Galactic Observer

John J. McCarthy Observatory

Volume 14, No. 2 February 2021

International Space Station transit of the Moon
Composite image: Marc Polansky

February Astronomy Calendar and Space Exploration Almanac

Six-Day-Old Moon mosaic captured with an antique telescope built by John Benjamin Dancer. Dancer is credited with being the first to photograph the Moon in England in February 1852

Apollo 11 and 17 landing sites are visible in the images, as well as Mare Nectaris, one of the older impact basins on the Moon

Bel'kovich (Long 90° E)

Hercules (L) and Atlas (R)

Posidonius

Taurus-Littrow Apollo 17

Tranquility Base Apollo 11

Mare Nectaris

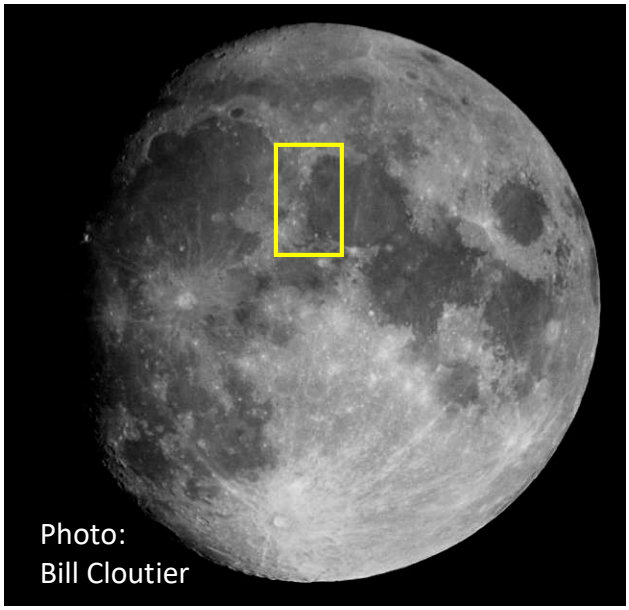
Altai Scarp

Photos: Bill Cloutier

In This Issue

"Out the Window on Your Left"

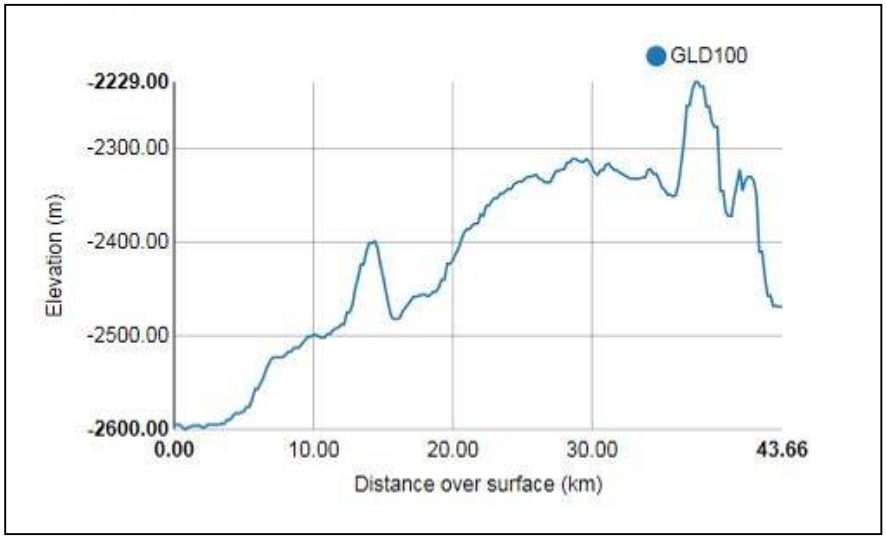
It's been more than 51 years since Neil Armstrong first stepped onto the moon's surface and 48 years since Gene Cernan left the last footprint. As a nation founded on exploration and the conquest of new frontiers, today's commitment to return to the moon has been as fleeting as the funding. But what 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).



Lunar seas are actually expansive low-lying plains formed by ancient lava flows

A broad, low-profile lava dome is visible as the waxing Moon achieves its first quarter phase on February 19, and the Sun is low in the lunar sky. Valentine dome is located on the northwestern shore of Mare Serenitatis (Sea of Serenity), along the base of the Caucasus Mountains, and just north of the breech that runs into the Imbrium basin (30.9° latitude, 10.1° longitude). It is one of the largest domes visible on the lunar surface, measuring approximately 18.6 miles (30 km) across its heart-shaped surface.

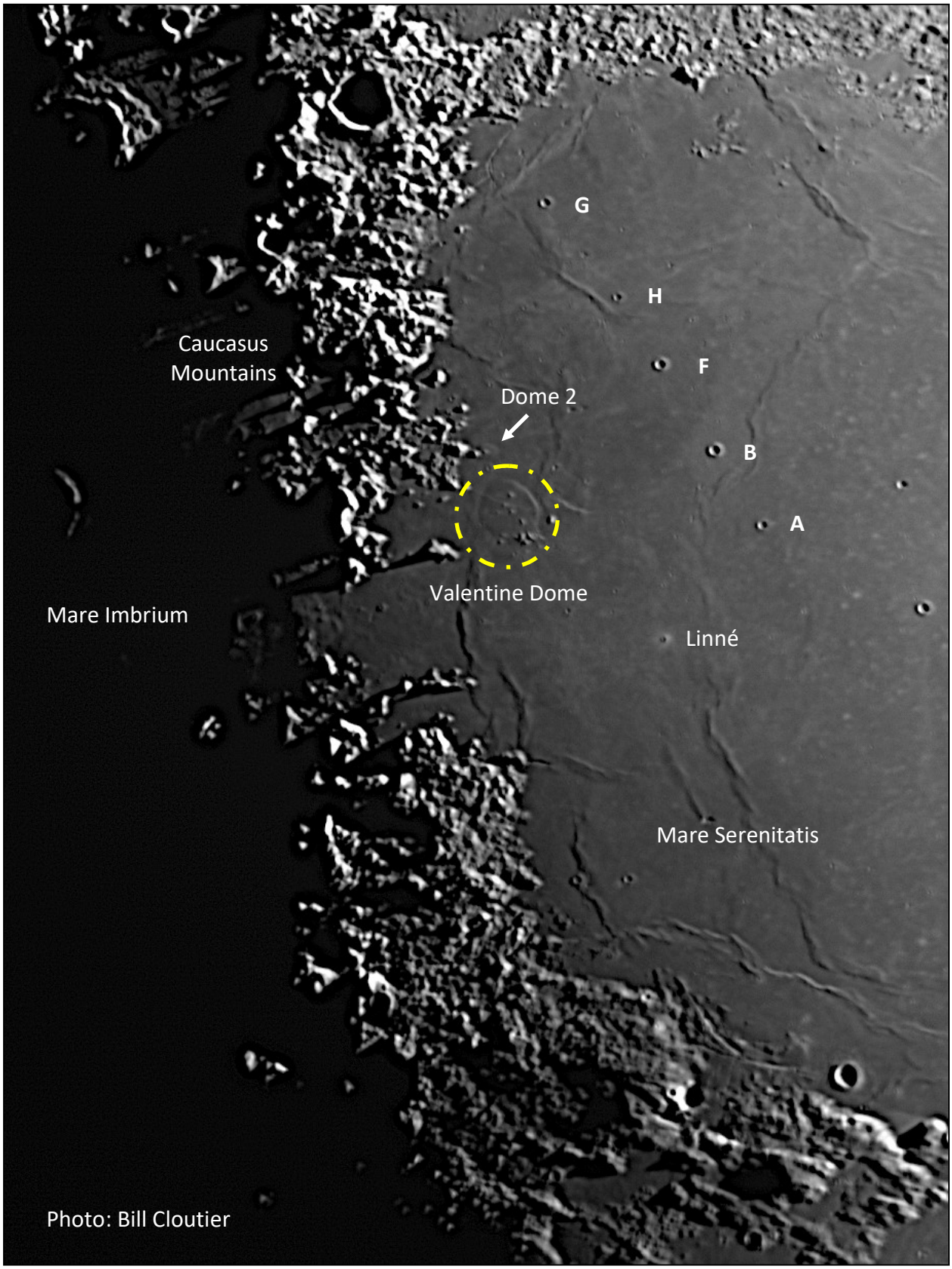
Lava domes are volcanic protrusions created by an upwelling of magma. On average, the top of the Valentine dome rises 400 feet (122 meters) above the mare. The dome's north-south profile (shown below) was generated from data collected by the Lunar Reconnaissance Orbiter. Older peaks poke through the surface of the dome -- several are visible in the photo on the following page, as well as a faint rille (fissure) that traverses the dome in an east-west direction. A second, much smaller dome, lies just to the north of Valentine.



LROC ACT-REACT-QuickMap
http://target.lroc.asu.edu/q3/

For scale, crater Linné is 1.5 miles (2.4 km) across, and craters F and B are 3 miles (4.8 km) in diameter. Despite its small size, Linné brightens as the Moon waxes, becoming a bright white spot under the sunlight of a Full Moon.

