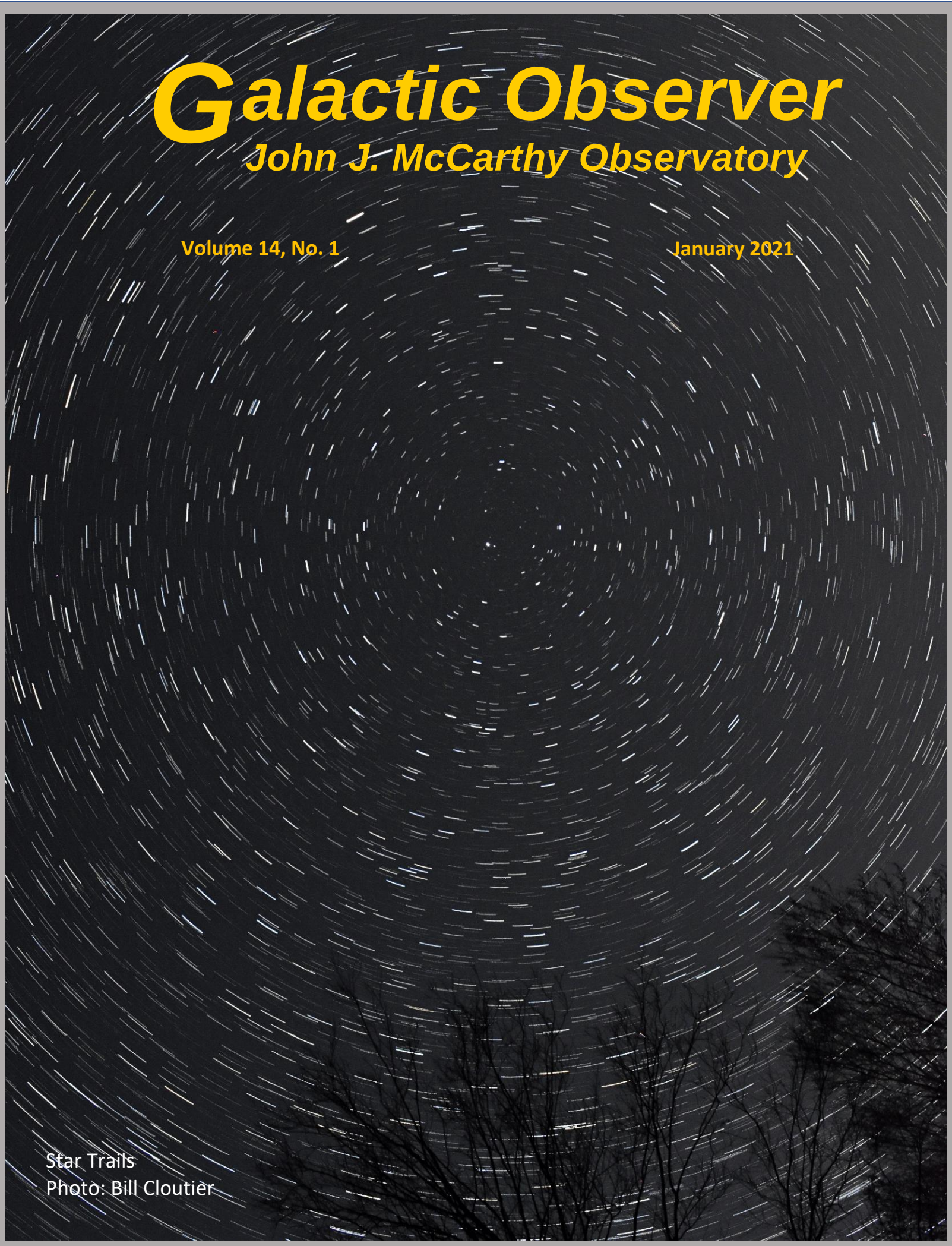
Galactic Observer

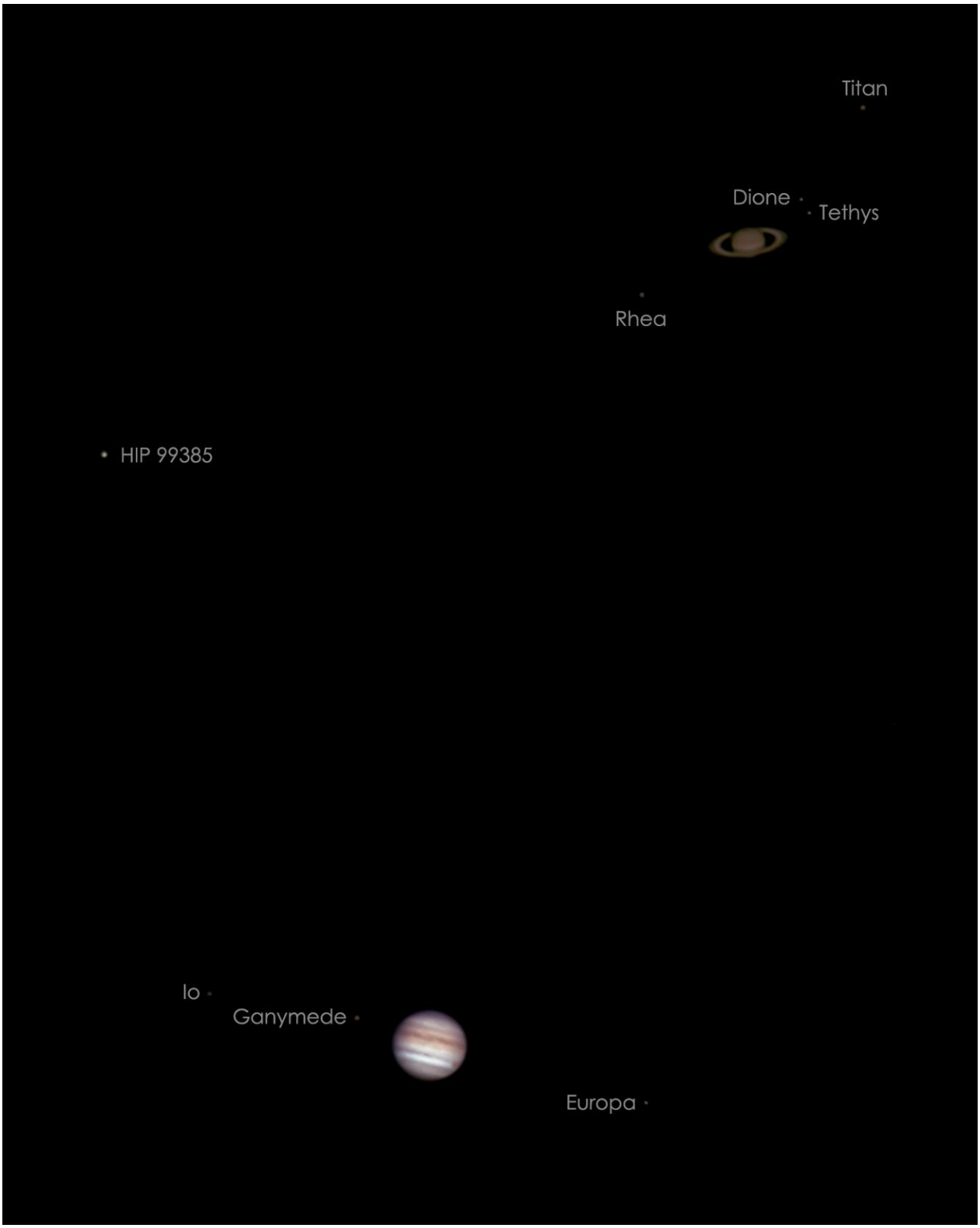
John J. McCarthy Observatory

Volume 14, No. 1 January 2021



Star Trails
Photo: Bill Cloutier

January Astronomy Calendar and Space Exploration Almanac



Grand Conjunction of 2020 captured through a 10" Meade telescope on 21 Dec 2020. Saturn was actually twice as far from Earth as Jupiter and, as such, almost 4 times fainter.
Photo credit: Marc Polansky

In This Issue

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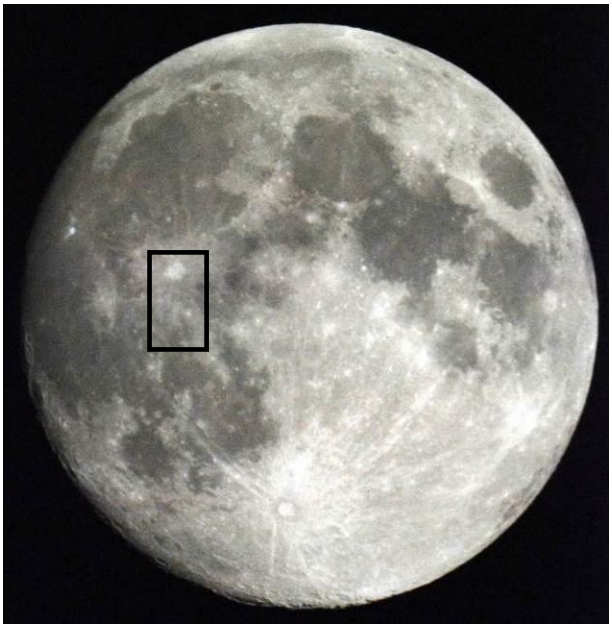
"Out the Window on Your Left"

It's been more than 51 years since Neil Armstrong first stepped onto the moon's surface and 48 years since Gene Cernan left the last footprint. 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 Moon's Fra Maura Region

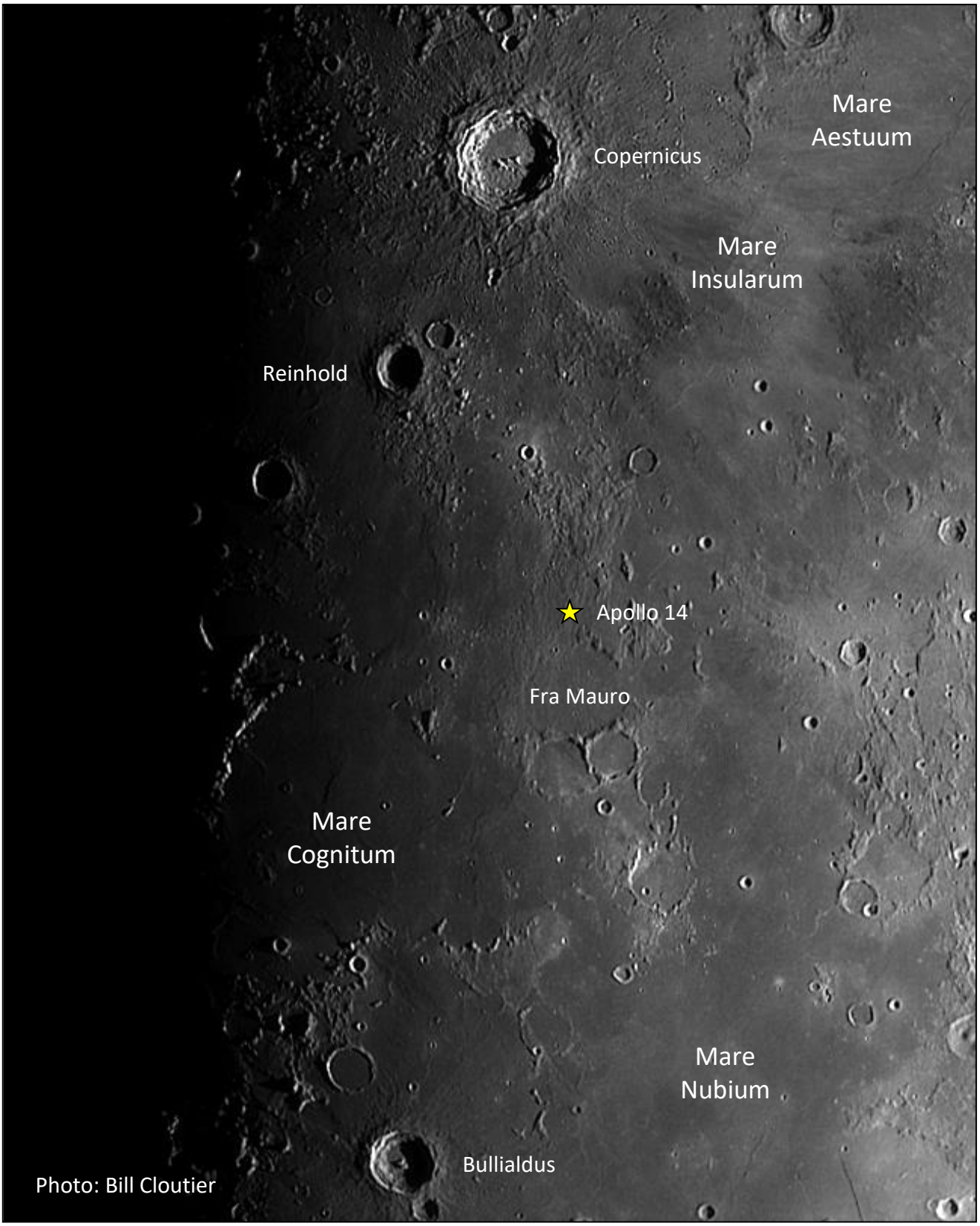
Apollo 14 was launched on January 31, 1971 at 4:03 pm EST. Commanding the mission was Alan B. Shepard Jr., the lone original-seven Mercury astronaut to fly to the Moon. It was only Shepard's second flight after becoming the first American to reach space in May 1961 with a 15-minute suborbital flight (he had been grounded for almost a decade with an inner ear ailment). Accompanying Shepard were Edgar Mitchell as Lunar Module Pilot and Stuart Roosa as Command Module Pilot.

