Galactic Observer
John J. McCarthy Observatory

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T-1 Year

Kyle Cloutier, Lead Magnetometer Engineer, with the Psyche spacecraft at NASA's Jet Propulsion Laboratory. Launch is currently scheduled for August 2022.

September Astronomy Calendar and Space Exploration Almanac

The Moon on July 20, 2021, fifty-two years after the Apollo 11 landing. The reddish hue was from the smoke and haze from fires burning in the western U.S., carried to the east by the jet stream, and scattering the shorter wavelengths of light. Photo: Bill Cloutier

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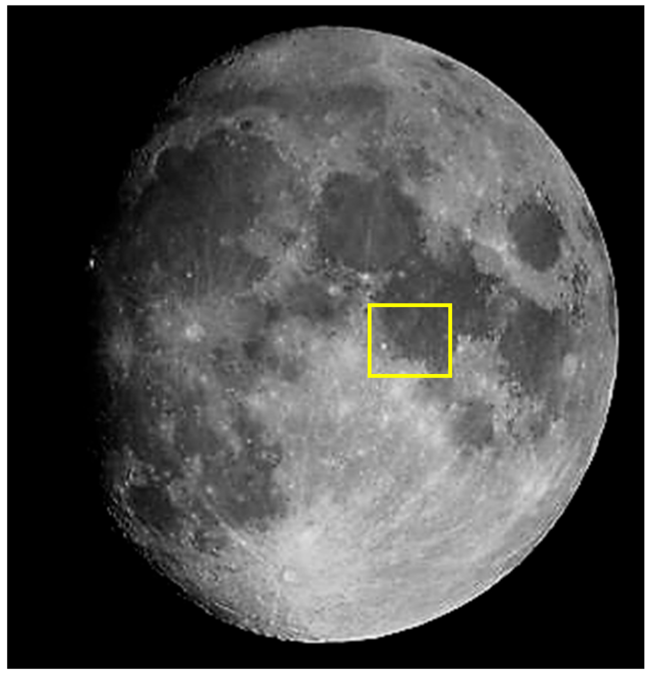
New Milford, CT

"Out the Window on Your Left"

It's been more than 52 years since Neil Armstrong first stepped onto the moon's surface and almost 49 years since Gene Cernan left the last footprint. As a nation founded on exploration and the conquest of new frontiers, today's commitment to return to the moon has been as fleeting as the funding. But what if the average citizen had the means to visit our only natural satellite; what would they see out the window of their spacecraft as they entered orbit around the moon? This column may provide some thoughts to ponder when planning your visit (if only in your imagination).



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

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 17.

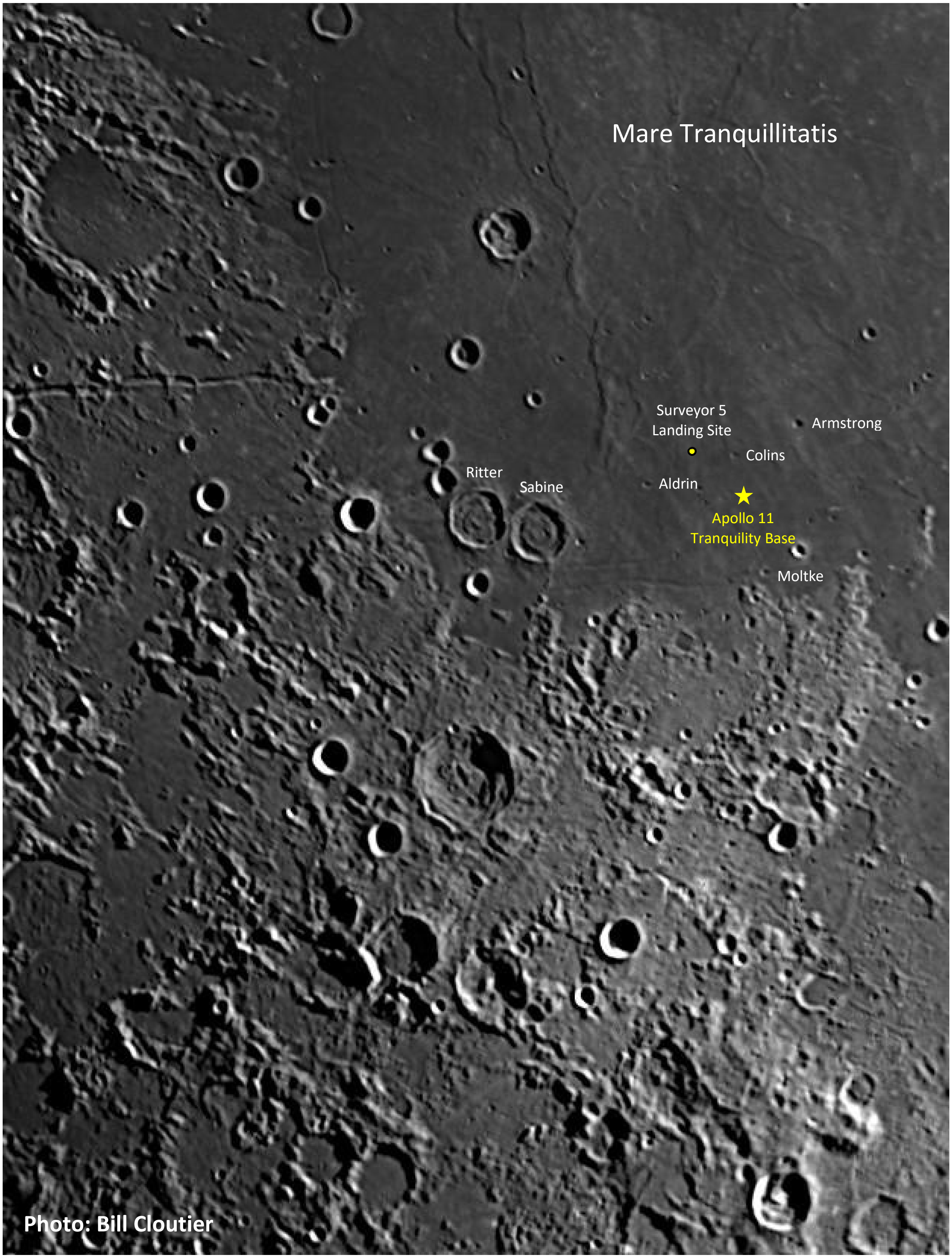
The Surveyor program was comprised of 7 robotic spacecraft. They were designed to support the upcoming Apollo missions by validating soft-landing technologies and providing data on the surface and environmental conditions that the astronauts would encounter. Surveyor 5 was the third successful soft-landing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

