Galactic Observer

John J. McCarthy Observatory

Volume 11, No. 7/8 July/August 2018

Clouds' Illusions

What's behind all that stormy weather on Jupiter?

Find out on page 29

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It is through their efforts that the McCarthy Observatory has established itself as a significant educational and recreational resource within the western Connecticut community.

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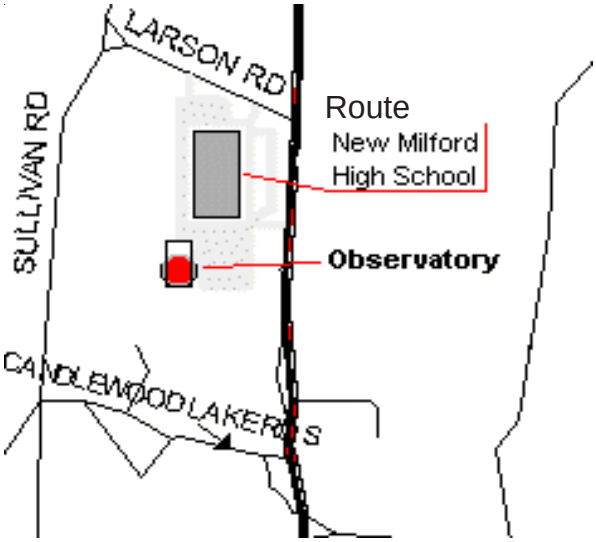
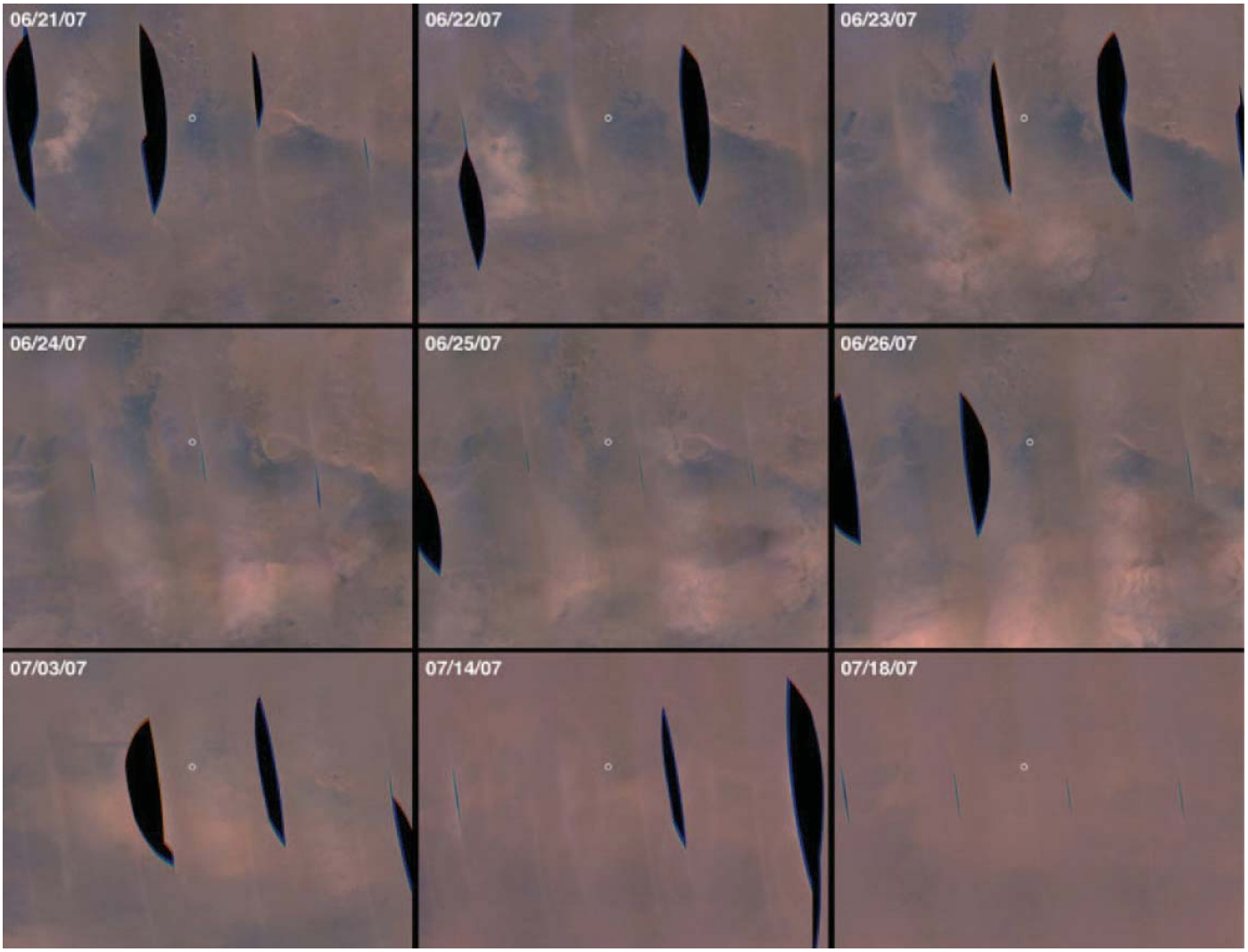


In This Issue

July and August Calendar and Space Exploration Almanac



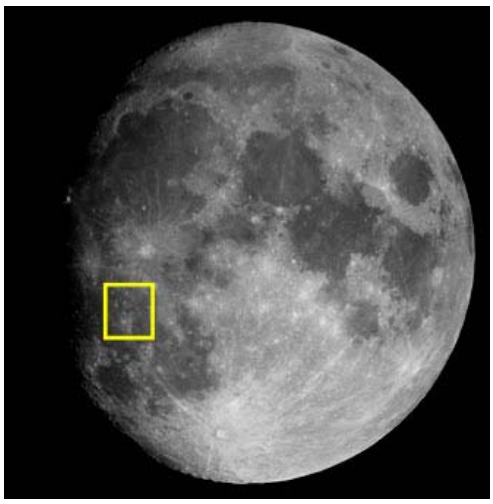
Opacity of Martian Sky during the 2007 Dust Storm Opportunity's location is marked by a white circle
Image credit: NASA/JPL/MSSS

Living on Mars can be challenging enough, but when your essential systems are dependent upon abundant sunshine for power, dust storms can curtail operations and even incapacitate. NASA's Mars Exploration Rover, Opportunity, has been exploring the Red Planet since landing on Meridiani Planum in January 2004. The intrepid, robotic geologist receives its power from two multi-panel solar arrays. The panels can generate up to 900 watt-hours of energy per Martian day (rating when the rover first landed and the panels were pristine). The electricity generated by the panels is used to conduct surface operations and recharge its two batteries.