The Apollo 14 landing site (originally the destination of the aborted Apollo 13 mission) was just north of the Fra Mauro impact crater. Bright ray material covered the site from the Copernicus crater, approximately 225 miles (360 km) to the north, along with impact ejecta from the Imbrium Basin, 310 miles or 500 km to the north. Nearby was Cone crater, a relatively young impact feature that penetrated the regolith layer – excavating older material.

On February 5, the lunar lander Antares executed a pinpoint landing (after glitches with the landing radar almost ended the mission), approximately 87 feet (26 meters) from its intended target, and 110 miles (177 km) east of the Apollo 12 landing site. Shepard and Mitchell spent 33½ hours on the Moon, including almost 9½ hours exploring the surface in two separate excursions. During the second excursion, the two astronauts attempted to summit Cone crater, 300 feet (91 meters) above the landing site. The trek consumed more time and energy than anticipated (the astronauts were also dragging a wheeled cart with tools and samples up the hill), and mission control had the astronauts turn back before they were able to reach the rim. Later Lunar Reconnaissance Orbiter images show the astronauts were less than 100 feet (30 meters) from the rim at turnaround.

The crew of Apollo 14 gathered almost 110 pounds (43 kg) of rock. The samples of Imbrium Basin ejecta returned by Shepard and Mitchell were radiometrically dated to approximately 3.85 billion years ago, making it one of the youngest impact basins, possibly second youngest to the Orientale Basin. Recent analysis of Lunar Sample 14321, collected by Shepard, found an embedded fragment that is likely of terrestrial (Earth) origin and roughly 4 billion years old, suggesting that the oldest Earth rocks may be found on the Moon.

Fra Mauro and Apollo 14



Planets in 2021

The superior planets (those that orbit further from the Sun than the Earth) return to the evening sky in the latter half of 2021, appearing at their brightest when they are at, or near Opposition (when the planet is opposite the Sun in our sky). At that time, the planets rise at sunset and are highest in our sky around midnight.

Saturn reaches Opposition on August 2, about 13 days later than in 2020. The ringed planet can be found in the constellation Capricornus, the Sea Goat, shinning at an apparent magnitude of +0.1 at its brightest. It will be 8.94 AU from Earth at that time (approximately 831 million miles or 1.337 billion km). Saturn has an axial tilt of 27°, so our view of the gas giant changes from year to year. This year, the planet's rings will be tilted at an angle of +18° to our line of sight, slightly less than in 2020 (when it was 21°), with the planet's north pole sunlit.

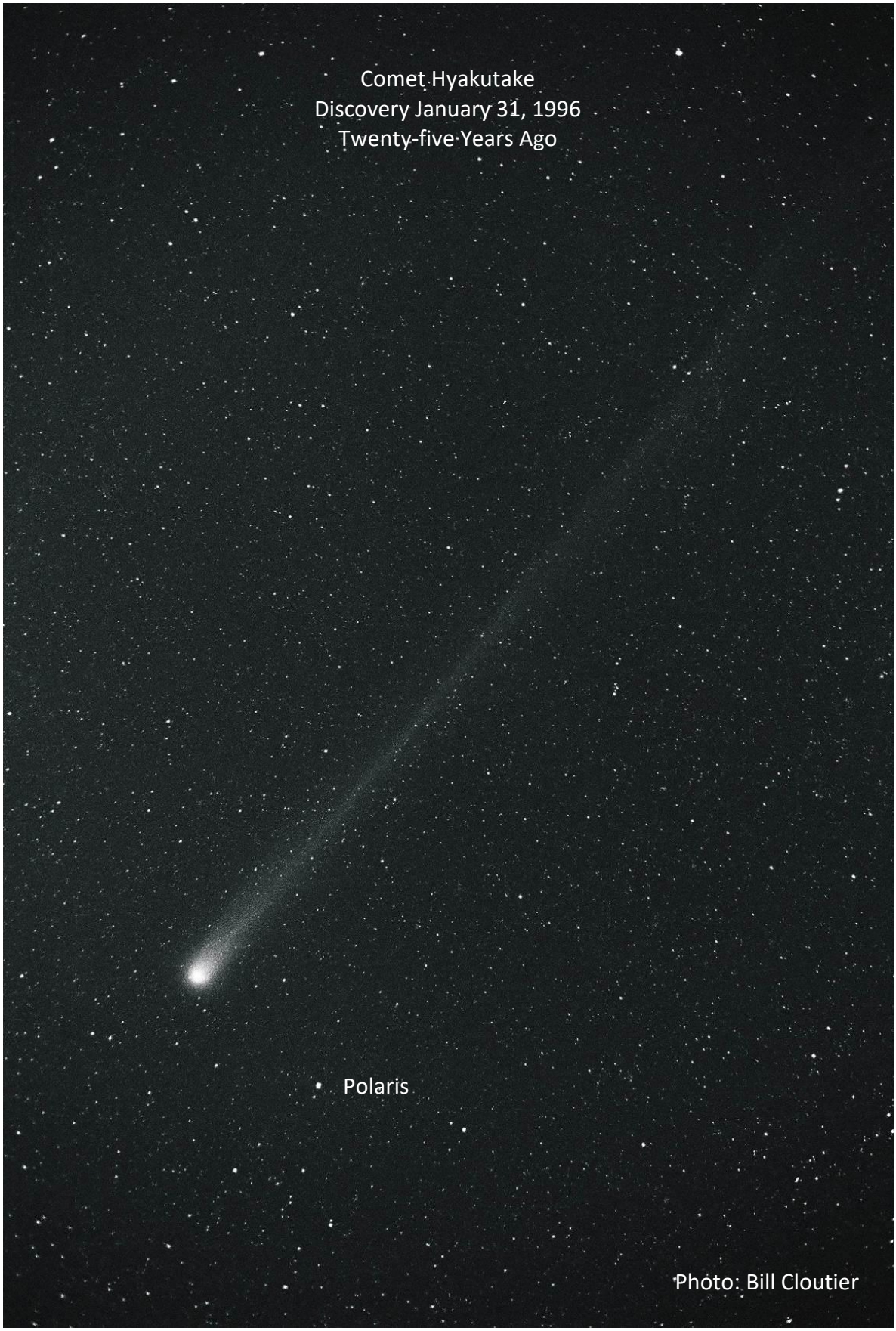
Jupiter reaches Opposition, on average, every 399 days or about 33 days later each successive year. In 2021, Opposition is on August 19 when the gas giant will be 4.01 astronomical units (AU) from Earth (approximately 373 million miles or 600 million km). Jupiter will shine at an apparent magnitude of -2.7 at its brightest (only surpassed by Venus for planetary luminosity) and can also be found in the constellation Capricornus, the Sea Goat.

Neptune reaches Opposition on September 14. The blue ice giant can be found in the constellation Aquarius, the Water Carrier, but at an apparent magnitude of +7.8, you will need binoculars or a telescope to even locate the eighth planet against the background stars. At its closest, Neptune will be a distant 28.92 AUs from the Earth (approximately 2.69 billion miles or 4.33 billion km).

Uranus reaches Opposition on November 4. The first planet to be discovered with the telescope can 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 18.74 AUs from the Earth (approximately 1.74 billion miles or 2.80 billion km). Only with the aid of a telescope will you be able to see the blue-green disk of the sideways-spinning planet.

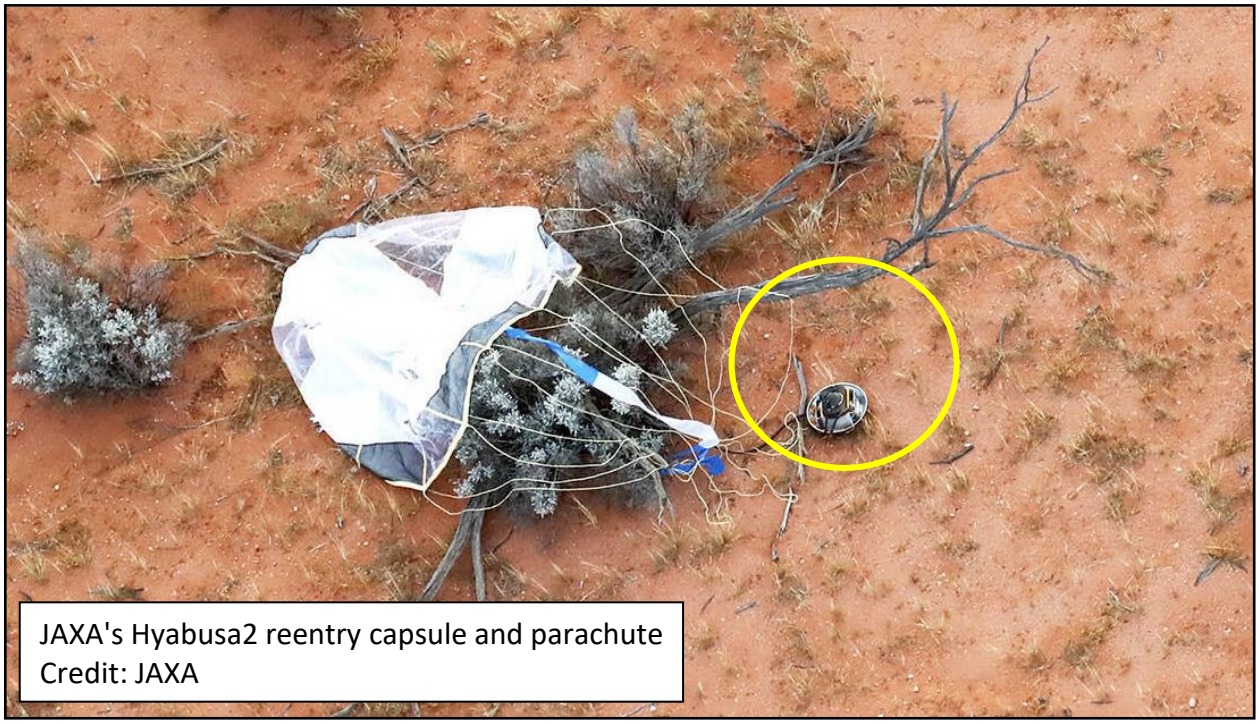
Mercury is best seen when farthest from the Sun in Earth's sky. The best evening views (Greatest Eastern Elongation or GEE) occur on January 24, May 17 and September 14, when the inner planet is 18.6°, 22°, and 26.8° from the Sun, respectively, and is visible up to 90 minutes after sunset, shining as bright as 0.6 magnitude. The best morning prospects (Greatest Western Elongation) are on March 6, July 4, and October 25, when Mercury rises up to 2 hours before sunrise and shines as bright as magnitude -0.7.

Venus is brightest when closest to Earth (crescent phase) and its separation greatest from the Sun. The planet reaches GEE on October 29, with an eastern elongation of 47°, although it will be relatively low in the western sky after sunset. Venus reaches its highest point in the sky on December 6 with a beautiful conjunction – joining a three-day-old crescent moon, with Saturn and Jupiter nearby. The following day (December 7), the cloud-shrouded planet is at its brightest in 2021 at magnitude -4.7. On December 13, Venus will pass within ⅓ of a degree (north) of Pluto (at magnitude 15.1) – for reference, the full moon is about ½ of a degree in angular size in the night sky.


Comet Hyakutake
Discovery January 31, 1996
Twenty-five Years Ago
Polaris
Photo: Bill Cloutier

Special Delivery from Hayabusa2

The Japanese spacecraft Hayabusa2 began moving away from the asteroid Ryugu in mid-November 2019, before embarking on its return to Earth. After a journey of almost 180-million-miles (290-million-km), the spacecraft released its sample return capsule from a distance of 140,000 miles (220,000 km), as it flew by the Earth on December 6. The 16-inch (40-cm) capsule entered the atmosphere at 27,000 miles per hour (12 km/s), relying upon its heat shield to protect its payload and shed velocity. At an altitude of about 6 miles (10 km), a parachute was deployed, further slowing the descent to a soft landing on the sandy ground of Australia's Woomera Range Complex. The capsule was recovered about two hours later by the Japan Aerospace Exploration Agency (JAXA), after having landed before sunrise within the 40 square mile (100 sq. km) target zone.



