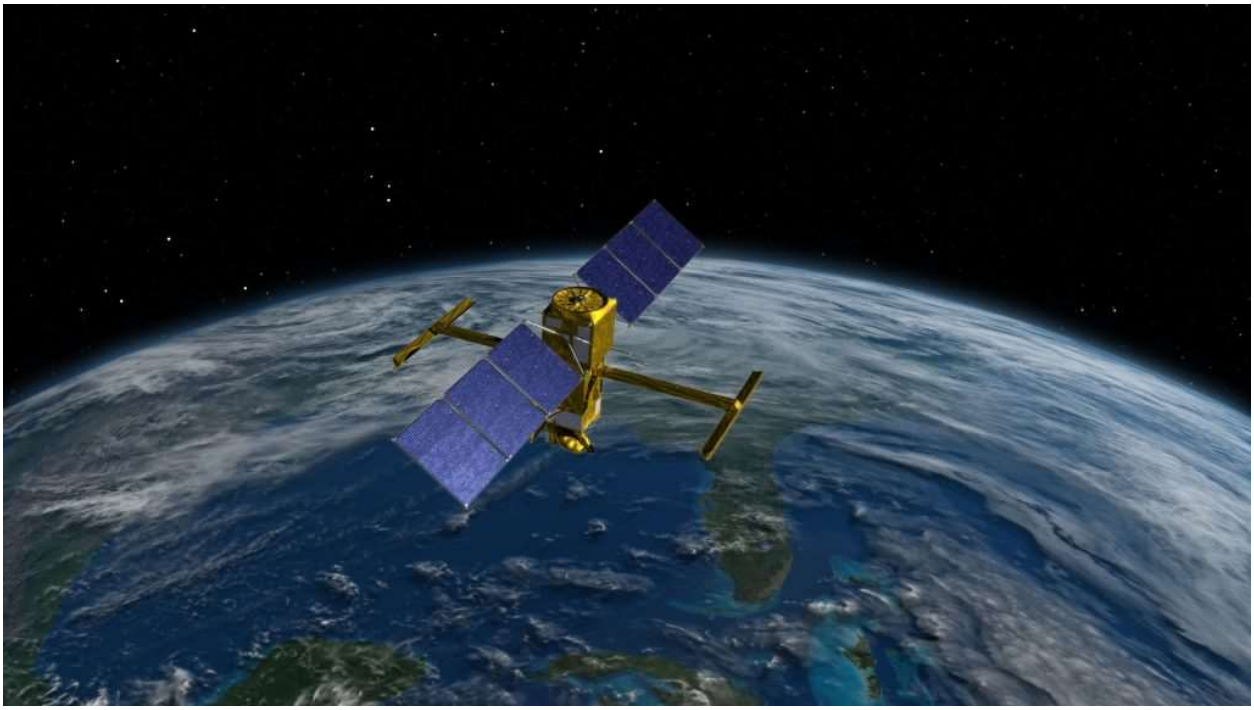
Researchers discovered that the surface around the Cerberus Fossae fissures has been uplifted by more than a mile (1.6 km), an anomaly in the low lying northern plains. Subtle variations in the local gravity field indicate that this uplift is supported from deep within the planet. In addition, the floors of craters in the area around the fissures are tilted towards the center of the uplift.

The plume is estimated to be 2,500 miles wide (4,000 km), based upon tectonic modeling, with the molten rock projected to be 95° to 285° K warmer than its surroundings. Cerberus Fossae is also the site of the planet's most recent volcanic event, approximately 53,000 years ago, when an eruption covered the area in volcanic ash.

If confirmed, heat from the plume could provide a source of energy, as well as keep any subsurface water liquid, for microbial life that might have been driven underground as the planet's surface cooled and desiccated.

SWOT

The Surface Water and Ocean Topography (SWOT) spacecraft, jointly developed by NASA and Centre National D'Etudes Spatiales (CNES), with contributions from the Canadian Space Agency (CSA) and United Kingdom Space Agency, was launched from the Vandenberg Space Force Base in California aboard a SpaceX Falcon 9 rocket on December 16th. SWOT is the first satellite mission designed to observe nearly all of Earth's surface water, measure the height of water in more than 95% of the world's lakes larger than 15 acres (62,500 square meters), rivers wider than 330 feet (100 meters), ocean levels, as well as changes over time.

