Galactic Observer

John J. McCarthy Observatory

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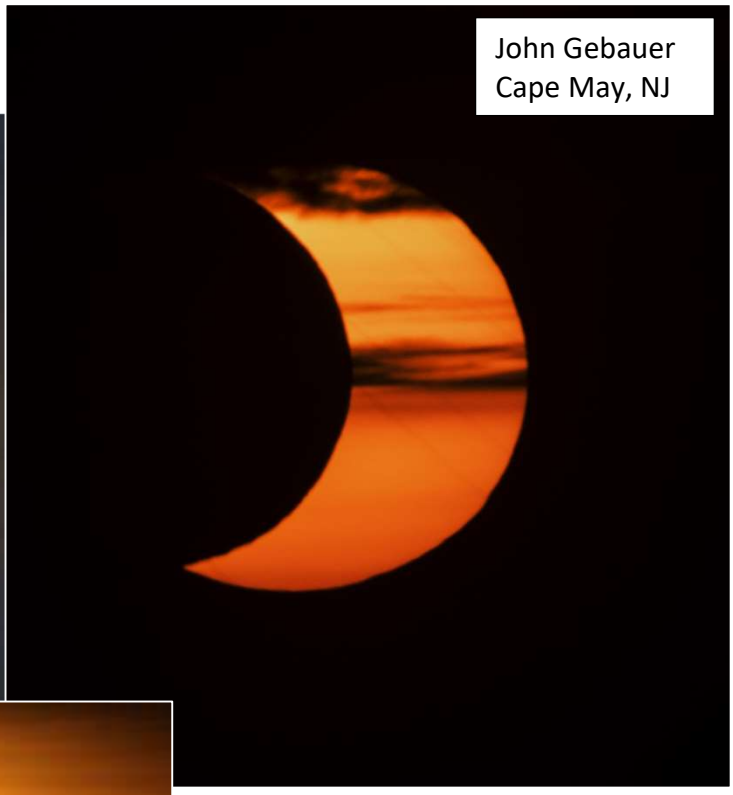
Hadley Rille

Apollo 15 astronaut and lunar module pilot Jim Irwin salutes the flag set up at the Hadley-Apennine landing site. The Lunar Module "Falcon" is in the center and the Lunar Roving Vehicle on the right. Mount Hadley Delta rises 11,500 ft (3.5 km) above the plain in the background.
Photo credit: NASA/David Scott

July and August Astronomy Calendar and Space Exploration Almanac

10 June Eclipse Gallery

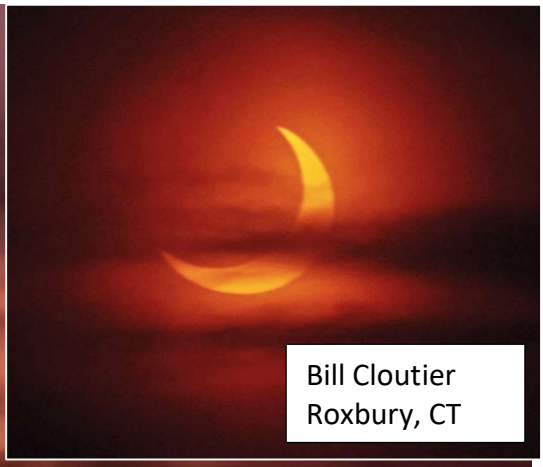
Joe Privitera
Bantam, CT



John Gebauer
Cape May, NJ

Jim Wood
Woodbury, CT

Images from the staff of the
McCarthy Observatory



Bill Cloutier
Roxbury, CT

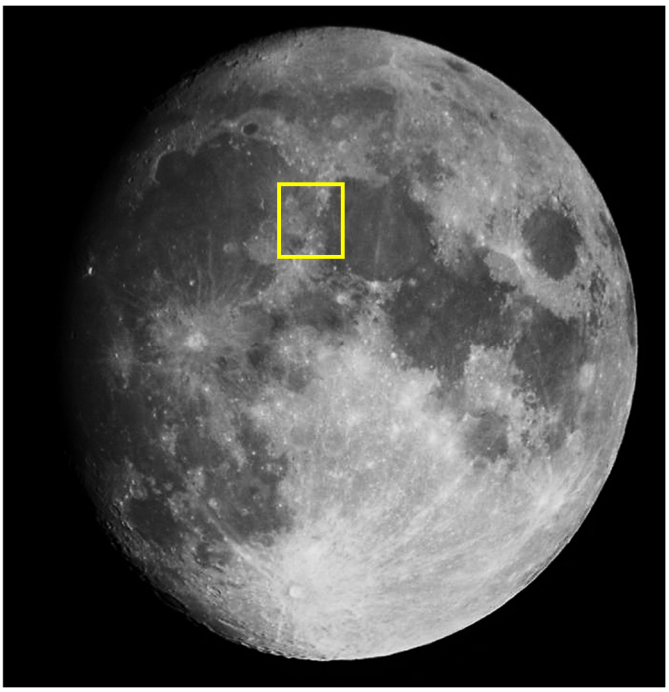
Marc Polansky
Woodbury, CT

In This Issue

"Out the Window on Your Left"

It's been 52 years since Neil Armstrong first stepped onto the moon's surface and almost 49 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).

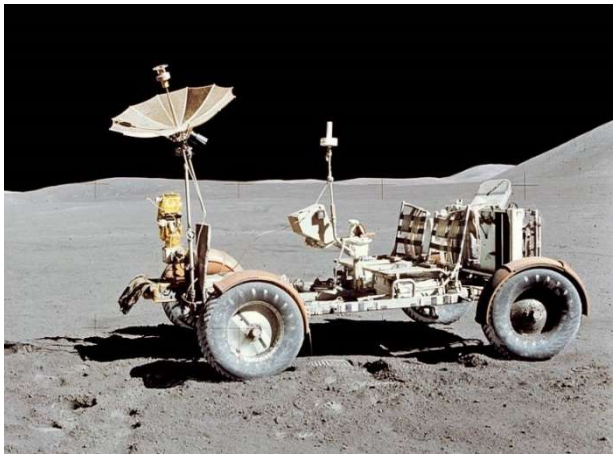
The lunar Apennine mountains cast long shadows across the Moon's ancient lava plains in this month's image. The mountain range was formed as a result of the impact that created the Imbrium basin 3.85 billion years ago and form the rim crest.



Location of the Apollo 15 Hadley-Apennine landing site on the eastern rim of the Imbrium impact basin

Apollo 15 landed just north of the massif Mons Hadley Delta in the northern segment of the Apennine range and east of a dark lava patch called Palus Putredinus (Marsh of Decay). The landing site was also adjacent to Hadley Rille, a "young" sinuous rille (lava-carved channel).

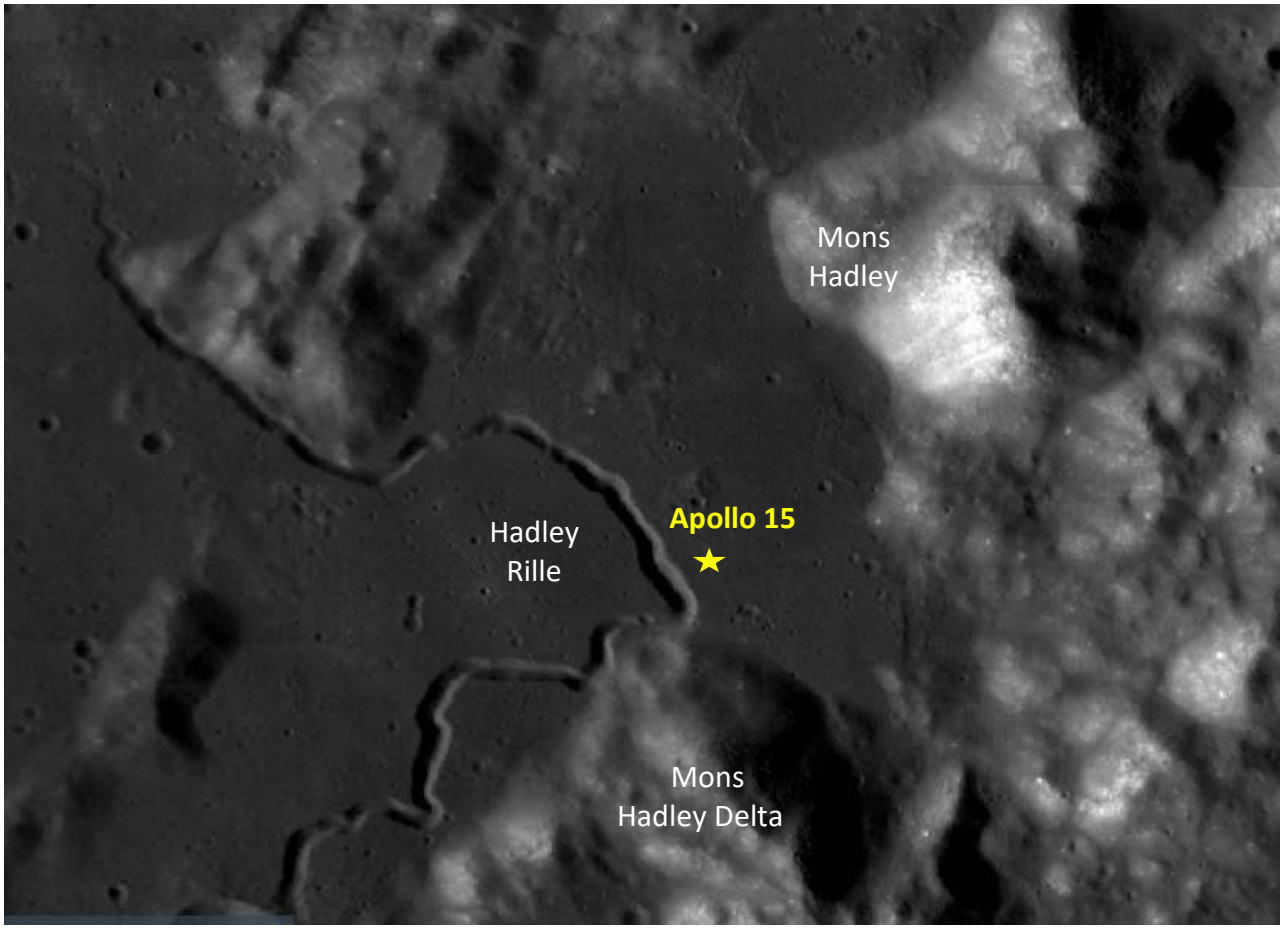
The site was selected with two main geology objectives – search for samples of the Moon's original crust (in the form of anorthosites) and investigate the nearby rille. Over the 18 hours and 37 minutes working on the lunar surface, astronauts Scott and Irwin were able to collect 370 individual rock and soil samples, as well as a deep drill core. During the second EVA, Scott found a piece of anorthosite (dubbed the "Genesis Rock") along the rim of Spur crater. The sample was later determined to be about 4 billion years old. Traces of water have been detected within the rock's crystalline structure, raising questions as to its origin.

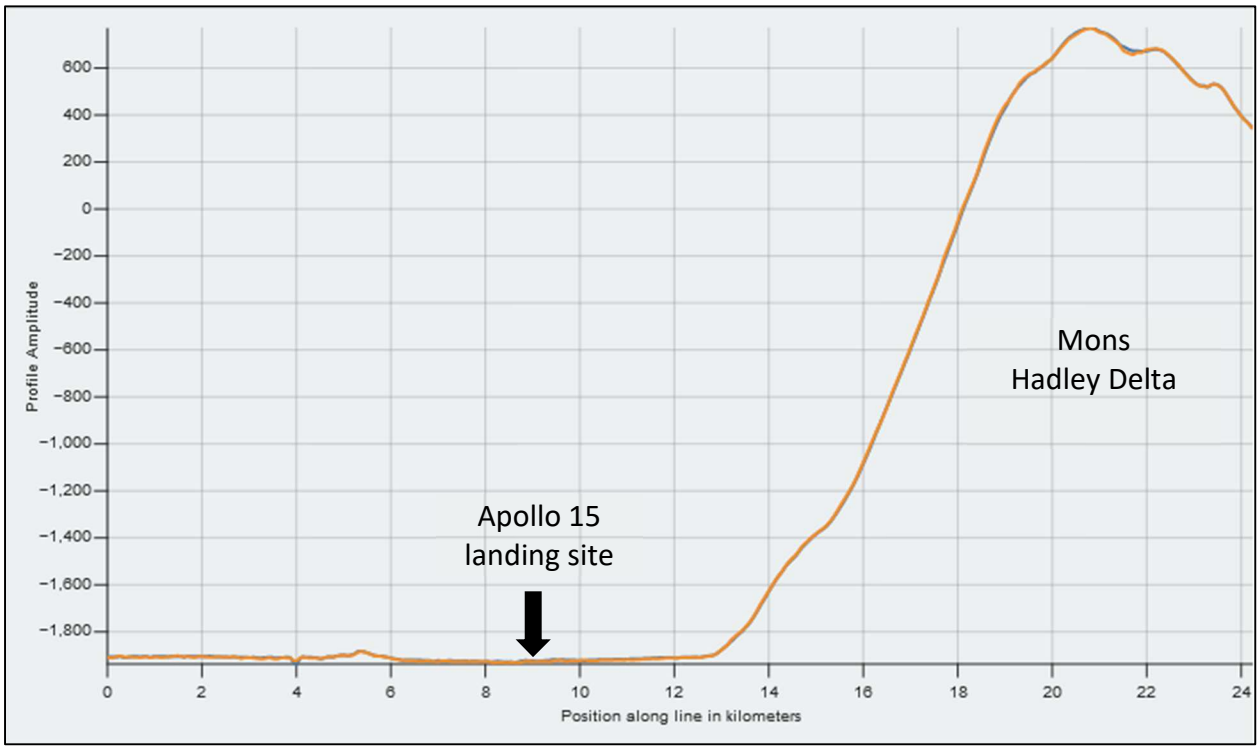


Lunar Roving Vehicle
NASA Photo

The addition of a lunar roving vehicle allowed the astronauts to extend the range of their exploration - driving a total of 17 miles (28 km) during their sojourn.

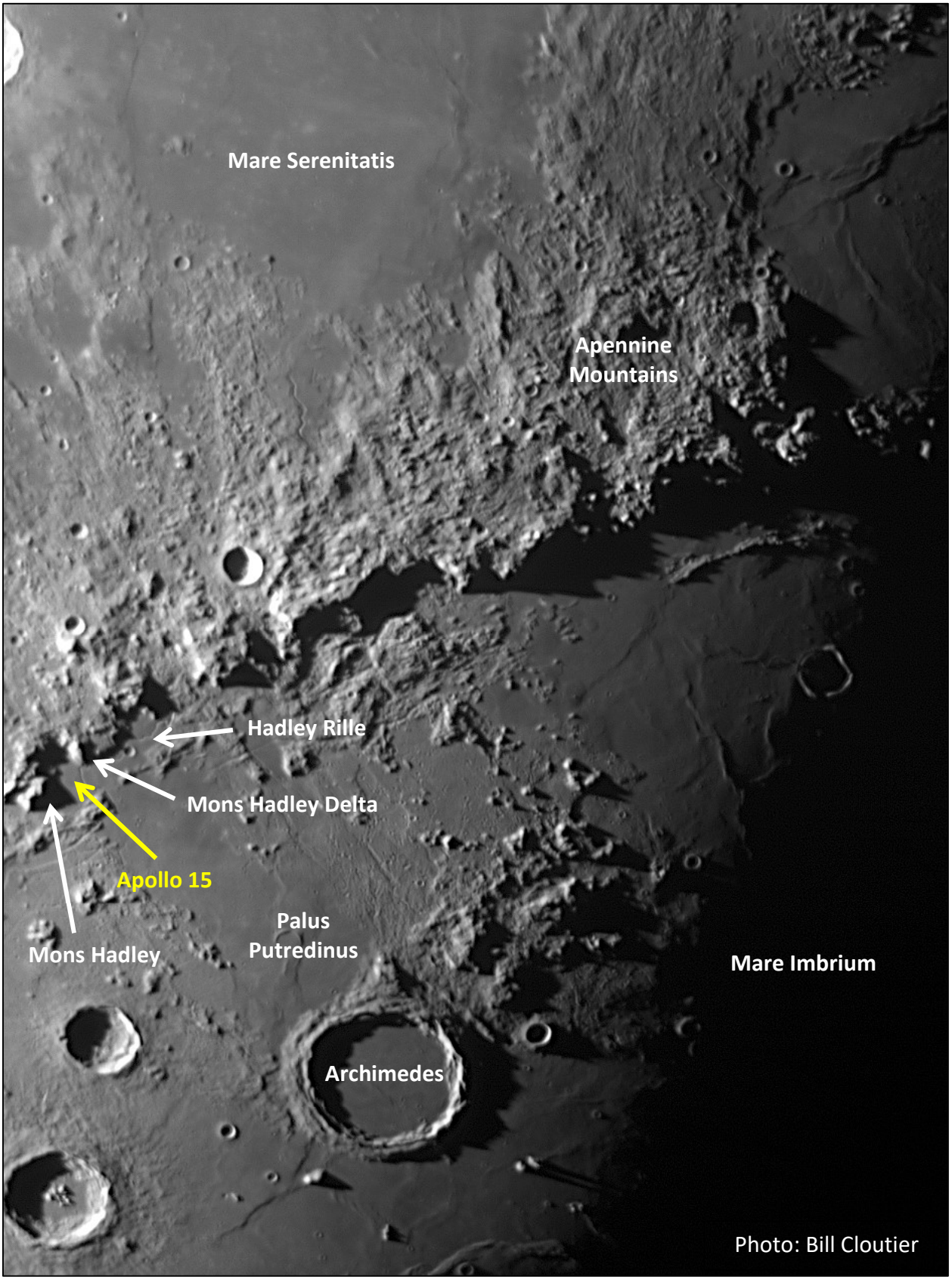
Before heading for home, the crew placed the Particles and Fields satellite into lunar orbit - designed to investigate the moon's mass and the disparities in its gravitational field.