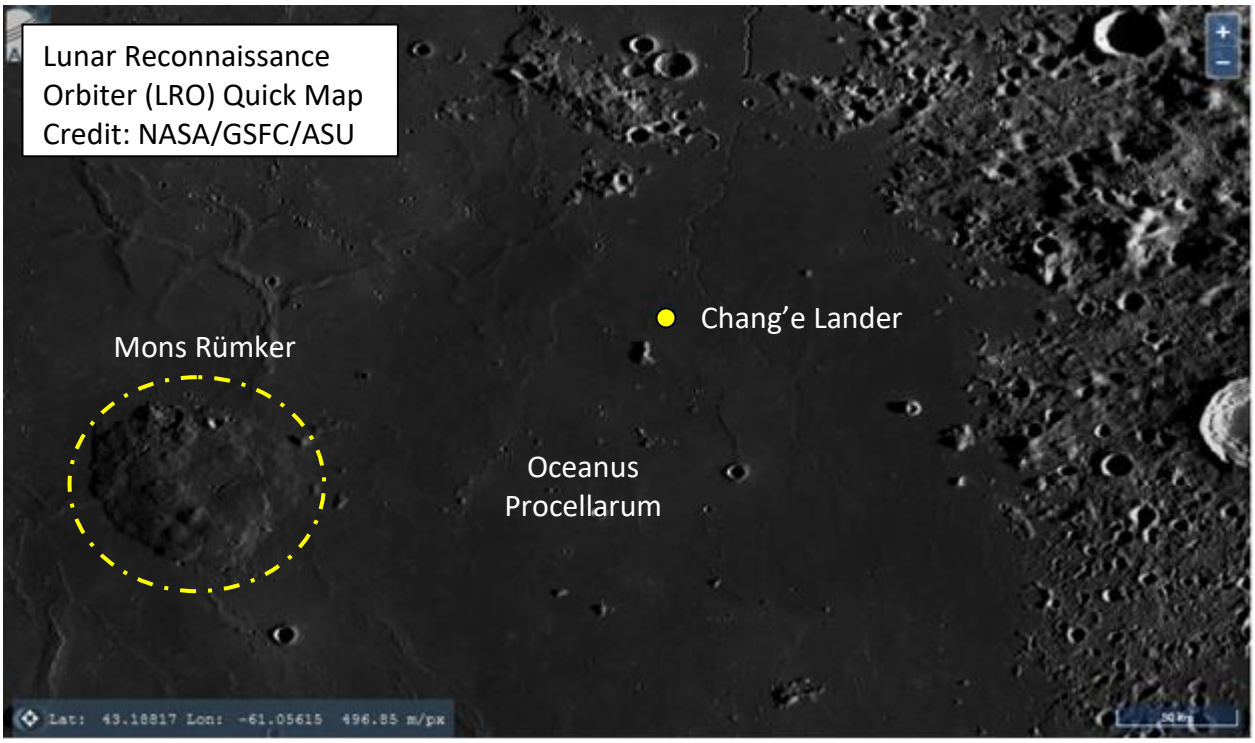
JAXA's Hyabusa2 reentry capsule and parachute
Credit: JAXA

Hayabusa2 was launched in December 2014 and spent sixteen months exploring the primitive, carbonaceous asteroid - touching down on the surface on two separate occasions to collect samples. Scientists have confirmed that the capsule contains about 5.4 grams of small black rocks, gravel and dust (the target was 0.1 gms). JAXA will be sharing a portion with NASA in exchange for a sample from the asteroid Bennu, when the OSIRIS-ReX spacecraft returns in 2023.

JAXA team member carrying the capsule from the recovery area. Credit: JAXA/EPA

To the Moon and Back

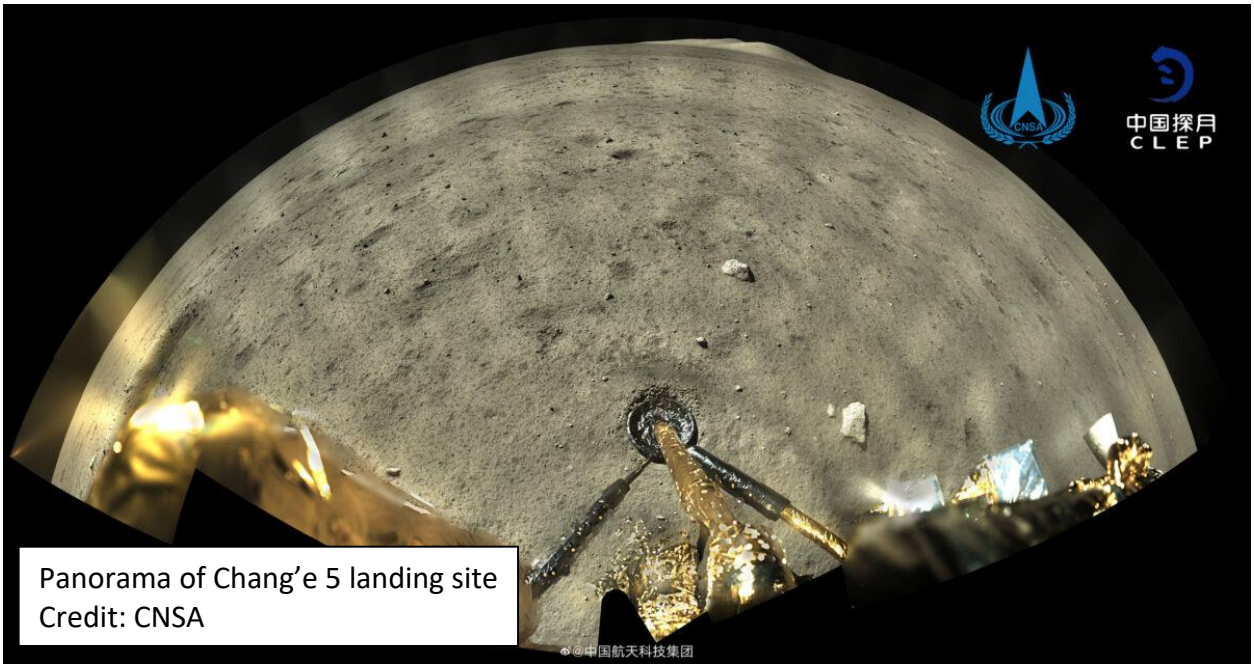
China's Chang'e 5 mission has concluded with the landing of its sample return capsule ("Return Vehicle") on the snow-covered plains of Inner Mongolia at 1:59 a.m. local time on December 17. The capsule is expected to contain up to 4.4 pounds (2 kgs) of rock and regolith (lunar soil) from the Mons Rümker region of the Moon's Oceanus Procellarum ("Ocean of Storms"). It is the first time in 44 years that lunar material will have been retrieved from the Moon since the Soviet Union's Luna 24 returned 6 ounces (170.1 grams) of material in August 1976.



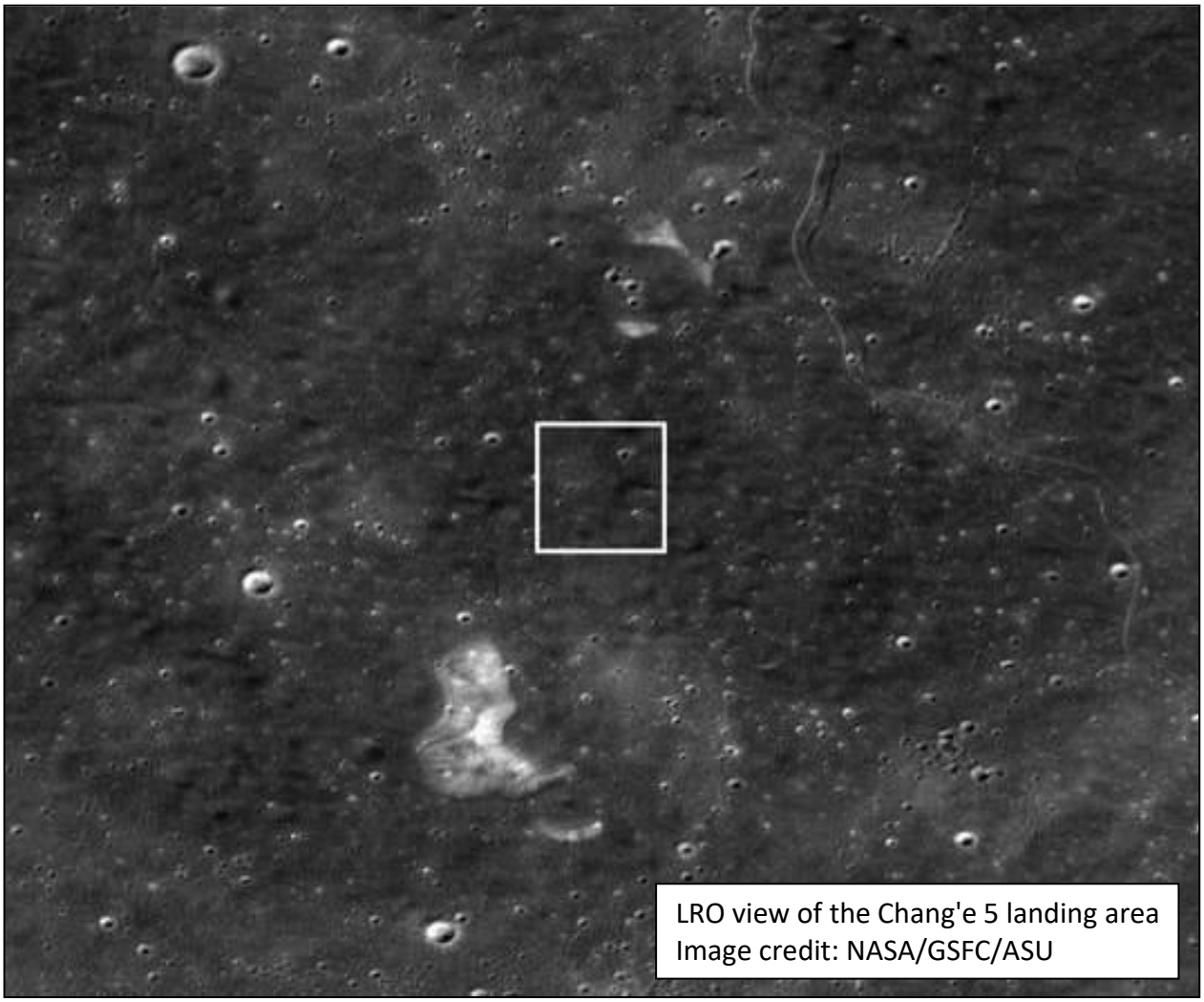
The Chang'e 5 spacecraft consisted of four components: a Service Module (the main component and primary propulsion unit for the trip to and from the Moon); the Lander (which separates from the Service Module in lunar orbit, lands on the Moon and collects rock and soil samples); the Ascent Vehicle (which launches from the lander and transports the samples back to the Service Module, where the lunar payload is transferred to the Return Vehicle); and the Return Vehicle (which separates from the Service Module upon approach to Earth and delivers the payload to the recovery area).

The 23-day mission was launched on November 23. Eight days later, the lander set down on the surface and began to collect surface and core samples, which were then loaded into the Ascent Vehicle. Two days later, the Ascent Vehicle blasted off into lunar orbit where it rendezvoused with the Service Module and transferred the lunar material into the Return Vehicle. The Service Module remained in lunar orbit for several days waiting for a favorable return trajectory.