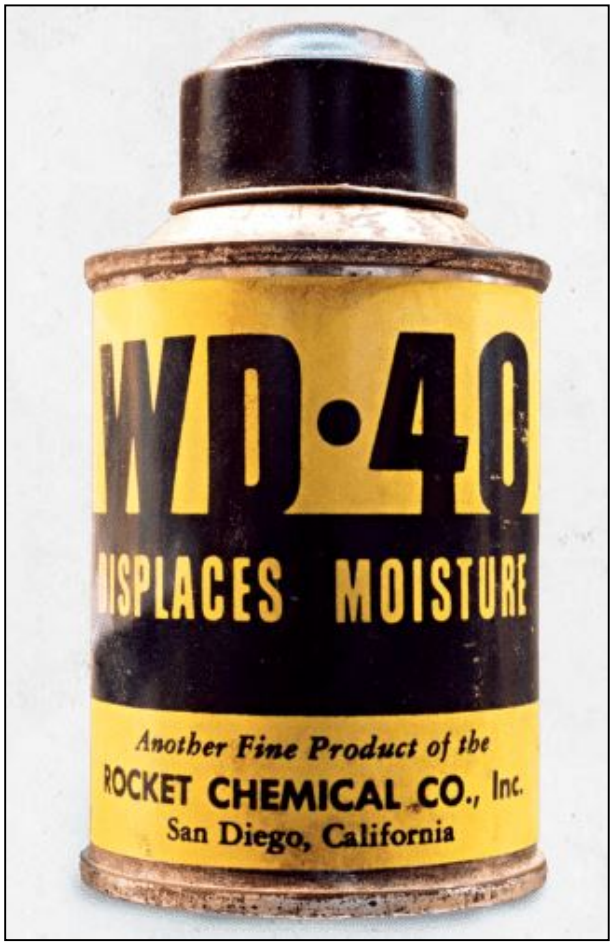
Valentine Dome



Rocket Trivia

Today you can find the solvent WD-40, in its classic blue and yellow can with the red top, in almost every workbench or garage, but what does WD-40 have to do with John Glenn's historic February 20, 1962 orbital flight? The product was developed by the Rocket Chemical Company in San Diego, California. At the time (circa 1953), the company, with a staff of three, were attempting to create a rust-prevention solvent and degreaser for the aerospace industry. The

Atlas-Mercury Courtesy NASA



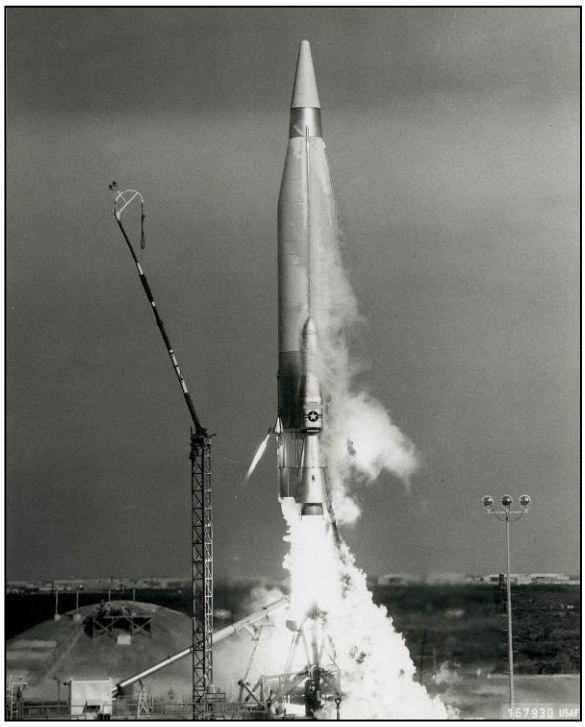
Water **D**isplacement formula was perfected on the **40**th attempt. Convair, a local aerospace contractor, was the first to use **WD-40** to protect the stainless steel outer skin of the Atlas missile from rust and corrosion.

The San Diego company, Convair formed in 1943 by the merger of Consolidated Aircraft and Vultee Aircraft, was contracted by the U.S. Air Force to develop a ballistic missile, in response to a mounting Soviet threat. Convair's engineers came up with an innovative and controversial design using paper-thin stainless steel as the structural material. Nicknamed the "gas bag," the booster was pressurized with helium for rigidity (or it would collaspse). The balloon design offered a significant reduction in the missile's weight (estimated at less than two percent of the propellant). Not everyone was enamoured with the design, including U.S. Army contractor and German rocket engineer Wernher von Braun who viewed the Atlas as "inflated competition."

As America's first operational Intercontenential Ballistic Missile (ICBM), the early Atlas had an innovative staging feature. Its three engines were started at launch but after a few minutes of flight, as the rocket's fuel was consumed, the two outer engines dropped off. The weight reduction allowed the Atlas to achieve orbit with just its central or "sustainer" engine.

Despite some early development issues with its turbopumps and fuel sloshing, ten Atlas-B missiles (the Atlas A was an earlier suborbital version, with only two booster engines and no sustainer engine) were launched during 1958 and 1959, with three failures. On December 18, 1958, an Atlas-B carried a communication experiment to orbit, known as SCORE (Satellite Communications by Orbiting Relay Equipment). Messages were sent to the satellite by ground stations, recorded, and then retransmitted back to Earth, including a prerecorded broadcast of a Christmas message by President Eisenhower.

Atlas-D was the first operational version of the Atlas and, with the miniaturization of thermonuclear warheads, able to deliver its payload over a 6,300 mile range. It also became the United State's best hope to challenge the Soviet's early domination of the "high ground" – launching John Glenn's Frienship 7 Mercury capsule into Earth orbit in 1962.



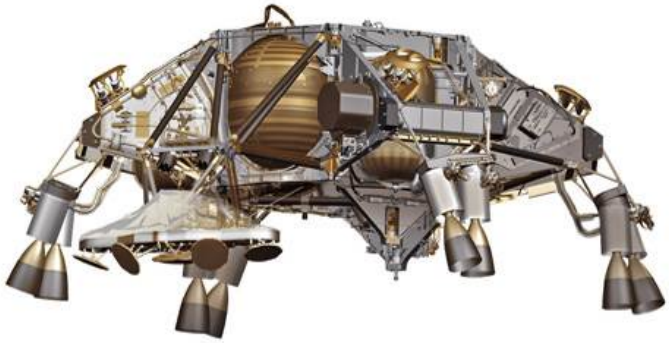
Atlas ICBM Courtesy U.S. Air Force

The Atlas was eventually retired as an ICBM in 1965, replaced by the solid-fueled Minuteman missile that had entered operation in early 1963. The rocket went on to serve as a reliable launch platform for both manned and unmanned science and exploration missions. An Atlas booster launched all of the Ranger, Surveyor, and Lunar Orbiter probes to the Moon, paving the way for the Apollo manned mission. It was also used to launch robotic missions to Mercury (Mariner 10), Venus (Mariner 2), Mars (Mariner 4), Jupiter (Pioneer 10), Saturn (Pioneer 11), and Pluto (New Horizons).

Mars Time (Landing of Perseverance)

Cruise Stage

Backshell



Descent Stage

Rover

Heat Shield

Credit: NASA/JPL-Caltech

On February 18, around 3:30 in the afternoon (EST on Earth), after a journey of seven months and almost 300 million miles (480 million kms), the Mars 2020 spacecraft will enter the Martian atmosphere for a seven-minute, high-speed ride down to the surface. At that time, Earth will be 127 million miles (204.85 million km) or 11 light-minutes from Mars, so by the time engineers at NASA's Jet Propulsion Laboratory receive the signal from the spacecraft that Entry, Descent and Landing (EDL) has begun, the rover will have been on the surface for four minutes.

Since launch on July 30, 2020 atop an Atlas V-541 rocket from the Cape Canaveral Air Force Station, Florida, the solar-powered cruise stage has been supporting spacecraft operations. Its systems have provided power to the spacecraft/rover, maintained communications, and adjusted course, as needed, to stay on target. About ten minutes before the spacecraft encounters the top of the Martian atmosphere, the cruise stage is discarded. The backshell then orients the heat shield for the plunge.

The spacecraft enters the Martian atmosphere at approximately 12,000 mph (about 20,000 kph). While only one percent as thick as Earth's, the Martian atmosphere provides sufficient drag to slow the protective aeroshell to about 1,000 miles an hour (1,600 kph). In the process, the 15-foot (4.5 meters) diameter, gold-colored heat shield, reaches a peak temperature of about 2,370°F (about 1,300°C), approximately 80 seconds after entering the atmosphere. As the spacecraft descends, small thrusters on the backshell keep the heat shield aligned at the required entry angle and direction of lift.

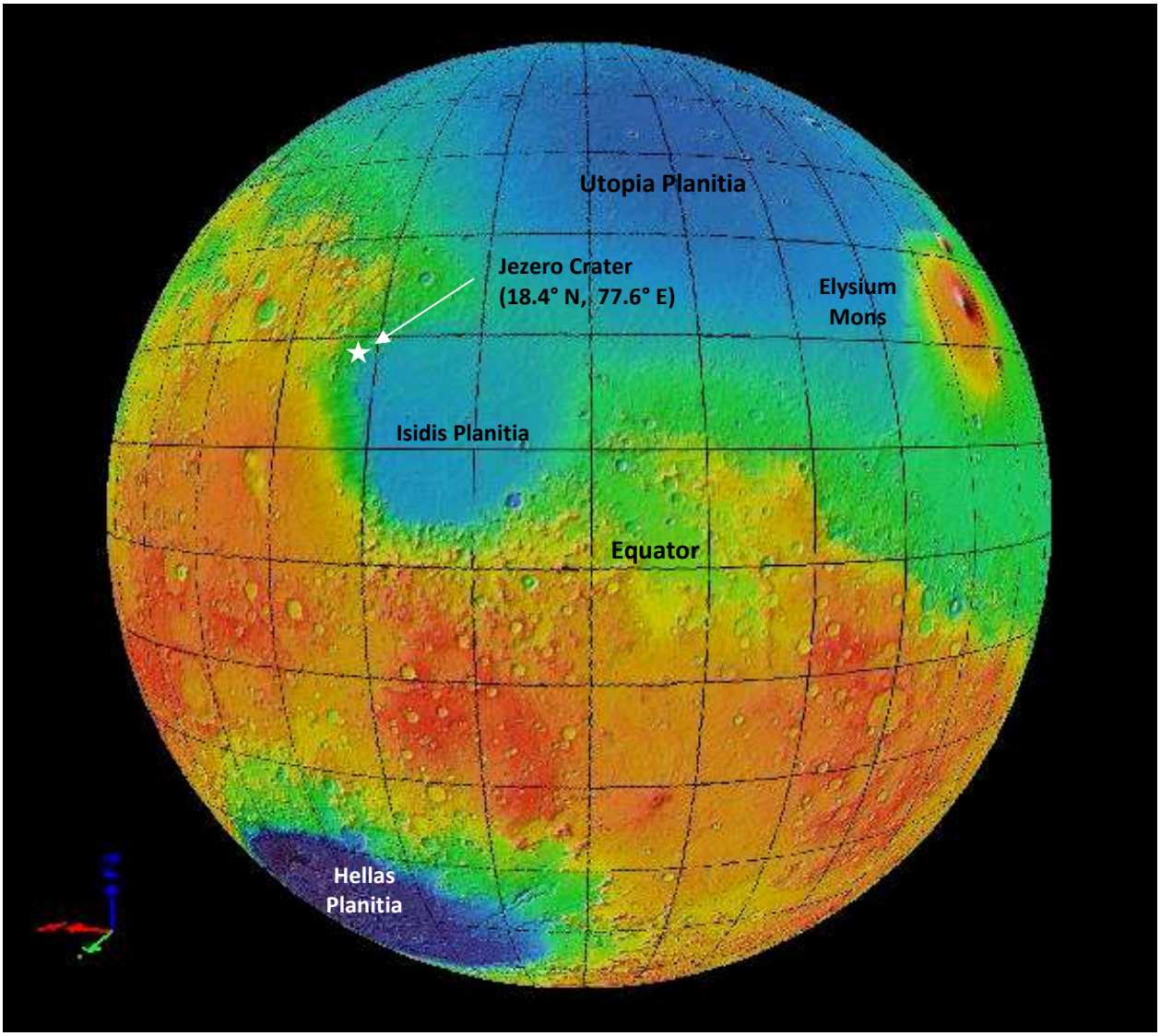
Four minutes into EDL, a supersonic parachute is released using a new technology (called Range Trigger) to time the opening at an expected altitude of 7 miles (11 kms). The parachute, 70.5 feet (21.5 meters) in diameter, rapidly deaccelerates the aeroshell and, twenty seconds after the deployment, the heat shield drops off, exposing the descent stage and rover.