Lunar QuickMap: https://quickmap.lroc.asu.edu

Hadley-Apennine Landing Site



Partial Solar Eclipse

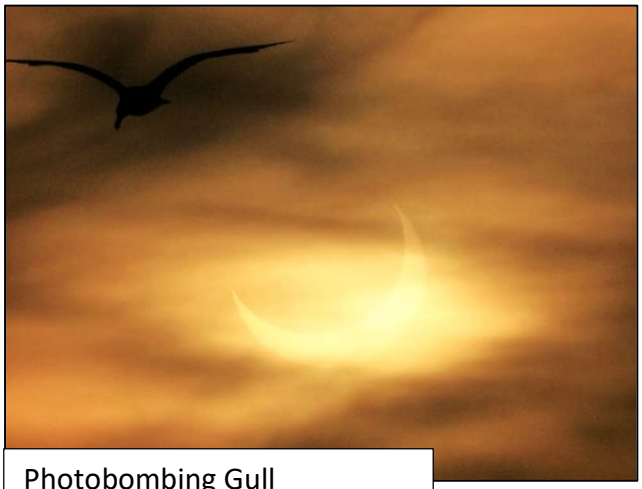
On June 10, residents in parts of Russia, Greenland, and northern Canada were able to experience an annular eclipse of the Sun (when the Moon moves in front of the Sun, but due to its furthest distance from Earth, does not block the entire solar disk, resulting in a ring of fire encircling the lunar disk). In Northern Asia, Europe, and parts of the United States, the eclipse was partial.

Sunrise from Roxbury, CT
Bill Cloutier

In the Danbury area, the eclipse was underway before sunrise and clouds along the eastern horizon added to the challenge of seeing the thin crescent of light. Maximum eclipse, when the Moon was closest to the center of the Sun, occurred around 5:33 am. At that time, the Moon was less than 2° above the horizon and the lunar disk obscured about 73% of the solar disk.

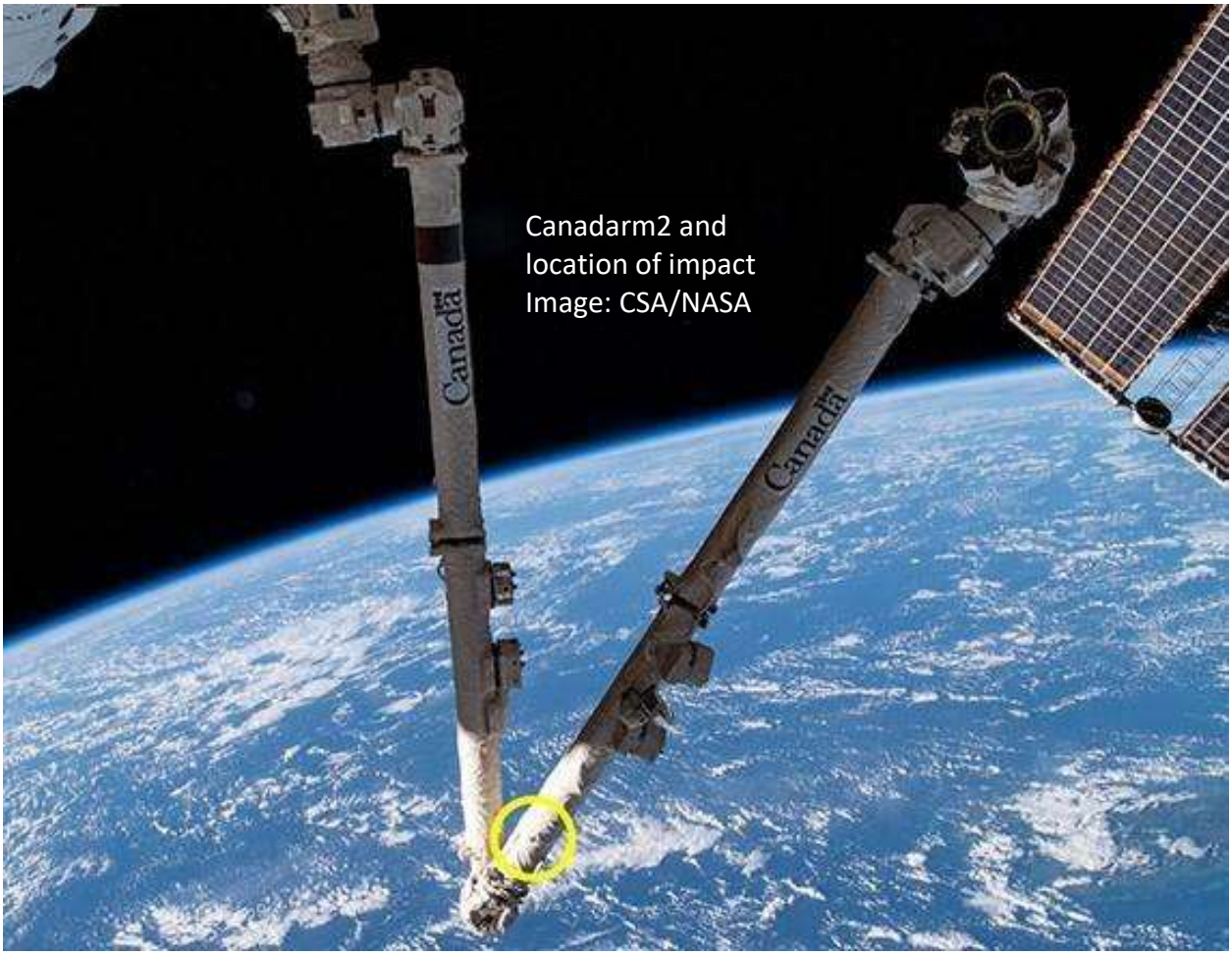
Initially, the clouds provided a natural filter, but as the Sun gained altitude and the Moon started to move away from the Sun, a photographic filter was required. The eclipse ended around 6:30 am when the Moon was clear of the solar disk.

Another annular eclipse will be visible from the western United States in October 2023 with the shadow's path starting on the coast of Oregon and traveling down through Texas. It will be followed by a total solar eclipse on April 8, 2024, which will be visible along a narrow corridor from Texas to Maine.



Photobombing Gull
Cecilia Detrich, Nahant, MA

Space Debris and Impact Hazards



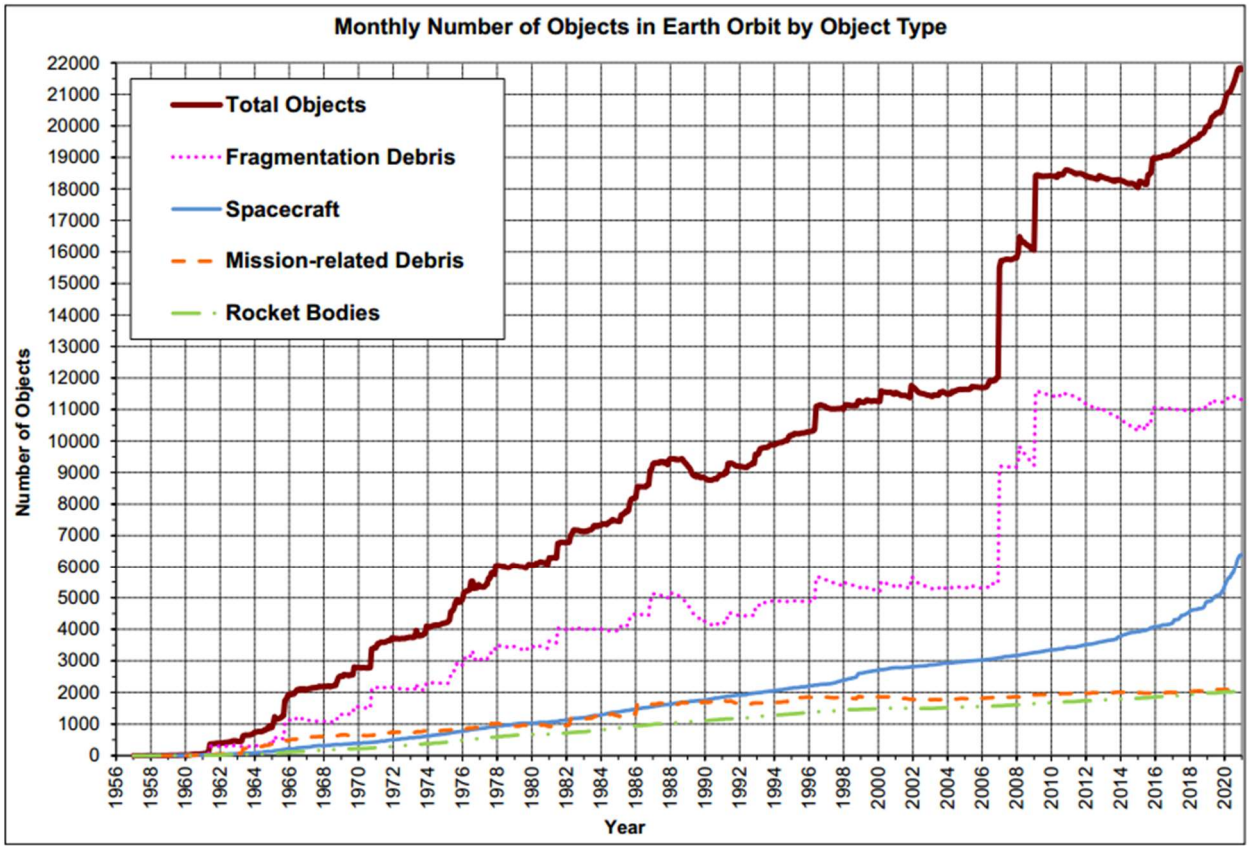
It is estimated that the debris orbiting the Earth exceeds 8,000 metric tons – including more than 23,000 objects larger than 4 inches (10 cm) and approximately 500,000 between the size of .4 and 4 inches (1 and 10 cm) in diameter. Particles greater than 1 millimeter number more than 100 million and are too small to track with ground-based radars. Despite their small size, these objects pose an extreme hazard when moving at collision speeds which average 10 kps or 22,000 mph. The International Space Station (ISS) has conducted 26 debris avoidance maneuvers since 1999 (3 in 2020), typically using the engines of a docked spacecraft to change the station's orbit.

In early May, a routine inspection found that the thermal blanket on the ISS's Canadarm 2 had been punctured. NASA and the Canadian Space Agency have since determined that the damage to the multi-jointed titanium robotic arm will not affect its performance.

Man-made orbital debris can come from a variety of sources – spent rocket stages, deactivated satellites, collisions, explosions of old rocket motors, effluent from solid rocket motors, and flecks of paint, insulation, and other material released in the deployment of payloads.

There are 24 Battery Charge-Discharge Units (BCDUs) on the ISS, operating as part of the station's electrical system. The BCDUs are located at the base of each of the solar arrays and are housed in aluminum enclosures, covered with a layer of betacloth (a type of fireproof silica fiber cloth similar to fiberglass). In 2019, two BCDUs failed and were replaced during an extravehicular activity. The failures were not related to any impact, but since the units were being returned to Earth for repair, they were also inspected for any damage on their exterior surfaces from meteorites or man-made orbital debris. One unit (SN 16) had been in service for almost 13 years and the other (SN 11) for almost 19 years.

The inspections recorded a total of 63 impacts on the enclosure for SN16, with none penetrating the aluminum face sheet. A total of 31 impacts were record for SN11, with two perforating the enclosure cover. The average size of the impact features were .38 mm and .64 mm, for SN16 and SN11, respectively.



Monthly number of tracked objects in Earth orbit as of 5 January 2021, as cataloged by the U.S. Space Surveillance Network.
Source: Orbital Debris, A publication of the NASA Orbital Debris Program Office, Volume 25, Issue 1, February 2021

Return to Venus

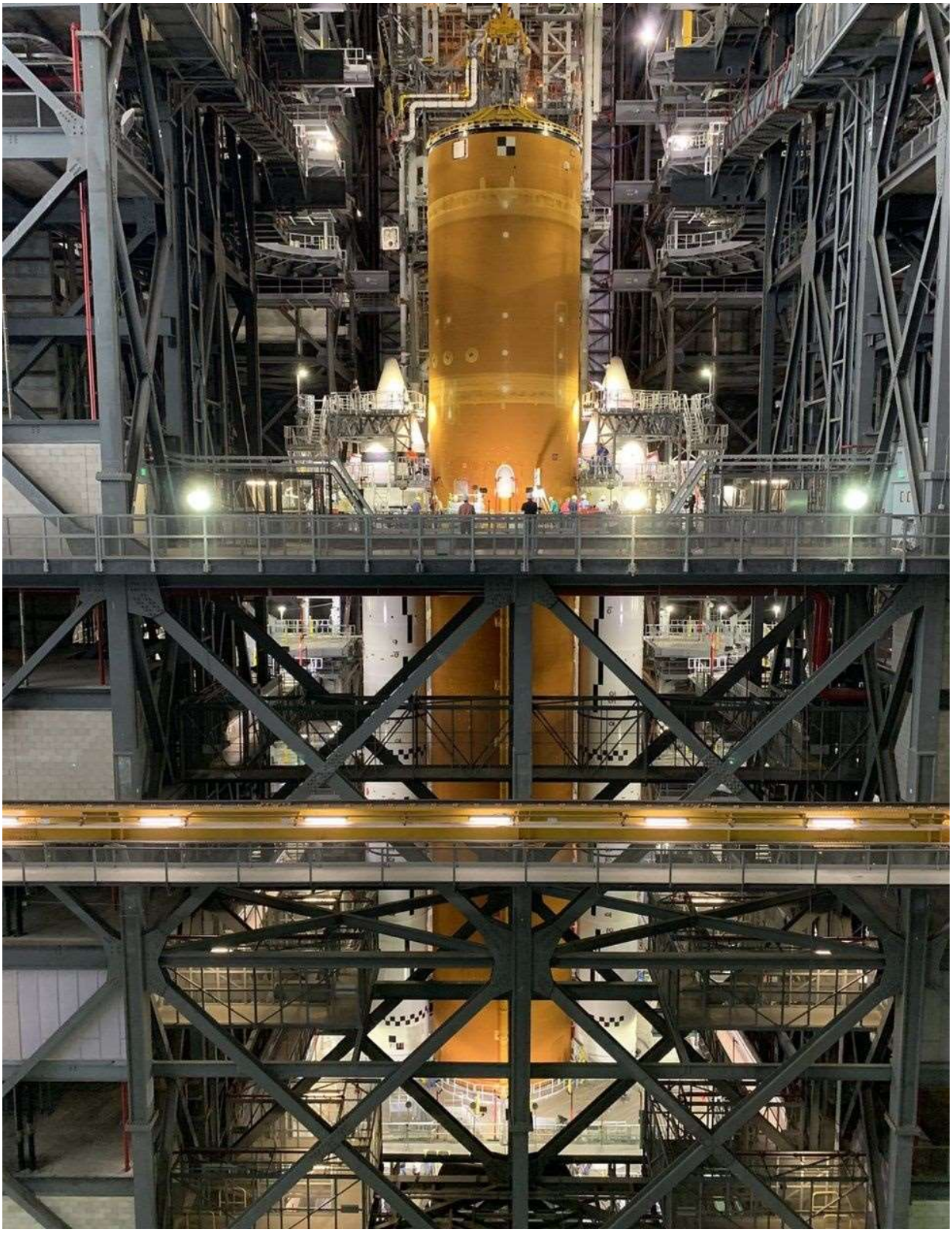
Composite of image data from NASA's Magellan spacecraft and Pioneer Venus Orbiter
Credits: NASA/JPL-Caltech

After more than 30 years, NASA is returning to Venus (the Magellan spacecraft visited Venus in August 1990 for a four-year mission). The agency has selected two new missions that will target Earth's sister planet as part of the agency's Discovery Program. Based on their potential scientific value and the feasibility of their plans, NASA is awarding approximately $500 million, per mission, for development of DAVINCI+ (Deep Atmosphere Venus Investigation of Noble gases, Chemistry, and Imaging) and VERITAS (Venus Emissivity, Radio Science, InSAR, Topography, and Spectroscopy). The missions are expected to launch in the 2028-2030 timeframe.

The DAVINCI+ mission will deliver a "chemistry" probe to the Venusian atmosphere via a flyby-orbiter. During its 63-minute descent through the planet's thick atmosphere, the spherical probe will analyze the gases that compose each layer. Scientists expect that the information returned will shed some light on why Venus evolved so differently than either Earth or Mars. The mission may also provide insight on whether there was an early ocean on Venus, and the rate of volcanic eruptions – past and/or present. DAVINCI+'s Venus Mass Spectrometer and the Venus Tunable Laser Spectrometer will be also able to detect phosphine – a trace gas whose presence has puzzled scientists and created speculation as to whether there's a biologic source.