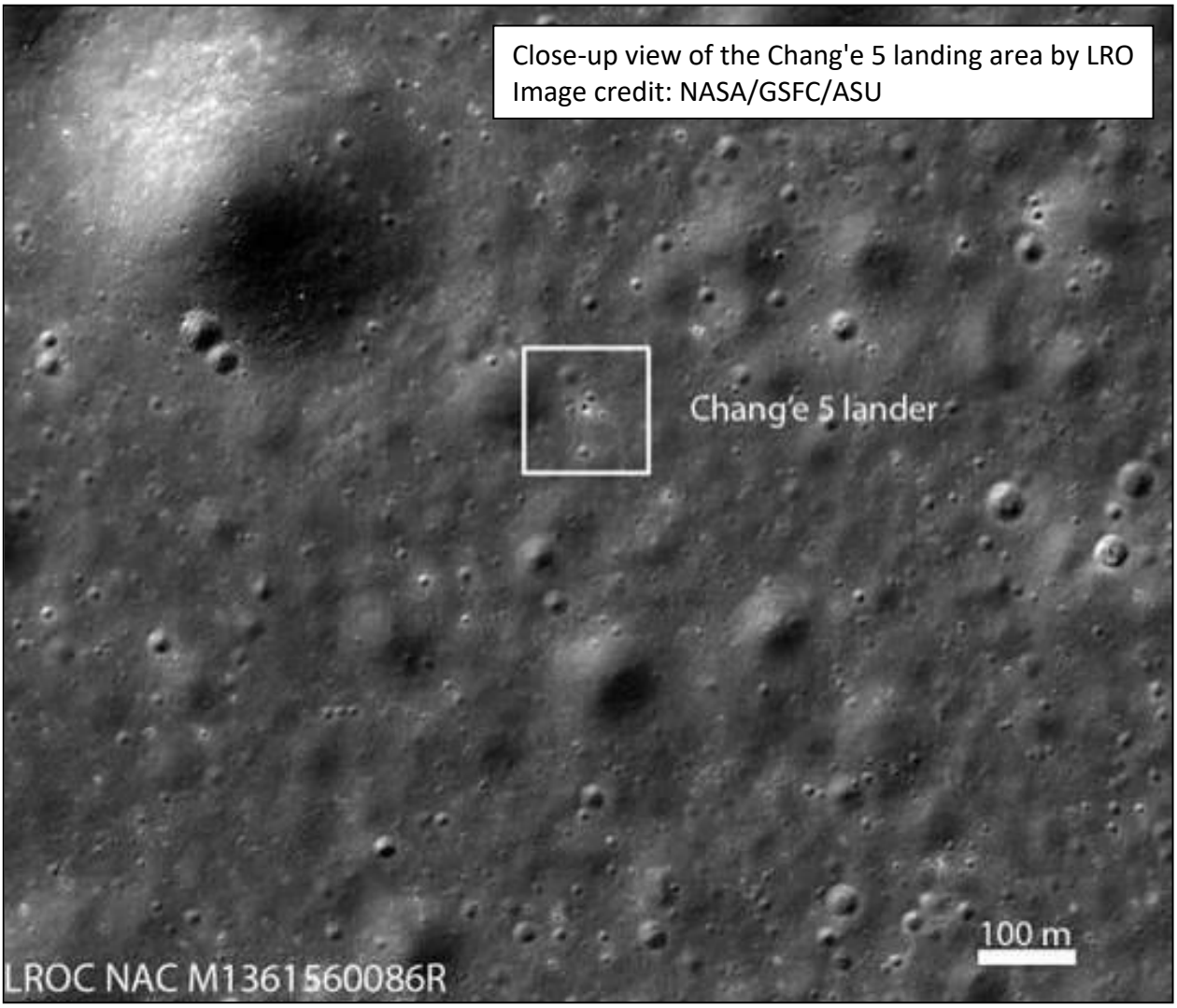
On December 13, Chang'e 5's Service Module left lunar orbit. Four days later, the Return Vehicle separated (about 3,100 miles or 5,000 kilometers from Earth) for a high-speed reentry and parachute landing. The capsule was recovered and transferred to Beijing, where it was opened (with about 3.8 pounds or 1.7 kg of sample). The lander is now inoperable - not designed to survive the cold lunar night and likely damaged from the launch of the Ascent Vehicle.



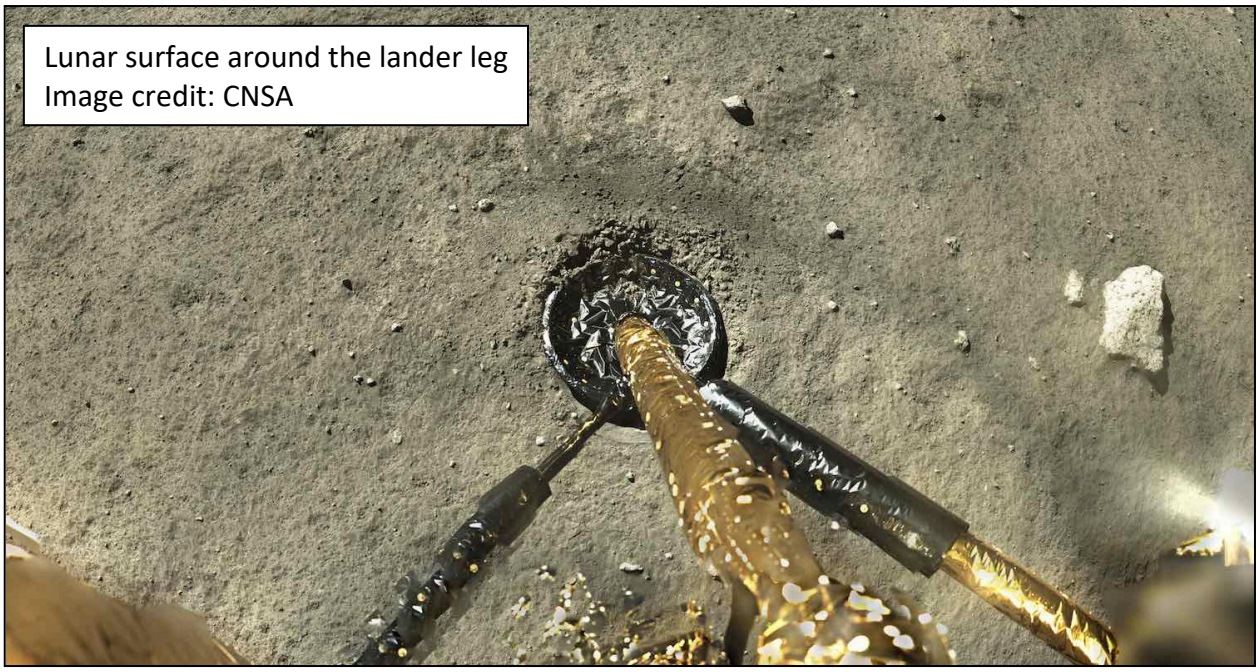
Panorama of Chang'e 5 landing site
Credit: CNSA



LRO view of the Chang'e 5 landing area
Image credit: NASA/GSFC/ASU

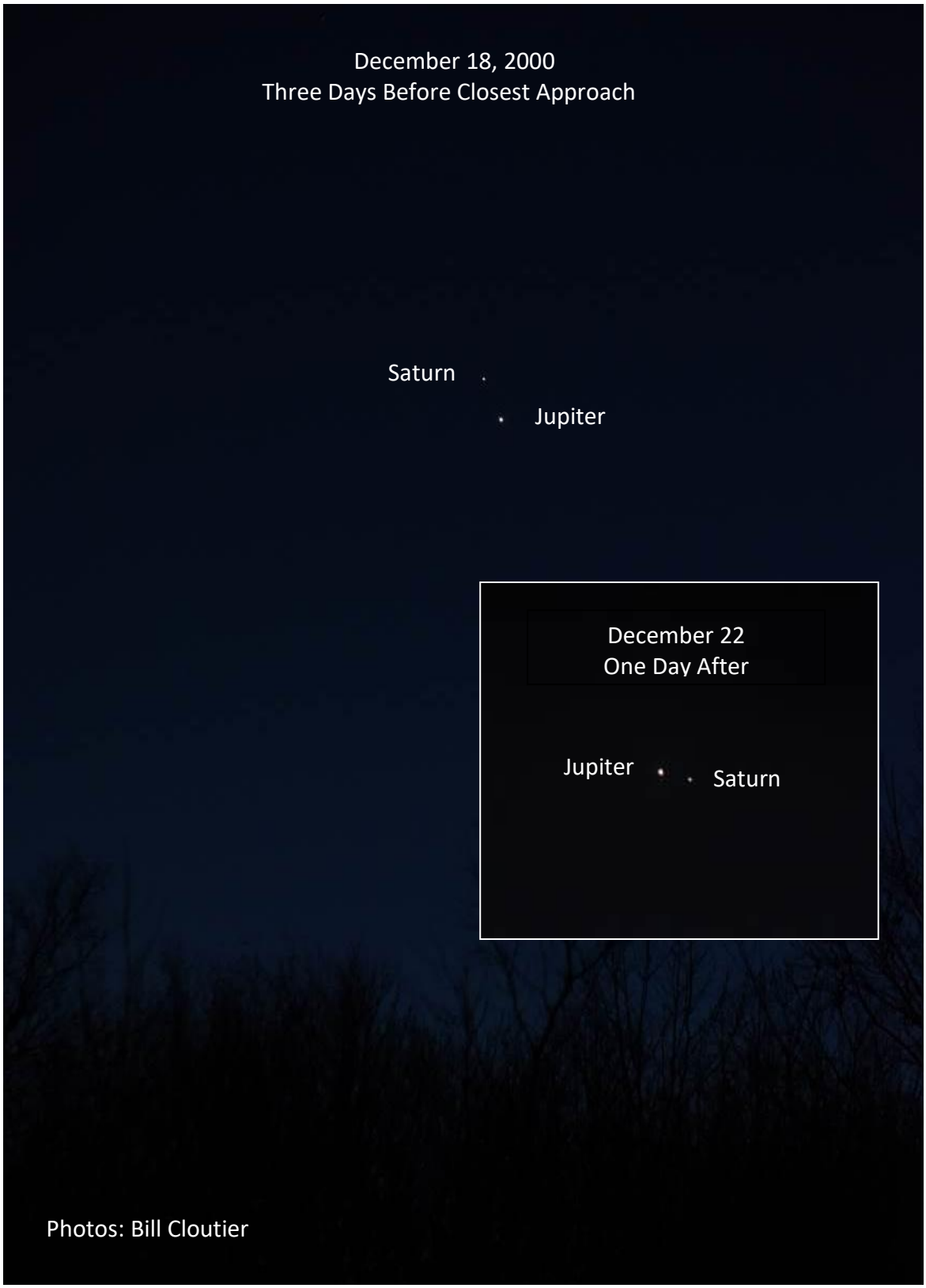


Close-up view of the Chang'e 5 landing area by LRO
Image credit: NASA/GSFC/ASU



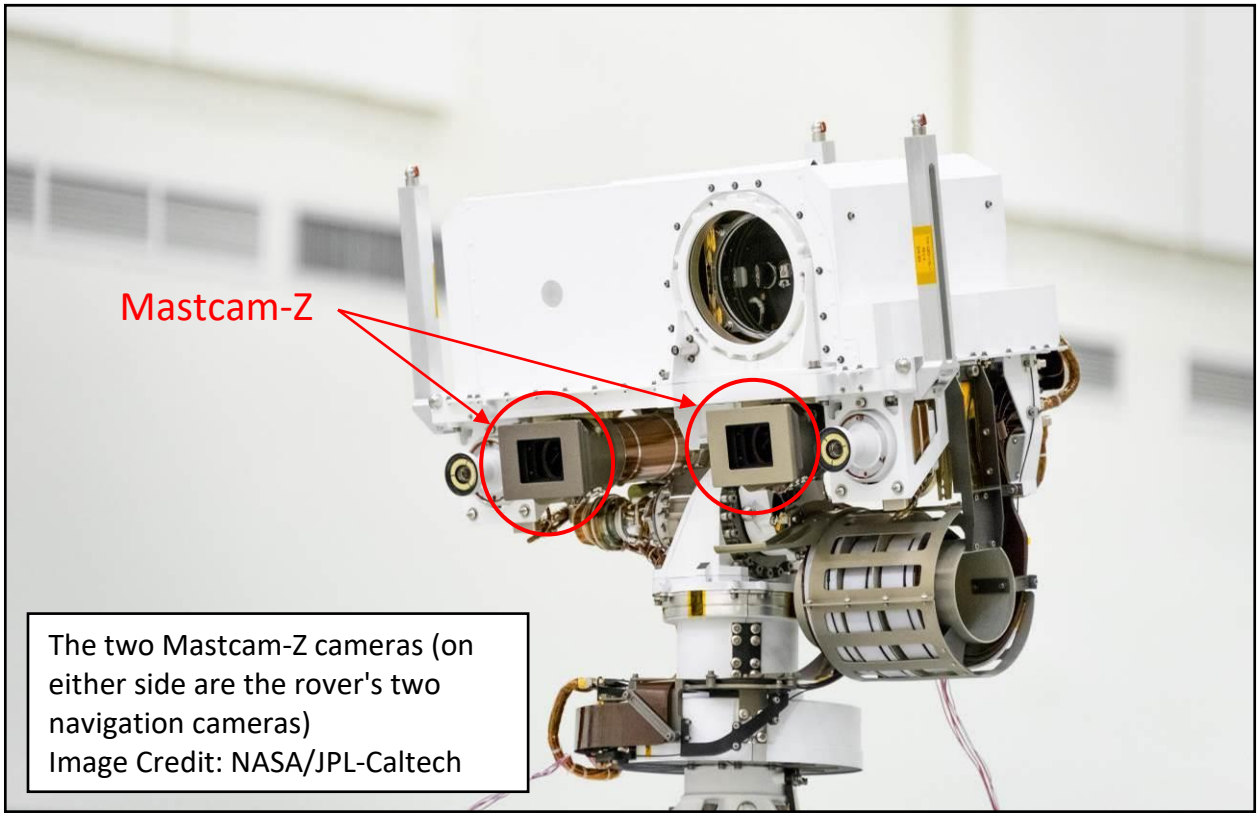
Lunar surface around the lander leg
Image credit: CNSA

Great Conjunction of Jupiter and Saturn



Mars in 3-D

In a technology upgrade, the Mars rover Perseverance will have 3-D vision, provided by a pair of zoomable cameras mounted on its mast. The cameras are located at eye level (of a 6½-foot-tall or 2-meter-tall person) and separated by 9.5 inches (24.2 centimeters) to provide stereo vision. "Mastcam-Z" will help scientists and rover drivers see the contours of the landscape with high-resolution color images and locate targets that might contain signs of ancient life (they can see features as small as a house fly – from the length of a soccer field).