With the heat shield gone, another new technology (Terrain-Relative Navigation) is activated, as well as the cameras and landing radar needed to assess the fast-approaching landing zone. Surface features are compared against an onboard map to chart the course to the most favorable landing area within the zone.

Despite its size, the parachute is only able to slow the spacecraft to about 200 miles per hour (320 kph). Almost 6 minutes into EDL, the descent stage (with the rover) separates from the backshell and powers up its eight rocket engines. The descent stage, with its onboard computer still evaluating landing options, slows to about 1.7 miles per hour (2.7 kph), as it hovers about 66 feet (20 meters) above the surface of Jezero crater. At this point, about 12 seconds before touchdown, the descent stage lowers the Perseverance rover to the surface using a set of 21-foot (6.4 meter) long cables. Once the rover is safely on the ground, the cables are cut and the descent stage flies away for an uncontrolled landing.

If all goes according to plan, the six-wheeled, robotic astrobiologist is then ready to roll.

Destination: Jezero Crater

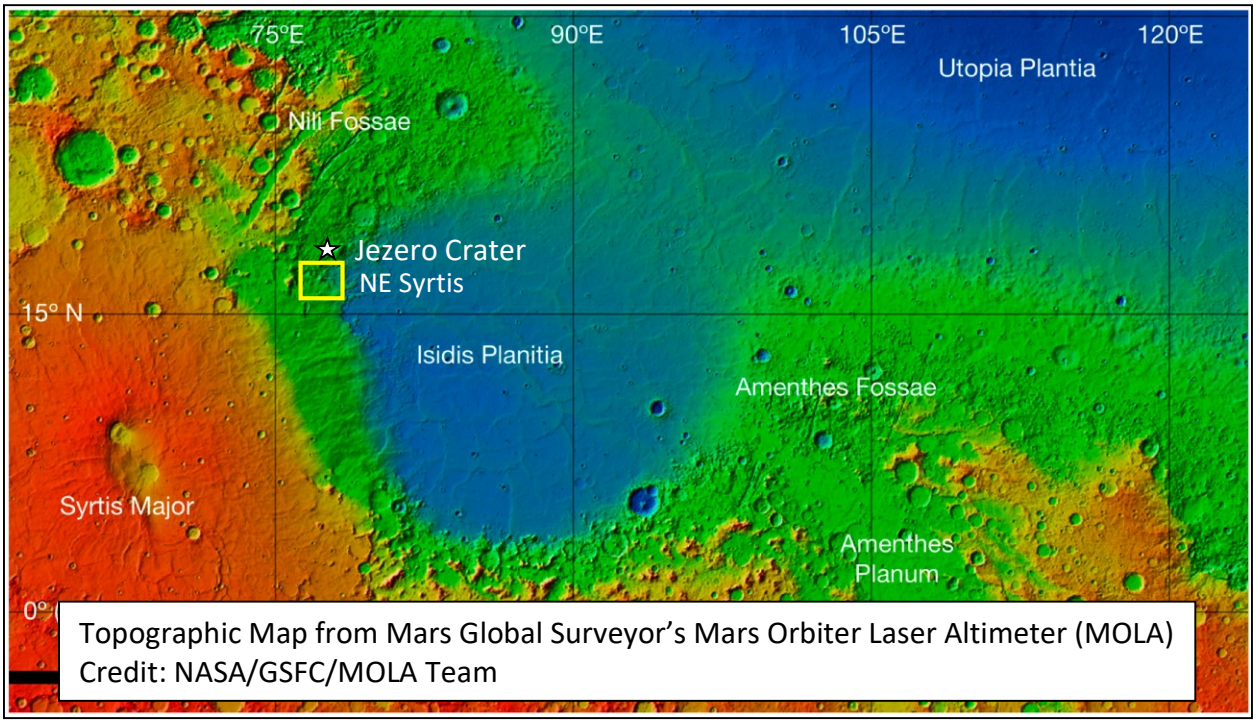


3-D view generated by JMARS, a product of the ASU Mars Scientific Software Team

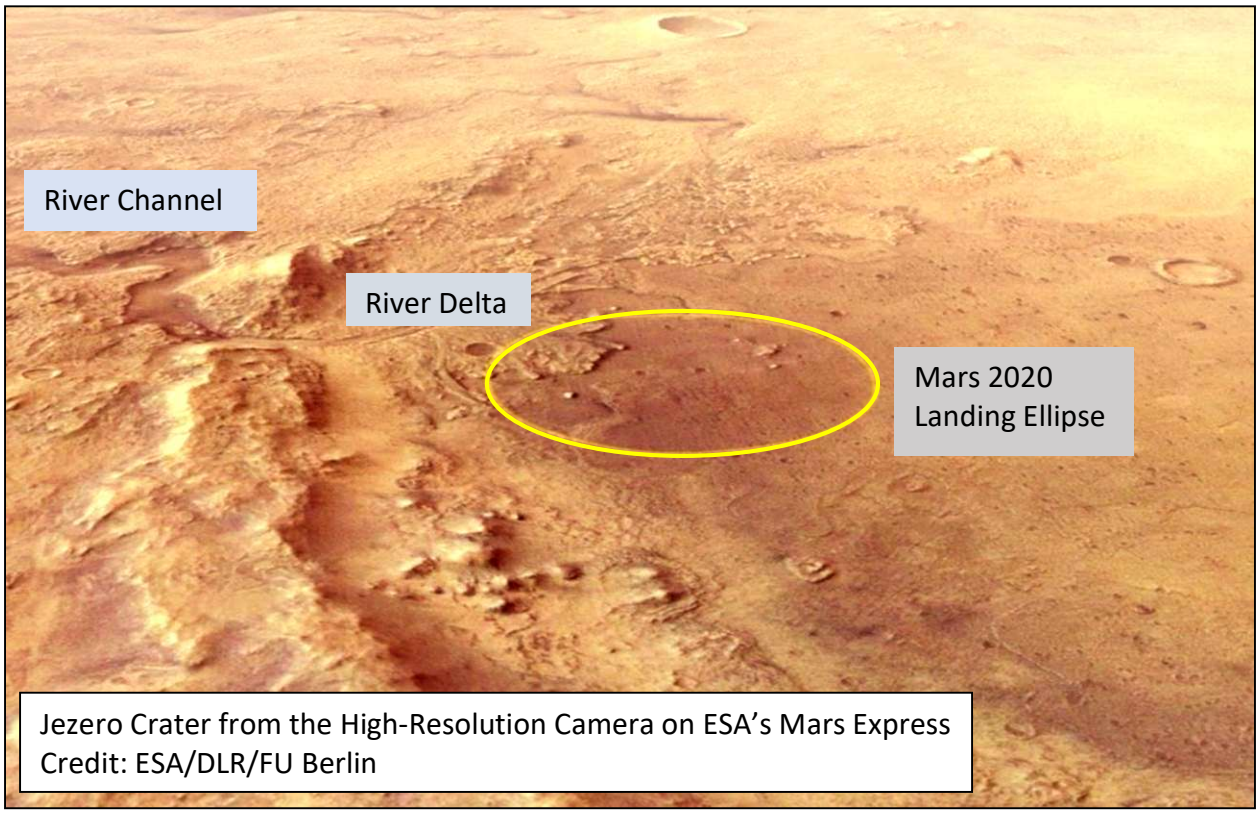
NASA has selected an ancient river delta (the larger of two within the Jezero crater) to explore with the Perseverance rover and look for signs of early microbial life that might be preserved within the clay strata. The crater, 28 miles (45 km) across, is located on the perimeter of a level plain called Isidis Planitia, just north of the Martian equator. Based upon the data collected by orbiting spacecraft, the 3.9-billion-year-old Jezero crater appears to have been flooded in the distant past, with a paleolake containing as much water as Lake Tahoe on Earth. The preferred landing site is near the front of the delta located along the western rim of the now-dry crater, and at the mouth of one of the river channels thought to have fed the lake.

Just south of Jezero is one of the other high-value science areas that had been evaluated by the engineering and science teams planning the Mars 2020 mission – Northeast Syrtis (there were originally three sites that made the final cut). The Northeast Syrtis area is characterized by several distinct volcanic features, that likely formed during each of Mars' three geologic time

periods or Epochs (from oldest to youngest: Noachian, Hesperian and Amazonian). Samples from this region could be useful in understanding the planet's evolution from wet and warm to dry and cold. Late in the site evaluation process, a fourth site was added – Midway. As the name implies, the site is halfway between Jezero crater and NE Syrtis. It could be a future destination for the Perseverance rover, should the rover's primary mission be extended.