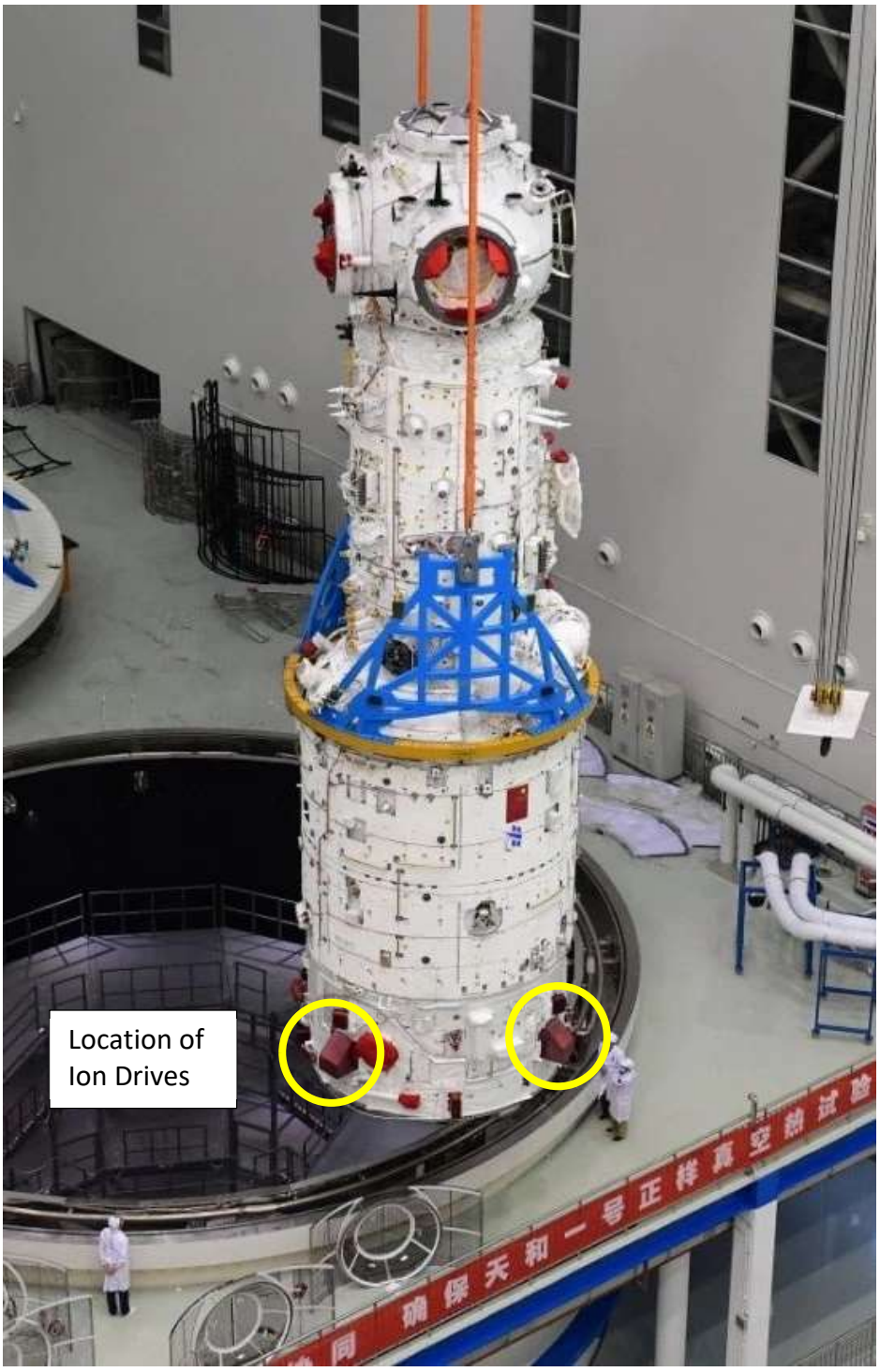
VERITAS will map the surface of Venus with a synthetic aperture radar. Mapping the topography in 3D, the high-resolution images will be used to explore the planet's unusual crustal structures (akin to plate tectonics on Earth) and volcanism. VERITAS will also be searching for water vapor emissions (from active volcanoes). Accompanying the orbiter, will be a technology demonstration in the form of a nanosat. Called "Cupid's Arrow," the nanosat is equipped with mass spectrometer sensitive enough to determine atmospheric noble gas abundances and isotope ratios.

First Space Launch System (SLS) Rocket Stacked



The 212-foot-tall (65 meter) core stage of the SLS seen lowered between two solid rocket boosters for the Artemis-1 launch later this year Credit: NASA

Ion Power



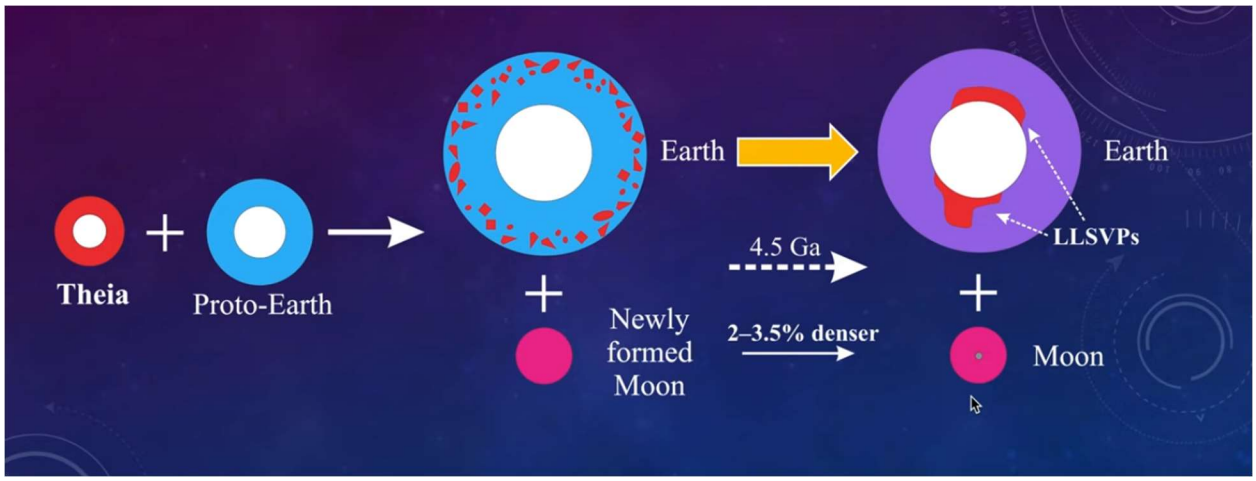
Tianhe space station module undergoing testing prior to launch
Credit: China Aerospace Science and Technology

On April 29, China launched the core component of its new space station. The 49,800-pound (22,600-kg) Tianhe module is 54 feet (16.6 meters) long with a width of 14 feet (4.2 meters). The module includes a propulsion unit, living quarters for up to three crew, a non-habitable service section, and a docking hub. It is also equipped with a robotic arm for the relocation and the installation of future modules.

The Tianhe module has four ion drives which can be used to modify the station's orbit (to counter the effects of atmospheric drag). The highly-efficient Hall effect thrusters are powered by two steerable solar power arrays. Thrust is produced by driving ionized propellant, for example, inert xenon or krypton gas, with an electric field to velocities of 20,000 meters per second (almost 45,000 mph).

China is looking to develop ion propulsion technology for its deep space missions. The technology holds the promise of saving months of travel time to places like Mars. Shorter transit times are critical for human space travel and to mitigate its adverse effects on the human body.

Hiding In Plain Sight



Graphic from Qian Yuan 2021 LPSC talk titled: "A Giant Impact Origin of the Large Low Shear Velocity Provinces"

The currently accepted theory on the formation of the Moon is based upon an impact of a young Earth by a protoplanet called Theia some 4.5 billion years ago. While the moon rocks returned by the Apollo astronauts largely support the violent birth scenario, no sign of the impactor remains. At this year's Lunar and Planetary Science Conference, Qian Yuan, a doctoral student in geodynamics at Arizona State University, offered a compelling hypothesis that brings together the latest work characterizing Theia and anomalies found deep within the Earth to create a case for remnants of a protoplanet hiding inside our planet.

The puzzle pieces include:

- Small samples of igneous rocks from the Apollo 15 landing site have exceptionally low deuterium/hydrogen (D/H) ratios, suggesting that the lunar mantle may contain materials from a planetary body large enough to trap gas from the solar nebula (which has a very low D/H ratio).
- Earth's mantle isn't completely uniform. There are two continent-size anomalies near the core-mantle boundary, called Large Low-Shear-Velocity Provinces, beneath the African continent and the Pacific Ocean, that are comprised of a denser rock (between 1.5 and 3.5% more dense than the rest of Earth's mantle), compositionally different and hotter (based upon the analysis of seismic waves traveling through the material).
- Plumes of magma from some Icelandic and Samoan volcanoes date back to a time when the Moon formed (within the first 100 million years of Earth history) and have been determined to have come from the anomalies.

Yuan's hypothesizes that the anomalies could be remnants of the impactor if Theia was closer to the size of the proto-Earth (rather than Mars), very dry (lacking deuterium), and having a dense, iron-rich mantle. In his scenario, Theia's iron-rich core would have mixed with Earth's but its denser mantle would have allowed some fragments to survive intact - coming to rest at the base of Earth's mantle and forming the two anomalies. The lighter material from Theia would have been cast into space, accreting to form the Moon.

Russian Nuclear Space Tug?

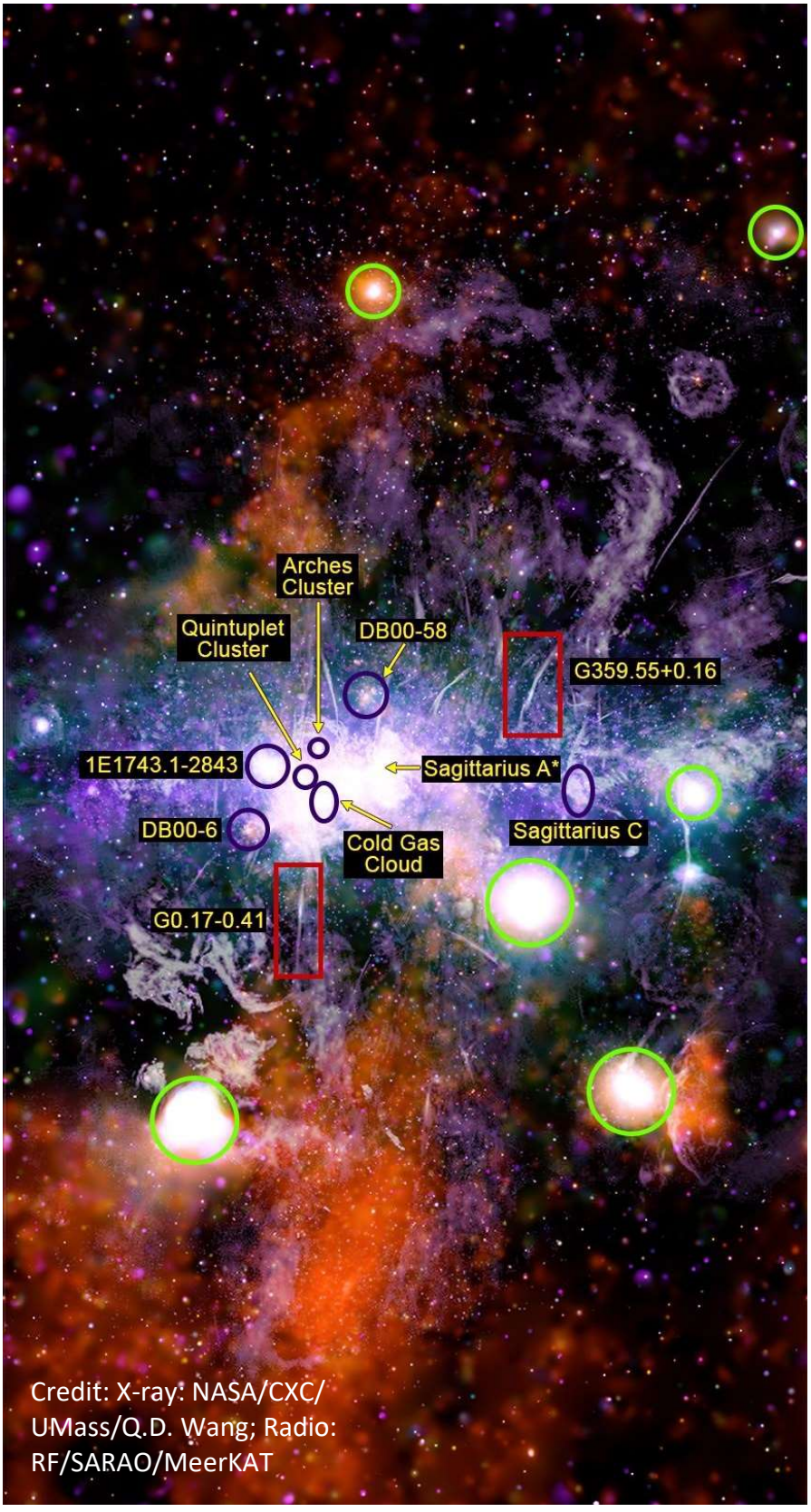
According to TASS, Russia's leading news agency, Roscosmos, Russia's space corporation, has signed a contract with the Arsenal design bureau for the development of a nuclear-powered space tug – with a delivery date in 2024. The first flight of the space tug, called Nuklon, is tentatively scheduled for 2030, with a mission that will include flybys of the Moon, Venus, and then, with a gravity assist, Jupiter. The 20 or 30-ton vehicle would likely be launched on Russia's new heavy-lift Angara-5 rocket from the Vostochny Cosmodrome in Siberia.

The project is officially known as the Transport and Energy Module or TEM. The nuclear electric spacecraft is designed around a gas-cooled, high temperature reactor and a cluster of ion engines. Reactor heat is converted into electrical power through a mechanical turbine or a thermal emission system. Excessive heat is released into space with a system of radiators. The 500-kilowatt nuclear reactor is designed to last 10 to 12 years and would be activated only after achieving a safe orbit (400 to 500 miles or 600 or 800 km from Earth). Power, until the ideal orbit is attained, would be supplied by solar panels attached to the propulsion module. The design concept places the reactor on a telescopic boom, away from the main vehicle, and includes a cone-shaped shield that protects Nuklon's systems from radiation.

In theory, the space tug would head to the Moon, dropping off a scientific payload, before heading to Venus. The encounter with Venus provides an opportunity to deliver another payload, as well as for a gravity assist that will accelerate the tug on its journey to Jupiter and, possibly, one of its moons. The entire mission is expected to last 50 months.

Unfortunately, Russia's track record for hardware development and meeting schedules is extremely poor. Its Nauka or Multipurpose Laboratory Module, tentatively scheduled to join the International Space Station in July 2021, was originally planned to launch in 2007.

Milky Way Galaxy in X-rays



In visible light, the center of the Milky Way Galaxy is hidden by clouds of dust and gas. However, at X-ray wavelengths, a much clearer picture emerges.

The latest panorama of our galaxy's inner core region was assembled by stitching together 370 separate observations from the Chandra X-Ray Observatory and radio data from the MeerKAT radio telescope in South Africa.

The Chandra image glows with color representing the different bands of X-ray energies. It builds upon previous images and expands the view to regions both above and below the galactic plane.

Individual X-ray sources are circled in green, and purple. Threads of superheated gas are bounded with red rectangles. Radio data is represented by gray and lilac colors.

Sagittarius A* is the high-energy source emanating from the supermassive black hole at the galaxy's center, located about 25,800 light-years from Earth. Galactic center is in the direction of the constellation Sagittarius in Earth's sky.

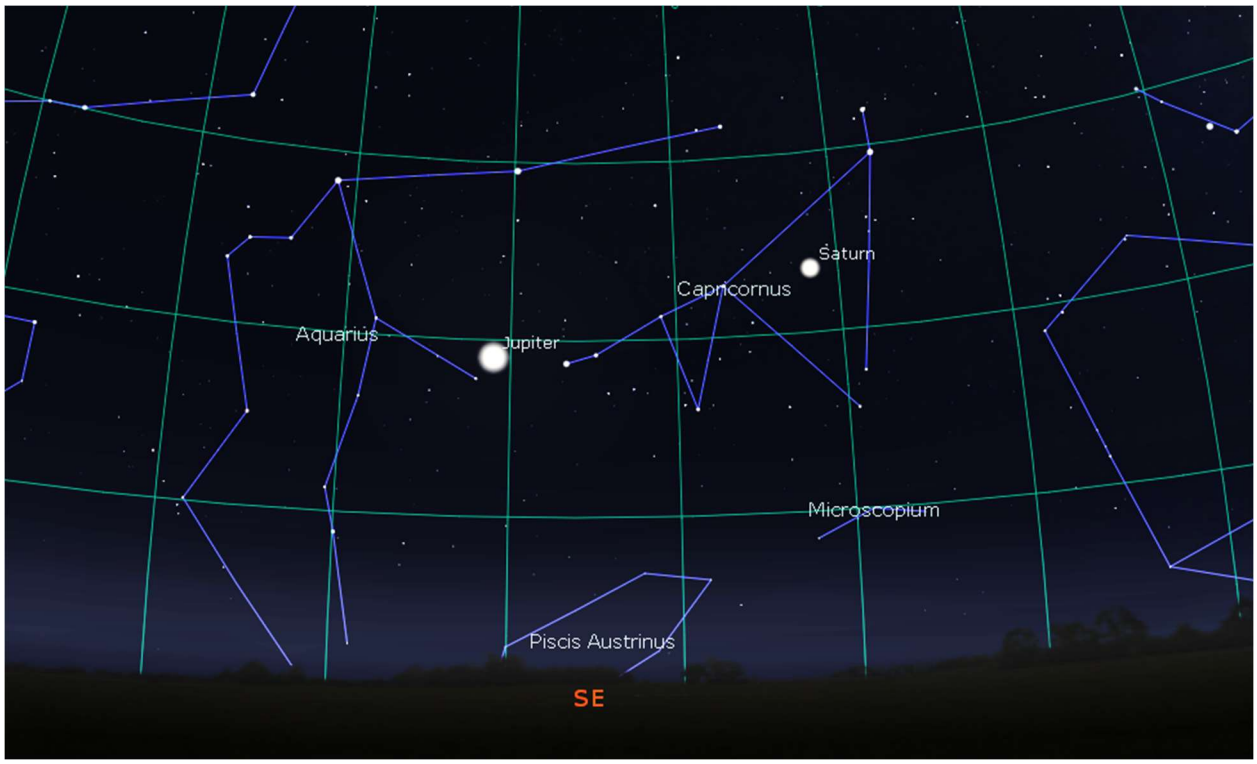
Saturn and Jupiter at Opposition

The solar system's gas giants, Saturn and Jupiter, reappear in the evening sky in July, rising about two and three hours, respectively, after sunset on the 1st and almost four hours earlier by the end of August (and before sunset). Transit times are provided for when the gas giants are at their highest in the southern sky. During the summer months, Saturn can be found in the constellation Capricornus and Jupiter in Aquarius.

