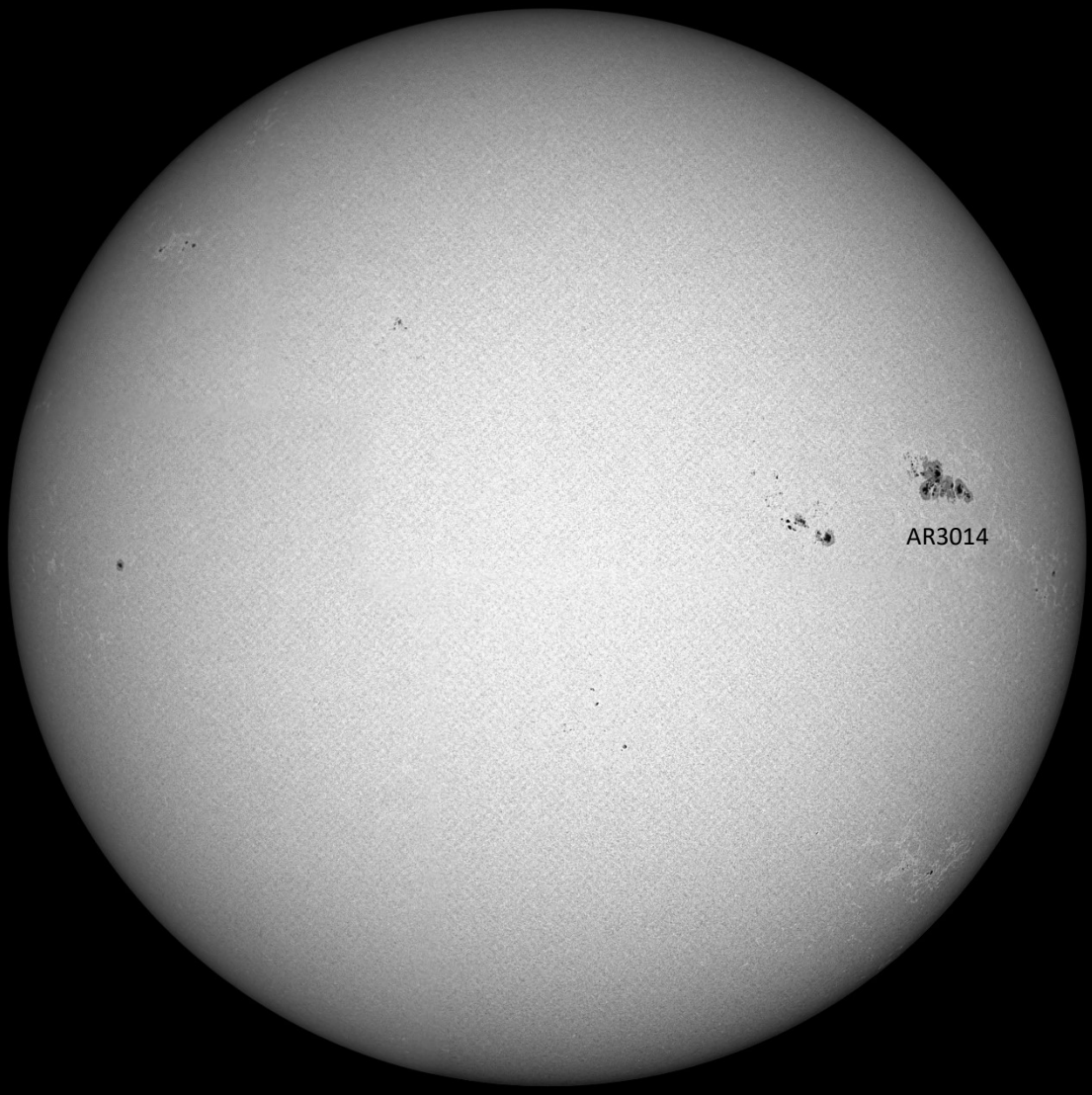
Galactic Observer

John J. McCarthy Observatory

Volume 15, No. 7 July/August 2022



Monster Sunspot

Sunspot AR3014, crackling with M-class solar flares, rotated into Earth's view in mid-May. In a few days the sunspot had doubled in size, large enough to be seen without magnification (with proper eye protection). It is, by far, the largest sunspot of the current solar cycle, with each of its dark cores wider than the Earth.

Photo credit: Marc Polansky

July and August Astronomy Calendar and Space Exploration Almanac

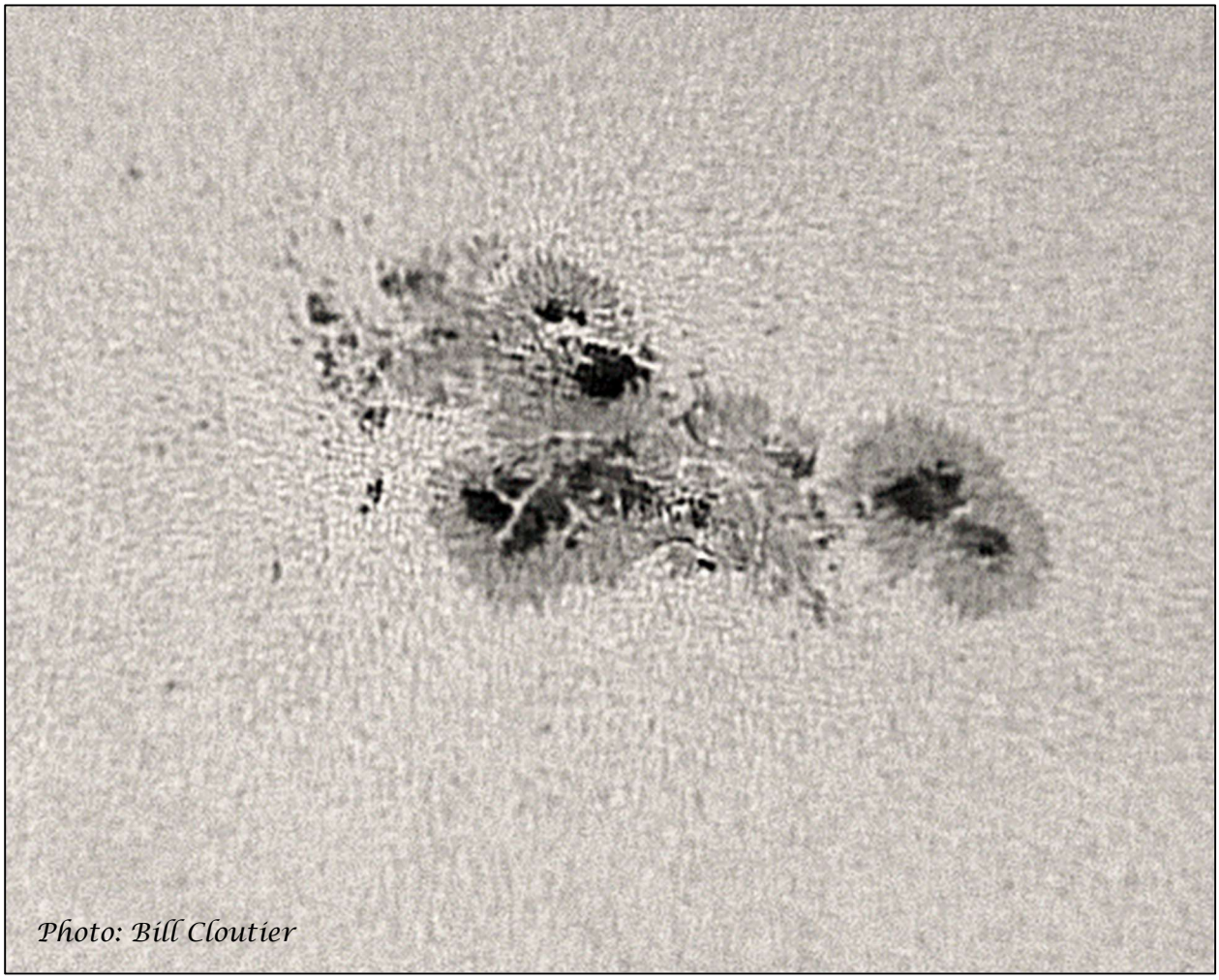
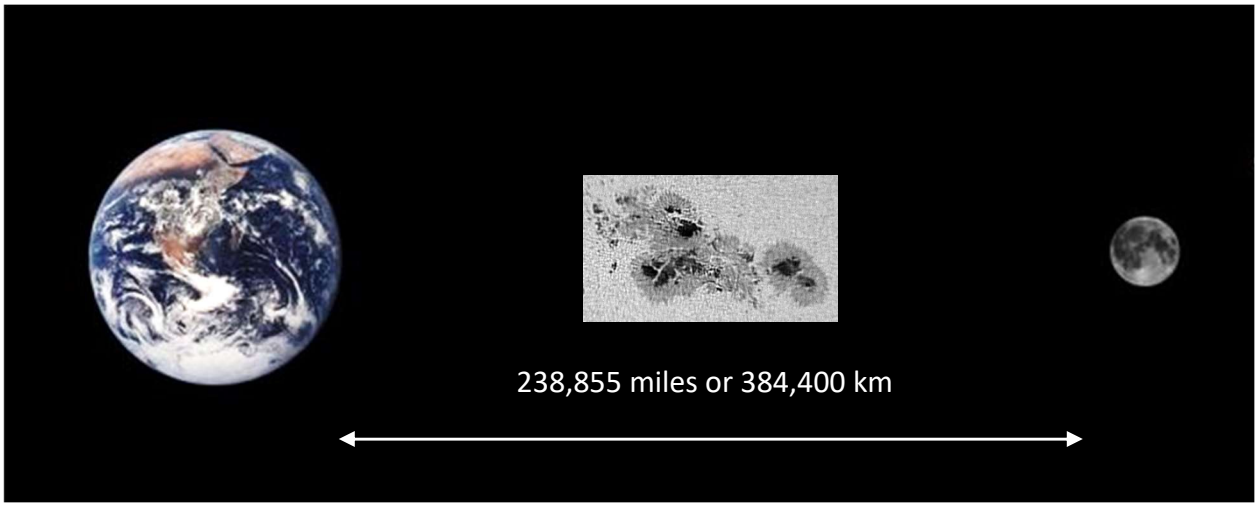


Photo: Bill Cloutier

Details of sunspot AR3014 captured with the McCarthy Observatory's 4-1/4 inch antique refractor through a solar filter. The span of the sunspot was equivalent to a third of the average distance between the Earth and the Moon.

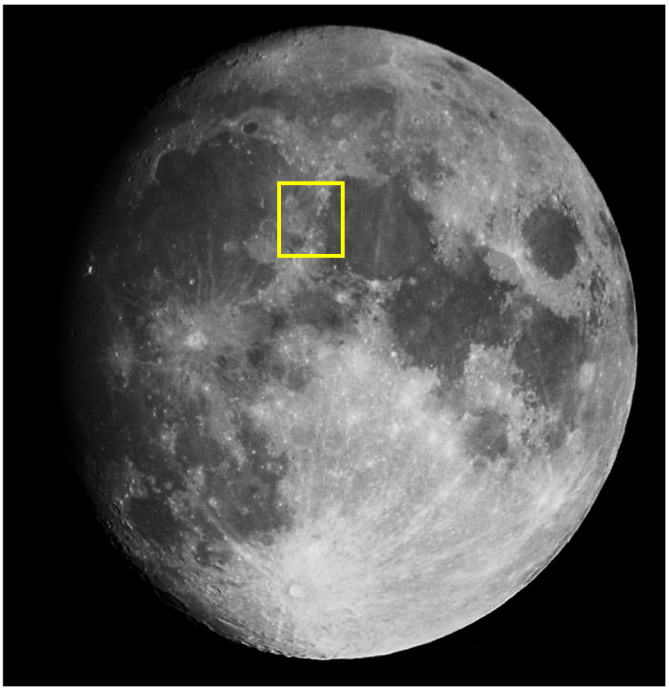


In This Issue

"Out the Window on Your Left"

It's been 53 years since Neil Armstrong first stepped onto the moon's surface and almost 50 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).

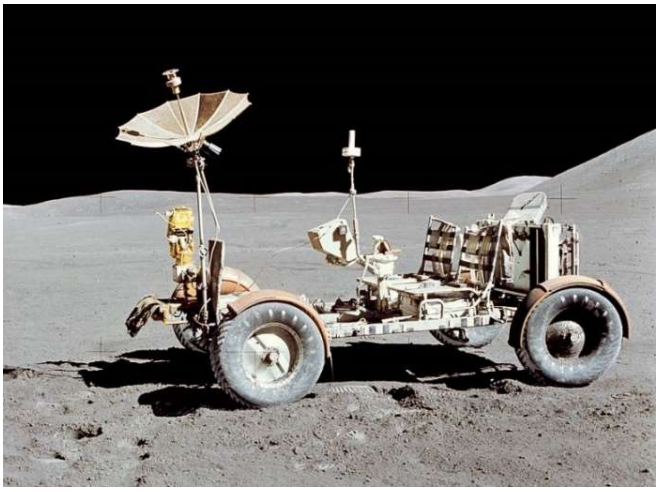
The lunar Apennine mountains cast dark shadows across the Moon's ancient lava plains in this month's image. The mountain range was formed in the impact that created the Imbrium basin 3.85 billion years ago and are part of the crater's rim crest.



Location of the Apollo 15's 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).