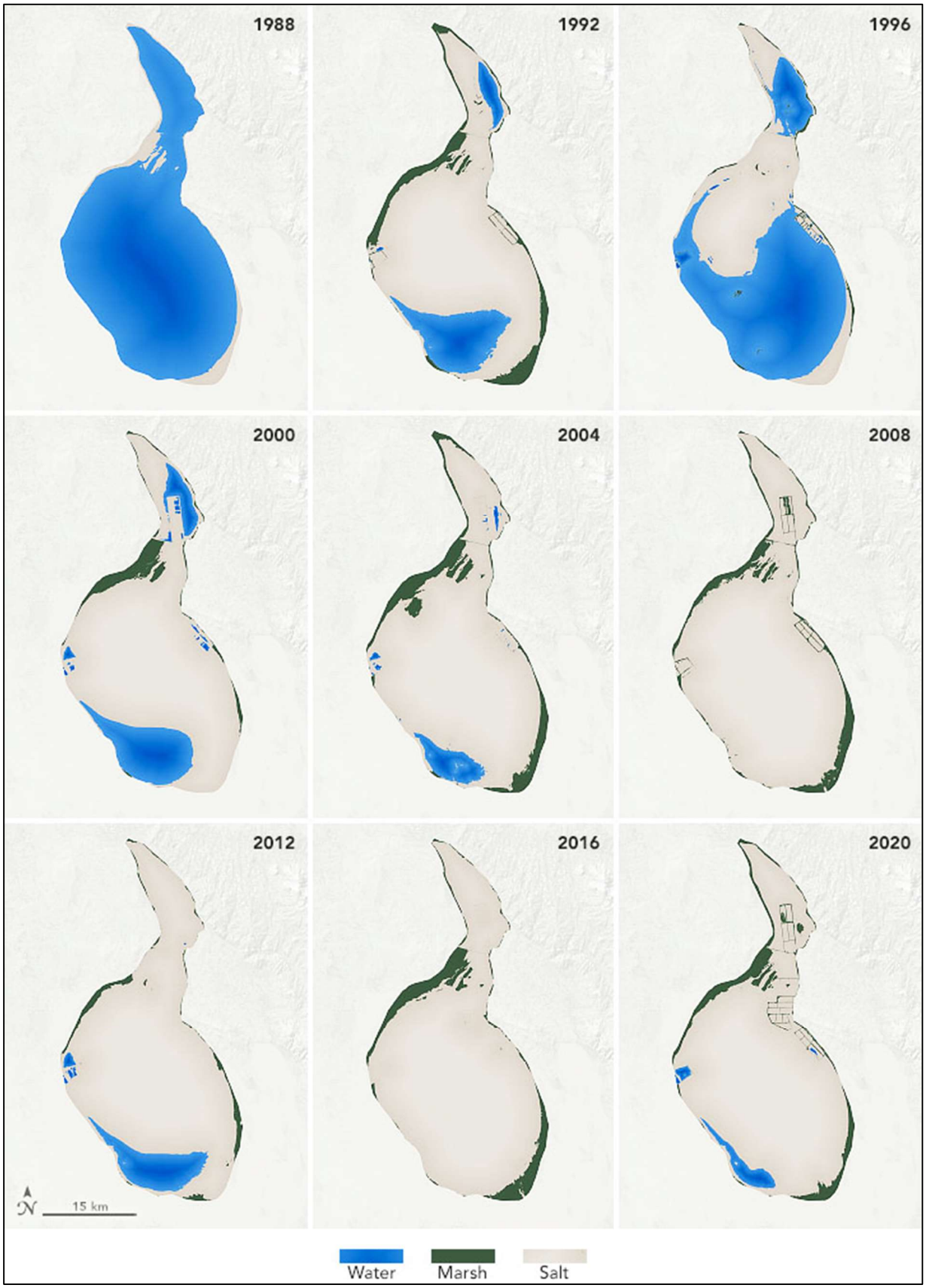


An artist's concept of the Surface Water and Ocean Topography (SWOT) spacecraft with its two-wing radar interferometer.
Credits: NASA

The rocket booster placed SWOT into an orbit about 532 miles (857 km) above Earth, at an inclination of 77.6° to the equator. The spacecraft is expected to undergo a six-month commissioning/test campaign before beginning science operations in mid-2023.

SWOT will aid scientists in cataloguing the water inventory of Earth's oceans, lakes and rivers and the effects of climate change on their ability to absorb heat and greenhouse gases like carbon dioxide. Its instruments will see Earth's water in higher definition than ever before and provide critical information on changes along the coastlines, which can then be used to improve computer models for sea level rise projections and the forecasting of coastal flooding.

SWOT data will also be used to monitor drought conditions in lakes and improve flood forecasts for rivers. This information will be available to disaster preparedness agencies, educational institutions, water management organizations, local communities and others who need to track local and regional water budgets and environmental consequences.