Topographic Map from Mars Global Surveyor's Mars Orbiter Laser Altimeter (MOLA)
Credit: NASA/GSFC/MOLA Team



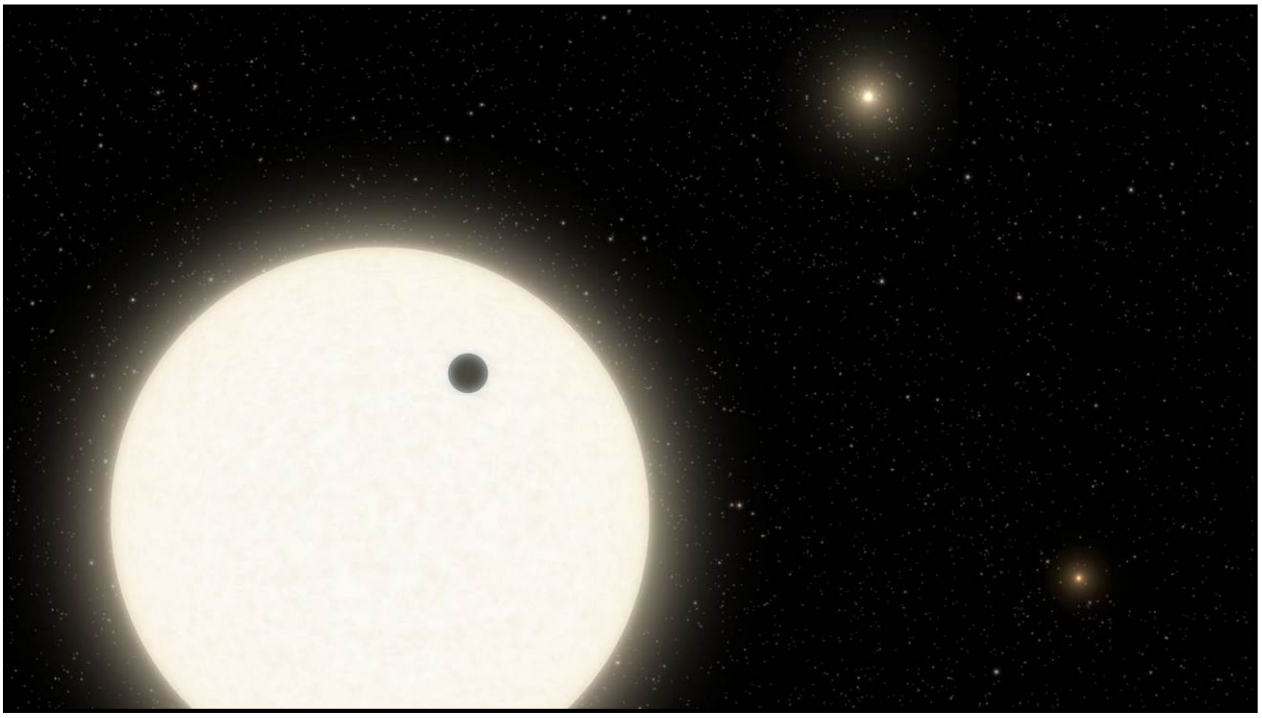
Jezero Crater from the High-Resolution Camera on ESA's Mars Express
Credit: ESA/DLR/FU Berlin

Revisiting an Exoplanet Discovery

On March 7, 2009, the Kepler space telescope was launched into an Earth-trailing heliocentric orbit. The telescope's prime mission, to continuously monitor more than 150,000 stars in the Cygnus-Lyra region for transiting exoplanets, ended after 4 years when the second of four reaction wheels (used to point the telescope) failed. Within a year, the project team had found a way to continue a modified search with the two remaining wheels – a quest that would continue for another five years and identify thousands of additional candidates.

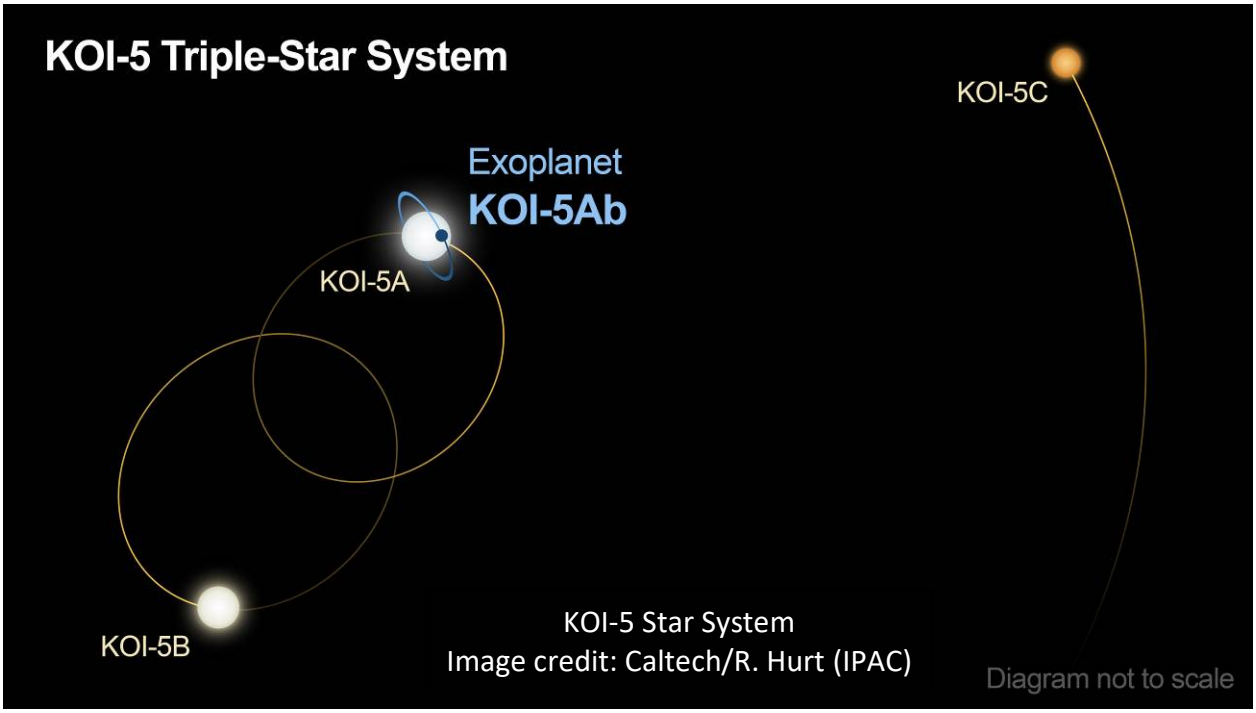
Kepler finds planets by monitoring stars over time for small decreases in their brightness – as a result of one or more planets passing in front and blocking a tiny bit of light from the star reaching the telescope. Once a planet is detected, its orbit can be calculated from the time it takes to complete a circuit around its parent star (as well as the star's mass), its size deduced from the amount of star light the planet blocks, and its physical parameters from the temperature of the star and the planet's distance from it.

Shortly after Kepler commenced operations in 2009, the telescope detected a potential planet around the multiple star system KOI-5 (the telescope's second finding). Designated KOI-5Ab, the discovery was ultimately set aside, with questions as to whether the signal was real or an artifact of the multiple star system, and as additional, more easily confirmed, candidates were identified. By the time the telescope was decommissioned in 2018, almost 2,400 new exoplanets had been discovered by Kepler, with almost an equal number of candidates that needed additional confirmation – including KOI-5Ab.



Planet KOI-5Ab crossing in front of or transiting the A Star of the triple star system located 1,800 light-years away in the Cygnus constellation
Credits: Caltech/R. Hurt (Infrared Processing and Analysis Center, or IPAC)

With the retirement of Kepler, the search was taken up by NASA's Transiting Exoplanet Survey Satellite, or TESS, and a number of ground-based telescopes. TESS is designed to survey the 200,000 brightest stars closest to our Sun, working much that same way as Kepler (detecting transits). When one of the TESS surveys included a portion of the sky where the KOI-5 system resides, it too detected a potential planet within the system. Astronomers then turned to another method of planet finding, radial-velocity, to confirm the discovery (the technique measures the gravitational pull of an orbiting planet by the "wobble" of the parent star, as both the star and the planet orbit their common center of mass). Ground-based instruments at the Keck Observatory in Hawaii were able to reveal a planet, about half as massive as Saturn, orbiting the A star in the system with a period of about 5 days.



The KOI-5 star system consists of three stars, labeled A, B, and C, in this diagram. Stars A and B orbit each other every 30 years. Star C orbits stars A and B every 400 years.

David Ciardi, chief scientist of NASA's Exoplanet Science Institute (NExScI), located at Caltech's Infrared Processing and Analysis Center (IPAC), presented the findings at the 2021 virtual meeting of the American Astronomical Society (AAS). Ciardi noted the planet is unusual in that its orbit is skewed from the plane of the two stars (A/B) – tilted about 50°. Planets and stars form out of the same disk of material (comprised of gas and dust) so that, initially, all bodies occupy the same orbital plane. It is likely that star B may have disrupted the planet's orbit at some point in the star system's history, sending into its current inclination, and possibly moving it closer to the A star.

Few planets have been discovered in triple star systems (making up only about 10% of all star systems surveyed), and planet KOI-5Ab is unusual in its skewed orbit. Astronomers don't know if planet formation around multiple star systems is rare or that the sample size is currently too small from which to draw such a general conclusion.