Now, more than 14 Earth-years later, the dust-coated panels are not nearly as efficient, particularly when the Sun is dimmed by dust in the atmosphere and in the winter when the Sun is low in the sky. In the summer of 2007, Opportunity was caught in a global dust storm. For almost a month, dust blocked 99 percent of the available sunlight. On July 18th, output from the rover's solar panels dropped to its lowest point (128 watt-hours). The mission team, having already suspended all surface operations, were forced to curtail communications with Opportunity so as to maintain battery reserves for critical systems, such as equipment heaters. Fortunately, the storm abated and Opportunity emerged to roll again across the Martian plains. The summer of 2018 appears to be equally, if not more, challenging with emerging dust storms as Mars nears its closest approach to the Earth and Sun and the planet warms.

"Out the Window on Your Left"

IT'S BEEN MORE than 45 years since we left the last foot print on the dusty lunar surface. Sadly, as a nation founded on exploration and the conquest of new frontiers, we appear to have lost our will to lead as a space-faring nation. But, what if the average citizen had the means to visit our only natural satellite; what would they see out the window of



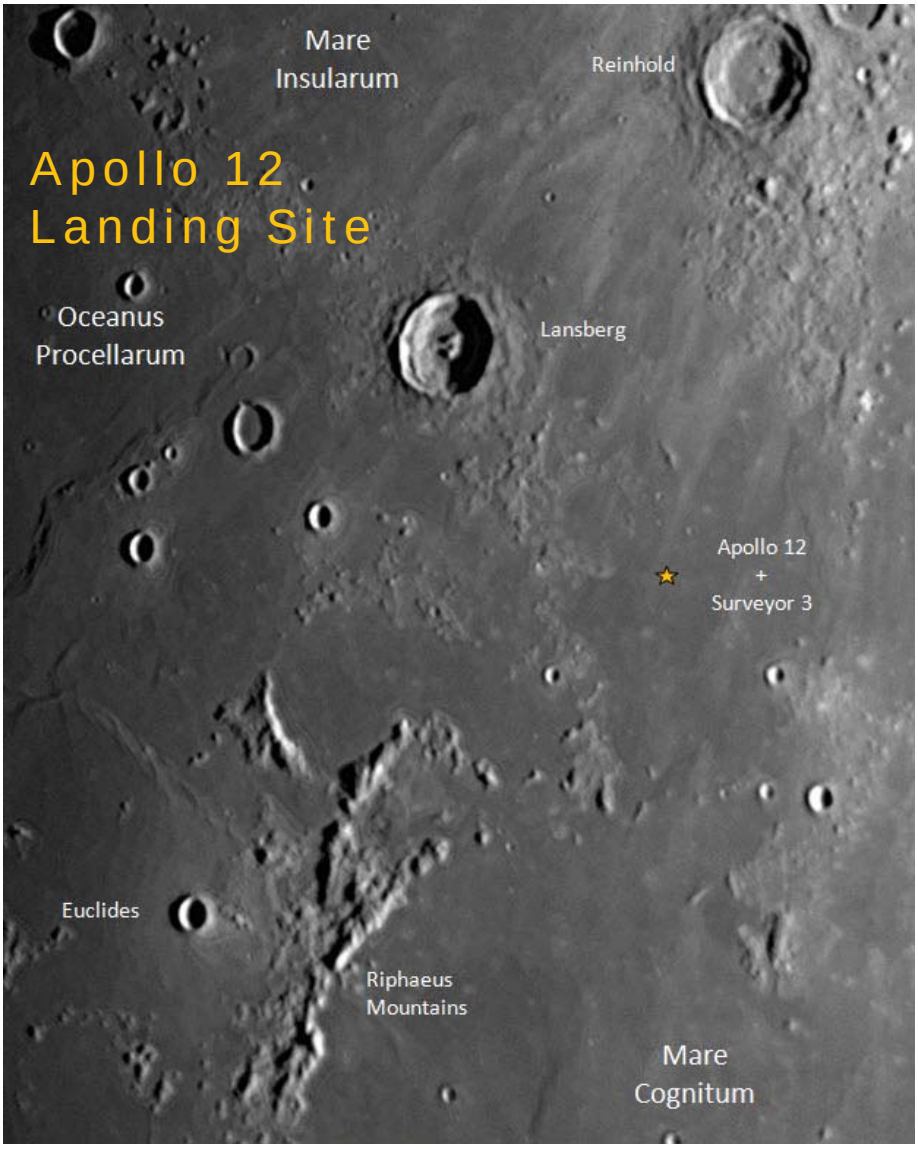
their spacecraft as they entered orbit around the Moon? This column may provide some thoughts to ponder when planning your visit (if only in your imagination).

Alan Bean, Apollo 12 lunar module pilot and Skylab commander, passed away on May 26th at the age of 86, after a short illness. Following his retirement from NASA in 1981, Bean devoted his life to recording his experiences as an astronaut and with the space program through art. His paintings depict lunar exploration scenes and events, both real and imaged. He worked with his former comrades to capture the human spirit. Bean's unique style included bits of moon dust and fragments of spacecraft materials blended into the pigments.

Apollo 12 was launched on November 14, 1969. Lightning discharges at 36.5 seconds after liftoff, and again at 52 seconds as the rocket passed through a low cloud layer, caused major electrical disturbances in the Command Module, triggering alarms and knocking systems offline. Fortunately, the discharges did not adversely affect the Saturn V booster which stayed the course. Except for a few non-critical systems, there was no permanent damage and Apollo 12 was able to set course for the Moon.

