Galactic Observer
John J. McCarthy Observatory

Volume 15, No. 9 September 2022

Saturn

Image by McCarthy Observatory volunteer Marc Polansky
on August 15th (EDT) shortly after Opposition

10' Meade LX200 ACF f/20
ZWO ASI224MC w/ZWO ADC
Watertown, CT

September Astronomy Calendar and Space Exploration Almanac

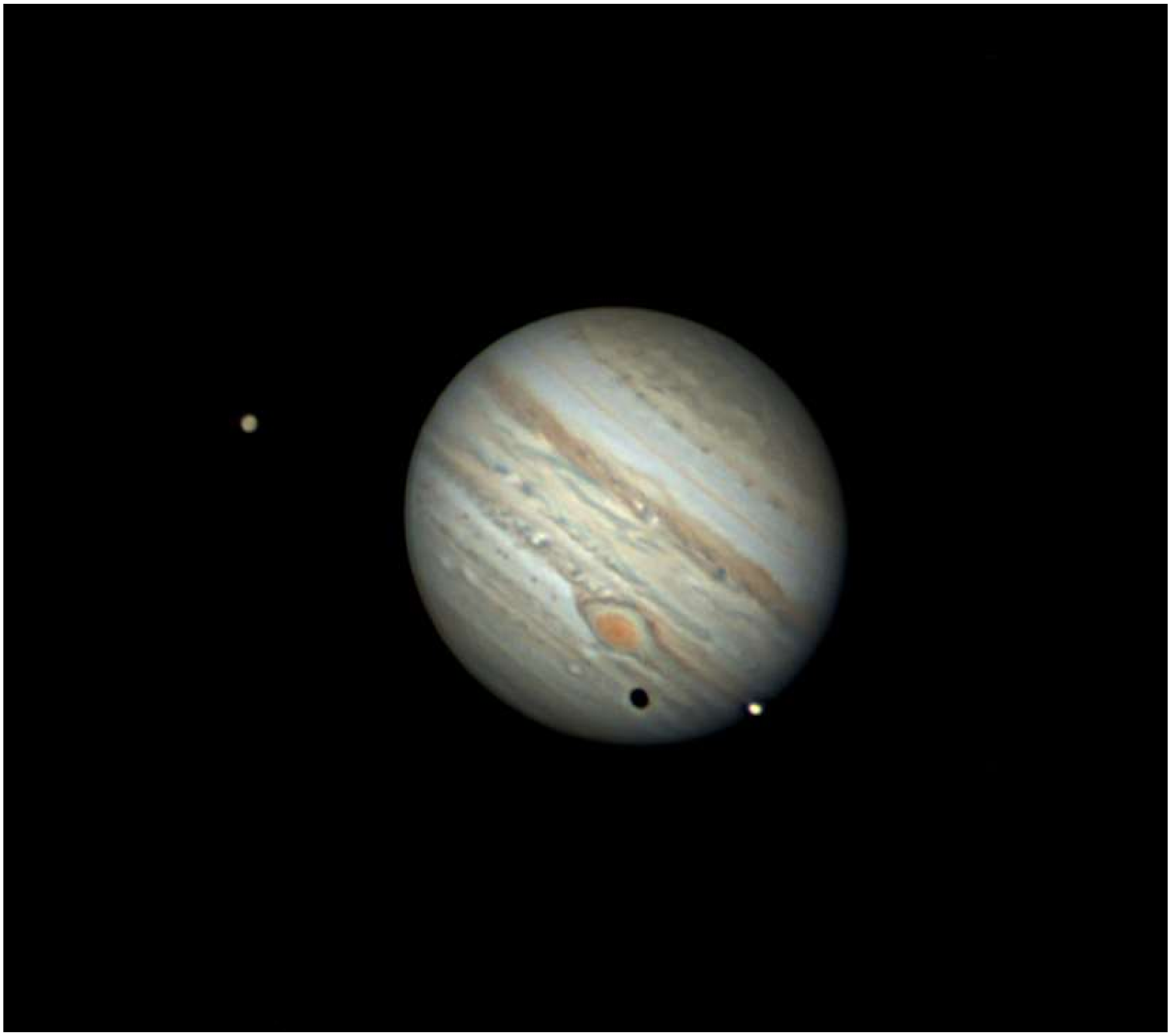


Image by McCarthy Observatory volunteer Marc Polansky of Jupiter on the morning of August 16, 2022 during of transits of Io (on right) and Ganymede (on left). Jupiter reaches Opposition this year on September 26th, less than four months before reaching perihelion or closest approach to the Sun. As such, this year is an excellent time to observe the gas giant, being relatively high in sky (reaching almost 50° in altitude as it passes the meridian) and unusually close to Earth (it won't be closer until the year 2129).

In This Issue

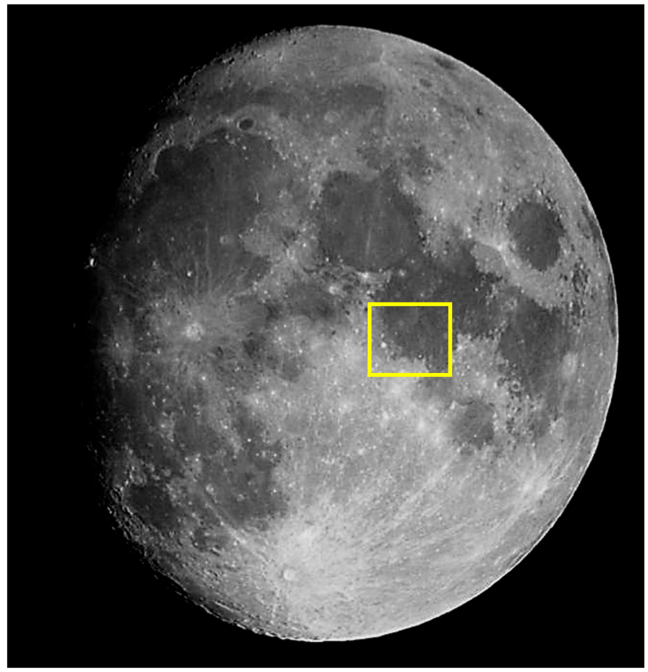
Page

- "Out the Window on Your Left" 3
- Surveyor 5 4
- Artemis I 5
- Into the Infrared 7
- DART 12
- Back in the Air 13
- Ten Years on Mars 14
- Mars Sample Return Campaign Update 16
- Psyche Mission Delayed 17
- Five Years Ago 20
- Twenty Years Ago – the J002E3 Mystery 22
- Destination Moon 24
- Jupiter in the Infrared 25
- Neptune at Opposition 26
- The Carrington Event 27
- Saturn 28
- Jupiter 28
- Jovian Moon Transits 29
- Great Red Spot Transits 29
- Autumnal Equinox 29
- Aurora and the Equinoxes 29
- Sunrise and Sunset 30
- September Nights 30
- Present and Future Pole Stars 30
- Astronomical and Historical Events 30
- Commonly Use Terms 34
- References on Distances 34
- International Space Station and Artificial Satellites 34
- Solar Activity 34
- NASA's Global Climate Change Resource 34
- Mars – Mission Websites 35
- Lagrange Points 35
- James Webb Space Telescope 35
- Contact Information 36

“Out the Window on Your Left”

It’s been more than 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 Surveyor 5 spacecraft landed on the inside slope of a small impact crater (a rimless crater approximately 30 by 40 feet or 9 by 12 meters in size), on the lava plains of Mare Tranquillitatis (Sea of Tranquility) on September 11, 1967. It had been launched three days earlier from Cape Kennedy on an Atlas-Centaur rocket. The lander operated over the course of four lunar days (approximately 3 Earth-months), with a final transmission on December 17th.



Lunar “seas” are expansive, low-lying plains formed by ancient lava flows

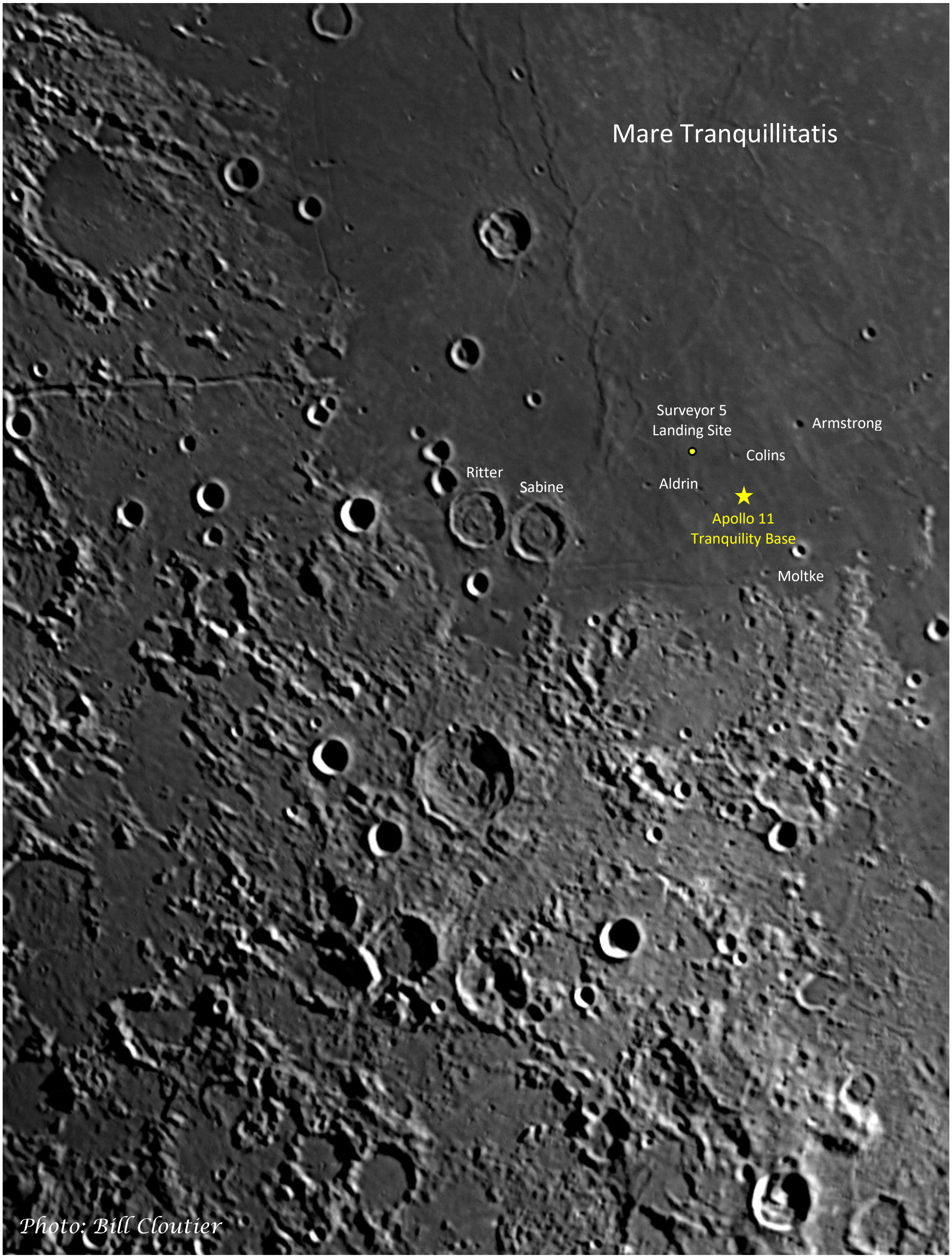
The Surveyor program was comprised of 7 robotic spacecraft. They were designed to support the upcoming Apollo missions by validating soft-landing technologies and providing data on the surface and environmental conditions that the astronauts would encounter. Surveyor 5 was the third successful soft-landing of the series.

The basic Surveyor spacecraft consisted of an aluminum-tube tripod that provided mounting surfaces for equipment, systems and instruments. Its three footpads extended 14 feet (4.3 meters) from the spacecraft’s center. The spacecraft was about 10 feet (3 meters) tall, topped by a central mast. A solar array mounted on the mast provided power for the spacecraft’s instruments and rechargeable batteries. At landing, the spacecraft had a mass of 670 pounds (303 kg).

Surveyor 5 landed less than 16 miles (25 km) from Tranquility Base, where Armstrong and Aldrin would set the lunar module *Eagle* down two years later, and just north of a chain of craters that would later be named for the three astronauts. It was the first Surveyor mission to return data on the regolith’s chemistry and composition, finding that the surface resembled pulverized basalt on Earth. The samples returned by the Apollo 11 astronauts had similar properties and chemistry.

The robotic spacecraft returned a total of 19,118 pictures from the Moon’s surface and 83 hours of data (chemical analysis of the regolith) during the first lunar day. On October 18th, the spacecraft was able to provide thermal data during a total eclipse of the Sun. All mission objectives were achieved.

