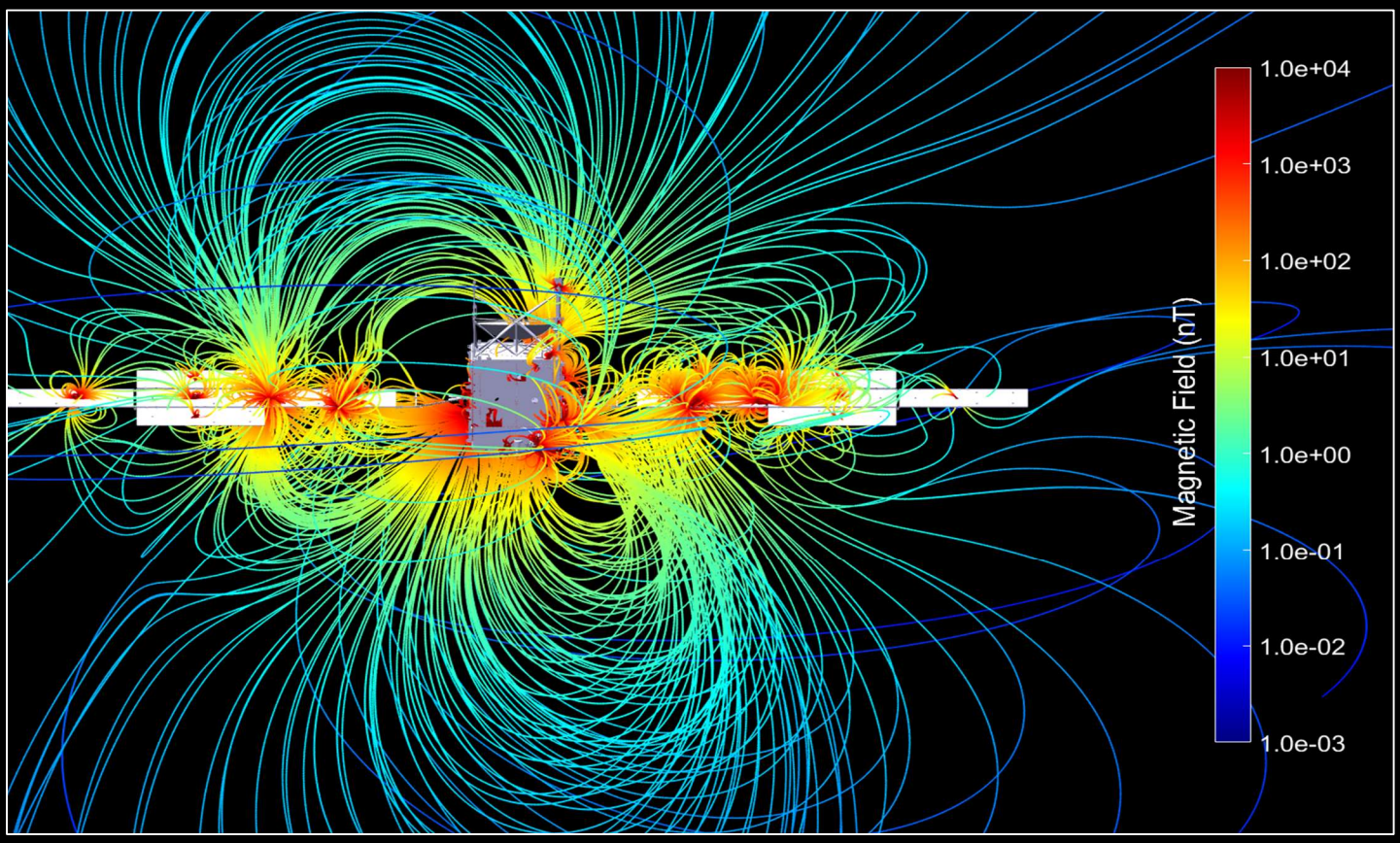
Galactic Observer

John J. McCarthy Observatory

Volume 16, No. 9 September 2023



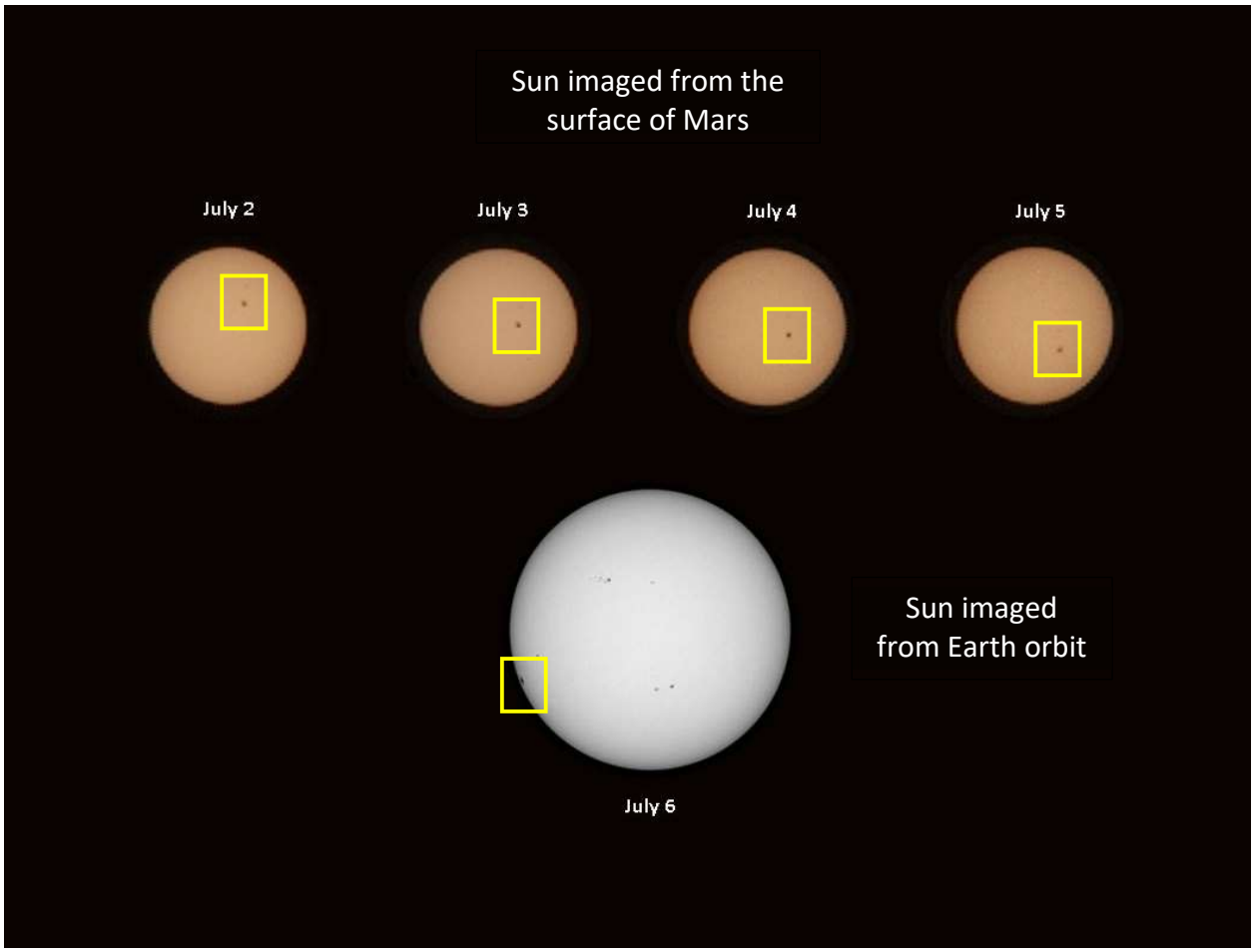
A visualization of the Psyche spacecraft's magnetic field, modeled as the sum of over 200 individual sources arising from various spacecraft subsystems and instruments. The magnetic field lines are color coded where red colors indicate higher field strengths and blue colors lower values.