Commander Pete Conrad and lunar module pilot Bean guided the Intrepid to a pinpoint landing on Oceanus Procellarum (the Ocean of Storms), at the edge of Surveyor Crater and only 600 feet from the Surveyor III spacecraft, which had landed two years earlier. Conrad and Bean spent a total of almost 8 hours, in two excursions, exploring the lunar surface, setting up experiments and collecting samples. The samples returned by Apollo 12 (75 pounds or 34 kilograms of 45 rocks, regolith and cores) were different than those returned by Apollo 11. Almost all of the Apollo 12 samples were basalts that formed 3.1 to 3.3 billion years ago, approximately 500 million years later than the Apollo 11 samples. The Apollo 12 basalts formed at depths at least 100 to 150 miles (150 to 250 km) below the surface.

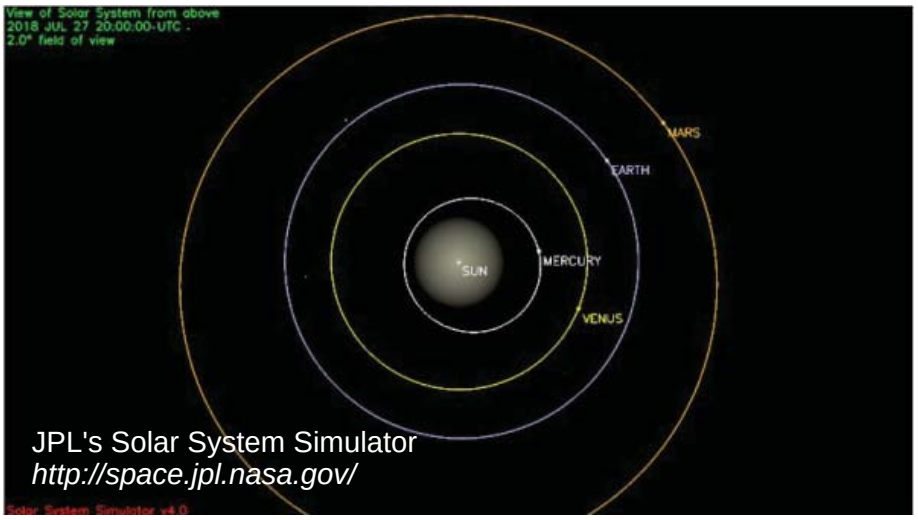
The regolith samples included, what is likely, ejecta from the impact that created Copernicus crater to the north. The ejecta dated the impact to 800 million years ago. The most unusual rock



returned was known as KREEP, an acronym for rocks rich in the elements potassium (K), rare earth elements (REE), and phosphorus (P). The formation of KREEP is associated with the crystallization of the Moon's primal, global magma ocean over 4 billion years ago.

Mars at Opposition

The Earth will come between Mars and the Sun on July 27th (EDT), an arrangement called Opposition. On that day, Mars will rise as the Sun sets and will be at its highest after midnight. At closest approach, Mars will be approximately 35.9 million miles (57.8 km) from Earth (the distance at Opposition can vary from 34.6 million miles to 63 million miles due to Mars' highly elliptical orbit). The planet will appear larger than in its previous 2016 Opposition being almost 13 million miles closer, but for northern hemisphere observers, several degrees lower in sky. Mars has the greatest variation in Opposition distances than any other planet. In 2018, the planet will appear at 94% of its maximum size (at the closest Opposition). Observers in the southern hemisphere, where Mars will be much higher in the sky, will have the best view.



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

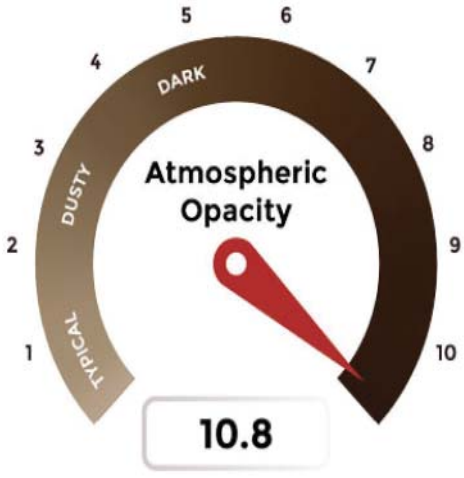
Mars can be found in the constellation Capricornus during the month of July, just to the east of Saturn. The planet will briefly enter Sagittarius near the end of August before returning to Capricornus. Mars will be relatively bright with an apparent magnitude of -2.8 (equaling Jupiter in brilliance). For telescopic observers attempting to view the planet's surface features, Martian weather reports can be found on the Malin Space Science Systems website (*http://www.msss.com/*). The genesis of local and regional dust storms is closely watched since they can quickly propagate to engulf the entire planet for months, as they did in 2001. Mars rotates once every 24 hours and 37 minutes, so the view will change little if you observe at the same time each night. To see the entire planet, you will need to observe at different times of the night or over a relatively long period of time (a month or more). On nights of good seeing (steady atmospheric conditions), the bright polar ice caps should be visible. In July, it is late spring in the southern hemisphere with the south pole tipped towards Earth.

Surface markings are difficult to discern on Mars due to the planet's relatively small size and great distance, even in the largest telescope. A map or guidebook such as William Hartman's "A Traveler's Guide to Mars" can be helpful in identifying those Martian landmarks that are visible.

Deadly Weather

The Mars Reconnaissance Orbiter's (MRO) Mars Color Imager (MARCI) acquires almost 300 images each week, using three different color filters. The images are used to monitor changes in the Martian weather. As the planet moves closer to the Sun in its highly elliptical orbit, the additional heating of the surface can spawn dust storms (around perihelion, sunlight can be 20% more intense than average). Dust storms can grow exponentially over a matter of days, with global dust storms occurring every three Martian years, on average.