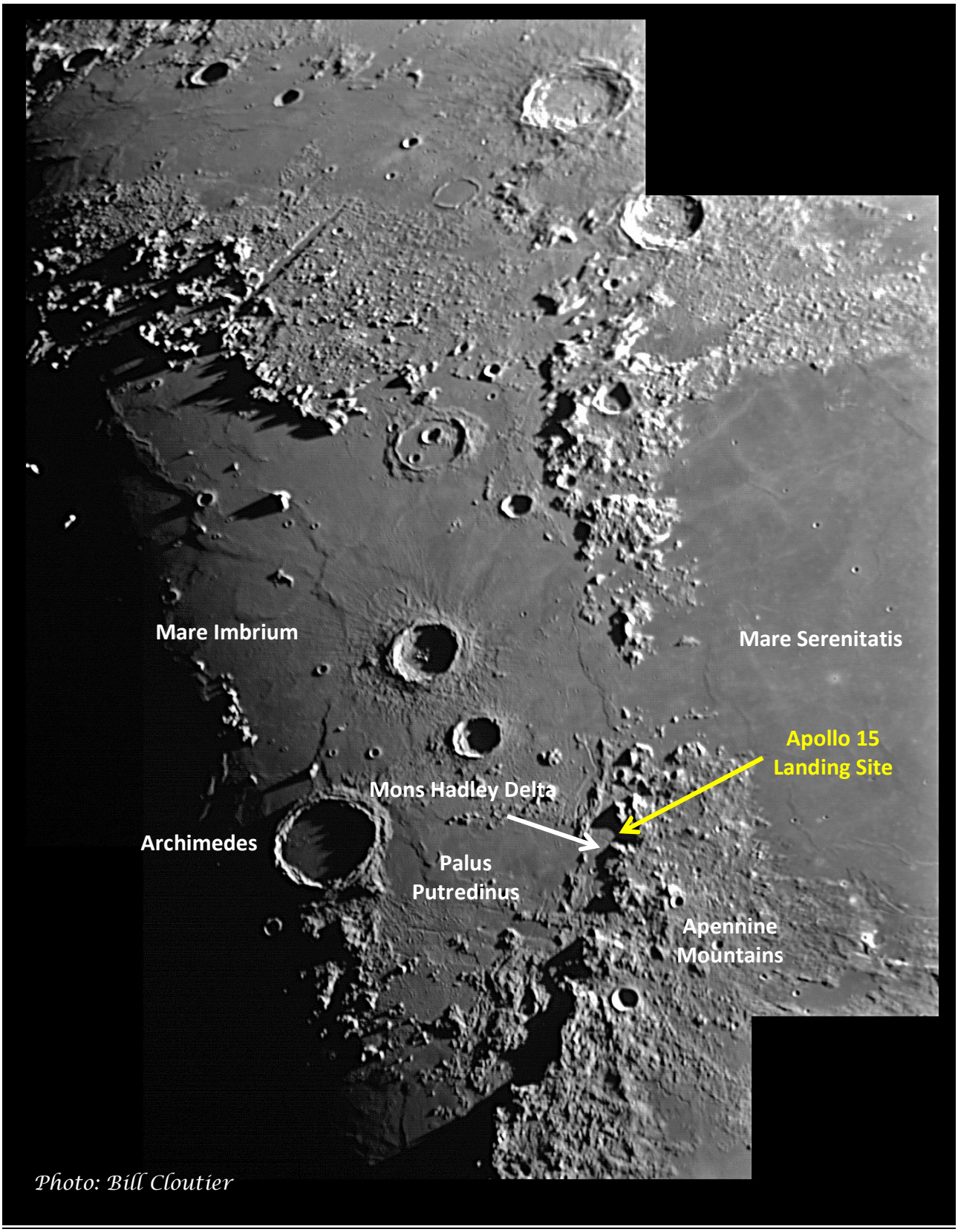
The site was selected with two main geology objectives – search for samples of the Moon's early crust (in the form of anorthosites) and investigate the nearby rille. Over the 18 hours and 37 minutes working on the lunar surface, astronauts Scott and Irwin were able to collect 370 individual rock and 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 more than 4 billion years old. Traces of hydroxyl (water-forming element) have been detected within the rock's crystalline structure, raising questions as to its origin. The astronauts also returned the first deep drill core and first sample of pyroclastic glass from eariler fire-fountain eruptions.



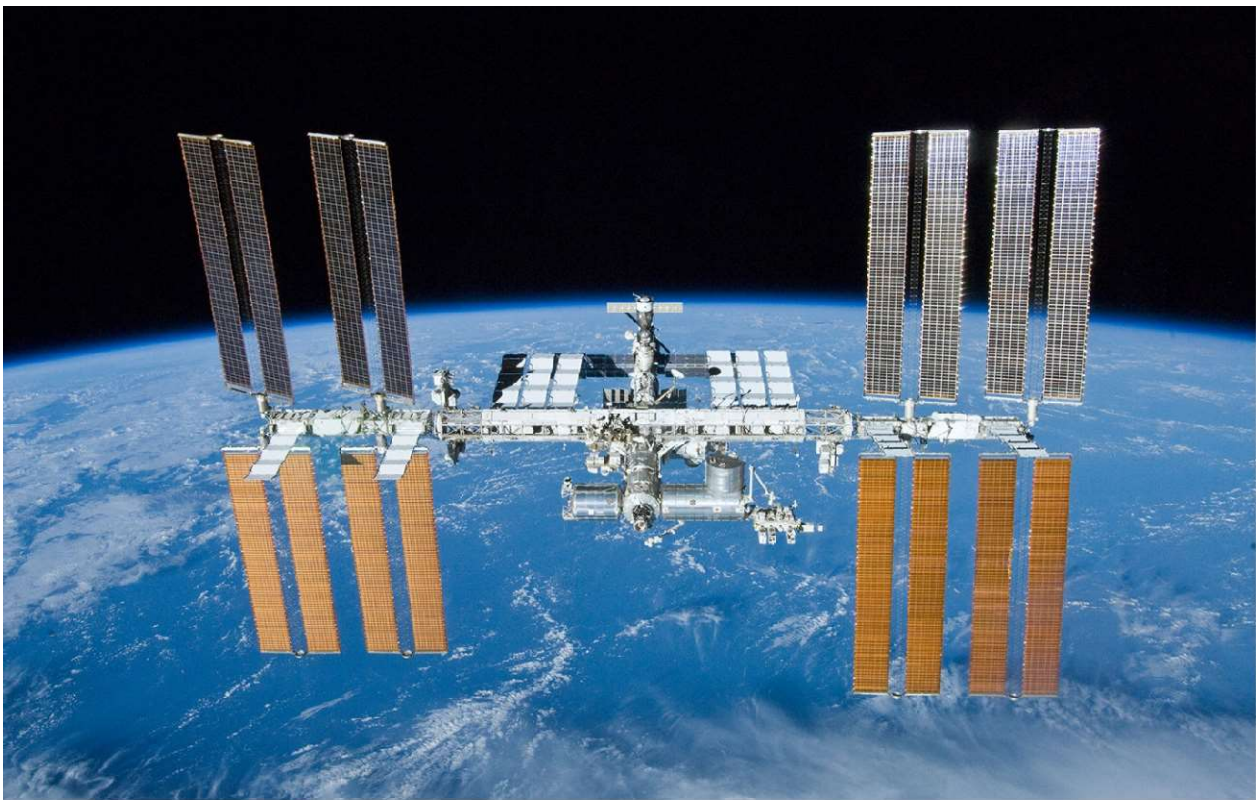
Lunar Roving Vehicle
NASA Photo

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.

Hadley-Apennine Landing Site



STS-114: Return to Flight



NASA image of the International Space Station assembly progress as of December 2002 and its final configuration in 2011 at the conclusion of the space shuttle program

The International Space Station (ISS) was the largest orbiting construction project undertaken with a mass of 905,000 pounds (410,501 kg) and a pressurized volume of approximately 32,333 cubic feet (916 m^3). Assembly required 5 Russian launches and 36 U.S. space shuttle flights. The first component (the Functional Cargo Block or Zarya module) was launched on a Russian Proton rocket in November 1998. It was joined a month later by the U.S. Pressurized Mating Adapter (Unity module), which was delivered by the space shuttle Endeavour.

By November 2002, 11 shuttle flights had delivered the large truss sections that form the backbone of the station, docking ports, a remote manipulator, and the first of four pair of solar arrays. However, with the loss of the Columbia orbiter on February 1, 2003, it would be more than two years before another shuttle would visit the ISS and continue the assembly process.

The Columbia accident was the death knell for the shuttle program – a program that had become too costly and dangerous to continue. However, ISS assembly (which was supported by an international consortium) couldn't be completed without the shuttle's cargo-carrying capacity. In a January 2004 address on space policy, President Bush announced that the "shuttle's chief purpose over the next several years will be to help finish assembly" of the ISS, at which time it would be retired.

After two and a half years of investigation, detailed inspections of the space transportation system's components, and implementing numerous safety improvements, the space shuttle flew again on July 26, 2005. STS-114 was the second "Return to Flight" mission flown by the space shuttle Discovery and was commanded by Eileen Collins (who had also commanded the STS-93 mission). Seventeen years earlier, Discovery had flown the first "Return to Flight" mission, STS-26, after the loss of the orbiter Challenger. The success of the STS-114 mission was critical to future of the ISS and not without challenges, including a bird strike, foam loss from the external tank and protruding gap fillers between several of the underside tiles. While it would be more than a year between STS-114 and the next mission (STS-115), as NASA struggled to find a solution to the foam loss, the remaining fleet of three shuttles would eventually finish the assembly of the ISS with the final flight in July 2011 (STS-135).

STS-114 would conclude its 14-day mission on August 9, 2005, landing at Edwards Air Force Base in California. Discovery's main gear touched down on Runway 22 at 5:11:36 AM PDT. The orbiter rolled down the runway for about a minute (1.5 miles or 2.4 km) after traveling a total distance of 5.8 million miles (9.3 million km).

The orbiters have 4 main gear tires (two pairs). The left main outboard tire from STS-114 is on display at the McCarthy Observatory. The 34-ply tire was acquired in 2012 through the Federal Disposition of Surplus NASA Artifacts program. The tire is complete with rim and mounted such that the rear assembly is accessible for viewing.

Sunrise at Edwards Air Force Base, California, after the nighttime landing of the space shuttle Discovery. Fifty-four operational space shuttle missions landed at Edwards, the prime backup site when the runway at the Kennedy Space Center was not available, typically due to dynamic weather conditions. The left main outboard tire from the STS-114 orbiter now resides at the McCarthy Observatory. Photo credit: NASA