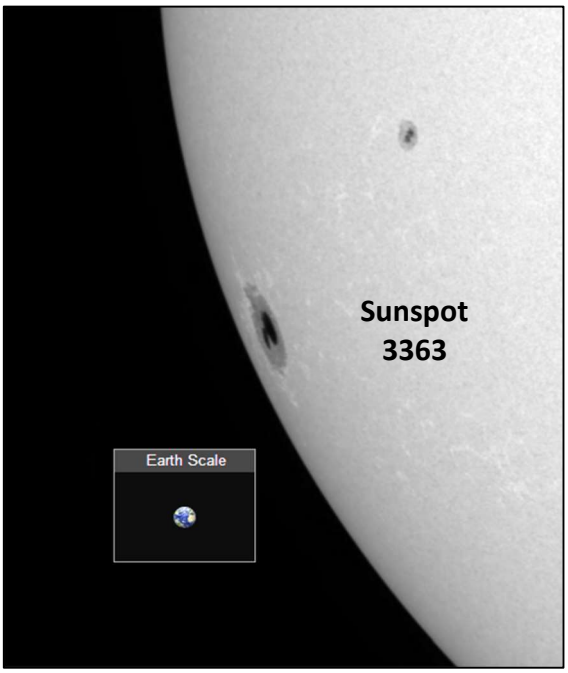
NASA's Psyche spacecraft has two identical, high-sensitivity magnetic field sensors located at the middle and outer end of a 6-foot long (2-meter) boom. The instruments are designed to detect and measure remnant magnetic signatures in Psyche's rocks and metals at different distances from the asteroid. Detection could support the premise that the largest known metallic body in the solar system formed from the core of a differentiated planetesimal.

In order to accurately determine the magnetic signature of the Psyche metal-rich asteroid, scientists need to account for the many unavoidable magnetic field sources from the spacecraft which are created by such things as hard magnets, as well as current loops that generate variable magnetic fields in the two solar array wings.

Source: NASA/JPL_Caltech

September Astronomy Calendar and Space Exploration Almanac





On July 6th, a massive sunspot (designated 3363) rotated into Earth's view.

Due to Mars' then-current orbital position (as compared to Earth), the sunspot had been imaged over the days prior to the 6th by the Mars Perseverance rover (orange colored sequence above). The rover routinely images the Sun (using a solar filter) to assess atmospheric transparency. A dimming Sun can portend an impending dust storm - an event that can affect the entire planet and impede surface operations.

Images from Mars: NASA/JPL-Caltech/ASU

Image from Solar Dynamics Orbiter courtesy of NASA/SDO

In This Issue

"Out the Window on Your Left"

It's been 54 years since Neil Armstrong first stepped onto the Moon's surface and almost 51 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 United States and China are planning to send astronauts to the lunar South Pole within the next ten years. While the initial forays would be exploratory, both countries are determined to establish a long term presence on our nearest celestial neighbor.