During the week of May 28th, MARCI recorded two large regional dust storms in the northern hemisphere. By mid-week, a new dust storm had formed over the Acidalia Planitia region and was propagating eastward. By week end, the storm covered an area equivalent to North America and was affecting surface operations of the Mars Exploration Rover, Opportunity, at Endeavor crater.



Conditions at Endeavour crater quickly deteriorated as midday became dark as night. Tau values (a measurement of the clarity of the sky) exceeded 10 (the highest recorded value during the 2007 storm was around 5.5). Since Opportunity is solar powered, all surface operations were suspended to conserve power reserves. By June 10th, the output of the rover's solar arrays had dropped to 22 watt hours (from a high of 645 watt hours prior to the storm) and all communications from the rover ceased.

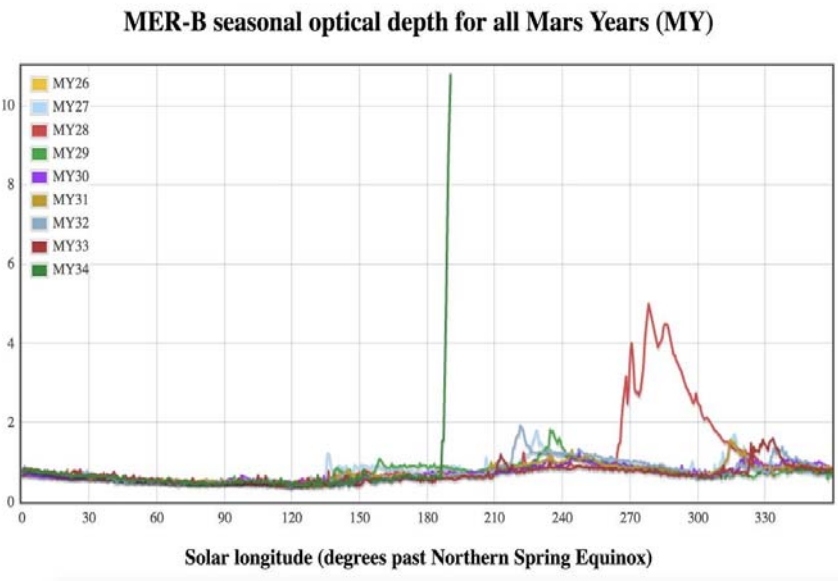
At a power level this low, only the rover's mission clock was running, with the rover in a programmed sleep mode. Below 22 watt hours, a mission clock fault would occur and the rover would have to periodically check the output from the solar arrays to determine if the Sun was in the sky (once conditions improve). If the mission clock is lost, the rover can't call home at a predetermined time. As a precaution, NASA has requested emergency assistance from the Deep Space Network, so when conditions improve and power levels allow communications, NASA is able to respond when Opportunity calls.

Unlike Spirit (Opportunity's twin) that entered a low power fault condition in the winter and was unable to recover, it's spring in the southern hemisphere. The atmosphere dust also provides some insulation against temperatures dropping too low. As such, the mission team does not expect temperatures at the Endeavour site to drop below the design limits for the rover. The rover´s essential systems are contained within a Warm Electronics Box (WEB), which is designed to operate within a temperature range of -40º F to +104º F (-40º C to +40º C). At night, when outside temperatures can drop to -140º F (-96º C), eight radioisotope heater units provide a total of 8 watts to warm the WEB through the decay of a plutonium isotope.

While the Curiosity rover is nuclear powered and therefore not affected by the darkening skies, the rover has experienced record dust levels in the atmosphere, despite being almost 5,200 miles (8,400 km) east of Opportunity's location.

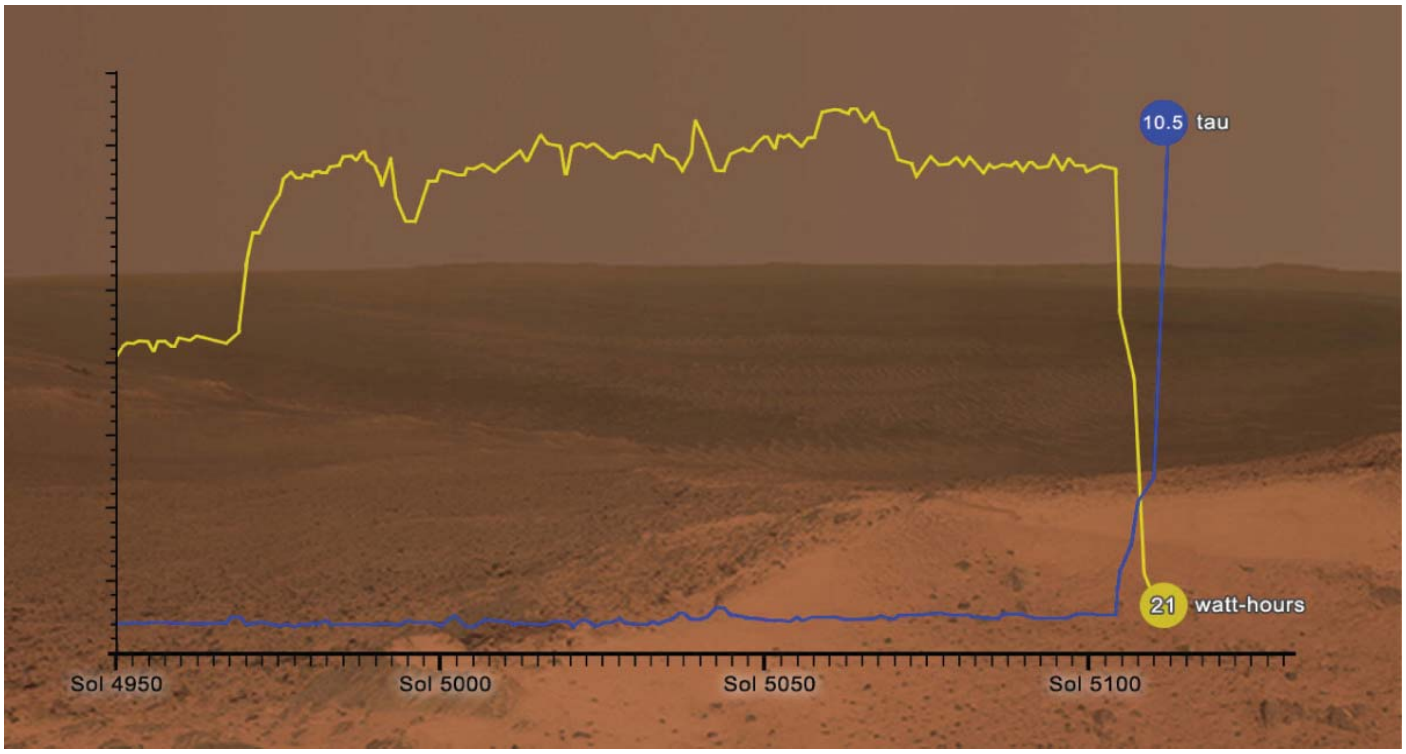
The last data transmission before Opportunity went into hibernation reported a WEB temperature of -20° (-29° C). The storm has continued to grow and