Webb Hit by Micrometeorite

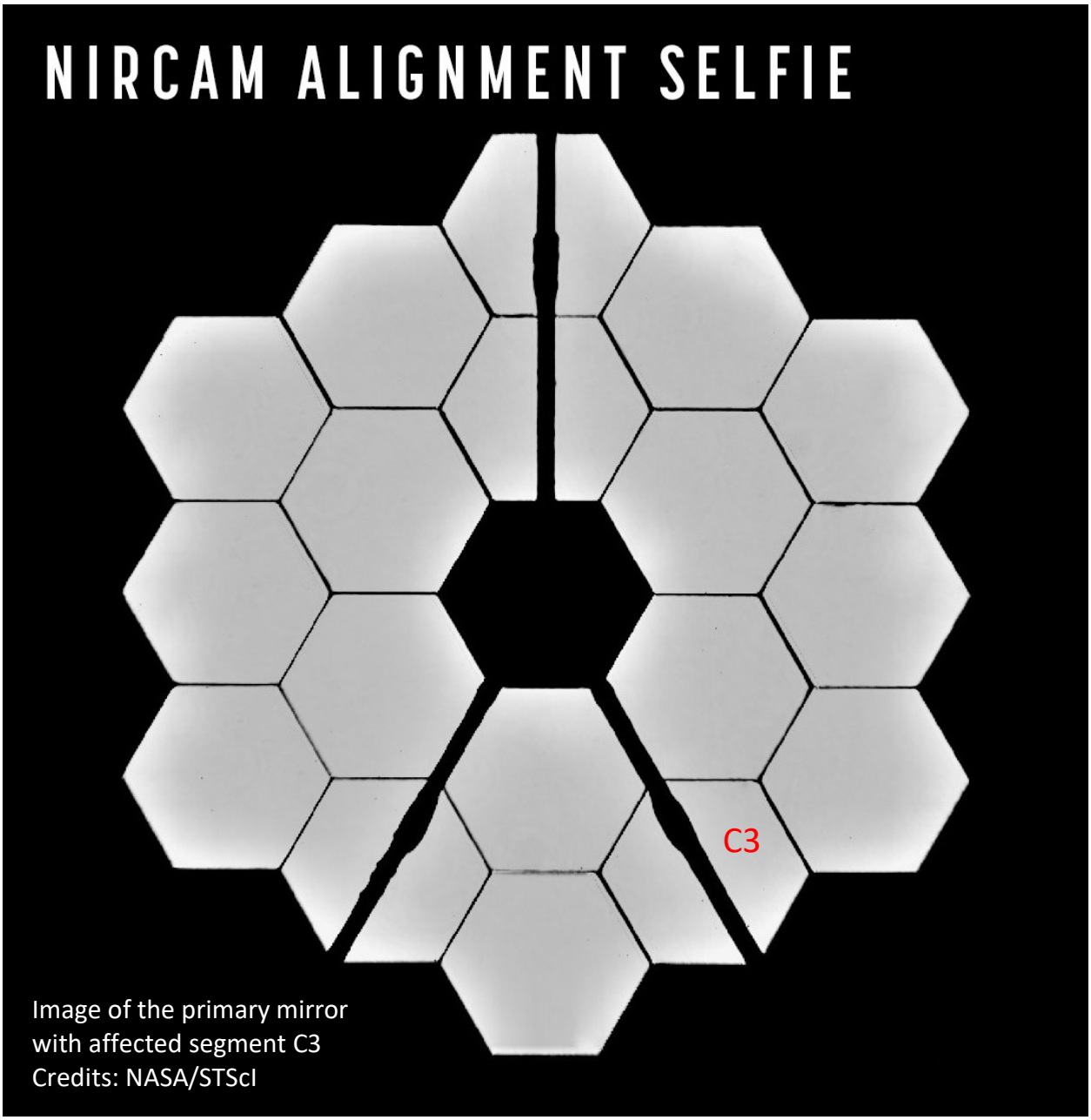
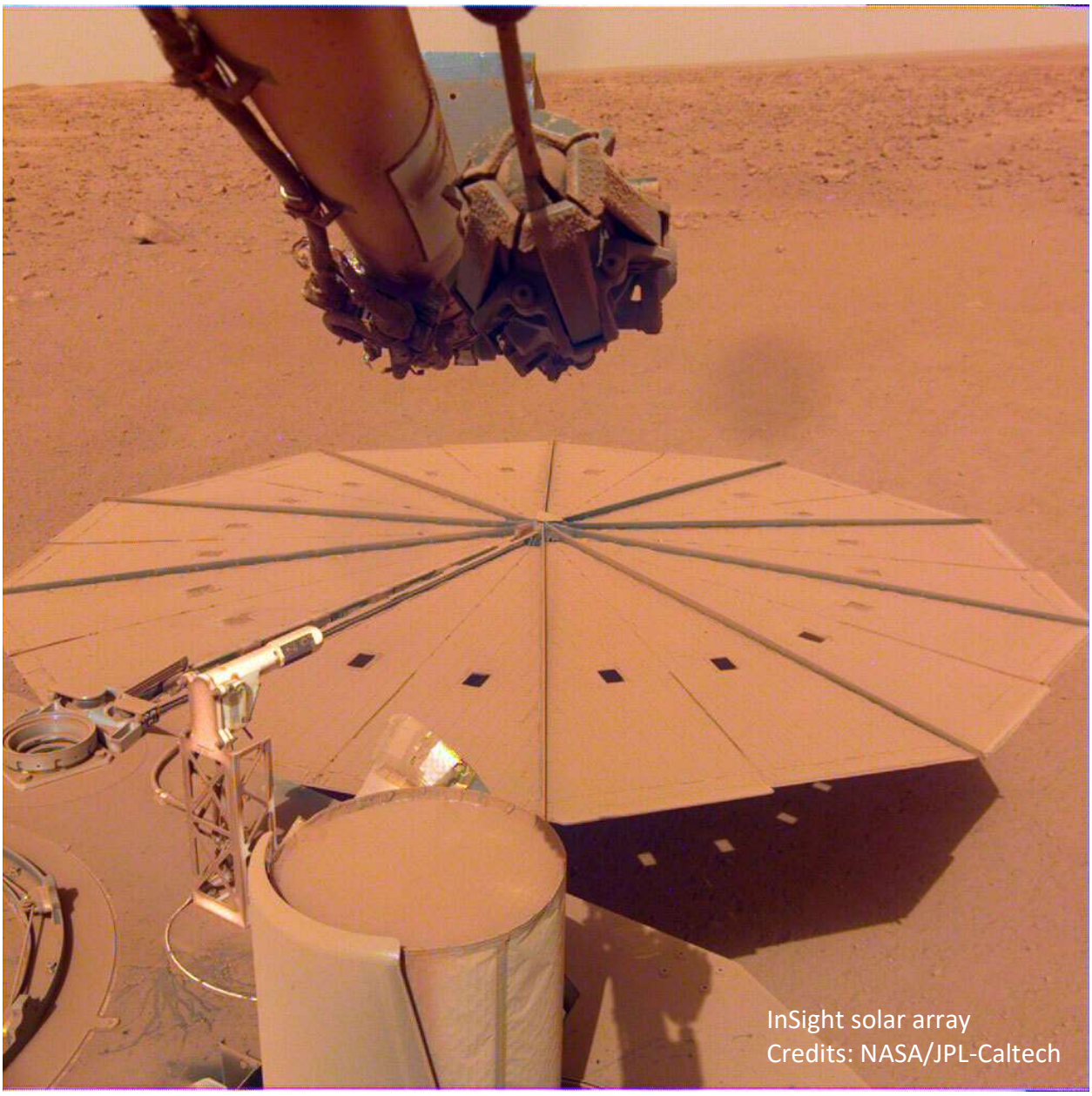


Image of the primary mirror with affected segment C3
Credits: NASA/STScI

NASA's James Webb Space Telescope, which has been orbiting the Lagrange L2 point about a million miles (1.6 million km) from Earth since February, has been hit by several micrometeoroids (a total of five measurable strikes) in its short life. The main 6.5-meter mirror, comprised of the 18 beryllium-gold segments, was designed to survive impacts with small dust particles without degrading its performance and the telescope can be moved to avoid known hazards such as meteor showers, but the impact that occurred sometime between May 23rd and 25th was larger than had been modeled in the telescope's design.

Engineers have already started making small adjustments to the affected C3 segment of the infrared telescope to mitigate any effects from the impact. This is a process that will be repeated throughout the mission – a consequence of operating in the relatively unknown environment of deep space.

InSight's Last Selfie



NASA's InSight mission is coming to an end. The lander's dust ladened 7 foot wide (2.2 meter) solar panels are now producing 500 watt-hours each sol compared to the 5,000 when they landed in November 2018 (enough to power an electric oven for just 10 minutes today vs. an hour and 40 minutes at landing). Science operations, with winter approaching and the amount of dust in the atmosphere increasing, are becoming more challenging with power levels nearing critical levels.

InSight took its final selfie on April 24th, its 1,211th Martian day of the mission. The lander's robotic arm was used to take several images from multiple angles to create the selfie. After the photo, the robotic arm was put in its resting position (called the "retirement pose") for the last time. The original plan was for the seismometer to run intermittently to conserve power, but the mission team has now decided to operate the seismometer on a full-time basis, even though it might end the mission sooner by depleting the lander's batteries, to maximize science return.

Ingenuity Helicopter Lives to Fly Again

NASA's Ingenuity helicopter captured by the Perseverance rover's Mastcam-Z instrument
Credits: NASA/JPL-Caltech/ASU/MSSS.

Flying on Mars is becoming increasingly difficult for the diminutive helicopter. Added to the Mars 2020 mission as a demonstration, with a 30-day window in which to establish that flight was even possible in the rarified Martian atmosphere, Ingenuity is still operational after more than 14 months on the surface. The unexpected success of the helicopter during its early test flights led NASA to extend its mission and repurpose Ingenuity as a scout for the rover Perseverance.

Being solar powered, the helicopter's ability to recharge its tiny lithium batteries is lessened by the dust accumulating on its solar panel, as well as the atmosphere's deteriorating opacity. Ingenuity was deployed onto the surface in the Martian Spring with a clean panel and clear skies. Winter is now approaching with colder temperatures and dust-laden skies.

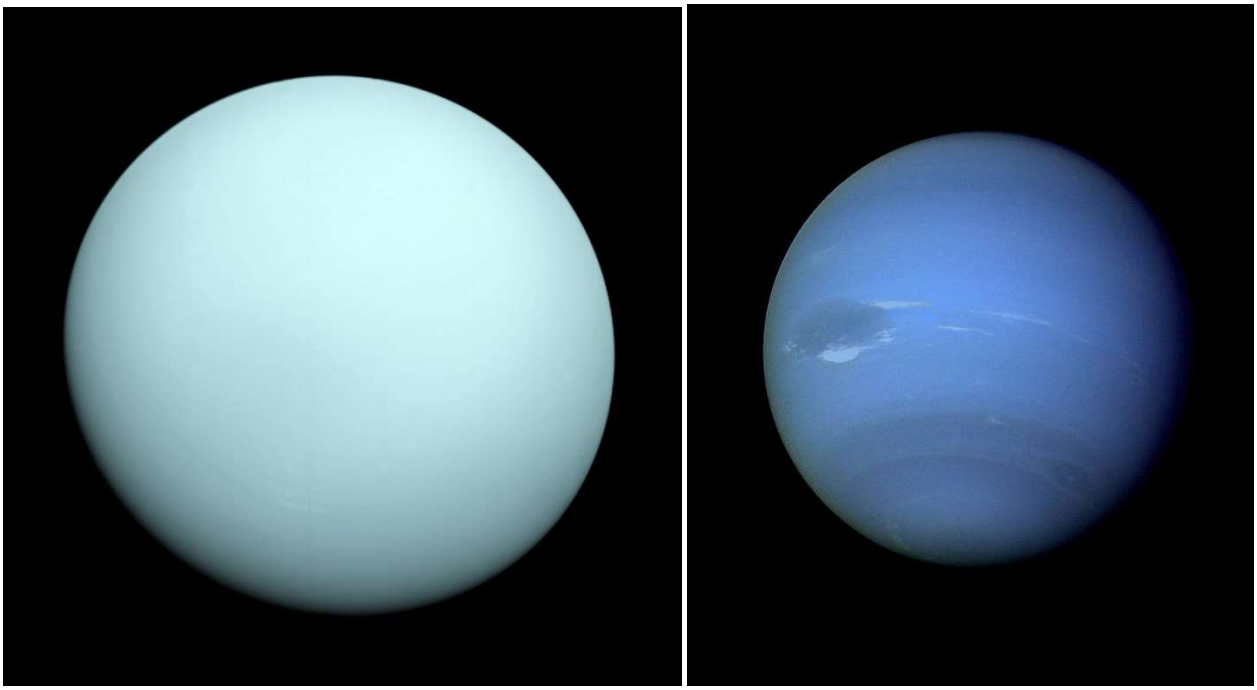
In early May the helicopter lost contact with the rover (used to communicate with Earth). Engineers believe that Ingenuity's internal clock reset after entering a depleted power state due to a low overnight temperatures and battery levels. Contact was reestablished two days later after NASA shut down rover operations so that it could listen for Ingenuity's call. Return to flight was further delayed when engineers had to develop a work-around for one of the helicopter's navigation sensors, called the inclinometer, which has stopped working. However, built to fly, the little rotor craft took to the Martian skies again on June 11th, after more than a month of inactivity, and flew a successful 29th sortie to reposition itself closer to the rover. Ingenuity has now flown 23,256 feet (7,088 meters) with almost an hour of total flight time.

Mercury Flyby

A monitoring camera on ESA's BepiColombo spacecraft captured several black-and-white images of the innermost planet during a June 23rd flyby. The high-speed pass of Mercury, the second of six planned, was designed to decrease the spacecraft's velocity, setting up an orbital capture in 2025. June's flyby reduced BepiColombo's velocity by about 2,900 mph (1.3 kps) relative to the Sun. While gravity assists are used to increase velocity on missions to the outer planets, they are also used to shed velocity for missions to the inner planets and the Sun.

BepiColombo is a joint project between the European Space Agency (ESA) and the Japan Aerospace Exploration Agency (JAXA). The spacecraft is comprised of two separate vehicles – ESA's Mercury Planetary Orbiter and JAXA's Mercury Magnetospheric Orbiter, stacked on a propulsion or transfer module. This module will be jettisoned shortly before the spacecraft arrives at Mercury, with the two orbiters using onboard thrusters to move into their science trajectories.

Ice Giants



Images of Uranus (left) and Neptune (right) captured by the Voyager 2 spacecraft during flybys in 1986 and 1989, respectively.
Credits: NASA/JPL

The ice giants Uranus and Neptune are similar in composition but not in appearance with Neptune being a deeper blue as compared to the lighter greenish hue of Uranus. Both planets have an outer atmosphere primarily composed of hydrogen and helium, along with "ices" such as water, ammonia, methane, and traces of other hydrocarbons.

An international team led by Patrick Irwin, Professor of Planetary Physics at Oxford University, created a model of the aerosol layers in the atmospheres of the two ice giants that, they believe, offers clues to the visual dissimilarity. While both planets have a layer of concentrated haze, the modeling suggests a thicker layer in the atmosphere of Uranus.

The “haze” is attributed to a methane snow, created as methane ice condenses onto particles in the middle layer of the atmosphere. Neptune’s atmosphere appears to be more efficient at removing the haze which contributes to the “whitening" of Uranus’ appearance. Without the haze, it is believed that Uranus and Neptune would be similar in appearance.

A Uranus orbiter and atmospheric probe have been recommended as a flagship priority for the next ten years in the Academy of Sciences, Engineering and Medicine’s most recently released decadal survey, prepared at the request of NASA. The mission could answer many of the questions about this most intriguing world with its extreme axial tilt, complex magnetic field, active atmosphere and low internal energy (Uranus while closer to the Sun is colder than Neptune). Solar system formation theories, based upon simulations of conditions within the solar nebula (disk of gas and dust surrounding our primordial sun) indicate that Uranus and Neptune formed significantly closer to the protosun than their current locations and likely swapped positions early on.