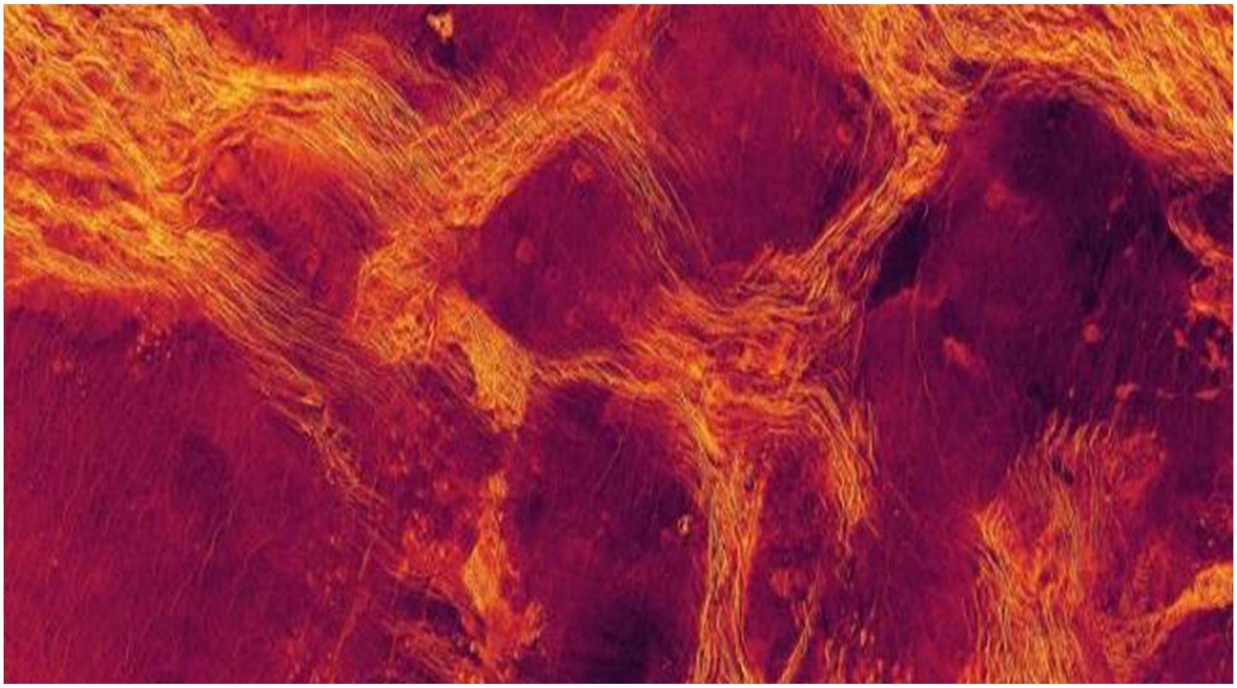
The robotic spacecraft returned a total of 19,118 pictures from the Moon's surface and 83 hours of data (chemical analysis of the regolith) during the first lunar day. On October 18, the spacecraft was able to provide thermal data during a total eclipse of the Sun. All mission objectives were achieved.

Surveyor 5


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

Venusian Lithosphere

Earth's crust is comprised of 15 to 20 tectonic plates that are constantly shifting. Venus, sometimes called Earth's sister planet, was thought to have a more rigid crust, much like that of Mars. A reexamination of images from the Magellan mission, which spent four years in orbit around the cloud-shrouded world between 1990-1994, has now revealed plate-like structures.



False-color radar view of Lavinia Planitia, one of the lowland regions on Venus where the crust has fragmented into blocks (purple) delineated by belts of tectonic structures (yellow). The field of view is approximately 680 miles or 1,100 km across.
Credit: NC State University, based upon original NASA/JPL imagery

Venus may have been more Earth-like in the distant past, with oceans and a more moderate temperature. The planet's current hellish landscape includes relatively young volcanic features, prompting scientists is question whether tectonic-like forces are still operating beneath the surface. Upcoming missions to Venus in the next decade may provide some answers.

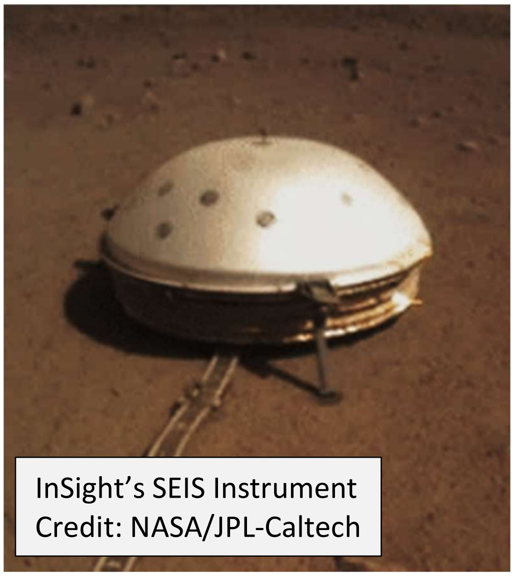
NASA will be launching two Discovery missions: DAVINCI+ (Deep Atmosphere Venus Investigation of Noble gases, Chemistry, and Imaging) and VERITAS (Venus Emissivity, Radio Science, InSAR, Topography, and Spectroscopy). The missions are expected to launch in the 2028-2030 timeframe. The European Space Agency has committed to a third exploratory mission to Venus, called ENVision, targeting a launch in the early 2030s. ENVision's instrument package is being designed to probe the layers below the planet's surface, as well as its internal structure and gravity field, image and map the surface, search for indications of active volcanism, and investigate the structure and composition of the atmosphere.

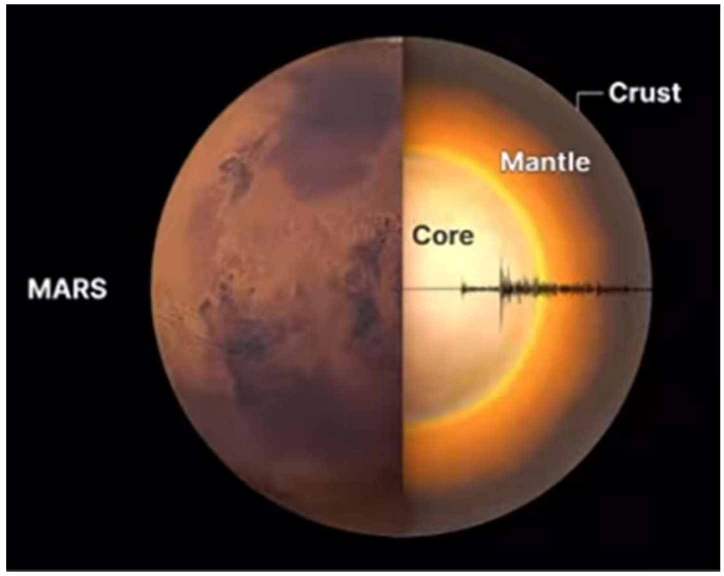
The three complementary missions should provide scientists a greater understanding into how Venus evolved so much differently than Earth, any signs of any crustal motion (since the Magellan mission) and whether volcanic activity continues today.

Starship Stacked

On Friday, August 6, SpaceX stacked its Starship spacecraft on top of its Super Heavy booster for the first time, as a fit test. At roughly 395 feet (120 meters) tall, it is the world's tallest rocket. Credit: SpaceX

InSight Update


InSight's SEIS Instrument
Credit: NASA/JPL-Caltech



NASA's InSight lander has been on Mars for almost three Earth-years, with its ultrasensitive seismometer, called the Seismic Experiment for Interior Structure (SEIS), recording more than 700 distinct marsquakes. On Earth, earthquakes are typically associated with the shifting of its tectonic plates. Mars has no plates, but faults and fractures along which quakes can occur form as the planet continues to cool and the crust shrinks.

Most marsquakes barely register, but several have been strong enough to reveal details of the planet's interior (from how the seismic waves vary in speed and shape as they travel through different regions and materials). The strongest quakes (registering between magnitudes 3.0 and 4.0) all appear to have come from Cerberus Fossae, a region that may have been volcanically active within just the last few million years.

Three papers, published in the journal Science in July and reporting on different regions of the interior, summarize what scientists have learned so far from SEIS's data. According to the analyses, the core of Mars appears to be completely molten (by comparison, Earth has a solid inner core and a molten outer core). The Martian core has a radius of 1,137 miles (1,830 km), larger than predicted, and extending almost halfway to the planet's surface. It is however, less dense than expected, suggesting that, unlike Earth's nickel/iron core, Mars' core is enriched with lighter elements such as sulfur and oxygen.

Surrounding the Martian core is a relatively thin mantle (as compared to Earth's). There doesn't appear to be any exchange of material between the core and mantle – a process called convection that drives Earth's dynamo and generates its protective magnetic field. This explains why Mars lacks a magnetic field today, and if it once had an active dynamo, that it likely shut down shortly after the planet formed.