	Rise and Transit Times (EDT)					
	July 1		August 1		August 31	
Planet	Rise	Transit	Rise	Transit	Rise	Transit
Saturn	10:21 pm	3:14 am	8:13 pm	1:03 am	6:05 pm	10:57 pm
Jupiter	11:14 pm	4:31 am	9:07 pm	2:20 am	6:56 pm	12:07 am

Saturn and Jupiter will reach Opposition in August when they lie directly opposite the Sun (on August 2 and August 19, respectively). On August 2, the ringed-planet will be 831 million miles (1,337 million km) from Earth or about 74 light minutes (time for light to travel from Saturn to Earth). Saturn's north pole will be tilted towards the Earth and its rings inclined at an angle of 18° to our line of sight (less than their maximum inclination in 2017, but still a nice presentation).

Jupiter comes to Opposition roughly every 13 months and this year will be about 17 times brighter than Saturn. On August 19, Jupiter will be 373 million miles (600 million km) from Earth or about 33 light minutes.



The evening sky on 15 August around 10 pm, with Jupiter and Saturn rising in the southeast

Graphics: Stellarium

Jovian Moon Transits

On nights of good visibility, the shadow(s) of Jupiter's moon(s) can be seen on the cloud tops as they cross (transit) the planet's disk. Only events that start and/or end between 8 pm and midnight are included. A more complete listing can be found in Sky & Telescope's monthly magazine.

Date	Moon	Transit Begins	Transit Ends
July 3rd	Europa	7:51 pm	10:42 pm
July 4th	Io	9:26 pm	11:44 pm
July 10th	Europa	10:25 pm	1:16 am (11th)
July 11th	Io	11:20 pm	1:38 am (12th)
July 12th	Callisto	5:46 pm	10:30 pm
July 17th	Ganymede	6:38 pm	10:17 pm
July 20th	Io	7:43 pm	10:01 pm
July 24th	Ganymede	10:39 pm	1:18 am (25th)
July 27th	Io	9:37 pm	11:55 pm
August 3rd	Io	11:32 pm	1:50 am (4th)
August 4th	Europa	7:25 pm	10:16 pm
August 11th	Europa	10:00 pm	12:50 am (12th)
August 12th	Io	7:55 pm	10:14 pm
August 19th	Io	9:50 pm	12:09 am (20th)
August 26th	Io	11:45 pm	2:04 am (27th)
August 29th	Ganymede	6:43 pm	10:21 pm

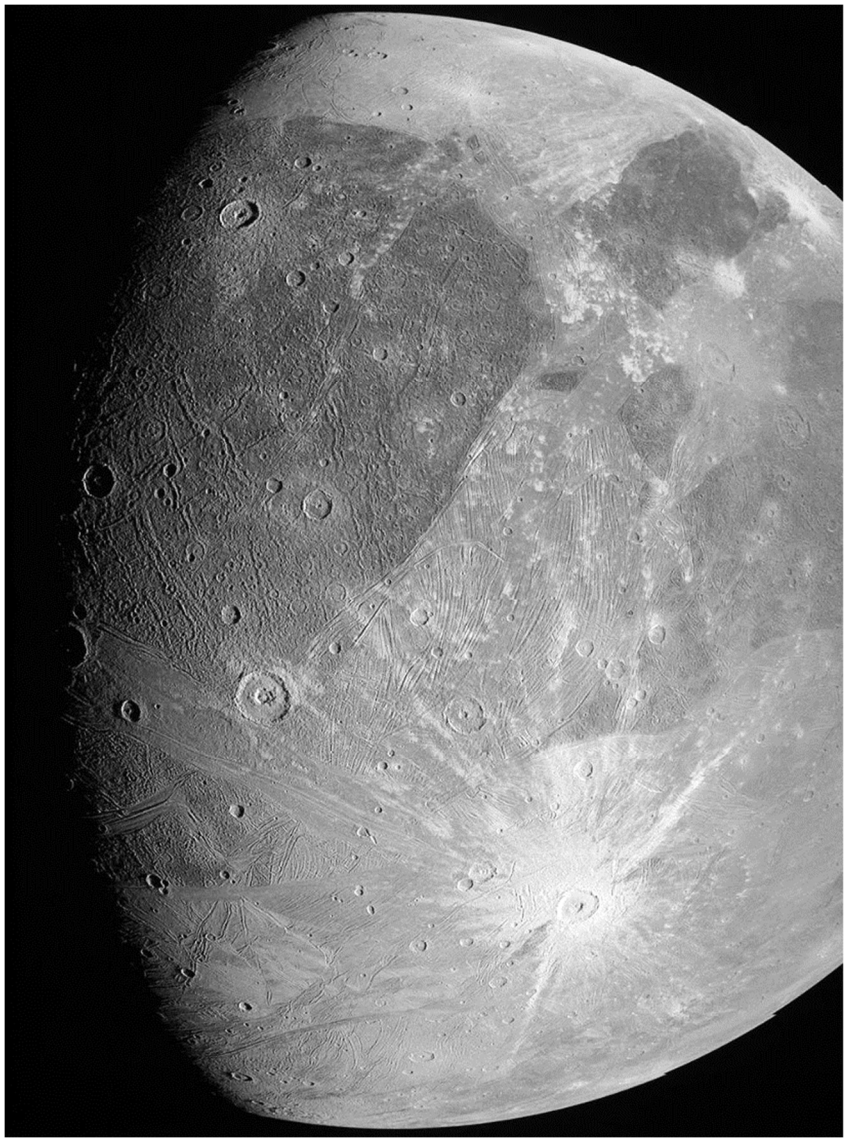
The Great Red Spot is a large, long-lived cyclone in the upper Jovian atmosphere. The Earth-size storm will cross the center line of the planetary disk on the following evenings during the hours between 8 pm to midnight local time.

Great Red Spot Transits

Date	Transit Time	Date	Transit Time
July 2nd	9:51 pm	July 31st	8:45 pm
July 4th	11:29 pm	August 2nd	10:24 pm
July 7th	8:59 pm	August 5th	12:01 am
July 9th	10:37 pm	August 7th	9:31 pm
July 12th	12:15 am	August 9th	11:09 pm
July 12th	8:06 pm	August 12th	8:38 pm
July 14th	9:44 pm	August 14th	10:16 pm
July 16th	11:22 pm	August 16th	11:54 pm
July 19th	8:51 pm	August 19th	9:23 pm
July 21st	10:29 pm	August 21st	11:01 pm
July 24th	12:07 am	August 24th	8:30 pm
July 26th	9:36 pm	August 26th	10:08 pm
July 28th	11:14 pm	August 28th	11:46 pm

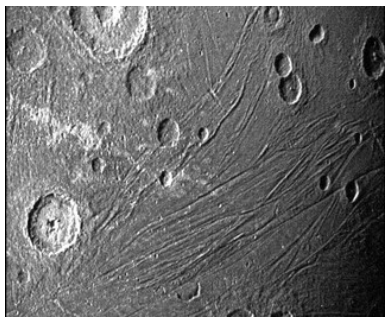
Ganymede by Juno

Not since May 2000 has a spacecraft flown so close to the solar system's largest moon, Ganymede. On June 7, the Galilean moon was visited by NASA's Juno spacecraft, coming within 645 miles (1,038 km) of its icy surface. Juno has been observing Jupiter since its arrival in July 2016, collecting data on the planet's atmosphere, including water content, temperature and cloud movements. It has also been mapping Jupiter's magnetic and gravity fields, providing scientists information on the planet's internal structure and contributing to our understanding of its evolution.



The point where Juno comes closest to Jupiter in its 53-day orbit (perijove) has migrated northward over time. The shifting orbit will carry the spacecraft past three of Jupiter's four largest moons: Ganymede, Europa and Io.

Juno's first encounter with Ganymede on June 7 reduced its orbital period to 43 days – setting up the spacecraft for a close flyby of Europa in September 2022. The Europa encounter will further reduce Juno's orbital period to 38 days. Flybys of Io in December 2023 and February 2024 will further decrease the spacecraft's orbital period to just 33 days.



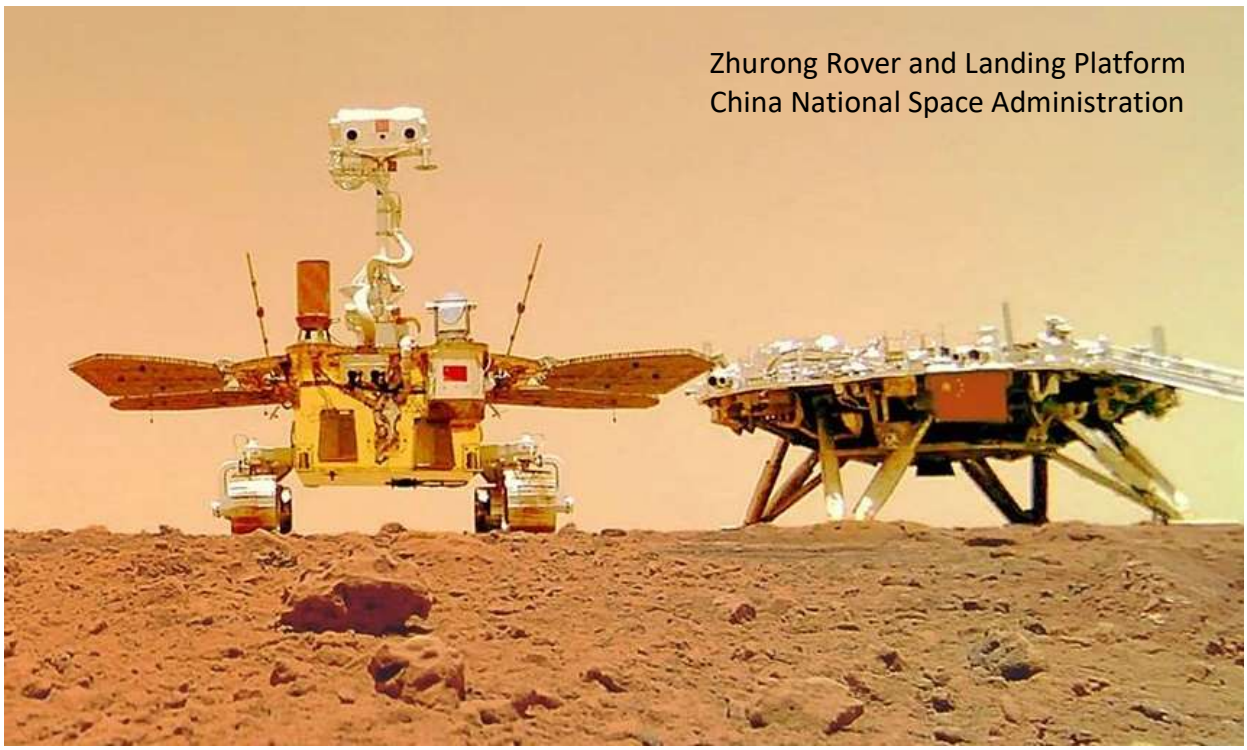
Credits: NASA/JPL-Caltech/SwRI

The image of Ganymede (left) was obtained by the JunoCam visible-light imager using its green filter (red and blue filter images are expected to be downloaded later for a full-color composite).

Juno's Stellar Reference Unit, a black-and-white navigation camera used to keep the spacecraft on course, was able to capture a view of Ganymede's unlit side (right), illuminated only by the reflected light of Jupiter.

Postcards from Utopia Planitia

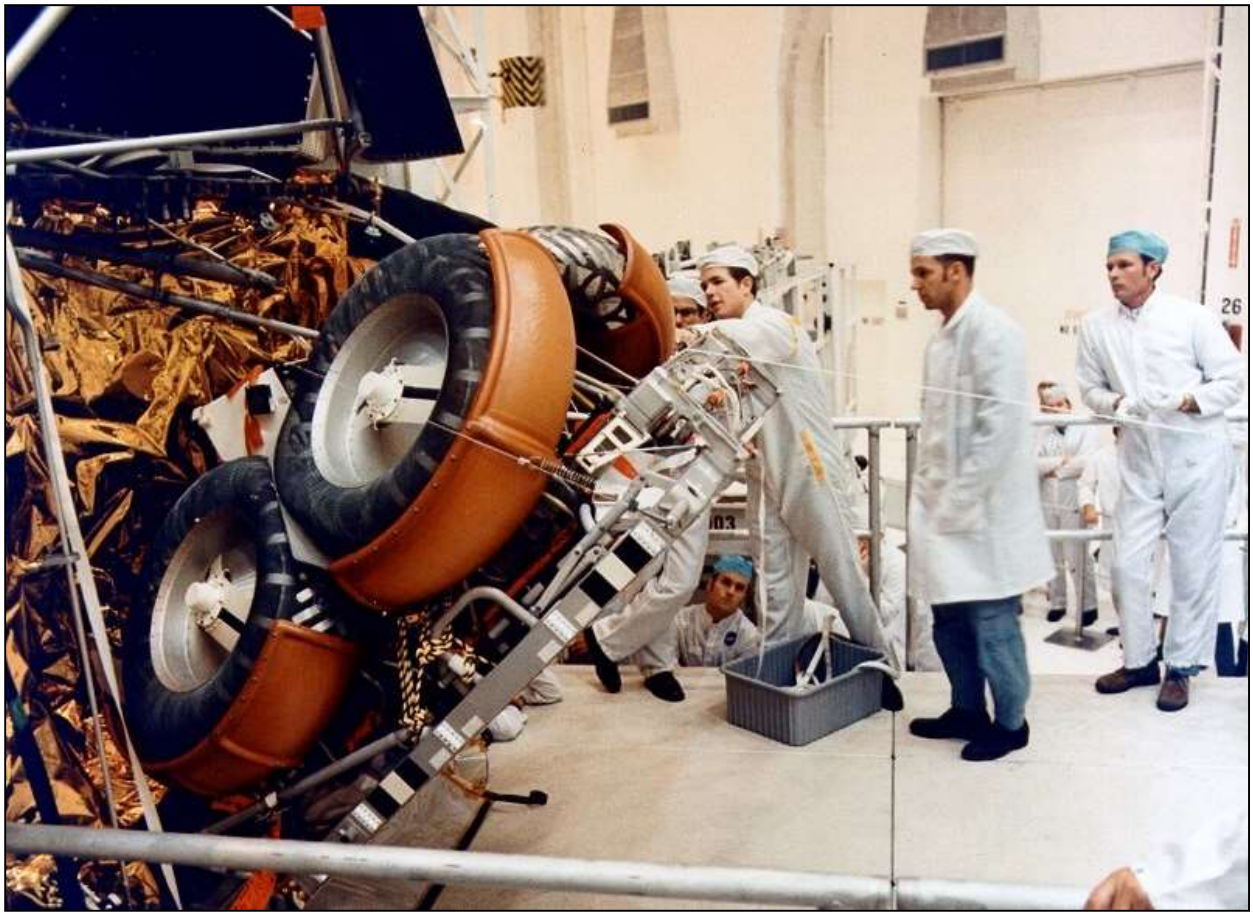
Images sent back by China's Zhurong rover include one of the rocket-powered landing platform, which delivered the six-wheeled rover to Utopia Planitia (above), and a selfie using a wireless camera positioned on the surface. The rover, with a design life of 90 Sols (Martian days), is exploring the ancient impact basin located in Mars' northern hemisphere, investigating the local mineralogy and looking for sub-surface water ice with its ground-penetrating radar. The 530-pound (240-kg) Zhurong is similar in appearance to NASA's solar-powered, robotic geologists Spirit and Opportunity that explored Mar between 2004 and 2018.



First Wheeled Vehicle on Moon

Fifty years ago, astronaut David Scott became the first person to drive a vehicle on the Moon. The Commander of the Apollo 15 mission used an electric powered vehicle that had been specifically designed and built (by Boeing and Delco) to operate in lunar conditions (lower gravity, vacuum, and on loose, fragmented regolith). The Apollo 15 Lunar Roving Vehicle (LRV) was the first of three rovers driven on the Moon. It covered a total of 17 miles (28 km) in three separate excursions, carrying the astronauts up to 3 miles (5 km) from the landing site.