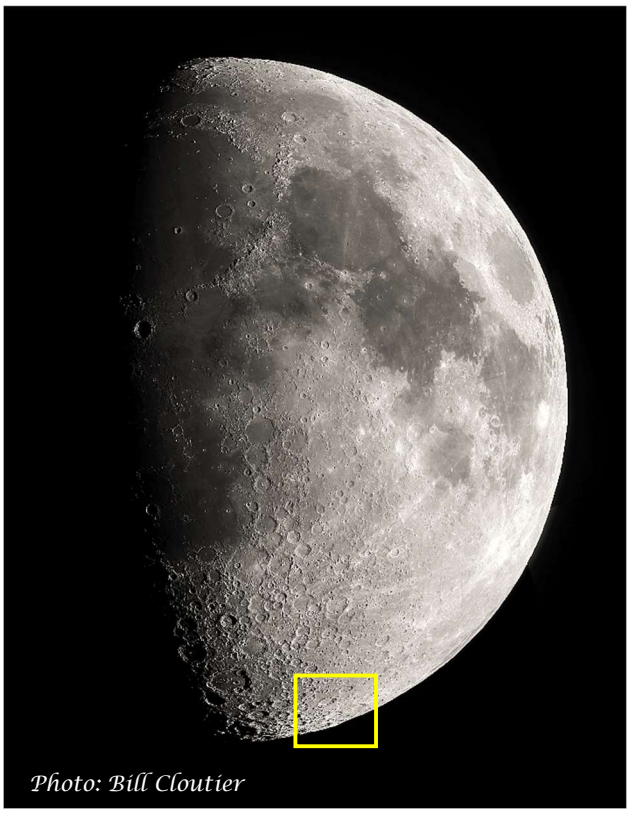


Photo: Bill Cloutier

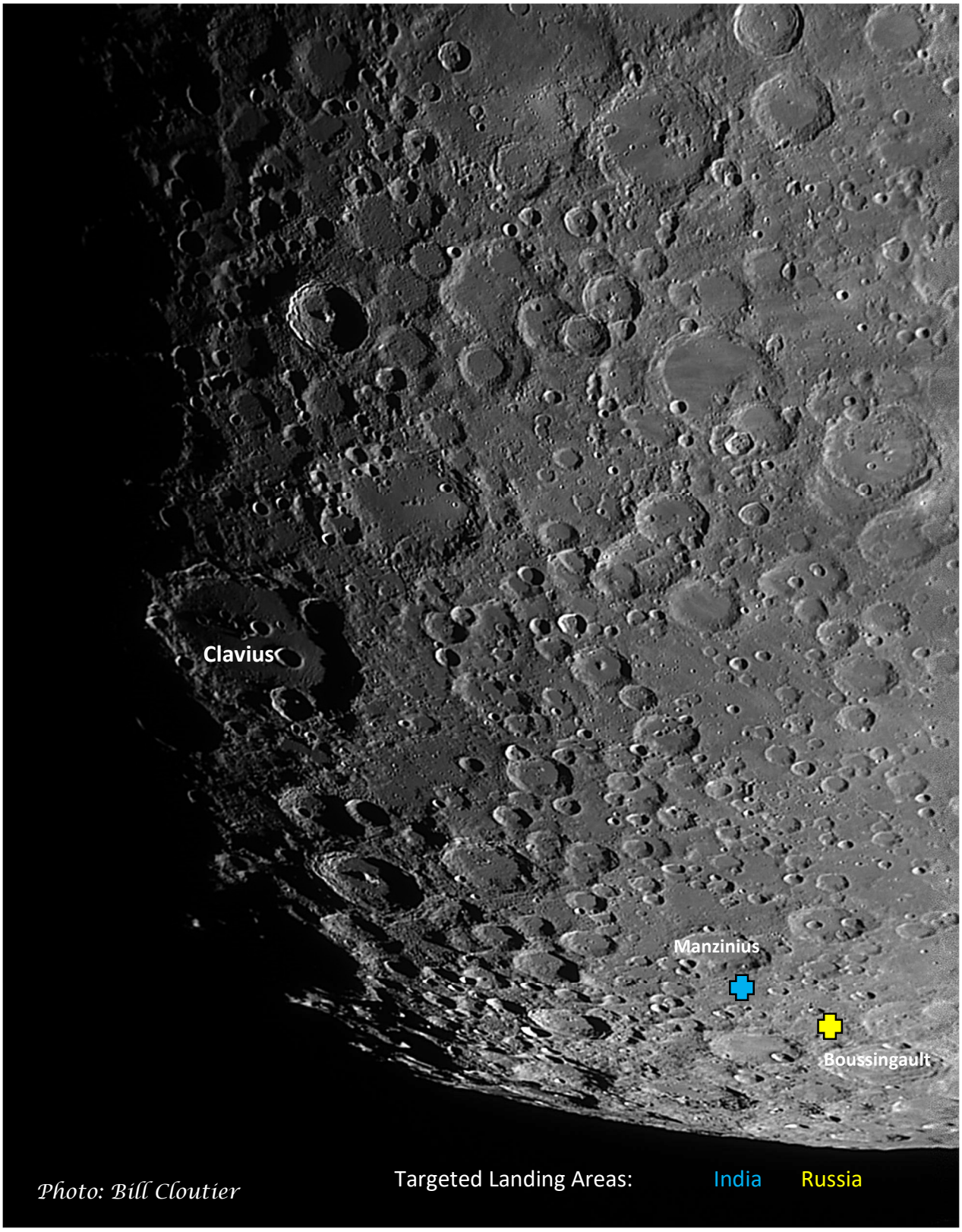
South polar region targeted by India's and Russia's latest lunar missions

NASA's Apollo missions landed near the equator, which was generally less rugged than the lunar highlands to the south. Over the past 50 years, robotic orbiters have detected likely deposits of water ice and other volatiles in the heavily cratered polar regions. If elements such as oxygen and hydrogen are easily accessible, can be harvested from the lunar regolith or from within permanent shadowed regions, and converted into drinking water, breathing air, rocket fuel, and other life sustaining ingredients, they could be used to support humans both on the Moon and in future deep space ventures.

SpaceX's Falcon 9 rocket is currently the most economical transport to a geostationary orbit, at about $3,700/pound or $8,100/kg. The National Academy of Medicine suggests a daily intake of fluids of about thirteen 8-ounce cups for healthy men (with 9 cups for women). At SpaceX's current price, the cost to supply drinking water for one male astronaut, for one day, is about $24,800 (exclusive of the additional costs for the container and the trip from geostationary to the Moon). If water can be extracted from lunar materials or from pockets of ice, the avoided cost is truly astronomical.

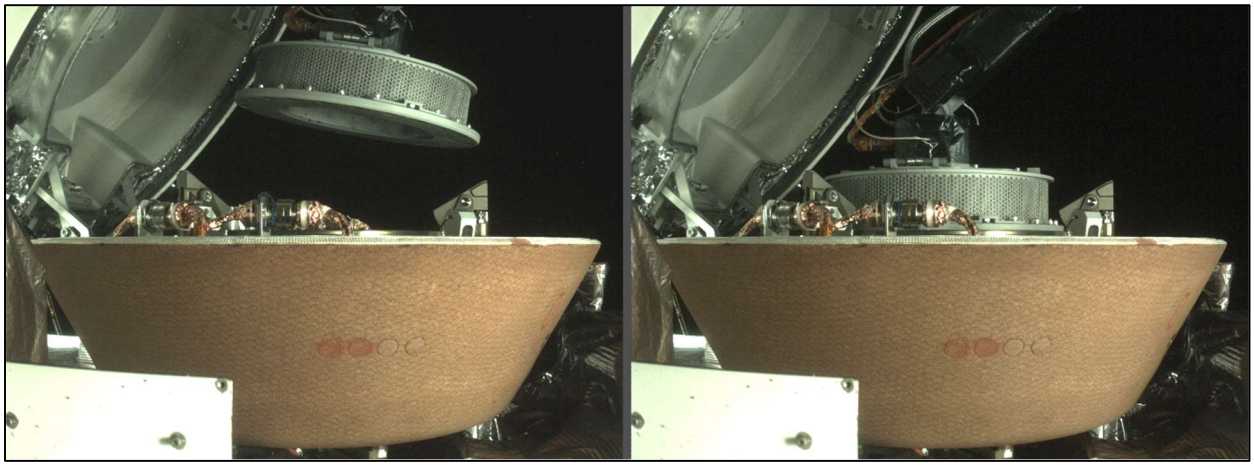
In preparation of human landing, several countries have launched robotic missions to the Moon's south polar region. India and Russia have targeted areas on the near side, not far from the south pole (shown on next page). China is currently exploring the Aitken basin on the Moon's far side, the largest impact basin in the Solar System. NASA's Volatiles Investigating Polar Exploration Rover, or VIPER, is scheduled to fly to the lunar south pole next year. The mobile robot will study and map water ice deposits over a nominal 100-day mission, which will include brief excursions into the permanently shadowed regions. Japan and India are planning a post-2024 mission with similar objectives with their Lunar Polar Exploration Mission (LUPEX) rover.