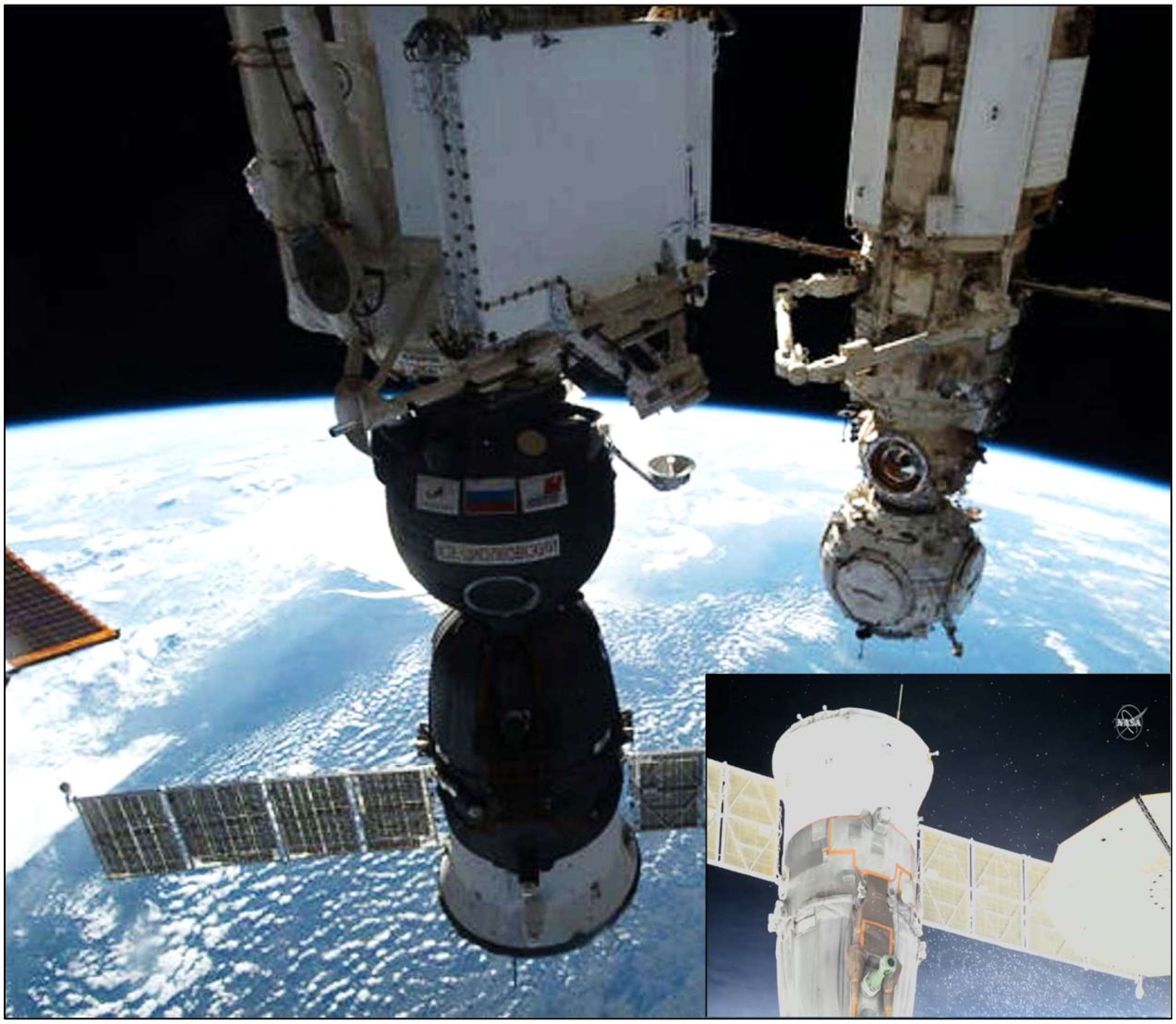
Lake Tuz, once the second-largest lake in Turkey, over time in August. Credit: NASA Earth Observatory images by Joshua Stevens, using Landsat data from the U.S. Geological Survey and data courtesy of Aydin, F., Erlat, E., & Türkeş, M

Lake Tuz is a saline lake located on the Central Anatolia plateau, about 90 miles (150 km) south-southeast of Ankara. The lake is fed by groundwater, two major streams and springtime rains. The images of the lake every few years (previous page) are from annual maps developed from Landsat satellite data. In recent years, the lake has all but disappeared (along with its wild life) due to more frequent and intense droughts, the diversion of inlet water for irrigations and the extraction of the groundwater to meet the needs of the local population.

The Mediterranean Basin is considered a global hotspot. The area has warmed more since the pre-industrial period compared to the global average (1.5°C/2.7°F as compared to 1.1°C/2.0°F).

Faster than a Speeding Bullet - Space Danger

A Russian Soyuz spacecraft parked at the International Space Station (ISS) sprung a coolant leak on December 15th. The leak, which drained the system that cools the spaceship's instrumentation compartment (where the primary guidance, navigation, control and computer systems are located), raised concerns as to whether the spacecraft is able to safely return its crew to Earth.



The Soyuz spacecraft docked to the Russian Rassvet ISS module and the cloud of coolant. Photos: NASA

An inspection by the station's robotic arm did find a small hole in the capsule. A micrometeorite or tiny piece of space debris is suspected of causing the damage although the investigation is not complete. The Soyuz capsule was to be used to return NASA astronaut Frank Rubio and Roscosmos cosmonauts Sergey Prokopyev and Dmitri Petelin to Earth in the early spring. While a SpaceX spacecraft is also parked at the station, it cannot accommodate the entire ISS contingent.

If the Soyuz spacecraft is not deemed to be flight-worthy, Roscosmos, the Russian space agency, could elect to expedite the launch of a replacement capsule (the Soyuz is designed for automated docking so it could be launched without a crew).