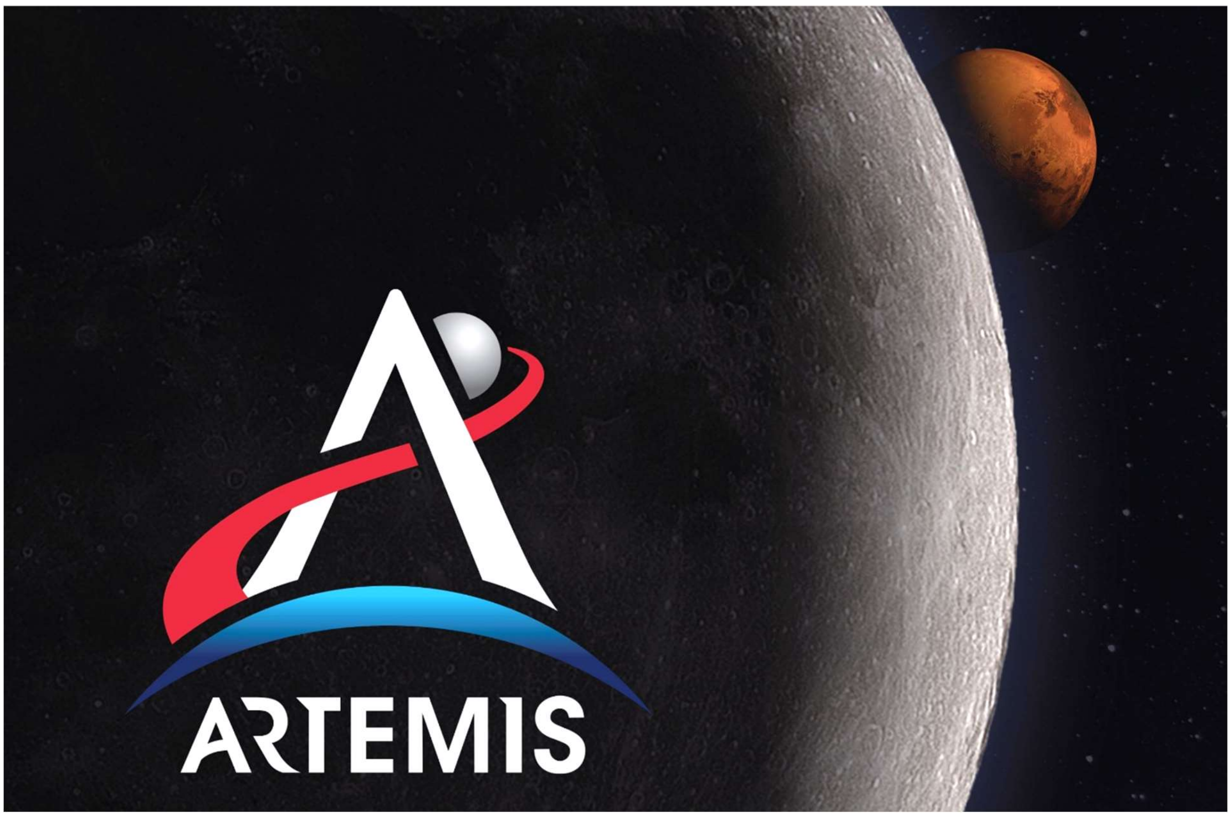
Surveyor 5



Mare Tranquillitatis
Surveyor 5
Landing Site
Armstrong
Colins
Ritter
Sabine
Aldrin
Apollo 11
Tranquility Base
Moltke
Photo: Bill Cloutier

Artemis I

NASA is returning to Moon after 50 years with innovative technologies to explore previously inaccessible areas of the lunar surface. The Artemis program (named for the twin sister of Apollo in Greek mythology) is a collaboration with commercial and international partners. The first launch, without a crew, will test the various components of NASA's new Space Launch System in a deep space mission lasting more than a month. Crewed missions will follow with astronauts tentatively scheduled to visit the Moon's South Polar region in 2025, a prelude to establishing a more permanent presence on our natural satellite, and as a stepping stone to the exploration of Mars and the outer solar system.



The Orion spacecraft in which the astronauts will ride will travel 280,000 miles (450,000 km) from Earth, about 40,000 miles (70,000 km) beyond the Moon during the mission. Propulsion, power and life support will be provided by a service module built by the European Space Agency.

As Orion approaches the Moon, coming as close as 62 miles (100 km) above the lunar surface, it will use the Moon's gravitational force to propel the spacecraft into a deep space orbit. Upon its return, Orion will use the Moon once again to set a course for Earth. The spacecraft will enter the Earth's atmosphere at 25,000 mph (11 km/s), with its heat shield experiencing temperatures of approximately 5,000°F (2,760°C), before splashing down off the coast of Baja, California.

Three mannequins will be riding along for a total million-mile journey. Helga and Zohar, supplied by the German space agency, are fitted with 5,600 sensors to measure radiation. Zohar will also wear an AstroRad radiation protection vest. They will be joined by Commander Moonikin Campos, named after Apollo 13 engineer Arturo Campos, who will be recording information on acceleration and vibration throughout the journey, as well as radiation exposure.

Artemis I

Into the Infrared

NASA's James Webb Space Telescope, a partnership with the European Space Agency (ESA) and Canadian Space Agency (CSA), released the first full-color scientific images and spectroscopic data from the telescope in July. The release, which signified the official beginning of Webb's science operations, showcased the telescope's capabilities and potential. The targets were selected by an international committee of representatives from NASA, ESA, CSA, and the Space Telescope Science Institute.

The first image shared with the public was a "deep field," a patch of sky approximately the size of a grain of sand held at arm's length, containing thousands of galaxies. At the center of the image is the galaxy cluster SMACS 0723. The mass of the cluster distorts the space around it, magnifying distant objects (an effect known as gravitational lensing). Soon after the image was released, astronomers were identifying galaxies within the image whose light started out several hundred million years after the beginning of the observable universe (approximately 13.8 billion years ago). The Webb was able to produce this deepest and sharpest infrared image of the distant universe in only 12.5 hours (it took several weeks for the Hubble Space Telescope to create a similar, but less in-depth image in visible light).

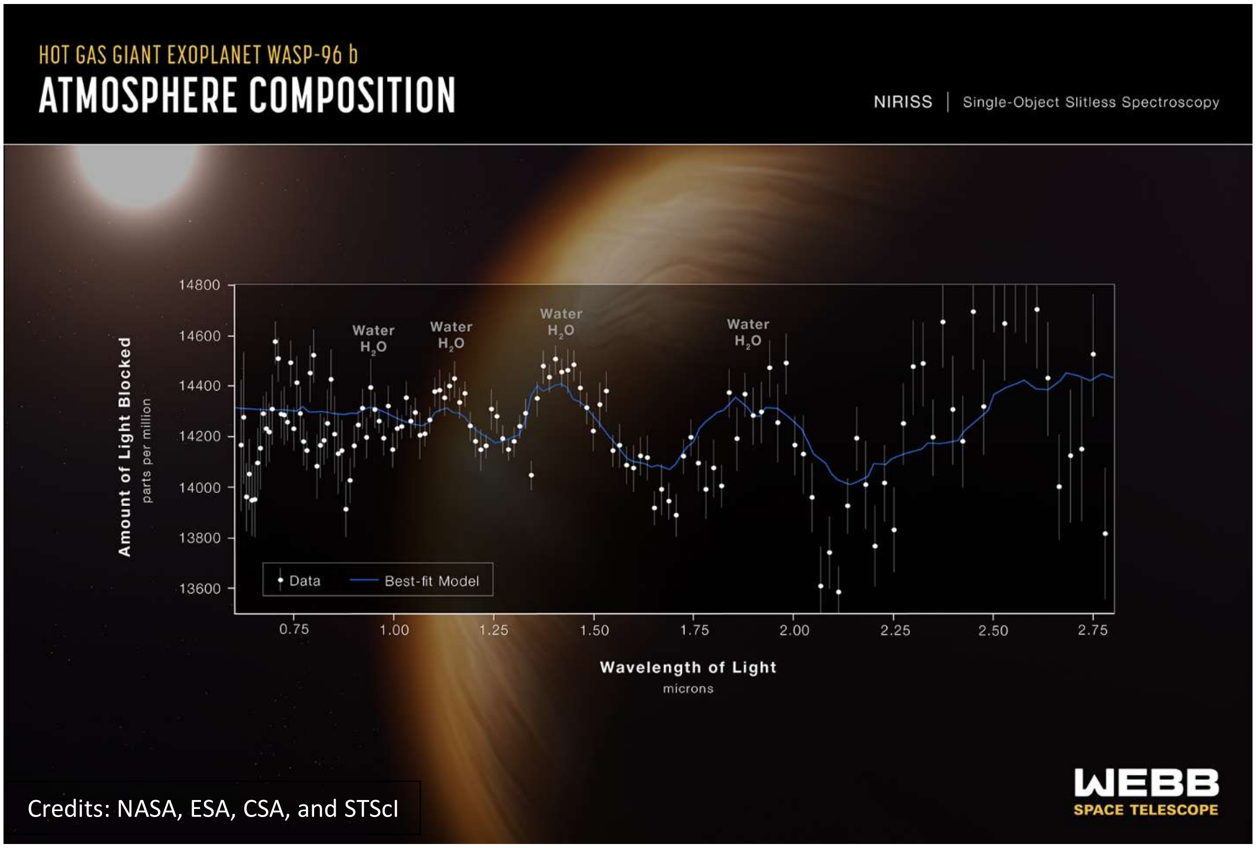
Webb's next image was of a star-forming region called NGC 3324 in the Carina Nebula. Its infrared instruments revealed newly forming stars and the gas and dust from which they originated. Ultraviolet radiation from the new stars carved away the surrounding nebula, creating a three-dimensional landscape of light-year-sized peaks and valleys.

Credits: NASA, ESA, CSA, and STScI

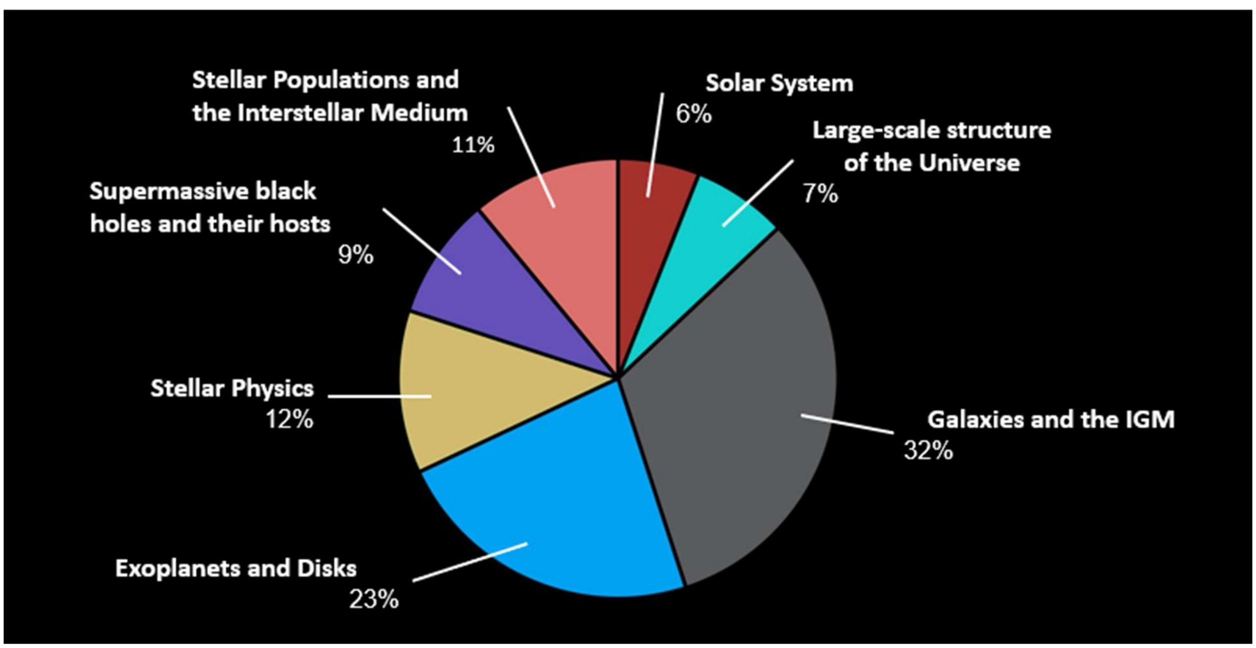
Stephan's Quintet is a compact group of galaxies located in the constellation Pegasus. The four galaxies on the right side of the image are at a similar distance and interacting (the galaxy on the left is 250 light years closer than the other galaxies). Webb's infrared cameras are able to penetrate the dust that shrouds the galaxies in visible light and reveal the star forming regions triggered as a result of the ongoing mergers. Its instruments are also able to determine the composition and velocity of the gas around the central, supermassive black holes within the galaxies.

The Southern Ring is a planetary nebula - an expanding cloud of dust and gas expelled from a dying star. The star (now a white dwarf) is approximately 2,000 light years away and member of a binary system. Webb's mid-infrared instrument reveals the smaller star and details of the expelling shells of stellar material. Energy from its companion, the larger main sequence star, is interacting with the cloud to produce the streamers and filaments.

Gas and dust released by dying stars can enrich the surrounding area with heavier elements – material that may one day be incorporated in a new star or planet.



The final release was spectrographic data of a "hot Jupiter," a planet a bit larger in size than Jupiter and one half its mass. It orbits the star, WASP-96, in less than 4 days. Webb was able to analyze the planet's atmosphere as it passed in front of the star, revealing the distinct signature of water vapor, along with evidence for clouds and haze.



Webb's first year of science will encompass a wide range of targets, from nearby in our own solar system to the furthest galaxies.

DART

On September 26th, (around 7:14 p.m. EDT) the DART spacecraft will approach the Didymos asteroid before intentionally colliding with its moon, Dimorphos. The collision, at roughly 4 miles per second (6 kps), is expected to change the orbital period of Dimorphos around Didymos by a measurable amount (several minutes). This is the first time that a mission has been dedicated to assessing the effectiveness of deflecting an asteroid through a kinetic impact.