The Sun in the Martian sky for increasing tau values (1, 3, 5, 7, 9 and 11 from left to right). *Credits: NASA/JPL-Caltech/TAMU*



This graph shows how quickly the current storm (green spike) developed as compared to the 2007 storm (red profile) and the corresponding tau values (vertical axis). Credits: NASA/JPL-Caltech/TAMU

Atmospheric Changes over three Martian Sols in Gale Crater (June 3 and 7)
Images: NASA/JPL-Caltech/MSSS



Energy production of Opportunity's solar arrays (in watt-hours) compared to tau value from December 26, 2017 through June 10, 2018 when Opportunity was engulfed in a dust storm
Credit: NASA/JPL-Caltech/New Mexico Museum of Natural History

on June 19th, almost three weeks after it was first detected, the storm was officially classified as a "global event," as it circled the planet. The storm itself is not as large as the one Opportunity encountered in 2007. It is also more dispersed and asymmetrical than previous global storms that completely obscured the globe.

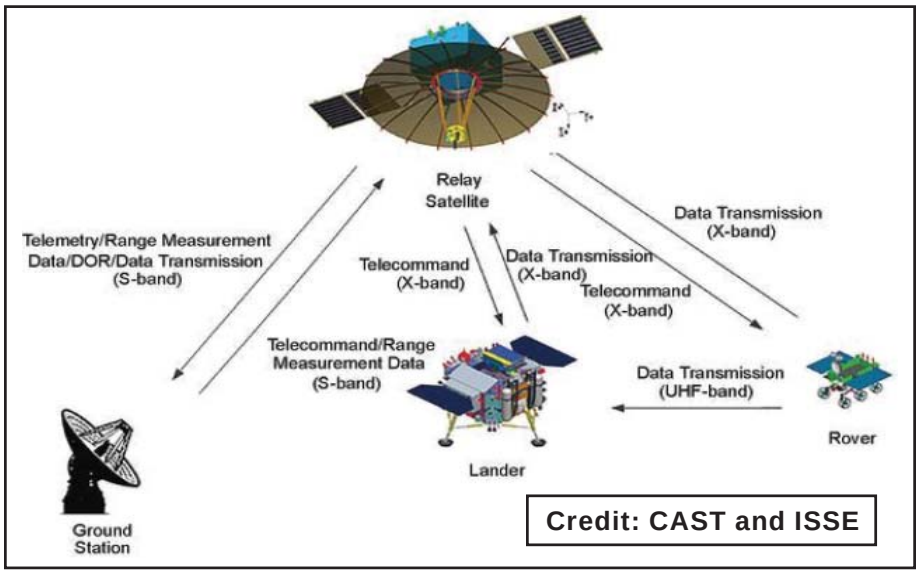
As of June 20, no signal has been received from Opportunity as the rover continues to hunker down in Perseverance Valley on the west rim of Endeavour Crater and wait. The storm shows no signs of subsiding.

To be continued …

Lunar Relay

The communication satellite launched on May 20th from China's Xinhua space center arrived at the Earth-Moon L2 Lagrange point on June 14th. The 900 pound (400 kg) Queqiao spacecraft, which name translates to "magpie bridge," is currently positioned in a halo orbit at the gravitationally-stable point, 280,000 miles (450,000 km) from Earth. Queqiao was accompanied by two microsatellites, one of which successfully entered lunar orbit.

Queqiao will provide a communication link for the Chang'e 4 lunar lander which is currently scheduled to be launched in December. The lander is destined for the Von Kármán Crater, located in the South Pole-Aitken impact basin on the Moon's far side. The Chang'e 4 lander was built as a backup for the Chang'e 3 mission, which was launched in December 2013 and soft-landed in Mare Imbrium (Sea of Rains). The Chang'e 4 lander will likely include a rover, as did its predecessor.



Juno - Mission Extended

Images captured by NASA's Juno spacecraft during its twelfth close pass, or perijove, provided a different perspective of Jupiter and its south polar region. In this view, the Great Red Spot, which is located deep in the southern hemisphere, appears near the top of the field of view.

The images used to construct these colorful composites were captured by the JunoCam imager as the spacecraft had completed its high-speed pass and was moving away from Jupiter. The distance to the cloud tops ranged from 10,768 miles (17,329 km) to 42,849 miles (68,959 km).