The outermost layer, the Martian crust, is similar to Earth's in thickness, but thinner than predicted (extending as deep as 23 miles, or 37 km, depending upon the number of sublayers). Unlike Earth, with its crust being periodically renewed through plate tectonics, lubricated by water, Mars retains its original, ancient crust.

Mars 2020 News

Perseverance

After exploring its landing site in Jezero crater for 164 Martian days, scientists thought they had found an ideal location for acquiring the first sample - in the "Cratered Floor Fractured Rough" geologic unit. While the mechanics of the rover's sampling system appeared to have performed flawlessly, sealing and storing the sample tube, the tube was later found to be empty.

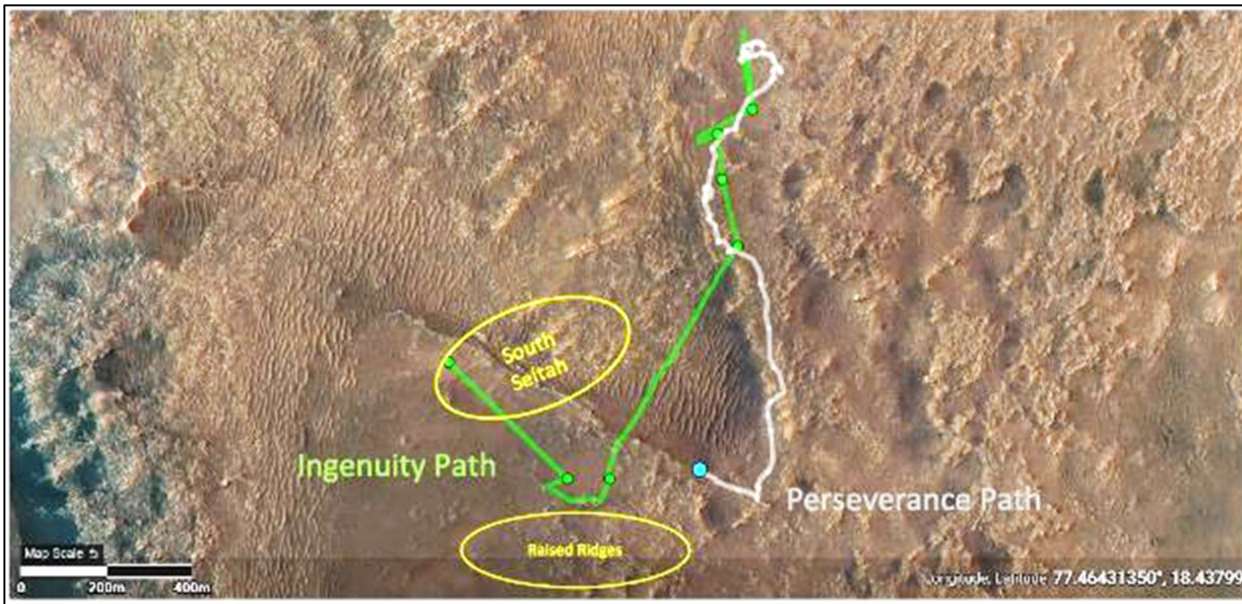
Light-colored "paver stones" like the ones seen in the lower left of the image (above) were the target of the first sampling activity. The 2.75 inch deep (7 cm) bore core is seen below. Credits: NASA/JPL-Caltech/ASU/MSSS

The science and engineering teams at NASA's Jet Propulsion Laboratory believe the rock to be at fault – too powdery to produce a core. The rover carries 43 sample tubes – researchers are hoping to fill some 35 tubes with samples of rock and soil from the crater and fossilized river delta for eventual return to Earth. The empty tube will serve as a sample of the Martian atmosphere.

Perseverance is moving on to its next sampling location in South Séítah where the rover team expects to find sedimentary rocks. Sampling, which is scheduled for early September, should be more akin to Earth-based test experience, and yield more robust cores.

Ingenuity

The diminutive helicopter completed its twelfth flight on August 16, reconning an area called South Séítah, the future target sampling area for the Perseverance rover. Since Ingenuity was deployed on April 6 it has flown 1.66 total miles (2.67 km) - the first 5 flights as a technology demonstration and the last 7 flights in support of rover operations (serving as a scout).



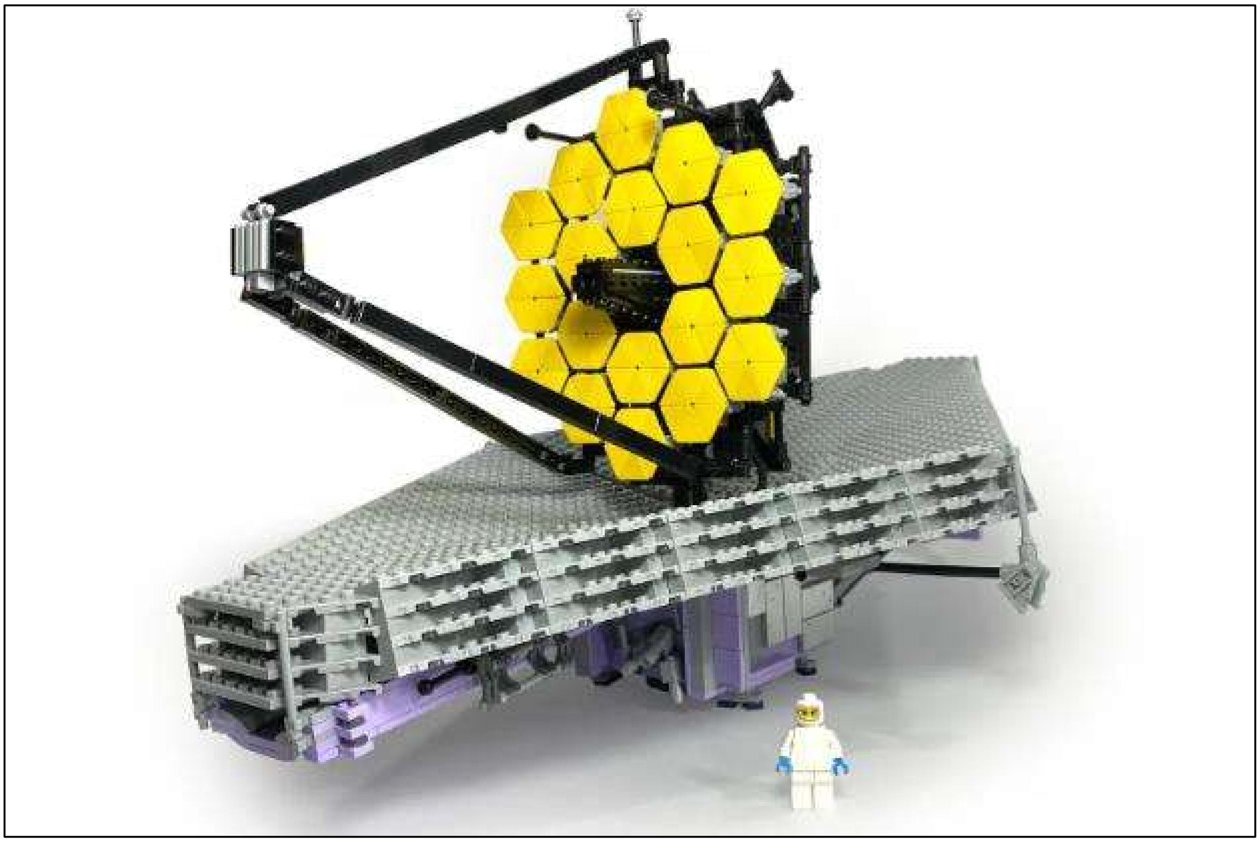
Ground tracks of the Perseverance rover (white) and the Ingenuity helicopter (green) since landing on February 18. The upper yellow ellipse was the target of the helicopter's 12th flight and future destination of the rover.
Credit: NASA/JPL-Caltech