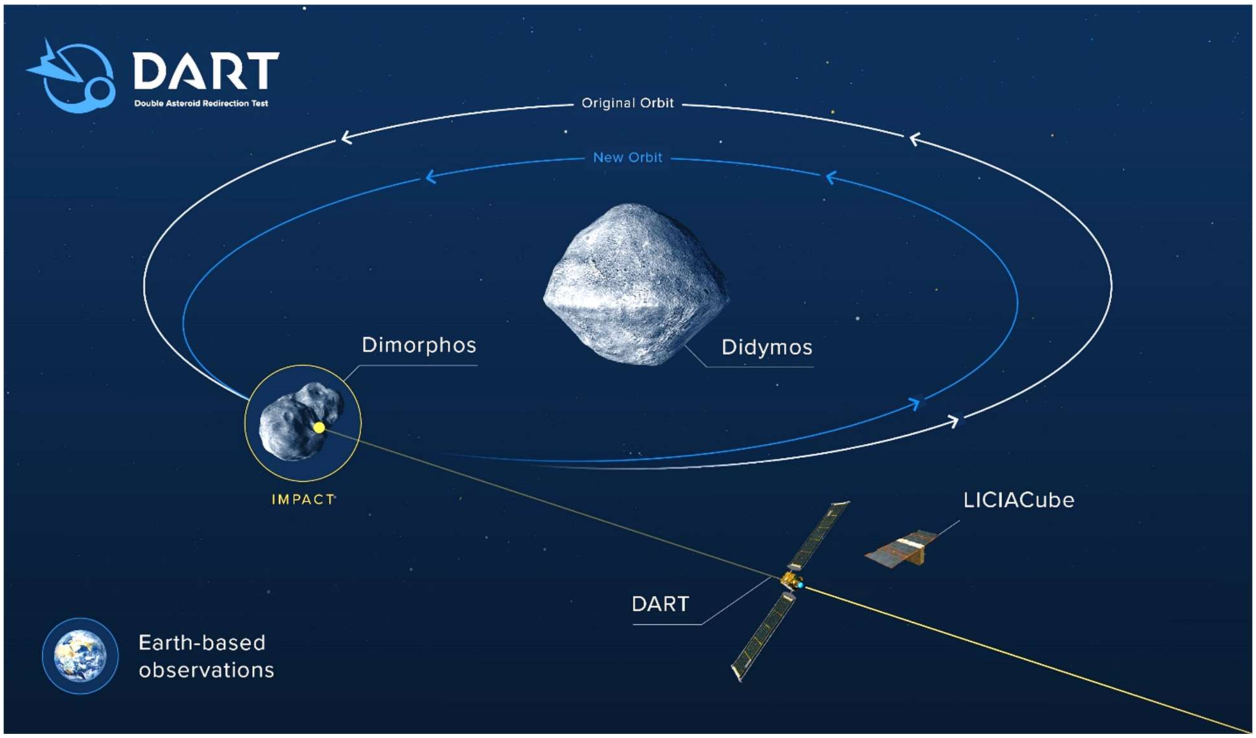
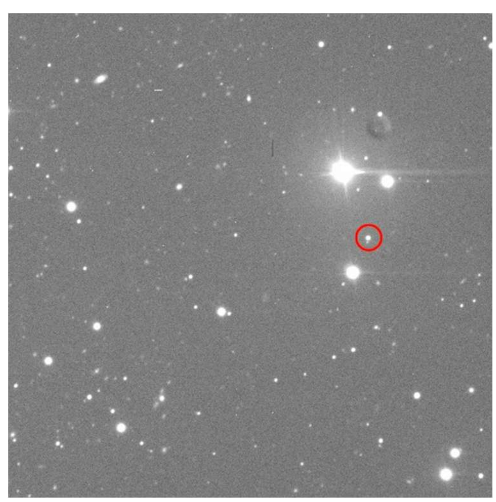


Illustration of how DART's impact will alter the orbit of Dimorphos about Didymos
Image credit: NASA/Johns Hopkins Applied Physics Lab

The 2,560-foot wide (780-meter) near-Earth asteroid Didymos will be close enough to Earth at the time of impact that researchers, using telescopes on Earth, will be able to precisely measure the change in the moon's orbit (Dimorphos is approximately 530 feet or 780 meters wide). The impact will be recorded by LICIACube, a CubeSat provided by the Italian Space Agency that will be released shortly before DART's impact.

In 2024, the European Space Agency will launch the Hera mission to Dimorphos. The spacecraft is expected to rendevous with the moon in 2026 and conduct detailed surveys of both asteroids, measure the mass of Dimorphos, as well as the shape and size of the crater created by the DART impact.



Didymos imaged from the Lowell Discovery Telescope near Flagstaff, Arizona on the night of July 7, 2022
Credits: Lowell Observatory/N. Moskovitz

Back in the Air

NASA’s Mars helicopter captured by the Perseverance rover’s Mastcam-Z camera
Credits: NASA/JPL-Caltech/ASU/MSSS.

The Mars Ingenuity helicopter has taken to the air once again, the first flight for the diminutive rotorcraft in more than two months. The 30th flight was similar to its second flight and designed as a test of its critical systems, as well as to dislodge any dust that has accumulated on its solar panel, over the long period of inactivity. The flight took place on August 20th and lasted just 33 seconds, covering about 7 feet (2 meters) of horizontal distance.

It’s winter in Jezero Crater, with overnight temperatures as low as -124°F (-86°C). The sunlight hitting the helicopter’s solar panel just isn’t strong enough to keep its batteries fully charged. Since Ingenuity hadn’t flown since June 11th, JPL’s helicopter team had the rotorcraft perform a 50-rpm spin on August 6th, and a short high-speed spin (2,573 rpm) on August 15th prior to its flight. The tests confirmed that Ingenuity was still flight-worthy after more than 100 Martian days, or sols.

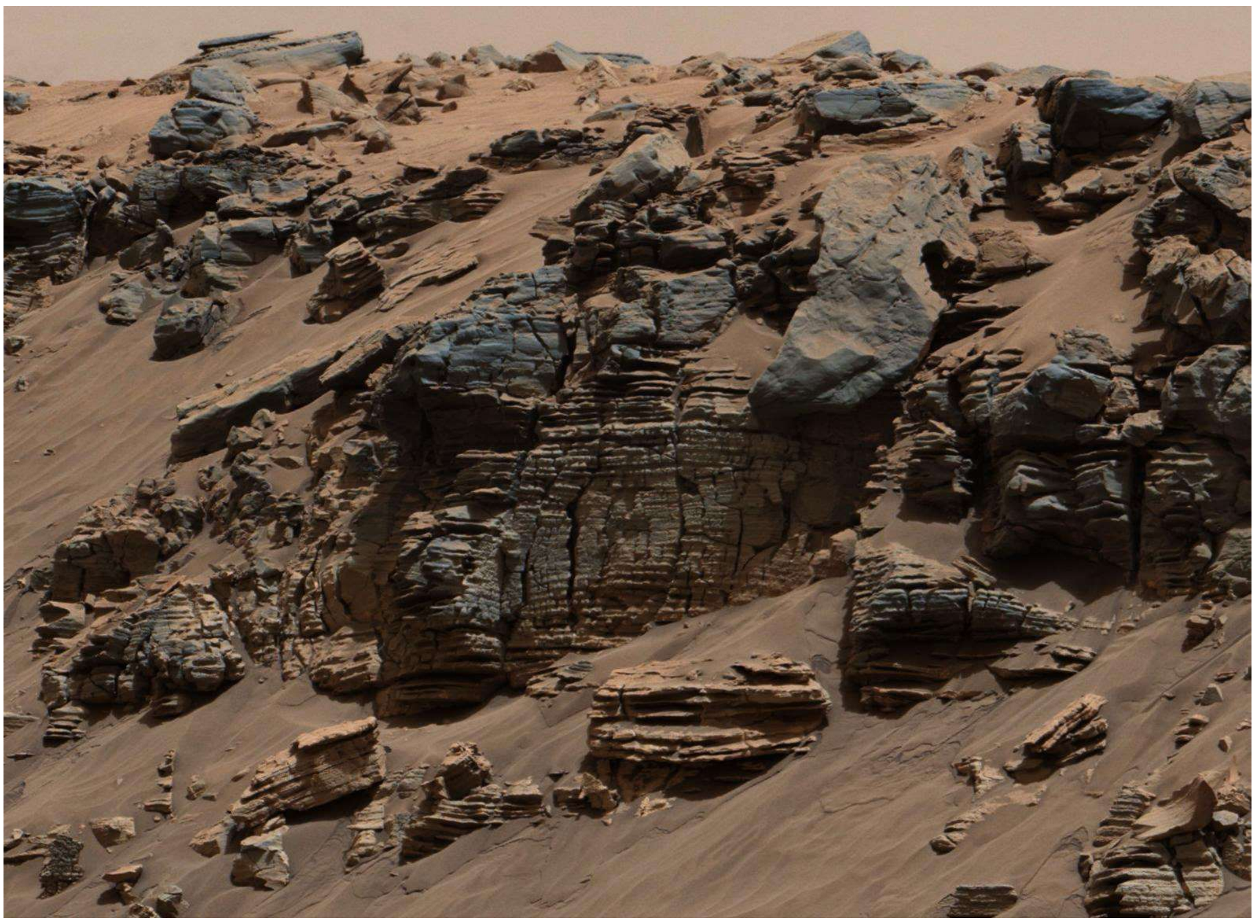
As conditions improve, the team plans to expand the flight envelop. Data from future flights will be used to support planning for NASA’s Mars Sample Return Campaign, which now includes helicopter(s) for possible sample tube collection/retrieval.

Ingenuity will also resume its trek towards the river delta as power levels continue to increase. Higher levels of charge on the batteries will also allow Ingenuity to power up its internal heaters overnight to prevent the electronics from freezing. The JPL team is also planning on upgrading the flight software in September with new navigational capabilities for traversing the delta terrain.

Ten Years on Mars

NASA's Mars Science Laboratory (the Curiosity rover) landed in the 96-mile diameter (154 km) Gale Crater on August 5, 2012. The impact crater was created approximately 3.7 billion years ago and, during Mars' early history, was likely flooded with groundwater and from small streams. The center of the crater is dominated by a massive, stratified mountain (informally referred to as Mount Sharp), which rises about 3.4 miles (5.5 km) above the crater floor.

Since landing, Curiosity has driven nearly 18 miles (29 km) and ascended 2,050 feet (625 meters) as it works its way up the central peak. The rover has analyzed 41 rock and soil samples as it uses its suite of science instruments to assess whether the crater had the right environmental conditions to support primitive life forms.



Layered rock formation shows a pattern typical of a lake-floor sedimentary deposit
Credit: NASA/JPL-Caltech/MSSS

Curiosity has added to our knowledge of the Red Planet with chemistry data, as well as radiation levels, seasonal changes in the weather, and images of Mars' high, thin clouds and diminutive moons. As the rover climbs higher, it has recorded evidence of major changes in the environment over time as the planet became drier and colder. While Curiosity has determined that liquid water, and the nutrients needed to support life, were present for at least tens of millions of years, scientists have yet to determine whether these conditions persisted into more recent times, were cyclical (disappearing and then reappearing) or just slowly ceased to exist.

In its ten years, Curiosity's on-board science laboratory has detected organic molecules in the rock samples collected. Organic molecules (those containing carbon) could be used as building blocks and an energy source for life. The rover's Tunable Laser Spectrometer has also detected fluctuations in the abundance of methane in the near-surface atmosphere (Curiosity isn't equipped to determine whether or not the methane it has detected originates from biological processes). While Curiosity has found the ingredients for life (including nitrogen) it can't confirm that life once existed in Gale crater. However, the importance of this astrobiology mission cannot be understated and earlier this year, NASA extended the rover's mission at least into 2025.

Rover operations are not without challenges. The rugged terrain has taken a greater toll on Curiosity's wheels than had been designed for, with engineers devising new ways to minimize wear and tear and keep the rover moving. This has included a novel traction control algorithm for reducing the pressure on the wheels from the rocks.


Curiosity's damaged left-middle wheel
Credit: NASA/JPL-Caltech/MSSS

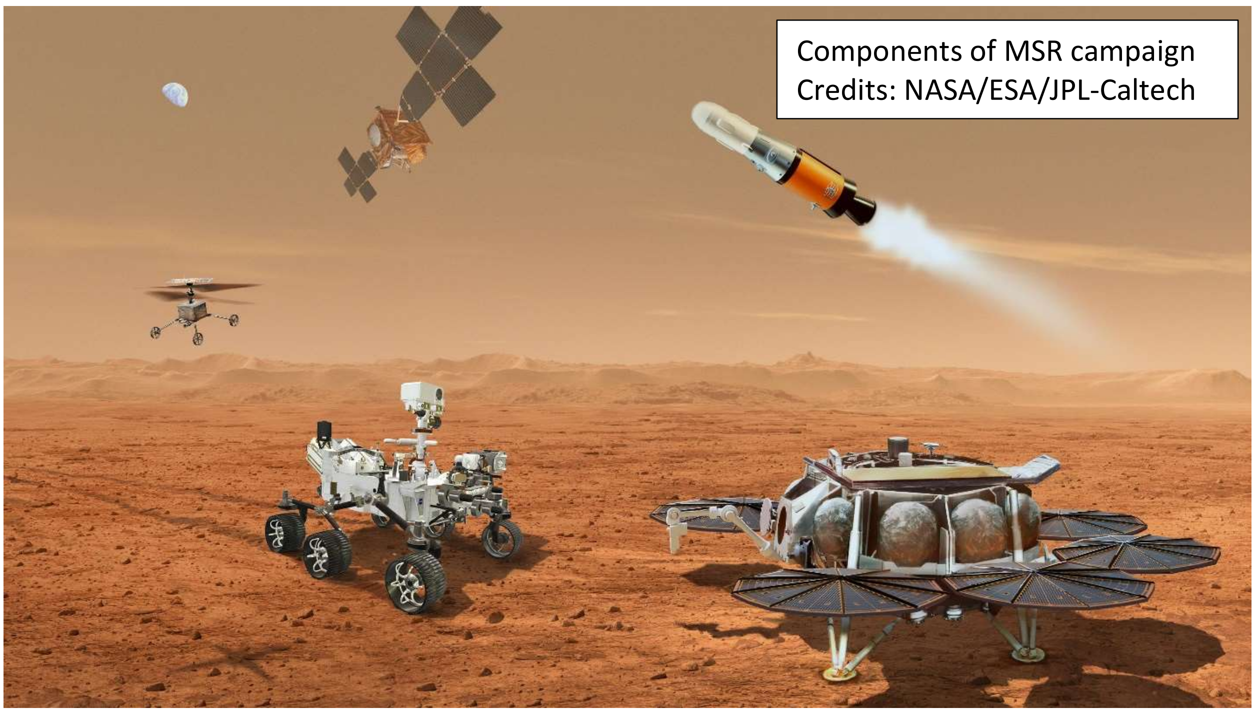
Curiosity has six wheels, each machined out of a single piece of aluminum and powered by individual motors. The wheels are 20 inches (0.5 meters) in diameter, with cleats for traction and curved titanium springs for springy support. The skin of the wheel is 0.75 millimeters thick (1/32 inch) - the absolute thinnest that could be machined. The grousers, in a chevon pattern, prevent sideways slip and provide structural strength. The wheel has a set of odometry marker holes, providing a way for the rover's navigational software to measure its driving progress by photographing its tracks. The holes also spell out "JPL" in Morse code.

