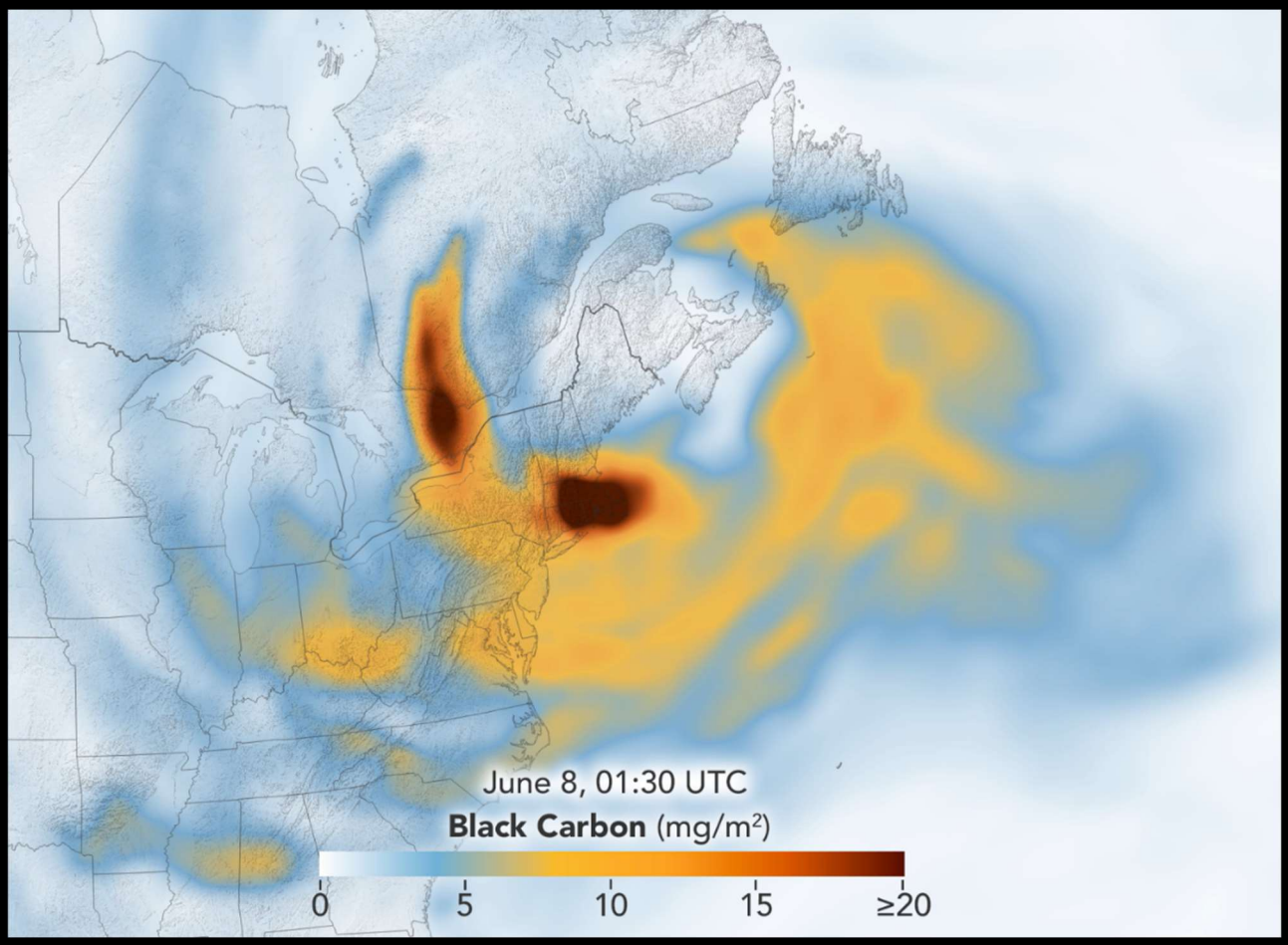
Galactic Observer

John J. McCarthy Observatory

Volume 16, No. 7 July/August 2023



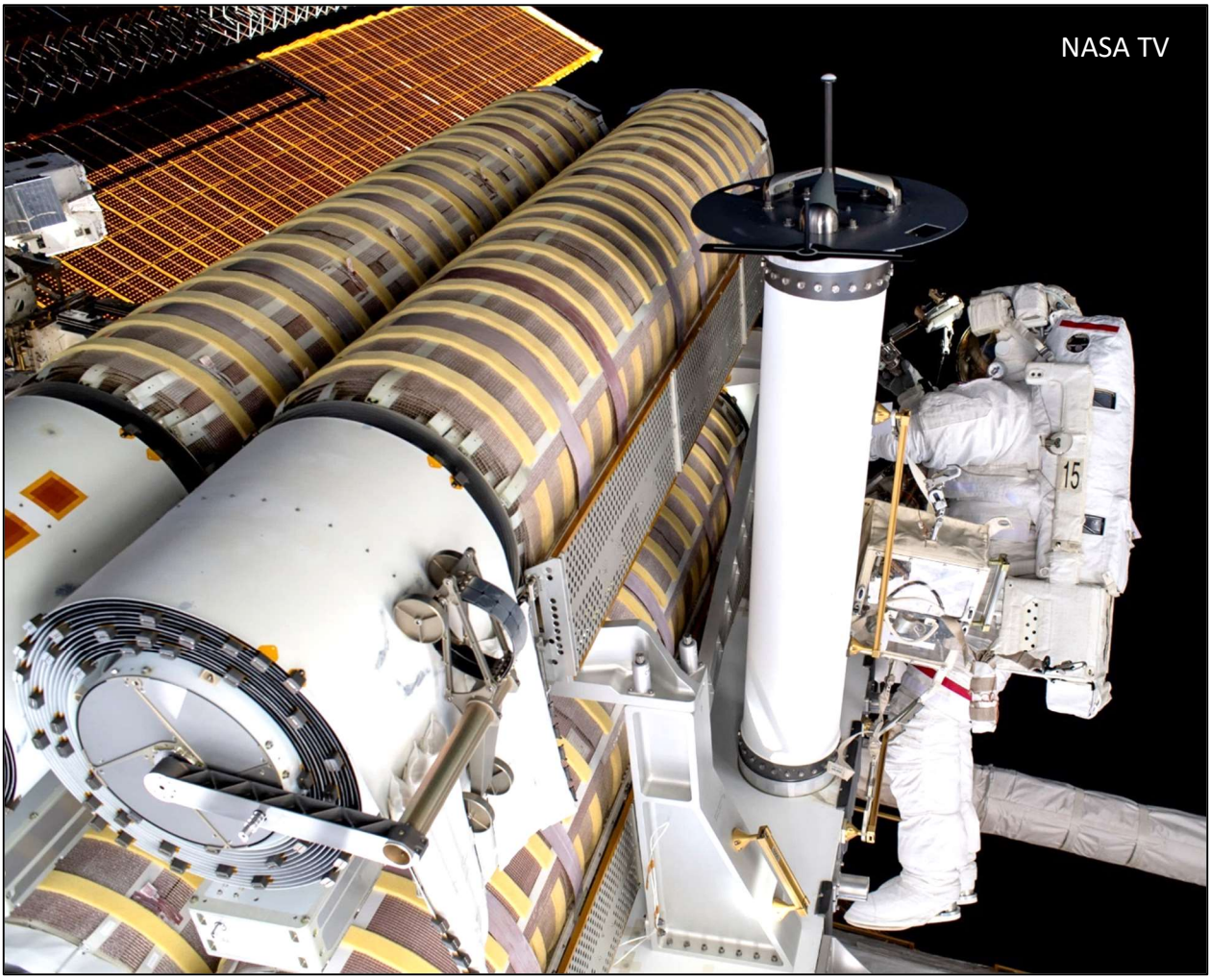
Observing Planet Earth

NASA's Earth-monitoring satellites recorded extremely hazardous levels of air quality in the northeastern U.S. as a result of particularly severe wildfire activity in Canada. On June 8, 2023, the province of Quebec reported 136 active fires that had charred an area approximately the size of Delaware. Weather systems pushed the smoke from those blazes down towards the northeast and mid-Atlantic states.

In addition to creating conditions that were detrimental to public health, the dense smoke particles reduced visibility to levels that caused flight delays at major airports in New York City, Newark, and Philadelphia.

Graphic: NASA

July and August Astronomy Calendar and Space Exploration Almanac



Astronauts Steve Bowen and Woody Hoburg spent six hours in their spacesuits outside the International Space Station (ISS) on June 9th. During the spacewalk, the astronauts proceeded to install and unroll an upgraded solar array wing that had been delivered to the station earlier in the week by a SpaceX Cargo Dragon.

The original solar arrays were designed for a 15-year service life. The first pair was deployed in December 2000, with additional array pairs delivered in September 2006, June 2007, and March 2009. While power production is currently sufficient to support routine ISS operations, the arrays are well past their design life and showing signs of degradation. With operations expected to continue until 2030, NASA is in the process of augmenting six of the eight existing power channels of the space station with new solar arrays. While smaller, the new arrays are more efficient and when the upgrade is complete, power production will be comparable to when the original arrays were installed (a 20 to 30 percent increase from current levels).

The new Roll-Out Solar Arrays, or iROSA units, are delivered in pairs in the unpressurized truck of SpaceX's spacecraft. Once docked to the station, the iROSA units are retrieved by the ISS's Canadian-built robotic arm for installation by the spacewalkers.

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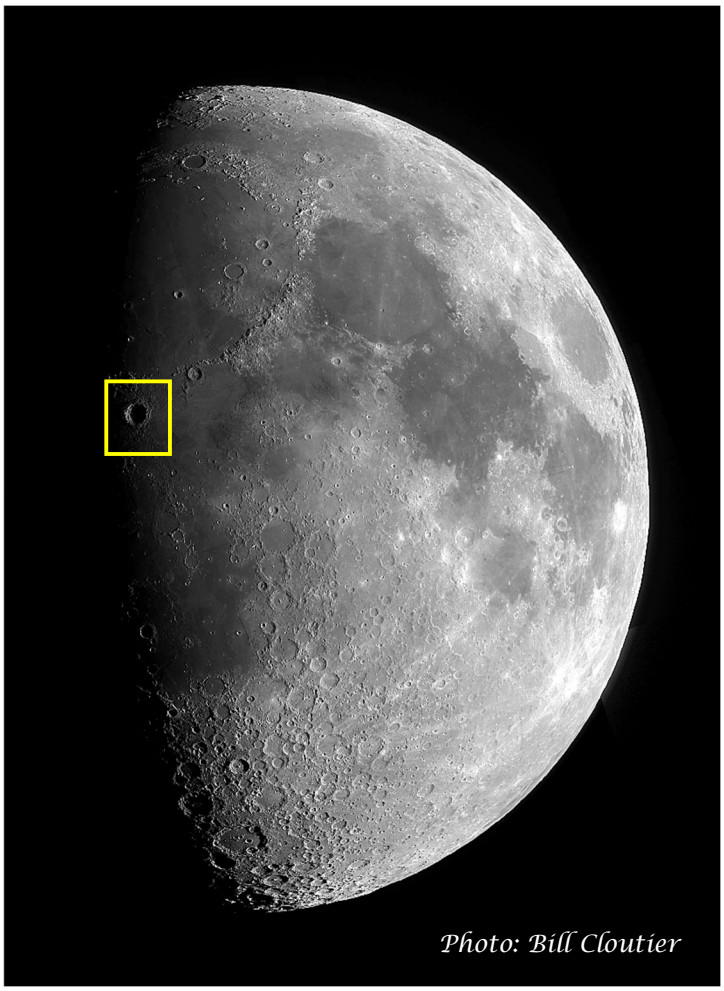
"Out the Window on Your Left"

It's been 54 years since Neil Armstrong first stepped onto the Moon's surface and more than 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).



Location of the Copernicus crater

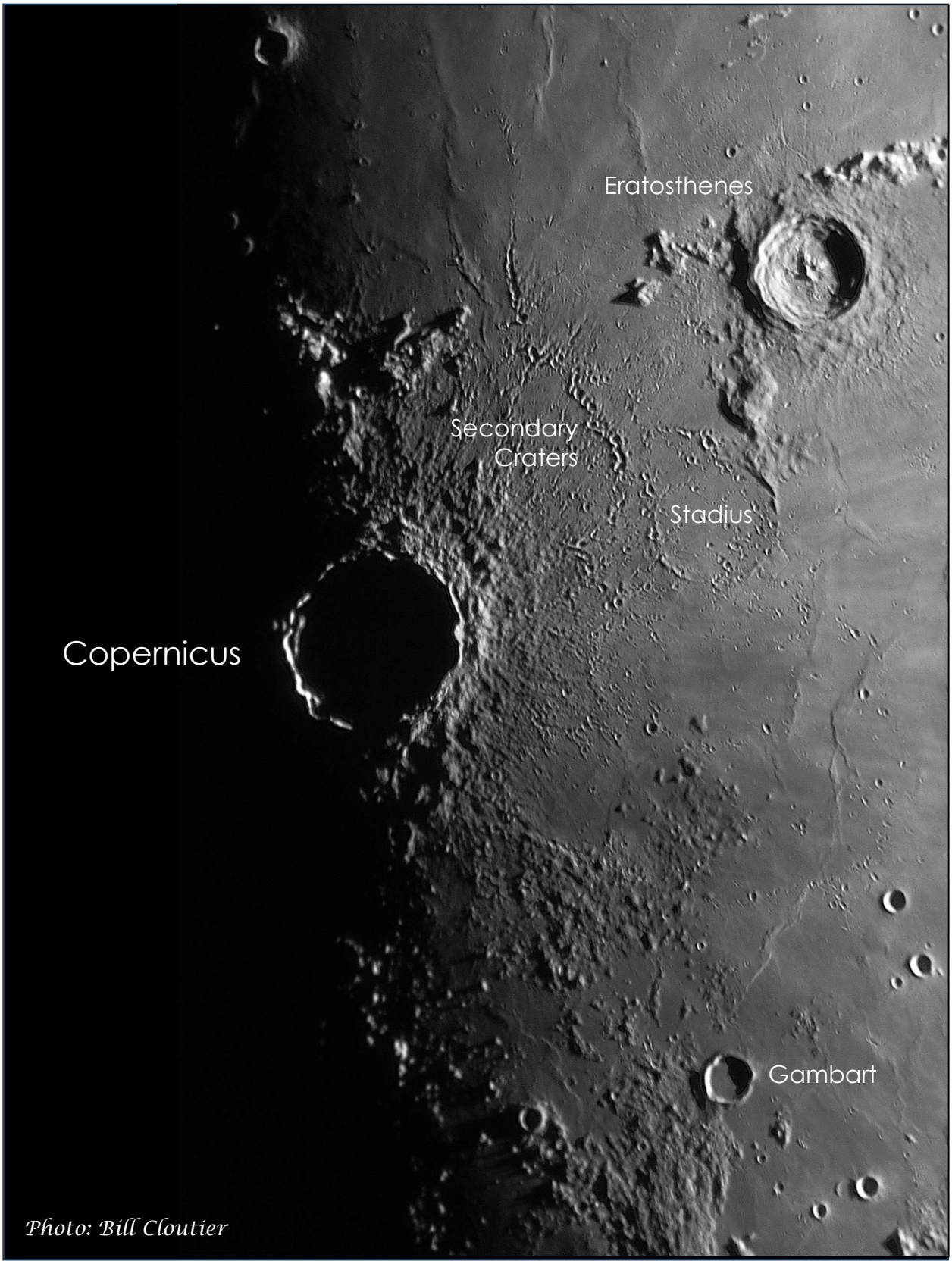
Copernicus crater (58 miles or 93 km in diameter) is one of the most prominent craters on the lunar nearside. It formed approximately 800 million years ago when an asteroid about 6 miles across (10 km) slammed into the Moon with a velocity somewhere around 32,400 mph (15 km/s).