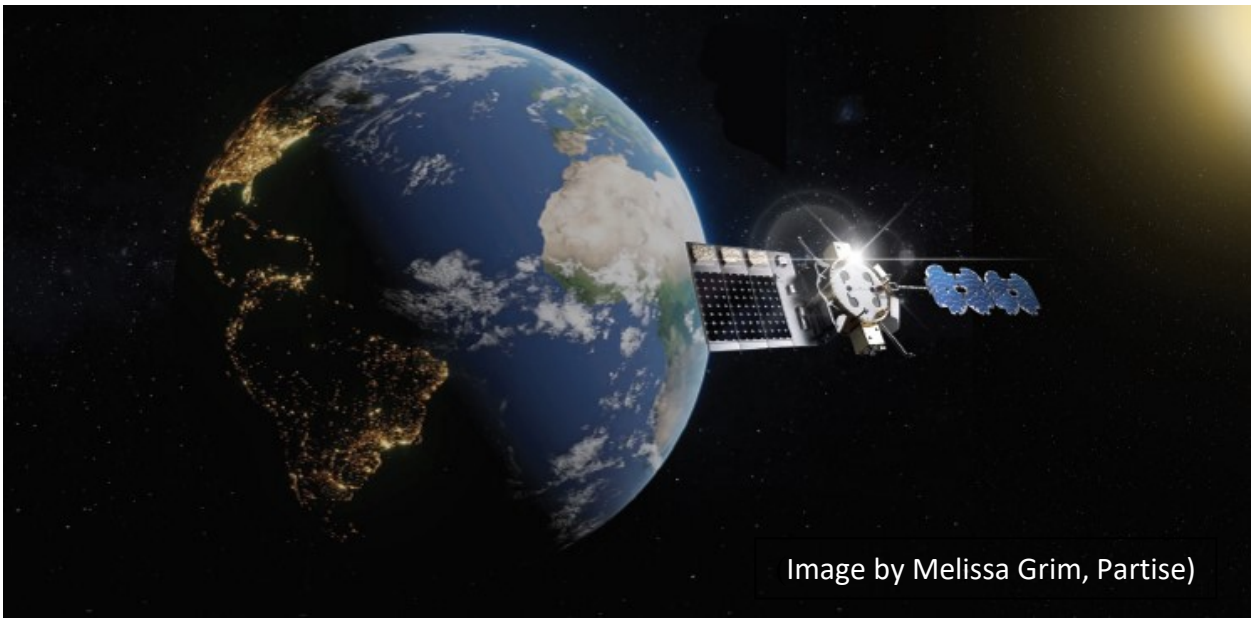
Moon Rock in the White House

At the request of the Biden Administration, NASA delivered a Moon rock (on loan) to the Oval Office. The display is intended to represent the accomplishments of earlier generations and future support for the Moon to Mars initiative. The 332-gram piece (less than a pound) was collected by the Apollo 17 astronauts in 1972 – chipped from a large boulder at the base of the North Massif in the Taurus-Littrow Valley. The 3.9-billion-year-old sample is believed to be a remnant of an impact event that created the Imbrium basin.

Photo credit: NASA

Solar Beaming Project

The Air Force Research Laboratory (AFRL) is working on a space-based solar power transmission system that would be capable of delivering power anywhere on the globe, at any time, and in any weather. AFRL recently received the spacecraft "bus" (the first flight hardware) for its Arachne spacecraft, the flagship experiment within the Space Solar Power Incremental Demonstrations and Research project. The bus, named "Helios," was provided by Northrop Grumman and is the part of the spacecraft that includes the components for controlling the spacecraft's orientation, managing power and communications, as well as serving as the platform for experiments. Helios is a commoditized spacecraft bus – developed from AFRL technology that was transferred to the commercial industry and that is now available at a cost savings to the government as a platform for future spacecraft. The bus can host multiple payloads.



AFRL will customize the bus for the Arachne spacecraft to host the Space Solar Power Radio Frequency Integrated Transmission Experiment or SSPRITE. The demonstration project will assess technologies that convert solar energy to radio frequency power, as well as the feasibility of transmitting and converting that power to a usable form back on Earth.

Launch of the Arachne spacecraft with the Helios and SSPRITE components is currently forecasted for 2024.

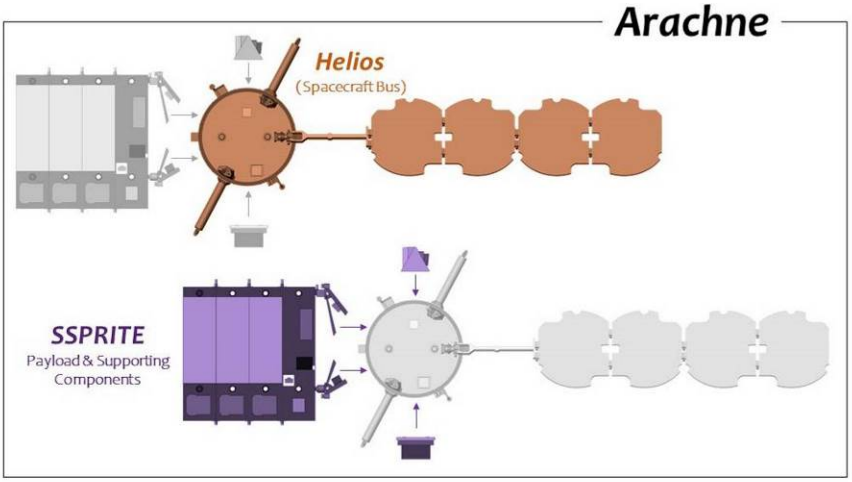
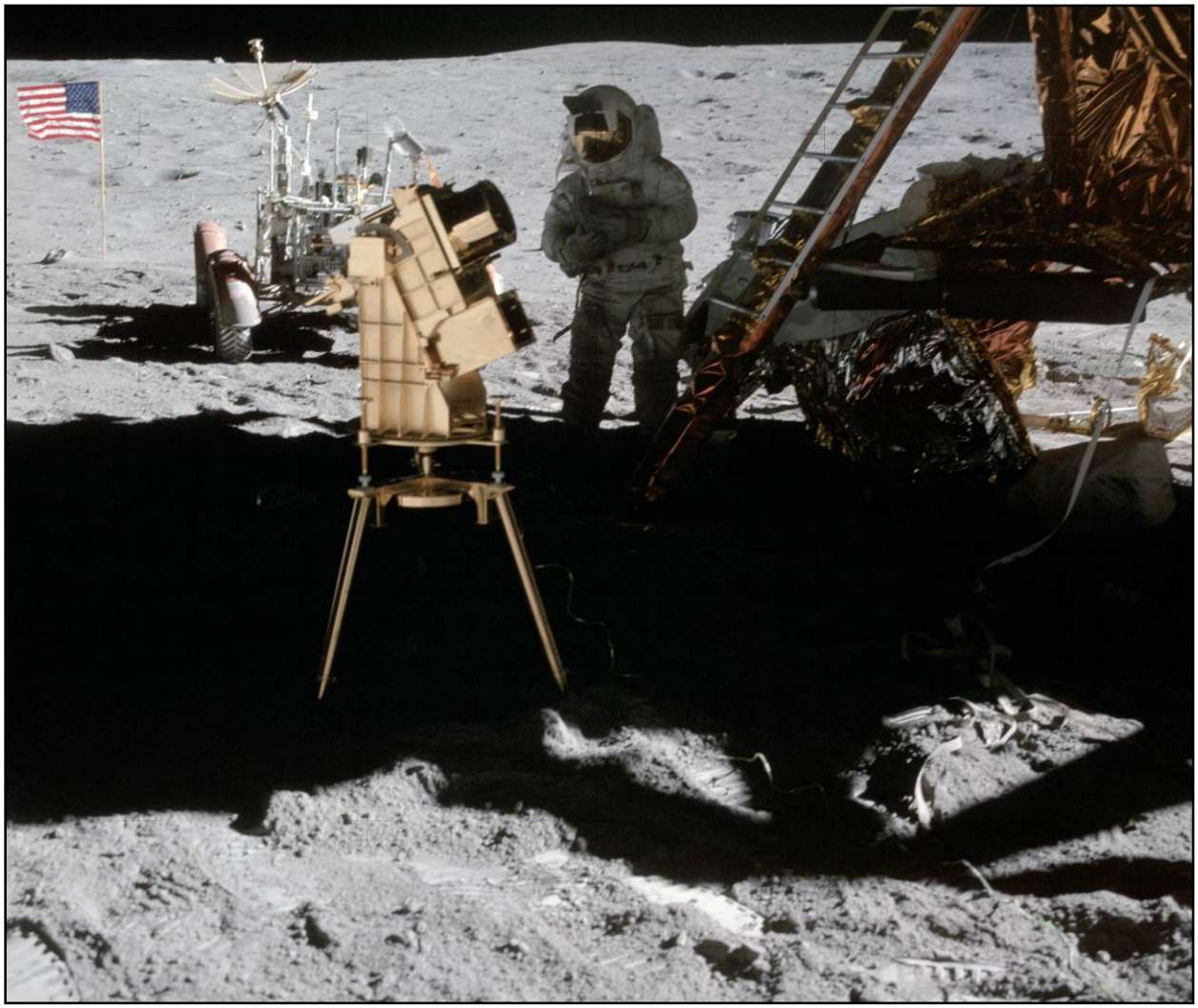


Image courtesy of AFRL. AFRL is the primary scientific research and development center for the Department of the Air Force.

Remembering Dr. George Carruthers

Dr. George Robert Carruthers passed away on December 26, 2020. Born in Cincinnati, Ohio, Carruthers earned his bachelor's degree in physics, masters in nuclear engineering, and Ph.D. in aeronautical and astronautical engineering, while studying at the University of Illinois. In 1964, he began working at the U.S. Naval Research Laboratory, where he perfected an ultraviolet camera/spectrograph for NASA that was carried to the Moon on the Apollo 16 in 1972.