The two Mastcam-Z cameras (on either side are the rover's two navigation cameras)
Image Credit: NASA/JPL-Caltech

The primary calibration target for Mastcam-Z is mounted on the rover's body and will be used to fine-tune the cameras' settings. The aluminum shadow post (at the center), painted with ultralow-reflectance black paint, and the four grey scale rings, are used to calibrate for lighting conditions. High-strength magnets, mounted under the circular color patches, are used to keep the patch centers relatively free from the iron oxide-bearing, Martian atmospheric dust. The symbols or "festooning" around the post were developed in collaboration with The Planetary Society and include a fern; an Apatosaurus; a man and woman raising their hands in greeting (similar to the symbols included on the plaques attached to Pioneer 10 and 11, as well as the Golden Record aboard Voyagers 1 and 2); a rocket traveling from Earth (blue dot) to Mars (red dot); a model of the inner solar system; a DNA molecule, and Cyanobacteria.

Perseverance's calibration target.
Credit: NASA/JPL-Caltech/ASU/
MSSS/ University of Copenhagen

Demise of the Arecibo Radio Telescope

Arecibo Observatory, in Puerto Rico, was damaged beyond repair when the remaining cables suspending the 900-ton receiver platform 450 feet (140 meters) above the radio disk failed on December 1. The receiver smashed through the dish to the ground below, taking with it the structural steel and long support cables which caused considerable collateral damage.

In August 2020, an auxiliary cable slipped, creating a 100-foot-long gash in the disk. This was followed by the failure of one of the main cables in November which resulted in additional damage to the dish and also to nearby cables (both cables that failed had been connected to the same support tower). The November collapse was the beginning of the end for the historic radio telescope as the National Science Foundation believed that the structure was too unstable to repair.

The radio telescope with its receiver suspended by cables from the three support towers (pre-accident) Photo: Arecibo Observatory

The telescope operated for almost 60 years and was at the forefront of many groundbreaking discoveries, including the detection of the first binary pulsar in 1974 (as well as featured in the movies "Contact" and "GoldenEye").

The versatile telescope was able to send, as well as receive radio waves, "painting" objects with radar as they flew by the Earth. It also clocked the spin of the pulsar at the center of the Crab Nebula (at 33 milliseconds), revealed Mercury's true rotation rate and detected the signature of water ice at the planet's poles, mapped Venus' volcanic terrain, and broadcast the first radio message intended for an alien audience toward a star cluster some 25,000 light-years away.

Twisted steel and damage sustained to the dish from the falling receiver
Credit: University of Central Florida

Starship Sub-Orbital Jump and Fiery End

Starship SN8 (Serial Number 8) lifted off from a pad at SpaceX's Boca Chica facility (Texas) for the first suborbital test flight of the Mars' rocket at 4:45 p.m. CST on Wednesday, December 9. The full-size prototype, standing 164 feet tall (50-meters), was powered by three cryogenic methane and liquid oxygen-powered Raptor engines, generating more than a million pounds of thrust. The stainless-steel spaceship soared to an altitude of about 41,000 feet (12.5 km) on a flight lasting about 7 minutes. The first Raptor engine was shut down after more than a minute-and-a-half, followed by the second after three minutes of burn time, with the third engine shutdown about 4 minutes and 40 seconds after liftoff. Following engine shutdown, Starship performed a "belly flop," maneuver before using its thrusters, forward aerosurfaces and body flaps, to execute a controlled glide back to the launch facility.

The spaceship righted itself over the landing pad, relighting the Raptors (fed by a separate fuel header tank). Unfortunately, low pressure in the tank resulted in a higher than designed touchdown velocity and loss of the vehicle in a spectacular fireball. Despite the loss, Elon Musk (SpaceX CEO and Chief Designer), considered the first test flight to be an overwhelming success, generating all the data needed. Once the pad is cleared, a series of Starships, in various stages of completion, are being readied to fly, in this fast-paced development program.

The fully-reusable Starship is designed to carry more than 100 metric tons of cargo into orbit, or as many as 100 people on expeditions to Mars (Starship has also been selected by NASA as one of three contenders for a human-rated lunar lander). Once operational, Starship will launch on top of an even larger, fully-reusable, "Super Heavy" booster powered by as many as 28 Raptor engines.

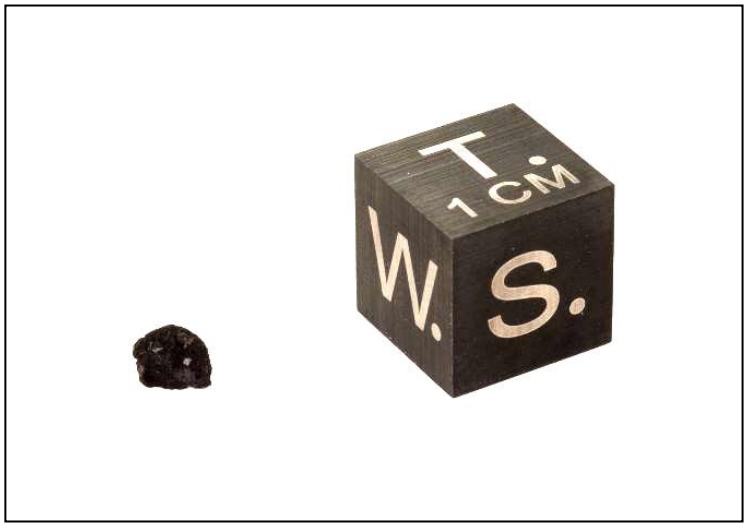
Starship on powered ascent (above) and on its landing attempt (right) Credit: SpaceX

The Starship SN8 in a controlled glide (above) and its explosive, pinpoint landing on the pad (bottom) Credit: SpaceX

Meteorite Spotlight – Tagish Lake

In the summer of 2018, the Observatory greatly expanded its meteorite teaching collection with the addition of a diverse and comprehensive set of meteoritic specimens from a reputable collector looking to convey his collection to someone who would maintain its integrity and capitalize on its intrinsic educational value. The collection includes whole stones, slices and fragments, numbering more than 200, from historic and scientifically-significant falls and meteorite finds dating back to 1492. From time to time, we will highlight one or more of the specimens from the collection in this newsletter.

In the early morning of January 18, 2000, a large meteoroid exploded in the atmosphere over northern British Columbia, Canada. Fragments rained down on the frozen surface of Tagish Lake. The fireball, followed by loud detonations, was widely observed from the ground, as well as by satellites in Earth orbit. Because it was a witnessed fall, the meteorites were quickly collected from the frozen lake surface – the quick recovery and extreme cold minimized the potential for terrestrial contamination. Total mass recovered was between 11 and 22 pounds (5 and 10 kg).



McCarthy Observatory's sample of the Tagish Lake meteorite Image: Gerard Bianchi

The Tagish Lake meteorites are classified as highly brecciated ungrouped carbonaceous chondrites (C2, ungrouped), rich in carbon and containing an assortment of organic matter, including amino acids. When scientists examined the pristine samples, they found that different pieces contained differing amounts of amino acids, with some pieces have 10 to 100 times the abundance of others – making the Tagish Lake meteorites the most diverse recovered. The disproportion is thought to be related to the exposure to various amounts of water – the first evidence of water percolating through an asteroid.

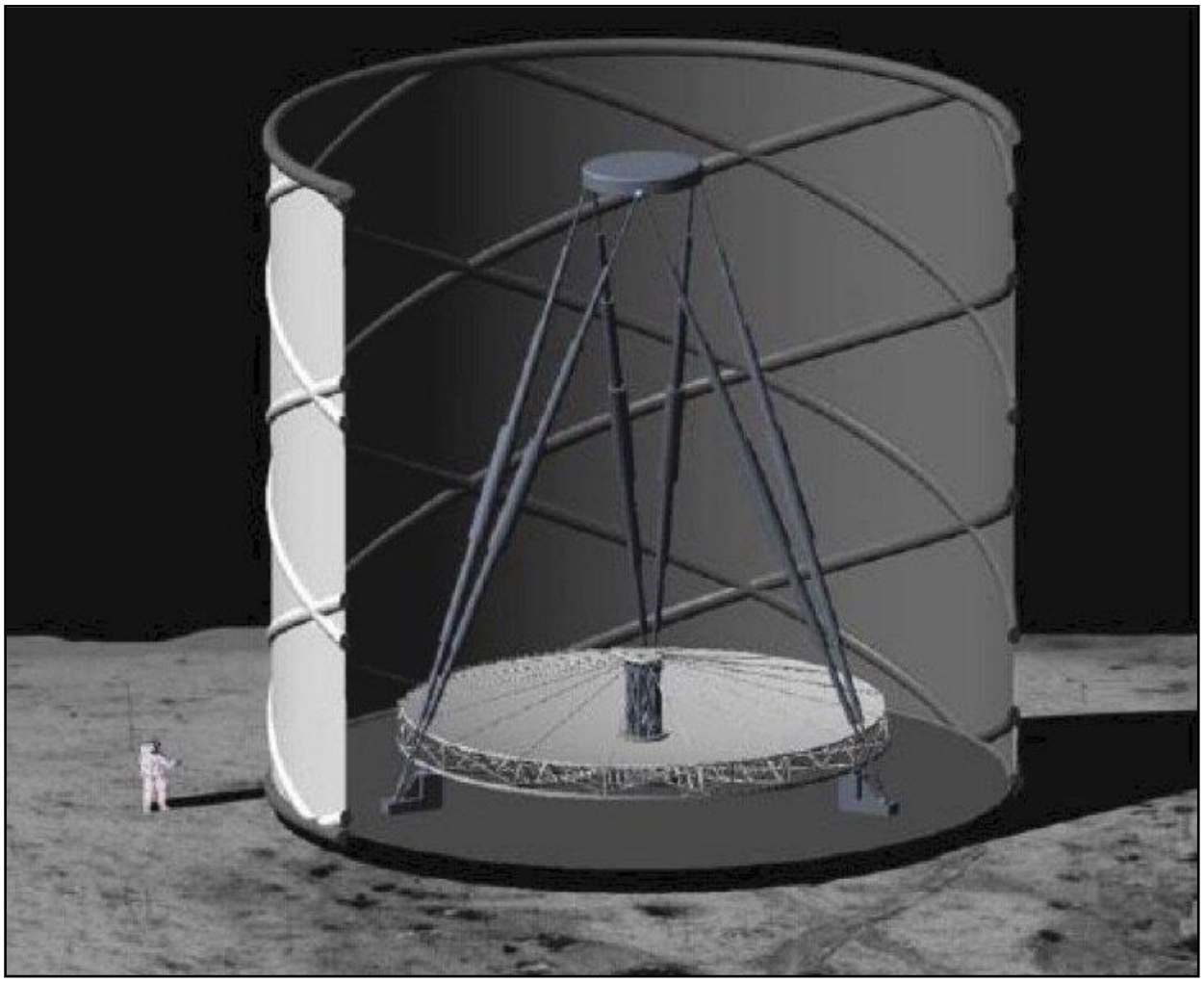
The amino acids in the Tagish Lake meteorites are enriched in carbon-13, a heavier and less abundant isotope of carbon – an indication that they were created in space on the parent asteroid by non-biological processes (the chemistry of life prefers lighter isotopes). Researchers also found evidence of 4.55-billion-year-old sodium-rich alkaline fluids in the Tagish Lake meteorite, an environment that would have been ideal for the synthesis of amino acids.

The unusual chemistry in the Tagish Lake meteorites provides a glimpse into conditions in the early solar system. Amino acids, the building blocks of life, are precursors to the formation of microbial life. Collisions with other asteroids and/or interactions with the large gas giants, such as Jupiter, could have delivered the ingredients of life to the surfaces of the terrestrial planets.

The Tagish Lake meteorite sample in the McCarthy Observatory collection is a 0.038-gram fragment.

Looking Back to the Edge of Time

Astronomers from the University of Texas at Austin have resurrected an old concept that would allow them to study the first stars in the universe – a massive lunar telescope. According to the team, while the James Webb Space Telescope will be able to reach back to the time when galaxies first formed, a more powerful telescope is needed to probe an earlier time when, theory predicts, individual stars formed. These hypothetical stars (called Population III stars) would have formed about 13 billion years ago. Extremely massive (likely tens or 100 times larger than our Sun) and luminous, these stars would have been devoid of metals and comprised of hydrogen and helium with very small amounts of lithium and beryllium.