The wheels were redesigned for the Perseverance mission. They are slightly larger in diameter and narrower. They have twice as many treads as Curiosity's and curved instead of the chevron-pattern.

Mars Sample Return Campaign Update

The Perseverance rover has collected 12 rock cores to date (out of an anticipated 38 total sample tubes available). Once the rock core is hermetically sealed in its titanium tube, it is then stored internally until such time that the JPL team elects to drop them off onto the surface for future retrieval.

NASA and the European Space Agency (ESA) have been working on a strategy to collect the samples and return them to Earth (the Mars Sample Return or MSR mission). The plan originally called for the delivery of a "fetch rover" on one lander to retrieve the sample tubes. The rover would then carry the tubes back to a second lander where they would be loaded onto a small rocket. The rocket would rendezvous with an orbiting transfer vehicle for the ride back to Earth.


Components of MSR campaign
Credits: NASA/ESA/JPL-Caltech

The latest design simplifies the complexity of the previous concept, eliminating the fetch rover and the second lander. The new NASA-ESA mission campaign now includes two mini helicopters. They would provide a backup method of retrieving the sample tubes should the Perseverance rover be unable to perform the task (NASA fully expects Perseverance to be operational in 2028/29 when the lander arrives).

The helicopters will be similar in size and mass to Ingenuity. However, the landing legs will include "mobility wheels," allowing the helicopters to move across the surface and over the sample tube cache. A small robotic arm will enable the helicopter to pick up the tube(s).

Once back at the lander, the helicopter(s) would roll over to and drop the tubes within reach of the lander's ESA-built transfer arm. Perseverance has been scouting sites near the delta where the lander could set down safely.

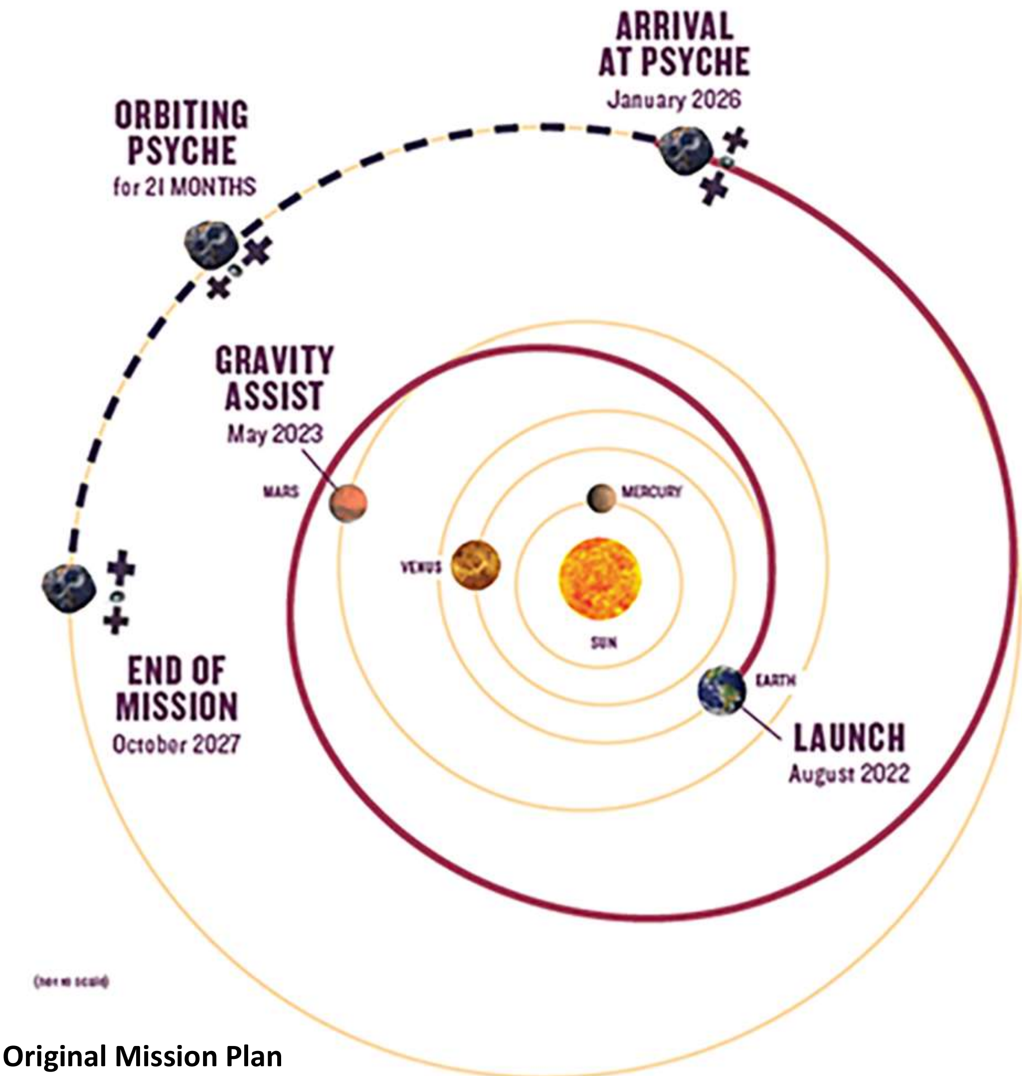
The current timetable would have the rocket carrying the samples launch from the surface of Mars in 2031, with an expected arrival on Earth around 2033.

Psyche Mission Delayed

NASA’s Psyche spacecraft inside the Payload Hazardous Servicing Facility at NASA’s Kennedy Space Center in Florida on May 9, 2022 being prepared for launch
Image Credit: NASA

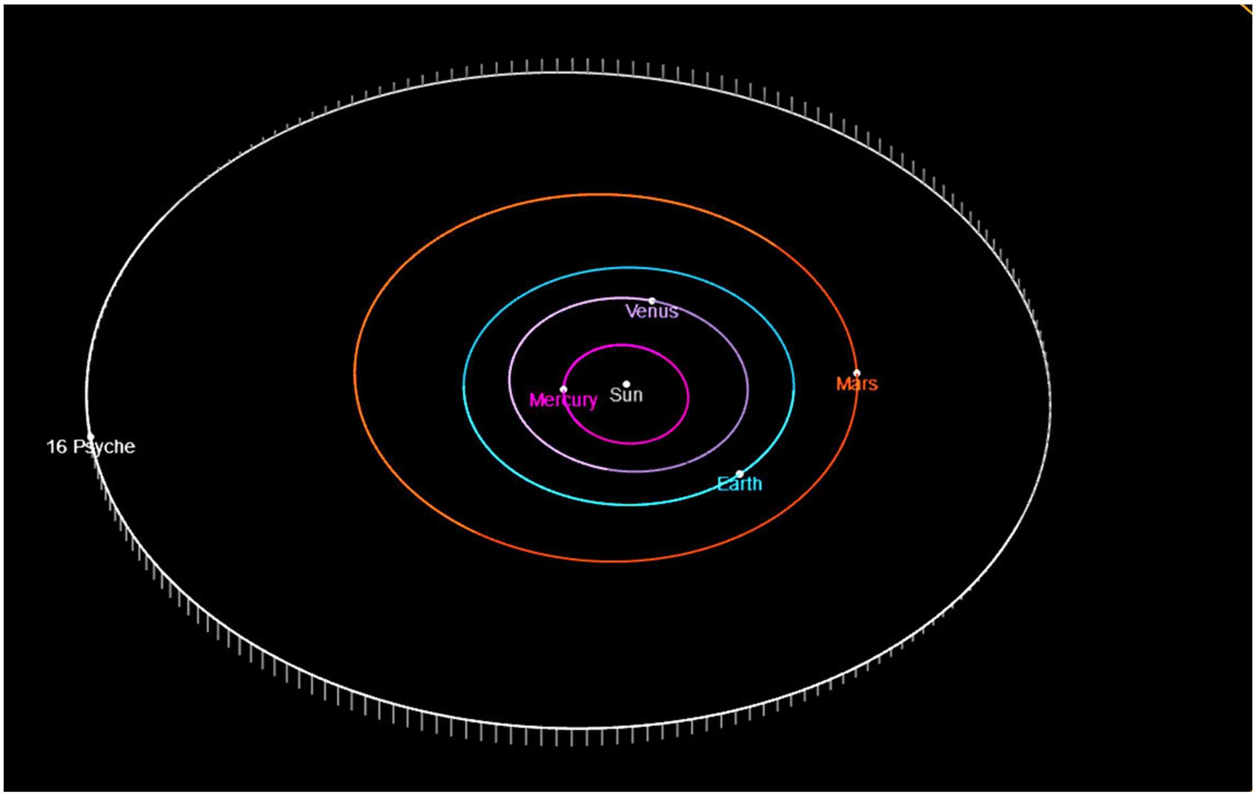
The Psyche mission to a metal-rich asteroid, originally scheduled to launch on August 1st, has been postponed indefinitely. The decision was announced on June 24th after it was revealed that the spacecraft's flight software was delivered too late for testing prior to launch. The spacecraft had already been transported to the Kennedy Space Center when the decision was made.

The spacecraft was scheduled to arrive at the asteroid 16 Psyche in 2026, with a gravitational assist from Mars. While there are launch windows available in July and September of 2023, the relative orbital positions of the Earth and Psyche are not as favorable, and neither is Mars in a position to provide an assist which would have increased the spacecraft's velocity, saved propellant and time. The one-year launch delay will therefore result in a three-year delay in arrival (2029).