Copernicus is the example of a complex impact crater. Large lunar craters (with diameters greater than about 9 miles or 15 km) have relatively flat floors, central peaks and inner walls with slumps or terraces. Newer impacts have conspicuous rays from pulverized ejecta and are typically surrounded by a plethora of smaller, secondary impact features.

Mid-crater profile spanning 107 miles (173 km) from NASA's Lunar Reconnaissance Orbiter Laser Altimeter data highlighting the crater's raised rim and central peak

The ejection of large pieces of the Moon's crust from the primary event crash into the nearby terrain, creating what are known as secondary craters. Those closest to Copernicus are irregular in shape, with multiple impacts forming crater chains. As the distance increases, the secondaries become more circular due to the projectile's higher velocity.

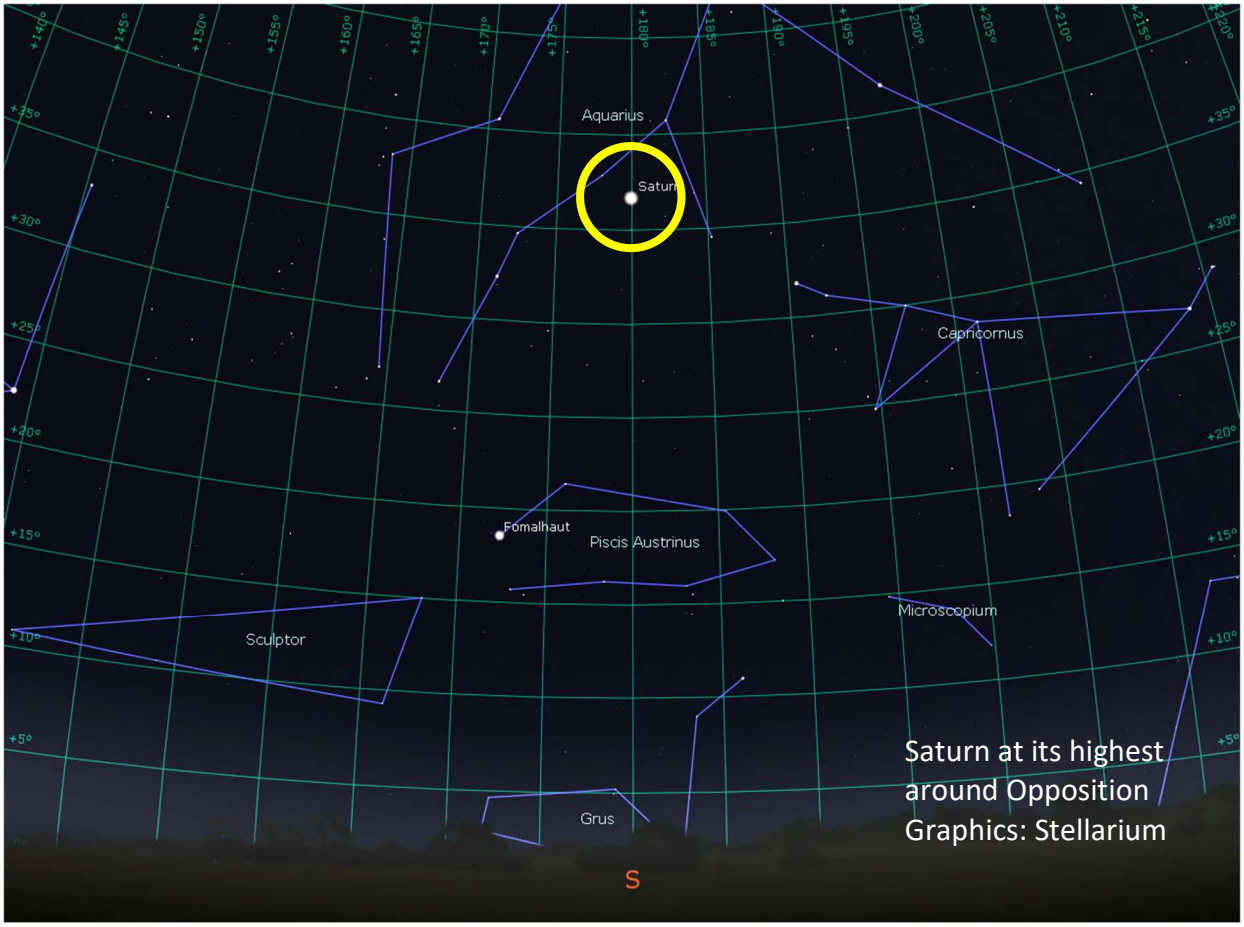
Sunrise on Copernicus



Saturn at Opposition

The solar system's most picturesque gas giant, Saturn, reappears in the evening sky in August, rising a little more than an hour after sunset on the 1st and almost two hours earlier by the end of the month. Transit times are provided for when the ringed world is at its highest in the southern sky. Saturn can be found in the constellation Aquarius.

	Rise and Transit Times (EDT)					
	August 1		August 31		September 30	
	Rise	Transit	Rise	Transit	Rise	Transit
Saturn	9:25 pm	2:47 am	7:22 pm	12:41 am	5:19 pm	10:36 pm

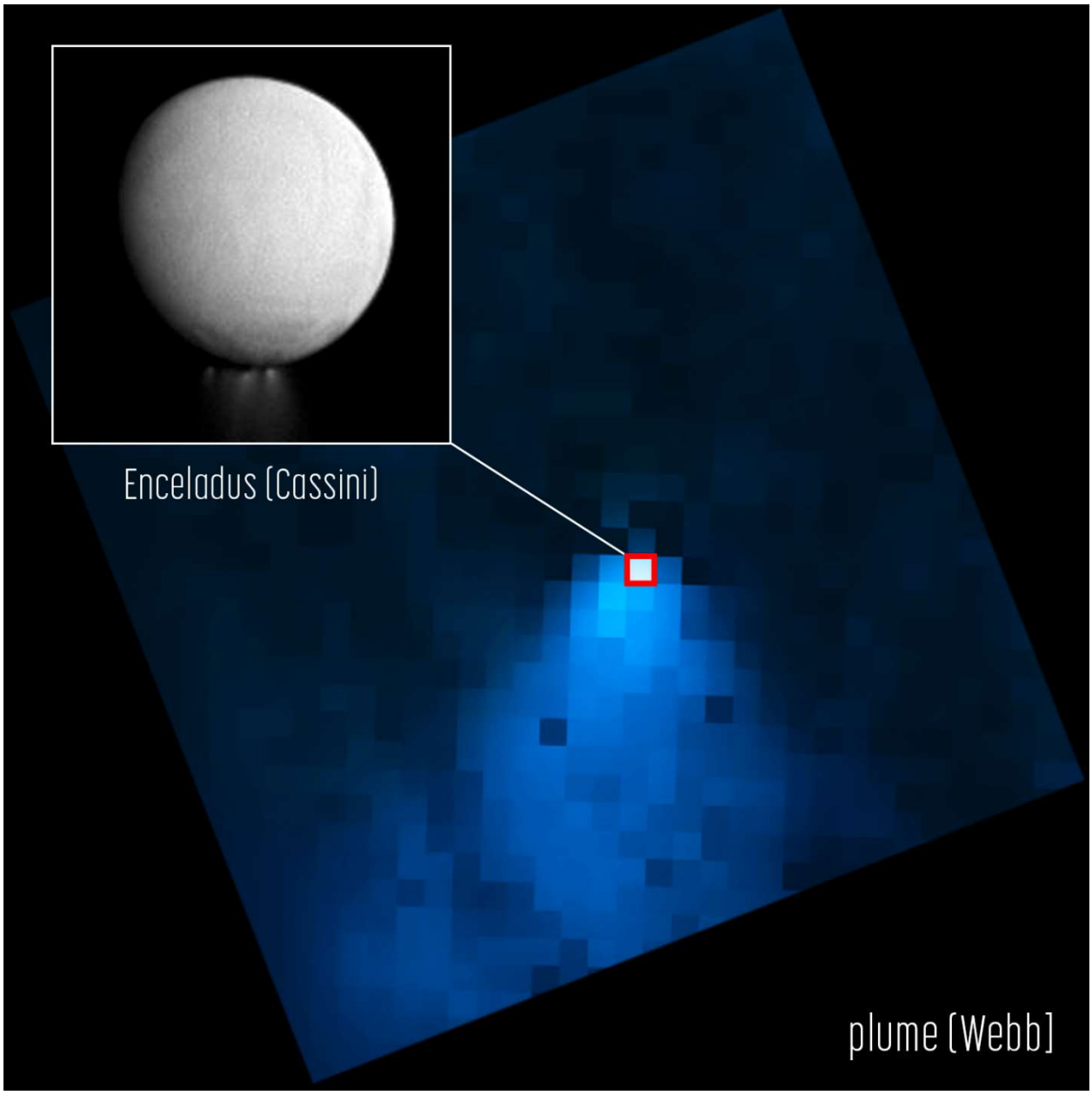


Saturn will reach Opposition on August 27th, when its lies directly opposite the Sun. On that date, the ringed-world will be 815 million miles (1,311 million km) from Earth or about 73 light minutes (time for light to travel from Saturn to Earth). Saturn will rise at 7:39 pm on the 27th and will be at its highest about an hour after midnight.

Saturn's north pole will be angled towards the Earth and its rings inclined just 8° to our line of sight. The tilt angle of the planet's rings can be anywhere from 0° (edge-on) to ± 27°, as seen from Earth, and we are currently approaching "ring crossing," which will occur in March 2025. At that time, the rings will seem to disappear from our sight. The rings will then begin to "open," revealing their underside, along with a view of the southern polar region.

Webb on Enceladus

Enceladus is Saturn's sixth-largest moon. At only 310 miles (500 km) in diameter, the diminutive moon is about a tenth of the size of Saturn's largest moon, Titan. Relatively unremarkable except for its smooth, bright white, snowy surface, Enceladus was thrust into the limelight by the Cassini mission as among the most likely places to host extraterrestrial life. Now, almost six years after the end of the Cassini mission, the James Webb Space Telescope (Webb) has set its sights on this enigmatic ocean world.

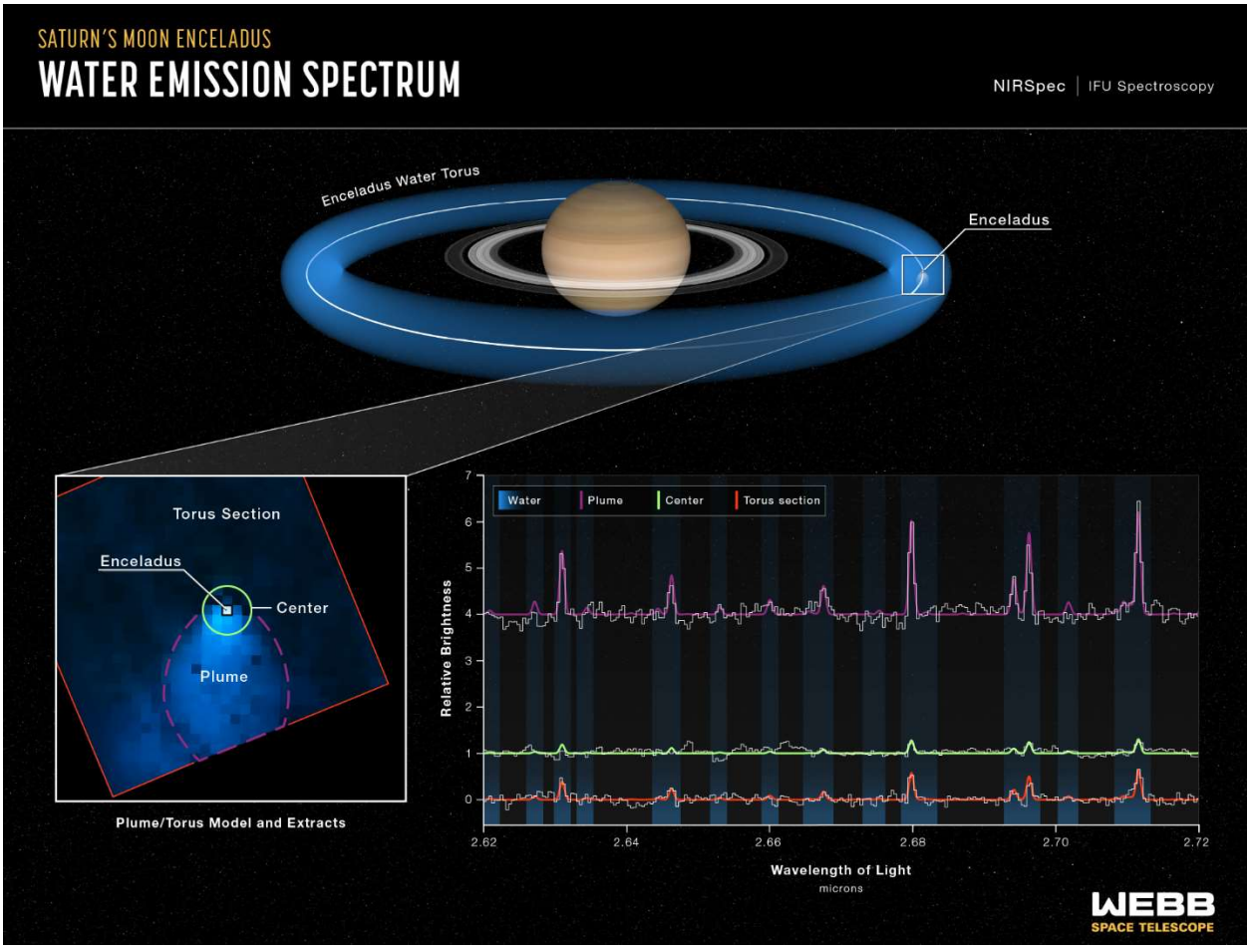


Water vapor plume emanating from Enceladus' south polar region
Credits: NASA, ESA, CSA, STScI, and G. Villanueva (NASA's Goddard Space Flight Center)
Image Processing: A. Pagan (STScI).