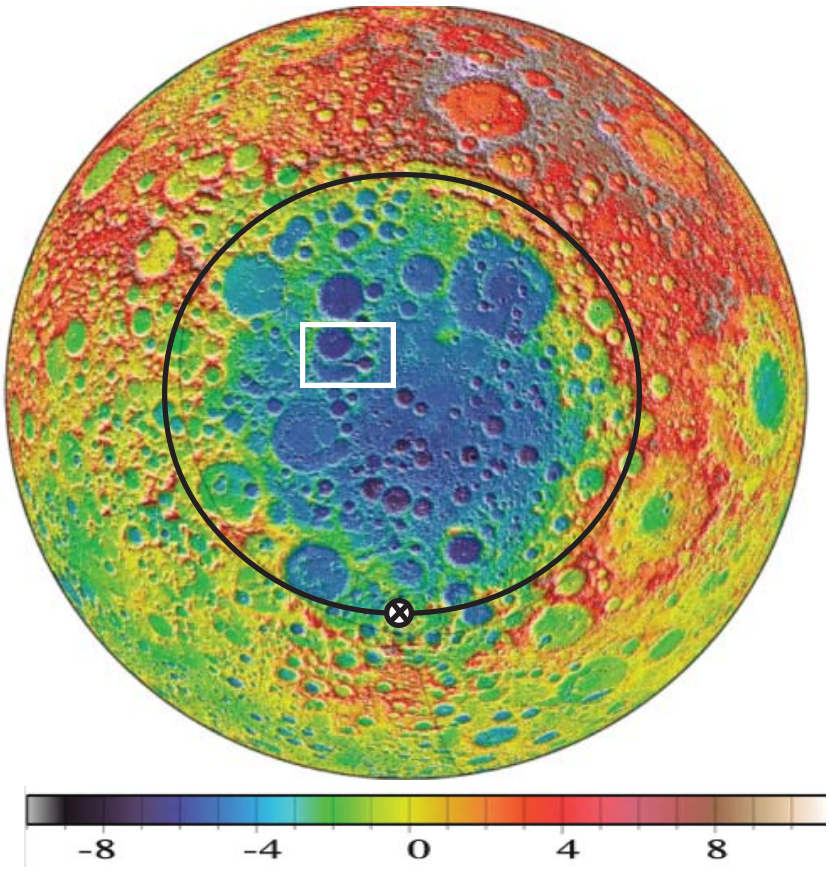


Image generated by the Lunar Reconnaissance Orbiter's Lunar Orbiter Laser Altimeter or LOLA instrument. The boundaries of the South Pole-Aitken (SPA) basin are identified by the black oval, the location of the Moon's south pole by a white circle, and the Von Kármán Crater by a white rectangle. SPA is one of the largest impact basins in the solar system with a diameter of approximately 1,600 miles (2,600 km). The basin is approximately 5 miles (8 km) in depth, an excavation that may reveal relics of the Moon's lower crust and mantle. The Von Kármán Crater is 110 miles (180 km) in diameter and filled with basalt lava flows.

Image credit: NASA/Goddard

Juno's original mission was scheduled to end this year, however, due to concerns with its main engine, it was decided to leave the spacecraft in its original, highly elongated 53.5-day orbit rather than lowering Juno into a more circular 14-day orbit. As such, by July, the spacecraft will have only executed 14 of the planned 32 perijoves needed to complete its mapping mission.

NASA recently elected to extend Juno's mission three years to 2021, or longer depending upon the health of the spacecraft (the sensitive electronics and circuitry are being slowly degraded by each pass through Jupiter's intense radiation field). NASA still plans to destroy the spacecraft at some time in the future, plunging it into Jupiter. Deliberate destruction of the spacecraft (much like the termination of the Cassini mission at Saturn) is being done to preclude contaminating Jupiter's moon Europa. With an ocean that may contain twice the water on Earth, and the recent discovery of icy plumes, Europa is being targeted by two separate missions (ESA's JUpiter ICy moons Explorer or JUICE and NASA's Europa Clipper) for habitability assessments.

Image credit: NASA/JPL-Caltech/SwRI/MSSS/Gerald Eichstad/Sean Doran

Journey to the Sun

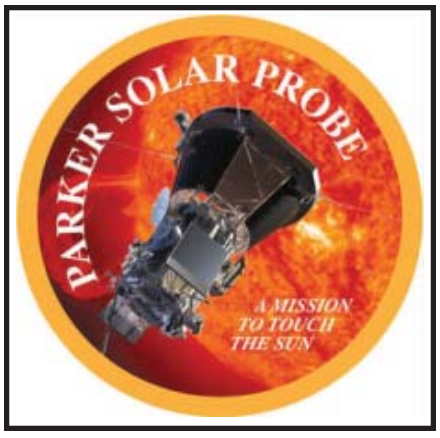
NASA's launch of the Parker Solar Probe is currently scheduled for no earlier than August 4th, with a launch window that remains open until August 19th. The spacecraft will be carried into orbit by a Delta IV Heavy rocket booster from the Kennedy Space Center in Florida. Using Venus to modify its orbit, the probe will make seven flybys of the Sun in seven years.

In its last three orbits, the spacecraft will come as close as 3.8 million miles (6.1 million km) of the Sun's surface (10 times closer than the planet Mercury). At that distance, the spacecraft's solar shield will experience temperatures as high as 2,500° F (1,377° C).

The Parker Solar Probe will give scientists a close-up look at the inner workings of the Sun and, in particular, the solar corona. The corona is the Sun's outer atmosphere and more tenuous than the lower, denser regions. It is generally only visible from Earth during a total solar eclipse when the Moon completely covers the brighter regions. The corona is also millions of degrees hotter than the Sun's surface (the photosphere). This contradiction is not fully understood.

Life on Earth is dependent upon the Sun's energy. However, when the Sun's output becomes chaotic and explosive, events such as flares and coronal mass ejections can disrupt communications on Earth, overload electrical grids, damage orbiting satellites, and expose astronauts to dangerous levels of radiation.

The four instruments carried by the Parker Solar Probe will study the solar wind (stream of charged particles that floods the solar system), measure the Sun's



Sun's corona visible during the 2017 solar eclipse

Photo: Bill Cloutier

magnetic field, and characterize the plasma and energetic particles in the Sun's outer atmosphere. At closest approach, the spacecraft will be traveling at speeds approaching 430,000 mph (700,000 kph).

Martian Organics

Two papers published in the June 8th issue of Science (Volume 360, Issue 6393), fortify the argument for life, past and present, on Mars. The first paper describes the discovery of organic molecules in samples analyzed by NASA's Curiosity rover from three-billion-year-old sedimentary rocks in Gale crater. Organic molecules can be created by non-biological processes, but their presence bodes well for future missions with more advanced diagnostic capabilities.