Dr. George Carruthers (on the right) next to his invention - the gold-plated ultraviolet camera/spectrograph, which he had patented several years earlier
Credits: U.S. Naval Research Laboratory

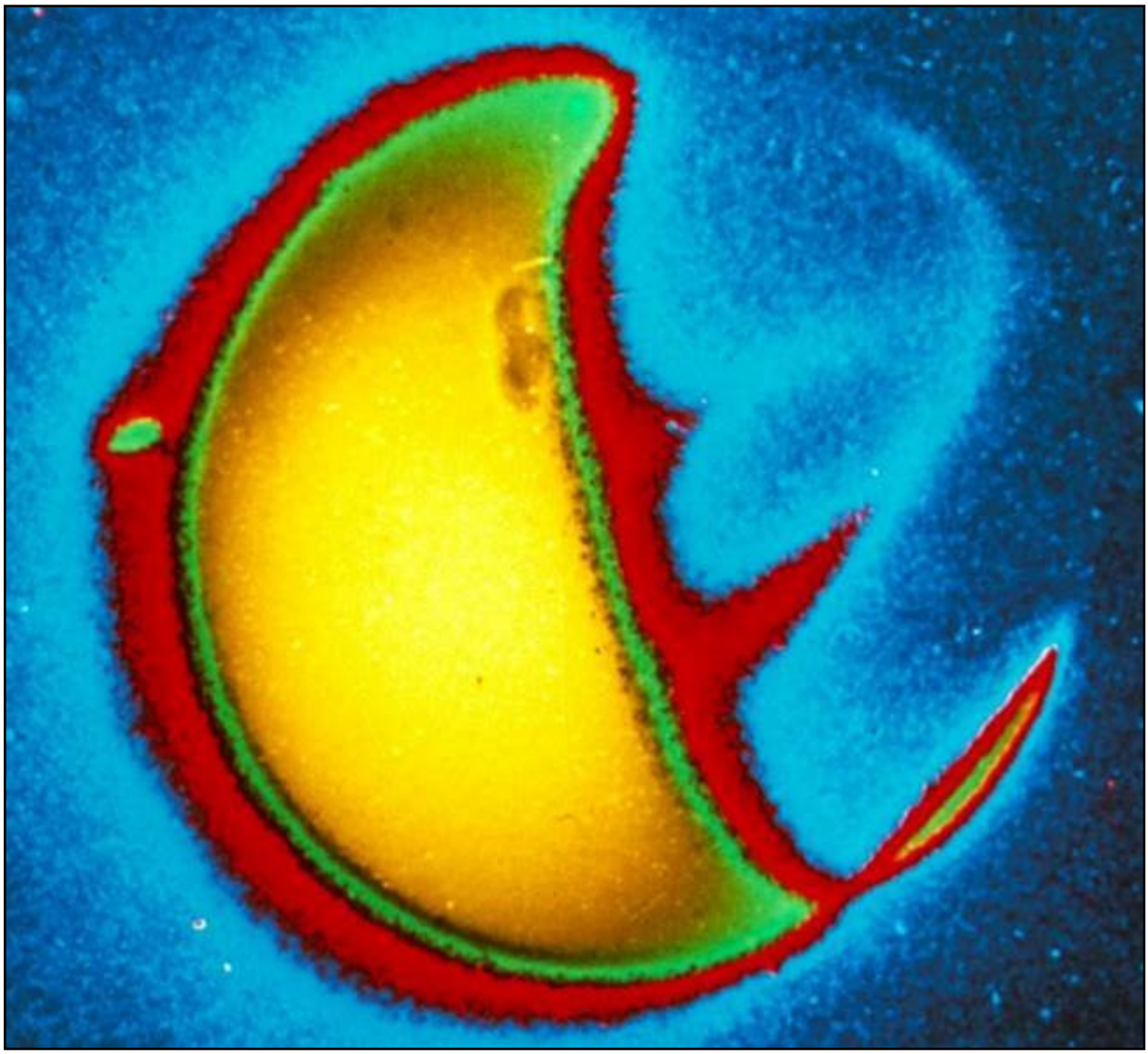


The first camera/spectrograph used to make astronomical observations from the surface of another planetary body - set up by the Apollo 16 astronauts.
Credits: NASA

The first lunar observatory was located in the shadow of the Apollo 16 lunar lander, Orion, on the Moon's Descartes highland region in April 1972. The tripod-mounted, f/1.0 electronographic Schmidt camera, with a 3-inch aperture lens, weighed 48.5 pounds (22 kg). It had a 20° field of view in the imaging mode.

Astronaut John Young used the camera/spectrograph to photograph star clouds, nebulae, and Earth's outermost atmosphere. In all, 178 useable frames of film were exposed and returned to Earth for analysis (the camera remained behind) – 85 imagery, 68 spectra, and 25 combined frames of the 10 preselected target areas in the lunar sky. Exposures varied from minutes for bright objects (like Earth) to several hours. When asked to explain the significance of the observations, Carruthers said "the most immediately obvious and spectacular results were really for the Earth observations, because this was the first time that the Earth had been photographed from a distance in ultraviolet (UV) light, so that you could see the full extent of the hydrogen atmosphere, the polar auroris and what we call the tropical airglow belt."

Carruthers other achievements included the first detection of molecular hydrogen in space using a sounding rocket (in 1970), development of UV detectors to image Comet Halley, carried aboard Skylab and the space shuttle, and on Defense and research satellites. In 2012, he was awarded the National Medal of Technology and Innovation. In the 1980s, he helped launch a program called the Science and Engineers Apprentice Program, and also taught science classes at Howard University in Washington, D.C.



False color image of the Earth in UV from the Moon
Credits: NASA

The UV images taken by Carruthers' telescope shows the Earth's outermost atmosphere, or geocorona. The camera/ spectrograph recorded light in a wavelength invisible to the human eye and too short to penetrate the Earth's atmosphere. In this region, atomic oxygen and molecular nitrogen glow brightly in the UV on the Sun-facing side of the Earth.

Streamers extending into the night side are produced by charged particles as they spiral towards the Earth along the planet's magnetic field lines.

Meteorite Spotlight – Allende

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.

A fireball in the sky over the southwest province of Chihuahua, Mexico on February 8, 1969, was followed by detonations and a rain of stones from the sky. The meteorites were strewn over an area of 19 square miles (50 square km). Samples were collected quickly, minimizing terrestrial contamination (the first meteorite was discovered in village of Pueblito de Allende), with several of the meteorites taken to NASA's Lunar Receiving Laboratory in Houston, Texas for analysis. The newly commissioned laboratory was preparing to receive lunar material from the Apollo missions (Allende was the first extraterrestrial rocks analyzed in the lab). Two tons of material are reported to have been collected, to date, from the fall.

Allende is a stony meteorite, classified as a carbonaceous chondrite. Radioactive dating (based upon two isotopes of lead) yielded an age close to that of the Sun (about 4.6 billion years old). The meteorite has abundant calcium-aluminum-rich inclusions (some of the oldest and most primitive material to condense out of the solar nebula). Allende also contains presolar grains (composed of silicon carbide) that predate the Sun – relatively rare since presolar grains are typically degraded or destroyed in the environment where the inclusions are formed (closer to the Sun), where the temperature of the solar nebula increases. In Allende, researchers found presolar grains inside the inclusions.

Researchers also found evidence that isotopes (forms of the same element that contain equal numbers of protons but different numbers of neutrons in their nuclei) inside the meteorite were likely produced by a nearby supernova. The rest of the meteorite was comprised of debris from supernova, but arrived later. The discoveries will help improve the theories of solar system evolution.

Two of the smaller samples of Allende in the McCarthy Observatory's meteorite collection
Image: Gerard Bianchi

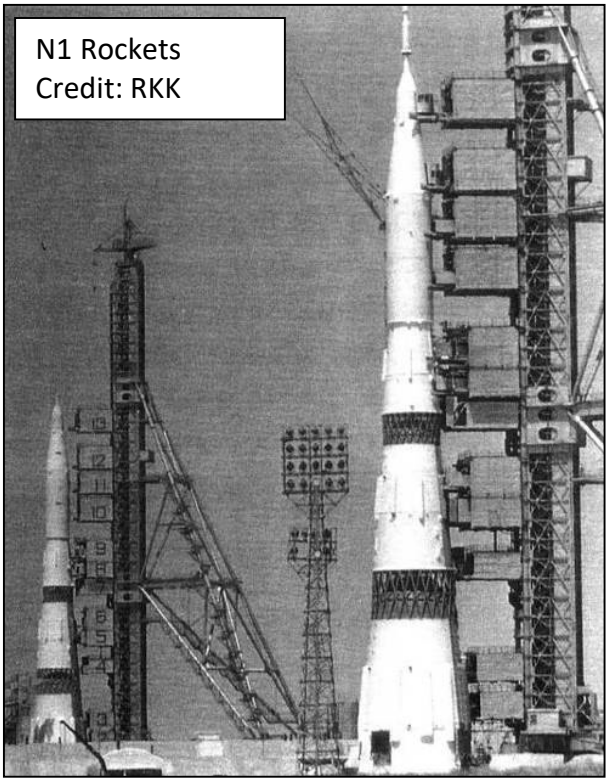
There are three samples of the Allende meteorite in the collections at the McCarthy Observatory. They include a 2.0-gram fragment, a 3.9-gram slice and 23.0-gram stone.

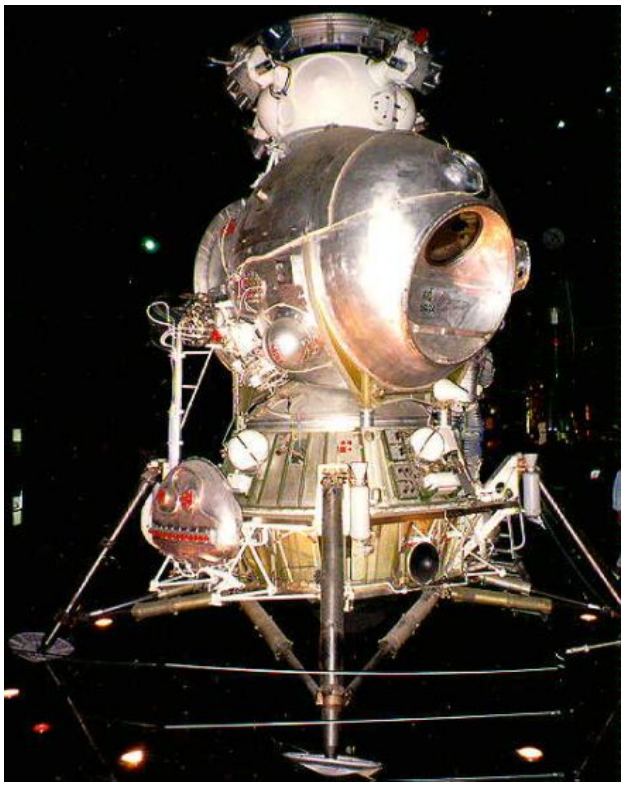
Twenty Years Ago: Discovery's Final Mission

Soviet Moon Program

February marks the beginning of the end of the Soviet Moon program. While publicly denying its intentions to send cosmonauts to the Moon during the 1960s, the Soviets were secretly constructing rockets of mammoth proportions (rivaling the Saturn V). On February 21, 1969, the N1 moon rocket exploded during its first test flight. The rocket fell back to Earth after a safety system mistakenly shut down all 30 engines when a fire was detected in the first stage less than 70 seconds after liftoff. Three more failures would follow before the Soviet government would abandon their manned-Moon program.