Ingenuity helicopter
Credit: NASA/JPL-Caltech

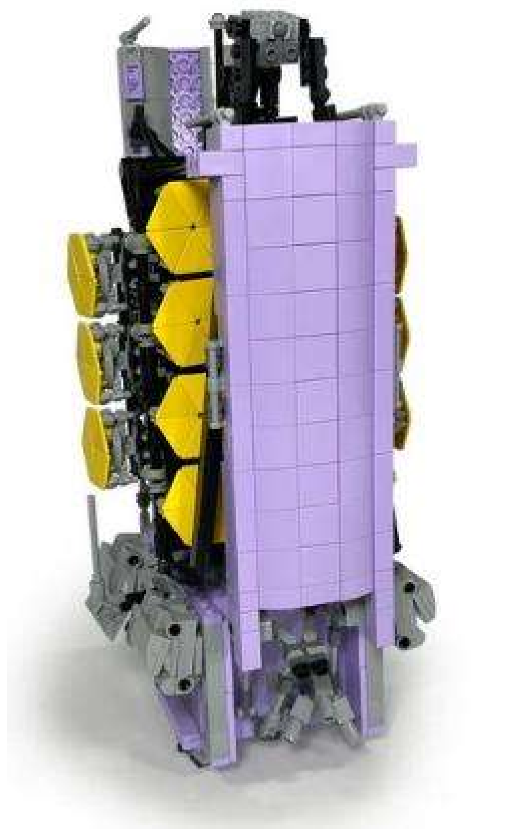
The twelfth flight was different from its other scouting sorties in that Ingenuity backtracked to the starting point, where it will eventually meet up with Perseverance, after completing its recon of the target area. The flight lasted 169 seconds and covered 1,476 ft (~450 m) at an altitude of 32.8 ft (10 m). The color photos captured during the trip are being used to construct 3D images of the area.

The flight did present the helicopter team with a new challenge. Ingenuity's navigation system was designed to work with relatively smooth terrain. Flying to Séítah and back required the helicopter to cross an uneven and furrowed landscape – which it was able to do successfully.

LEGO Webb

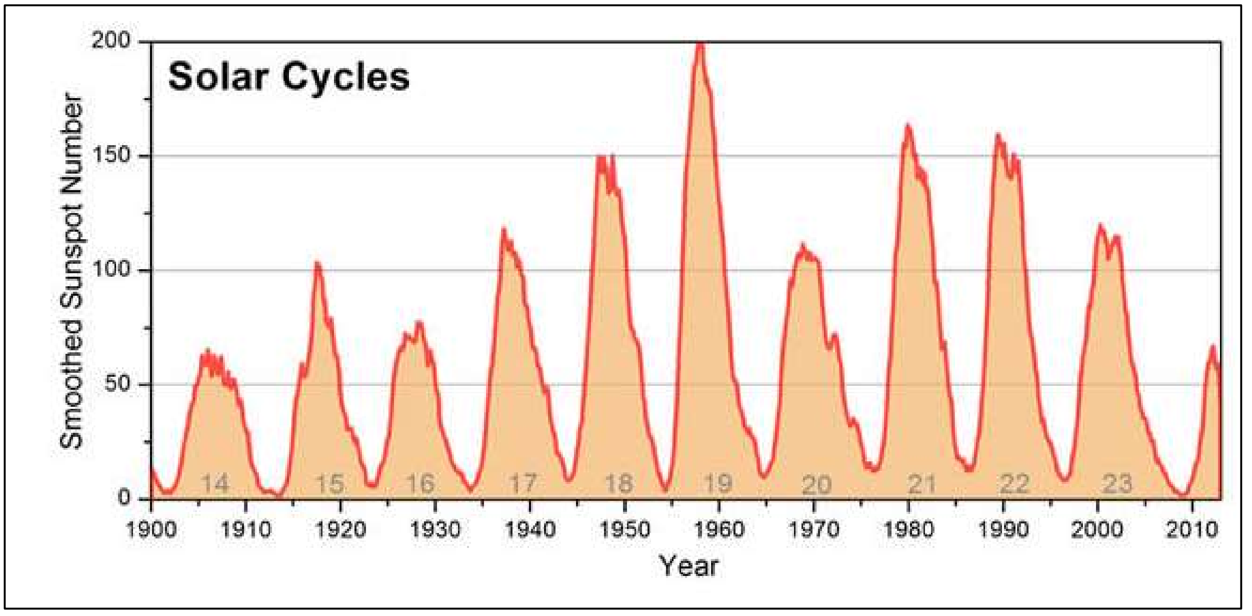


Created by an astronomer, the LEGO scale model of the James Webb Space Telescope (JWST) incorporates all of JWST's major subsystems, including the science instruments, and the propulsion, power, and communications subsystems. It also unfolds like the real thing. The model has been submitted to "LEGO Ideas." If it gathers enough public support, the idea will undergo internal review by LEGO and could be selected for future production.



Solar Cycle Explored

The Sun has multiple, cyclical fluctuations – the eleven-year "Schwabe cycle" being the most familiar (during which the number of sunspots on the surface of the Sun increases and then decreases). There are also the "Gleissberg cycle" (about 85 years), the "Suess-de Vries cycle" (about 200 years) and the quasi-cycle of "Bond events" (about 1500 years) - each named after their discoverers. The cycles are believed to be driven by changes in the Sun's magnetic field, but there is some statistical evidence that the gravitational forces of the larger planets in the solar system may play a role.



The 11-year Schwabe cycle
Credit: National Oceanic and Atmospheric Administration

The idea that researchers tested with their model is that the tidal forces exerted by the solar system's planets can trigger changes within the Sun and affect the internal dynamo that produces its magnetic field. Coincidence, or not, researchers found an eleven-year correlation with the alignment of the planets Venus, Earth and Jupiter. They were then able to find alignments or what they termed "clocks," that would reproduce a repeatable pattern in the strength of the magnetic field over a 193-year period (akin to the Suess-de Vries cycle). Expanding their solar dynamo simulations to a longer period of 30,000 years, researchers found irregular, and sudden drops in magnetic activity every 1000 to 2000 years – much like what happened during the "Maunder Minimum" or "Little Ice Age" when, between 1645 and 1715, there was a prolonged absence of sunspots and solar activity. Chance, or do planets act as metronomes for their stars?

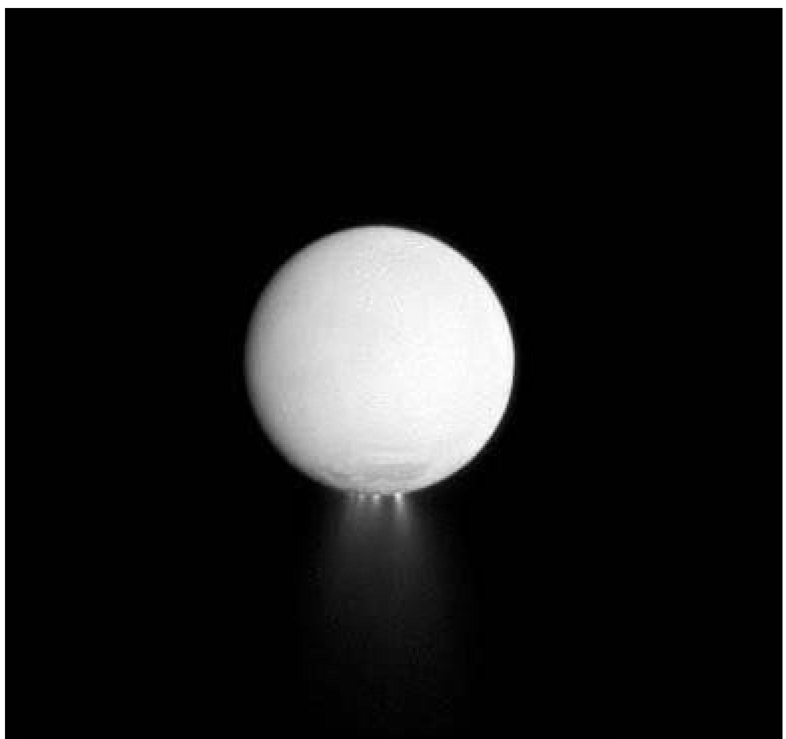
Magnetic map created using the Potential Field Source Surface model – field lines superimposed on an extreme UV image
Credits: NASA/SDO/AIA/LMSAL

Enceladus and Methane

The Cassini flagship mission to Saturn was one of NASA's most prolific scientific endeavors, with the spacecraft completing 294 orbits over 13 years and visiting many of the ringed-planet's major moons (with 162 targeted flybys). Since the mission ended in 2017, scientists have been mining the 635 GB of science data collected, which has already produced almost 4,000 scientific papers.