Orbital Debris – An Increasing Threat

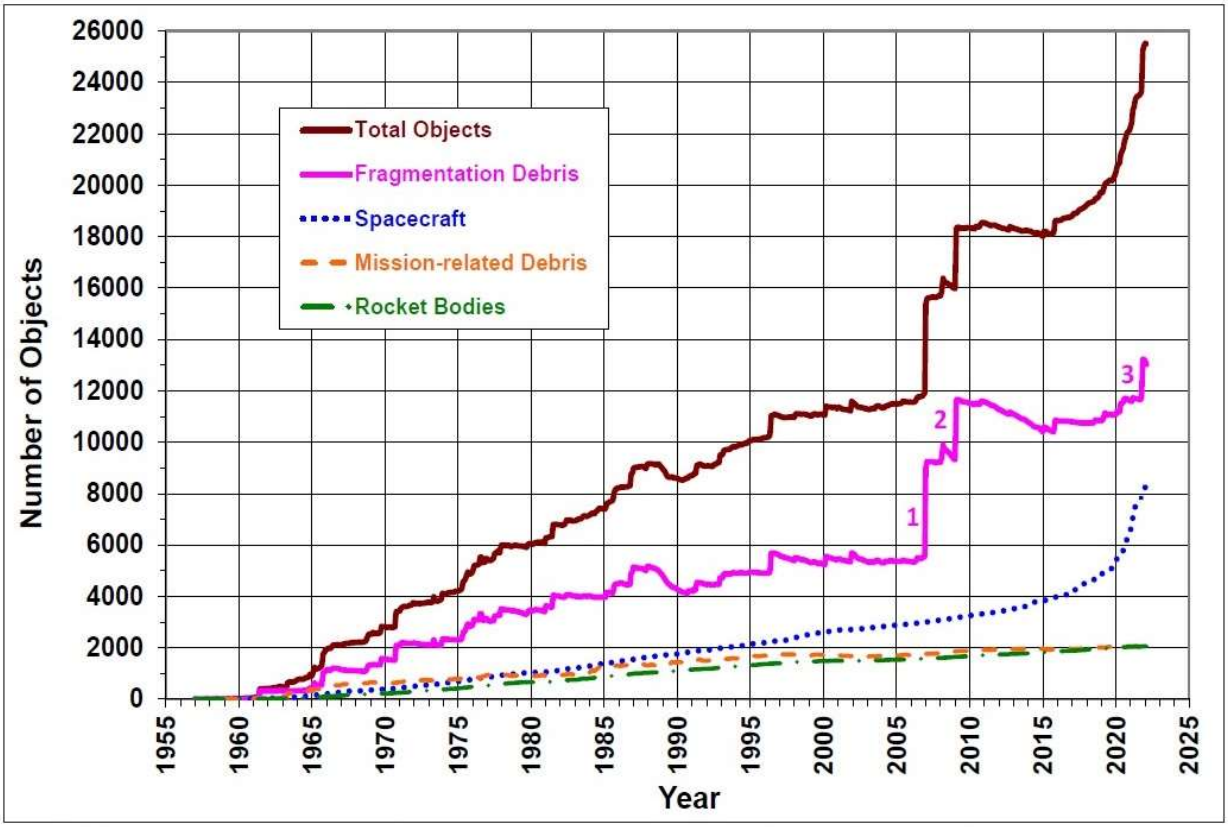


Figure 4. Historical increase of the cataloged objects based on data available on 1 March 2022. The three upward jumps in fragmentation debris correspond to (1) the ASAT test conducted by China in 2007, (2) the accidental collision between Iridium 33 and Cosmos 2251 in 2009, and (3) the ASAT test conducted by the Russian Federation in November 2021. More Cosmos 1408 fragments are expected to the added to the catalog in the coming weeks and months.

The intentional and catastrophic destruction of satellites as a means of testing anti-satellite weapons by both China (2007) and Russia (2021) have greatly increased the debris in low-Earth orbit. The debris presents a hazard to operators of other spacecraft, as well as the occupants of the ISS.

Diagrams from "Orbital Debris, Quarterly News," Volume 26, Issue 1, March 2022

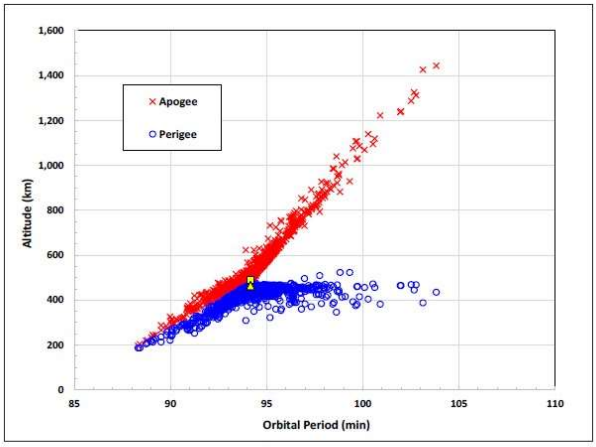
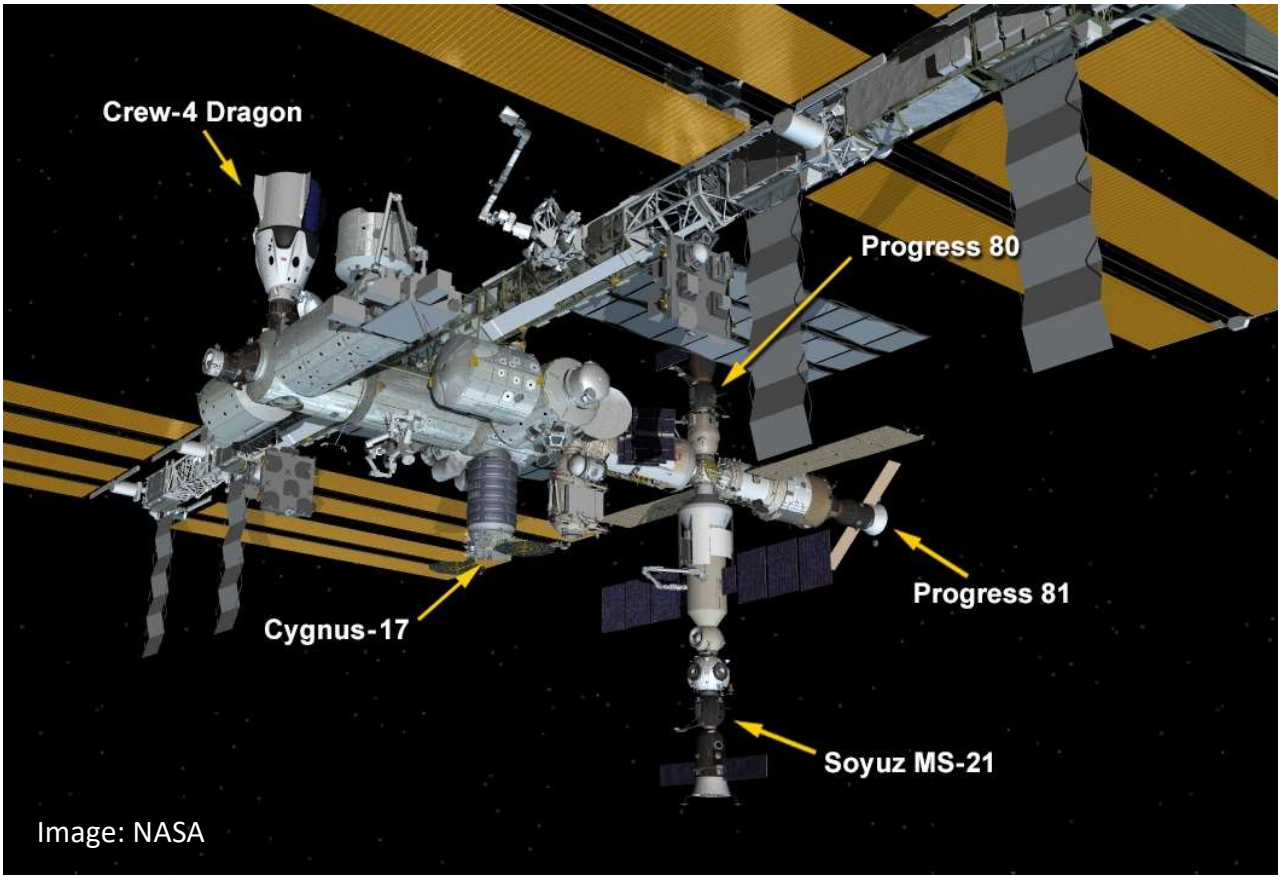


Figure 2. Gabbard diagram of the cataloged Cosmos 1408 fragments. Approximate epoch is 17 January 2022. The apogee (yellow square) and perigee (yellow triangle) altitudes of the parent object, Cosmos 1408, at the time of the breakup are also shown.

Russia's destruction of its derelict Cosmos 1408 satellite produced more than 1500 pieces of large, trackable fragments. Some of the fragments reached an altitude as high as 900 miles (1,440 km).

While the ISS has approximately 500 different impact shields, the station has conducted 31 collision avoidance maneuvers since 1999. While >90% of the Cosmos 1408 fragments are expected to reenter the Earth's atmosphere within 5 years, some fragments will remain in orbit much longer (in November 2021, the ISS was moved to avoid a fragment from the 2007 Chinese weapon's test). On average the impact speed of orbital debris with another object is approximately 22,400 mph (10 km/s), with velocities up to 33,500 mph (15 km/s).



Five spaceships were parked at the International Space Station (ISS) in early June including SpaceX's Crew Dragon Freedom, the Northrop Grumman Cygnus space freighter, Russia's Soyuz MS-21 crew ship, and the Russian Progress 80 and 81 resupply ships.

On June 16th, the docked Russian Progress 81 cargo-carrying spacecraft was remotely commanded to fire its thrusters for 4 minutes, 34 seconds in a Pre-Determined Debris Avoidance Maneuver (PDAM). The maneuver was designed to provide an additional margin of safety from a fragment of the Russian Cosmos 1408 debris.

NASA is currently evaluating an option to move the ISS with the Cygnus spacecraft. Unfortunately, a planned 5-minute test of the spacecraft's engine ended after only 5 seconds on June 20th. The cause of the abort is being investigated. Having a backup to the Russian spacecraft for periodic reboosts to counter orbital decay and avoidance maneuvers from debris has become a greater concern with Russia threatening to leave the international partnership.

While retests are being schedule for Cygnus, the spacecraft is not always available. The Northrop Grumman freighter is typically on station for 30 days and the time between resupply missions can be as long as months. By comparison, a Russian Progress spacecraft generally remains docked at the station until it is replaced by another Progress or crew-carrying Soyuz spacecraft (the image shows that there were three Russian spacecraft docked at the station in June).

Elon Musk, SpaceX's CEO, has indicated that his Dragon spacecraft should be capable of changing the station's orbit, if required, and with sufficient fuel reserves.

Commercial Crew Update

Boeing's Starliner approaches the ISS over the south Pacific before automatically docking to the Harmony module's forward port. Credit: NASA

Since the end of the space shuttle program in 2011, NASA had to rely on Russia to transport its astronauts to the ISS (a costly and now politically sensitive endeavor). NASA's Commercial Crew Program was established in 2010 as a partnership with the American aerospace industry to develop safe, reliable and cost-effective access to the ISS. In 2014, the agency selected SpaceX and Boeing to move forward with the development of their conceptual spacecraft, Crew Dragon and Starliner, respectively.

SpaceX's capsule was the first to be certified by NASA and has been shuttling crews to the ISS since 2020. Boeing has had a more challenging path, with its first uncrewed orbital flight test ending prematurely in December 2019 without reaching the station due to software anomalies. A retest in the summer of 2021 never left the launch pad when several valves in the propulsion system refused to open. After an eight-month stand-down to fully understand the problem, Boeing was able to get its Starliner off the ground and to the ISS in May 2022. The six-day test flight concluded with a parachute-assisted landing at White Sands Space Harbor in New Mexico. Despite a few glitches, Boeing accomplished all the planned test objectives and believes that it is ready to fly a crew on the vehicle on the next flight (two thrusters on the Starliner's service module failed during the orbital insertion burn and another two had to be shut down during the approach to the ISS, but the backup systems worked as expected, in both instances).

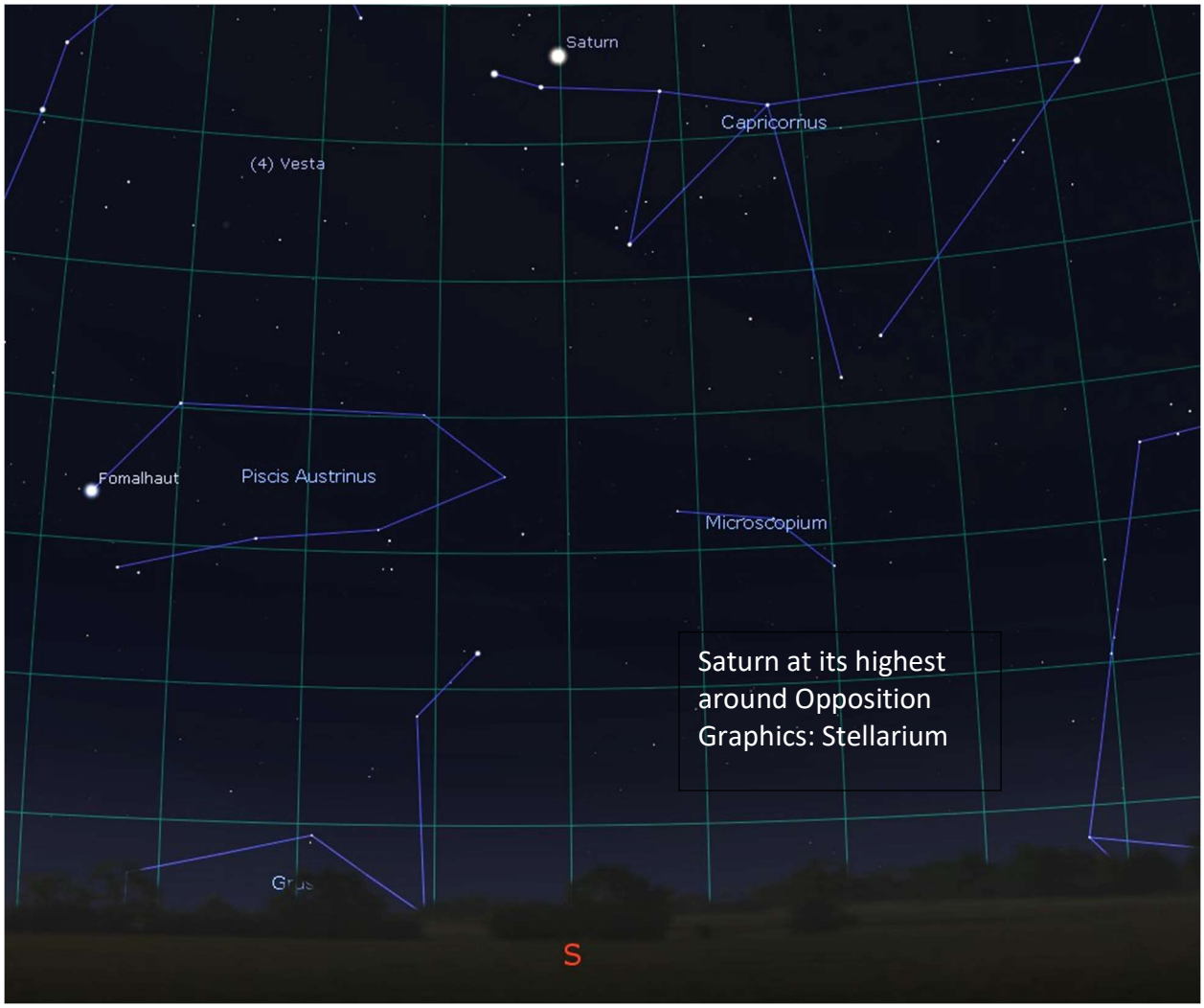
The Starliner will give NASA two options for crew transport. Expectations are for Boeing to fly a crewed mission sometime before the end of this year with NASA assigning astronauts Butch Wilmore as commander and Suni Williams as pilot.