Explorer 1

Sixty-five years ago, on January 31, 1958, the United States successfully launched its first satellite, Explorer 1. The launch occurred during the International Geophysical Year, a global initiative which actually ran from July 1957 to December 1958 and coincided with the peak in the 11-year solar cycle. Unlike Sputnik 1, which had been launched by the Soviet Union in October of 1957 and designed to only broadcast radio pulses (or Sputnik 2 which carried a dog into space as a crude biological demonstration), Explorer 1 carried a suite of instruments to study cosmic rays, micrometeoroids, and the satellite's temperature. It was the first artificial satellite designed to return scientific data.

The launch of Explorer 1 followed the unsuccessful launch of a U.S. satellite on a Navy Vanguard rocket in December (the rocket fell back to the pad and exploded shortly after liftoff). Following the humiliating loss of Vanguard, which was widely publicized by the Soviets, the competing Army's rocket team (headed by Wernher von Braun) offered their Jupiter C ballistic missile as an alternative launch vehicle. Teamed with the Jet Propulsion Laboratory (JPL) which designed and constructed the satellite and James Van Allen who designed the cosmic ray detector, the 31-pound (14 kg) satellite was successfully placed into an orbit around Earth with an apogee of 1,563 miles (2,515 km) and a perigee of 220 miles (354 km).

L to R: Pickering, Van Allen and von Braun
Credit: NASA

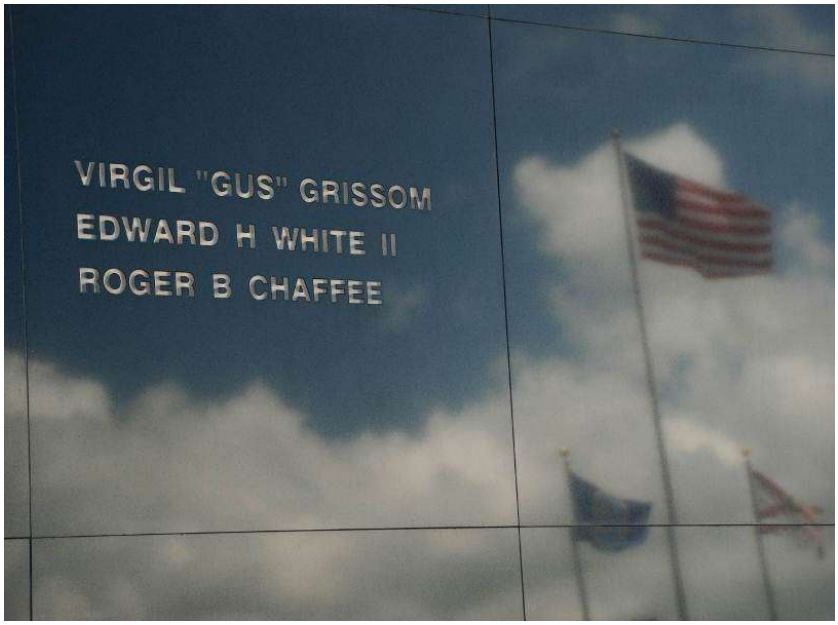
During a 1:00 am press conference at the National Academy of Sciences on February 1, shortly after the successful night launch of Explorer 1, the three team leaders Bill Pickering (JPL), James Van Allen (State University of Iowa) and Wernher von Braun (Army's Redstone Arsenal) celebrate by holding aloft a model of the satellite.

Explorer 1 would end up completing more than 58,000 orbits before reentering the Earth's atmosphere on March 31, 1970. The lower-than-expected counts recorded by the cosmic ray detector led Van Allen to theorize that the instrument had been affected by charged particles trapped by the Earth's magnetic field. The existence of two and sometimes three toroidal "radiation belts" encircling the Earth were later confirmed by subsequent missions and named the Van Allen Belts.

In August 2012, NASA launched the Van Allen Probes to study this dynamic region of space (http://vanallenprobes.jhuapl.edu/). With two identical spacecraft, traveling in tandem, scientists were able to measure changes in the belts over time and space. The probes have provided researchers a new understanding of how the belts respond to fluctuations in the Sun's output. The two-year mission was later extended to seven years as the probes continued to return ground-breaking results. The orbits of the two probes were lowered in 2019, before they ran out of fuel, to ensure that they would eventually burn up in the Earth's atmosphere and not add to the growing orbital debris fields that pose hazards to spacecraft and space travelers. NASA's mission to explore Earth's radiation belts ended when ground controllers shut down the first probe in July 2019 and the second in October.