The Cassini orbiter spent over a decade exploring the Saturnian system. The discovery of icy plumes erupting from V-shaped channels at the Enceladus' south pole in 2005 and evidence of a global ocean, led to targeted flybys of the moon over the course of the mission. In October 2015, Cassini executed a high-speed, deep dive through the plumes, coming within 30 miles (45 km) of Enceladus' surface.

The polar plumes blast water vapor and tiny grains of ice into space. In addition to organic compounds being present in the plumes, Cassini's instruments detected sodium, potassium, chlorine, and carbonate-containing compounds. A recent discovery of Phosphorus, a key chemical element for many biological processes, was detected inside the plume's salt-rich ice grains.

Webb's observations revealed water vapor reaching out more than 6,000 miles (9,700 km) – almost 20 moon diameters. The observations are providing scientists a direct look at how the plumes feed Saturn's tenuous E-ring (within which Enceladus orbits), as well as the entire system. (Approximately 30% of the plume water stays within the E-ring, while the remaining 70% migrates throughout the Saturnian system). Because of Webb's wavelength coverage and sensitivity, scientists expect to learn more about the composition of the underlying ocean from changes in plume emissions over time.

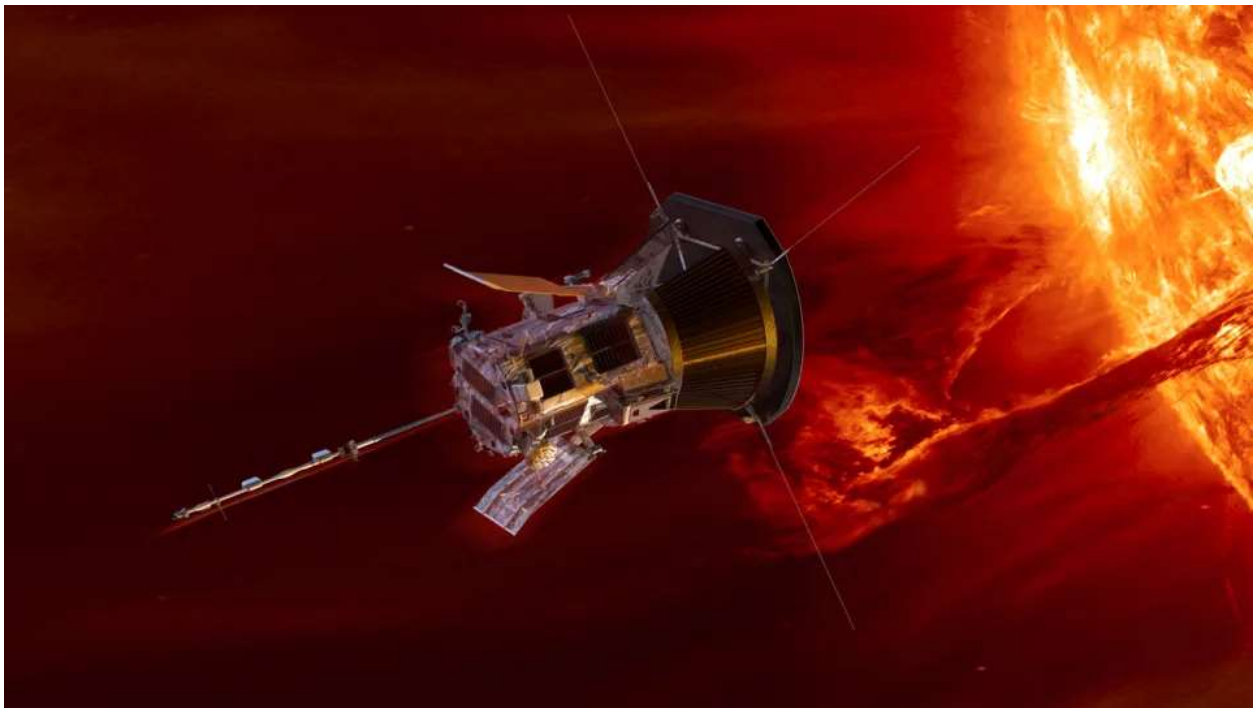


Credits: NASA, ESA, CSA, STScI, Leah Hustak (STScI)

Origin of the Solar Wind

First proposed in the 1950s by University of Chicago physicist Eugene Parker, the solar wind is comprised of charged particles that stream outward from the Sun's corona (outermost atmosphere). The particles, heated to a plasma state, flow along the Sun's magnetic field lines throughout the solar system. There are two types of this wind: the faster solar wind that escapes from holes in the corona, typically near the poles, at peak speeds of 1.8 million miles per hour (800 kps); and a slower wind, confined to equatorial regions, that flows at almost 900,000 miles per hour (400 kps).

Launched on Aug. 12, 2018, the Parker Solar Probe has three detailed science objectives: trace the flow of energy that heats and accelerates the solar corona and solar wind; determine the structure and dynamics of the plasma and magnetic fields at the sources of the solar wind; and explore mechanisms that accelerate and transport energetic particles. The spacecraft is using Venus (with seven flybys) to gradually modify (shrink) its orbit around Sun, and will come within 3.83 million miles (6.16 million km) by the end of its 24-orbit mission. It is now close enough to the Sun to see the detailed structure the solar wind at its source.



An illustration of Parker Solar Probe approaching the Sun
Credit: JHU Applied Physics Laboratory/NASA's Goddard Space Flight Center

The photosphere (Sun's surface) is covered with large convection cells created by rising columns of superheated plasma from inside the Sun. As the plasma cools, it descends along the cell boundaries between the granules. This downward flow drags the magnetic field along with the plasma. As magnetic fields pass each other within these confined regions, moving in opposite directions, they break and reconnect, blasting charged particles out of the Sun.

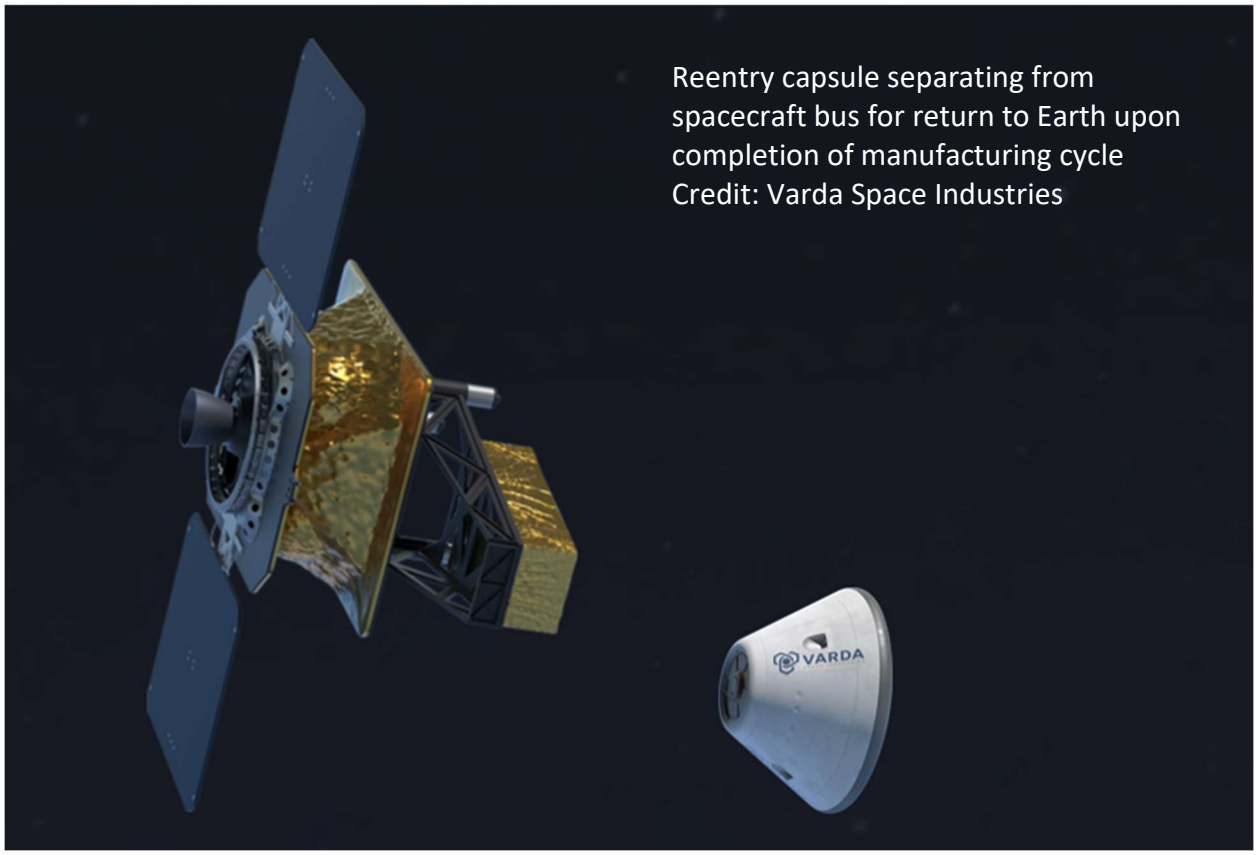
Researchers now believe, based on data from the Parker Solar Probe, that magnetic reconnection at the cell boundaries is providing the energy source of the fast solar wind. Understanding its source will improve the forecast of major space-weather (and Earth-directed) events.

Orbital Manufacturing

Among the host of payloads carried on SpaceX's Transporter-8 rideshare mission, launched on June 12th, was a prototype drug manufacturing factory. The Varda Space Industries' spacecraft consists of a satellite bus, a microgravity manufacturing module and a reentry capsule. The space factory will orbit the Earth for a little over a month during which time Varda will conduct tests on both the spacecraft and its abilities to produce particular drugs. The end product will be returned to Earth aboard the reentry capsule, landing in the Utah desert in mid-July.

The spacecraft is the first of three being built by RocketLab for Varda. The goal is for a spacecraft to spend approximately three months in orbit, with the reentry module returning around 90 to 130 pounds (40-60 kgs) of manufactured materials. The first experiment will be to crystallize ritonavir in microgravity, a drug that has been used to treat HIV and that is also included in Paxlovid, a drug combination that targets COVID-19. The microgravity environment allows enhanced growth of larger, higher-quality crystals in solution.

Ritonavir is an example of polymorphism in pharmaceuticals, where differences in the symmetry and structures of the crystals result in drastic changes in solubility and bioavailability (the proportion of a drug which enters circulation when introduced into the body and so is able to have an active effect). Varda is hoping to use microgravity to customize the drug's efficacy.



Reentry capsule separating from spacecraft bus for return to Earth upon completion of manufacturing cycle
Credit: Varda Space Industries

Varda's reentry capsule will enter the atmosphere at Mach 25+ (traveling at 17,900 mph or over 8 km/s). The extreme environment of reentry provides a unique opportunity to test hypersonic flight conditions. The company is currently working with the Air Force to use their reentry vehicle as a hypersonic testbed.

In Praise of Mystery: A Poem for Europa

Arching under the night sky inky
with black expansiveness, we point
to the planets we know, we

pin quick wishes on stars. From earth,
we read the sky as if it is an unerring book
of the universe, expert and evident.

Still, there are mysteries below our sky:
the whale song, the songbird singing
its call in the bough of a wind-shaken tree.

We are creatures of constant awe,
curious at beauty, at leaf and blossom,
at grief and pleasure, sun and shadow.

And it is not darkness that unites us,
not the cold distance of space, but
the offering of water, each drop of rain,

each rivulet, each pulse, each vein.
O second moon, we, too, are made
of water, of vast and beckoning seas.

We, too, are made of wonders, of great
and ordinary loves, of small invisible worlds,
of a need to call out through the dark.