While NASA prepares for its next mission to an ocean world (Jupiter's moon Europa), questions remain as to what Cassini found in the plumes of Saturn's icy moon Enceladus. In 2005, during one of Cassini's earlier flybys, jets of icy material were discovered erupting from the southern regions of the tiny (about as wide as Arizona), geologically-active moon. Most of the material contained within the jets falls back to the surface of Enceladus as a fine white snow, renewing its surface and making the moon the most reflective body in the solar system (the portion that does escape the moon feeds Saturn's diffuse E-ring).

Cassini's instruments were not designed to detect life, but they did find that the plumes of Enceladus have many of the ingredients to support the type of organisms that you would find around hydrothermal vents on Earth's ocean floor. In addition to water ice, Cassini detected several gases, including water vapor, carbon dioxide, methane and dihydrogen, as well as salts and silica, and complex organics in the jets - fed by a global ocean which lies beneath a crust of ice one-half a mile to 3 miles (1 to 5 kilometers) thick at the south pole.



Polar plumes on Enceladus
Credit: NASA/JPL/Space Science Institute

A new study published in Nature Astronomy by scientists at the University of Arizona and Paris Sciences & Lettres University delved into the unexpectedly high levels of methane in the plumes. The study concludes that the levels can't be explained by known geochemical processes alone. Adding biological methanogenesis (from Earth-like microbes that consume dihydrogen and produce methane), however; does yield methane levels that are consistent with the Cassini data.

While the authors are not suggesting that life exists on Enceladus, they do conclude that microbes, known as methanogens, are a viable alternative to an alien form (not found on Earth) of abiotic methane production (methane production without biological aid such as geochemical). Unfortunately, at this time, NASA is not planning to return to Enceladus, or even entertaining the prospect of exploring the moon's ocean.

Asteroid Missions

Asteroids are relics from when the solar system was young and more dynamic. It is likely that our solar system looked very different 5 billion years ago - populated with primitive bodies, some of which would survive and evolve into the planets and minor planets we see today, others destroyed by impacts or exiled to the most distant regions by gravitational encounters. The bits and pieces that remain document those turbulent times and are the focus of several NASA missions.

The Lucy mission launches in October (2021). It is the first mission to target a population of asteroids that orbit the Sun at the same distance as Jupiter – known as Trojans. The asteroids are located in two gravitationally stable areas – positioned in front of and behind Jupiter. The solar-powered Lucy spacecraft will visit seven asteroids, collecting information on their geology, surface color and composition, mass and density, as well as looking for any satellites and rings. Lucy will use three Earth flybys (and gravity assists) to visit the two groups, as well as a main belt asteroid.

NASA's Lucy spacecraft being unloaded at the Kennedy Space Center in Florida where it will be processed for launch on a United Launch Alliance Atlas V rocket in October
Credits: NASA/Kim Shiflett

In November, the launch window opens for the Double Asteroid Redirection Test mission or DART. A planetary defense demonstration, the DART spacecraft will be placed on an intercept trajectory with the binary, near-Earth asteroid (65803) Didymos. The actual target of the spacecraft is the asteroid's small moonlet, which is about 525 feet (160 meters) across. In September 2022, the DART spacecraft will impact the moonlet, which orbits less than a mile from the parent body, at a speed of almost 15,000 miles per hour (6.6 km/s). The collision is expected to change the orbital period of the tidally-locked moonlet (currently at 11.9 hours) by several minutes – a large enough difference to be observed and measured by the telescopes on Earth. The test will assess the effectiveness of the kinetic impactor technique for defending the Earth from other potentially hazardous asteroids.

In August 2022, NASA will be launching a mission to the main belt asteroid 16 Psyche, a M-type or metallic body with a unique composition of silicate rock and iron and nickel. With a gravity assist from Mars in 2023, the solar-electric propelled spacecraft (also called Psyche) is expected to enter orbit around the asteroid in 2026. Over the 21-month primary mission, the spacecraft's instruments will map and characterize the asteroid from four increasingly-closer staging orbits (the final orbit will be about 44 miles or 70 km from the surface). The asteroid has been theorized to be the core of a protoplanet that, through some cataclysmic event, lost its outer layers.

An artist's concept of the Psyche spacecraft in orbit around the metal-world Psyche
Credit: Maxar/ASU/P. Rubin/NASA/JPL-Caltech

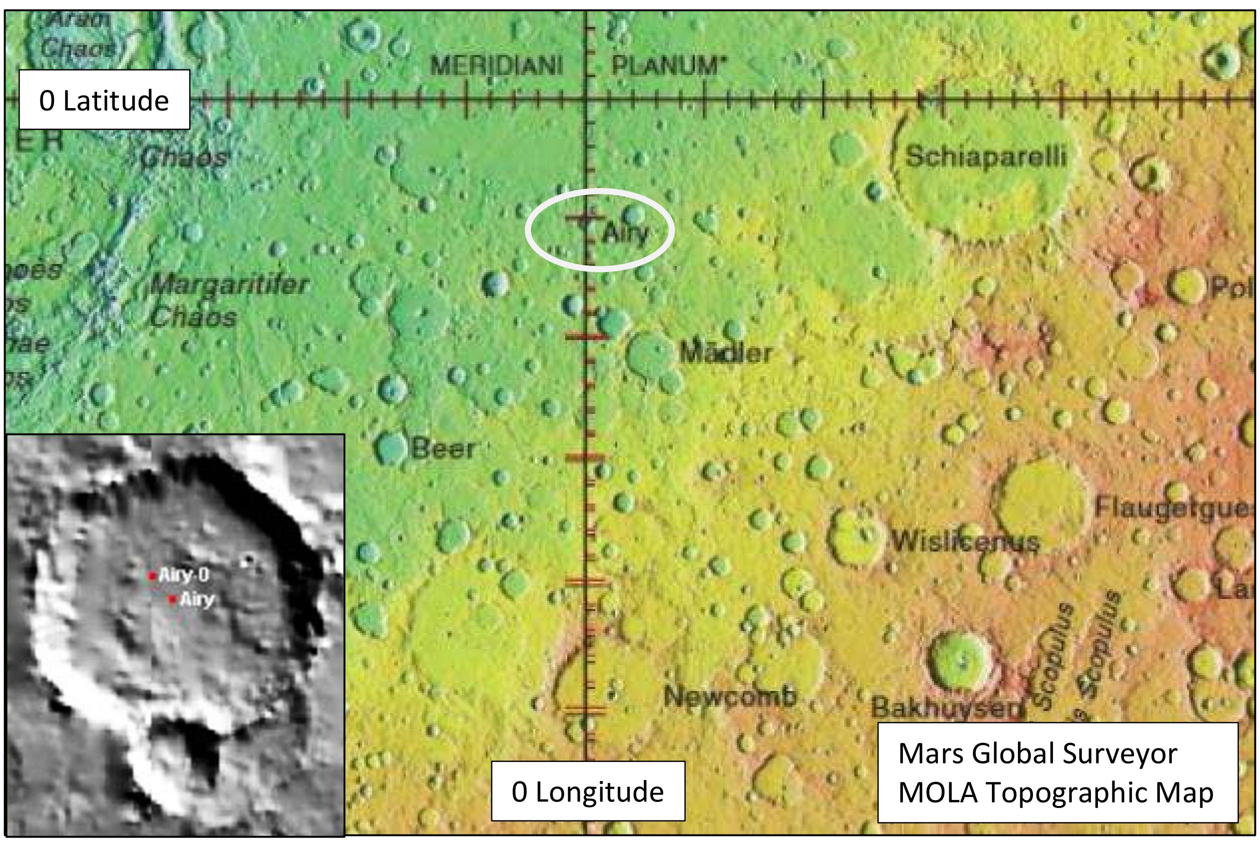
OSIRIS-REx will return to Earth in 2023 after spending more than two years in orbit around the carbonaceous, near-Earth asteroid Bennu. The spacecraft was able to collect a small sample of rock and dust from the asteroid's surface. A return capsule, containing the sample, will separate from the main spacecraft as OSIRIS-REx passes by Earth, landing by parachute at the Utah Test and Training Range.