January History

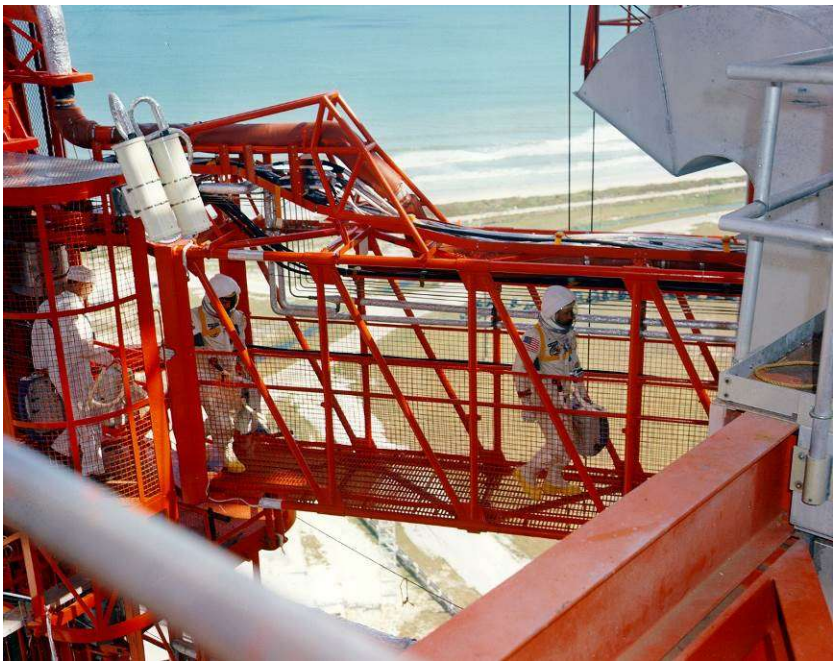
The month of January has been a difficult one for both the American and Soviet space programs. Untimely deaths set back both the American and Soviet moon programs. The two space shuttles that have been lost were also launched in January.



Space Mirror Memorial on the grounds of the Kennedy Space Center Visitor Complex Photo: Bill Cloutier

Sergei Korolev, the "Chief Designer" of the Soviet space program, died on January 14, 1966 from a botched medical procedure. Korolev co-founded the Moscow rocketry organization in the 1930s before being thrown into prison during the peak of Stalin's purges. He spent a year in the Kolyma gold mine, the most dreaded part of the Gulag in Siberia before he was recalled to Moscow to aid the Red Army in developing new weapons. Korolev went on to lead the Soviet space effort. Unfortunately,

the Soviet Moon program died with Korolev in 1966. While the race continued for some time after his death, his N-1 moon rocket never made a successful flight.



The crew of Apollo 1 crosses the gantry to the spacecraft on the day of the fire, Jan. 27, 1967 Credit: NASA

In January of 1967, after a successful conclusion to the Gemini program, NASA was moving forward with testing the new Apollo spacecraft. On the afternoon of the 27th, Gus Grissom, Ed White and Roger Chaffee were sealed inside the Apollo 1 command module sitting on top of an unfueled Saturn rocket in a simulated countdown. The command module had been plagued with problems and was in a state of constant redesign. At 6:31 pm, a spark from a damaged wire ignited the pure oxygen atmosphere in the spacecraft. Within seconds the temperature reached 2,500°. The astronauts never had a chance to undo the bolts of the hatch before they were asphyxiated. Following their deaths, the spacecraft was completely redesigned. Lessons learned from this accident served to make the spacecraft much safer and contributed to the success of the six moon landings.

Thirty-six years ago, on January 28, 1986, the United States lost its first space shuttle, the Challenger. Due to the low temperature on the launch pad, a rubber-like O-Ring used to seal the joints of the solid rocket boosters failed to seat and stop the hot gasses from escaping. The gas produced a blowtorch-like flame that penetrated the external tank filled with liquid oxygen and hydrogen. The tank exploded 73 seconds after liftoff, destroying the shuttle and killing all seven crew members. Among the crew was Christa McAuliffe, a New Hampshire teacher. Christa graduated from Framingham State College (Framingham, Massachusetts) in 1970. Following her death, the college established *The Christa McAuliffe Center* on the campus as a means to continue the educational mission which was Christa's life's work.

On February 1, 2003, a second space shuttle, the Columbia, was lost. The Columbia was the oldest shuttle in the fleet, having been first flown in 1981 by astronauts John Young and Robert Crippen. On its 28th flight, Columbia broke apart during reentry at an altitude of some 200,000 feet and a speed of 12,500 miles per hour. The shuttle and its crew of seven had just completed a 16-day science mission. The most likely cause of the accident was damage to a seal on the left wing from a piece of insulating foam that broke loose from the external fuel tank at launch, striking the wing. The resulting gap in the wing allowed the superheated atmosphere to penetrate the wing during reentry and destroy the spacecraft. The Columbia accident ultimately led to the decision to stop flying the space shuttle once the International Space Station was complete and spurred efforts to develop a safer manned vehicle.

The "Forever Remembered" memorial in the Space Shuttle Atlantis exhibit at the Kennedy Space Center Visitor Complex in Florida. Visitors entering the darkened room will see a section of the fuselage recovered from space shuttle Challenger (left) and the flight deck window frames recovered from the space shuttle Columbia.

Photo: Bill Cloutier

January Nights

January nights can be clear and cold with frigid blasts of polar wind. They also present an opportunity to see stars at every stage in their life cycle, from birth (Orion Nebula) to fiery demise (Crab supernova remnant).