Ode to Europa

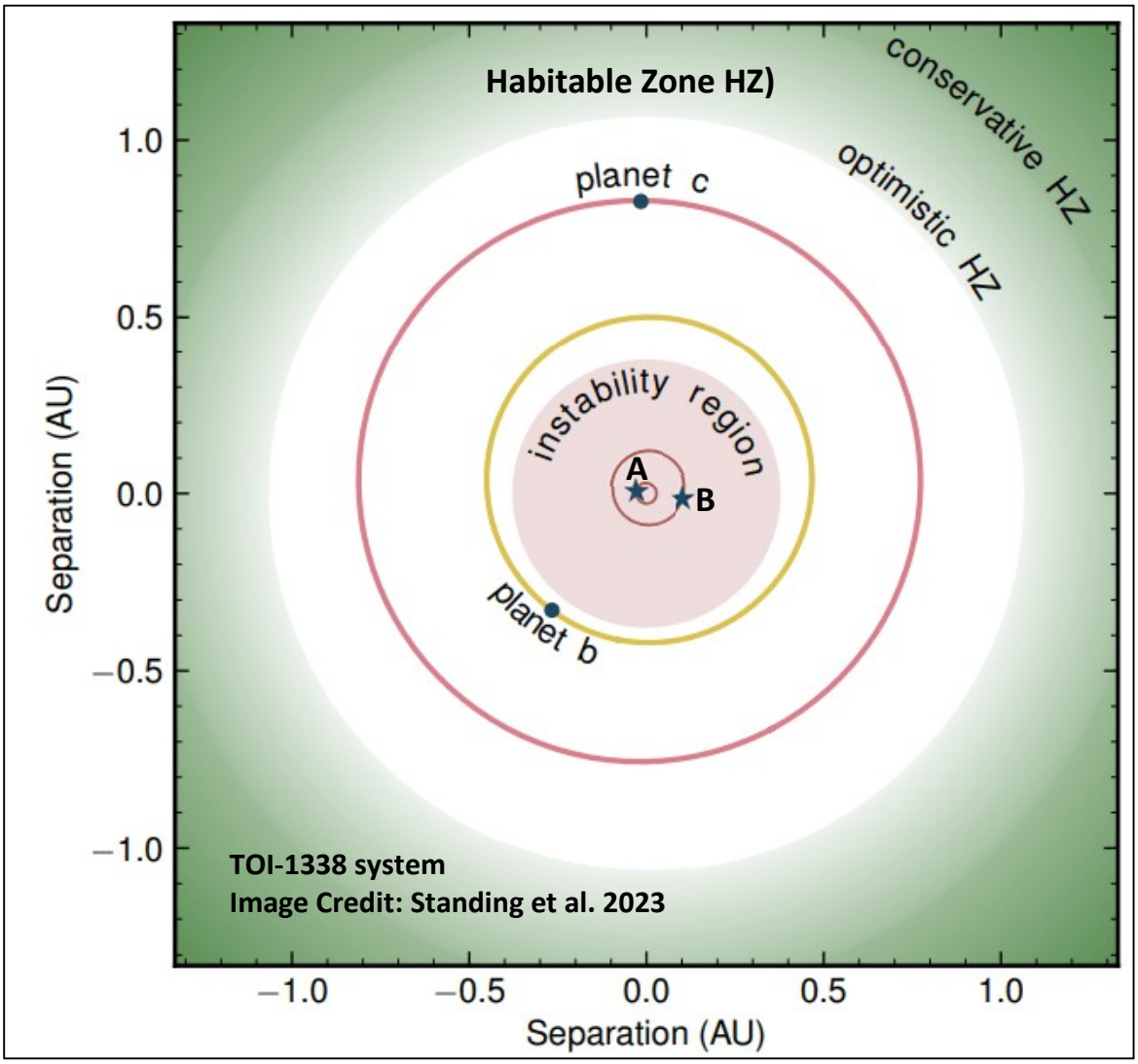
NASA is planning to launch the Europa Clipper spacecraft in October 2024 on a 1.8-billion-mile (2.6-billion-km) mission to the smallest of Jupiter's four Galilean moons. Engraved on the inside of a tantalum metal plate, that will seal the aluminum-zinc alloy vault containing the spacecraft's radiation-sensitive electronics, will be a poem written for the mission by U.S. Poet Laureate Ada Limón.

Limón and the Library of Congress are collaborating on a "Message in a Bottle" campaign where the public can add their names to Limón's tribute. Names will be stenciled onto a microchip to accompany Limón's ode to Europa. The spacecraft is expected to arrive at Jupiter in 2030 and fly by Europa about 50 times in an astrobiology mission.

Ada observes the assembly of the spacecraft during her visit to NASA's Jet Propulsion Laboratory. Credit: NASA/JPL-Caltech

Astronomers Detect a Second Planet Orbiting Two Stars

Planets orbiting binary stars was the stuff of science fiction until the discovery of the Saturn-sized Kepler-16b exoplanet in 2011. Since that discovery, 14 transiting planets in 12 binary systems have been discovered by the Kepler and TESS spacecrafts. Binary stars were thought to disrupt the formation of planets with their chaotic gravitational fields, either resulting in catastrophic collisions or ejection from the system. Planet detection is also more difficult in an eclipsing binary system (where the stars can eclipse each other). However, in 2017 the first planet (planet b) was discovered in a binary star system called TOI 1338, approximately 1,300 light-years away in the constellation Pictoris. TOI 1338 A is a main sequence star of 1.12 solar masses and TOI 1338 B is an M-dwarf (red dwarf) of 0.3 solar masses. The star system is about 4.4 billion years old.



Now astronomers have found a second planet orbiting TOI 1338 (planet c). The new planet is a gas giant about 65 Earth masses with an orbital period of about 215 days. It was discovered using radial-velocity spectral data (that shows the star moving towards and then away from Earth - caused by the presence of planets and the gravitational interaction with their suns), collected with the European Southern Observatory's HARPS and ESPRESSO spectrographs. It is the first time astronomers have found a circumbinary planet using the radial velocity method and only the second multiple-planet circumbinary system discovered.

One Step Closer to Flight

ULA's Vulcan Centaur's first stage at Space Launch Complex-41, Cape Canaveral Space Force Station. Credit: ULA

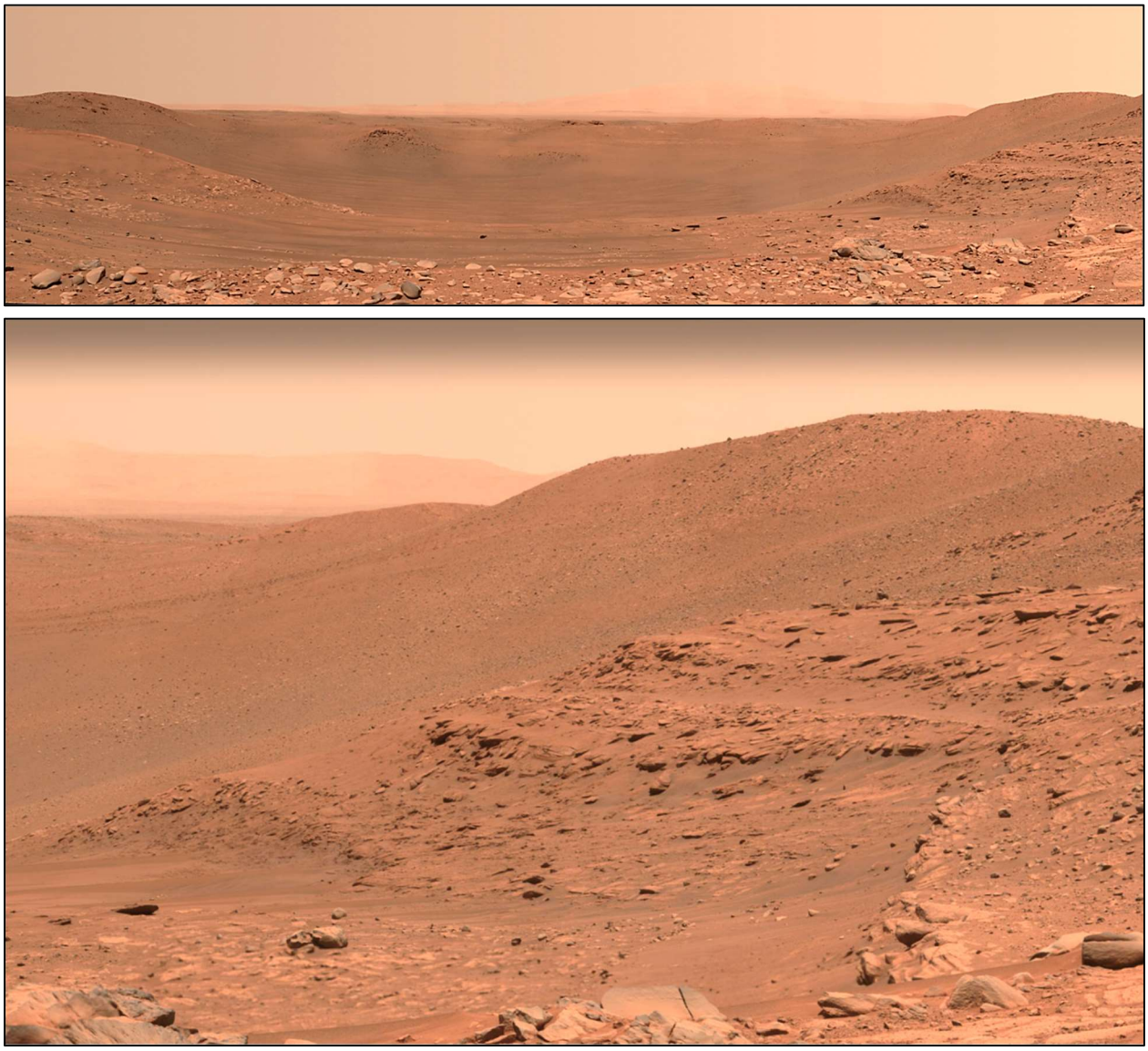
BE-4 engines throttling up during test firing Credit: ULA

United Launch Alliance, a 50-50 joint venture between Lockheed Martin and Boeing, successfully test-fired their new Vulcan Centaur rocket, completing the last major milestone before the first launch. The rocket is powered by two Blue Origin-built BE-4 methane-burning engines. The engines throttled up to about 60% power before coasting down, while the hold-down restraints kept the rocket firmly on the pad. The Vulcan Centaur is destined to replace the company's Atlas V and Delta IV launch vehicles.

The U.S. military requires two "certification flights" before carrying national security payloads. On the first certification flight, the new rocket will launch a commercial Moon lander developed by Astrobotic and two prototype satellites for Amazon's Kuiper broadband network. Sierra Space's Dream Chaser spaceplane is scheduled for the second test flight, which will be headed to the International Space Station.

A Fortuitous Excavation

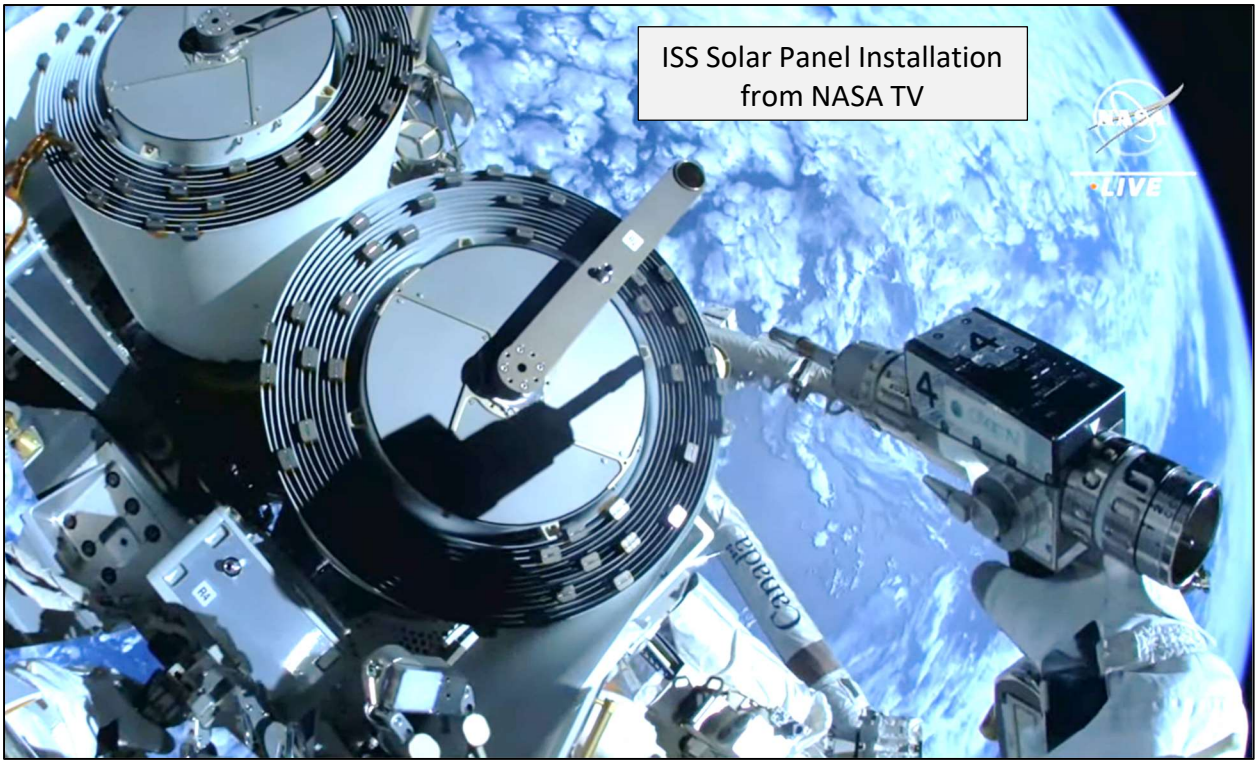
NASA's Perseverance rover stopped to explore the rim of Belva Crater on its climb up the Jezero delta formation. Belva Crater, created by a meteorite impact billions of years ago, is about 0.6 miles (0.9 km) across. The impact excavated the top surface layers and revealed rock and other geological features that are typically hidden from view.



The view looking across the Belva Crater (top) and towards the distant east-northeast wall of the much-larger Jezero Crater (center of the image), some 25 miles (40 km) away. The lower image shows the rock layers exposed by the impact that created the crater.
Credits: NASA/JPL-Caltech

Created from 152 individual images, the mosaic of Belva crater shows multiple locations of bedrock exposed in vertical cross-section. Called "dipping beds," these steeply angled bedrock sections are signs of a large Martian sandbar. The dipping beds, as well as the coarse sediment grains and cobbles found along the way, indicate that the lake that Jezero Crater once held was fed by a rapidly flowing river.