The LRV's chassis was constructed from aluminum alloy tubing and was hinged so that it could be folded for storage on the outside of the Lunar Module. Its four wire wheels were constructed of woven steel strands and titanium chevrons for traction. Each wheel was equipped with its own electric motor for a top speed of approximately 8 miles per hour (13 km/hr). The LRV was designed to carry the two astronauts and their life support systems, communications and scientific equipment, photographic gear and up to 60 pounds (27 kg) of lunar samples as they explored their surroundings. However, NASA restricted the rover's range to the distance the astronauts could walk back to the Lunar Module in the event of an emergency.



Astronaut David Scott (center) watches as technicians fit check the folded Lunar Rover Vehicle in an exterior bay of the Lunar Module. The rover was deployed by the astronauts once on the Moon's surface using a system of pulleys, ropes and cloth tapes.

Photo Credit: NASA

Space Shuttle Legacy

The dramatic success of the Apollo program was also responsible for its demise. Once Kennedy's challenge had been met and the Soviet Union bested, Congress quickly lost interest in funding NASA's ambitious and expansive exploration programs, including an expedition to Mars, development of a nuclear rocket, construction of a space station and deep space bases, and a space shuttle to service orbiting facilities.

Less than six months after Neil Armstrong had stepped onto the Moon, NASA began to cancel future missions due to draconian budget cuts. Apollo 20 was cancelled in January 1970, followed by two additional cancelations by the following September. One by one, cancelation of the other programs followed.

If not for the political support of the Air Force, the shuttle would have met the same fate. The Air Force, after having several of its own space programs canceled in the 1960s, including Dyna-Soar and the Manned Orbiting Laboratory, was interested in a low-cost means of launching reconnaissance satellites and military hardware. Air Force support on Capitol Hill, however, did not come without a cost. The price of their support was the redesign of the shuttle from a straight wing to a delta wing for greater cross-range capability (for example, to execute a one-orbit mission from Vandenberg Air Force Base, polar orbit and short-duration capture missions (capturing Soviet satellites in flight)). The change in flight profile and wing configuration would significantly increase the reentry temperature - and therefore the demands on the shuttle's thermal protection system - which would one day have disastrous consequences.

The space shuttle that flew was a compromise, designed to meet Air Force requirements and the Office of Management and Budget's constraints. It was likely a much different (and more expensive) vehicle than if NASA had been allowed to pursue its fully reusable, potential hot-metal, straight-wing, initial design.

The space shuttle (or orbiter) is only one component of the Space Transportation System (STS). The three main engines of the reusable orbiter, carrying crew and cargo into orbit, are powered by 143,000 gallons of liquid oxygen and 385,000 gallons of liquid hydrogen contained within an expendable external tank during the first 8½ minutes of flight. Two solid rocket boosters (recoverable) provide an additional 2.6 million pounds of thrust during the first two minutes of flight. The solid rockets return to Earth (ocean) by parachute. The orbiter returns in an unpowered glide to a runway landing.

Six orbiters were built at Rockwell International's facility in Palmdale, California. The first, Enterprise, was used for atmospheric testing, the other five for travel to, and for long-duration stays in, low-Earth orbit. Between April 12, 1981 and July 21, 2011, the five space-worthy orbiters (Columbia, Challenger, Discovery, Atlantis and Endeavour) completed a total of 135 missions, carried 355 men and women, flew over 500 million miles, and spent more than 1,300 days in orbit.

The orbiters rendezvoused with Russia's Mir space station nine times, the International Space Station more than 35 times, and the Hubble Space Telescope five times. They carried to orbit satellites, space station components, space telescopes, laboratories and laboratory experiments, and spacecraft to explore the solar system.

Unfortunately, the STS never delivered as a low-cost transportation system. The greater concern, however, was the loss of two shuttles and crew. The loss of the Columbia upon reentry on February 1, 2003 prompted a comprehensive reevaluation of the program. The Columbia Accident Investigation Board concluded that: "*Because of the risks inherent in the original design of the Space Shuttle, because that design was based in many aspects on now-obsolete technologies, and because the Shuttle is now an aging system but still developmental in character, it is in the nation's interest to replace the Shuttle as soon as possible as the primary means for transporting humans to and from Earth orbit*." Shortly after the release of the Board's findings, President Bush announced the remaining space shuttle fleet would be retired once the construction of the International Space Station was complete.

The landing of Atlantis on July 21, 2011 signaled the end of the shuttle program and the beginning of the effort to prepare the orbiters for a new life on public display. Toxic fuels were drained, hazardous materials and toxic chemicals neutralized, pyrotechnics disarmed, the main engines removed and preserved for future use and the shuttle's control systems placed in a safe configuration.

The Smithsonian requested the Discovery as the oldest and most traveled orbiter for display at its National Air and Space Museum, Udvar-Hazy Center in Virginia. The Enterprise, which had been on display at the Udyar-Hazy Center, was moved to the Intrepid Sea, Air & Space Museum in New York City.

NASA awarded Endeavour to the California Science Museum in Los Angeles, close to the Palmdale facility where it was built. Atlantis stayed close to home and put on display at the Kennedy Space Center.

Enterprise

The Enterprise, designated Orbital Vehicle (OV)-101, was a test vehicle. It was not intended for spaceflight but provided critical test data on the orbiter's handling within the atmosphere, needed for a successful return from flight. It flew several captured flights (attached to the top of a Boeing 747) and five free flights at the Edwards Air Force Base. The orbiter was originally to be named Constitution; however, a write-in campaign by viewers of the Star Trek television show persuaded the administration to christen OV-101: Enterprise.

Once the Smithsonian acquired Discovery, the Enterprise was transported by barge to the Intrepid Sea, Air & Space Museum where it went on display on July 19, 2012.

Discovery

Discovery was NASA's third orbiter (OV-103) and flew more missions than any of the other orbiters - 39 flights between 1984 and 2011. It was the workhorse of the fleet and the orbiter that flew the "return-to-flight" missions after the Challenger and Columbia accidents. Discovery delivered the Hubble Space Telescope to orbit and flew two of the follow-on servicing missions in 1997 and 1999. The orbiter made two flights to the Russian space station Mir and 13 flights to the International Space Station. The name Discovery was chosen to honor historic sailing ships of the past.

Discovery was delivered to the Smithsonian (near Dulles Airport) in April 2012 mounted atop NASA's Shuttle Carrier Aircraft, a modified Boeing 747 jumbo jet. It is displayed in a landing configuration with its gear deployed.

Endeavour

Endeavour (OV-105) was the last orbiter to join the fleet, built to replace the Challenger. Its maiden flight was on May 7, 1992 - the first of 25 missions. Endeavor carried the "corrective optics" in the first servicing mission to the Hubble Space Telescope. The orbiter also delivered the first U.S. component, the Unity Module, to the International Space Station. The orbiter is named after the British HMS Endeavour, the ship commanded by Captain James Cook on his first expedition to Australia and New Zealand between 1769 and 1771.

The California Science Center was selected to display the Endeavour, based, in part, on its proximity to Palmdale. The orbiter was delivered to the Los Angeles International Airport by the Shuttle Carrier Aircraft on September 21, 2012. Three weeks later, the orbiter was towed 12 miles through the streets of Los Angeles to the museum. Endeavor is on temporary display until a permanent home can be constructed. It is currently mounted in an elevated horizontal position, allowing visitors to walk beneath the orbiter. The orbiter will eventually be displayed in a vertical, launch configuration.

The California Science Center also acquired two solid rocket boosters from the Kennedy Space Center in 2012 (currently in storage at NASA's Armstrong Flight Research Center). The museum had planned to use a replica for the external tank, since the tanks used for flight were not recovered. However, by happenstance, one tank was never used (it was too heavy to be used for ISS construction). Instead, the tank became a test article and even considered for future use on the Space Launch System. Ultimately, it was recently decided not to repurpose the tank, making it available to the California Science Center. The tank was transported from NASA's Michoud Assembly Facility in Louisiana by barge, through the Panama Canal to Los Angeles, arriving on May 18, 2016. Once the new 188,000 square foot addition to the California Science Center is complete (the Samuel Oschin Air and Space Center), the tank will be joined to the orbiter and solid rocket boosters and lifted into place. The exhibit is scheduled to open in 2022.

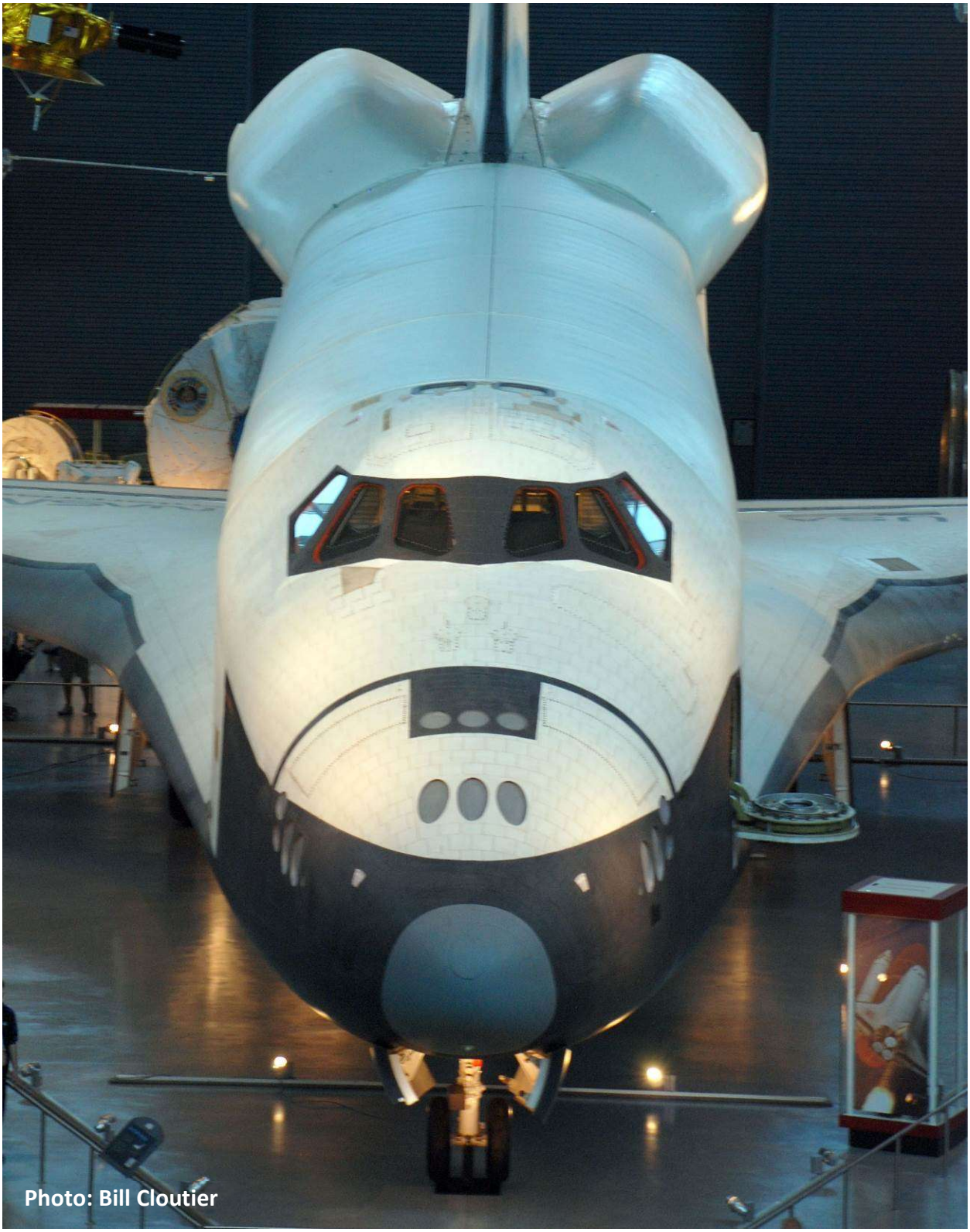
Atlantis

Atlantis was NASA's fourth orbiter (OV-104), named after the two-masted boat that served as the primary research vessel for the Woods Hole Oceanographic Institute from 1930 to 1966. It benefited from the lessons learned in the construction of its predecessors, being completed in half the hours spent on Columbia and weighing in at 3.5 tons lighter (allowing it to carry more payload).

Atlantis was the first orbiter to dock with the Russian Mir space station. It carried to orbit planetary probes that would explore Venus (Magellan) and Jupiter (Galileo) and the Compton Gamma Ray Observatory. Atlantis delivered the U.S. laboratory module Destiny and the Joint Airlock Quest to the International Space Station, as well as sections of the Integrated Truss Structure (the structural backbone of the ISS).

Atlantis is on display at the Kennedy Space Center's Visitor Center. It is displayed as in flight, with payload doors open and its Canadarm (robotic arm) extended.