NASA will also receive material returned from the asteroid Ryugu by JAXA's Hayabusa 2.

Mars Prime Meridian

Latitude is a measurement of distance, north or south, from a planet's equator – longitude is more subjective and arbitrary when it comes to the starting point or "Prime Meridian." On Earth, the Prime Meridian (0 degrees longitude) runs through the Royal Observatory in Greenwich, England, as per an 1884 international agreement. Before the International Meridian Conference adopted Greenwich, the world's cartographers would use a starting point that was significant to their particular country.

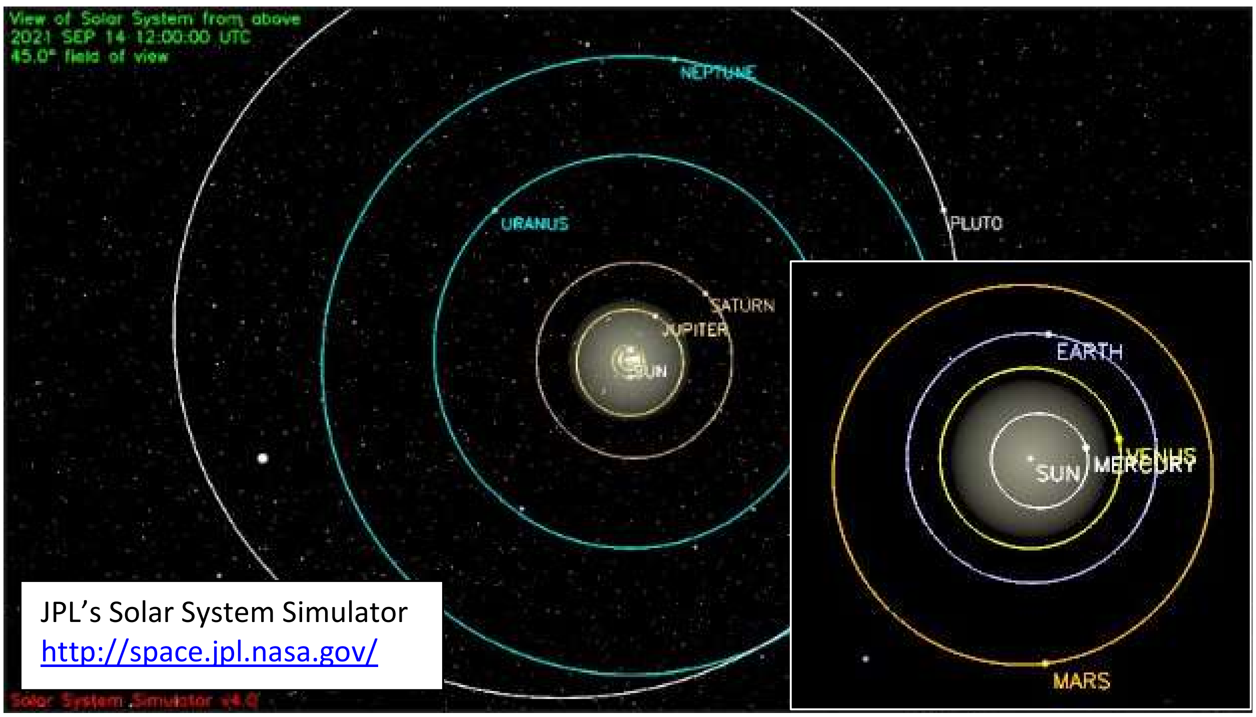
With the invention of the telescope, other worlds could be resolved in enough detail that topographies could be described and features labeled. Observers documented their discoveries, creating maps that incorporated a grid system. In the case of Mars, the equator was defined by its rotation, but a starting point for longitude was left up to the individual aerographer (from Greek Areos Mars + -graphy). Johann Heinrich Mädler and Wilhelm Beer, selenographers and best known for their publication "Der Mond" (The Moon) also made detailed observations of the Mars in the 1840s. They used a small albedo (high contrast) feature on the surface of Mars as their starting point in measuring the rotational period of the planet. That point, which they designated as 'A,' was located near a crater originally called Sinus Meridiani (not far from where the Mars Exploration Rover "Opportunity" landed). The Italian astronomer Schiaparelli used the same reference point as a Prime Meridian in his 1877 map of Mars. The crater was later renamed "Airy" after Sir George Biddell Airy, the seventh Astronomer Royal, who built the large 'transit circle' in the Greenwich Observatory's Meridian Building. In the Space Age, with orbiting spacecraft mapping the Red Planet in high resolution, a more precise position was needed for the Prime Meridian. A small 0.5-kilometre-wide crater, within the larger crater Airy, was selected from the Mariner 9 images as the starting position for longitude (subsequently named 'Airy-0').



Neptune at Opposition

Earth will come between the planet Neptune and the Sun on September 14, 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.



JPL's Solar System Simulator
http://space.jpl.nasa.gov/

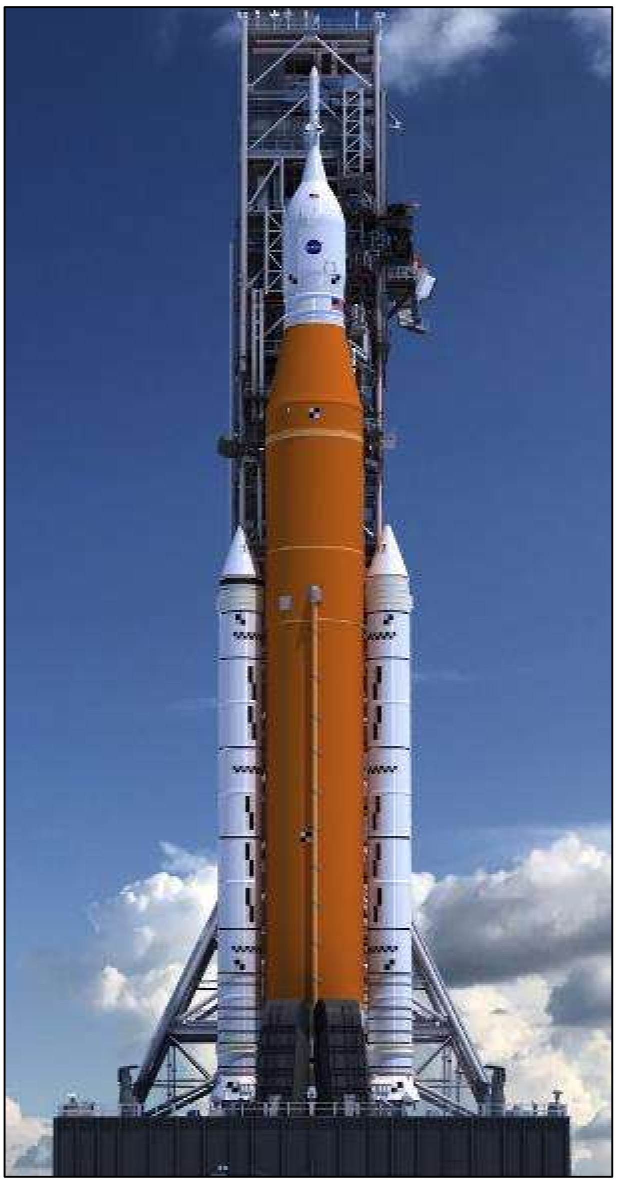
Neptune has 14 moons, the last one being discovered by Mark Showalter of the SETI Institute in 2013 after noticing a small object orbiting between two of Neptune's other moons in images captured by NASA's Hubble Space Telescope. The moon, called Hippocamp, is no more than 20 miles (34 km) across. By 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.