Curiosity detected the organics in mudstone (formed from silt deposited in an ancient lake). The sedimentary material extracted by the rover's drill was heated in an on-board oven to 900° F (500° C) to liberate the molecules. While Curiosity's drill has a limited range (depth), future rovers will be able to extract samples from much greater depths where organics would be shielded from destructive solar and cosmic radiation.

The second paper describes seasonal variations in methane over the three Martian years that Curiosity has spent on Mars. The data was collected by the rover's Sample Analysis at Mars (SAM) instrument. Methane is a powerful greenhouse gas, but is quickly removed from the atmosphere (within 12 Earth-years) by a chemical reaction. Detection of methane would imply an active source, either biological or from rock chemistry. SAM has chronicled an increase in the methane concentration in the summer and corresponding decline in the winter season.

The discovery of organic molecules near the surface and the cyclical trends in atmospheric methane are just two of the many discoveries made by the rover in Gale crater that support an ancient Mars where conditions were much more hospitable to life. Curiosity's discoveries are also being incorporated into the planning for the next Mars' missions, including NASA's Mars 2020 rover and ESA's (European Space Agency's) ExoMars rover.

Curiosity's surface operations have not been without challenges. Its drill, which is also used to feed samples to its mineralogy laboratory, had not been used for over a year after a mechanical problem developed. Drilling resumed in May after JPL's engineers developed a new, percussive technique using the permanently extended drill bit. With a revised sample delivery procedure, the rover's onboard laboratory is now back in operation.


Image Credit: NASA/JPL-Caltech/MSS

MOMA

ExoMars Rover, a joint mission between the European Space Agency (ESA) and the Russian space agency, Roscosmos, is scheduled to launch in 2020 from the Baikonur Cosmodrome in Kazakhstan. Two landing sites are currently being evaluated in western Arabia Terra: Oxia Planum and Mawrth Vallis. The sites have an abundance of clay that may have adsorbed and trapped organic material from a time period in Mars' history when liquid water was present on the surface (late-Noachian/early-Hesperian periods, 3 to 4 billion years ago). The area was subsequently covered by lava flows which have since eroded, exposing the ancient clays.

The rover's drill will be able to extract samples from depths up to six feet (two meters), where organic compounds would be shielded from solar radiation and cosmic rays. The samples will be processed by the Mars Organic Molecule Analyzer or MOMA, a toaster oven-sized chemistry lab. MOMA uses a Gas Chromatograph and Mass Spectrometer to identify the abundance and type of organic molecules in the gas produced when the samples are heated in an oven. For molecules where heat could be destructive, MOMA is equipped with a laser. The laser is able to vaporize some organic molecules without total dissociation. The by-products are then sent to the mass spectrometer for analysis. NASA Goddard is providing a mass spectrometer and associated electronics for MOMA.

Cygnus spacecraft captured by the station's robotic arm

The rover will work with the ExoMars Trace Gas Orbiter, which arrived on orbit in 2016 to search for methane and other trace gases that could be biosignatures (NASA's Curiosity rover has recorded seasonal fluctuations in atmospheric methane). The orbiter will also serve as a communication relay for the surface platform, rover, and for other Mars missions.

Maintaining Altitude

The vacuum of space is not completely devoid of matter, particularly, in low-Earth orbit where there are enough atmospheric molecules to produce a drag on orbiting objects as large as the International Space Station (ISS). The lower the altitude, the greater the concentration of molecules, the greater the drag. On average, the ISS can lose 300 feet (100 meters) each day in altitude and at even a greater rate during periods of high solar activity that causes the Earth's atmosphere to expand. To counteract this, the station is periodically reboosted, primarily, by visiting spacecraft (the ISS does have thrusters that can maneuver the station for hazard avoidance). Since the retirement of the space shuttle, reboosts have primarily been accomplished by the Russian Progress resupply spacecrafts.

On May 24, 2018, Orbital ATK's OA-9 Cygnus cargo spacecraft arrived at the ISS with 3 metric tons of supplies. The spacecraft is expected to stay on station for two months. Once released, the spacecraft will be returned to Earth, to burn up in the atmosphere.

With the uncertainty as to Russia's future participation in ISS operations, NASA is evaluating other options for station reboost. Prior to the departure of Cygnus, and as a demonstration, the spacecraft's thrusters will be used to boost the station's altitude while still attached to the Unity node. This will require the station to be orientated to align Cygnus' main engine with the station's forward direction of travel. While thrusting will be along the station's center of gravity, the thrusters on the station's Russian segment will be engaged to maintain alignment.

The one-minute test burn (a typical Progress boost can last up to 15 minutes) is expected to change the station's velocity by about 5 feet per second (1.5 meters per second). If the test is successful, the Cygnus spacecraft could be upgraded (for example, with a more powerful engine and additional fuel), should NASA elect to use it to reposition the station in the future.

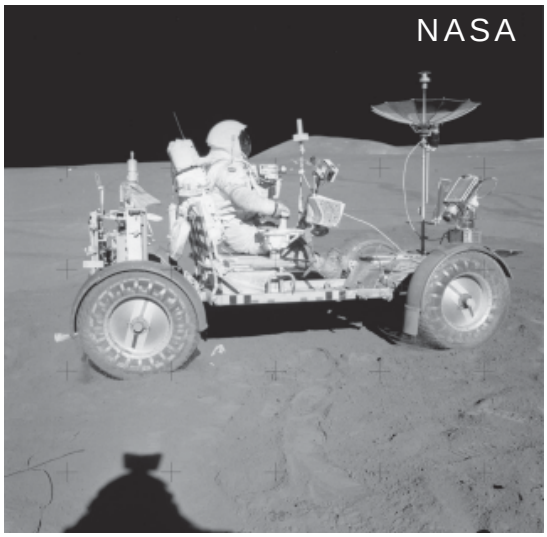
Martian Helicopter

As a demonstration, NASA will include a small, autonomous rotorcraft with the Mars 2020 rover, scheduled to launch in July 2020. The rotorcraft weighs about four pounds (1.8 kg) with twin, 48 inch (1.21 meter) counter-rotating blades (the counter rotating blades negate the need for a tail rotor, saving space). With the thin Martian atmosphere (equivalent to an altitude of nearly 100,000 feet on Earth), the blades will rotate at a much higher rate (about 10 times) than an Earthly counterpart. Solar cells will recharge its lithium-ion batteries that power the rotorcraft's instruments, essential systems, and a heater for the cold nights. Carbon fiber and tubing are used in the construction to keep the overall vehicle mass as low as possible.