Intended Landing Sites of Chandrayaan-3 and Luna 25



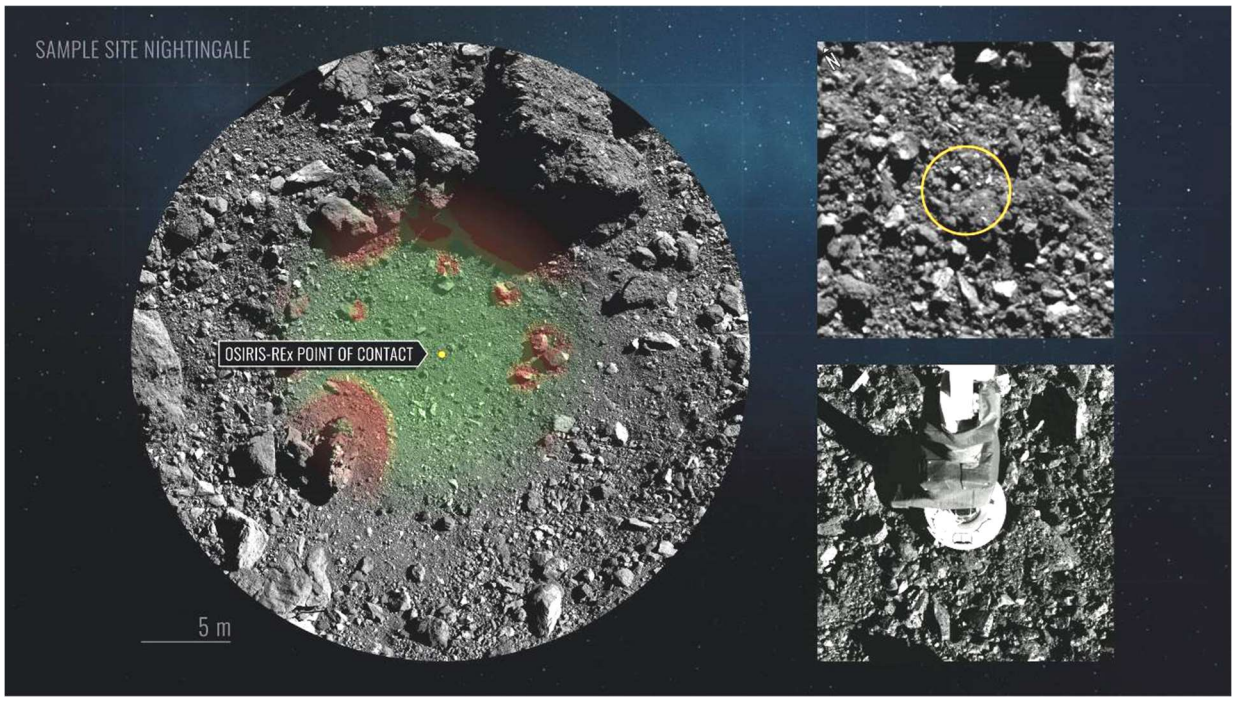
Special Delivery

On September 24th, seven years after leaving Earth, NASA's Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer (OSIRIS-REx) spacecraft will deliver a sample of the asteroid Bennu as it flies by its home planet. The reentry capsule containing rocky material from the asteroid will be released into the Earth's atmosphere and descend by parachute to the Utah Test and Training Range in Utah's West Desert for retrieval.



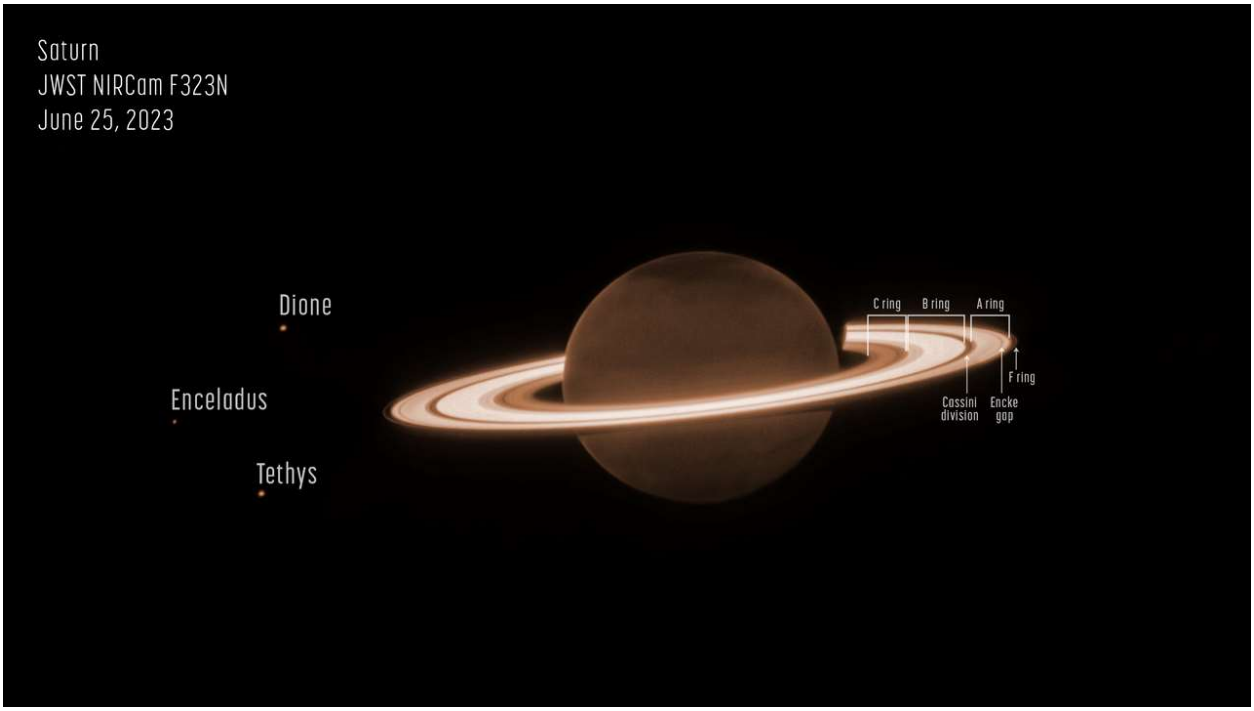
Sample collector being placed inside return capsule (above) and sample site details (below)
Credits: NASA/Goddard/UArizona/Lockheed Martin

The material had been collected in October 2020 when, at a distance of more than 200 million miles (321 million km) from Earth, OSIRIS-REx descended onto the surface of Bennu. The choreographed sequence of maneuvers brought the spacecraft down among a boulder-strewn field at the "Nightingale" site, agitating the dust and rocks on the surface. Images of the sampling head suggest that the spacecraft collected more than the minimum required amount to meet mission objectives (at least 2 ounces or 60 grams) in its six seconds of contact with the surface.



Saturn in a New Light

Astronomers, for the first time, have used the James Webb Space Telescope to image Saturn. The observing campaign was designed to test the telescope's ability to detect faint moons around a large planet with bright rings. Imagery from Webb's NIRCam (Near-Infrared Camera) shows a relatively dark Saturn (at infrared wavelengths), with the methane in the planet's atmosphere absorbing almost all of the light received from the Sun. However, the rings, which are composed of water-ice, are comparatively bright.



Saturn and several of its moons, imaged by the James Webb Space Telescope's NIRCam (Near Infrared Camera) instrument on June 25, 2023
Credit: NASA, ESA, CSA, STScI, M. Tiscareno (SETI Institute), M. Hedman (University of Idaho), M. El Moutamid (Cornell University), M. Showalter (SETI Institute), L. Fletcher (University of Leicester), H. Hammel (AURA); image processing by J. DePasquale (STScI).