Voyager 2, during its 1989 flyby, imaged a large dark spot or vortex in Neptune's southern hemisphere. While that spot has since disappeared, new one(s) have emerged. The spot(s) are high pressure systems and are typically accompanied by bright clouds. Unlike Jupiter's Red Spot, the dark storms on Neptune last only a few years before dissipating.

New Ride to Europa

Congress has finally withdrawn the legal mandate requiring NASA to launch its Europa Clipper spacecraft on the agency's Space Launch System (SLS) rocket. The space agency now has the option to launch the mission to Jupiter's moon on the best available launch vehicle, potentially saving taxpayers up to $1 billion, if the long-delayed SLS isn't ready.

The spacecraft is currently scheduled to be ready for launch in 2023, two years prior to the most optimistic schedule for SLS availability – requiring NASA to place and maintain the spacecraft in protective storage. NASA has therefore elected to go with Space X's Falcon Heavy rocket as the preferred launch vehicle along with an October 2024 launch date. The trip to Europa will take longer with the less powerful rocket and likely require a gravity assist, but the decision eliminates the uncertainty that had prevented mission planners from moving ahead with the project.



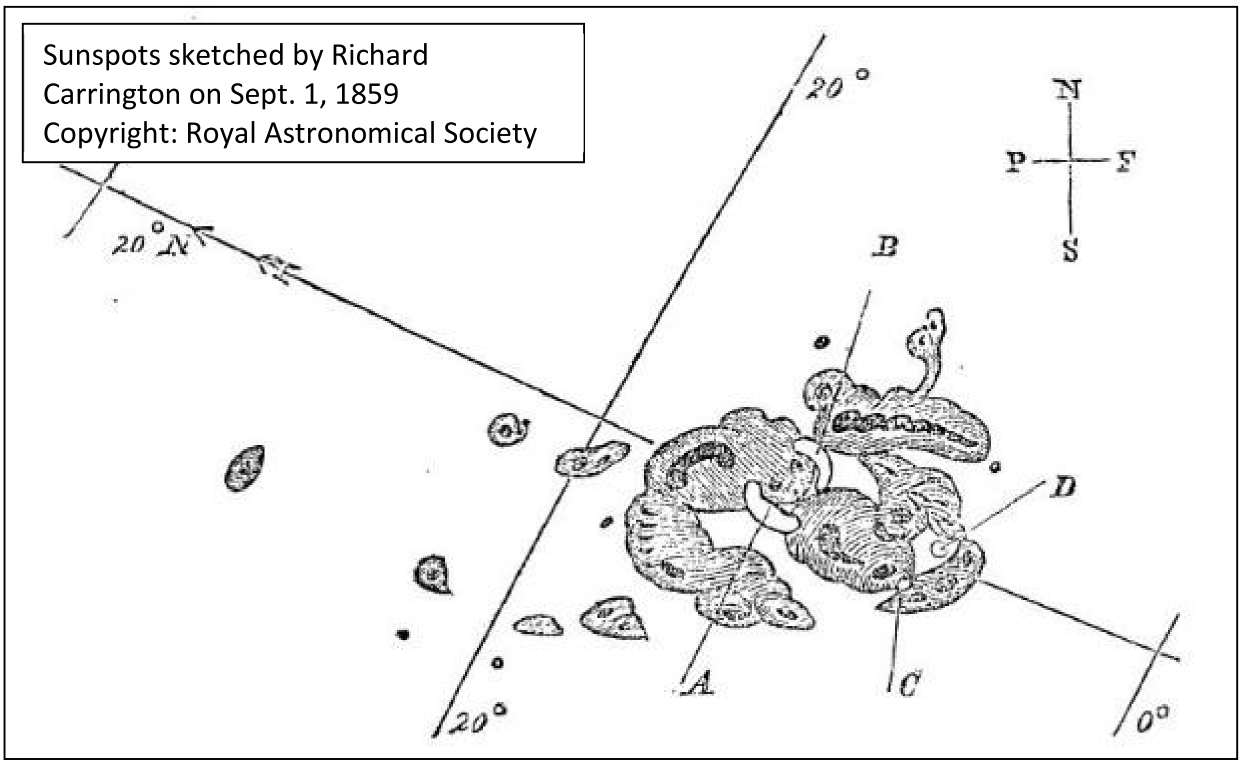
Artist conception of the SLS on the pad.
Credit: NASA

SpaceX's Falcon Heavy rocket at pad 39A.
Credit: SpaceX

The Carrington Event

One hundred and sixty-two 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.

Image: Marc Polansky

Saturn

Saturn reached Opposition in early 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 evening sky, just to the west of Jupiter in the constellation Capricornus and east of the Milky Way. The planet's north pole is tilted towards the Earth and its rings inclined at an angle of 18° to our line of sight (less than their maximum inclination in 2017, but still a nice presentation).

Image: Marc Polansky

Jupiter

Jupiter was also closest to the Earth in August. In September, Jupiter shines brightly in the southern sky after sunset (more than 18 times brighter than Saturn). The largest planet in the solar system is also in the constellation Capricornus and just to east of Saturn.

	Rise and Transit Times (EDT)			
	September 1		September 30	
Planet	Rise	Transit*	Rise	Transit*
Saturn	5:58 pm	10:51 pm	4:00 pm	8:52 pm
Jupiter	6:49 pm	12:01 am	4:47 pm	9:56 pm

* 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
4th	Io	8:09 pm	10:28 pm
5th	Europa	7:02 pm	9:52 pm
5th	Ganymede	10:45 pm	2:22 am (6th)
11th	Io	10:05 pm	12:23 am (12th)
12th	Europa	9:37 pm	12:27 am (13th)
17th	Calisto	6:41 pm	11:13 pm
20th	Io	6:29 pm	8:47 pm
27th	Io	8:25 pm	10:42 pm

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	10:55 pm	17th	8:18 pm
5th	8:25 pm	19th	9:56 pm
7th	10:03 pm	21st	11:34 pm
9th	11:41 pm	24th	9:04 pm
12th	9:10 pm	26th	10:42 pm
14th	10:48 pm	29th	8:12 pm

Autumnal Equinox

The Sun crosses the celestial equator at 3:21 PM (EDT) on the afternoon 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	06:34	19:02
September 30th	06:49	18:36