If you are out observing the open star clusters Pleiades or Hyades (in mythology, half-sisters to the Pleiades) in the constellation Taurus, don't overlook the orange-colored star Aldebaran (spectral type of K5 with a surface temperature of 4,010° K as compared to the Sun's 5,780° K temperature). While not part of the Hyades cluster (which is more than twice as far away as the red giant), the "eye of the bull," and the brightest star in Taurus, is estimated to be about 67 light years away and the fourteenth brightest star in our sky.

Sunrise and Sunset (from New Milford)

Sun	Sunrise	Sunset
January 1st (EST)	07:20	16:34
January 15th	07:17	16:48
January 31st	07:06	17:07

Astronomical and Historical Events

1st Plutino *2005 TV189* at Opposition (31.940 AU)
1st History: flyby of the Kuiper Belt Object 486958 *Arrokoth* (2014 MU69) by the New Horizons spacecraft (2018)
1st History: GRAIL-B spacecraft enters lunar orbit (2012)
1st History: Giuseppe Piazzi discovers the first asteroid, now dwarf planet, *Ceres* (1801)
2nd Apollo Asteroid *2021 NF* near-Earth flyby (0.046 AU)
2nd Amor Asteroid *164215 Doloreshill* closest approach to Earth (2.221 AU)
2nd Plutino *2002 XV93* at Opposition (37.158 AU)
2nd History: flyby of comet *Wild 2* by the Stardust spacecraft (2004)
2nd History: launch of the Soviet spacecraft Luna 1; first probe to fly by the Moon (1959)
3rd Quadrantids meteor shower peaks; radiates from the constellation Boötes (name from an obsolete constellation called Quadrans Muralis)
3rd Aten Asteroid *2011 WR41* near-Earth flyby (0.041 AU)
3rd History: exploration rover Spirit lands on Mars in Gusev Crater; operational for six years before getting bogged down in loose soil at a winter haven called Troy (2004)
3rd History: Stephen Synnott discovers Uranus' moons *Juliet* and *Portia* (1986)
4th Earth at Perihelion – closest distance from Sun (0.983 AU)
4th Apollo Asteroid *2019 AY3* near-Earth flyby (0.043 AU)
4th History: Isaac Newton born; inventor of the reflecting telescope, described universal gravitation, compiled the laws of motion, and invented calculus (1643)
5th Binary Apollo Asteroid *2017 YE5* closest approach to Earth (0.987 AU)
5th Asteroid *376 Geometria* closest approach to Earth (1.657 AU)
5th History: discovery of dwarf planet *Eris* (the Pluto killer) by Mike Brown, et al. (2005)
5th History: President Nixon announces the development of the space shuttle; "a space vehicle that can shuttle repeatedly from Earth to orbit and back" (1972)
5th History: launch of the Soviet atmospheric probe, Venera 5, to Venus (1969)
5th History: discovery of Jupiter's moon *Elara* by Charles Perrine (1905)
6th Full Moon
6th History: launch of the Lunar Prospector spacecraft; detected signs of water ice in permanently shadowed craters, mapped surface composition and Moon's gravity field and detected outgassing events in the vicinity of craters Aristarchus and Kepler (1998)
6th History: launch of Surveyor 7, the last of the unmanned Surveyor spacecrafts; soft-landed near Tycho crater (1968)
7th History: discovery and first recorded observations of Jupiter's four largest moons *Io*, *Europa*, *Ganymede* and *Callisto* by Galileo Galilei (1610)
8th Moon at apogee (furthest distance from Earth)
8th Kuiper Belt Object 2014 WP509 At Opposition (41.940 AU)
8th History: launch of Japanese spacecraft Sakigake with mission to rendezvous with Comet *Halley*; measured the solar wind and magnetic field (1985)
8th History: launch of Luna 21 and the Lunokhod 2 moon rover (1973)
8th History: Stephen Hawking born (exactly 300 years after the death of Galileo); discovered that black holes could emit radiation - subsequently known as Hawking radiation (1942)
9th History: Alex Wolszczan and Dale Frail discover two exoplanets (Poltergeist and Phobetor) orbiting a pulsar PSR B1257+12 (1992)
9th History: Voyager 2/Stephen Synnott discovers Uranus' moon *Cressida* (1986)
10th History: launch of the Soviet atmospheric probe, Venera 6, to Venus (1969)

Astronomical and Historical Events (continued)