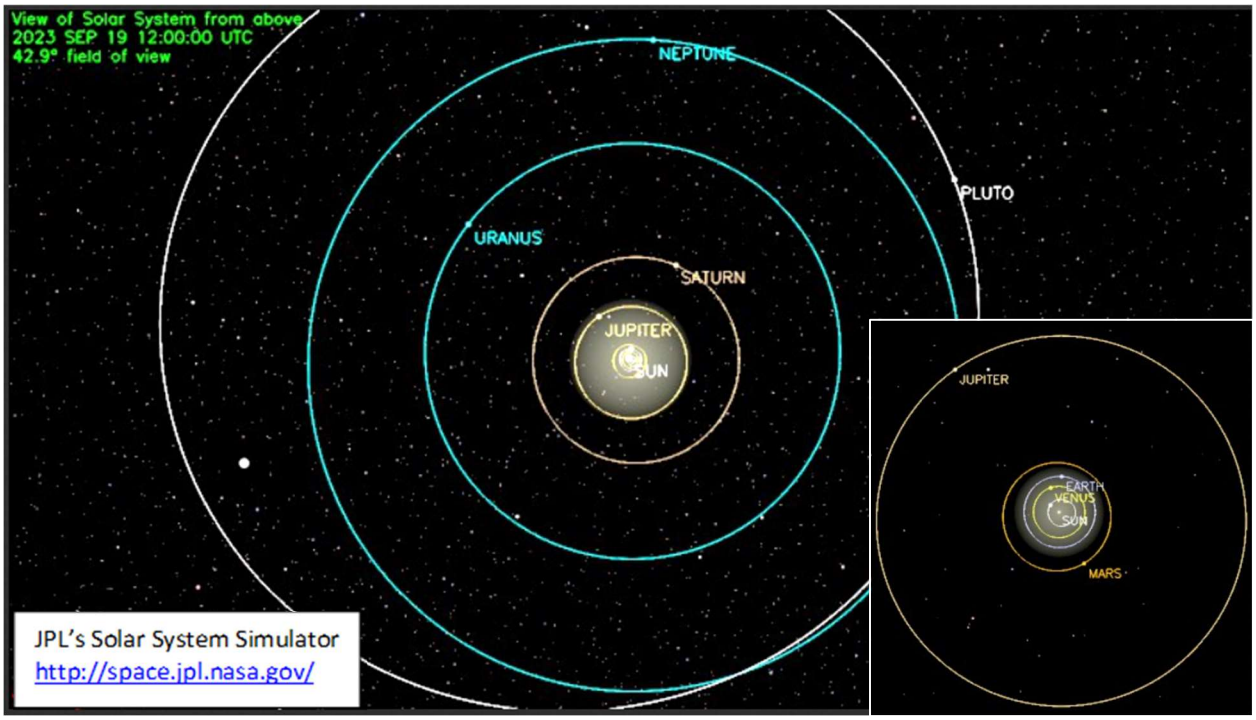
At this particular wavelength (3.23 microns), our view of Saturn's atmosphere is much different than its light and creamy banded appearance in visible light. Large, dark diffuse structures appear in the northern hemisphere with even darker hues near the planet's poles. The dissimilarities between the two hemispheres may be related to seasonal effects, as it is currently summer in the northern hemisphere, or from large-scale planetary waves in the stratospheric aerosols high above the main cloud layers, as seen in Webb's observations of Jupiter. Scientists will use Webb's spectrographic instruments to isolate the chemical constituents in the gas giant's atmosphere and determine their role in the observed phenomena.

Deeper exposures (than shown here) are also providing astronomers unprecedented views of Saturn's fainter rings, including the thin G ring (located beyond the planet's outer A-ring) and the distant and diffuse E ring (nourished by the icy geysers of the moon Enceladus).

Neptune at Opposition

Earth will come between the planet Neptune and the Sun on September 19th, i.e., "Opposition." On that day the ice giant will rise as the Sun sets and be visible throughout the night (highest in the sky shortly after midnight). At magnitude 7.7, a telescope will be required to see the planet's disk, which can be found in the eastern region of the constellation Pisces.

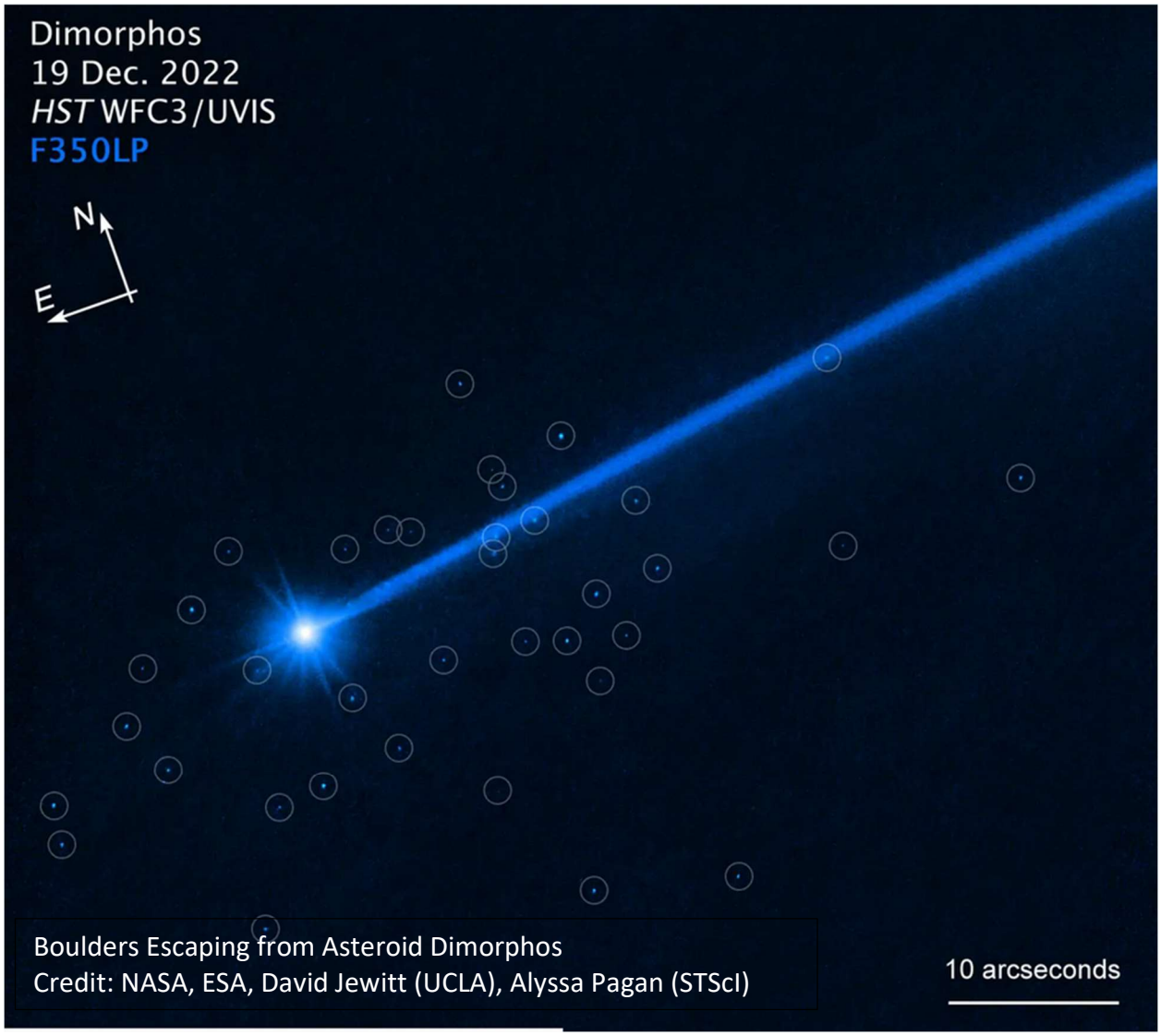
Neptune is the outermost planet in the solar system (since the demotion of Pluto), orbiting the Sun at an average distance of 2.7 billion miles (4.3 billion km). The ice giant was discovered in 1846, and, with an orbital period of 165 years, has only recently completed one orbit of the Sun since its 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. The ice giant 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 at 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.