Enterprise



Discovery


Photo: Bill Cloutier


NASA
United States
Discovery
Photo: Bill Cloutier

Endeavour

Photo: Bill Cloutier

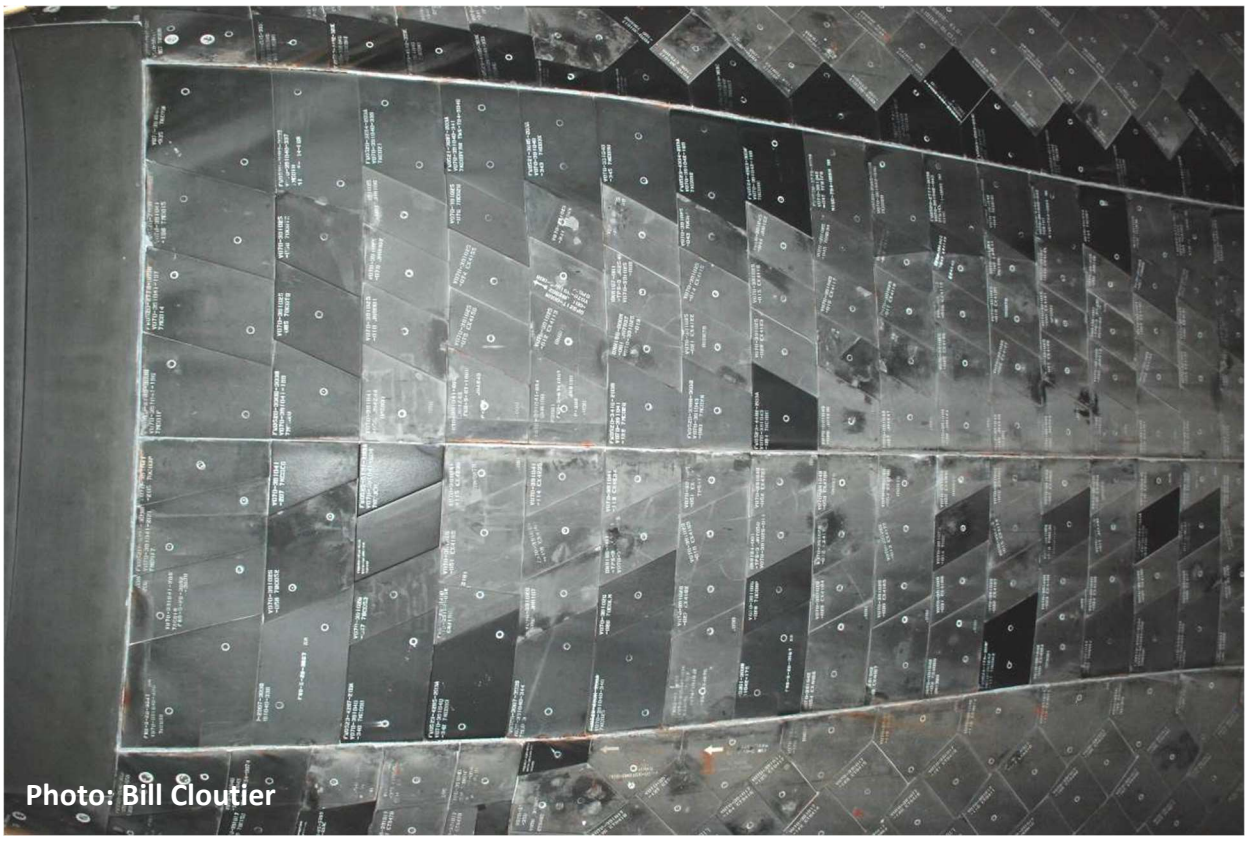
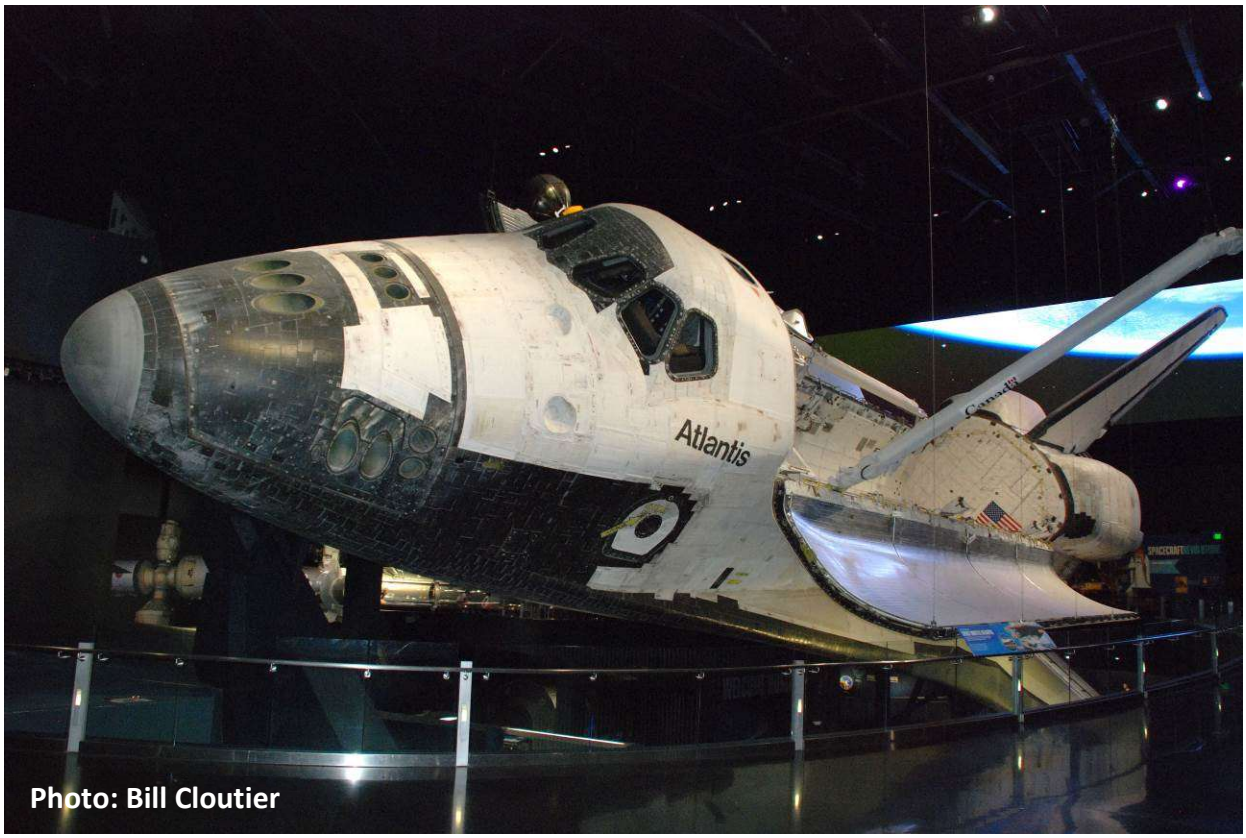
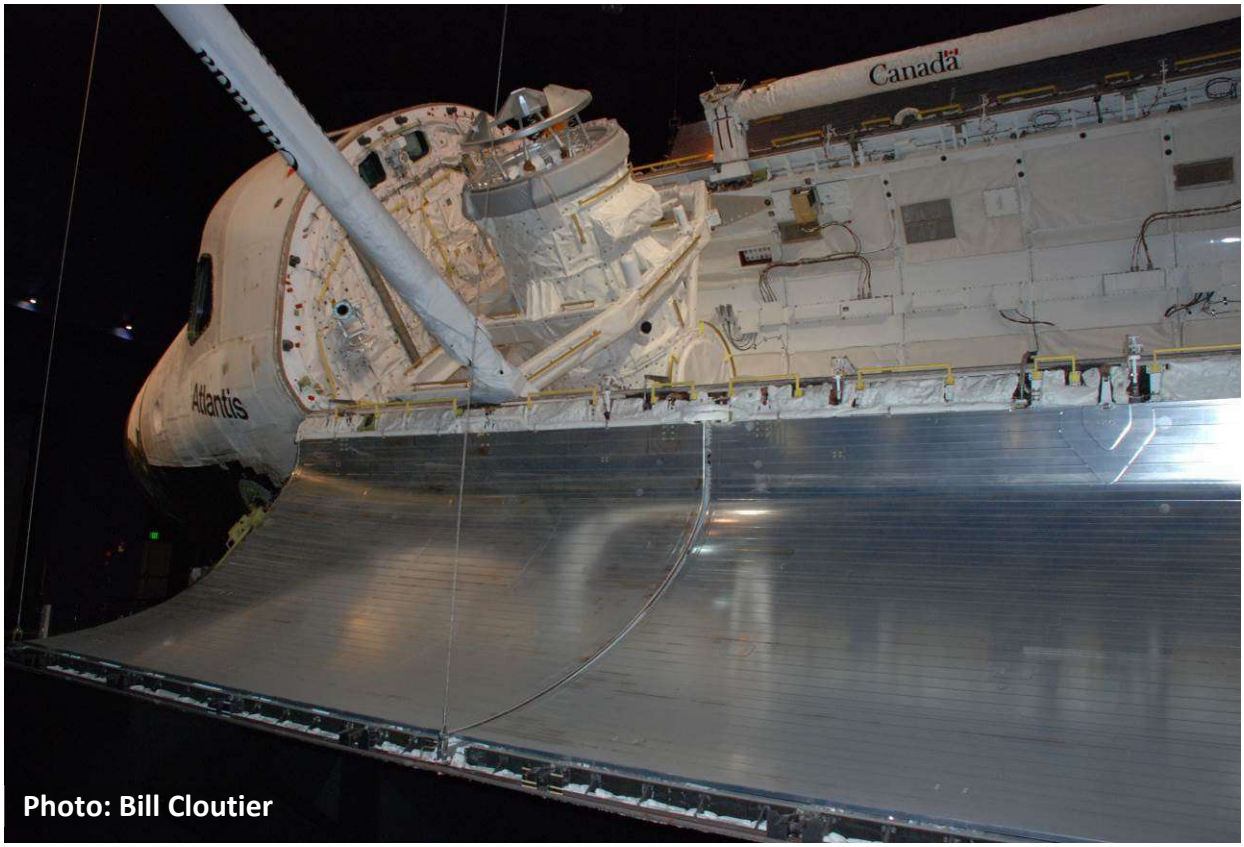


Photo: Bill Cloutier

Atlantis


Atlantis
Photo: Bill Cloutier


Canada
Atlantis
Photo: Bill Cloutier

Lost Orbiters

Columbia

Columbia (OV-102) was NASA's first space-worthy orbiter. It lifted off on its maiden voyage on April 12, 1981, piloted by mission commander (and former Gemini and Apollo astronaut) John Young and pilot Robert Crippen. The orbiter was named for the first American ship to circumnavigate the globe in 1790 as well as the Apollo 11 command module. Among its many accomplishments, Columbia carried the Chandra X-ray Observatory into orbit in July 1999.

The orbiter and crew were lost during reentry on February 1, 2003 when hot gases entered a hole in the orbiter's left wing. The hole had been created by a small piece of foam shed by the external tank on takeoff. The hot gases melted the airframe, causing the vehicle to break up in the atmosphere.

Challenger

Challenger (OV-099) was originally built as a test vehicle. In 1979, Rockwell International received a contract to convert the orbiter for space flight (NASA believed Challenger to be a less complex conversion than Enterprise). Challenger arrived at the Kennedy Space Center in 1982, joining the Columbia.

The orbiter was named after the British Naval research vessel HMS Challenger that sailed the Atlantic and Pacific oceans during the 1870s.

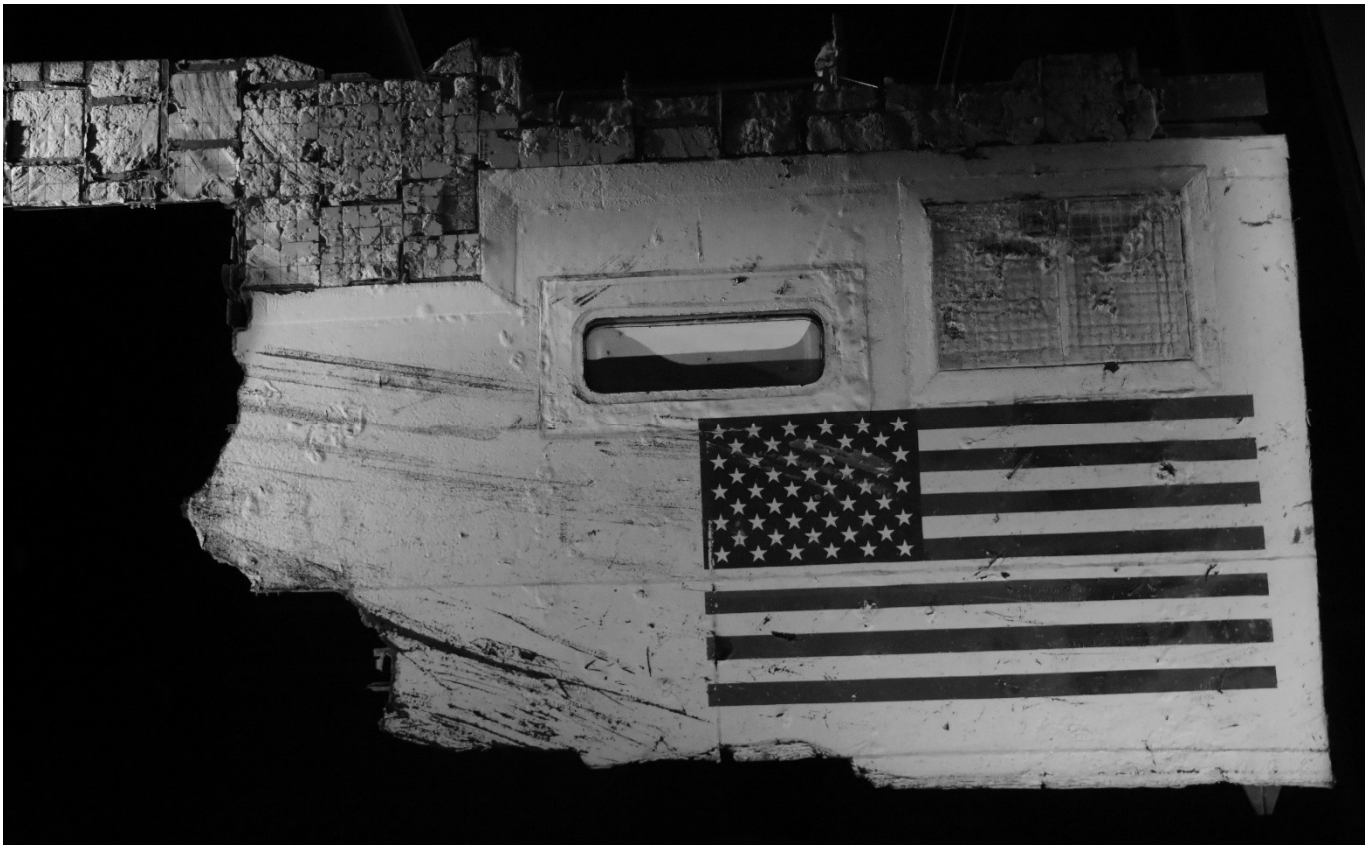
Challenger made her maiden voyage on April 4, 1983. That mission included the first spacewalk from an orbiter, as well as the deployment of the first satellite in the Tracking and Data Relay Satellite System (TDRSS) constellation. Several spacelabs were carried into orbit in Challenger's payload bay. Sally Ride, the first American woman in space, rode to orbit aboard the Challenger.

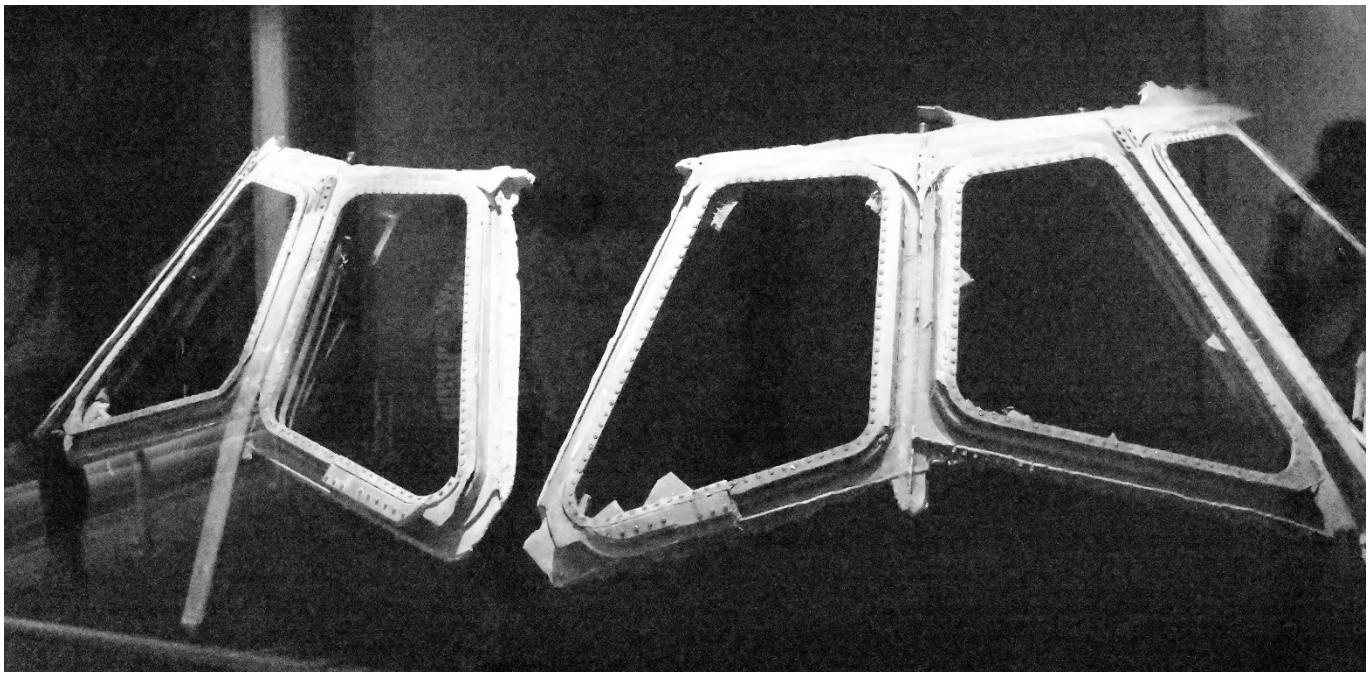
Challenger was the first orbiter to be launched at night and the first to land at the Kennedy Space Center (prior missions had landed at either the Edwards Air Force Base in California or at White Sands, New Mexico).

The orbiter and crew (including high school teacher Sharon Christa McAuliffe) were lost when a seal failed in the right rocket booster. The open joint allowed burning fuel to escape from the rocket booster and breech the external tank. Seventy-three seconds after liftoff, the orbiter was destroyed in an explosion from the failure of the hydrogen and oxygen fuel inner tanks.

Space Shuttle Memorial

In June 2015, a permanent memorial, "Forever Remembered," opened at the Kennedy Space Center Visitor Complex. The memorial honors the crews lost on the Challenger (1986) and Columbia (2003) space shuttles. Personal items from the crew members are included, as well as debris from both orbiters never before displayed in public. Visitors entering the darkened room will see a section of the fuselage recovered from space shuttle Challenger and the flight deck window frames recovered from the space shuttle Columbia.





The “Forever Remembered” memorial in the Space Shuttle Atlantis exhibit at the Kennedy Space Center Visitor Complex in Florida. Challenger fuselage (top), Columbia window frame (bottom).

Photos: Bill Cloutier

Summer Activities

Summer is a great time to enjoy the night sky. Some suggestions for this summer:

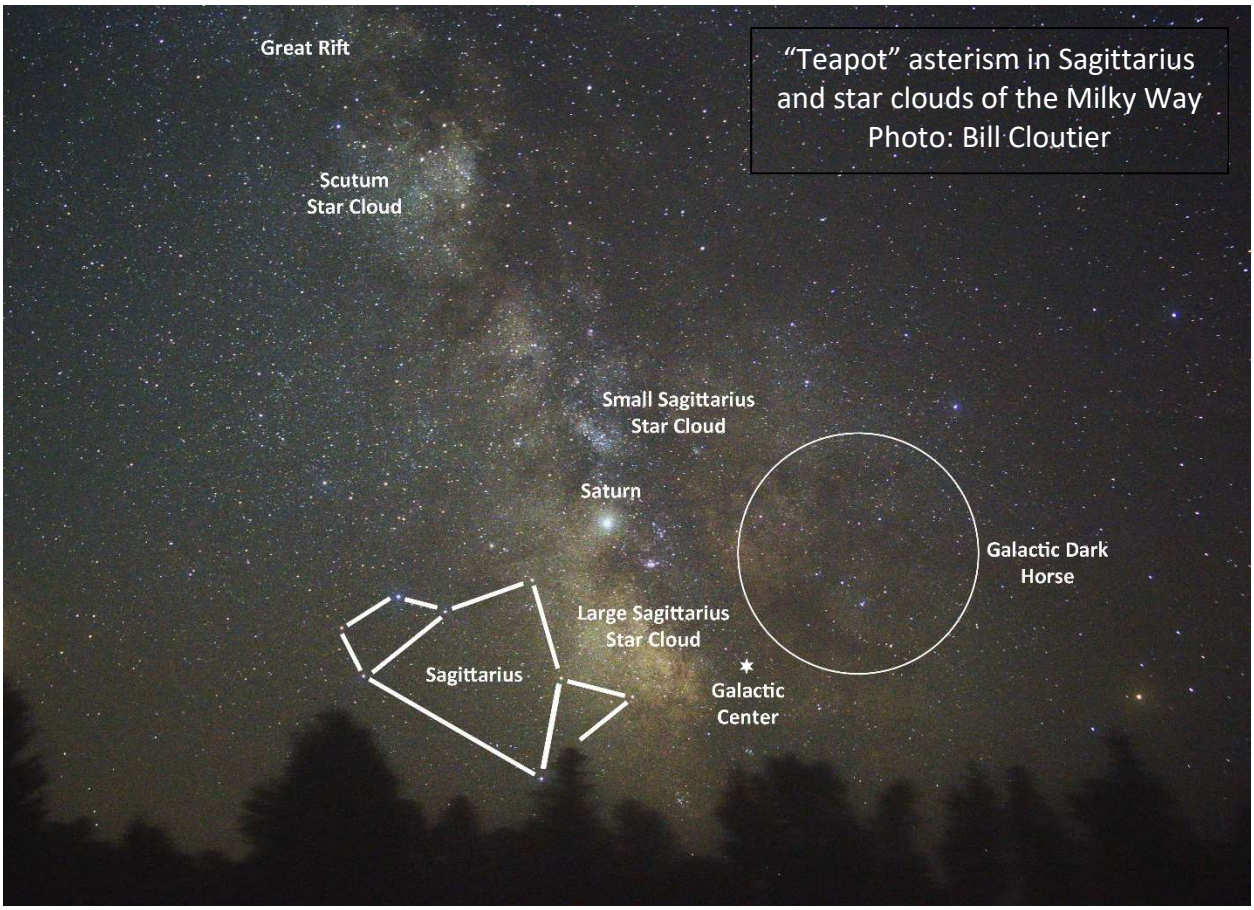
1. Spot the polar mesospheric clouds (also known as Noctilucent clouds or NLCs). These high-altitude clouds, seeded by meteoroid dust and comprised of water-ice crystals, form between 47 to 53 miles (76 to 85 km) above the Earth's surface, near the boundary of the mesosphere and thermosphere, a region known as the mesopause. They are best seen 30 minutes to 60 minutes after sunset or before sunrise. While typically confined to the polar regions, record cold temperatures in the mesosphere are increasing the production of NLCs and pushing them farther south. In 2019, they were seen as far south as Los Angeles and Las Vegas (a record low latitude)

2. Take in a meteor shower. With no telescope required, this naked-eye activity can be enjoyed in a lawn chair and a warm blanket. While an occasional meteor can be spotted at any time, August 12th is the night to catch the Perseids meteor shower. A meteor shower occurs when the Earth passes through a cloud of debris usually left behind by a comet. Comet Swift-Tuttle is the source of the small grains of dust that create the Perseid shower. As one of the most famous showers, the Perseids meteor shower usually delivers an impressive display. Expect dark skies this year with the crescent Moon setting at 10:24 pm.