Saturn at Opposition

The solar system's most picturesque gas giant, Saturn, reappears in the evening sky in July, rising almost two and half hours 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 ringed world is at its highest in the southern sky. During the summer months Saturn can be found in the constellation Capricornus.

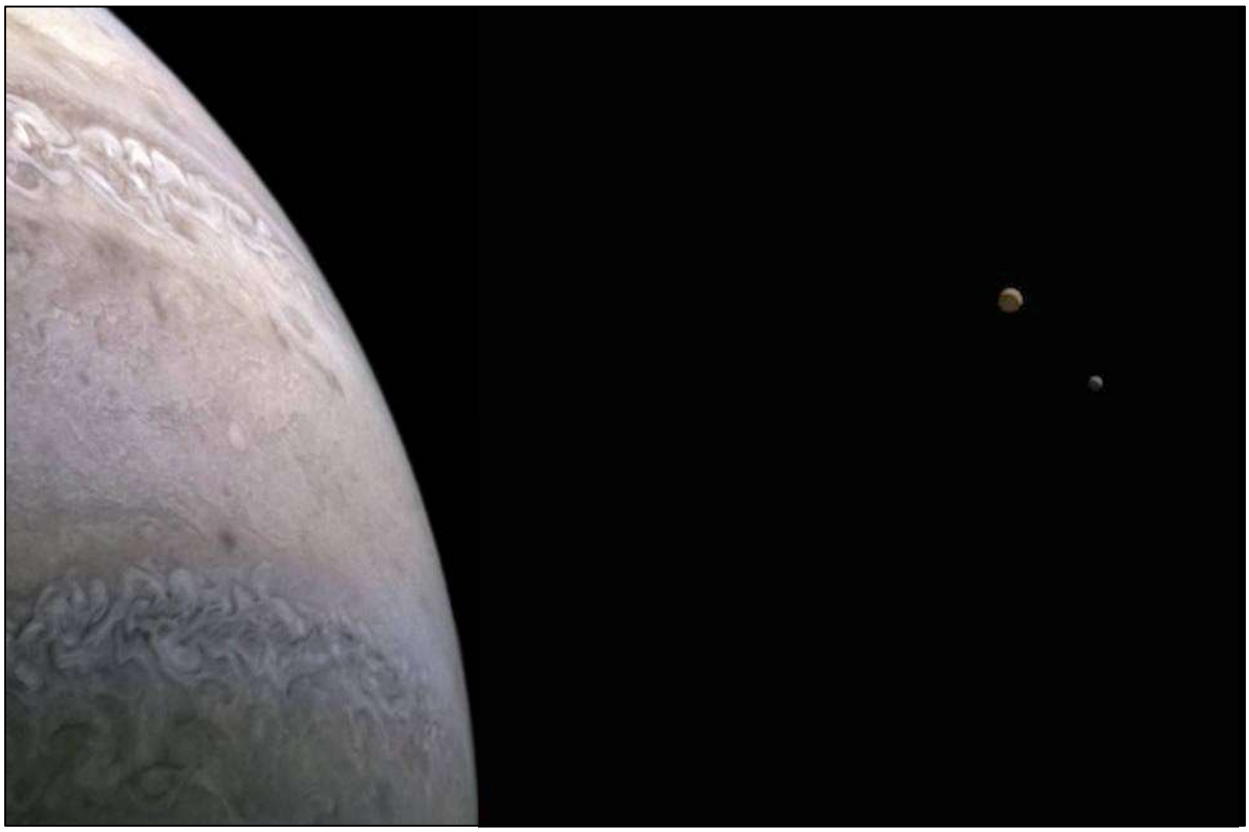
	Rise and Transit Times (EDT)					
	July 1		August 1		August 31	
	Rise	Transit	Rise	Transit	Rise	Transit
Saturn	10:52 pm	4:02 am	8:46 pm	1:53 am	6:42 pm	11:46 pm

Saturn will reach Opposition in August when its lie directly opposite the Sun (on August 14). On August 14, the ringed-planet will be 823 million miles (1,325 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 13° to our line of sight (less than their maximum inclination in 2017, but still a nice presentation). The ringed world will rise at 7:52 pm on that date and be highest in the sky about an hour after midnight.



Saturn at its highest around Opposition
Graphics: Stellarium

Galilean Moons Photobomb Jupiter



Credits: NASA/JPL-Caltech/SwRI/MSSS, Image processing by Andrea Luck

The JunoCam instrument on NASA's Juno spacecraft captured two of the Galilean moons during the 39th close flyby of the Jupiter. The spacecraft was traveling over the gas giant's southern hemisphere about 38,000 miles (61,000 km) above the cloud tops when Io and Europa appeared in the camera's field of view.

Io (left) is the solar system's most volcanic world. In Juno's extended mission, which is expected to continue through September 2025, the spacecraft is scheduled to make close flybys of Io in late 2023 and early 2024 – up to eleven before mission end. The flybys will provide an opportunity to study Io's polar volcanoes, search for evidence of a magma ocean, as well as the moon's interactions with Jupiter's magnetosphere.

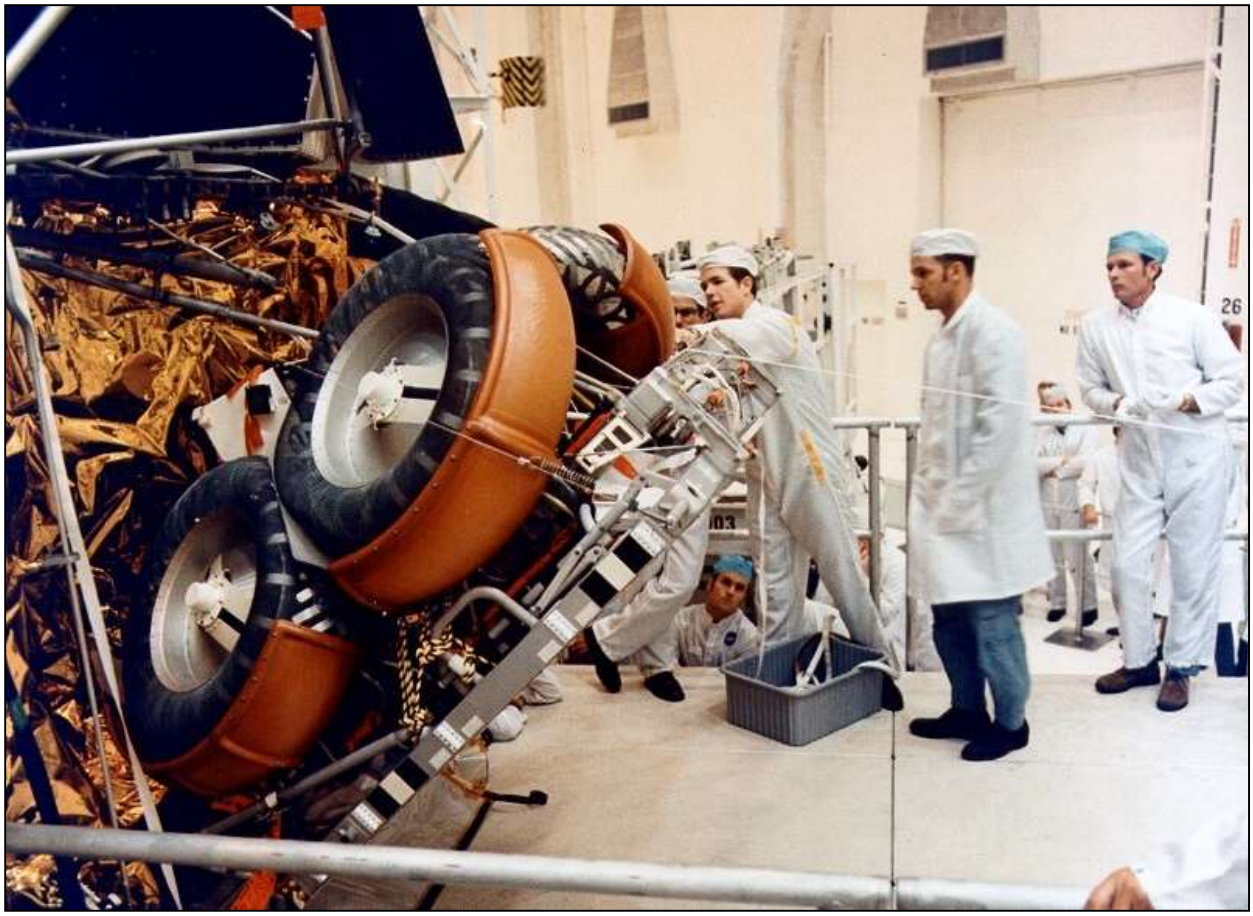
Europa (right) is the target of the upcoming Europa Clipper mission (as well as the European Space Agency's Jupiter Icy Moons Explorer or JUICE). Three encounters are possible, with the actual number of flybys budget dependent (two encounters are also possible for Ganymede). Europa is believed to have a global ocean beneath its icy shell, a prime target for astrobiology. Juno's visible and low-light cameras could be used to detect active plumes and any surface changes since the Galileo mission that might be associated with localized eruptions. Juno's Microwave Radiometer could also be used to study the upper layer of the moon's surface and any shallow pockets of water.

The option to visit the Galilean moons is possible because of a northern adjustment in the spacecraft's orbit being made to study Jupiter's polar cyclones. Io and Europa orbit within Jupiter's magnetosphere so the radiation levels encountered by the spacecraft will be of interest to the Clipper and JUICE projects.

First Wheeled Vehicle on Moon

Fifty-one 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. On June 1, 2022, ground was broken on a new 200,000 square foot, 20-story addition to the California Science Center (the Samuel Oschin Air and Space Center), where the tank will be joined to the solid rocket boosters and then to the orbiter as it was in preparation for launch. Construction is expected to be completed in about 3 years (2025).