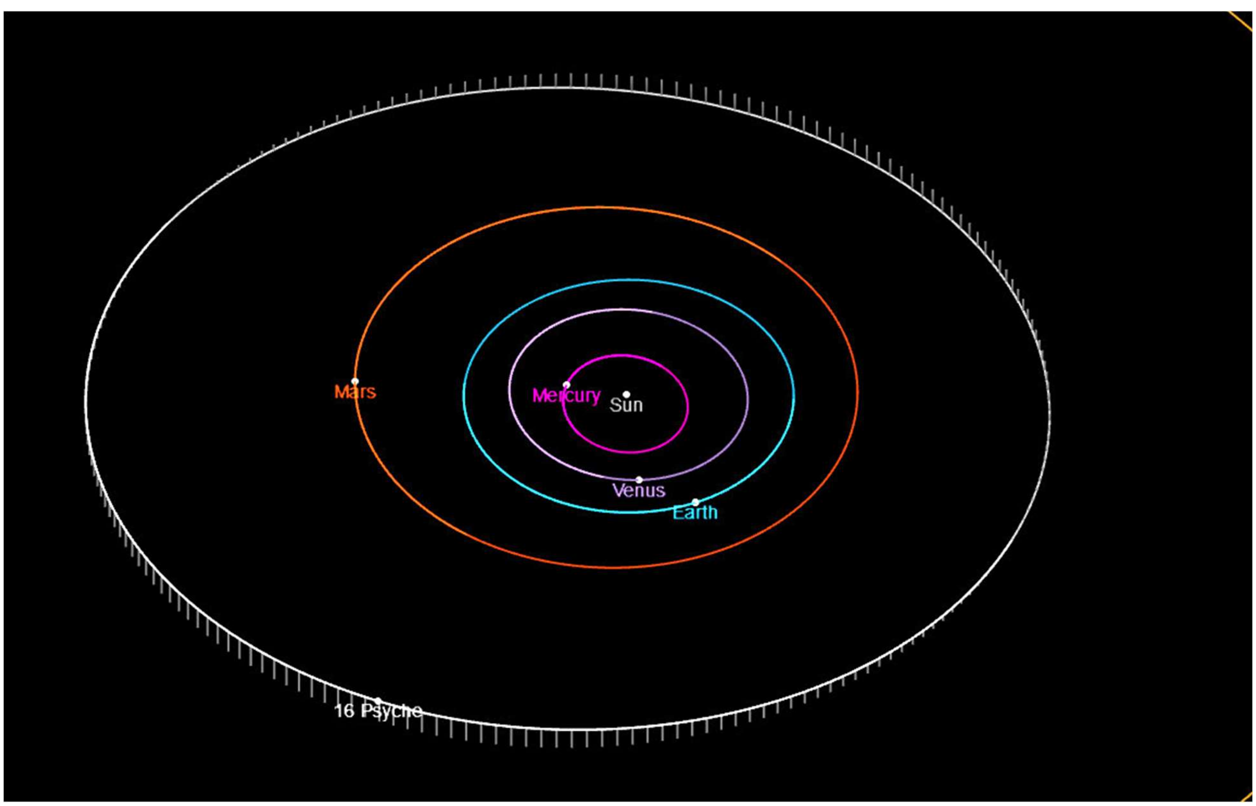


Original Mission Plan

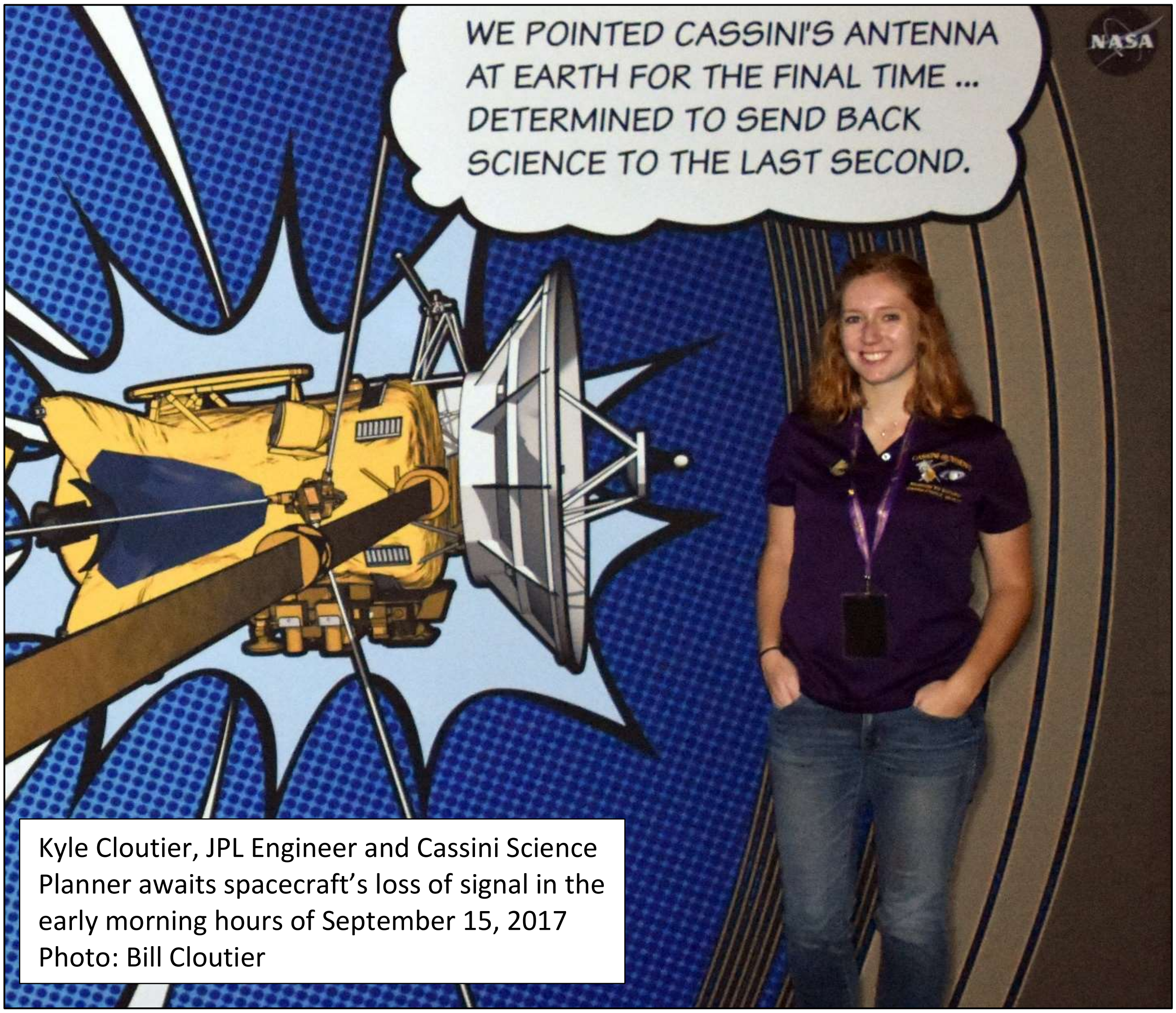
NASA has convened a 15-member review board to better understand what led to the failure to meet the 2022 launch schedule. as well as to assess factors of workforce environment, culture, communication, schedule, and both technical and programmatic risks. The board will present their findings in late September, including what work might be required to ensure that Psyche is ready for a potential future launch opportunity.



Orbital positions for an August 1, 2022 launch (above) and July 2023 launch (below) from JPL's Small-Body Database, Orbit Viewer, for asteroid 16 Psyche



Five Years Ago



Kyle Cloutier, JPL Engineer and Cassini Science Planner awaits spacecraft's loss of signal in the early morning hours of September 15, 2017
Photo: Bill Cloutier

Five years ago, the mission team (past and present) from NASA's Jet Propulsion Laboratory (JPL), along with friends and family, gathered together on the Caltech campus to watch the end of the Cassini mission play out on large movie-theater-size screens set up on the grounds. The outdoor theater provided a live view of JPL's control room, as well as the transmissions being received by NASA's Deep Space Network, Canberra station in Australia, from the spacecraft.

The almost 20-year-long epic mission came to a dramatic end as the spacecraft, running out of fuel, was deliberately plunged into Saturn's atmosphere to ensure its moons, e.g., Enceladus and Titan, remain unspoiled for future exploration. As Cassini began its entry, at about 1,200 miles (1,900 km) above the cloud tops, Saturn's tenuous atmosphere began to buffet the spacecraft. While its thrusters attempted to stabilize the school-bus-sized craft and keep its antennae pointed at Earth, it was a losing battle. Telemetry indicated that Cassini endured about 40 seconds longer than expected, before tipping over backwards during the last eight seconds and losing radio contact with Earth. Loss of signal was called at 4:55:46 AM PDT (83 minutes after the actual event at Saturn due to its great distance from Earth). While the mission ended, the data collected by Cassini in the Saturnian system continues to add to our understanding of the ringed-world and its moons.

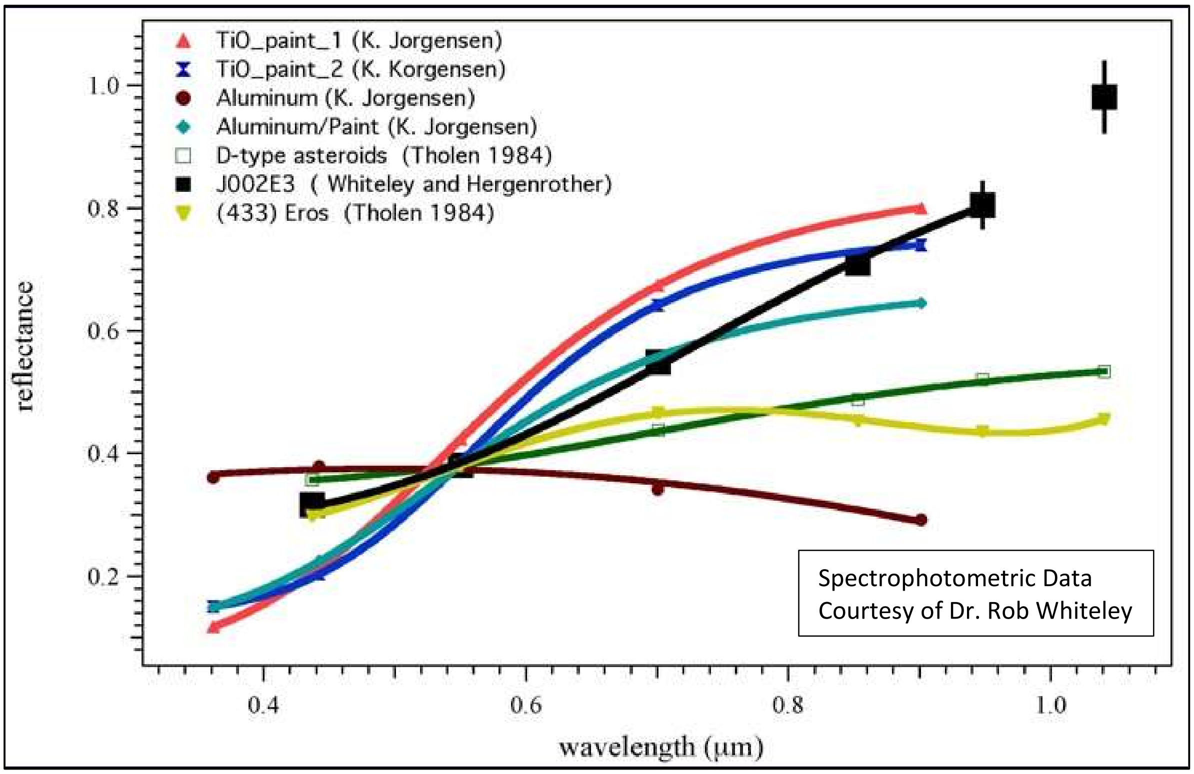
Pale Blue Dot: The Earth and Moon were captured by the Cassini spacecraft's cameras from the far, unlit side of Saturn and from a distance of 898.414 million miles (1.446 billion km). Images taken using red, green and blue spectral filters were combined to create this natural color view.

Image Credit: NASA/JPL-Caltech/Space Science Institute

Twenty Years Ago – the J002E3 Mystery

On September 3, 2002, amateur astronomer Bill Yeung discovered what was initially thought to be an asteroid that had been captured by the Earth. As the astronomical community rushed to observe this new visitor, evidence began to accumulate that this was no ordinary object.

The object rotated or tumbled every minute or so, faster than any known asteroid. The influence of the pressure from solar radiation was detectable in the motion of the body, suggesting it was a man-made object. Astronomers also measured its rotational light curve and spectrum of light reflected from J002E3 using the 61-inch telescope at the Stewart Observatory (Mt. Bigelow, Arizona). In a fortuitous meeting at the University of Arizona, astronomer Dr. Rob Whiteley graciously shared with me the results of those observations.

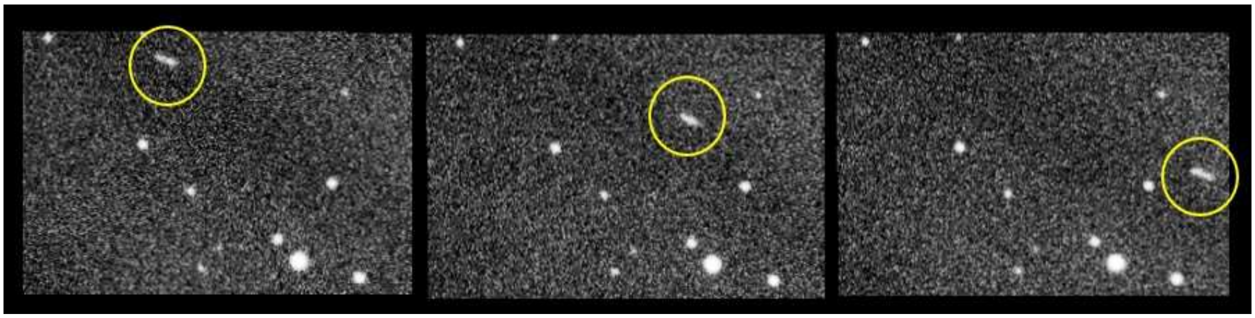


Spectrally, the results were incompatible with a typical Near-Earth Object. The spin period and spectral properties however, were well-matched with a man-made object, e.g., a tumbling rocket booster. The acceleration of J002E3 (from solar pressure) was also consistent with expectations for a spent rocket stage. In addition, the spectrophotometric data was in close agreement with the titanium oxide paint used on the Saturn V rocket.

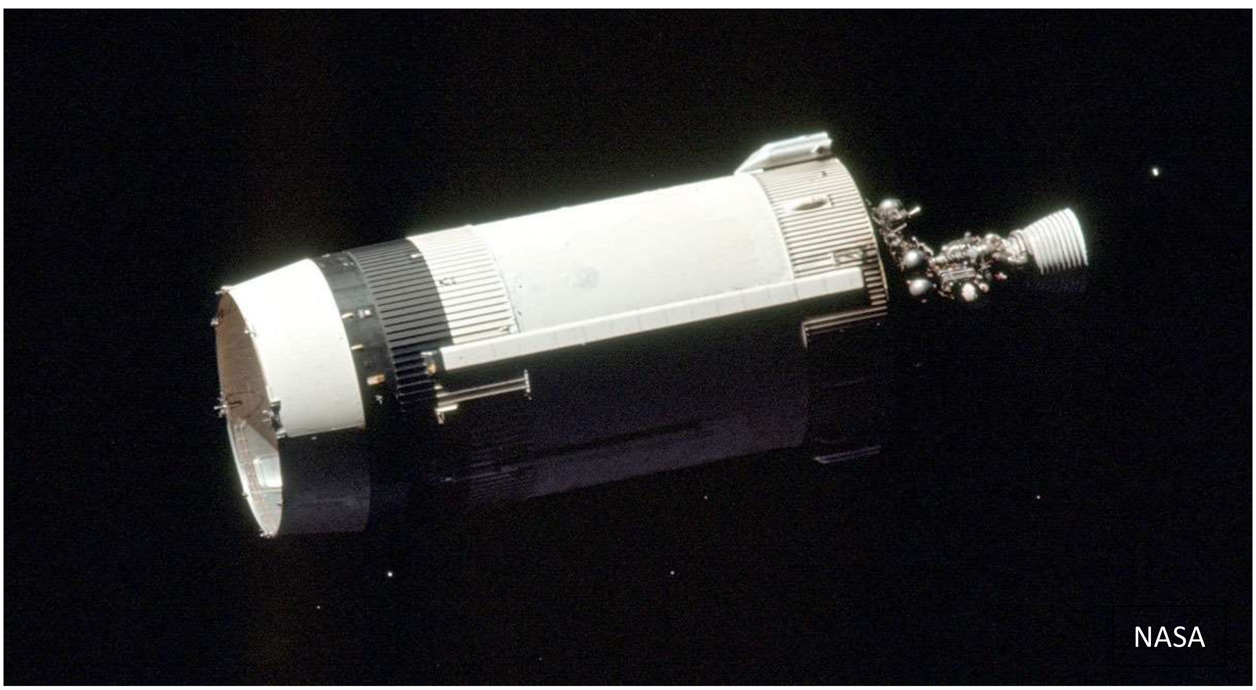
The prime suspect was a S-IVB built by the Douglas Aircraft Company and used as second stage for the Saturn I and IB and third stage for the Saturn V. The S-IVB was 21.7 feet (6.6 meters) in diameter with a height of 58.3 feet (17.8 meters) and a dry weight of 25,050 pounds (11,363 kg). The third stages from Apollo 8 through 12 were placed in heliocentric orbits while the later stages were impacted on Moon for seismic experiments.