The Right Tool for the Job



Whether installing new solar arrays on the International Space Station (ISS) or conducting a servicing call to the Hubble Space Telescope, having the right tool is essential in getting the task done quickly and efficiently. One of the tools commonly used by astronauts in construction or repair activities is NASA's "pistol-grip tool." The cordless power drill was designed for use in microgravity and built by Swales Aerospace.

NASA's Pistol Grip Tool

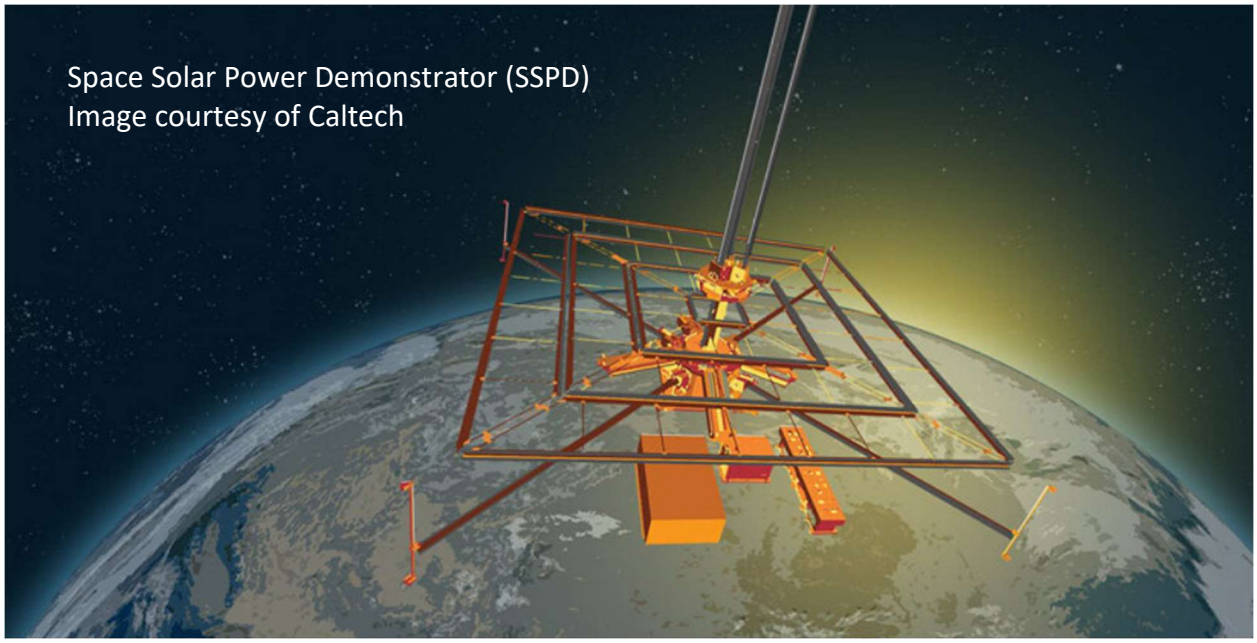
The tool is similar to one you might find in the local hardware store in that it has a battery pack that slots into the handle. NASA's drill, however, is oversized with specially designed handles and triggers that make it easier for astronauts to operate in their bulky spacesuits. The pistol-grip tool is also designed to work in a vacuum and uses dry film lubricants to withstand the rapid temperature fluctuations from day to night (hundreds of degrees), that occur sixteen times a day with the station's 90 minute orbit. It is also lightweight, being made of glass-infused plastic called Lexan, wrapped in aluminum tape.

The drill has a large information screen on the handle where astronauts can adjust the torque and speed (between less than 1 and 38 foot-pounds, and between 5 and 60 rpm). The drill is designed to turn slowly but still produce enough torque to undo frozen bolts and fasteners.

The pistol grip tool was the first successful, self-contained, computer controlled power tool used in space. It was invented to service the Hubble Space Telescope by Hubble program engineer, Paul Richards. He would later become an astronaut and use the tool in the assembly of the ISS.

Space Power

A satellite built to test key technologies by Caltech's Space Solar Power Project (SSPP) has wirelessly transmitted power from orbit for the first time. Launched in January, the satellite included three experimental technologies envisioned, designed, built, and tested by a team of faculty, postdocs, graduate students, and undergrads in the labs at Caltech.



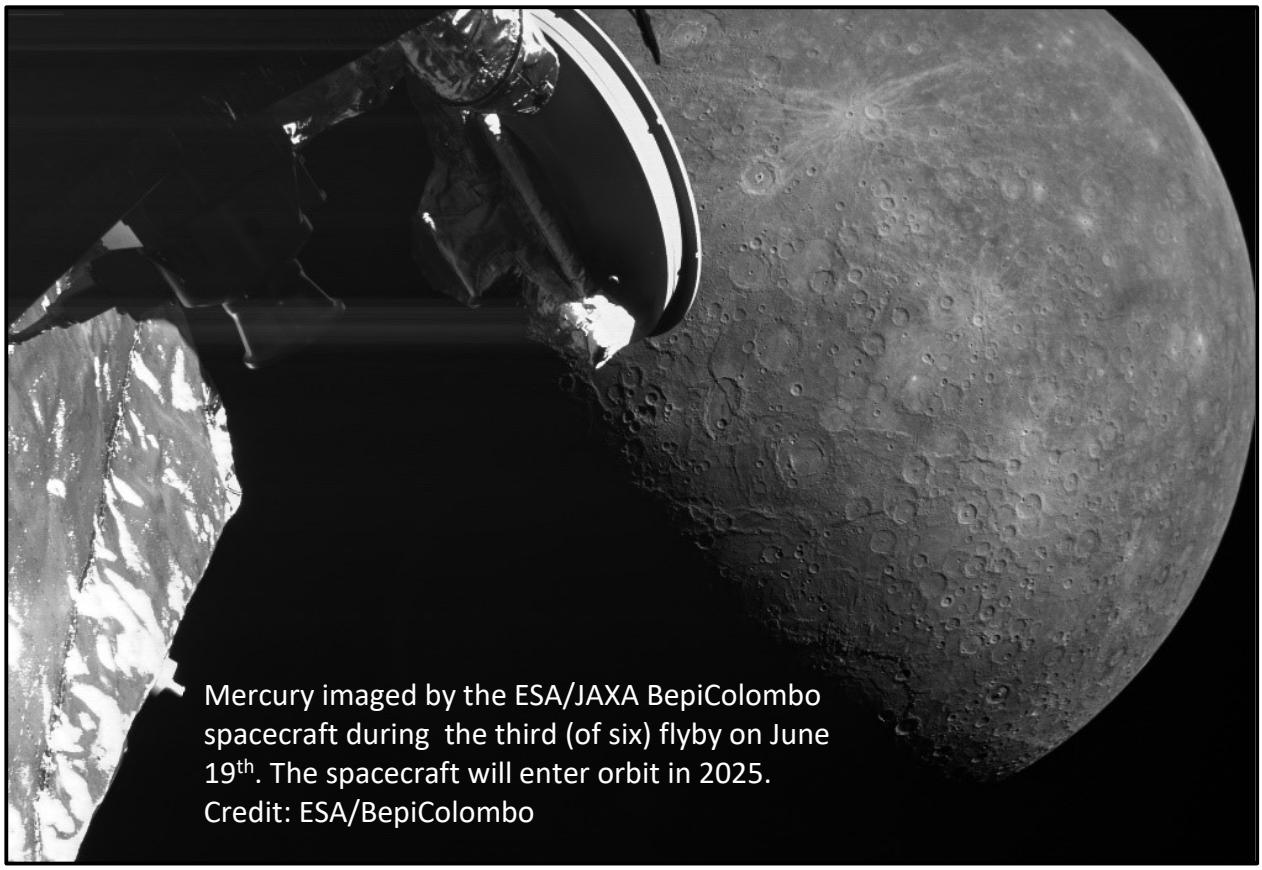
The Microwave Array for Power-transfer Low-orbit Experiment (MAPLE) consists of an array of flexible lightweight microwave power transmitters to beam energy from space. Energy transmissions were detected by a receiver on the roof of the Gordon and Betty Moore Laboratory of Engineering on Caltech's campus in Pasadena, at the expected time and frequency.

Caltech's SSPP's envisions the future deployment of a fleet of modular spacecraft with sail-like solar panels that can harvest abundant sunlight, transform it into electricity, then convert it to microwaves that can be transmitted wirelessly to where it is needed on Earth. The power constellation could supply areas on Earth with no access to reliable power.

Detecting power from MAPLE on the roof of Moore Laboratory. Credit: Ali Hajimiri

In addition to MAPLE, SSPD is testing a 6 foot by 6 foot Deployable on-Orbit ultraLight Composite Experiment (DOLCE) and a collection of 32 different types of photovoltaic cells (ALBA) against the rigors of the harsh space environment.

Mercury Flyby



Mercury imaged by the ESA/JAXA BepiColombo spacecraft during the third (of six) flyby on June 19th. The spacecraft will enter orbit in 2025. Credit: ESA/BepiColombo

The spacecraft came within 147 miles (236 km) of the heavily cratered surface. Beagle Rupes, a scarp that probably formed as a result of the planet cooling and contracting is identified in the image. Credit: ESA/BepiColombo

Orbital Debris – A Deadly Menace

The Top-10 Worst Historical Breakup Events Based on Catalog Data as of 31 January 2023

Rank	International Designator	Common Name	Year of Breakup	Apogee Altitude (km)	Perigee Altitude (km)	Debris Cataloged	Debris in Orbit	Assessed Cause of Breakup
1	1999-025A	Fengyun-1C	2007	865	845	3532	2793	Anti-satellite (ASAT) test
2	1982-092A	Cosmos 1408	2021	490	465	1785	364	ASAT test
3	1993-036A	Cosmos 2251	2009	800	775	1715	1021	Accidental collision (with Iridium 33)
4	1994-029B	STEP II upper stage	1996	820	585	754	76	Accidental explosion
5	1997-051C	Iridium 33	2009	780	775	657	300	Accidental collision (with Cosmos 2251)
6	2022-151B	CZ-6A upper stage	2022	847	813	533	529	Accidental explosion
7	2006-026A	Cosmos 2421	2008	420	400	509	0	Unknown
8	1986-019C	SPOT 1 upper stage	1986	835	805	498	30	Accidental explosion
9	1981-053A	Cosmos 1275	1981	1015	960	479	418	Accidental explosion
10	1965-082DM	Titan 3C-4 transtage	1965	790	710	473	32	Accidental explosion

Orbital Debris Quarterly News, March 2023

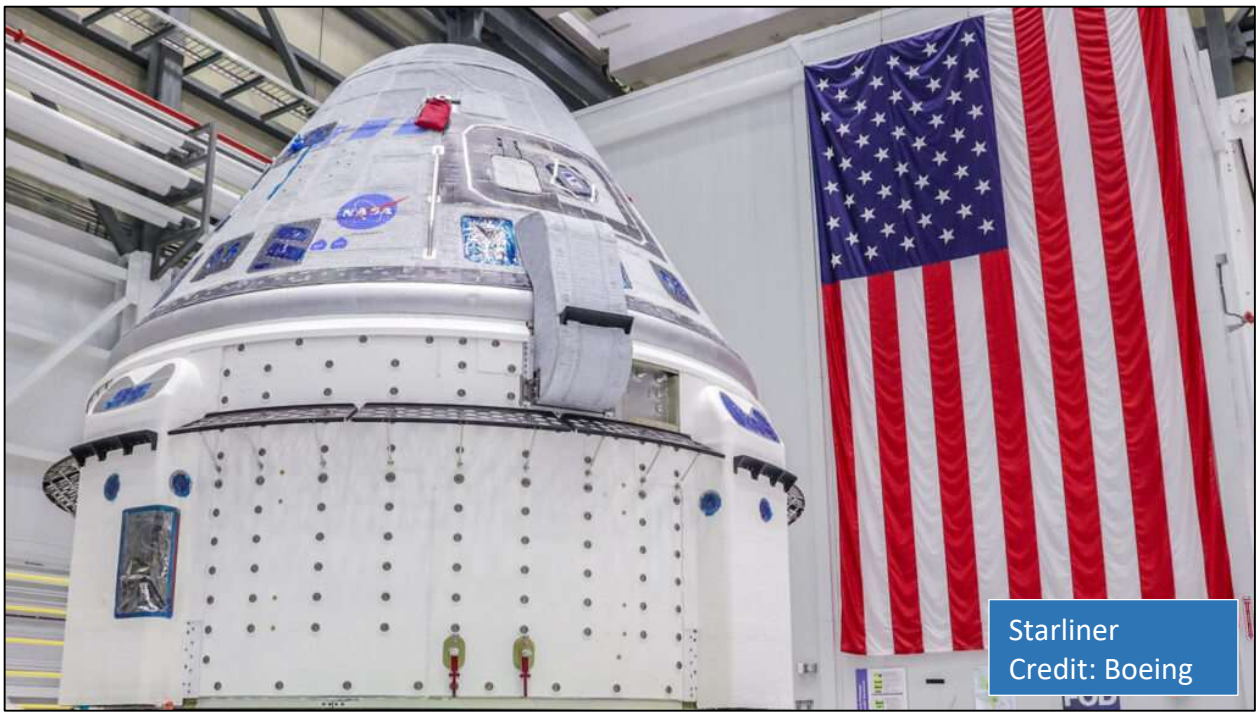
The intentional and catastrophic destruction of satellites as a means of testing anti-satellite weapons by both China (2007) and Russia (2021) have greatly increased the debris in low-Earth orbit. The debris presents a hazard to operators of other spacecraft, as well as occupants of the International Space Station (ISS). 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). Fragments large enough to be detected and cataloged by the Space Surveillance Network comprise a small percentage of the hundreds of thousands of fragments, some as small as one millimeter in size, that were likely generated from these breakups.