10th History: U.S. Army first bounces radio waves off the Moon (1946)
11th History: Lunar Prospector spacecraft enters lunar orbit for a nineteen-month chemical mapping mission (1998)
11th History: William Herschel discovers Uranus' moons *Titania* and *Oberon* (1787)
12th History: launch of the Deep Impact spacecraft for a flyby of comet *Tempel 1*; a small "impactor" was later released from the main spacecraft for a July 4th collision with the comet's nucleus (2005)
12th History: Sergei Pavlovich Korolev born, Chief Designer of the Soviet space program (1907)
12th History: Astronomical Society of London conceived with Sir William Herschel first President (chartered in 1831 as the Royal Astronomical Society) (1820)
13th History: Stephen Synnott discovers Uranus' moons *Desdemona*, *Rosalind* and *Belinda* (1986)
13th History: discovery of the Martian meteorite EETA 79001 in Antarctica; second largest Martian meteorite recovered after *Zagami* (1980)
14th Last Quarter Moon
14th Second Saturday Stars – Open House at the McCarthy Observatory, 7 PM
14th History: first of three flybys of the planet Mercury by the Messenger spacecraft (2008)
14th History: landing of the Huygens probe on Saturn's largest moon *Titan* (2005)
15th History: Stardust spacecraft returns samples of Comet P/*Wild 2* (2006)
15th History: launch of the spacecraft Helios 2, solar orbiter (1976)
15th History: Lunokhod 2, the second of two Soviet unmanned lunar rovers, lands in Le Monnier crater; covered a total distance of 23 miles (37 km) in almost five months of exploring the floor of the crater and its southern rim (1973)
16th History: final launch of space shuttle Columbia (STS-107); lost on re-entry (2003)
17th History: Astronomer Edwin Hubble publishes paper that the Universe is expanding – "*A Relation Between Distance and Radial Velocity Among Extra-Galactic Nebulae*" (1929)
17th History: launch of Jason 3, an ocean altimetry satellite from the Vandenberg Air Force Base, California (2016)
17th History: Pierre Mechain's discovery of Comet 2P/*Encke* (1786); short period comet that completes a circuit around the Sun every 3.3 years, named after Johann Encke who computed the comet's orbit, recognizing it as a periodic comet
19th History: launch of the New Horizons spacecraft to Pluto; executed a close encounter with the dwarf planet in July 2015 (2006)
19th History: Mars Exploration Rover "Opportunity" discovers first meteorite on Mars (Heat Shield Rock) (2005)
19th History: discovery of the Martian meteorite SAU 090, a basaltic shergottite, in Oman (2002)
19th History: discovery of Saturn's moon *Janus* by the Voyager 1 spacecraft (1980)
19th History: launch of Gemini 2, an unmanned suborbital flight designed to test the spacecraft's heat shield (1965)
19th History: Johann Bode born, popularized an empirical law on planetary distances originally developed by J.D. Titius, known as "Bode's Law" or "Titius-Bode Law" (1747)
20th History: Rich Terrile discovers Uranus' moons *Cordelia* and *Ophelia* (1986)
21st New Moon
21st Moon at perigee (closest distance from Earth)

Astronomical and Historical Events (continued)

21st History: launch of the rocket Little Joe-1B and a rhesus monkey named "Miss Sam" in a successful test of the Mercury capsule's escape system (1960)
21st History: John Couch Adams born, astronomer and mathematician who was the first person to predict the position of a planet beyond Uranus (1792)
22nd History: launch of Apollo 5, the first Lunar Module flight (1968)
23rd History: Brad Smith discovers Uranus' moon *Bianca* (1986)
24th History: launch of space shuttle Discovery (STS-51-C); 100th human spaceflight to achieve orbit (1985)
24th History: discovery of the Martian meteorite Dhofar 019 in Oman (2000)
24th History: launch of Japan's Hiten spacecraft; first use of a low-energy transfer to modify an orbit and the first demonstration of a transfer to the Moon requiring no change in velocity for capture (1990)
24th History: flyby of Uranus by the Voyager 2 spacecraft (1986)
25th History: exploration rover Opportunity lands on Mars at Meridiani Planum; operated for over 14 years before being crippled by a global dust storm in 2018 (2004)
25th History: launch of the Infrared Astronomical Satellite (IRAS); first space telescope to survey of the entire sky at infrared wavelengths (1983)
25th History: launch of the U.S. Moon orbiter Clementine (1994)
25th History: Joseph Lagrange born (1736); mathematician who discovered five special points in the vicinity of two orbiting masses where a third, smaller mass can orbit at a fixed distance from the larger masses. The L1 Lagrange Point of the Earth-Sun system is the current home of the Solar and Heliospheric Observatory Satellite (SOHO), the James Webb Space Telescope is heading for L2 (1 million miles beyond the Earth and away from the Sun).
26th History: discovery of dwarf planet *Haumea*'s moon *Hi'laka* by Mike Brown, et al. (2005)
26th History: discovery of Saturn's moon *Epimetheus* by the Voyager 1 spacecraft (1980)
26th History: launch of the International Ultraviolet Explorer (IUE); space telescope and spectrographs; designed to take ultraviolet spectra (1978)
27th History: fire in the Apollo 1 spacecraft kills astronauts Gus Grissom, Edward White and Roger Chaffee (1967)
27th History: Philibert Melotte discovers Jupiter's moon *Pasiphae* (1908)
28th First Quarter Moon
28th History: final launch of the space shuttle Challenger (STS-51L); lost on lift-off (1986)
28th History: Johannes Hevelius born; leading observational astronomer of the 17th century, published detailed maps of the Moon and determined the rotational period of the Sun (1611)
29th History: Soviet spacecraft Phobos 2 enter orbit around Mars; successfully returned 38 images before contact was lost; its lander was not deployed (1989)
30th Mercury at its Greatest Western Elongation (25°) – apparent separation from the Sun in the morning sky
30th History: Yuji Hyakutake discovers the Great Comet of 1996 (1996)
31st History: launch of SMAP (Soil Moisture Active Passive) satellite into a polar orbit around Earth (2015)
31st History: launch of Apollo 14; third manned moon landing with astronauts Alan Shepard, Stuart Roosa and Edgar Mitchell (1971)