J002E3 was believed to have entered Earth orbit in March 2002 through Lagrange Point (L1) located approximately 1.5 million miles (2.4 million km) from Earth in the direction of the Sun. It completed several 48-day orbits, traveling within and outside the orbit of the Moon before re-entering heliocentric orbit through L1 portal in June 2003. The Apollo age artifact could return again, but no sooner than the mid-2040s.

The best candidate for J002E3 is the Apollo 12 S-IVB. Launched on November 14, 1969, the third stage was restarted around the 4 hour and 36-minute mark, once the command module had extracted the lunar module and moved some distance away. The engine burn lasted 300 seconds too long, placing the spacecraft in an unstable geocentric orbit (with orbit of 43 days). It was thought to have escaped through the L1 portal in March 1971.

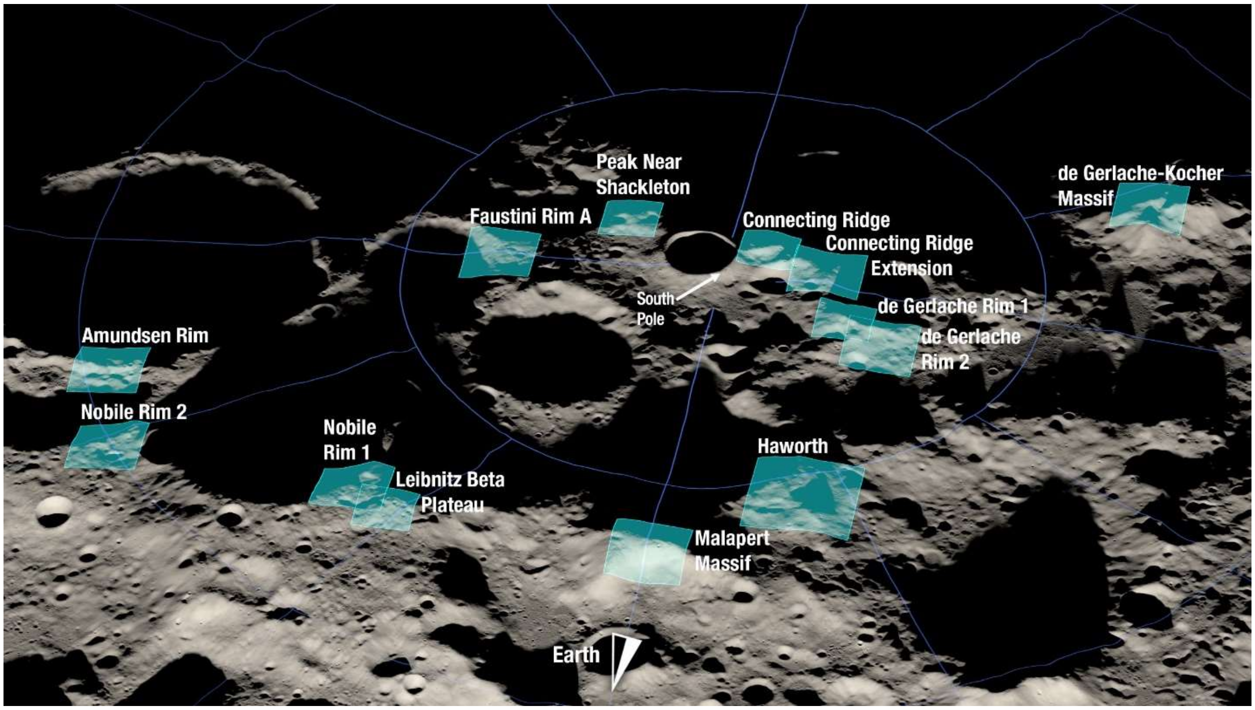


J002E3 moving through a star field in Aquarius on December 17, 2002. Images of the visitor were captured from the McCarthy Observatory every two minutes from a distance of approximately 130,000 miles (209,000 km) Credit: Bill Cloutier



The photo (above) shows the Saturn V S-IVB after the lunar module has been removed and before the "slingshot" maneuver was executed. The maneuver was designed to minimize the probability of spacecraft and launch vehicle collision and to avert a S-IVB collision with the Earth or Moon. The process involved dumping the remaining propellent, thereby changing its velocity sufficiently so as to place the vehicle in a solar orbit.

Destination Moon



Location of candidate landing regions near the Moon's South Pole for the Artemis III mission
Credit: NASA

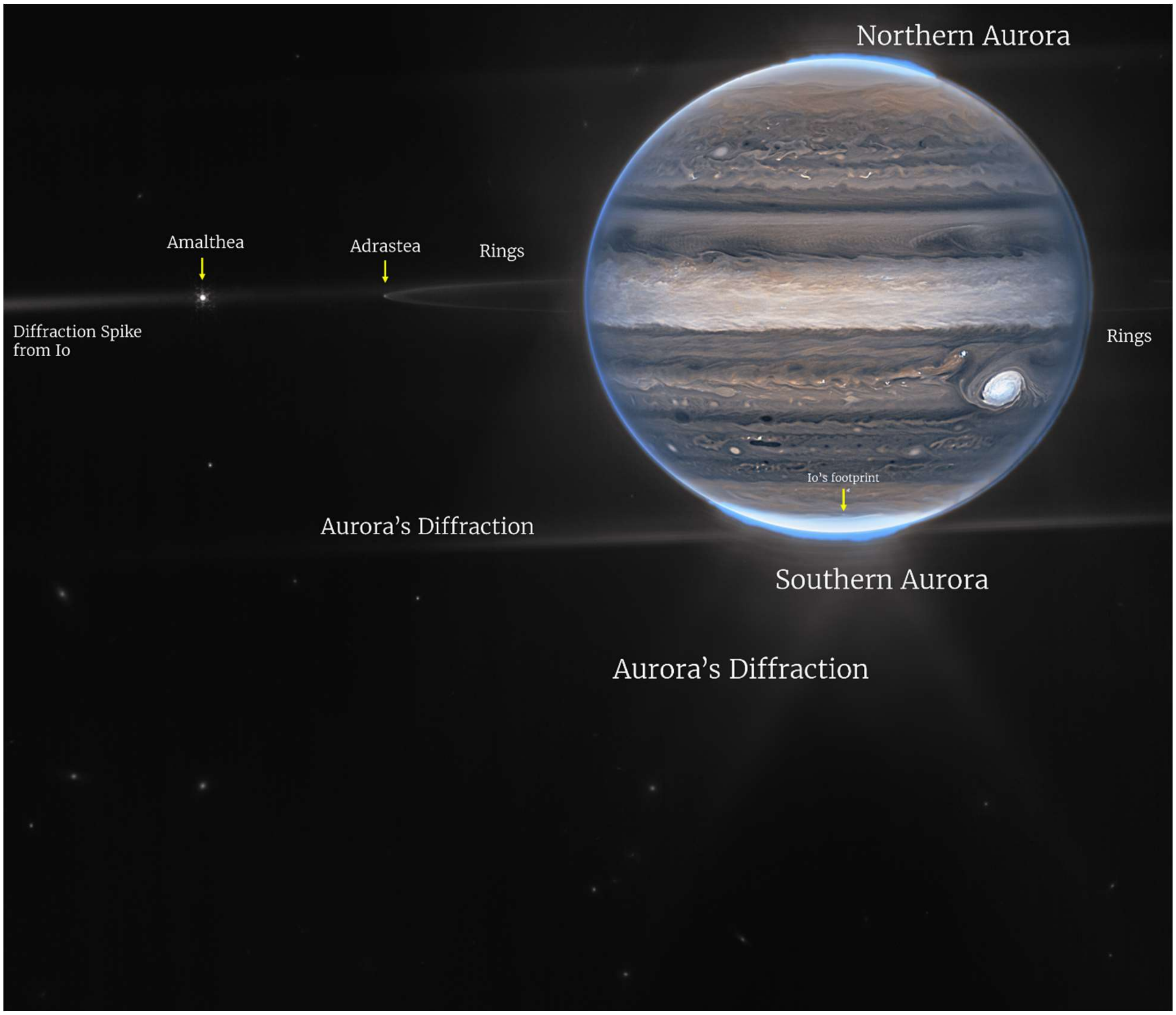
In preparation for the first landing of U.S. astronauts on the Moon in more than 50 years, NASA has identified 13 possible sites near the lunar South Pole. The sites are in close proximity to the permanently shadowed region (suspected of containing water-ice) and will be in continuous sunlight during the duration of the 6.5-day long Artemis III mission.

The landing regions shown in the graphic above are approximately 9.3 by 9.3 miles (15 by 15 km) and are all located within six degrees of the lunar pole (by comparison, all six of the Apollo landing sites were relatively near the equator). Within the regions, a landing site has been designated with an approximate 328-foot (100-meter) radius. The selection process benefited greatly from the topographic and scientific data collected by NASA's Lunar Reconnaissance Orbiter (in operation since 2009). The sites were selected with consideration of landing conditions (slope, ease of communications with Earth, and lighting conditions), as well as the capabilities of the "human landing system."

Starship Concept
Image credit: SpaceX

The Artemis III mission will carry 4 astronauts to the Moon and is tentatively scheduled for 2025. Two astronauts will transfer to the lunar lander while the other two would remain aboard the Orion spacecraft in lunar orbit. The schedule is highly dependent on the success of the two previous missions, the readiness of SpaceX's Starship for the landing, as well as other critical components including the new spacesuits which will be worn by the astronauts.

Jupiter in the Infrared



Composite image of Jupiter (using two different filters) with Webb's near-infrared camera
Credit: NASA, ESA, CSA, Jupiter ERS Team; image processing by Ricardo Hueso (UPV/EHU) and Judy Schmidt

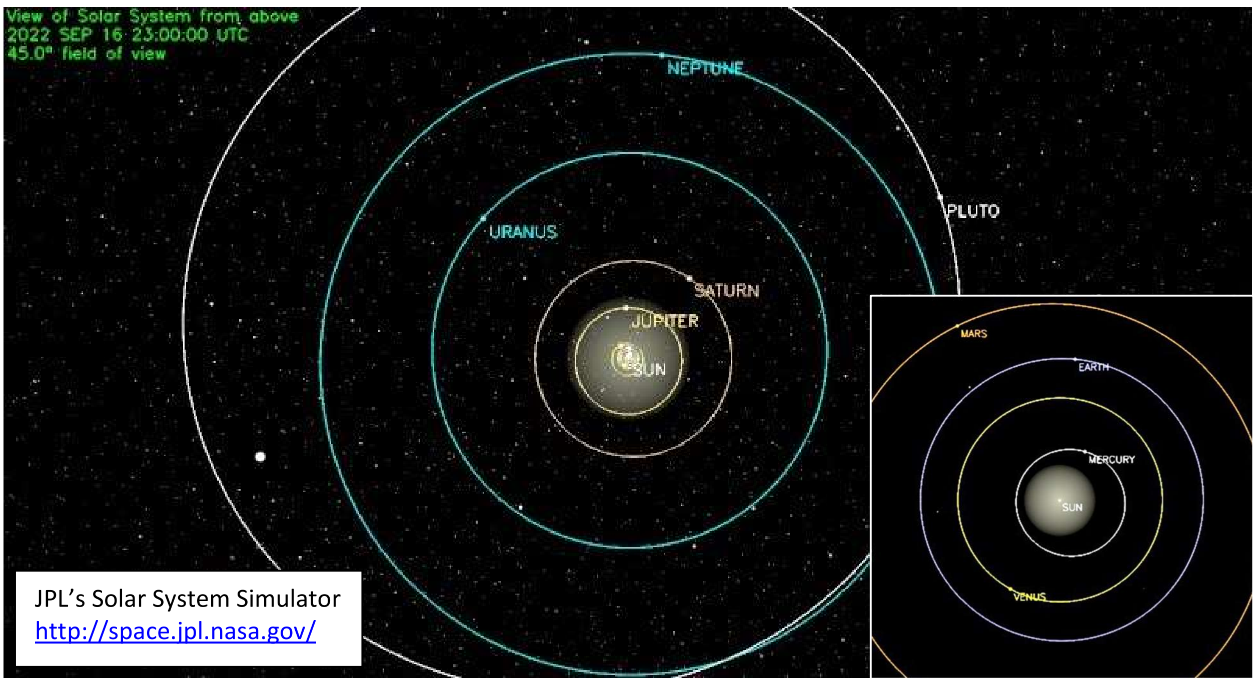
The infrared light from Jupiter, which is invisible to the human eye, has been mapped onto the visible spectrum with the longest wavelengths appearing redder and the shortest wavelengths appearing bluer. The Great Red Spot (lower right) appears white, as does the equatorial band and other clouds, because they are at a higher altitude and reflecting more sunlight. Darker features indicate the absence of cloud cover. Jupiter's faint ring is visible within the image, as well as several small moons and faint background galaxies.

An electric blue glow from the aurora is present at both poles as Jupiter has the brightest and most powerful aurora in the solar system. Unlike Earth, where aurora result from the interaction of the solar wind and Earth's intrinsic magnetic field (and therefore highly dependent upon solar activity), Jupiter's auroral activity is constant with its magnetosphere largely powered by the internal rotation of the planet (10-hour day) which drags its magnetic field around.

Neptune at Opposition

Earth will come between the planet Neptune and the Sun on September 16, i.e., "Opposition." On that day, the ice giant will rise as the Sun sets and will be visible throughout the night (highest in the sky shortly after midnight). At magnitude 7.8, a telescope will be required to see the planet's disk in the eastern region of the constellation Aquarius.