DART-Produced Debris Spotted by Hubble

NASA's DART (Double Asteroid Redirection Test) mission was a demonstration designed to assess the effectiveness of a kinetic impact in changing the course of an asteroid. Conducted on September 26, 2022, the DART spacecraft intentionally collided with the moon (Dimorphos) of the near-Earth asteroid Didymos. The spacecraft's collision with the 530 foot or 780 meter wide moon, at a speed of 14,000 miles per hour (6.6 km/s), exceeded all expectations – changing Dimorphos' orbital period by almost 33 minutes (NASA had defined a minimum orbital period change of 73 seconds or more as the criteria for success).



Boulders Escaping from Asteroid Dimorphos
Credit: NASA, ESA, David Jewitt (UCLA), Alyssa Pagan (STScI)

The impact was observed by telescopes on Earth, in space, as well as by a cubesat that had traveled along with the DART spacecraft. The collision resulted in an estimated 2.2 million pounds (1 million kg) of material being released from the surface of the moon. In December, the Hubble Space Telescope was able to image dozens of boulder-sized objects that had been knocked off the asteroid by the force of the impact. Drifting away at a little more than a half-mile per hour (less than 1 km/hour), the boulder swarm is providing astronomers valuable insight into the aftermath of a collision, the structural cohesiveness of the primordial body, and the contribution of the ejected material to the observed momentum change.

Webb Anniversary

To celebrate the first anniversary of the James Webb Space Telescope's science operations, NASA released an image of a small star-forming region in the Rho Ophiuchi cloud complex. At a distance of 390 light-years, it is the nearest stellar nursery to Earth. Its proximity provides astronomers a detailed and relatively unobstructed look at the gas and dust cloud.

Rho Ophiuchi
Credits: NASA, ESA, CSA, STScI, Klaus Pontoppidan (STScI)

Approximately 50 young stars are visible in the Webb image, most similar in mass to our Sun, or smaller. The darkest areas of the cloud are the densest, where thick dust hides still-forming protostars. Massive bipolar jets of molecular hydrogen, created by the newborn stars, are shown in red. They appear as horizontal wisps across the upper third of the image and vertically on the right side. The pale-yellow, cave-like structure in the lower half of the image has been carved out by the one star (designated S1) that is more massive than our Sun. Several stars also show hints of circumstellar disks, the early stage of formation of future planetary systems.

India is on the Moon

Launch of the Indian Moon mission from the Sriharikota space center on July 14th (above) and the first image from the lunar surface on August 23rd (right)
Image: ISRO

Early Wednesday morning, August 23, 2023, India became the fourth country to land a robotic probe on the Moon, joining the United States, Russia and China. After a failed attempt in 2019, India successfully executed a touch down of its spacecraft just days after a similar Russian failed attempt. The landing site is near the south pole at a latitude of approximately 70°S.

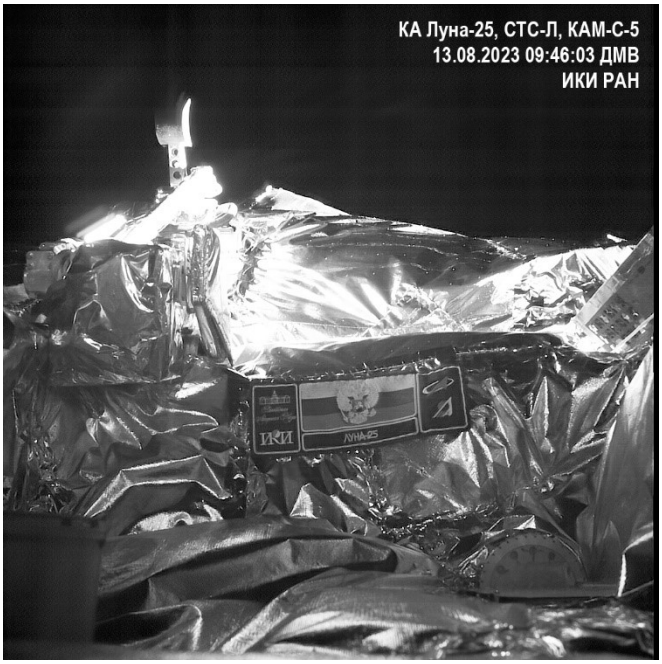
The Vikram lander (Sanskrit for "valor"), which has a mass of about 3,858 pounds (1,750 kg), includes a 57 pound (26 kg) six-wheeled rover named Pragyan (Sanskrit for "wisdom"). The rover and lander are both expected to operate for one lunar day (about two Earth weeks).

The rover, deployed shortly after landing, is equipped to analyze the chemical composition of the surrounding lunar regolith and rock. The lander's seismometer will record moonquakes which can reveal details on the composition of the Moon's interior. A heat probe will record regolith temperature while another instrument will study the plasma environment close to the surface. NASA also provided a retroreflector for studying the dynamics of the Earth-Moon system.

Luna 25 Lost

Luna 25, Russia's first Moon mission in 47 years, was lost when the spacecraft developed a problem shortly before it was scheduled to land. Roskosmos, Russia's space agency, reported that they lost control of the robotic craft on Sunday, August 20th, as it prepared for a soft landing near the Moon's south pole on Monday.

Launch and first image of the spacecraft from deep space
Roscosmos State Space Corporation/AP



Luna 25 was the first post-Soviet Union lunar mission (its predecessor, Luna 24, was a sample-return mission carried out in 1976). It was launched aboard a Soyuz rocket on August 11th from the Vostochny cosmodrome and intended for a landing site north of Boguslavsky crater (69.5°).

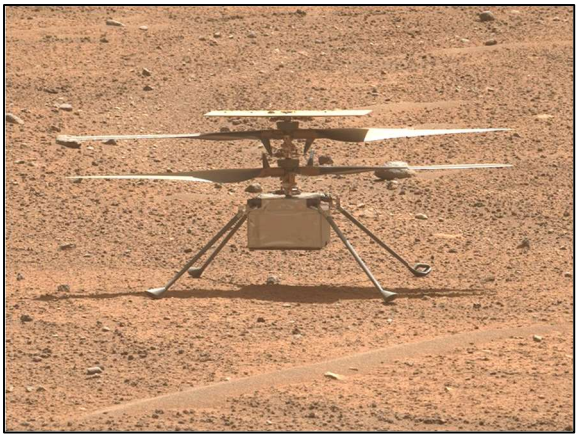
The solar-powered spacecraft carried 9 science instruments designed to assess the water-ice content of the lunar regolith and local radiation environment, and eight cameras for documenting the surrounding landscape and for managing the lander's manipulator.