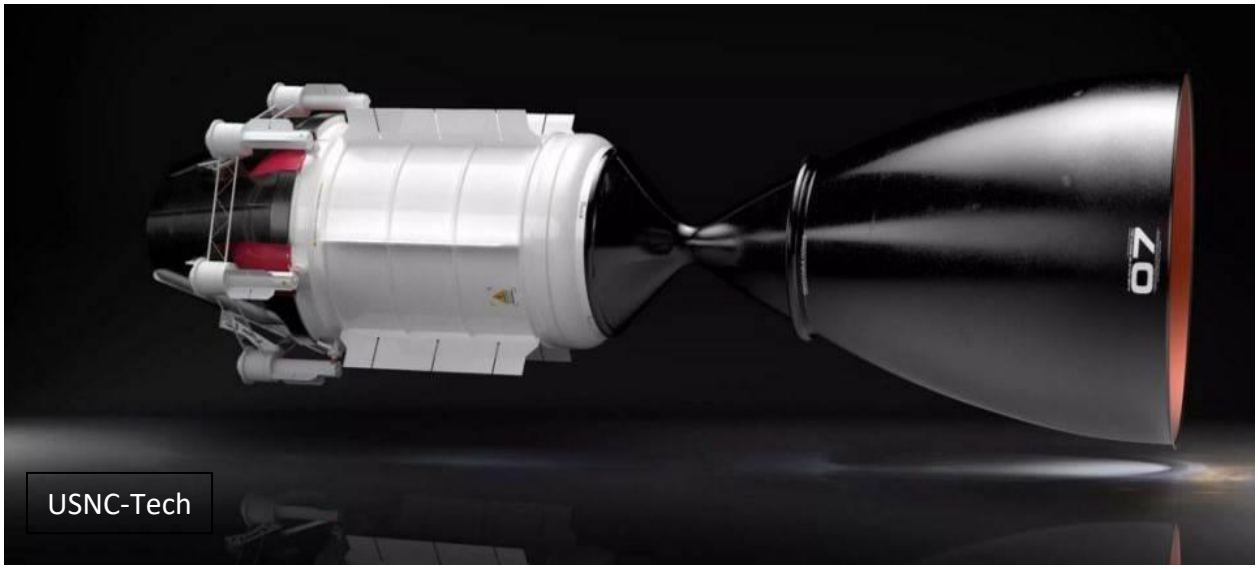


Ultimately Large Telescope
Credit: University of Texas McDonald Observatory

The proposed design (shelved by NASA more than a decade ago) was for a liquid metal telescope that would operate from the surface of the Moon. A rotating reflective liquid mirror (rotating to maintain the correct paraboloid shape), over 300 feet (100 meters) in diameter, would be powered by a solar power station and operate autonomously, transmitting data back to Earth by a relay satellite. The stationary telescope, for example, constructed in a crater at one of the poles where solar energy is abundant throughout the lunar day, would gaze at a fixed area of the sky, collecting as much light as possible in order to detect these ancient relics.

Nuclear Comeback

Astronauts traveling to Mars will be exposed to radiation from the Sun, as well as galactic sources, over a minimum of six months (one-way) with current spacecraft designs that use chemical-fueled propulsion. Ultra Safe Nuclear Technologies (USNC-Tech) has designed a new thermal nuclear engine that could cut that travel time, and radiation exposure time, in half.

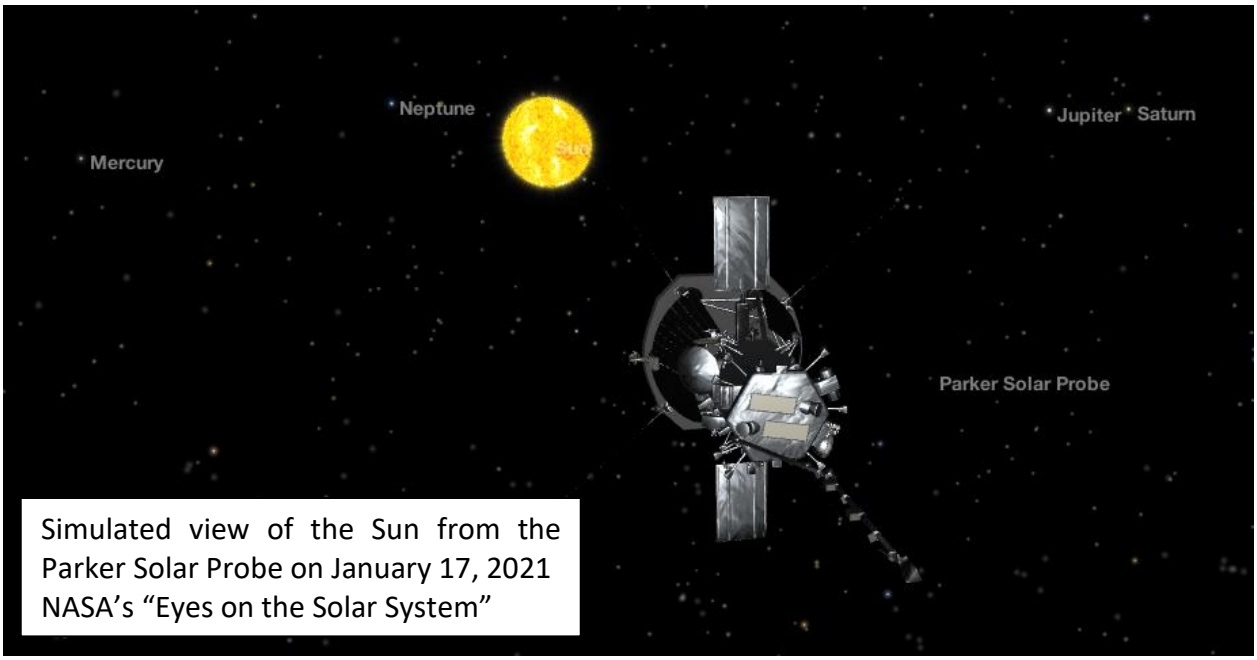


Nuclear propulsion is an old concept. General Atomics developed a nuclear-pulse drive launch vehicle (Project Orion) in the late '50s and early '60s (the spacecraft would be propelled by the shock wave from atomic bombs ejected from the back of the rocket and exploded behind it). In the 1960s, the Atomic Energy Commission and NASA worked jointly on developing the technology for a nuclear thermal rocket engine called NERVA. NASA subsequently tested the engine (built by Aerojet General Corporation), using highly-enriched uranium to heat a liquid hydrogen propellent. While considered a successful demonstration, the challenge remained to produce a nuclear reactor that was both light in weight and durable enough to launch, while being safe enough for the crew.

NASA is now revisiting nuclear powered spacecraft with the advances in nuclear technology and materials and controls over the past 50 years. The agency is working with BWXT Nuclear Energy, Inc., on fuel and core design, fabrication, and systems that use low-enriched uranium. USNC-Tech's design is also based on low-enriched uranium (a U-235 assay above 5% but below 20%), which is inherently safer and more readily available than higher-enriched uranium. The tiny fuel kernels are encapsulated within a layered ceramic coating and encased within a dense silicon carbide matrix. The multiple-barrier design yields a rugged, corrosion and oxidation resistant, and stable fuel at extreme operating temperatures and when exposed to neutron irradiation. Containment of fission products within the multiple layers ensures astronaut safety and environmental protection. USNC-Tech believes that their product can achieve high thrust and specific impulse (more than twice that of chemical systems) with small quantities of the lower-enriched fuel, comparable to that of previous higher-enriched uranium designs. Their design concept has been recently delivered to NASA as part of a broader study on the flight applications of nuclear thermal propulsion. NASA's initiatives are just part of a broader effort, as outlined in the recent Space Policy Directive-6, issued by the White House on December 16, on a national strategy for space nuclear power and propulsion.

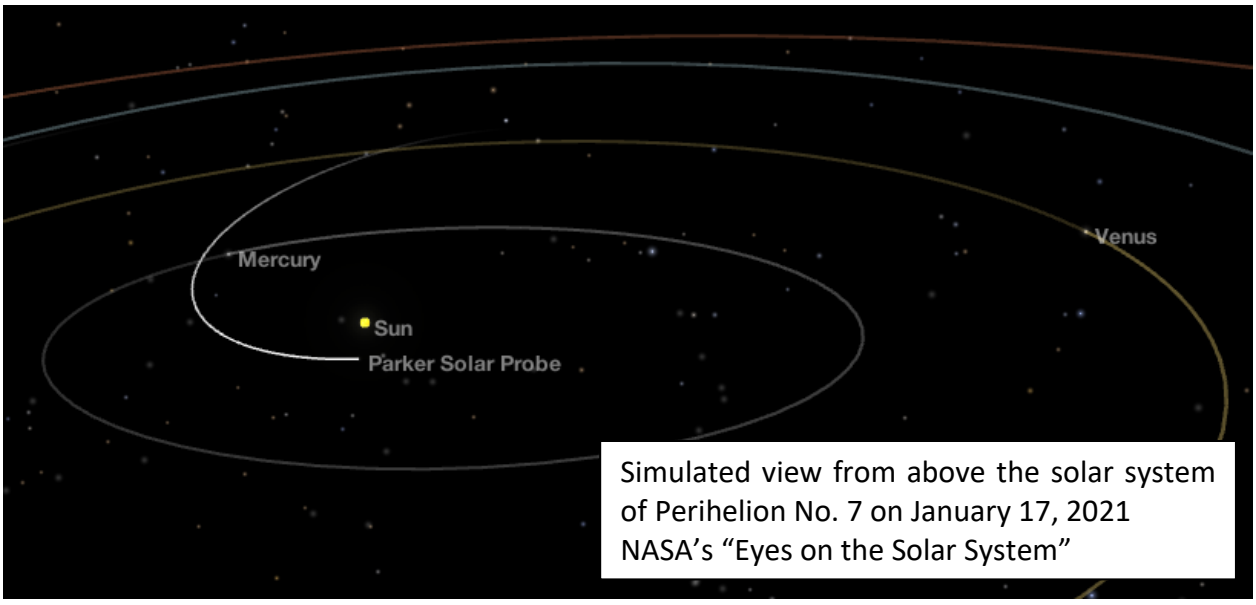
Perihelion No. 7

Starting in January, the Parker Solar Probe will be performing four solar encounters and two Venus flybys over the course of the year as it continues to move even closer to the Sun. On January 17, the spacecraft will come within 8.4 million miles (13.5 million km) of the Sun's surface (defined as the photosphere) - less than one-tenth of the distance between Earth and the Sun - while reaching a top speed of 289,000 miles per hour (465,000 km per hour).



Simulated view of the Sun from the Parker Solar Probe on January 17, 2021
NASA's "Eyes on the Solar System"

January's encounter (the seventh perihelion or close approach) was set up by an encounter with Venus (3rd flyby) in 2020. The Parker Solar Probe is expected to operate through 2025 and complete as many as 24 flybys – getting successively closer to the Sun as the mission progresses (getting as close as 4 million miles or 6 million km from the visible surface).

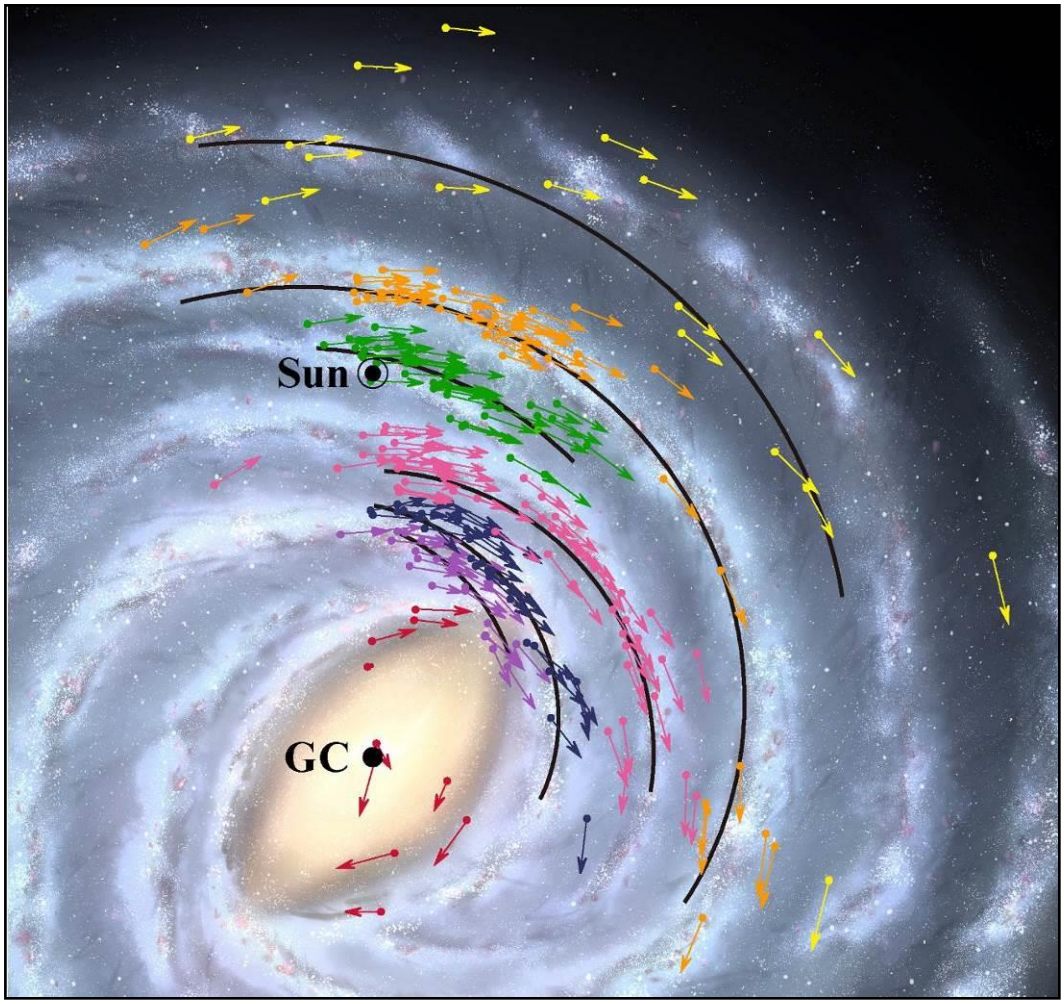


Simulated view from above the solar system of Perihelion No. 7 on January 17, 2021
NASA's "Eyes on the Solar System"

Closer to the Center

The Japanese radio astronomy project VERA (VLBI Exploration of Radio Astrometry), started in 2000, uses interferometry ("VLBI" stands for Very Long Baseline Interferometry) to combine data from radio telescopes located across Japan to map objects and their velocities within the Milky Way Galaxy. Working together, the individual radio telescopes are able to achieve a resolution comparable to a single dish 1,430 miles (2,300 km) across.