While the ISS has approximately 500 different impact shields, the station has needed to conduct 35 collision avoidance maneuvers since 1999 (the most recent on March 6th of this year). Historically, a docked Russian Progress spacecraft is used to reposition the ISS (raise orbit). NASA has explored the possible use of Northrop Grumman's Cygnus cargo freighter for such a task (as an option), but the spacecraft is not always at the station. 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

When the U.S. space shuttle program ended in 2011, astronauts access to the International Space Station (ISS) became dependent on Russian spacecraft (a costly and now politically sensitive option). 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 for all the partners. 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, (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 test was deemed a success by Boeing. However, moving on to a crewed demonstration and final flight readiness test has been problematic and increasingly frustrating for both the astronauts assigned to the flight, as well as NASA.

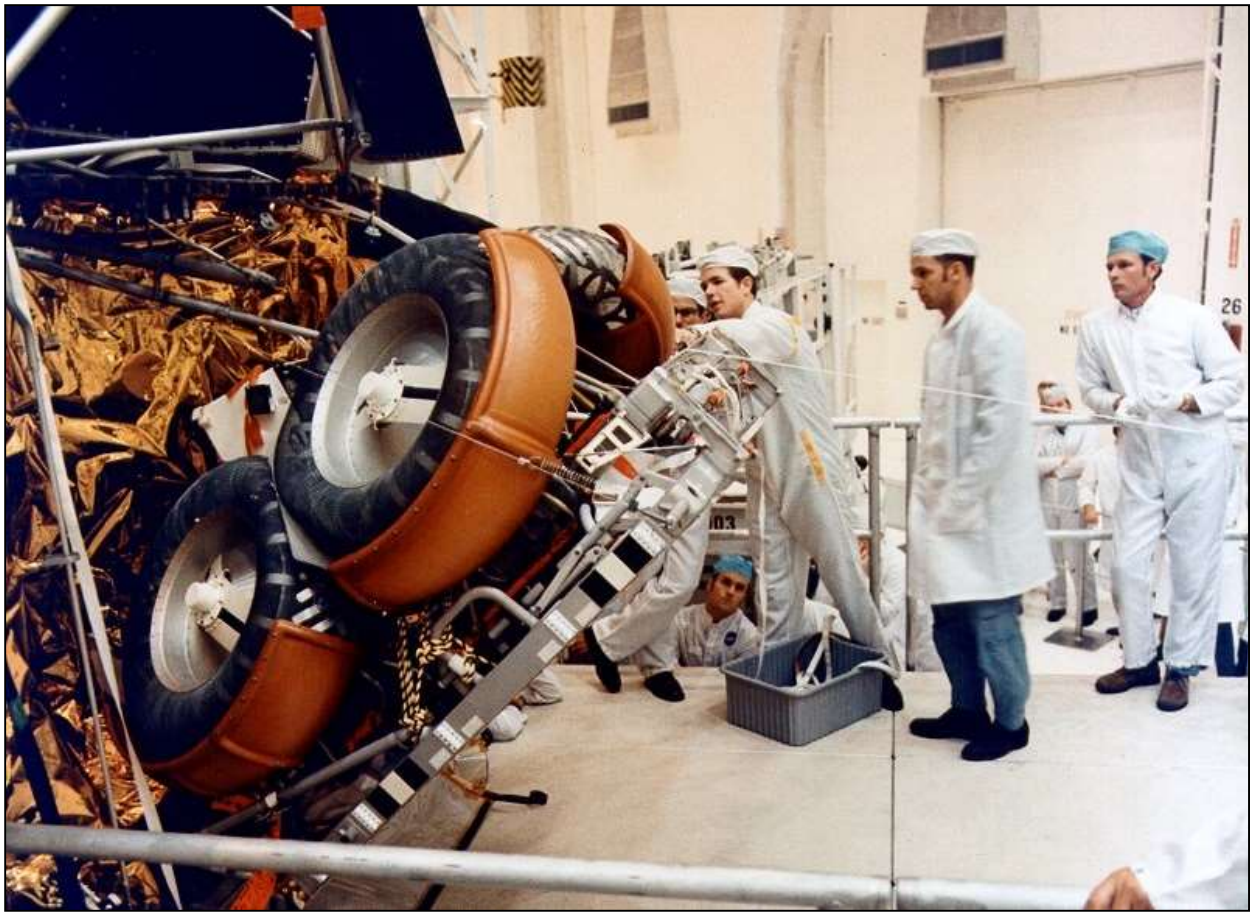


Boeing had tentatively planned to conduct the next flight at the end of July. Unfortunately, continued concerns regarding the Starliner's parachute system's safety margins, replacement of a by-pass valve on the active thermal control system (used to flow coolant into the system to cool the onboard avionics), and an emerging issue of insulating tape on wiring that could present a flammability risk under certain conditions need to be addressed before the spacecraft can be fueled and rolled out to the pad. The flight date has now been delayed indefinitely.

First Wheeled Vehicle on Moon

Fifty-two 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 Udvar-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). Construction is expected to be completed in about 3 years (2025). The shuttle components will be relocated to the new building while there is still access from above and then protected by a temporary roof while the remaining structure is completed.