The loss of Luna 25 is a setback to what was hoped to be a revival of Russia's lunar exploration program and the first in a series of increasingly ambitious missions to the surface of the Moon.

Return to Flight

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

NASA's Ingenuity helicopter has returned to action once again. After a 63-day gap in flights, the team at the Jet Propulsion Laboratory is now putting the diminutive Mars' rotorcraft through its paces.



Flight 52, on April 26th, concluded with Ingenuity landing in the rugged terrain of the Jezero river delta and out of the line-of-sight with the Perseverance rover (the rover is used to relay communications to and from Earth). The sightline was reestablished at the end of June. During that blackout period, Perseverance had moved ahead of the helicopter as it follows an ancient river bed towards the crater wall.

At the end of July, Ingenuity was back in the rarified air of Mars, covering almost 470 feet (142 meters) of horizontal distance in its 53rd flight. Flight 53 had been planned as a long-duration scouting sortie, with a complicated flight profile to collect imagery for the Perseverance Mars rover science team. The foray was cut short when the flight-contingency program was triggered and the helicopter automatically landed. The likely cause was a mismatch between the image frames from the helicopter's navigation camera and the data from the rotorcraft's inertial measurement unit. Flight 54 was a short pop-up flight to check Ingenuity's navigation system. Its success set up Flight 55 on August 12th which carried the little scout once again out in front of Perseverance.

Ingenuity first flew on April 19, 2021 as a technology demonstration. Its exceptional performance led NASA to redefine its mission and consider rotorcraft applications for future missions.

Psyche Ready to Fly

Installation of the first of two solar arrays for NASA's Psyche spacecraft inside Astrotech's Space Operations payload processing facility in Titusville, Florida. The 800 square feet (75 square meters), five-panel, cross-shaped solar arrays will produce more than 20 kilowatts of power when the spacecraft is near Earth, but just over 2 kilowatts at the asteroid Psyche due to its vast distance from the Sun.
Credits: NASA/Isaac Watson

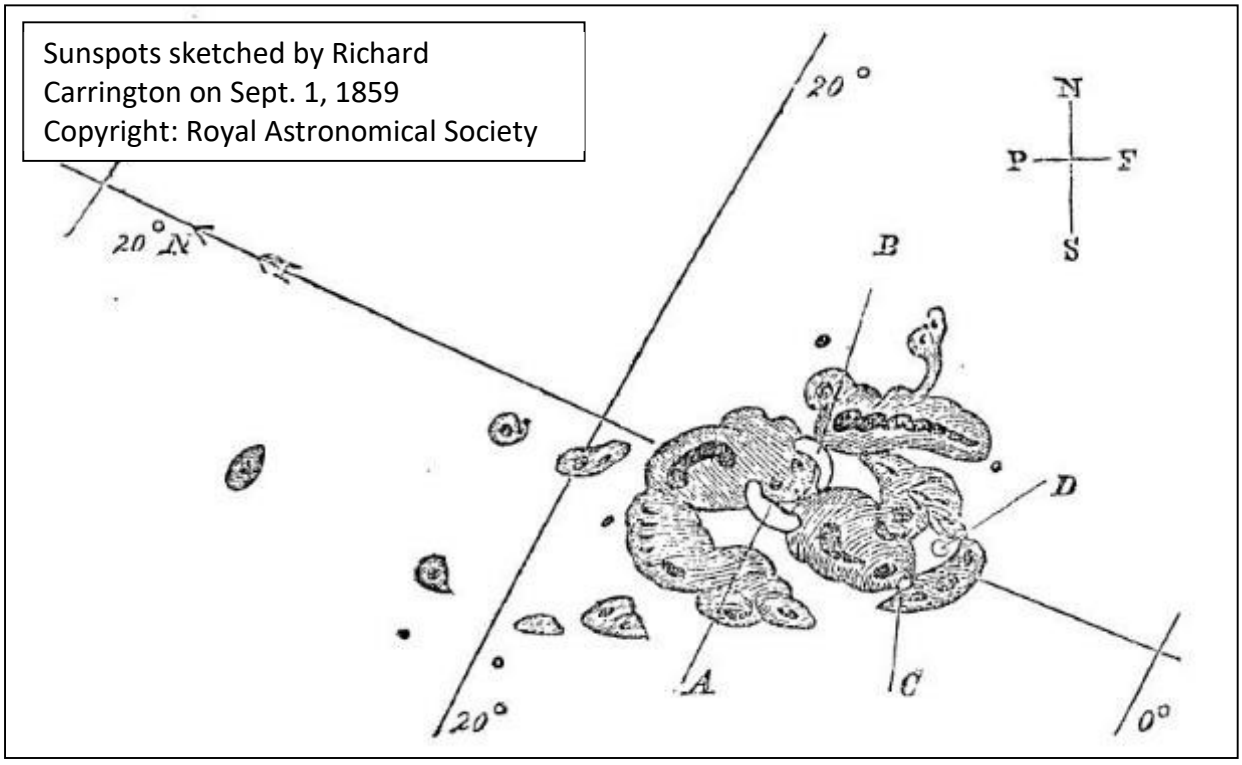
A NASA Discovery Mission, Psyche, originally scheduled to launch in August of 2022, is in the final stage of preparations for an October 2023 launch. The solar panels that will provide power for the spacecraft's science instruments, telecommunications, equipment that controls the orbiter's temperature, and the spacecraft's solar electric propulsion engines have been installed. In August, technicians loaded about one metric ton of xenon gas (1,085 kgs) into seven 22-gallon (83 liter) tanks inside the spacecraft. The spacecraft's four Hall thrusters will use electric and magnetic fields to accelerate and expel charged xenon ions to create the thrust and propel the spacecraft to its destination.

The launch period for the spacecraft (also called Psyche) to a metal-rich asteroid is October 5th through the 25th. The instantaneous launch opportunity (the spacecraft needs to launch at an exact time or reset for the next day) for October 5th is at 10:38 A.M. EDT aboard a SpaceX Falcon Heavy rocket from Launch Complex 39A at NASA's Kennedy Space Center. With a gravity assist from Mars in 2026, the spacecraft is expected to arrive at the asteroid in August 2029. A 26-month-long science phase will then be conducted from four different altitudes.

The Carrington Event

One hundred and sixty-four 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 1st, 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.

Saturn

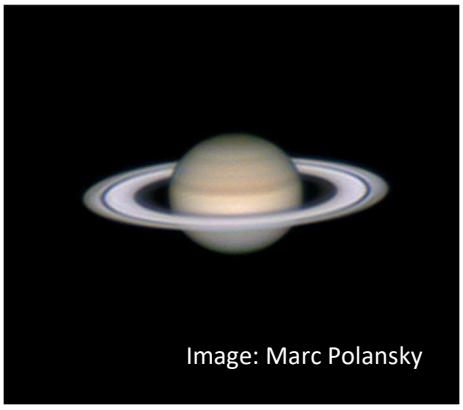


Image: Marc Polansky

Saturn reached Opposition on August 27th when the ringed-world was closest to Earth. Since that time, the distance between the Earth and Saturn has been gradually increasing with Earth's higher orbital velocity. Saturn is still well placed in the evening sky in the constellation Aquarius. The planet's north pole is currently tilted towards the Earth with its rings inclined at an angle of almost 8° to our line of sight. We see the ring tilt change (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.