Neptune is the outermost planet in the solar system (since the demotion of Pluto), orbiting the Sun at an average distance of 2.8 billion miles (4.5 billion km). The ice giant was discovered in 1846, and, with an orbital period of 165 years, has only recently completed one orbit of the Sun since its detection. Primarily composed of gaseous hydrogen and helium, Neptune is 17 times more massive than Earth. Its bluish hue comes from trace amounts of hydrocarbons (e.g., methane) in the atmosphere. Neptune rotates around its axis once every 16 hours and while furthest from the Sun (and its energy), the planet's winds are the most powerful in the solar system, exceeding 1,000 mph in the upper altitudes.



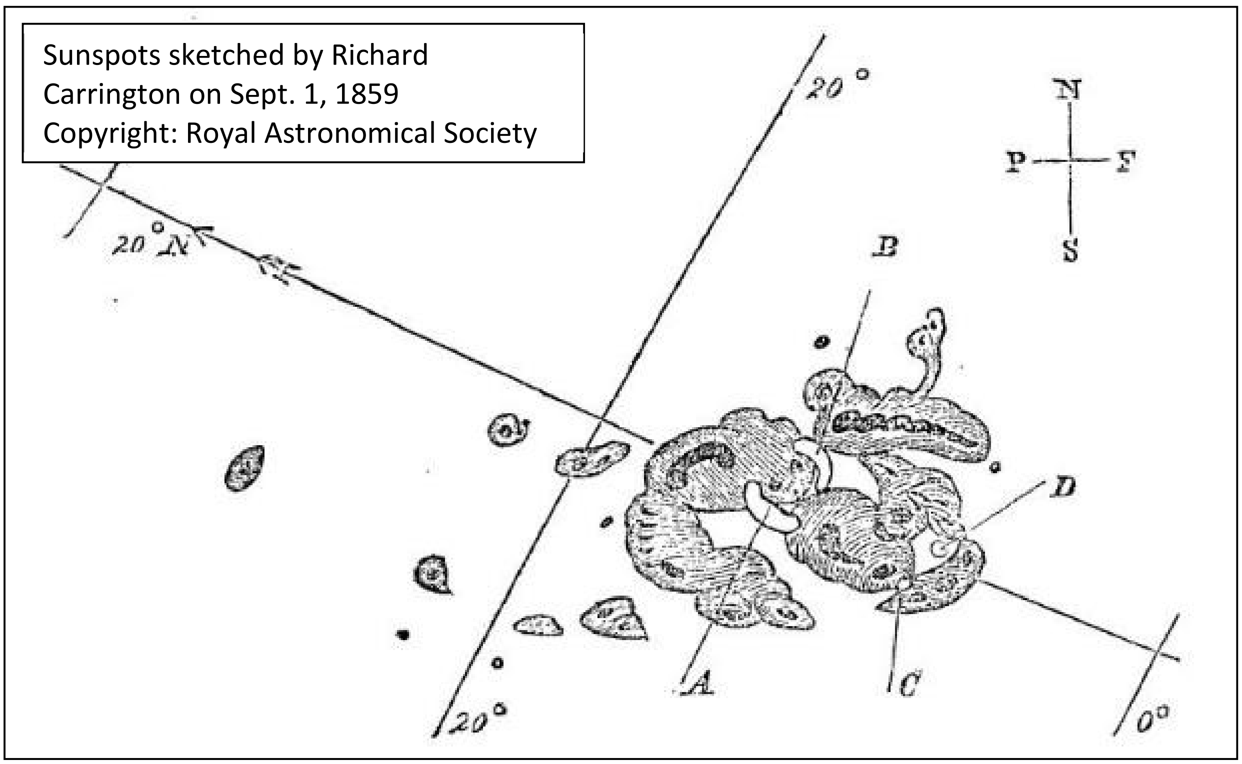
Neptune has 14 moons, the last one being discovered by Mark Showalter of the SETI Institute in 2013 after noticing a small object orbiting between two of Neptune's other moons in images captured by NASA's Hubble Space Telescope. The moon, called Hippocamp, is no more than 20 miles (34 km) across. By comparison, Neptune's largest moon, Triton, has a diameter of 1,680 miles (2,700 km). Triton is the only large moon in the solar system that orbits in a direction opposite that of its host planet's rotation, suggesting that the moon was captured and did not form nearby. Triton's crust of frozen nitrogen is believed to cover a core of rock. It is also one of the few moons found to be geologically active, with icy geysers.

Neptune meteorology continues to perplex astronomers. Although summer was beginning in the southern hemisphere when the latest observing campaign started, most of the planet has gradually cooled over the last two decades with the global average temperature dropping by 46°F (26°C) between 2003 and 2018, reversing an earlier warming trend. Meanwhile, the south pole has heated up (52°F or 29°C) between 2018 and 2020.

The Carrington Event

One hundred and sixty-three years ago, on the morning of September 1st, Richard Carrington was at his observatory in Surrey, England, sketching sunspots from an image projected by his telescope. At 11:18 am, two bright flares emerged from a group of sunspots. After realizing that the blinding points of light were coming from the Sun and not stray light or reflections entering the observatory, he hastened to find another witness to what he had observed. Unfortunately, the flares faded quickly and all but disappeared within five minutes. While he remained at his telescope for several hours, the sunspots did not display any additional activity.

The following morning, the sky as far south as Hawaii and the Caribbean erupted in filaments of color as aurora bright enough to easily read a newspaper were visible. Sailors reported compass needles swinging wildly, making it impossible to navigate, and power surges in telegraph wires damaged equipment, sending sparks that set nearby paper on fire.



Sunspots sketched by Richard Carrington on Sept. 1, 1859
Copyright: Royal Astronomical Society

Carrington subsequently traveled to the observatory at Kew Gardens in London, looking for confirmation of what he had witnessed. While the observatory didn't have any images of the Sun on September 1, it did have records from its magnetometer (an instrument measuring changes in the Earth's magnetic field).

The Kew Gardens magnetometer showed a significant magnetic disturbance approximately 17 hours after Carrington had seen the flares. Today, we know that Carrington had seen a white-light (visible in only the most intense solar eruptions) and that the magnetic disturbance was the result of a Coronal Mass Ejection (cloud of solar plasma) that had traveled the distance between the Earth and Sun (approximately 93 million miles or 150 million km) in less than 24 hours. In the 1800's, when sunspots were thought by some to be localized phenomena in the Sun's atmosphere, the concept that activity on the Sun could affect the Earth was ground-breaking.

In November of 2003, the most powerful flare in the "space age" was recorded (twice as powerful, by some measurements, as the most powerful, previously recorded flares), saturating the detector of the satellite monitoring the Sun. Eruptions on the Sun have been linked to communication disruptions on Earth, widespread damage to the electrical grid and transmission equipment, and power blackouts. Flares have also been responsible for damaging the sensitive electronics in orbiting satellites and sending astronauts scampering into shelters on the International Space Station.

It is believed that the Carrington event was even more powerful than what has been observed to date. Instead of a sparse network of land lines and telegraphs of the 1800's, today's global economy is satellite-based, with fleets of spacecraft providing instantaneous communications, global positioning (in air, on sea and land), with national security applications, weather forecasting, as well as supporting multi-national transactions and business operations. The Federal Emergency Management Agency has identified extreme space weather as one of its greatest challenges, as severe damage to the U.S. electrical grid could take years to fully recover and leave a large portion of the population without life-saving power and essential services.

<u>Saturn</u>

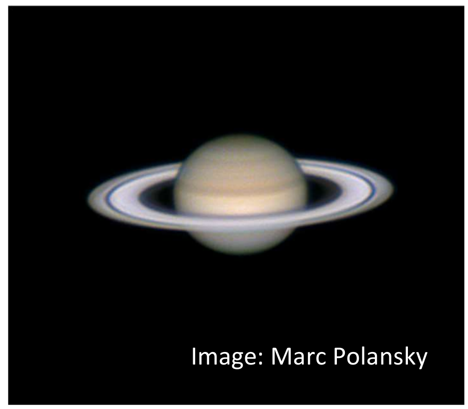


Image: Marc Polansky

Saturn reached Opposition in mid-August when the ringed-world was closest to Earth. Since that time, the distance between the Earth and Saturn has been steadily increasing with Earth's higher orbital velocity. Saturn is still well placed in the evening sky in the constellation Capricornus. The planet's north pole is currently tilted towards the Earth with its rings inclined at an angle of almost 14° to our line of sight. We see the ring tilt or inclination cycle (from our perspective) over Saturn's 29.5-year orbit. The last ring crossing (when the rings disappeared) was in 2009. Since then, the rings opened to a maximum of 27° before starting to close. The rings will disappear in 2025 before the process begins again, starting to open back up again, this time with the southern hemisphere tilted toward Earth.

<u>Jupiter</u>

Jupiter reaches Opposition this year on September 26th. The gas giant shines brightly in the eastern sky after sunset (about 24 times brighter than Saturn). The largest planet in the solar system can be found in the constellation Pisces to the east of Saturn.

	Rise and Transit Times (EDT)			
	September 1		September 30	
Planet	Rise	Transit*	Rise	Transit*
Saturn	6:36 pm	11:41 pm	4:38 pm	9:40 pm
Jupiter	8:31 pm	2:38 am	6:29 pm	12:31 am


Image: Marc Polansky

* The celestial meridian is an imaginary the line that connects the north and south points of the horizon with the observer's zenith (point directly overhead). A planet is highest in the sky when it crosses or transits the meridian.

Jovian Moon Transits

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

Date	Moon	Transit Begins	Transit Ends
Aug 31st	Io	9:41 pm	11:55 pm
6th	Europa	9:46 pm	12:20 am (7th)
7th	Io	11:36 pm	1:50 am (8th)
9th	Io	6:05 pm	8:19 pm
16th	Io	7:59 pm	10:14 pm
20th	Ganymede	8:06 pm	11:00 pm
23rd	Io	9:54 pm	12:09 am (24th)

Great Red Spot Transits

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

Date	Transit Time	Date	Transit Time
2nd	9:00 pm	14th	8:52 pm
4th	10:38 pm	16th	10:30 pm
7th	8:07 pm	21st	9:37 pm
9th	9:45 pm	23rd	11:15 pm
11th	11:23 pm	26th	8:44 pm

Autumnal Equinox

The Sun crosses the celestial equator at 9:04 PM (EDT) on the evening of September 22nd, marking the beginning of the fall season in the northern hemisphere.

Aurora and the Equinoxes:

Geomagnetic storms that are responsible for auroras happen more often during the months around the equinox (March and September). Check your evening sky or log onto www.spaceweather.com for the latest on solar activity.

Sunrise and Sunset (from New Milford, CT)

Sun	Sunrise	Sunset
September 1st (EDT)	06:19	19:26
September 15th	06:33	19:02
September 30th	06:49	18:37

September Nights

Enjoy the jewels of the summer Milky Way while the nights are still warm and the skies are clear. From Cygnus to Sagittarius, follow the star clouds and dust lanes that comprise the inner arms of our spiral galaxy. In the south after sunset, the stars in the constellation Sagittarius form an asterism, or pattern, of a teapot. The spout of the teapot points the way to the center of the Milky Way galaxy with its resident black hole. Check out the July/August calendar for more details.

Present and Future Pole Stars

Vega, the fifth brightest star and located in the constellation Lyra, is placed high in the evening sky during September. Vega is also destined to become the Pole Star in 12,000 years. Precession, or the change in the direction of the rotational axis of the Earth over time, is best exemplified in a comparison of the position of Vega to that of Polaris (the current Pole Star).

Astronomical and Historical Events

1st Apollo Asteroid *2021 CQ5* near-Earth flyby (0.022 AU)
1st Apollo Asteroid *161989 Cacus* near-Earth flyby (0.058 AU)
1st Aten Asteroid *2100 Ra-Shalom* closest approach to Earth (0.187 AU)
1st Apollo Asteroid *136795 Tatsunokingo* closest approach to Earth (1.618 AU)
1st History: astronomer Richard Carrington observes solar flares which created the "Solar Storm of 1859" (1859)
1st History: flyby of Saturn by the Pioneer 11 spacecraft (1979)
2nd History: discovery of asteroid *3 Juno* by Karl Harding (1804)
3rd First Quarter Moon
3rd Apollo Asteroid *7092 Cadmus* closest approach to Earth (3.316 AU)
3rd History: controlled impact of the SMART-1 spacecraft on the lunar surface at the conclusion of a successful mission; precursor of NASA's LCROSS mission (2006)
3rd History: Apollo 12 third stage rediscovered (J002E3), by amateur astronomer Bill Yeung, after temporarily transferring from a heliocentric orbit to an Earth orbit (2002)
3rd History: Viking 2 spacecraft lands on the Martian surface (1976)
4th Apollo Asteroid *54509 YORP* closest approach to Earth (0.901 AU)
4th Kuiper Belt Object *2003 QX113* at Opposition (59.533 AU)
4th History: Dawn spacecraft leaves *Vesta* orbit, bound for the dwarf planet *Ceres* (2012)
5th History: flyby of Asteroid 2867 *Steins* from a distance of 500 miles (800 km) by the Rosetta spacecraft (2008)
5th History: launch of Voyager 1 to the planets Jupiter and Saturn (1977); at 13.6 billion miles (21.9 billion km) from Earth, Voyager 1 has entered the interstellar space

Astronomical and Historical Events (continued)