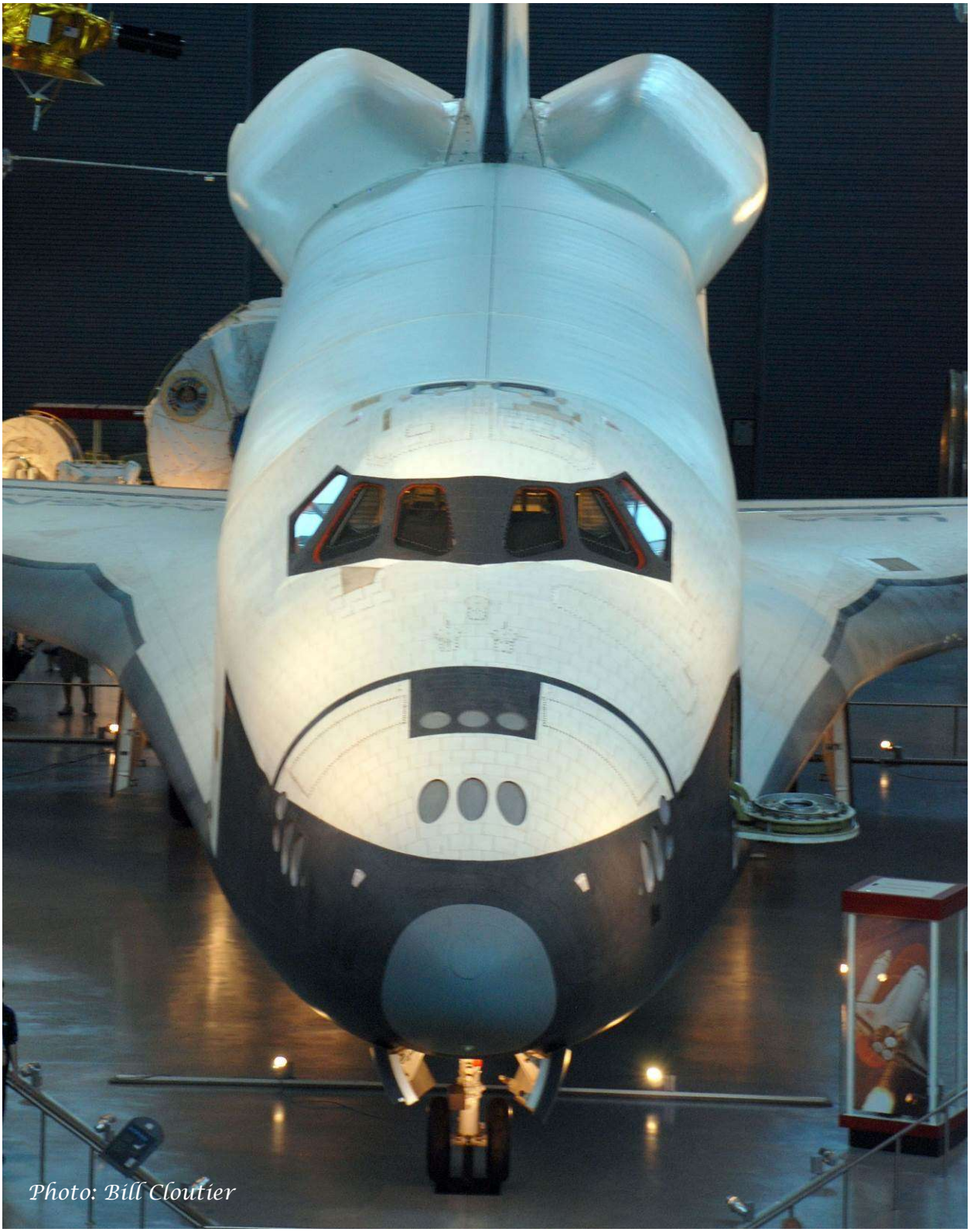
Atlantis

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

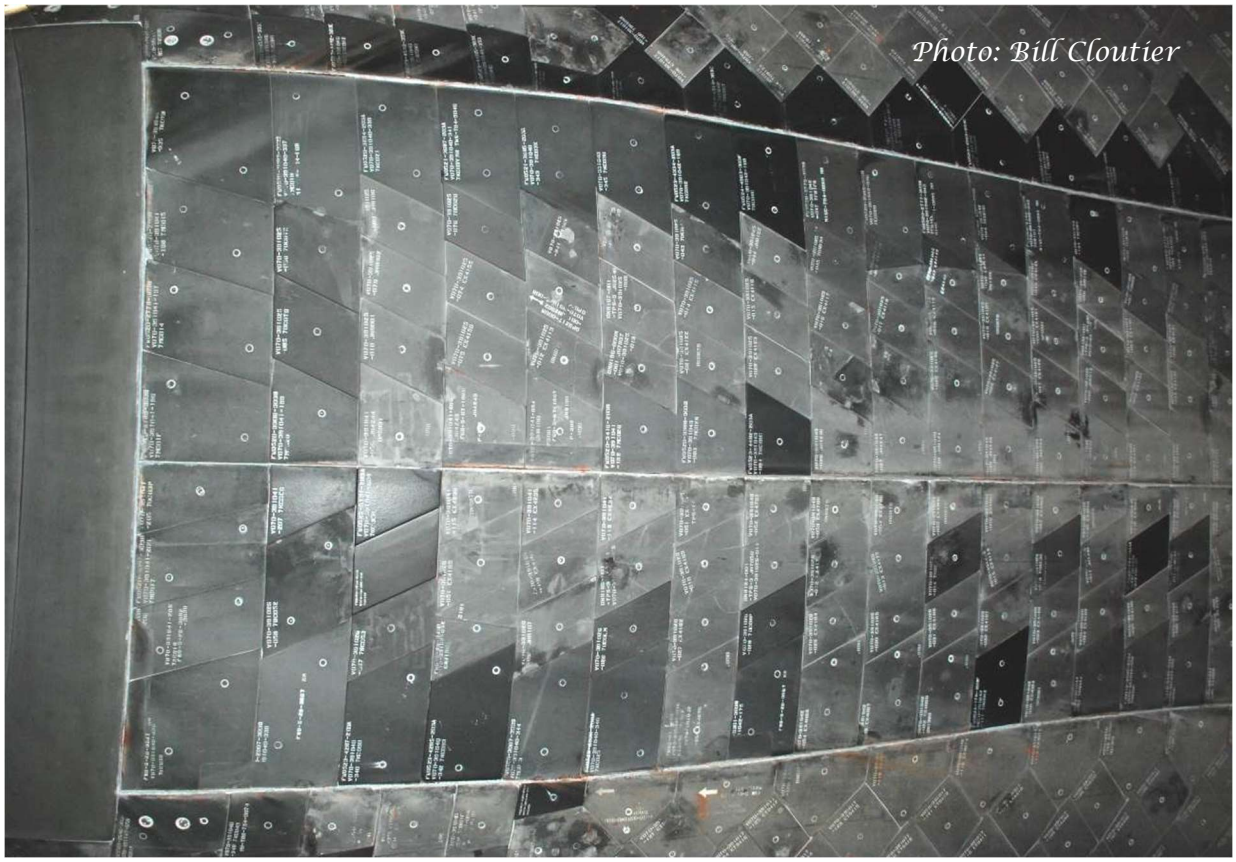


Photo: Bill Cloutier

Atlantis

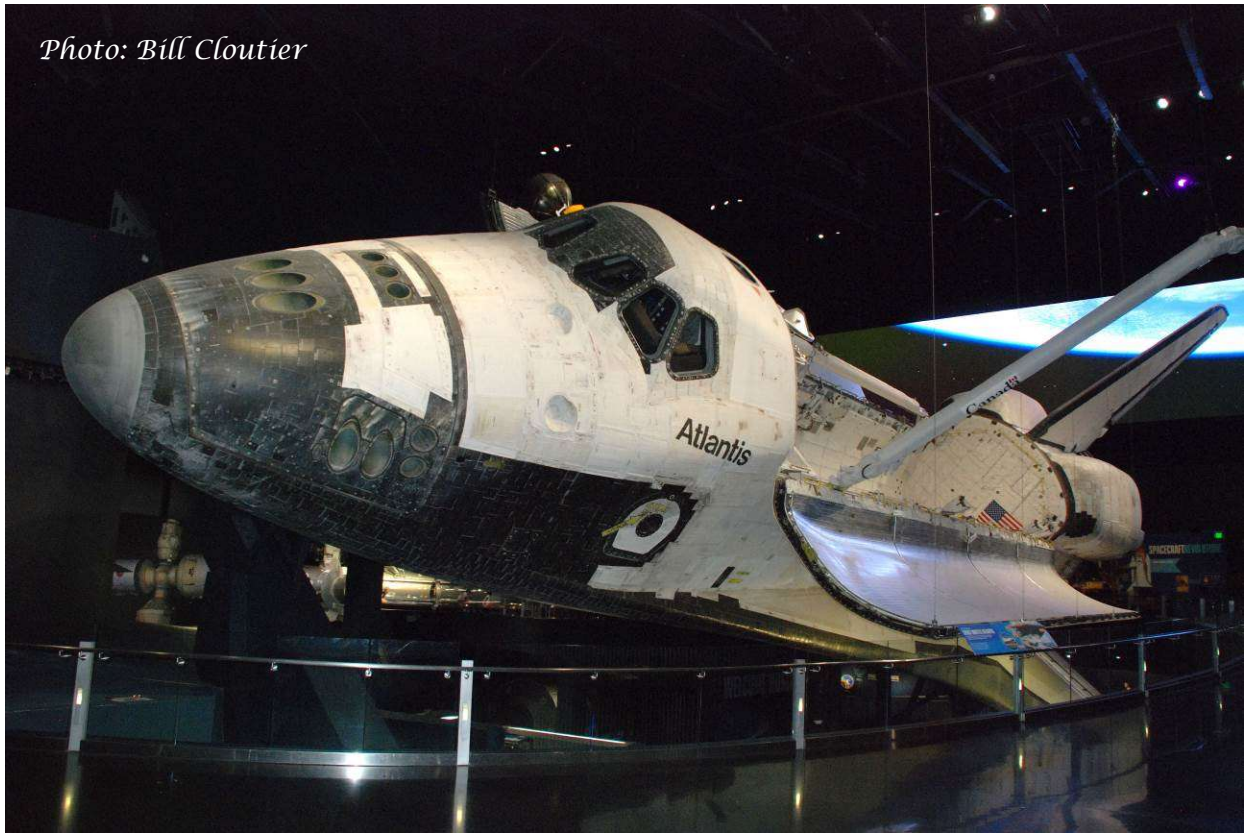
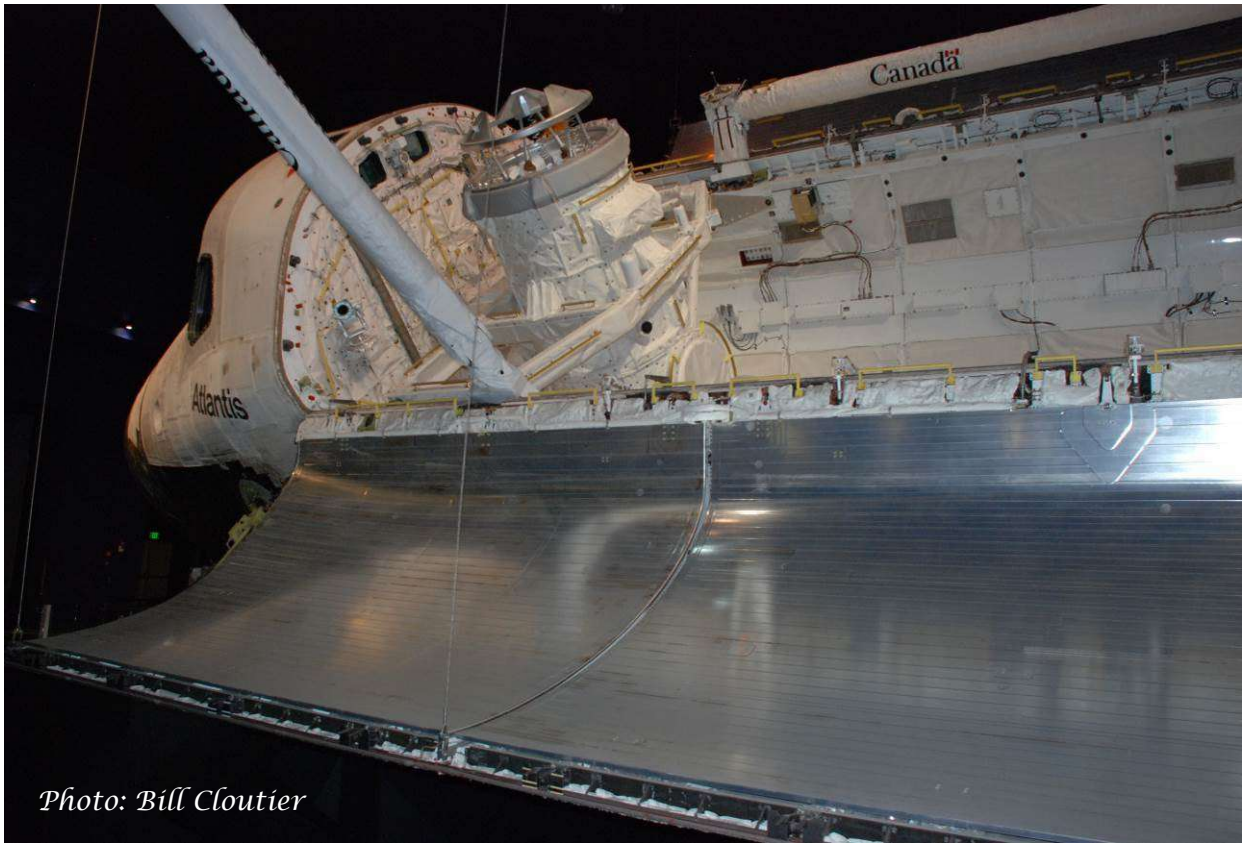


Photo: Bill Cloutier
Atlantis


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.