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 54509 *YORP* closest approach to Earth (0.853 AU)
1st Apollo Asteroid 29075 (1950 DA) closest approach to Earth (0.948 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 Kuiper Belt Object 2003 QX113 at Opposition (59.442 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: Viking 2 spacecraft lands on the Martian surface (1976)
3rd History: Apollo 12 third stage rediscovered (J002E3), by amateur astronomer Bill Yeung, after temporarily transferring from a heliocentric orbit to an Earth orbit (2003)
4th Kuiper Belt Object 408706 (2004 NT33) at Opposition (38.669 AU)
5th Apollo Asteroid 2015 SW6 near-Earth flyby (0.041 AU)
5th Atira Asteroid 2018 JB3 closest approach to Earth (1.464 AU)
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
6th New Moon
6th Amor Asteroid 154991 *Vinciguerra* closest approach to Earth (1.247 AU)
6th Centaur Object 7066 *Nessus* at Opposition (28.877 AU)
6th Kuiper Belt Object 307982 (2004 PG115) at Opposition (38.253 AU)

Astronomical and Historical Events (continued)

6th Plutino 175113 (2004 PF115) at Opposition (40.606 AU)
6th Kuiper Belt Object 120178 (2003 OP32) at Opposition (41.676 AU)
7th Centaur Object 52872 *Okyrhoe* at Opposition (9.782 AU)
8th Centaur Object 365756 *ISON* at Opposition (6.312 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 Apollo Asteroid 2010 RJ53 near-Earth flyby (0.024 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 Aten Asteroid 2020 KR2 near-Earth flyby (0.036 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)
11th McCarthy Observatory's Second Saturday Stars
11th Moon at perigee (closest distance to Earth)
11th Kuiper Belt Object 2010 RF43 at Opposition (53.299 AU)
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 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)
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 First Quarter Moon
13th Aten Asteroid 2100 *Ra-Shalom* closest approach to Earth (1.056 AU)
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 Mercury at its Greatest Eastern Elongation – separation from the Sun in the evening sky (27°)
14th Neptune at Opposition

Astronomical and Historical Events (continued)

14th Apollo Asteroid 6239 *Minos* closest approach to Earth (0.633 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 Scheduled launch of a SpaceX Crew Dragon from the Kennedy Space Center, Florida, with the first all-private, all-civilian orbital mission, known as Inspiration4 to raise money for St. Jude Children's Research Hospital
15th History: launch of China's second space station (Tiangong 2) (2016)
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)
16th Scheduled launch of the Landsat 9 Earth observation satellite atop a United Launch Alliance Atlas 5 rocket from the Vandenberg Space Force Base, California
16th Atira Asteroid 2020 HA10 closest approach to Earth (1.530 AU)
16th History: discovery of Saturn's moon *Hyperion* by William and George Bond and William Lassell (1848)170th Anniversary (1848)
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 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 Atira Asteroid 2014 FO47 closest approach to Earth (0.455 AU)
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)
20th Full Moon (Full Harvest Moon)
20th Aten Asteroid 2017 SL16 near-Earth flyby (0.033 AU)
20th Atira Asteroid 2017 XA1 closest approach to Earth (1.530 AU)
20th Kuiper Belt Object 66652 *Borasisi* at Opposition (41.395 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)
22nd Autumnal Equinox at 3:21 PM (EDT) or 19:21 UT
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 11885 *Summanus* closest approach to Earth (0.949 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)

Astronomical and Historical Events (continued)

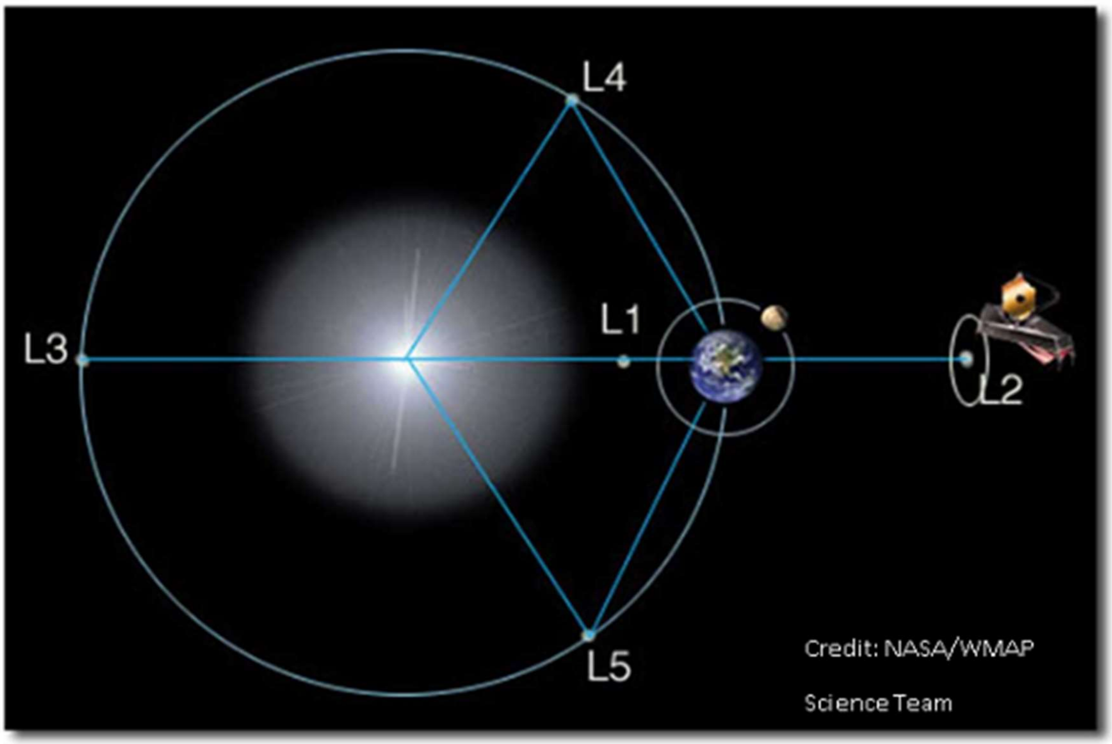
24th History: India's MOM (Mars Orbiter Mission) spacecraft enters orbit around Mars (2014)
24th History: John Young born (1930), first person to fly in space six times, including Gemini 3 (1965), Gemini 10 (1966), Apollo 10 (1969), Apollo 16 (1972), STS-1, the first flight of the Space Shuttle (1981), and STS-9 (1983)
25th Apollo Asteroid 12923 *Zephyr* closest approach to Earth (0.217 AU)
26th Moon at apogee (furthest distance from the Earth)
26th Aten Asteroid 2019 SF6 near-Earth flyby (0.042 AU)
26th Apollo Asteroid 5786 *Talos* closest approach to Earth (0.967 AU)
26th History: Cosmonauts V. Titov and Strekalov escape moments before Soyuz T-10-1 explodes on the pad (1983)
27th Kuiper Belt Object 523639 (2010 RE64) at Opposition (49.739 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 Last Quarter Moon
28th Amor Asteroid 15817 *Lucianotesi* closest approach to Earth (2.008 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 Atira Asteroid 2019 AQ3 closest approach to Earth (1.088 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 Kuiper Belt Object 120347 Salacia at Opposition (44.128 AU)
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 4th and 5th Lagrange points (leading and trailing) of major planets in the Solar System

Lagrange Points



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

References on Distances

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

International Space Station and Artificial Satellites

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

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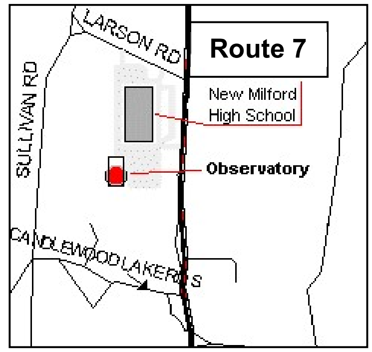

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