6th Parker Solar Probe, 13th Perihelion and sixth encounter with the corona, the Sun's upper atmosphere
6th Kuiper Belt Object 408706 (2004 NT33) at Opposition (38.796 AU)
7th Moon at perigee (closest distance to Earth)
7th Apollo Asteroid *6063 Jason* closest approach to Earth (2.703 AU)
8th Centaur Object *7066 Nessus* at Opposition (29.362 AU)
8th Kuiper Belt Object 307982 (2004 PG115) at Opposition (38.550 AU)
8th Plutino 175113 (2004 PF115) at Opposition (40.612 AU)
8th Kuiper Belt Object 120178 (2003 OP32) at Opposition (41.777 AU)
8th History: launch of OSIRIS-REx (asteroid sample return mission) to the near-Earth asteroid *Bennu* for arrival in 2018 (2016)
8th History: sample return canister from the Genesis spacecraft crashes back to Earth when drogue parachute fails to deploy. Spacecraft was returning to Earth from Lagrange Point 1 with its collection of solar wind particles (2004)
8th History: launch of the Surveyor 5 spacecraft (lunar science mission); landed on Mare Tranquillitatis three days later (1967)
8th History: first Star Trek episode airs on television (1966)
8th History: Marshall Space Flight Center's dedication by President Eisenhower (1960)
9th Atira Asteroid 2021 LJ4 closest approach to Earth (0.598 AU)
9th Atira Asteroid 2015 ME131 closest approach to Earth (1.341 AU)
9th History: launch of Conestoga I, first private rocket (1982)
9th History: launch of Soviet spacecraft Venera 11 (Venus lander) to the planet Venus (1978)
9th History: launch of the Viking 2 spacecraft (Mars Orbiter/Lander) (1975)
9th History: discovery of Jupiter's moon *Amalthea* by Edward Barnard (1892)
10th Apollo Asteroid *11500 Tomaiyowit* closest approach to Earth (1.691 AU)
10th History: launch of the GRAIL spacecraft aboard a Delta 2 rocket from the Canaveral Air Force Station; lunar gravity mapping mission (2011)
10th History: debut flight of the Japanese H-2 Transfer Vehicle (or HTV) to the International Space Station (2009)
10th History: discovery of Dwarf Planet Eris' moon *Dysnomia* by Mike Brown, et al's (2005)
10th Full Moon (Full Harvest Moon)
10th McCarthy Observatory's Second Saturday Stars (open house)
11th History: discovery of Jupiter's moon Leda by Charles Kowal (1974)
11th History: Mars Global Surveyor enters orbit around Mars (1997)
11th History: flyby of Comet *Giacobini-Zinner* by the International Cometary Explorer (ICE), first spacecraft to visit a comet (1985)
12th Atira Asteroid 2021 PH27 closest approach to Earth (0.849 AU)
12th Apollo Asteroid *314082 Dryope* closest approach to Earth (1.184 AU)
12th Kuiper Belt Object 2010 RF43 at Opposition (53.482 AU)
12th History: President John F. Kennedy's Moon Speech at Rice University (1962)
12th History: Japanese sample return spacecraft Hayabusa arrives at Asteroid *25143 Itokawa* (2005)
12th History: astronaut Mae Jemison becomes the first African American woman in space as a member of the space shuttle Endeavour crew (STS-47) (1992)
12th History: launch of Soviet Luna 16; first robotic probe to land on the Moon and return a coring sample (101 grams) of lunar regolith to Earth (1970)

Astronomical and Historical Events (continued)

12th History: launch of Gemini XI with astronauts Charles Conrad and Richard Gordon (1966)
12th History: launch of the Soviet spacecraft Luna 2, first to impact the Moon's surface (1959)
13th Kuiper Belt Object 145452 (2005 RN43) at Opposition (39.600 AU)
13th History: launch of the Japanese Moon orbiter "Kaguya" (Selene 1) (2007)
14th Comet *2P/Encke* at Opposition (2.790 AU)
14th History: launch of Soviet spacecraft Venera 12 (Venus lander) to the planet Venus (1978)
14th History: discovery of Jupiter's moon *Leda* by Charles Kowal (1974)
14th History: launch of the Zond 5 spacecraft from the Baikonur Cosmodrome - first successful Soviet circumlunar Earth-return mission (1968)
14th History: John Dobson born, architect of the Dobsonian alt-azimuth mounted Newtonian telescope (1915)
15th History: launch of NASA's ICESat 2 from the Vandenberg Air Force Base in California to observe ice-sheet elevation change and sea-ice (2018)
15th History: End of the Cassini mission with plunge into Saturn's atmosphere (2017)
15th History: launch of China's second space station (Tiangong 2) (2016)
16th Neptune at Opposition
16th Centaur Object *52872 Okyrhoe* at Opposition (9.566 AU)
16th History: discovery of Saturn's moon *Hyperion* by William and George Bond and William Lassell (1848)170th Anniversary (1848)
17th Last Quarter Moon
17th Atira Asteroid 2021 PH27 Perihelion (0.134 AU)
17th Amor Asteroid *3757 Anagolay* closest approach to Earth (1.251 AU)
17th History: Konstantin Tsiolkovsky born in Izhevskoye, Russia; one of the fathers of rocketry and cosmonautics, along with Goddard and Oberth (1857)
17th History: discovery of Saturn's moon *Mimas* by William Herschel (1789)
18th Apollo Asteroid 2013 EC20 closest approach to Earth (1.789 AU)
18th History: discovery of Comet *Ikeya-Seki* by Kaoru Ikeya and Tsutomu Seki (1965)
18th History: discovery of Neptune moons *Thalassa* and *Naiad* by Rich Terrile (1989)
18th History: launch of Vanguard 3, designed to measure solar X-rays, the Earth's magnetic field, and micrometeoroids (1959)
19th Moon at apogee (furthest distance from the Earth)
19th History: NASA unveiled plans to return humans to the moon (2005)
19th History: first launch of the Wernher von Braun-designed Jupiter C rocket from Cape Canaveral (1956)
21st Scheduled launch of a Russian Soyuz spacecraft with cosmonauts Sergey Prokopyev and Dmitry Petelin and NASA astronaut Frank Rubio to the International Space Station from the Baikonur Cosmodrome, Kazakhstan
21st Apollo Asteroid *5786 Talos* closest approach to Earth (0.655 AU)
21st Amor Asteroid *452307 Manawydan* closest approach to Earth (1.830 AU)
21st Kuiper Belt Object *66652 Borasisi* at Opposition (41.475 AU)
21st History: MAVEN (Mars Atmosphere and Volatile Evolution) spacecraft enters orbit around Mars (2014)
21st History: second flyby of Mercury by the Mariner 10 spacecraft (1974)
21st History: Gustav Holst born, composer of the symphony "The Planets" (1874)
21st History: Soviet spacecraft Zond 5 returns after circumnavigating the Moon (1968)
21st History: Galileo spacecraft impacts Jupiter after completing its mission (2003)

Astronomical and Historical Events (continued)

22nd Autumnal Equinox: 9:04 pm EDT (01:04 UT on the 23rd)
22nd Comet *2P/Encke* closest approach to Earth (2.778 AU)
22nd History: Deep Space 1 spacecraft passes within 1,400 miles (2,200 km) of the 5-mile-long potato-shaped nucleus of Comet *Borrelly* (2001)
23rd Apollo Asteroid *1865 Cerberus* closest approach to Earth (1.515 AU)
23rd Amor Asteroid *154991 Vinciguerra* closest approach to Earth (2.127 AU)
23rd History: discovery of Saturn's moons *Siarnaq*, *Tarvos*, *Ijiraq*, *Thrymr*, *Skathi*, *Mundilfari*, *Erriapus* and *Suttungr* by Brett Gladman & John Kavelaars (2000)
23rd History: Johann Galle discovers the planet Neptune (1846)
24th History: India's MOM (Mars Orbiter Mission) spacecraft enters orbit around Mars (2014)
24th History: John Young born (1930), first person to fly in space six times, including Gemini 3 (1965), Gemini 10 (1966), Apollo 10 (1969), Apollo 16 (1972), STS-1, the first flight of the Space Shuttle (1981), and STS-9 (1983)
25th New Moon
25th History: launch of the Mar Observer (also known as the Mars Geoscience/Climatology Orbiter) - communications were lost shortly before spacecraft was scheduled to enter orbit, likely due to a catastrophic failure of the propulsion system (1992)
26th Jupiter at Opposition
26th Centaur Object *365756 ISON* at Opposition (5.137 AU)
26th History: Cosmonauts V. Titov and Strekalov escape moments before Soyuz T-10-1 explodes on the pad (1983)
27th Amor Asteroid *4401 Aditi* closest approach to Earth (1.422 AU)
27th Amor Asteroid *1580 Betulia* closest approach to Earth (2.087 AU)
27th History: Zhai Zhigang becomes first Chinese taikonaut to spacewalk during Shenzhou 7 mission (2008)
27th History: launch (2007) of the Dawn spacecraft to *Vesta* (2011) and *Ceres* (2015)
27th History: launch of SMART-1, the first European lunar probe (2003)
28th Amor Asteroid *5869 Tanith* closest approach to Earth (0.917 AU)
28th Kuiper Belt Object 523639 (2010 RE64) at Opposition (49.354 AU)
28th History: launch of Soviet lunar orbiter Luna 19; studied lunar gravitational fields and mascons (mass concentrations), radiation environment, and the solar wind (1971)
28th History: launch of Alouette, Canada's first satellite (1962)
28th History: discovery of Jupiter's moon *Ananke* by Seth Nicholson (1951)
29th Aten Asteroid 2016 HF2 near-Earth flyby (0.049 AU)
29th Binary Apollo Asteroid *69230 Hermes* closest approach to Earth (0.957 AU)
29th Apollo Asteroid *25143 Itokawa* closest approach to Earth (1.534 AU)
29th History: 3rd Mercury flyby by the MESSENGER spacecraft (2009)
29th History: discovery of asteroid 243 *Ida* by Johann Palisa (1884)
29th History: launch of Salyut 6, first of a second generation of Soviet orbital space station designs (1977)
30th History: controlled descent of the Rosetta spacecraft to the surface of Comet 67P/*Churyumov-Gerasimenko* (mission complete) (2016)
30th History: all instruments deployed on the Moon by the Apollo missions are shut off (1977)
30th History: discovery of Jupiter's moon *Themisto* by Charles Kowal (1975)
30th History: Henry Draper takes first photo taken of the Orion (1880)

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

Visit www.heavens-above.com for the times of visibility and detailed star charts for viewing the International Space Station and other man-made objects in low-Earth orbit.

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

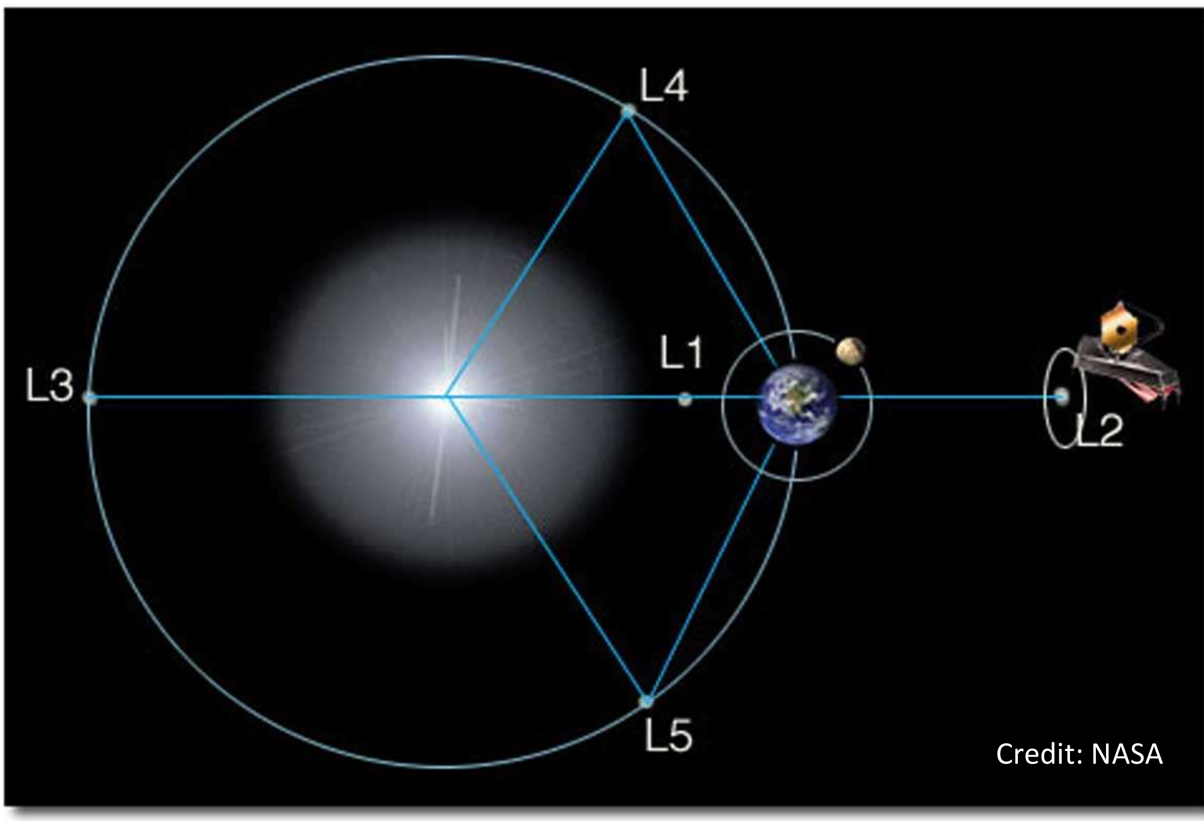
- Vital Signs of the Planet: https://climate.nasa.gov/

Mars – Mission Websites

- Mars 2020 (Perseverance rover): https://mars.nasa.gov/mars2020/
- Mars Helicopter (Ingenuity): https://mars.nasa.gov/technology/helicopter/
- 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 future location of the James Webb telescope) is located 1.5 million kilometers beyond the Earth (as viewed from the Sun).



James Webb Space Telescope

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

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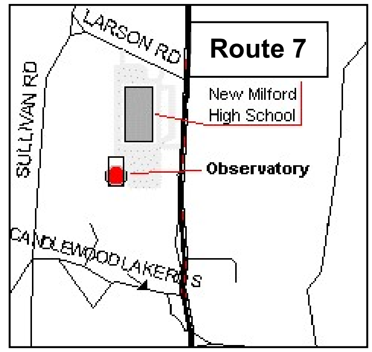

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