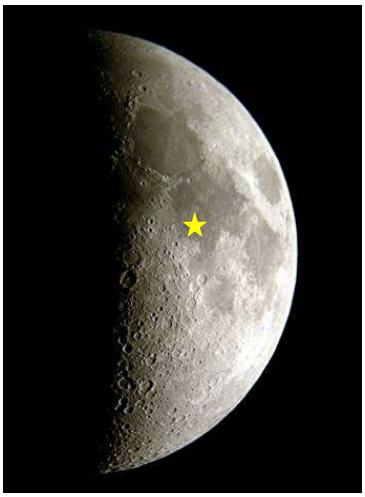
3. Locate the Summer Milky Way. Our solar system resides in one of the outer arms of a very large, rotating pinwheel of 200-300 billion stars called the Milky Way Galaxy. During the summer, we can see the inner arms of the pinwheel in the direction of the galactic core. Unfortunately, a dark sky is required, as excessive lighting is ruining the natural inky black of the celestial sphere. However, it can be seen from parts of New Milford, late at night and once the moon has set. If you have never seen the Milky Way:

   - Locate the Big Dipper (the most prominent asterism in the northern sky). The last two stars in the bowl of the Dipper point to the North Star.
   - Imagine a line extended from the two Dipper stars, through the North Star and an equal distance beyond. You should now be between the constellations Cepheus and Cassiopeia. Cassiopeia is shaped like a W or Σ and is the starting point for our journey down the Milky Way.
   - The Milky Way flows from Cassiopeia south to Cygnus (the Swan or Northern Cross). Cygnus can be recognized by its brightest star Deneb (at the tail) and the three bright stars that form the wing.
   - Continuing south, the bright star Altair provides the next navigation aid, directing us to Sagittarius, an asterism shaped like a teapot. On a dark night, the star clouds of the Milky Way appear like steam from the spout of the teapot. The spout is also in the general direction of the center of our galaxy (26,000 light years away).

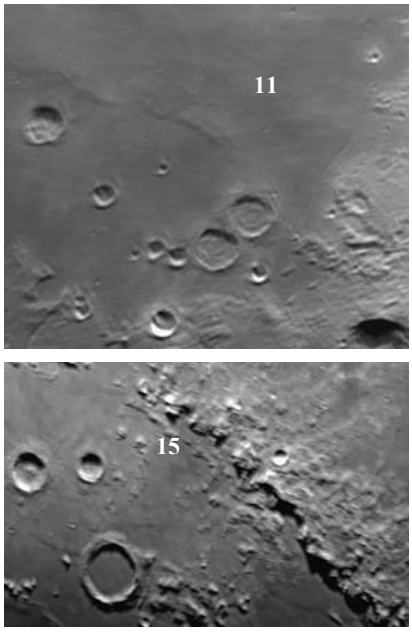
   From a good observing site, you should see a band of cloudiness through this area of the sky. Through binoculars, the "clouds" can be resolved into bright areas populated by stars and darker areas with few or no stars. The darker patches are regions of gas and dust that obscure our view of the galactic center.



4. Find the Apollo landing sites. July marks the anniversaries of two moon landings. Apollo 11 landed on the southwestern shore of the Sea of Tranquility on July 20, 1969. Apollo 15 landed in the foothills of the Apennine Mountains on July 30, 1971. The southwestern shore of the Sea of Tranquility is visible 5 days after a New Moon. The Sun rises on the Apennine Mountains around the First Quarter Moon.



Sea of Tranquility and Apollo 11 landing site



Apennines Mts and Apollo 15 landing site

Sunrise and Sunset (from New Milford, CT)

Sun	Sunrise (AM)	Sunset (PM)
July 1st (EDT)	05:23	8:31
July 15th	05:32	8:25
July 31st	05:47	8:11
August 1st	05:48	8:10
August 15th	06:02	7:52
August 31st	06:18	7:27

Astronomical and Historical Events for July and August

July

1st Last Quarter Moon
1st History: opening of the Smithsonian National Air & Space Museum (1976)
1st History: NASA officially activates the Launch Operations Center on Merritt Island, Florida; later renamed the Kennedy Space Center (1962)
1st History: 100-inch diameter mirror for the Hooker Telescope arrives on Mt. Wilson (1917)
1st History: discovery of asteroid *6 Hebe* by Karl Hencke (1847)
2nd Apollo Asteroid 2021 GM4 near-Earth flyby (0.031 AU)
2nd Apollo Asteroid 4769 *Castalia* closest approach to Earth (1.138 AU)
2nd History: launch of the Orbiting Carbon Observatory-2 (OCO-2) (2014)
2nd History: launch of European Space Agency's Giotto spacecraft to Comet Halley (1985)
3rd History: launch of the ill-fated Nozomi spacecraft to Mars by Japan (1998)
3rd History: launch of the Solar Anomalous and Magnetospheric Particle Explorer (SAMPEX) by a Scout rocket (1992)
4th Mercury at its Greatest Western Elongation (22°) – apparent separation from the Sun in the morning sky
4th Apollo Asteroid 2020 AD1 near-Earth flyby (0.007 AU)
4th Atira Asteroid 2020 OV1 closest approach to Earth (0.311 AU)
4th History: Juno spacecraft enters orbit around Jupiter (2016)
4th History: impact of Comet *Tempel 1* by Deep Impact's impactor (2005)
4th History: Pathfinder spacecraft, with rover Sojourner, lands on Mars (1997)
4th History: Chinese astronomers record a "guest star" (supernova) in the constellation Taurus; visible for 23 days and 653 nights (1054); the remnant (Crab Nebula) later catalogued by Charles Messier as Messier 1 or M1
5th Moon at Apogee (furthest distance from Earth)
5th Earth at Aphelion – furthest from the Sun (1.017 AU or 94.5 million miles)
5th Amor Asteroid *162011 Konnohmaru* closest approach to Earth (2.383 AU)
5th Amor Asteroid *4401 Aditi* closest approach to Earth (3.083 AU)
5th History: Isaac Newton's "Mathematical Principles of Natural Philosophy" published, describing the laws of motion (1687)
6th Kuiper Belt Object 307261 (2002 MS4) at Opposition (45.457 AU)
6th History: discovery of Jupiter's moon *Lysithea* by Seth Nicholson (1938)
7th History: launch of the Mars Exploration Rover B (Opportunity) (2003)

Astronomical and Historical Events for July (continued)

8th Amor Asteroid *4487 Pocahontas* closest approach to Earth (0.751 AU)
8th Apollo Asteroid *10563 Izhdubar* closest approach to Earth (0.876 AU)
8th History: launch of the Space Shuttle Atlantis (STS-135) to the International Space Station; final space shuttle flight to low-Earth orbit (2011)
9th New Moon
9th History: closest pass of Jupiter's cloud tops by the Voyager 2 spacecraft (1979)
10th **McCarthy Observatory Star Party** (start time 9 pm – see website for details)
10th History: flyby of Comet Grigg-Skjellerup by the European Space Agency's Giotto spacecraft following its close encounter of Halley's Comet (1992)
10th History: flyby of asteroid *21 Lutetia* by the European Space Agency's Rosetta spacecraft (2010)
10th History: launch of Telstar 1, prototype communication satellite designed and built by Bell Telephone Laboratories (1962)
10th History: Alvan Graham Clark born, optician and telescope maker (1832)
11th Centaur Object *10370 Hylonome* at Opposition (23.962 AU)
11th History: launch of the Soviet Gamma Observatory (1990)
11th History: Skylab re-enters into the Earth's atmosphere (1979)
12th Kuiper Belt Object *486958 Arrokoth* at Opposition (42.120 AU)
12th History: launch of the High Energy Astronomical Observatory (HEAO-1), designed to survey the entire sky for x-ray emissions (1977)
12th History: launch of Soviet Mars orbiter Phobos 2 (1988)
13th History: Soviet Union launches Luna 15, a lunar lander and sample return mission, in an attempt to upstage Apollo 11; crashes during landing (1969)
13th Apollo Asteroid 2019 AT6 near-Earth flyby (0.011 AU)
13th Centaur Object *330836 Orius* at Opposition (18.260 AU)
13th History: Langley Research Center's birthday (1917)
14th Atira Asteroid 413563 (2005 TG45) closest approach to Earth (0.923 AU)
14th History: flyby of the dwarf plant Pluto by the New Horizons spacecraft dwarf planet and its largest moon Charon (2015)
14th History: flyby and first close-up view of Mars by the Mariner 4 spacecraft (1965)
15th Aten Asteroid *326290 Akhenaten* closest approach to Earth (0.400 AU)
15th History: Pioneer 10 becomes the first spacecraft to enter the main asteroid belt (1972)
16th First Quarter Moon
16th Centaur Object *55576 Amycus* at Opposition (21.450 AU)
16th Kuiper Belt Object *15810 Arawn* at Opposition (34.899 AU)
16th History: Dawn spacecraft enters orbit around the asteroid 4 *Vesta* (2011)
16th History: over twenty fragments of comet Shoemaker-Levy 9, up to 2 km in diameter, collide with Jupiter between July 16th and the 22nd (1994); the comet had been discovered a year earlier by astronomers Carolyn and Eugene Shoemaker and David Levy
16th History: launch of Badr-A, first Pakistan satellite (1990)
16th History: launch of Apollo 11, with astronauts Neil Armstrong, Edwin "Buzz" Aldrin and Michael Collins, first manned lunar landing (1969)
16th History: first launch of a Proton rocket by the Soviet Union (1965)
16th History: first photo of a star other than our Sun (Vega) taken at the Harvard College Observatory (1850)
17th Apollo Asteroid 2019 NB7 near-Earth flyby (0.039 AU)

Astronomical and Historical Events for July (continued)

17th History: docking (and crew handshake) of an Apollo spacecraft with astronauts Thomas Stafford, Vance Brand, and "Deke" Stayton with a Soyuz spacecraft with cosmonauts Alexei Leonov and Valeri Kubasov (the Apollo-Soyuz Test Project (ASTP)) (1975)
17th History: William Bond and John Adams Whipple take the first photograph of a star (Vega) at the Harvard College Observatory (1850)
18th Dwarf Planet *134340 Pluto* at Opposition (33.307 AU)
18th History: discovery of Jupiter's moon *Callirrhoe* (2000)
18th History: John Glenn born, first American to orbit the Earth in 1962 (1921)
18th History: launch of Rohini 1, India's first satellite (1980)
18th History: launch of Gemini X, with astronauts John Young and Michael Collins (1966)
18th History: launch of Soviet Zond 3 spacecraft; first successful flyby of Moon; transmitted photographs that included the far side (1965)
18th History: Allan Sandage born, astronomer specializing in observational cosmology (1926)
19th Amor Asteroid *7088 Ishtar* closest approach to Earth (1.676 AU)
19th Asteroid *90125 Chrissquire* closest approach to Earth (1.745 AU)
19th History: launch of UAE's Hope spacecraft atop a Japanese H-IIA rocket (2020)
19th History: launch of the Explorer 35 spacecraft into an elliptical lunar orbit; designed to study interplanetary plasma, magnetic field, energetic particles, and solar X-rays (1967)
20th History: Gus Grissom's Mercury capsule (Liberty Bell 7) retrieved from the Atlantic Ocean floor at a depth of 15,000 feet, 38 years after it had sunk after splashdown (1999)
20th History: Viking 1 lands on Mars (1976)
20th History: Apollo 11 lands on Moon at 4:17 pm EDT; first step onto the lunar surface at 10:56 pm (1969)
21st Moon at Perigee (closest distance to Earth)
21st Apollo Asteroid 2014 BP43 near-Earth flyby (0.037 AU)
21st Aten Asteroid 2013 ND15 (Venus Trojan) closest approach to Earth (0.153 AU)
21st Amor Asteroid *7358 Oze* closest approach to Earth (0.715 AU)
21st Apollo Asteroid *7092 Cadmus* closest approach to Earth (2.802 AU)
21st History: launch of the Soviet Mars mission Mars 4 (1973)
21st History: launch of Mercury-Redstone 4 with astronaut Virgil (Gus) Grissom; second suborbital flight by the United States (1961)
21st History: discovery of Jupiter's moon *Sinope* by Seth Nicholson (1914)
22nd History: launch of Chandrayaan 2 (consisting of an orbiter, the Vikram lander and a rover), India's second moon mission from the Satish Dhawan Space Center, Sriharikota, India. The lander crashed due to a software error just short of landing
22nd History: first dogs (Dezik and Tsygan) to make a suborbital flight aboard a Soviet R-1 rocket (wore pressure suits and acrylic glass bubble helmets) (1951)
22nd History: landing of Soviet spacecraft Venera 8 on Venus (1972)
23rd Full Moon (sometimes called Buck Moon)
23rd Apollo Asteroid *38086 Beowulf* closest approach to Earth (0.409 AU)
23rd Apollo Asteroid *6063 Jason* closest approach to Earth (2.479 AU)
23rd Plutino 2014 JR80 at Opposition (39.774 AU)
23rd History: launch of China's Tianwen-1 spacecraft to Mars from the Wenchang Spacecraft Launch Site. Spacecraft included an orbiter, lander and rover (2020)
23rd History: launch of Space Shuttle Columbia (STS-93) and the Chandra X-ray Observatory (1999); first mission commanded by a woman, Eileen Collins

Astronomical and Historical Events for July (continued)

23rd History: discovery of Comet Hale-Bopp by Alan Hale and Tom Bopp (1995)
23rd History: discovery of Neptune's rings (1984)
23rd History: launch of Landsat 1 into a near-polar orbit to obtain information on Earth's resources, environmental pollution, and meteorological phenomena (1972)
24th History: launch of the Geotail spacecraft, a joint JAXA/NASA mission to study the magnetic environs of Earth (1992)
24th History: first rocket launch from Cape Canaveral (Bumper/V-2 rocket) in 1950
25th Apollo Asteroid *471926 Jormungandr* closest approach to Earth (1.574 AU)
25th Centaur Object *10199 Chariklo* at Opposition (15.693 AU)
25th History: Svetlana Savitskaya becomes the first woman to walk in space (1984)
25th History: launch of Soviet Mars orbiter Mars 5 (1973)
26th History: launch of the Space Shuttle Discovery (STS-114) "Return to Flight," 907 days after the loss of Space Shuttle Columbia (2005)
26th History: launch of Apollo 15 with astronauts David Scott, James Irwin and Alfred Worden; fourth lunar landing (1971)
26th History: launch of Syncom 2, first geosynchronous satellite (1963)
27th Apollo Asteroid 2008 GO20 near-Earth flyby (0.026 AU)
27th Aten Asteroid 2020 BW12 near-Earth flyby (0.043 AU)
27th Apollo Asteroid 1566 Icarus closest approach to Earth (0.986 AU)
27th Asteroid 6 Hebe closest approach to Earth (1.260 AU)
28th History: discovery of Neptune's moons *Despina* and *Galatea* by Stephen Synnott (1989)
28th History: launch of Skylab-3 astronauts Alan Bean, Jack Lousma and Owen Garriott (1973)
28th History: launch of Ranger 7; Moon impact mission (1964)
29th South Delta-Aquarids Meteor Shower peak
29th History: deorbit and destruction of the Salyut 6 space station; first of the Soviet's second-generation space station design (1982)
29th History: Deep Space 1 flyby of asteroid *Braille* (1999)
30th Scheduled launch of Boeing's CST-100 Starliner for its second unpiloted test flight to the International Space Station from the Cape Canaveral Air Force Station, Florida
30th Aten Asteroid *5381 Sekmet* closest approach to Earth (1.578 AU)
30th History: launch of NASA's Mars 2020 rover (Perseverance) aboard an Atlas 5 rocket from the Cape Canaveral Air Force Station, Florida (2020)
30th History: the Cassini spacecraft arrives at Saturn after a seven-year journey (2004)
30th History: launch of the Wilkinson Microwave Anisotropy Probe (WMAP); mapped the Cosmic Microwave Background radiation and determined the age of the universe to be 13.73 billion years old to within one percent (2001)
30th History: Apollo 15 lands on Moon at 6:16 pm EDT (1971)
30th History: discovery of Jupiter's moon *Carme* by Seth Nicholson (1938)
30th History: discovery of the asteroid 951 *Gaspra* by Grigory Neujmin (1916); the Galileo spacecraft passed within 1,000 miles (1,600 km) of Gaspra on October 29, 1991 on its way to Jupiter
30th History: Galileo observes Saturn's rings (1610)
31st Last Quarter Moon
31st Apollo Asteroid 2019 YM6 near-Earth flyby (0.046 AU)
31st Plutino 2017 OF69 at Opposition (42.288 AU)