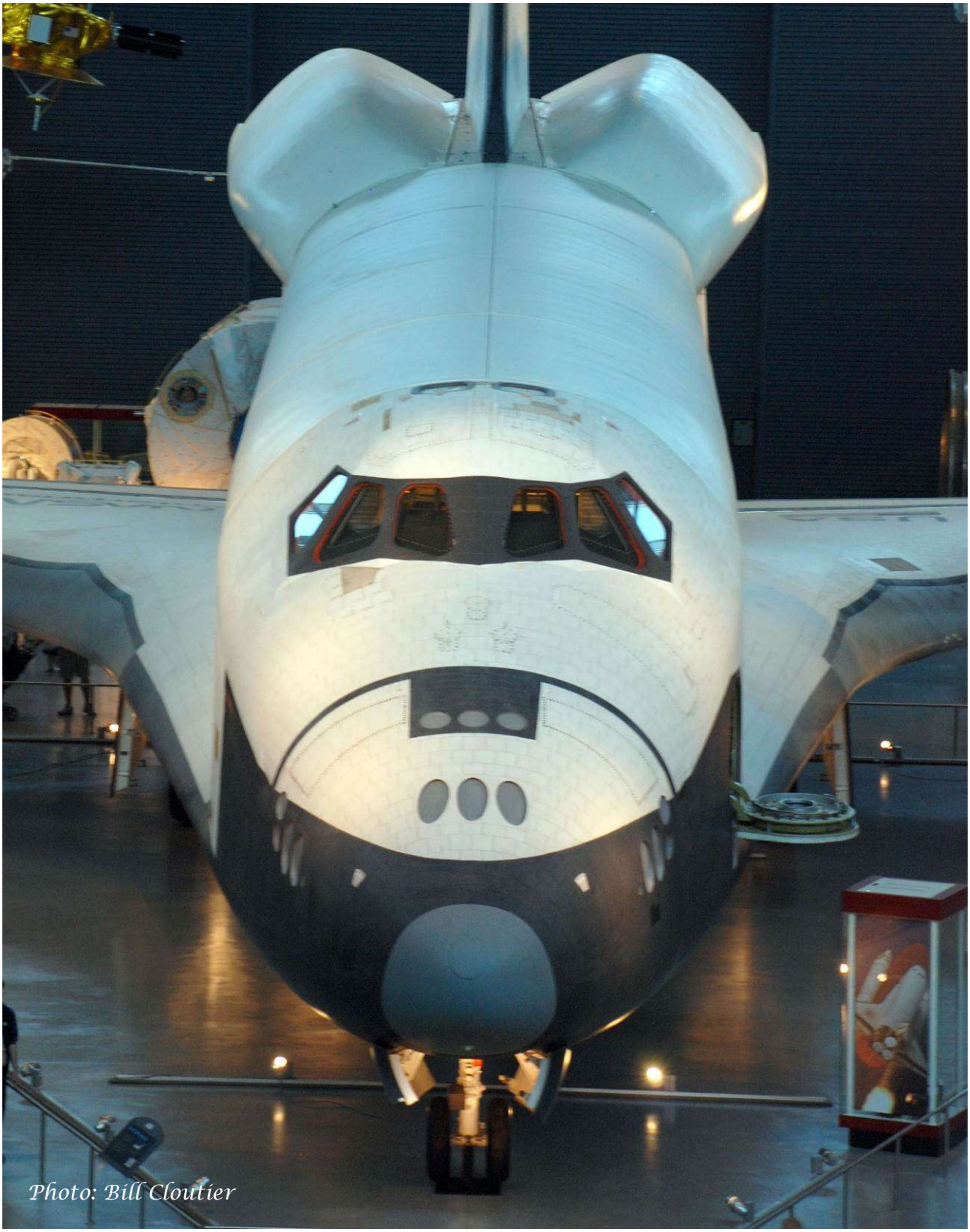
Atlantis

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

Photo: Bill Cloutier

Endeavour

Photo: Bill Cloutier

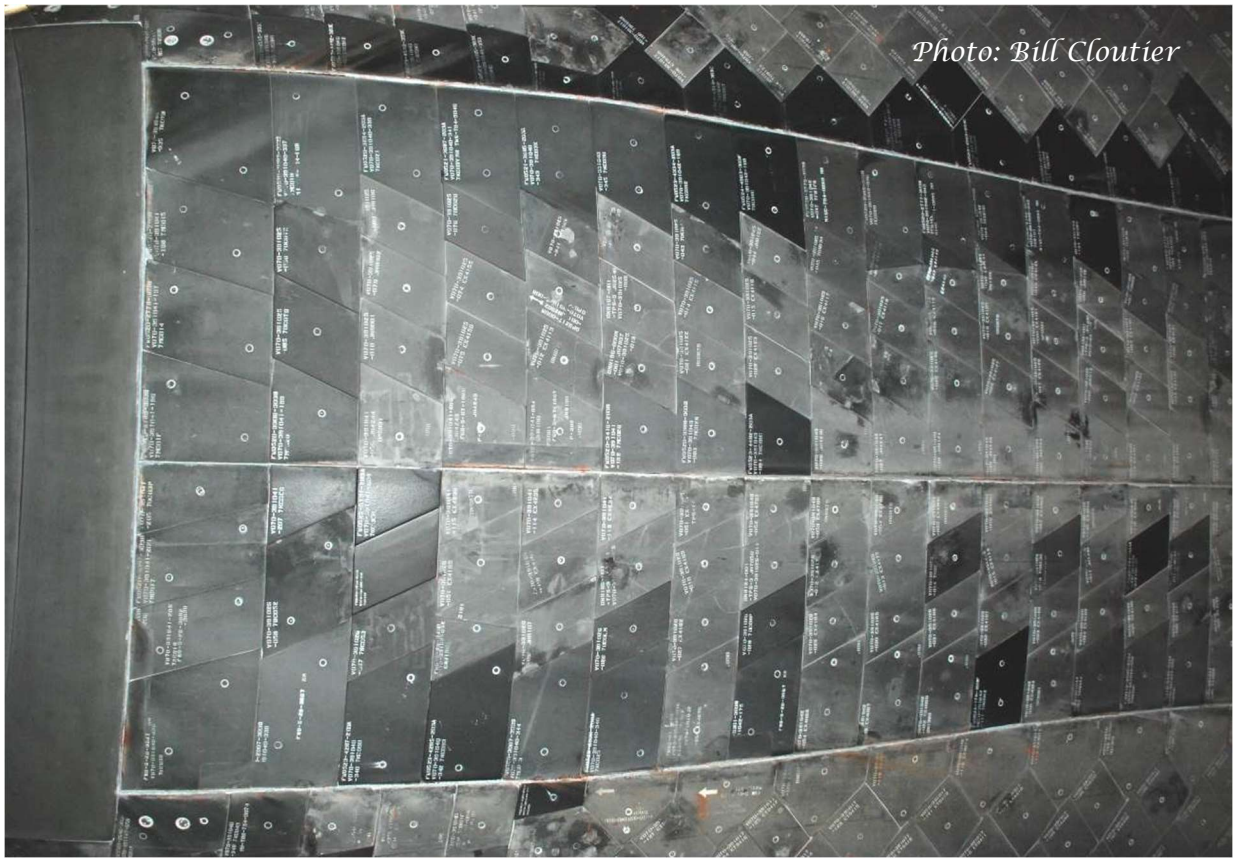


Photo: Bill Cloutier

Atlantis

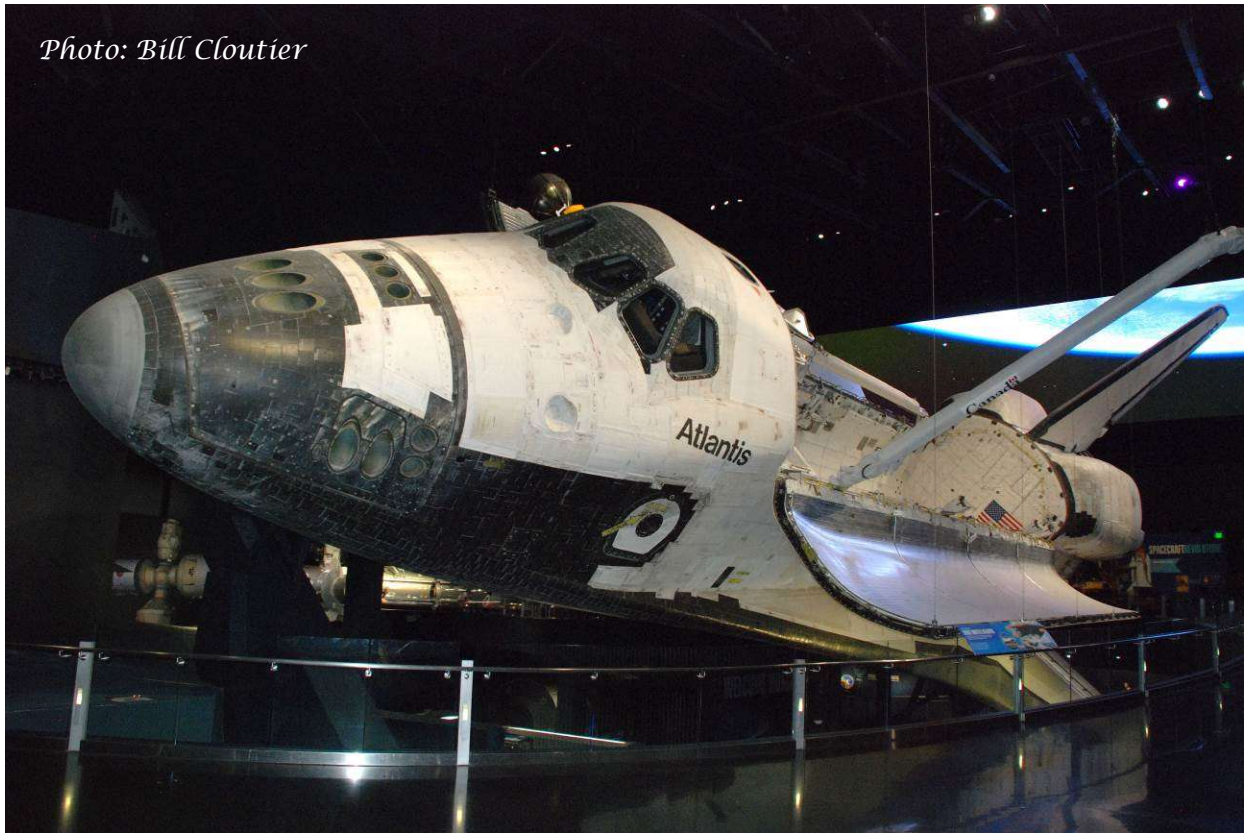
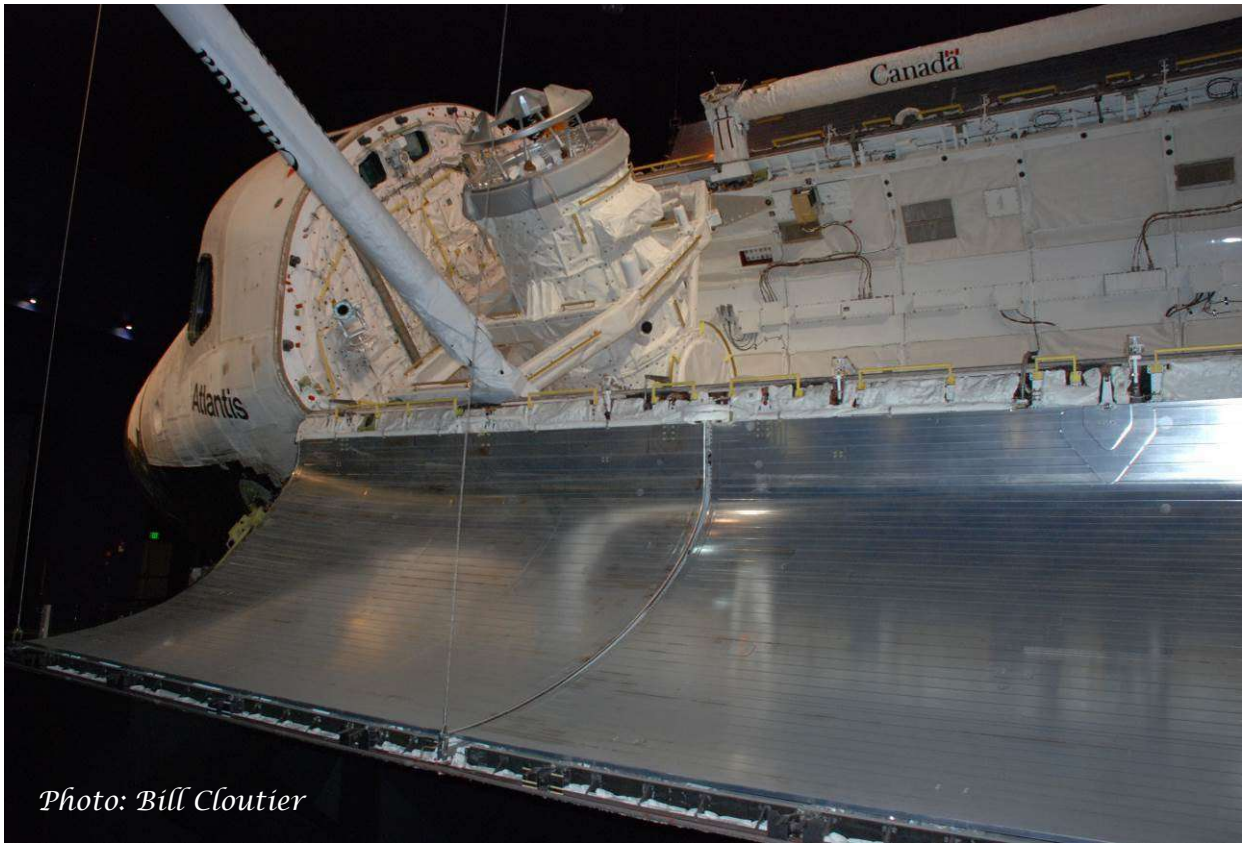


Photo: Bill Cloutier
Atlantis


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.

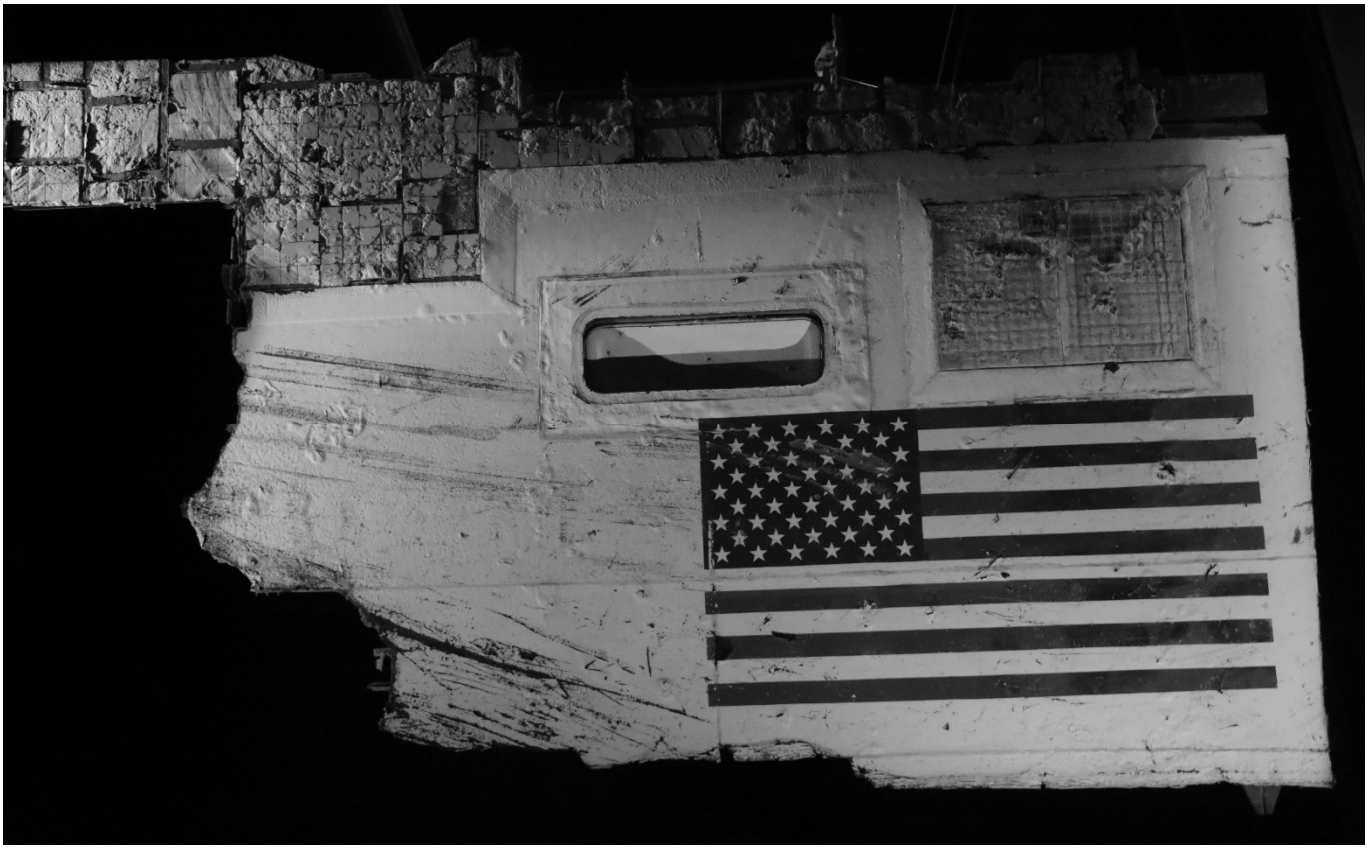
Challenger made her maiden voyage on April 4, 1983. That mission included the first spacewalk from an orbiter, as well as the deployment of the first satellite in the Tracking and Data Relay Satellite System (TDRSS) constellation. Several spacelabs were carried into orbit in Challenger's payload bay.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

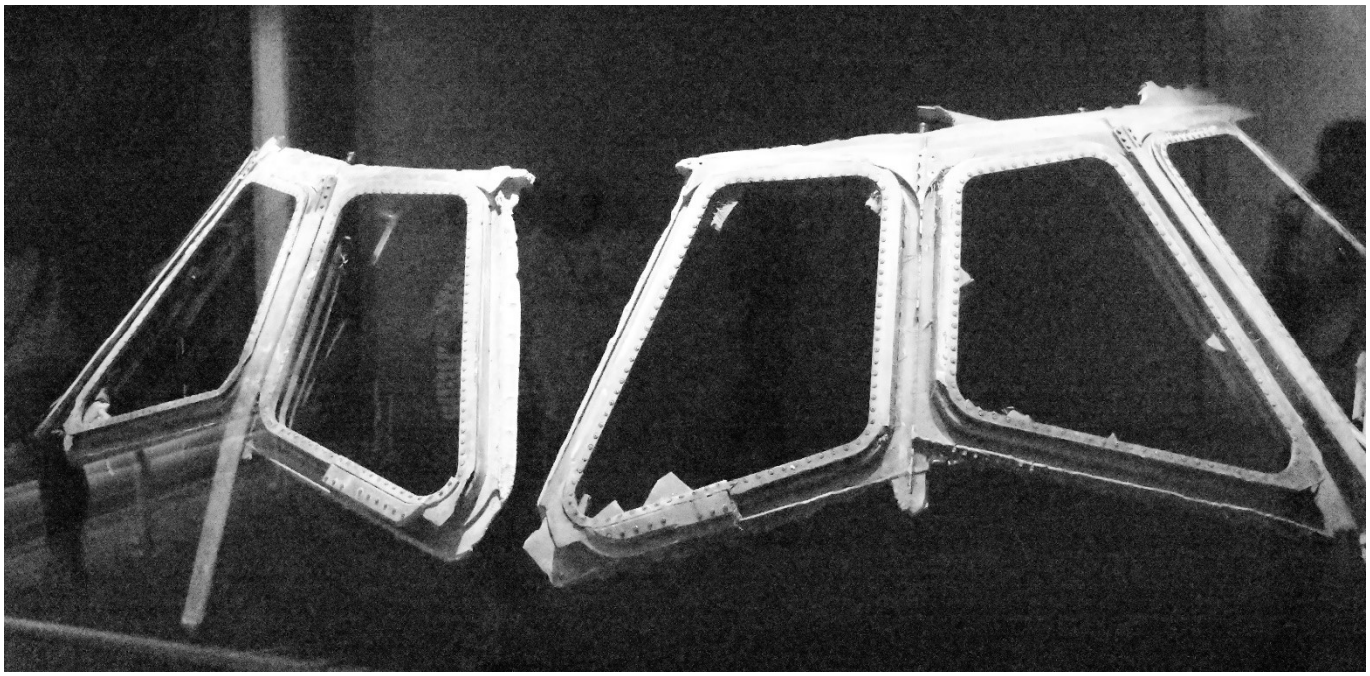
Challenger was the first orbiter to be launched at night and the first to land at the Kennedy Space Center (prior missions had landed at either the Edwards Air Force Base in California or at White Sands, New Mexico).

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:

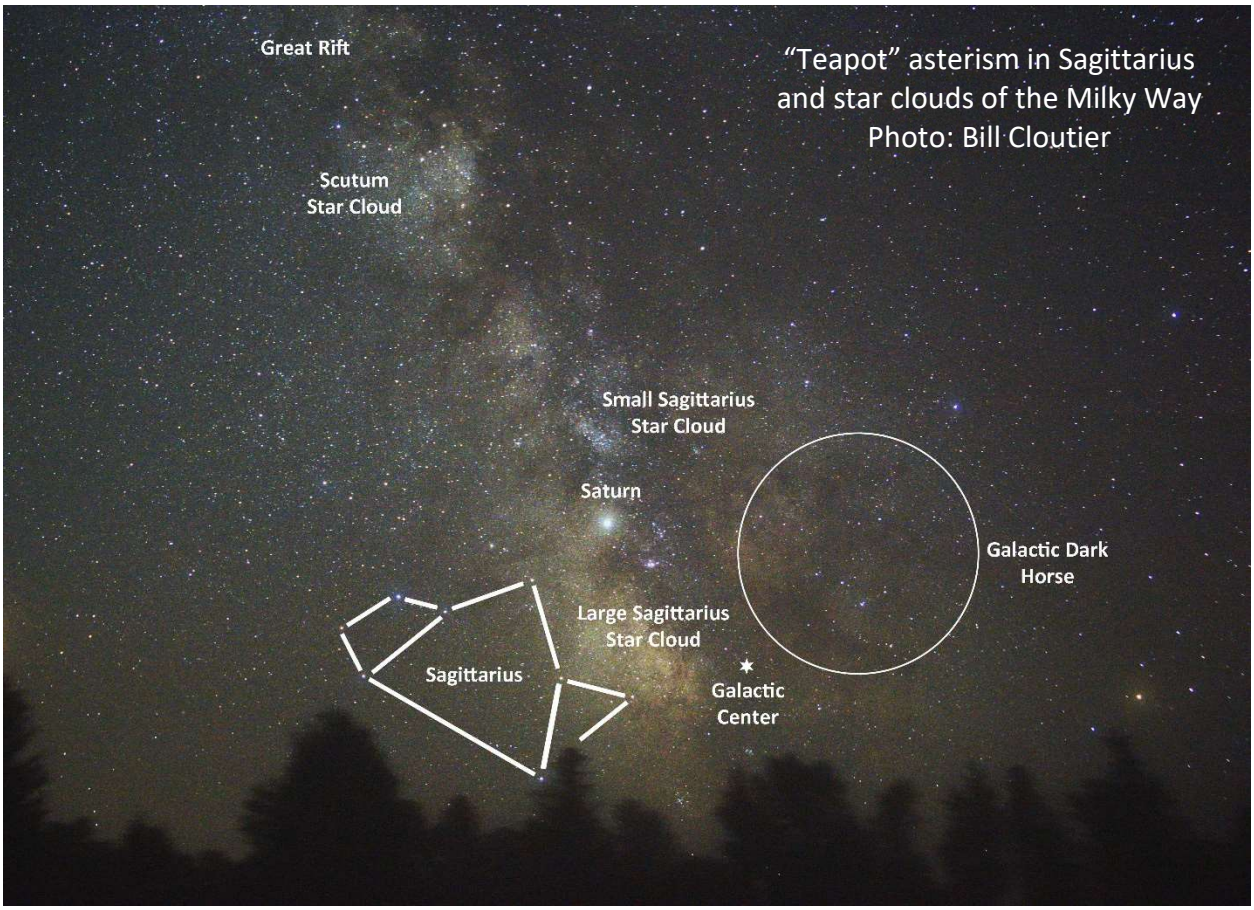
1. Spot the polar mesospheric clouds (also known as Noctilucent clouds or NLCs). These high-altitude clouds, seeded by meteoroid dust and comprised of water-ice crystals, form between 47 to 53 miles (76 to 85 km) above the Earth's surface, near the boundary of the mesosphere and thermosphere, a region 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. A meteor shower occurs when the Earth passes through a cloud of debris usually left behind by a comet. 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 $12^{th}/13^{th}$ is best time night to catch the Perseids meteor shower. Comet Swift-Tuttle is the source of the small grains of dust that create the Perseids. This year, the Moon will be absent from the sky, creating perfect viewing conditions for one of the best showers of the year.