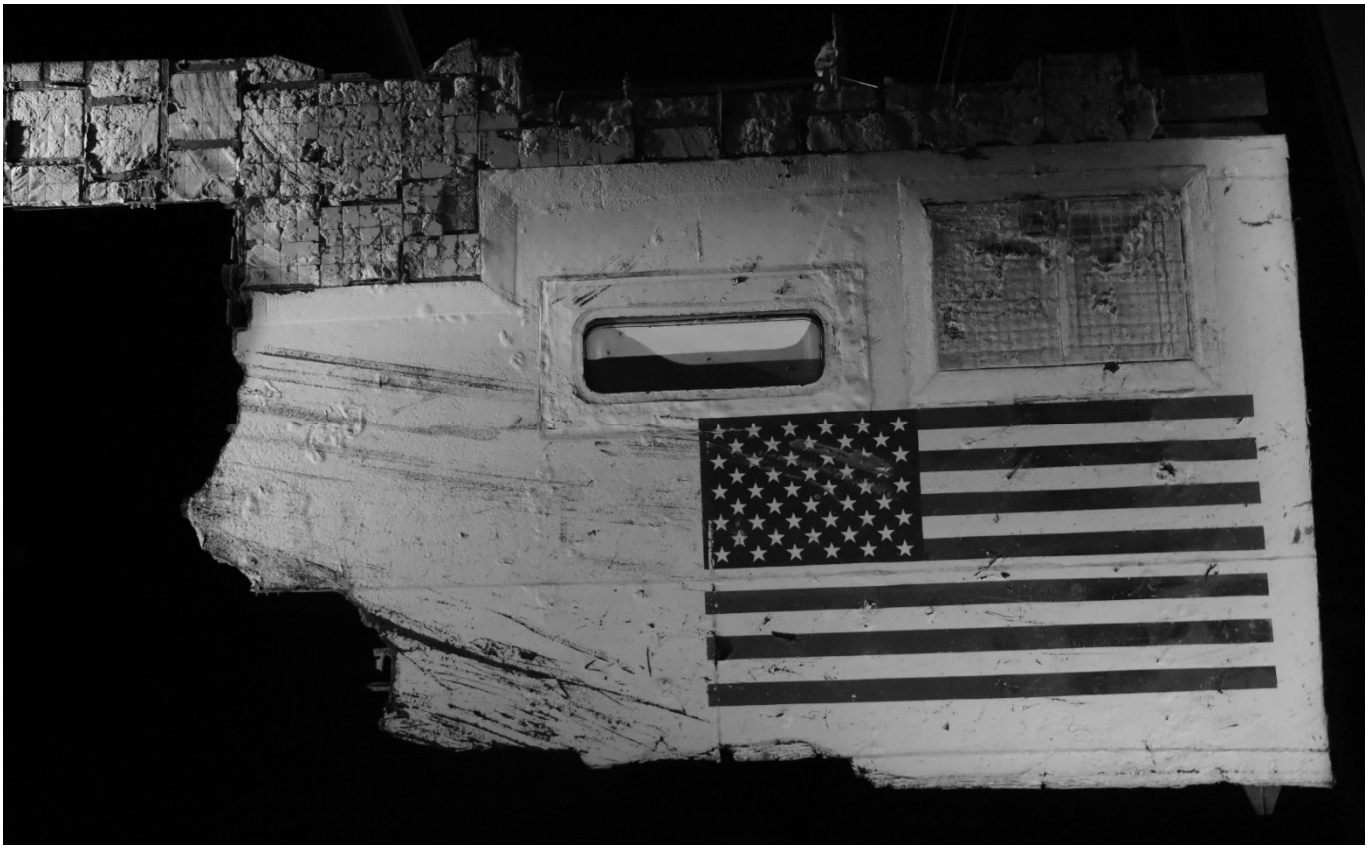
Challenger made her maiden voyage on April 4, 1983. That mission included the first spacewalk from an orbiter, as well as the deployment of the first satellite in the Tracking and Data Relay Satellite System (TDRSS) constellation. Several spacelabs were carried into orbit in Challenger's payload bay.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

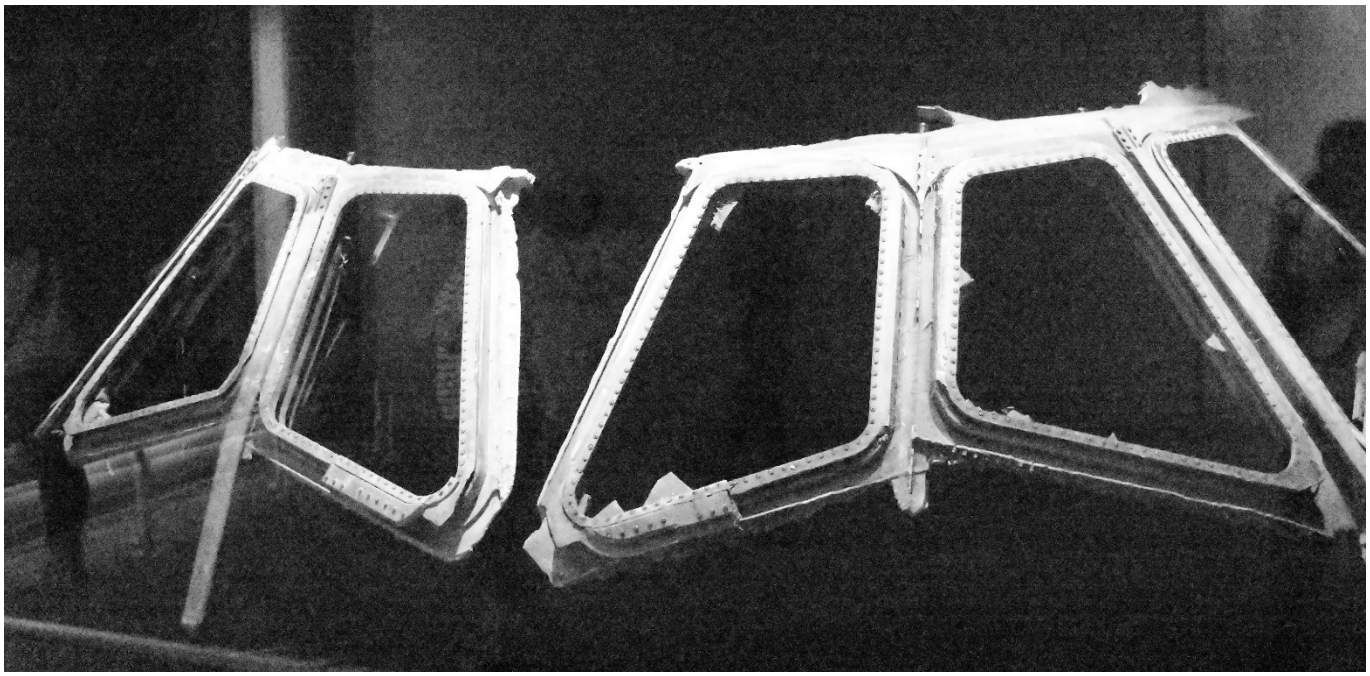
Challenger was the first orbiter to be launched at night and the first to land at the Kennedy Space Center (prior missions had landed at either the Edwards Air Force Base in California or at White Sands, New Mexico).

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:

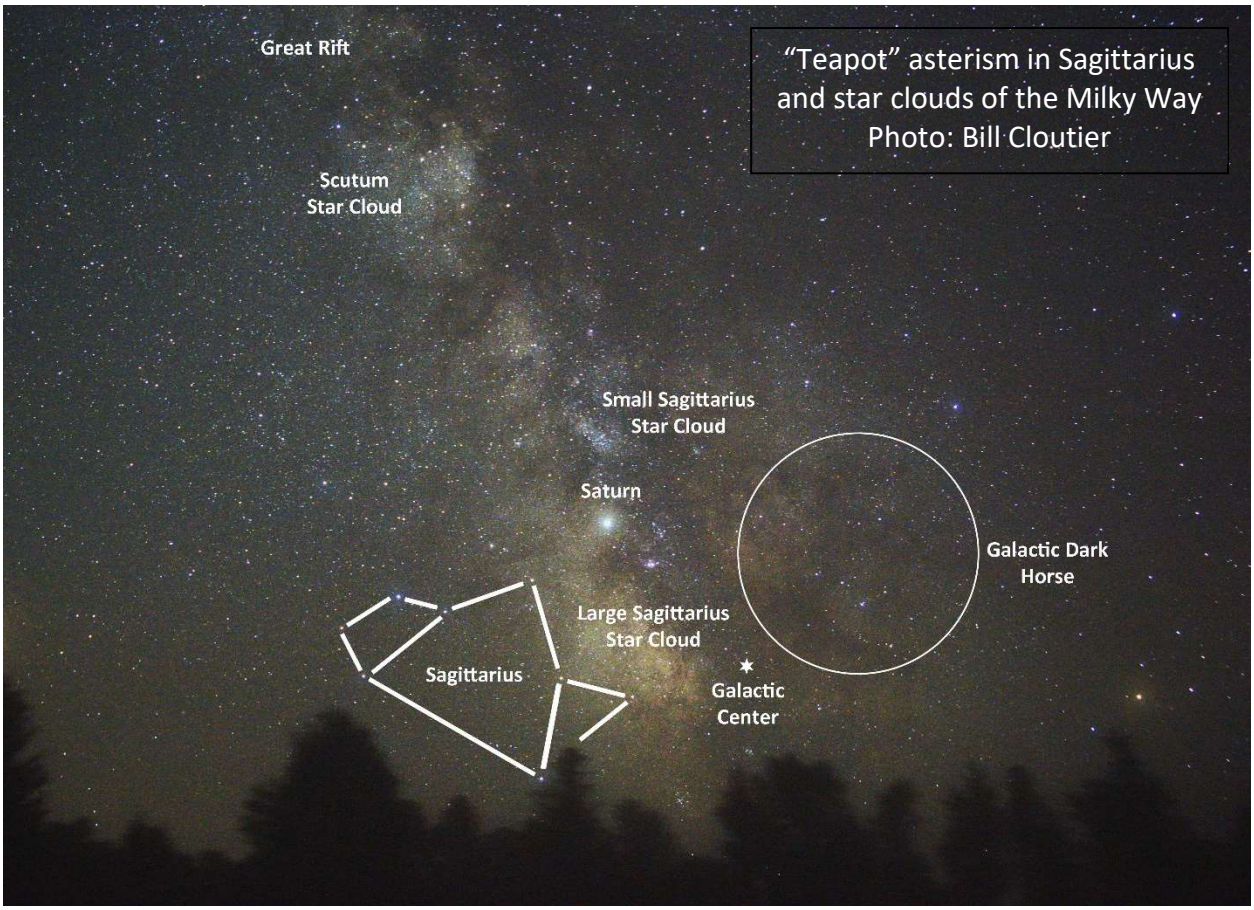
1. Spot the polar mesospheric clouds (also known as Noctilucent clouds or NLCs). These high-altitude clouds, seeded by meteoroid dust and comprised of water-ice crystals, form between 47 to 53 miles (76 to 85 km) above the Earth's surface, near the boundary of the mesosphere and thermosphere, a region 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. Unfortunately, a nearly full Moon this year will wash out all but the brightest meteors.

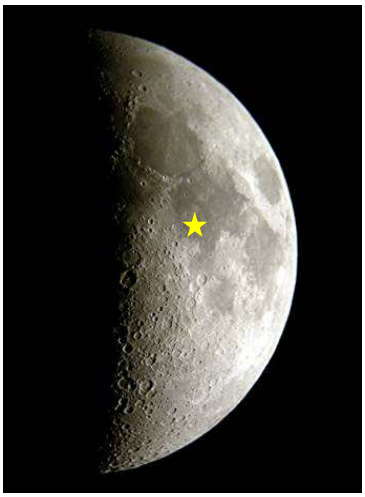
3. Locate the Summer Milky Way. Our solar system resides in one of the outer arms of a very large, rotating pinwheel of 200-300 billion stars called the Milky Way Galaxy. During the summer, we can see the inner arms of the pinwheel in the direction of the galactic core. Unfortunately, a dark sky is required, 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 wings.
   - 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).

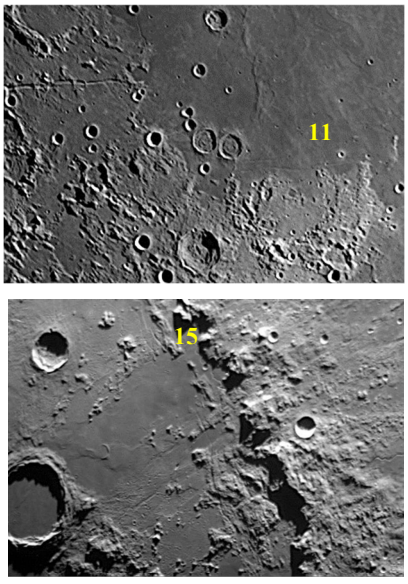
   From a good observing site, you should see a band of cloudiness through this area of the sky. Through binoculars, the "clouds" can be resolved into bright areas populated by stars and darker areas with few or no stars. The darker patches are regions of gas and dust that obscure our view of the galactic 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	8:26
July 31st	05:47	8:12
August 1st	05:48	8:11
August 15th	06:02	7:53
August 31st	06:18	7:28

Astronomical and Historical Events for July and August

July

1st Amor Asteroid *162011 Konnohmaru* closest approach to Earth (1.923 AU)
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 Amor Asteroid *6569 Ondaatje* closest approach to Earth (0.429 AU)
2nd Amor Asteroid *1915 Quetzalcoatl* closest approach to Earth (2.148 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 Earth at Aphelion – furthest from the Sun (1.017 AU or 94.5 million miles)
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 History: Isaac Newton's "Mathematical Principles of Natural Philosophy" published, describing the laws of motion (1687)
6th First Quarter Moon
6th History: discovery of Jupiter's moon *Lysithea* by Seth Nicholson (1938)
7th Amor Asteroid *52387 Huitzilopochtli* closest approach to Earth (0.480 AU)
7th History: launch of the Mars Exploration Rover B (Opportunity) (2003)
8th Amor Asteroid 16064 Davidharvey closest approach to Earth (3.238 AU)
8th Kuiper Belt Object 307261 (2002 MS4) at Opposition (45.374 AU)
8th History: likely breakup of Comet *Shoemaker-Levy 9* as a result of a close encounter with Jupiter – the fragments would impact the gas giant two years later (1992)
8th History: launch of the Space Shuttle Atlantis (STS-135) to the International Space Station; final space shuttle flight to low-Earth orbit (2011)

Astronomical and Historical Events for July (continued)