The historic photos on the right shows 1) the N1 under construction with the 30-engine first stage, 2) the Soviet lunar lander and 3) two N1 rockets on pads at the Baikonur Cosmodrome (also known as Tyuratam) in Kazakhstan. The five stage rockets stood approximately 340 feet high.





John Glenn and the Flight of Freedom 7

On the morning of February 20, 1962, John Glenn became the first American to orbit the Earth aboard a Mercury space capsule that Glenn named Friendship 7. Originally scheduled for the previous December, the launch was delayed by several technical and mechanical issues, including a fuel leak, and by weather.

Glenn served with the Marine Corps prior to being selected by NASA for its manned spaceflight program. As a fighter pilot, he flew 59 combat missions in the South Pacific during World War II. Following service in the Korean War (baseball Hall of Fame legend Ted Williams was one of his wingmen), he set a speed record for a transcontinental flight on July 16, 1957 when he flew a Vought F8U Crusader from California non-stop to New York in 3 hours 23 minutes in a test of a new Pratt & Whitney engine (it did require 3 mid-air refuelings).

Astronaut John Glenn entering the Mercury capsule
Credit: NASA

Glenn's trip around the Earth lasted 4 hours and 55 minutes and 23 seconds, completing 3 orbits before splashing down in the Atlantic Ocean southeast of Bermuda. While a public relations success, the flight was not without problems, the most serious of which was an indication that the capsule's heat shield had come loose and its landing bag deployed. Not knowing whether it was a faulty indicator, mission control asked Glenn to leave the retro-pack on during reentry. (The retro-pack consisted of three small rockets that were used to slow the spacecraft down. It was

attached to the spacecraft by three straps that extended over the heat shield.) Fortunately, the indicator was faulty and the flaming debris that Glenn saw streaming by his window during reentry was from the retro-pack and not the heat shield.

John Glenn would not return to space for another 36 years. In 1998, at the age of 77, Glenn joined the crew of the space shuttle Discovery for a nine-day mission. He was the oldest person to fly in space. John Glenn died Thursday, Dec. 8, 2016 at the age of 95. He was the last of the original Mercury 7 astronauts selected by NASA in 1958 for the agency's fledgling manned spaceflight program.

Sunrise and Sunset (from New Milford, CT)

Sun	Sunrise	Sunset
February 1st (EST)	07:05	17:07
February 15th	06:48	17:25
February 28th	06:29	17:40

Astronomical and Historical Events

1st Aten Asteroid 2016 CL136 near-Earth flyby (0.035 AU)
1st History: loss of the space shuttle Columbia upon reentry (2003)
2nd Amor Asteroid 5620 *Jasonwheeler* closest approach to Earth (1.911 AU)
2nd Asteroid 10 *Hygiea* closest approach to Earth (2.220 AU)
2nd History: Soviet space station Salyut 4 reenters the Earth's atmosphere (1977)
3rd Moon at perigee (closest distance from Earth)
3rd Apollo Asteroid 2020 SO near-Earth flyby (0.001 AU)
3rd Atira Asteroid 1998 DK36 closest approach to Earth (0.181 AU)
3rd History: Apollo 14, with astronauts Alan Shepard, Stuart Roosa and Edgar Mitchell, lands in the Moon's Fra Mauro region; 3rd manned Moon landing (1971)
3rd History: Soviet spacecraft Luna 9 becomes first spacecraft to soft land on the Moon (1966)
4th Last Quarter Moon
4th History: launch of Lunar Orbiter 3; photographed potential Apollo landing sites (1967)
4th History: Clyde Tombaugh born (1906); discovered the dwarf planet Pluto in 1930
5th Aten Asteroid 2018 PN22 near-Earth flyby (0.033 AU)
5th Apollo Asteroid 2018 CH2 near-Earth flyby (0.037 AU)
5th Apollo Asteroid 29075 (1950 DA) closest approach to Earth (0.494 AU)
5th Atira Asteroid 459883 (2014 JX25) closest approach to Earth (2.181 AU)
5th Amor Asteroid 18106 *Blume* closest approach to Earth (2.459 AU)
5th History: flyby of Venus by the Mariner 10 spacecraft on its way to Mercury; first U.S. spacecraft to photograph Venus, first to use gravity of one planet to propel itself to another, and the first spacecraft to visit Mercury (1974)
6th History: Soviet space station Salyut 7 reenters Earth's atmosphere (1991)
6th History: Apollo 14 astronaut Alan Shepard attempts to golf on the Moon (1971)
7th Mars Spring Equinox in the northern hemisphere
7th Apollo Asteroid 2018 RB near-Earth flyby (0.047 AU)
7th History: launch of the Stardust spacecraft for a rendezvous with Comet Wild 2 (1999)

Astronomical and Historical Events

7th History: Bruce McCandless makes first untethered spacewalk using a jet-powered backpack (1984)
7th History: Astronomical Society of the Pacific founded (1889)
7th History: William Huggins born, pioneered work in astronomical spectroscopy and first to differentiate nebular and galactic spectra (1824)
8th History: Allende Meteorite fall (meteorites from the fall were the first extraterrestrial rocks analyzed in the NASA Lunar Receiving Laboratory which had just been completed in September of 1967 to support the Apollo program) (1969)
8th History: discovery of the SAU 094 Mars meteorite in Sayh al Uhaymir, Oman; one of the largest Mars meteorites recovered and the only one with a documented strewn field (2001)
8th History: discovery of GRV 99027 Martian Meteorite on the ice sheet near the Grove Mountain region of Antarctica; the 9.97-gram meteorite was later characterized as a shergottite (2000)
8th History: flyby of Jupiter by the Ulysses spacecraft on its way to study the polar regions of the Sun (1992)
8th History: return of Skylab III crew (astronauts Gerald Carr, William Pogue and Edward Gibson) to Earth after a 3 month stay on the space station (1974)
8th History: Jules Verne born, author and futurist (1828)
9th Kuiper Belt Object 420356 *Praamzius* at Opposition (42.039 AU)
9th History: launch of the ESA's Solar Orbiter on an Atlas 5 rocket from the Cape Canaveral Air Force Station, Florida
10th Aten Asteroid 2019 YP5 near-Earth flyby (0.021 AU)
10th Apollo Asteroid 2008 DB near-Earth flyby (0.034 AU)
10th History: flyby of Venus by the Galileo spacecraft (for a gravity assist) on its way to Jupiter; the encounter provided the first views of mid-level clouds on Venus and confirmed the presence of lightning (1990)
10th History: flyby of Mars by the Soviet Mars 4 spacecraft; failed to enter orbit but did detect night-side ionosphere (1974)
10th History: MIT, using Millstone Hill radar in Westford, MA, bounces radar off Venus (1958)
10th History: discovery of Asteroid 624 *Hecktor*, largest Jupiter Trojan, by August Kopff (1907)
11th New Moon
11th China's spacecraft Tianwen-1 enters orbit around Mars
11th History: launch of NASA's Solar Dynamics Observatory from Cape Canaveral, Florida; the first mission in the space agency's "Living with a Star" program; five-year mission to study the Sun's energy and its influence on space weather (2010)
11th History: launch of the space shuttle Discovery (STS-82), second Hubble Space Telescope servicing mission; **shuttle tire** on display at the Observatory is from this mission (1997)
11th History: launch of first Japanese satellite: Oshumi (1970)
12th History: landing of the Near-Earth Asteroid Rendezvous (NEAR) – Shoemaker spacecraft on the asteroid *Eros* (2001)
12th History: Soviet spacecraft Mars 5 enters orbit around Mars, providing information on surface temperatures, CO_2 concentrations, and detecting a thin ozone layer and water vapor concentrations near the Tharsis region (1974)

Astronomical and Historical Events (continued)

12th History: Sikhote Alin meteorite fall in Russia, one of the largest modern falls at 28 tons (1947)

13th McCarthy Observatory– Virtual Second Saturday Stars

13th Binary Kuiper Belt Object 79360 *Sila-Nunam* at Opposition (42.448 AU)

14th Amor Asteroid 5879 *Almeria* closest approach to Earth (0.199 AU)

14th History: flyby of Comet *Tempel 1* by the Stardust spacecraft (2011)

14th History: NEAR-Shoemaker enters orbit around *Eros*, one of the largest of the near-Earth asteroids (2000)

14th History: Voyager 1 points its camera back towards the Sun and takes a family portrait, capturing six planets (Venus, Earth, Jupiter, Saturn, Uranus and Neptune) from a distance of approximately 4 billion miles; Mercury was too close to the Sun to be seen and Mars was lost in the scattered sunlight (1990)

14th History: launch of the Solar Maximum Mission (1980) to study the Sun during the peak of the solar cycle; a malfunction less than a year later cut the mission short. However, the satellite was recovered and repaired by the Space Shuttle Challenger in April 1984; operated successfully until burning up in the Earth's atmosphere in December 1989

14th History: launch of Luna 20, Soviet Moon sample return (1972)