Jupiter

Jupiter reaches Opposition this year on November 3rd. By the end of September, the gas giant shines brightly in the eastern sky after sunset (almost 25 times brighter than Saturn). The largest planet in the solar system can be found in the constellation Pisces and to the east of Saturn.


Image: Marc Polansky

	Rise and Transit Times (EDT)			
	September 1		September 30	
Planet	Rise	Transit*	Rise	Transit*
Saturn	7:38 pm	1:08 am	5:35 pm	11:03 pm
Jupiter	10:53 pm	5:37 am	8:56 pm	3:39 am

* 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
19th	Io	11:33 pm	1:42 am (20th)
25th	Europa	6:59 pm	9:18 pm
28th	Io	7:55 pm	10:05 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
16th	8:42 pm	23rd	9:27 pm
18th	10:20 pm	25th	11:05 pm
20th	11:58 pm	28th	8:34 pm

Autumnal Equinox

The Sun crosses the celestial equator at 2:50 AM (EDT) on the evening of September 23rd, 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	19:27
September 15th	06:33	19:03
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 Closest approach of asteroid 2017 BY32, a Near-Earth Object (NEO) and Apollo
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 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 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
6th Last Quarter Moon
6th Closest approach of asteroid 2021 JA5, a Near-Earth Object (NEO) and Apollo
8th Closest approach of asteroid 2020 GE, a Near-Earth Object (NEO) and Apollo
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 **McCarthy Observatory's Second Saturday Stars** (open house)
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)

Astronomical and Historical Events (continued)

9th History: discovery of Jupiter's moon *Amalthea* by Edward Barnard (1892)
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 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 Moon at apogee (furthest distance from the Earth)
12th Closest approach of asteroid 2020 RT2, a Near-Earth Object (NEO) and Apollo
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)
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 History: launch of the Japanese Moon orbiter "Kaguya" (Selene 1) (2007)
14th New Moon
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 Russian Soyuz spacecraft with cosmonauts Oleg Kononenko and Nikolai Chub, along with NASA astronaut Loral O'Hara, from the Baikonur Cosmodrome, Kazakhstan to the International Space Station
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 Closest approach of asteroid 2016 LY48, a Near-Earth Object (NEO) and Apollo
16th Closest approach of asteroid 2010 TE, a Near-Earth Object (NEO) and Aten
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)

Astronomical and Historical Events (continued)

18th History: launch of Vanguard 3, designed to measure solar X-rays, the Earth's magnetic field, and micrometeoroids (1959)
19th Neptune at Opposition
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 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 First Quarter Moon
23rd Autumnal Equinox: 2:50 am EDT (06:50 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 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 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 Closest approach of asteroid 2019 SF6, a Near-Earth Object (NEO) and Aten
26th History: Cosmonauts V. Titov and Strekalov escape moments before Soyuz T-10-1 explodes on the pad (1983)
27th Moon at perigee (closest distance to Earth)
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 Closest approach of asteroid 2013 TG6, a Near-Earth Object (NEO) and Aten
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 Full Moon (Full Harvest Moon)
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 Closest approach of asteroid 2009 UG, a Near-Earth Object (NEO) and Aten

Astronomical and Historical Events (continued)

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

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.

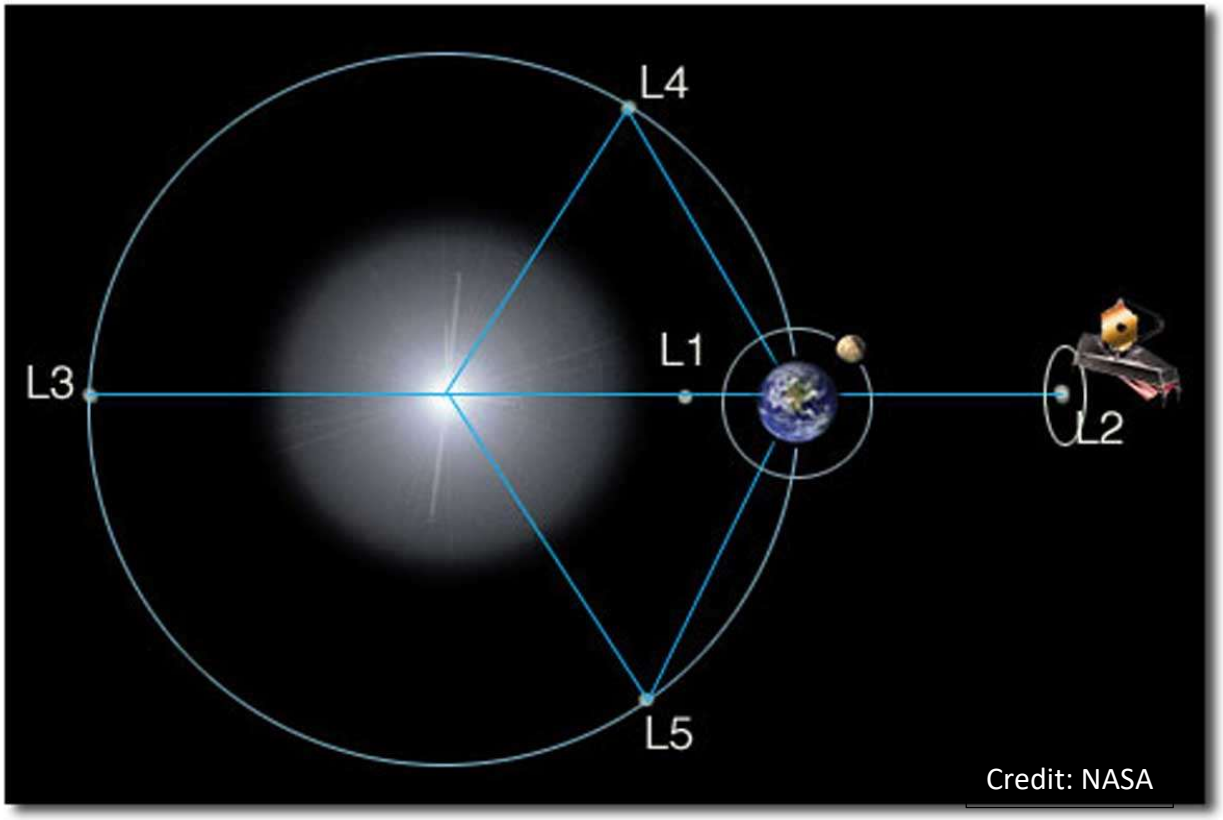
NASA's Global Climate Change Resource

- 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/

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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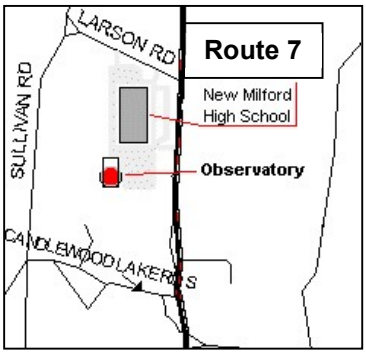

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