According to the data published in the first VERA Astrometry Catalog earlier this year, the Earth is not only closer to the center of the galaxy, but traveling faster in its circuit around the core. VERA's new galactic model places Earth at 25,800 light years from the supermassive black hole (Sagittarius A*) at galactic center, as compared to 27,700 light years adopted by the International Astronomical Union in 1985. The velocity component (the rate at which Earth is traveling around the galaxy) increased from the official value of 137 miles/second (220 km/s) to 141 miles/second (227 km/s).

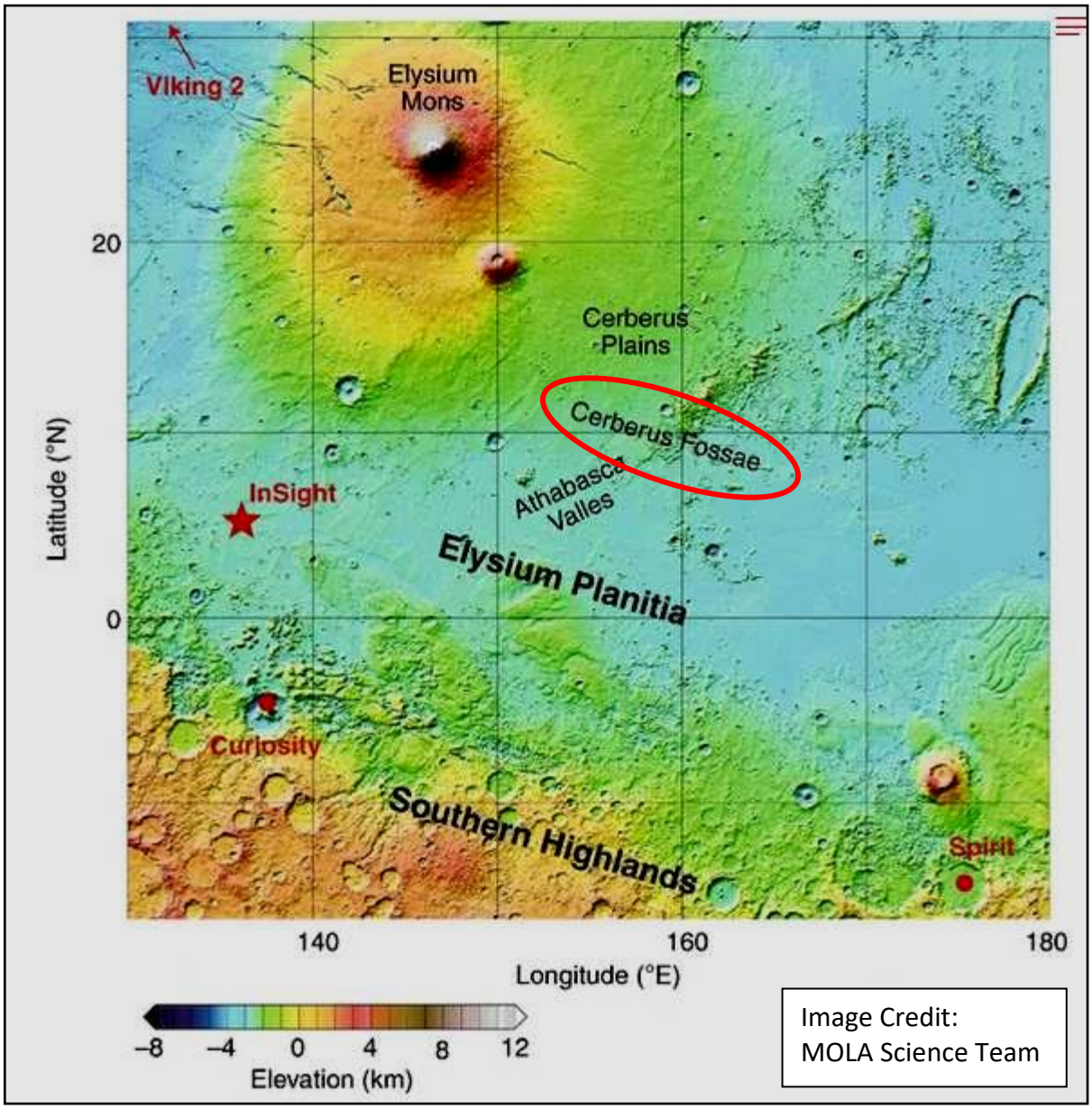


Position and velocity map for the 224 objects used to model the galaxy. The solid black lines show the positions of the spiral arms. The colors indicate groups of objects belonging in the same arm.
Credit: National Astronomical Observatory of Japan

Martian News

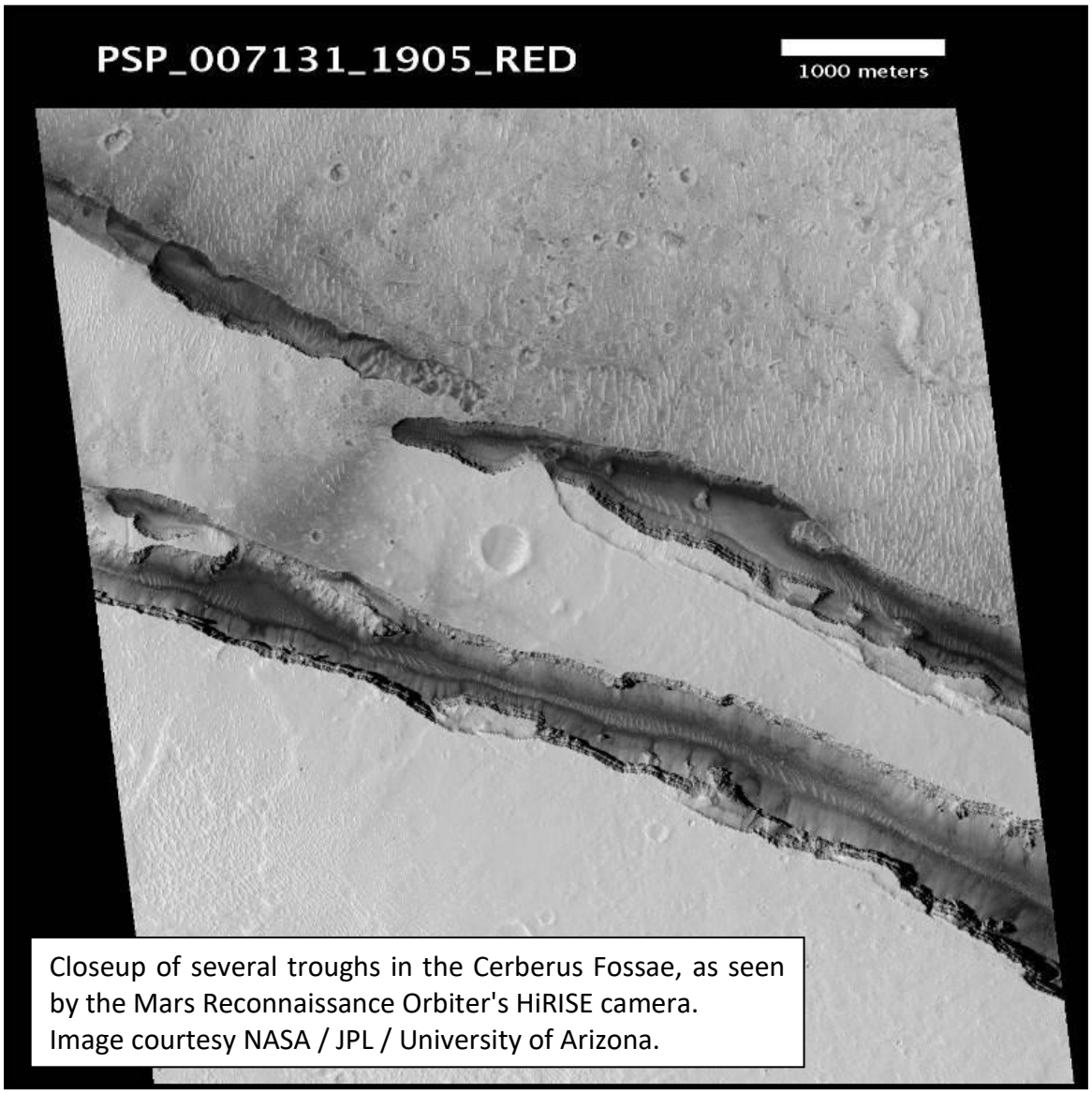
Olympus Mons, the largest volcano in the solar system (about two and half times the height of Mount Everest and expansive enough to cover the state of Arizona), formed about 3 billion years ago along with Mars' other shield volcanoes. As Mars cooled, volcanic activity waned. Today, Mars is viewed as a dead planet, with no active volcanism.

However, as planetary geologists review the data returned by NASA's orbiter, rovers and landers, there are indications that reports of Mars' demise, as an active world, may be premature. Relatively young volcanic features identified from visible light images, from the Mars Reconnaissance Orbiter and thermal infrared images from the Mars Odyssey spacecraft, coupled with the discovery of low levels of methane in parts of the Martian atmosphere by NASA's rovers, and seismic activity detected by InSight in the Cerberus Fossae region could be interpreted as being linked to magmatic activity today.



Cerberus Fossae is a set of semi-parallel fissures running across Elysium Planitia, a flat-smooth plain not far from one of Mars' large shield volcanoes, Elysium Mons. The fissures appear to be among the youngest volcanic features on Mars - less than 200,000 years old and possibly as young as 50,000 years old.

When InSight landed in November 2018, it deployed an extremely sensitive seismometer (it can detect surface movements smaller than a hydrogen atom). Over the past two years, it has detected hundreds of small-magnitude tremors – most were shallow from vibrations that propagated through the planet's crust, but there were a few that originated deeper in the mantle. Unlike Earth, Mars doesn't have tectonic plates so most tremors are likely from the planet's outer layers contracting as the planet continues to cool. However, the two largest marsquakes have been traced to the Cerberus Fossae region, about 1,000 miles (1,600 km) east of InSight's landing site. One possibility for the tremors in this region is the shrinkage of subsurface magma chambers as the hot magma cools. The presence of magma could provide a heat source, keeping water liquid, and as an energy source for microorganisms.



Closeup of several troughs in the Cerberus Fossae, as seen by the Mars Reconnaissance Orbiter's HiRISE camera. Image courtesy NASA / JPL / University of Arizona.

Explorer 1

Sixty-three 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).

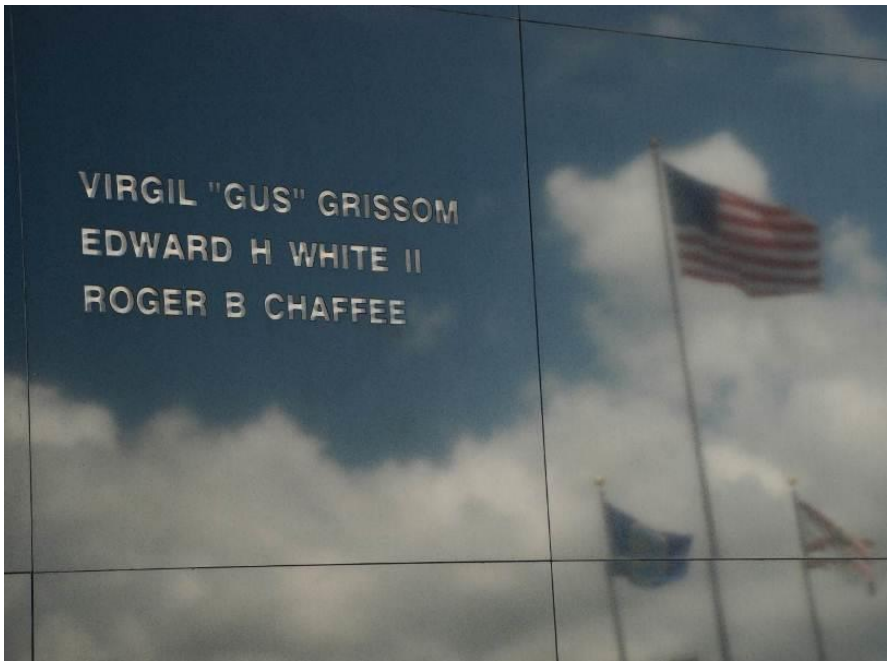
During a 1 AM press conference at the National Academy of Sciences on February 1st, shortly after the successful night launch of Explorer 1, the three team leaders (from left to right) Bill Pickering (JPL), James Van Allen (State University of Iowa) and Wernher von Braun (Army's Redstone Arsenal) celebrate 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 Korolyov, the "Chief Designer" of the Soviet space program, died on January 14, 1966 from a botched medical procedure. Korolyov 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. Korolyov went on to lead the Soviet space effort.