14th History: launch of Syncom 1, the first geosynchronous satellite (1963)

15th United Arab Emirates spacecraft Hope (Al-Amal) enters orbit around Mars

15th Scheduled launch of a Russian cargo-carrying Progress spacecraft to the International Space Station from the Baikonur Cosmodrome, Kazakhstan

15th Atira Asteroid 2019 LF6 closest approach to Earth (1.264 AU)

15th Amor Asteroid 5324 *Lyapunov* closest approach to Earth (3.754 AU)

15th History: meteor explodes over the Russian city of Chelybinsk causing hundreds of minor injuries (2013)

15th History: discovery of Centaur Object *Chariklo* by Jim Scotti (1997)

15th History: flyby of the Moon by the Hiten spacecraft; Earth orbiting satellite designed by the Japanese Space Agency to test technologies for lunar and planetary missions (1992)

15th History: Pioneer 10 becomes the first spacecraft to traverse the Main Asteroid Belt (1973)

15th History: Galileo Galilei born (1564)

16th Centaur Object 32532 *Thereus* at Opposition (11.283 AU)

16th Kuiper Belt Object 2014 AN55 at Opposition (44.740 AU)

16th History: Gerard Kuiper discovers Uranus' moon *Miranda* (1948)

17th Apollo Asteroid 1864 Daedalus closest approach to Earth (1.502 AU)

17th History: discovery of the Plutino 90482 *Orcus* with its large moon, Vanth, by American astronomers Michael Brown of Caltech, Chad Trujillo of the Gemini Observatory, and David Rabinowitz of Yale University (2004)

17th History: Ann Harch discovers *Dactyl*, the first natural satellite of an asteroid (*Ida*) discovered from Galileo Images (1994)

17th History: launch of Ranger 8; lunar impact mission (1965)

17th History: launch of NEAR spacecraft, asteroid orbiter/lander; first of NASA's Discovery missions and the first mission to go into orbit around an asteroid (1996)

17th History: launch of Vanguard 2; designed to measure cloud-cover distribution over Earth (1959)

18th Moon at apogee (furthest distance from Earth)

Astronomical and Historical Events (continued)

18th Scheduled landing of the Mars 2020 Perseverance rover in Jezero crater
18th Aten Asteroid 367943 *Duende* closest approach to Earth (1.046 AU)
18th History: Mike Brown and Jean-Luc Margot's discovery of *Romulus*, the larger of two moon that orbit Asteroid 87 *Sylvia* (2001)
18th History: American astronomer Clyde Tombaugh discovers Pluto (1930)
19th First Quarter Moon
19th Apollo Asteroid 161989 *Cacus* closest approach to Earth (0.723 AU)
19th Amor Asteroid 3102 *Krok* closest approach to Earth (2.131 AU)
19th History: Nicolas Copernicus born (1473)
20th Scheduled launch of a Cygnus cargo freighter to the International Space Station from Wallops Island, Virginia, on a Northrop Grumman Antares rocket
20th Flyby of Venus (4th) by the Parker Solar Probe, sending the spacecraft closer to the Sun
20th History: Clementine spacecraft enters lunar orbit and starts photographic survey; joint project between the Strategic Defense Initiative Organization and NASA, first of a new class of small spacecraft to enable long-duration, deep space missions at low cost using lightweight satellite technology (1994)
20th History: launch of the core module of the Soviet space station Mir (1986)
20th History: launch of Mercury-Atlas 6 and Friendship 7 with astronaut John Glenn; first American in orbit (1962)
21st History: launch of Israel's SpaceIL, privately-funded, lunar lander aboard a SpaceX Falcon 9 rocket from the Cape Canaveral Air Force Station, Florida
21st History: Soviet moon rocket (N-1) explodes during first test flight (1969)
22nd Atira Asteroid 418265 (2008 EA32) closest approach to Earth (0.925 AU)
22nd Apollo Asteroid 2102 *Tantalus* closest approach to Earth (1.872 AU)
22nd Kuiper Belt Object 55565 (2002 AW197) at Opposition (44.168 AU)
22nd History: launch of Viking, Sweden's first satellite (1986)
22nd History: launch of Soviet spacecraft Kosmos 110, with dogs Veterok and Ugolyok (1966)
22nd History: Max Wolf discovers asteroids 587 *Hypsipyle* and 588 *Achilles* – the first Trojan asteroid (1906)
23rd Aten Asteroid 2015 EQ near-Earth flyby (0.046 AU)
23rd Apollo Asteroid 2009 BD closest approach to Earth (0.923 AU)
23rd Kuiper Belt Object 308193 (2005 CB79) at Opposition (37.748 AU)
23rd Kuiper Belt Object 148209 (2000 CR105) at Opposition (62.173 AU)
23rd History: Supernova 1987A detected in the Large Magellanic Cloud (1987)
24th History: launch of the Space Shuttle Discovery (STS-133) on its final mission. The shuttle delivered space parts and critical components to the ISS (2011)
24th History: launch of Mariner 6; Mars flyby mission returned images showing the south polar cap as being composed predominantly of carbon dioxide; refined estimates of the mass, radius and shape of Mars (1969)
24th History: Jocelyn Bell announces discovery of rapidly rotating radio sources, later determined to emanate from neutron stars or pulsars (1968)
24th History: launch of Bumper WAC, first two-stage liquid-propellant rocket and the first human-made object to achieve hypersonic speeds (1949)
25th History: flyby of Mars by the Rosetta spacecraft (2007)
25th History: Soviet spacecraft Luna 20 returns lunar soil sample (30 grams) to Earth (1972)
26th History: launch of the first Saturn 1B rocket booster (1966)

Astronomical and Historical Events (continued)

27th Full Moon
27th Centaur Object 121725 *Aphidas* at Opposition (24.073 AU)
27th History: discovery of Jupiter's moon Herse was by Brett J. Gladman, John J. Kavelaars, Jean-Marc Petit, and Lynne Allen (2003)
28th History: original crew of Gemini 9, Elliot See and Charles Bassett killed in plane crash at the McDonnell Aircraft building in St. Louis (1966)
28th History: flyby of Jupiter by the New Horizons spacecraft bound for Pluto (2007)
28th History: launch of Discoverer 1; first of a series of satellites which were part of the Corona reconnaissance satellite program and first satellite launched into polar orbit (1959)

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

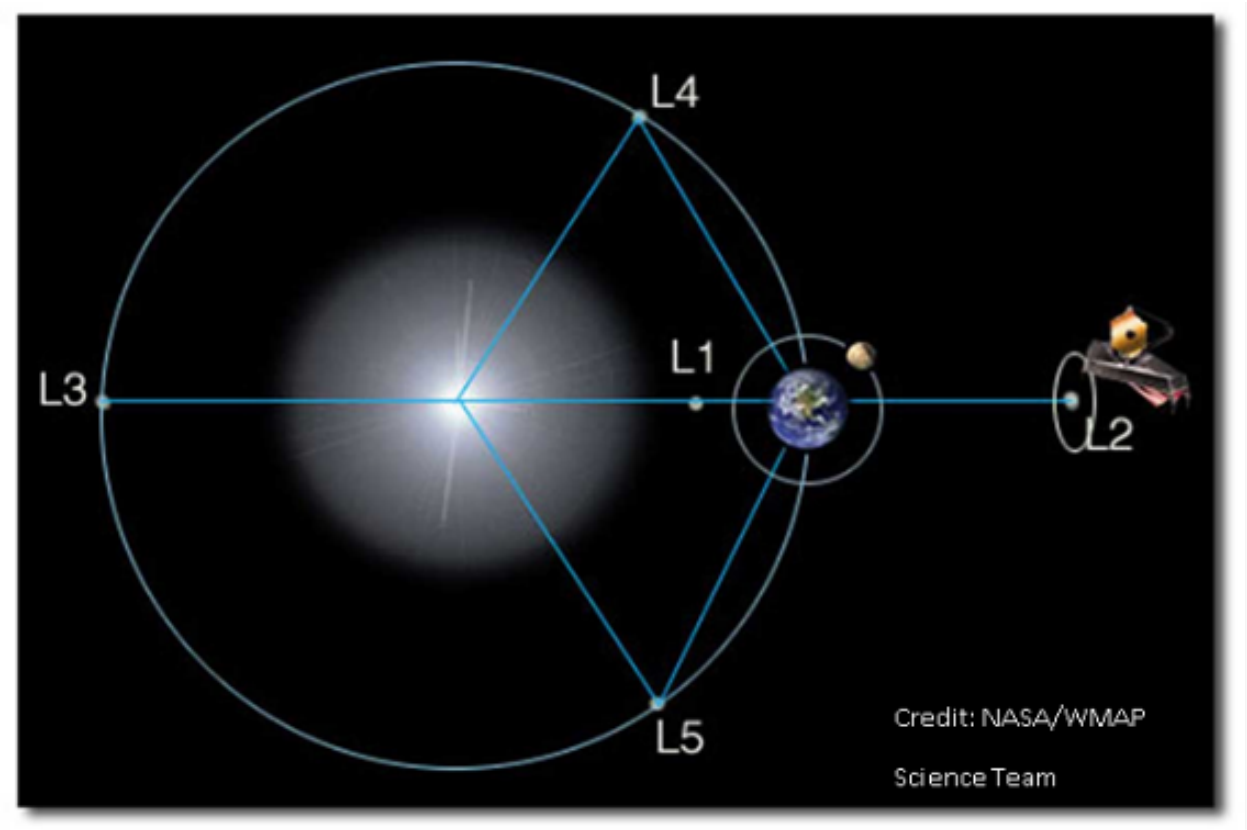
References on Distances

- 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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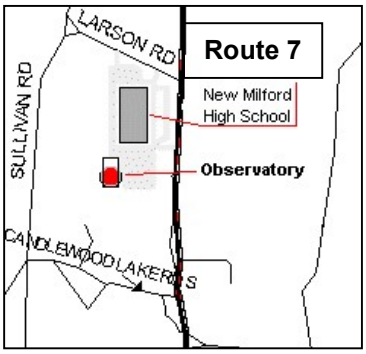

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