Astronomical and Historical Events (continued)

31st History: launch of Soviet Moon lander Luna 9; first spacecraft to land and to transmit photographs from the Moon's surface (1966)
31st History: launch of Mercury-Redstone 2 rocket with Ham the chimpanzee (1961)
31st History: launch of the first U.S. satellite, Explorer 1; detected inner radiation belt encircling the Earth (1958)

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 Artificial Satellites

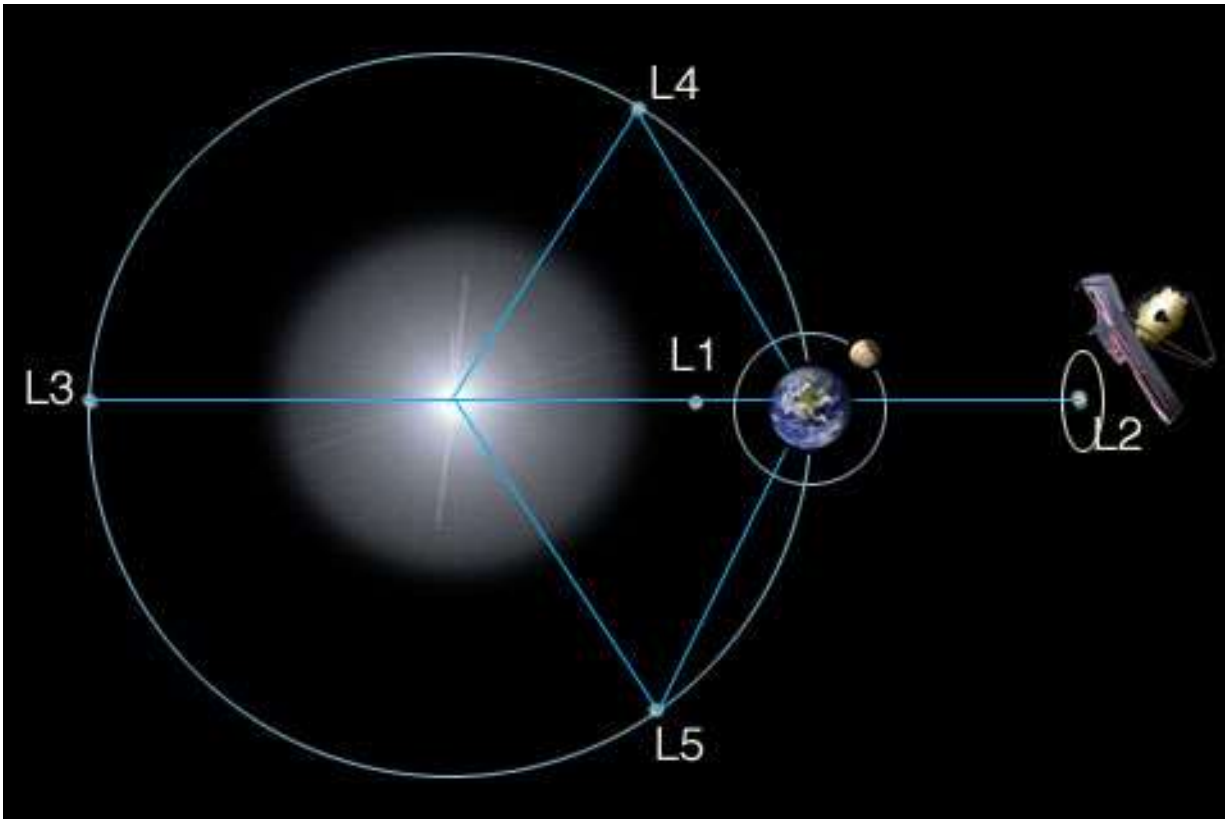
Visit www.heavens-above.com for the times of visibility and detailed star charts for viewing the International Space Station and the bright flares from Iridium satellites.

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/

Mars InSight (lander): https://mars.nasa.gov/insight/

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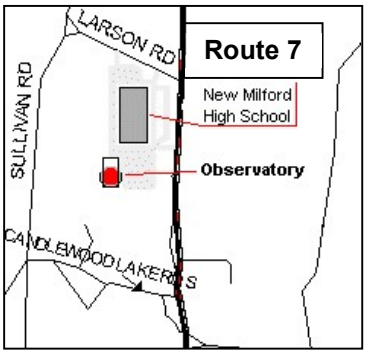

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