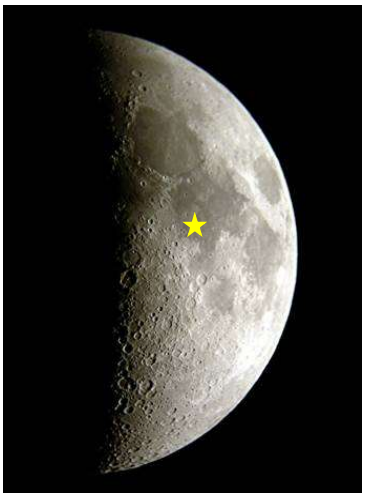
3. Locate the Summer Milky Way. Our solar system resides in one of the outer arms of a very large, rotating pinwheel of 200-300 billion stars called the Milky Way Galaxy. During the summer, we can see the inner arms of the pinwheel in the direction of the galactic core. Unfortunately, a dark sky is required,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

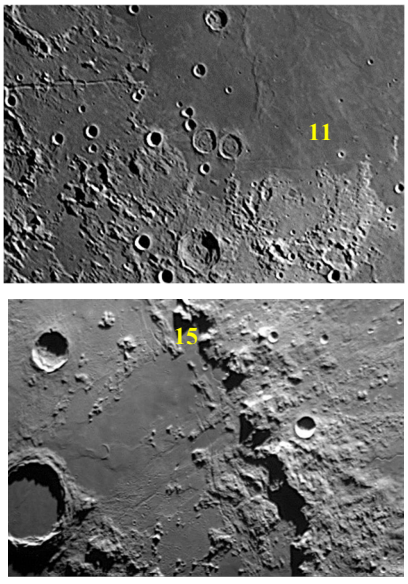
   From a good observing site, you should see a band of cloudiness through this area of the sky. Through binoculars, the "clouds" can be resolved into bright areas populated by stars and darker areas with few or no stars. The darker patches are regions of gas and dust that obscure our view of the galactic 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	7:52
August 31st	06:18	7:28

Astronomical and Historical Events for July and August

July

1st Scheduled launch of ESA's Euclide spacecraft (telescope and two scientific instruments designed to explore the evolution of the dark universe) aboard a SpaceX Falcon 9 rocket from Cape Canaveral, Florida
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 Closest approach of asteroid *2020 NC*, a Near-Earth Object (NEO) and Aten
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 Full Supermoon (sometimes called Buck Moon)
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 Moon at Perigee (closest distance to Earth)
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 Closest approach of asteroid *2023 HO6*, a Near-Earth Object (NEO), Apollo and Potentially Hazardous Asteroid (PHA)
5th History: Isaac Newton's "Mathematical Principles of Natural Philosophy" published, describing the laws of motion (1687)
6th Earth at Aphelion – furthest from the Sun (1.017 AU or 94.5 million miles)
6th History: discovery of Jupiter's moon *Lysithea* by Seth Nicholson (1938)
7th Closest approach of asteroid *2019 LH5*, a Near-Earth Object (NEO), Apollo and Potentially Hazardous Asteroid (PHA)
7th History: launch of the Mars Exploration Rover B (Opportunity) (2003)
8th **McCarthy Observatory Star Party** (see website for details)

Astronomical and Historical Events for July (continued)

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)
9th Last Quarter Moon
9th History: closest pass of Jupiter's cloud tops by the Voyager 2 spacecraft (1979)
10th Closest approach of asteroid *2018 NW*, a Near-Earth Object (NEO) and Apollo
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 History: launch of the Soviet Gamma Observatory (1990)
11th History: Skylab re-enters into the Earth's atmosphere (1979)
12th Closest approach of asteroid *2018 UY*, a Near-Earth Object (NEO), Apollo and Potentially Hazardous Asteroid (PHA)
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 History: Langley Research Center's birthday (1917)
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 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)
17th New Moon
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)

Astronomical and Historical Events for July (continued)

18th Closest approach of asteroid *2020 UQ3*, a Near-Earth Object (NEO) and Apollo
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 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 Moon at Apogee (furthest distance from Earth)
20th Closest approach of asteroid *2022 GX2*, a Near-Earth Object (NEO) and Aten
20th Closest approach of asteroid *2020 OM*, a Near-Earth Object (NEO) and Aten
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 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 Dwarf Planet *134340 Pluto* at Opposition (33.799 AU)
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 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 Closest approach of asteroid *2015 MA54*, a Near-Earth Object (NEO) and Apollo
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 First Quarter Moon
25th History: launch of Soviet Mars orbiter Mars 5 (1973)

Astronomical and Historical Events for July (continued)

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 Closest approach of asteroid *2018 BG5*, a Near-Earth Object (NEO) and Apollo
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 Southern Delta-Aquarids Meteor Shower peak (into morning of the 30th)
29th Closest approach of asteroid *2020 PP1*, a Near-Earth Object (NEO) and Apollo
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 Closest approach of asteroid *2021 BD3*, a Near-Earth Object (NEO) and Apollo
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 Closest approach of asteroid *2016 AW65*, a Near-Earth Object (NEO) and Apollo
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 Full Supermoon (sometimes called Sturgeon Moon)
1st Peak of the Alpha Capricornids meteor shower
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 Moon at Perigee (closest distance to Earth)

Astronomical and Historical Events for August (continued)

2nd Scheduled launch of a Cygnus cargo freighter on a cargo delivery flight to the International Space Station. The spacecraft will be launched aboard a Northrop Grumman Antares rocket from Wallops Island, Virginia
3rd Closest approach of asteroid 2020 PN1, a Near-Earth Object (NEO) and Apollo
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 Closest approach of asteroid 620082 (2014 QL433), a Near-Earth Object (NEO), Apollo and Potentially Hazardous Asteroid (PHA)
4th History: launch of the Phoenix polar lander spacecraft to Mars (2007)
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 Closest approach of asteroid *2004 KG1*, a Near-Earth Object (NEO) and Aten
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 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 Last Quarter Moon
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 Mercury at its Greatest Eastern Elongation (27.4°) – apparent separation from the Sun in the evening sky
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)

Astronomical and Historical Events for August (continued)

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 Closest approach of asteroid *2022 BS2*, a Near-Earth Object (NEO) and Apollo
11th History: Asaph Hall discovers Martian moon *Deimos* (1877)
12th **McCarthy Observatory Star Party** (see website for details)
12th Peak of the Perseids meteor shower (into the morning of the 13th)
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 History: discovery of Mars' south polar cap by Christiaan Huygens (1642)
15th Scheduled launch of a SpaceX Crew Dragon with four crew members to the International Space Station from Kennedy Space Center, Florida
16th New Moon
16th Moon at Apogee (furthest distance from Earth)
16th History: launch of Explorer 12 spacecraft, measured cosmic-ray particles, solar wind protons, and magnetospheric and interplanetary magnetic fields (1961)
17th Closest approach of asteroid *2022 CP1*, a Near-Earth Object (NEO) and Apollo
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 History: launch of Suisei; Japan's Comet Halley mission (1985)
19th Closest approach of asteroid *2011 QJ21*, a Near-Earth Object (NEO) and Apollo
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)

Astronomical and Historical Events for August (continued)

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 History: first light of the 100-meter Robert C. Byrd Green Bank Telescope - the world's largest fully steerable radio telescope. (2000)
23rd Closest approach of asteroid *6037 (1988 EG)*, a Near-Earth Object (NEO), Apollo and Potentially Hazardous Asteroid (PHA)
23rd History: Lunar Orbiter 1 takes first photo of the Earth from the Moon (1966)
24th First Quarter Moon
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 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 History: flyby of the planet Saturn by the Voyager 2 spacecraft (1981)
27th Saturn at Opposition (closest approach to the Earth)
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 History: discovery of a bright nova in the constellation Cygnus (Nova Cygni 1975); visible to the unaided eye for about a week (1975)
30th Full Supermoon (sometimes called Blue Moon)
30th Moon at Perigee (closest distance to Earth)
30th Closest approach of asteroid *2012 PZ17*, a Near-Earth Object (NEO) and Aten
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)

NET August Scheduled launch of the X-Ray Imaging and Spectroscopy Mission, or XRISM, a joint project between the Japan Aerospace Exploration Agency and NASA, from the Tanegashima Space Center, Japan

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

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 4^{th} and 5^{th} 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

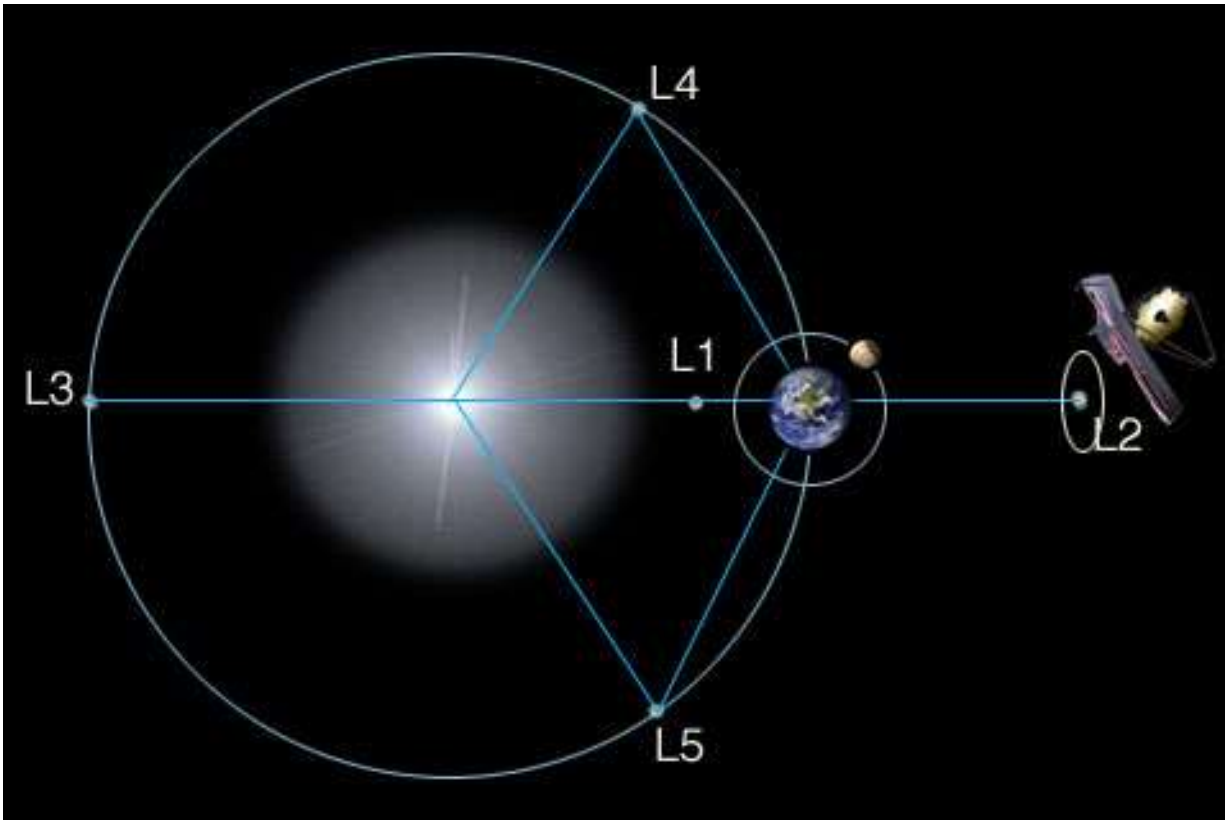
- Vital Signs of the Planet: https://climate.nasa.gov/

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/

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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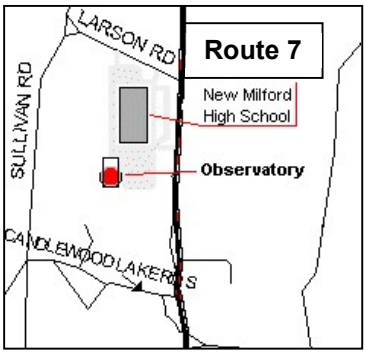

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