9th **McCarthy Observatory Star Party** (see website for details)
9th Apollo Asteroid 2015 TB145 closest approach to Earth (2.045 AU)
9th History: closest pass of Jupiter's cloud tops by the Voyager 2 spacecraft (1979)
10th Tentative scheduled launch of a SpaceX cargo-carrying Dragon 2 spacecraft to the International Space Station from the Kennedy Space Center, Florida
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 Apollo Asteroid *10563 Izhdubar* closest approach to Earth (0.920 AU)
11th Apollo Asteroid *1566 Icarus* closest approach to Earth (0.955 AU)
11th History: launch of the Soviet Gamma Observatory (1990)
11th History: Skylab re-enters into the Earth's atmosphere (1979)
12th History: launch of the High Energy Astronomical Observatory (HEAO-1), designed to survey the entire sky for x-ray emissions (1977)
12th Aten Asteroid 2015 OQ21 near-Earth flyby (0.047 AU)
12th Atira Asteroid 2020 OV1 closest approach to Earth (0.252 AU)
12th Amor Asteroid *21088 Chelyabinsk* closest approach to Earth (1.390 AU)
12th Apollo Asteroid *4197 Morpheus* closest approach to Earth (2.801 AU)
12th History: launch of Soviet Mars orbiter Phobos 2 (1988)
13th Full Super Moon (sometimes called Buck Moon)
13th Moon at Perigee (closest distance to Earth)
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 History: Langley Research Center's birthday (1917)
14th Asteroid *93 Minerva* (2 moons) closest approach to Earth (1.381 AU)
14th Centaur Object *10370 Hylonome* at Opposition (24.270 AU)
14th Kuiper Belt Object *486958 Arrokoth* at Opposition (42.080 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 Apollo Asteroid *12711 Tukmit* closest approach to Earth (0.129 AU)
15th History: Pioneer 10 becomes the first spacecraft to enter the main asteroid belt (1972)
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)

Astronomical and Historical Events for July (continued)

17th Atira Asteroid *2006 WE4* closest approach to Earth (0.383 AU)
17th Apollo Asteroid *2135 Aristaeus* closest approach to Earth (1.497 AU)
17th History: discovery of dwarf planet *225088 Gongong* by Megan Schwamb, Michael Brown, and David Rabinowitz (2007)
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 Centaur Object *330836 Orius* at Opposition (18.878 AU)
18th Kuiper Belt Object *15810 Arawn* at Opposition (34.984 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 Apollo Asteroid 349068 (2006 YT13) near-Earth flyby (0.045 AU)
19th Aten Asteroid *5381 Sekmet* closest approach to Earth (1.490 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 Last Quarter Moon
20th Dwarf Planet *134340 Pluto* at Opposition (33.552 AU)
20th Apollo Asteroid *85585 Mjolnir* closest approach to Earth (0.717 AU)
20th Centaur Object *55576 Amycus* at Opposition (21.982 AU)
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 Mars Winter Solstice (northern hemisphere)
21st Aten Asteroid *136818 Selqet* closest approach to Earth (1.601 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 Aten Asteroid *398188 Agni* closest approach to Earth (0.134 AU)
22nd Apollo Asteroid *428694 Saule* closest approach to Earth (1.015 AU)
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)

Astronomical and Historical Events for July (continued)

23rd Apollo Asteroid *101955 Bennu* closest approach to Earth (1.494 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
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 Aten Asteroid *2017 RX* near-Earth flyby (0.045 AU)
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 History: Svetlana Savitskaya becomes the first woman to walk in space (1984)
25th History: launch of Soviet Mars orbiter Mars 5 (1973)
26th Moon at Apogee (furthest distance from Earth)
26th Aten Asteroid *2013 ND15* (Venus Trojan) closest approach to Earth (0.860 AU)
26th Plutino 556068 (2014 JR80) at Opposition (39.689 AU)
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)
28th New Moon
28th Stellafane, 86th Convention of Amateur Telescope Makers on Breezy Hill in Springfield, Vermont (https://stellafane.org/convention/2022/index.html) (July 28th through 31st)
28th Binary Asteroid *163693 Atira* closest approach to Earth (0.471 AU)
28th Apollo Asteroid *4769 Castalia* closest approach to Earth (0.666 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 Apollo Asteroid *2016 CZ31* near-Earth flyby (0.018 AU)
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 Amor Asteroid 531944 (2013 CU83) near-Earth flyby (0.046 AU)
30th Atira Asteroid *2020 HA10* closest approach to Earth (0.568 AU)
30th Centaur Object *10199 Chariklo* at Opposition (15.927 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)

Astronomical and Historical Events for July (continued)

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 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 Apollo Asteroid *2020 PP1* near-Earth flyby (0.034 AU)
1st Binary Asteroid *90 Antiope* closest approach to Earth (1.610 AU)
1st Plutino *2017 OF69* at Opposition (42.113 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)
3rd Aten Asteroid *2020 PN1* near-Earth flyby (0.024 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 History: launch of the Phoenix polar lander spacecraft to Mars (2007)
5th First Quarter Moon
5th Kuiper Belt Object *2013 AT183* at Opposition (65.066 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 Plutino *2014 JP80* at Opposition (41.054 AU)
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)
6th History: Chinese astronomers first observe supernova in Cassiopeia; remained visible for more than 6 months (1181)
7th Apollo Asteroid *2201 Oljato* closest approach to Earth (2.046 AU)
7th History: Brett Gladman, et al's discovery of Saturn moons *Ymir*, *Paaliaq* and *Kiviuq* (2000)

Astronomical and Historical Events for August (continued)

7th History: announcement of possible microfossils found in Martian meteorite ALH84001 (1996)
7th History: Viking 2 arrives at Mars (1976)
8th History: launch of Genesis spacecraft, solar particle sample return mission (2001)
8th History: launch of Pioneer Venus 2 (1978)
8th History: deorbiting of the Soviet Salyut 5 space station (1977)
8th History: launch of the Soviet Zond 7 Moon probe (1969)
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 Moon at Perigee (closest distance to Earth)
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 Full Moon (sometimes called Sturgeon Moon)
11th Amor Asteroid *433 Eros* closest approach to Earth (2.129 AU)
11th Apollo Asteroid *306367 Nut* closest approach to Earth (3.403 AU)
11th History: Asaph Hall discovers Martian moon *Deimos* (1877)
12th Peak of the Perseids meteor shower (into the morning of the 13th)
12th Apollo Asteroid *2015 FF* near-Earth flyby (0.029 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)
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 **McCarthy Observatory Star Party** (see website for details)
13th History: discovery of Mars' south polar cap by Christiaan Huygens (1642)
14th Saturn at Opposition
14th Atira Asteroid *1998 DK36* closest approach to Earth (0.605 AU)

Astronomical and Historical Events for August (continued)

14th Kuiper Belt Object 470599 (2008 OG19) at Opposition (38.003 AU)
15th Scheduled launch of a Cygnus cargo-carrying spacecraft atop a Northrop Grumman Antares rocket to the International Space Station from Wallops Island, Virginia
15th Kuiper Belt Object *2015 UH87* at Opposition (80.037 AU)
16th Apollo Asteroid *5143 Heracles* closest approach to Earth (1.717 AU)
16th History: launch of Explorer 12 spacecraft, measured cosmic-ray particles, solar wind protons, and magnetospheric and interplanetary magnetic fields (1961)
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 Asteroid *4 Vesta* closest approach to Earth (1.282 AU)
18th History: launch of Suisei; Japan's Comet Halley mission (1985)
19th Last Quarter Moon
19th Centaur Object *83982 Crantor* at Opposition (19.411)
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 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 Moon at Apogee (furthest distance from Earth)
22nd Amor Asteroid *2020 QW3* near-Earth flyby (0.036 AU)
22nd Apollo Asteroid *2019 AV13* near-Earth flyby (0.049 AU)
22nd Tentative launch date for Luna 25 (Luna-Glob Lander) a Russian lander to the Moon's south pole
22nd History: first light of the 100-meter Robert C. Byrd Green Bank Telescope - the world's largest fully steerable radio telescope. (2000)
23rd Vatira Asteroid *594913 'Aylo'chaxnim* Perihelion (0.457 AU)
23rd History: Lunar Orbiter 1 takes first photo of the Earth from the Moon (1966)
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 Apollo Asteroid *4034 Vishnu* closest approach to Earth (0.314 AU)
25th History: flyby of Neptune by the Voyager 2 spacecraft (1989)

Astronomical and Historical Events for August (continued)

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 Amor Asteroid *16912 Rhiannon* closest approach to Earth (0.696 AU)
26th Amor Asteroid *2608 Seneca* closest approach to Earth (2.089 AU)
26th History: flyby of the planet Saturn by the Voyager 2 spacecraft (1981)
27th New Moon
27th Mercury at its Greatest Eastern Elongation (27°) – apparent separation from the Sun in the evening sky
27th History: launch of the Mariner 2 spacecraft to Venus; first successful planetary encounter (1962)
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 Apollo Asteroid *2017 BU* near-Earth flyby (0.040 AU)
29th Amor Asteroid *3102 Krok* closest approach to Earth (0.332 AU)
29th Apollo Asteroid *3752 Camillo* closest approach to Earth (0.550 AU)
29th Kuiper Belt Object *225088 Gonggong* at Opposition (87.973 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 Amor Asteroid *5626 Melissabrucker* closest approach to Earth (0.750 AU)
30th Amor Asteroid *5751 Zao* closest approach to Earth (2.213 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

Commonly Used Terms

- Opposition: celestial bodies on opposite sides of the sky, typically as viewed from Earth
- Plutino: an asteroid-sized body that orbits the Sun in a 2:3 resonance with Neptune
- Trojan: asteroids orbiting in the 4th and 5th Lagrange points (leading and trailing) of major planets in the Solar System

References on Distances

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

International Space Station and Artificial Satellites

- www.heavens-above.com for the times of visibility and detailed star charts for viewing the International Space Station and other manmade objects.

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

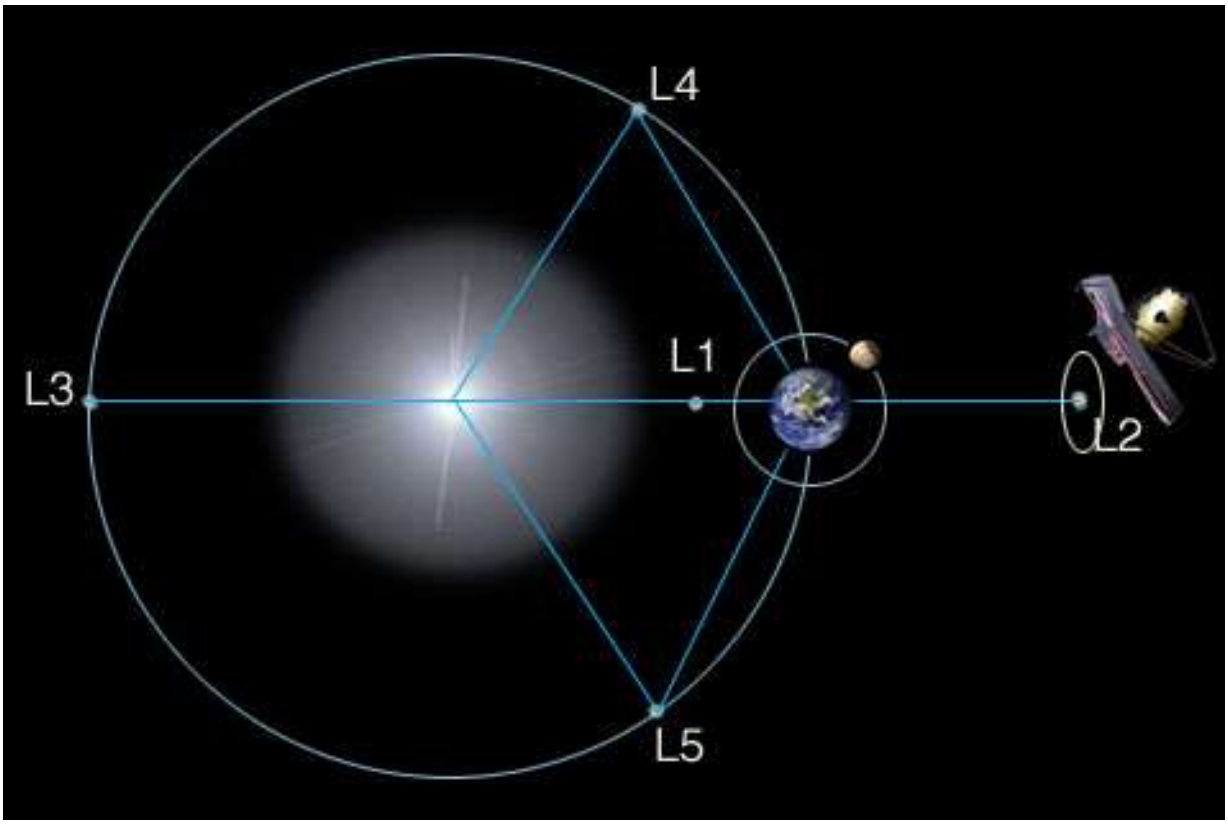
- Vital Signs of the Planet: https://climate.nasa.gov/

Mars – Mission Websites

- Mars 2020 (Perseverance rover): https://mars.nasa.gov/mars2020/
- Mars Helicopter (Ingenuity): https://mars.nasa.gov/technology/helicopter/
- Jezero Crater map: https://mars.nasa.gov/mars2020/mission/where-is-the-rover/
- Mars Science Laboratory (Curiosity rover): https://mars.nasa.gov/msl/home/
- Mars InSight (lander): https://mars.nasa.gov/insight/

Lagrange Points

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



James Webb Space Telescope

- https://www.jwst.nasa.gov/

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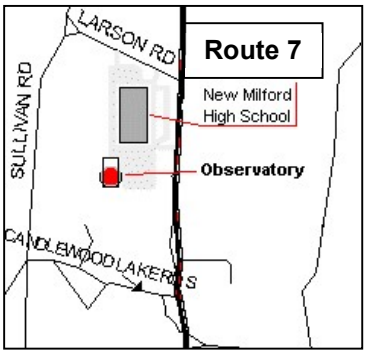

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