Unfortunately, the Soviet Moon program died with Korolyov 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-two 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 the constellation Taurus, don't overlook the red giant Aldebaran. This star is receding from us more rapidly than any other 1st magnitude star in the sky. It was the brightest star in the sky some 320,000 years ago when it was 21½ light years from Earth. Moving away, Aldebaran is currently 65 light years in distance and the thirteenth brightest star in the sky.

Sunrise and Sunset (from New Milford)

Sun	Sunrise	Sunset
January 1st (EST)	07:20	16:33
January 15th	07:17	16:47
January 31st	07:05	17:07

Astronomical and Historical Events

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)

Astronomical and Historical Events (continued)

1st History: Giuseppe Piazzi discovers the first asteroid, now dwarf planet, *Ceres* (1801)
2nd Earth at Perihelion – closest distance from Sun (0.983 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 2019 QW2 near-Earth flyby (0.022 AU)
3rd Aten Asteroid 2003 AF23 near-Earth flyby (0.047 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 Aten Asteroid 2012 BT1 near-Earth flyby (0.016 AU)
4th Amor Asteroid 3552 *Don Quixote* closest approach to Earth (5.615 AU)
4th History: Isaac Newton born; inventor of the reflecting telescope, described universal gravitation, compiled the laws of motion, and invented calculus (1643)
5th Apollo Asteroid 12711 *Tukmit* closest approach to Earth (1.304 AU)
5th Kuiper Belt Object 2014 WP509 at Opposition (41.786 AU)
5th History: discovery of dwarf planet *Eris* (the Pluto killer) by Mike Brown, et al. (2005)
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 Last Quarter Moon
6th Apollo Asteroid 2018 KP1 near-Earth flyby (0.021 AU)
6th Apollo Asteroid 332446 (2008 AF4) near-Earth flyby (0.025 AU)
6th Apollo Asteroid 2016 CO247 near-Earth flyby (0.049 AU)
6th Amor Asteroid 8709 *Kadlu* closest approach to Earth (2.735 AU)
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 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 Second Saturday Stars – Virtual Open House at the McCarthy Observatory
9th Moon at perigee (closest distance from Earth)
9th Apollo Asteroid 2019 NU13 near-Earth flyby (0.038 AU)
9th History: Voyager 2/Stephen Synnott discovers Uranus' moon *Cressida* (1986)
10th History: launch of the Soviet atmospheric probe, Venera 6, to Venus (1969)
10th History: U.S. Army first bounces radio waves off the Moon (1946)
11th Amor Asteroid 2013 YS2 near-Earth flyby (0.047 AU)
11th Apollo Asteroid 2020 RO6 near-Earth flyby (0.050 AU)

Astronomical and Historical Events (continued)

11th History: Lunar Prospector spacecraft enters lunar orbit for a nineteen-month chemical mapping mission (1998)
11th History: William Herschell discovers Uranus' moons *Titania* and *Oberon* (1787)
12th Apollo Asteroid 136617 (1994 CC) (2 Moons) closest approach to Earth (1.338 AU)
12th Kuiper Belt Object 230965 (2004 XA192) at Opposition (34.595 AU)
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 Korolyov 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 New Moon
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 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 Aten Asteroid 2017 QW1 near-Earth flyby (0.045 AU)
15th Apollo Asteroid 3838 *Epona* closest approach to Earth (1.659 AU)
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 Apollo Asteroid 4179 *Toutatis* closest approach to Earth (0.617 AU)
16th History: final launch of space shuttle Columbia (STS-107); lost on re-entry (2003)
17th Parker Solar Probe - 7th Perihelion (coming within about 8.4 million miles or 13.5 million kilometers of the Sun's surface)
17th Apollo Asteroid 65717 (1993 BX3) near-Earth flyby (0.047 AU)
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
18th Comet 9P/*Tempel* at Opposition (2.487 AU)
18th Amor Asteroid 21088 *Chelyabinsk* closest approach to Earth (1.081 AU)
19th Centaur Object 52975 *Cyllarus* at Opposition (27.806 AU)
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)

Astronomical and Historical Events (continued)

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 First Quarter Moon
20th History: Rich Terrile discovers Uranus' moons *Cordelia* and *Ophelia* (1986)
21st Moon at apogee (furthest distance from Earth)
21st Atira Asteroid 2017 YH closest approach to Earth (0.119 AU)
21st Amor Asteroid 8034 Akka closest approach to Earth (1.596 AU)
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 Aten Asteroid 2018 BX near-Earth flyby (0.023 AU)
22nd Apollo Asteroid 2020 PP near-Earth flyby (0.050 AU)
22nd History: launch of Apollo 5, the first Lunar Module flight (1968)
23rd History: Brad Smith discovers Uranus' moon *Bianca* (1986)
24th Mercury at its Greatest Eastern Elongation (19°) – apparent separation from the Sun in the evening sky
24th Aten Asteroid 341843 (2008 EV5) closest approach to Earth (1.129 AU)
24th Kuiper Belt Object 482824 (2013 XC26) at Opposition (35.850 AU)
24th Kuiper Belt Object 20000 *Varuna* at Opposition (43.039 AU)
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 Apollo Asteroid 2018 BA3 near-Earth flyby (0.004 AU)
25th Aten Asteroid 468727 (2010 JE87) near-Earth flyby (0.040 AU)
25th Amor Asteroid 16912 *Rhiannon* closest approach to Earth (0.790 AU)
25th Apollo Asteroid 25143 *Itokawa* closest approach to Earth (1.197 AU)
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).
26th Atira Asteroid 2010 XB11 closest approach to Earth (0.686 AU)

Astronomical and Historical Events (continued)

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 Comet 1P/Halley at Opposition (34.077 AU)
27th Plutino 208996 (2003 AZ84) at Opposition (43.262 AU)
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 Full 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 History: Yuji Hyakutake discovers the Great Comet of 1996 (1996)
31st Apollo Asteroid 65803 *Didymos* closest approach to Earth (0.695 AU)
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)
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

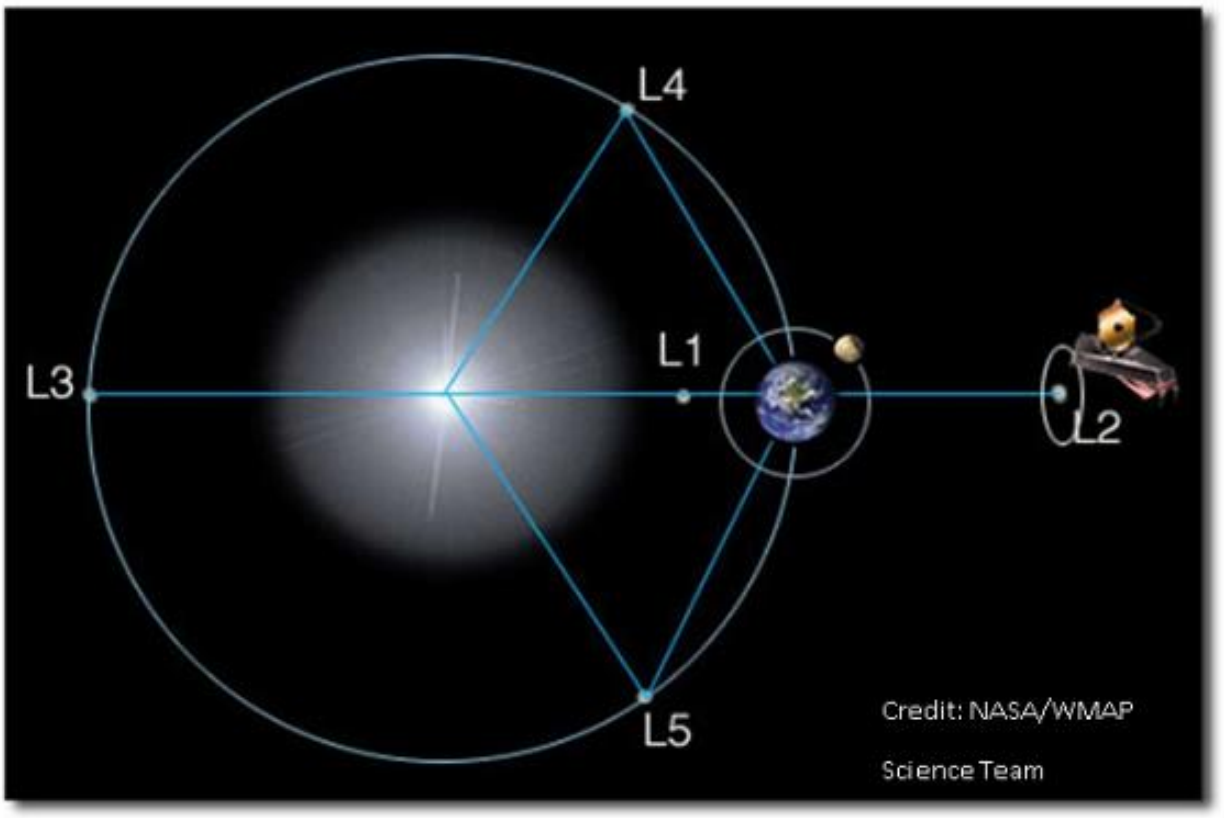
- Trojan: asteroids orbiting in the 4th and 5th Lagrange points (leading and trailing) of major planets in the Solar System

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

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 future location of the James Webb telescope) is located 1.5 million kilometers beyond the Earth (as viewed from the Sun).



International Space Station and Starlink 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

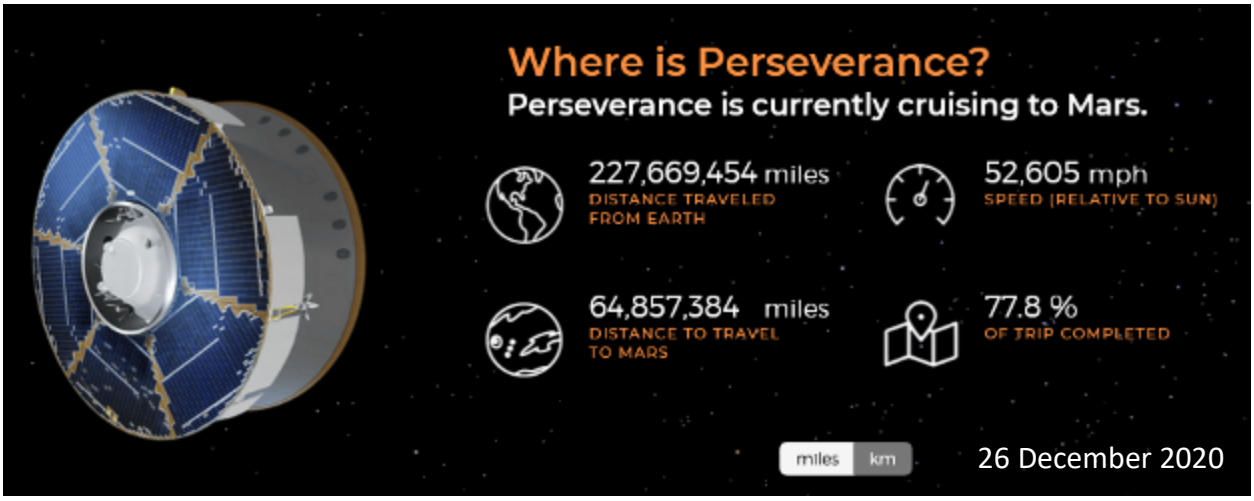
For the latest on what's happening on the Sun and the current forecast for flares and aurora, check out www.spaceweather.com

NASA's Global Climate Change Resource

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

Countdown to Mars (and landing on February 18, 2021)

https://mars.nasa.gov/mars2020/



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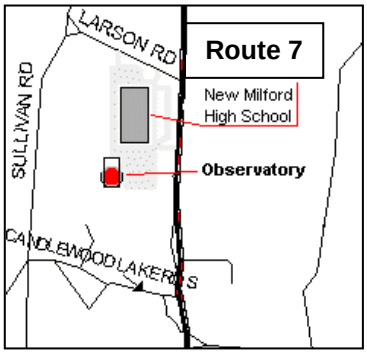

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