Astronomical and Historical Events for July (continued)

31st History: David Scott, Commander of Apollo 15, becomes first person to drive a vehicle on the Moon (1971)
31st History: impact of the Lunar Prospector (1999)
31st History: flyby of Mars by Mariner 6 (1969)

August

1st Peak of the Alpha Capricornids meteor shower
1st Scheduled launch of a Cygnus cargo-carrying spacecraft atop a Northrop Grumman Antares rocket to the International Space Station from Wallops Island, Virginia
1st Apollo Asteroid *3103 Eger* closest approach to Earth (0.237 AU)
1st Asteroid *780 Armenia* closest approach to Earth (1.911 AU)
1st History: discovery of Martian meteorite (shergottite class) SAU 051 in Oman (2000)
1st History: launch of Lunar Orbiter 5, last of the Lunar Orbiter series; photographed potential Apollo and Surveyor landing sites and captured the first image of a nearly full Earth from space (1967)
1st History: Maria Mitchell born, first woman to be elected as an astronomer to the American Academy of Arts and Sciences (1818)
2nd Saturn at Opposition
2nd Moon at Apogee (furthest distance from Earth)
3rd Aten Asteroid 2020 PN1 near-Earth flyby (0.025 AU)
3rd Apollo Asteroid 2020 PP1 near-Earth flyby (0.033 AU)
3rd Asteroid *951 Gaspra* closest approach to Earth (1.057 AU)
3rd History: launch of the MESSENGER spacecraft to Mercury (2004)
3rd History: discovery of long-period variable star Mira, (Omicron Ceti) by David Fabricius (1596)
4th Amor Asteroid *189011 Ogmios* closest approach to Earth (0.453 AU)
4th Apollo Asteroid 2013 EC20 closest approach to Earth (1.085 AU)
4th Apollo Asteroid 85585 Mjolnir closest approach to Earth (1.458 AU)
4th Apollo Asteroid *2135 Aristaeus* closest approach to Earth (1.717 AU)
4th Amor Asteroid *1915 Quetzalcoatl* closest approach to Earth (2.073 AU)
4th Kuiper Belt Object 2013 AT183 at Opposition (64.738 AU)
4th History: launch of the Phoenix polar lander spacecraft to Mars (2007)
5th Stellafane, 85th Convention of Amateur Telescope Makers on Breezy Hill in Springfield, Vermont (https://stellafane.org/convention/2021/index.html) (August 5th through 8th)
5th Plutino 2014 JP80 at Opposition (41.088 AU)
5th History: launch of the Juno spacecraft to Jupiter (2011); arrived on July 4, 2016
5th History: flyby of Mars by the Mariner 7 spacecraft (1969)
5th History: astronaut Neil Armstrong born (1930); Commander of Apollo 11 and first person to step out on the lunar surface
6th Southern Iota Aquarids meteor shower peak
6th History: the Rosetta spacecraft and her robotic lander companion Philae arrive in orbit around Comet 67P/Churyumov–Gerasimenko after a 10-year journey (2014)
6th History: landing of the Mars Science Laboratory (MSL or Curiosity) at the base of Mount Sharp inside Gale Crater (2012)
6th History: launch of Vostok 2 and cosmonaut Gherman Titov; second man in Space (1961)

Astronomical and Historical Events for August (continued)

6th History: Chinese astronomers first observe supernova in Cassiopeia; remained visible for more than 6 months (1181)
7th Asteroid *31 Euphrosyne* closest approach to Earth (2.781 AU)
7th History: Brett Gladman, et al's discovery of Saturn moons *Ymir*, *Paaliaq* and *Kiviuq* (2000)
7th History: announcement of possible microfossils found in Martian meteorite ALH84001 (1996)
7th History: Viking 2 arrives at Mars (1976)
8th New Moon
8th Apollo Asteroid *37655 Illapa* closest approach to Earth (0.191 AU)
8th History: launch of Genesis spacecraft, solar particle sample return mission (2001)
8th History: launch of Pioneer Venus 2 (1978)
8th History: launch of the Soviet Zond 7 Moon probe (1969)
9th Parker Solar Probe's 9th Perihelion - coming within 6.5 million miles (10.5 million kms) of the Sun and traveling at a record-breaking 330,000 mph (532,000 km/h)
9th History: discovery of *Remus*, moon of Asteroid 87 *Sylvia* by Franck Marchis, et al's (2004)
9th History: launch of the Soviet Luna 24 spacecraft, third attempt (and only successful attempt) to recover a sample from Mare Crisium (1976)
9th History: Henry Draper obtains the first spectrum photograph of a star (Vega) to show distinct lines (1872)
10th History: launch of TOPEX/Poseidon Earth-monitoring satellite, joint venture between CNES and NASA that measured ocean surface topography to an accuracy of 4.2 cm (1992)
10th History: launch of Mars Reconnaissance Orbiter to Mars (2005)
10th History: launch of Kitsat A, first South Korean satellite (1992)
10th History: the Magellan spacecraft enters orbit around Venus; radar mapped 98% of the planet over the following two years (1990)
10th History: launch of the Lunar Orbiter 1 spacecraft; photographed smooth areas of the lunar surface for assessing future landing sites and captured iconic image of the Earth rising above the lunar surface (1966)
11th Venus flyby (second) by ESA's BepiColombo spacecraft, coming within 343 miles (552 km) of the planet's surface and setting up the first flyby of Mercury in October 2021
11th Apollo Asteroid 2012 BA35 near-Earth flyby (0.018 AU)
11th History: Asaph Hall discovers Martian moon *Deimos* (1877)
12th Peak of the Perseids meteor shower (into the morning of the 13th)
12th Kuiper Belt Object 470599 (2008 OG19) at Opposition (37.914 AU)
12th History: launch of NASA's Parker Solar Probe aboard a Delta 4 Heavy rocket from the Cape Canaveral Air Force Station (2018)
12th History: launch of the Mars Reconnaissance Orbiter (2005)
12th History: launch of the International Sun-Earth Explorer-3 (ISEE-3) satellite into a heliocentric orbit. Renamed International Comet Explorer, (ICE), it became the first spacecraft to visit a comet, passing through the plasma tail of comet Giacobini-Zinner in 1985 (1978)
12th History: launch of the High Energy Astronomical Observatory (HEAO-1) to monitor x-ray sources (1977)

Astronomical and Historical Events for August (continued)

12th History: Soviet spacecraft Vostok 4 launched one day after Vostok 3 - first time multiple manned spacecraft in orbit, although they did not rendezvous (1962)
12th History: launch of Echo 1, the first experimental communications satellite (1960)
13th History: discovery of Mars' south polar cap by Christiaan Huygens (1642)
14th **McCarthy Observatory Star Party** (see website for details)
14th Apollo Asteroid 2016 BQ near-Earth flyby (0.011 AU)
14th Amor Asteroid *4954 Eric* closest approach to Earth (1.006 AU)
14th Kuiper Belt Object 2015 UH87 at Opposition (80.224 AU)
15th First Quarter Moon
15th Centaur Object *83982 Crantor* at Opposition (19.032)
16th Apollo Asteroid *4257 Ubasti* closest approach to Earth (1.109 AU)
16th Apollo Asteroid *5731 Zeus* closest approach to Earth (2.736 AU)
16th History: launch of Explorer 12 spacecraft, measured cosmic-ray particles, solar wind protons, and magnetospheric and interplanetary magnetic fields (1961)
17th Moon at Perigee (closest distance to Earth)
17th Comet 2P/*Encke* closest approach to Earth (2.836 AU)
17th Apollo Asteroid *5011 Ptah* closest approach to Earth (1.593 AU)
17th History: launch of Venera 7; Soviet Venus lander (1970)
17th History: launch of Pioneer 7 (1966)
17th History: Asaph Hall discovers Martian moon *Phobos* (1877)
18th Scheduled launch of a SpaceX cargo-carrying Dragon 2 spacecraft to the International Space Station from the Kennedy Space Center, Florida
18th History: launch of Suisei; Japan's Comet Halley mission (1985)
19th Jupiter at Opposition
19th Atira Asteroid 2019 LF6 closest approach to Earth (0.642 AU)
19th Apollo Asteroid *5786 Talos* closest approach to Earth (1.119 AU)
19th History: launch of first Philippine communications satellite Agila 2 (also known as Mabuhay 1 or ABS 5) (1997)
19th History: launch of Soviet Sputnik 5 spacecraft with dogs Belka and Strelka (1960)
19th History: discovery of S Andromedae (SN 1885A), supernova in the Andromeda Galaxy and the first discovered outside the Milky Way Galaxy; discovered by Irish amateur astronomer Isaac Ward in Belfast on the 19th and independently the following day by Ernst Hartwig at Dorpat (Tartu) Observatory in Estonia (1885)
19th History: Orville Wright born (1871)
19th History: John Flamsteed born; English astronomer known for his accurate astronomical observations and first Astronomer Royal (1646)
20th History: launch of Voyager 2 to the outer planets (1977)
20th History: launch of Mars orbiter/lander Viking 1 (1975)
20th History: Ernst Hartwig's discovery of S Andromedae Supernova (1885)
21st Apollo Asteroid 2016 AJ193 near-Earth flyby (0.023 AU)
21st Apollo Asteroid *4183 Cuno* closest approach to Earth (2.060 AU)
21st History: discovery of Dar al Gani 975 Mars meteorite in Libya (1999)
21st History: launch of the Orbiting Astronomical Observatory-3, Copernicus, with a UV telescope and X-ray detector (1972)
21st History: launch of Gemini V with astronauts Gordon Cooper and Charles Conrad (1965)
22nd Full Moon (sometimes called Sturgeon Moon)

Astronomical and Historical Events for August (continued)

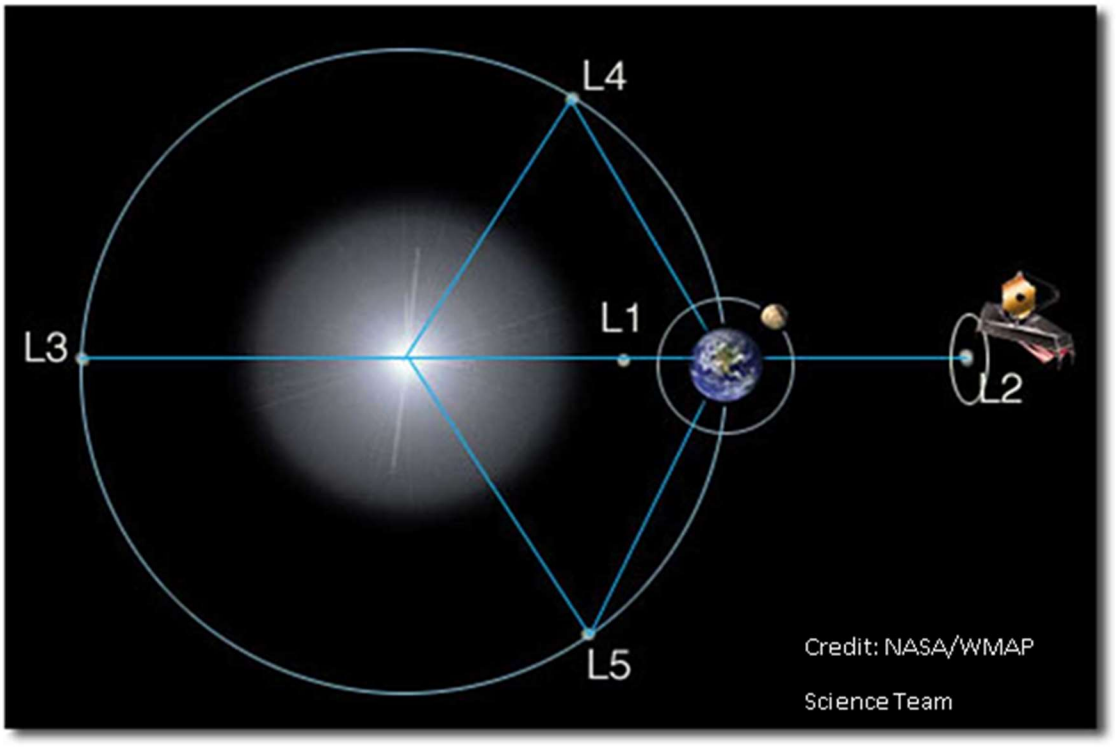
22nd Amor Asteroid 2019 UD4 near-Earth flyby (0.036 AU)
22nd Apollo Asteroid *2063 Bacchus* closest approach to Earth (0.499 AU)
22nd History: first light of the 100-meter Robert C. Byrd Green Bank Telescope - the world's largest fully steerable radio telescope. (2000)
23rd History: Lunar Orbiter 1 takes first photo of the Earth from the Moon (1966)
24th Apollo Asteroid 2011 UC292 near-Earth flyby (0.023 AU)
24th Apollo Asteroid 2020 BC16 near-Earth flyby (0.037 AU)
24th History: Pluto reclassified as a Dwarf Planet (2006)
24th History: launch of the Soviet Luna 11 spacecraft to analyze the Moon's chemical composition, study gravitational anomalies and measure radiation levels (1966)
25th Northern Iota Aquarids Meteor Shower Peak
25th Mars Summer Solstice (northern hemisphere)
25th Apollo Asteroid *1865 Cerberus* closest approach to Earth (0.999 AU)
25th Apollo Asteroid *11500 Tomaiyowit* closest approach to Earth (1.413 AU)
25th History: flyby of Neptune by the Voyager 2 spacecraft (1989)
25th History: launch of the Spitzer Space Telescope (2003)
25th History: launch of the Advanced Composition Explorer spacecraft to study energetic particles from the solar wind, the interplanetary medium, and other sources (1997)
26th Comet 2P/*Encke* at Opposition (2.850 AU)
26th Apollo Asteroid *2102 Tantalus* closest approach to Earth (1.526 AU)
26th History: flyby of the planet Saturn by the Voyager 2 spacecraft (1981)
27th Amor Asteroid *1943 Anteros* closest approach to Earth (0.569 AU)
27th History: launch of the Mariner 2 spacecraft to Venus; first successful planetary encounter (1962)
28th Apollo Asteroid *4034 Vishnu* closest approach to Earth (0.221 AU)
28th Kuiper Belt Object 225088 Gonggong at Opposition (87.749 AU)
28th History: flyby of the asteroids *Ida* and *Dactyl* by the Galileo spacecraft (1993)
28th History: discovery of Saturn's moon *Enceladus* by William Herschel (1789)
29th Moon at Apogee (furthest distance from Earth)
29th Aten Asteroid 2017 RK15 near-Earth flyby (0.036 AU)
29th History: discovery of a bright nova in the constellation Cygnus (Nova Cygni 1975); visible to the unaided eye for about a week (1975)
30th Last Quarter Moon
30th Apollo Asteroid *217628 Lugh* closest approach to Earth (2.990 AU)
30th History: discovery of first Kuiper Belt Object (1992 QB1) by David Jewitt and Jane Luu
30th History: launch of Japanese satellite Yohkoh (Sunbeam) to observe phenomena taking place on the Sun (1991)
30th History: launch of STS-8 and astronaut Guy Bluford; first African-American in space and first night launch and landing by a shuttle (1983)
31st History: President Kennedy signs the Communications Satellite which created the Communications Satellite Corporation (COMSAT) and committed the U.S. to building a global communications system (1962)
31st History: first photo showing Moon's shadow on the Earth during Solar Eclipse taken by stratospheric balloonist Captain Albert Stevens (1932)

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

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).



References on Distances

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

International Space Station and Artificial Satellites

Visit www.heavens-above.com for the times of visibility and detailed star charts for viewing the International Space Station and bright artificial 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/

Mars – Mission Websites

- Mars 2020 (Perseverance rover): https://mars.nasa.gov/mars2020/
- Mars Science Laboratory (Curiosity rover): https://mars.nasa.gov/msl/home/
- Mars InSight (lander): https://mars.nasa.gov/insight/

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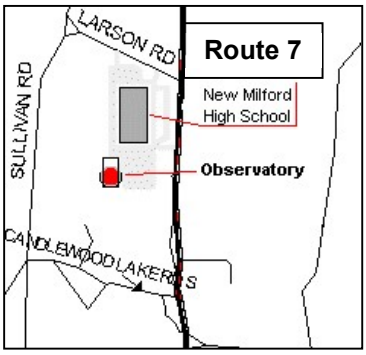

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