The rotorcraft will be mounted on the undercarriage of the 2020 rover and lowered onto the surface after landing. It will be capable of autonomous operations, with the distance between the Earth and Mars creating a several light minute lag in communications.

NASA is planning on a 30-day flight test, with incrementally longer

Artist depiction of the Mars Rotorcraft
Credits: NASA/JPL-Caltech



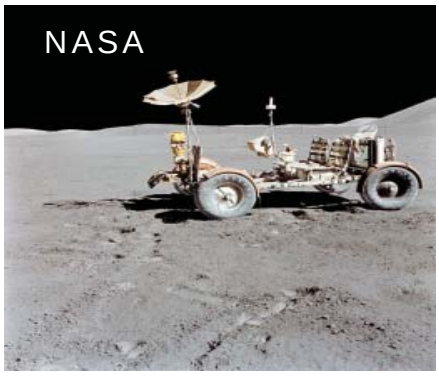
Apollo 15 astronaut David Scott at the controls of the Lunar Rover Vehicle

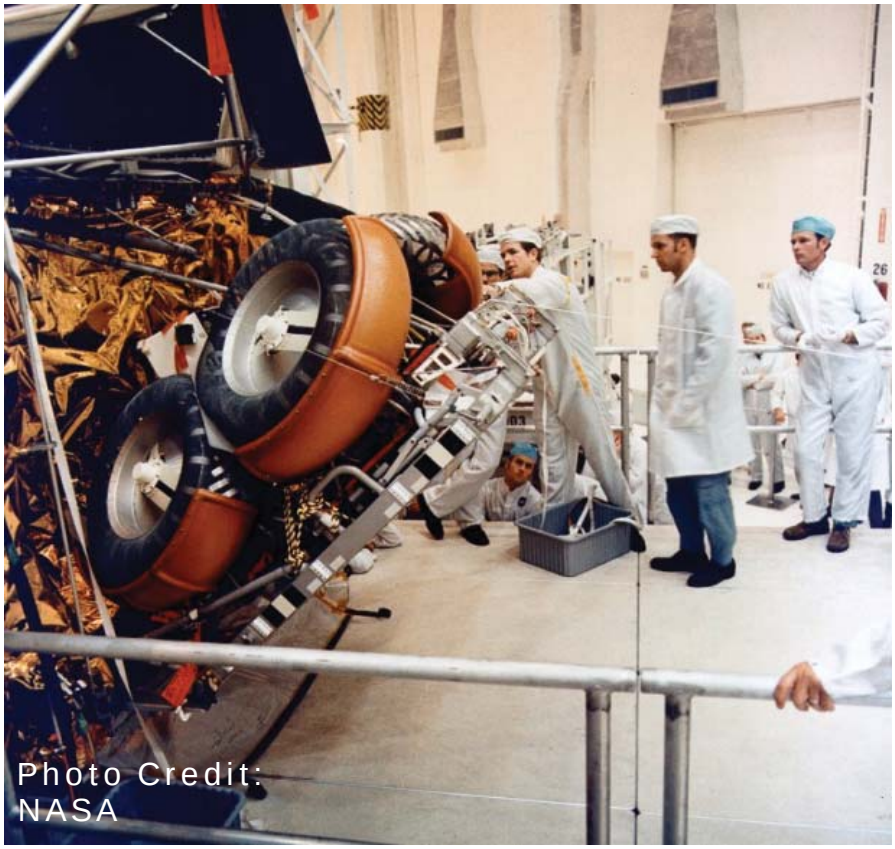
duration flights and distances. Its first flight will be a short, 30 second hover at a height of 10 feet (3 meters). If the demonstration proves successful, helicopters could be included in future missions as advanced scouts or to explore terrain inaccessible to wheeled vehicles.

First Wheeled Vehicle on Moon

Forty-seven years ago, astronaut David Scott became the first person to drive a vehicle on the Moon. The Commander of the Apollo 15 mission used an electricpowered vehicle that had been specifically designed and built (by Boeing and Delco) to operate in lunar conditions (lower gravity, vacuum, and on loose, fragmented regolith). The Apollo 15 Lunar Roving Vehicle (LRV) was the first of three rovers driven on the Moon. It covered a total of 17 miles (27.9 km) in three separate excursions, carrying the astronauts up to 3 miles (5 km) from the landing site.

The LRV's chassis was constructed from aluminum alloy tubing and was hinged so that it could be folded for storage on the outside of the Lunar Module. Its four wire wheels were constructed of woven steel strands and titanium chevrons for traction. Each wheel was equipped with its own electric motor for a top speed of approximately 8 miles per hour (13 km/hr).





Astronaut David Scott (center) watches as technicians fit check the folded Lunar Rover Vehicle in an exterior bay of the Lunar Module. The rover was deployed by the astronauts once on the Moon's surface using a system of pulleys, ropes and cloth tapes.

The LRV was designed to carry the two astronauts and their life support systems, communications and scientific equipment, photographic gear and up to 60 pounds (27 kg) of lunar samples as they explored their surroundings. However, NASA restricted the rover's range to the distance the astronauts could walk back to the Lunar Module in the event of an emergency.

Space Shuttle Legacy

The dramatic success of the Apollo program was also responsible for its demise. Once Kennedy's challenge had been met and the Soviet Union bested, Congress quickly lost interest in funding NASA's ambitious and expansive exploration programs, including an expedition to Mars, development of a nuclear rocket, construction of a space station and deep space bases, and a space shuttle to service orbiting facilities.

Less than six months after Neil Armstrong had stepped onto the Moon, NASA began to cancel future missions due to draconian budget cuts. Apollo 20 was cancelled in January 1970, followed by two additional cancelations by the following September. One-by-one, cancelation of the other programs followed.

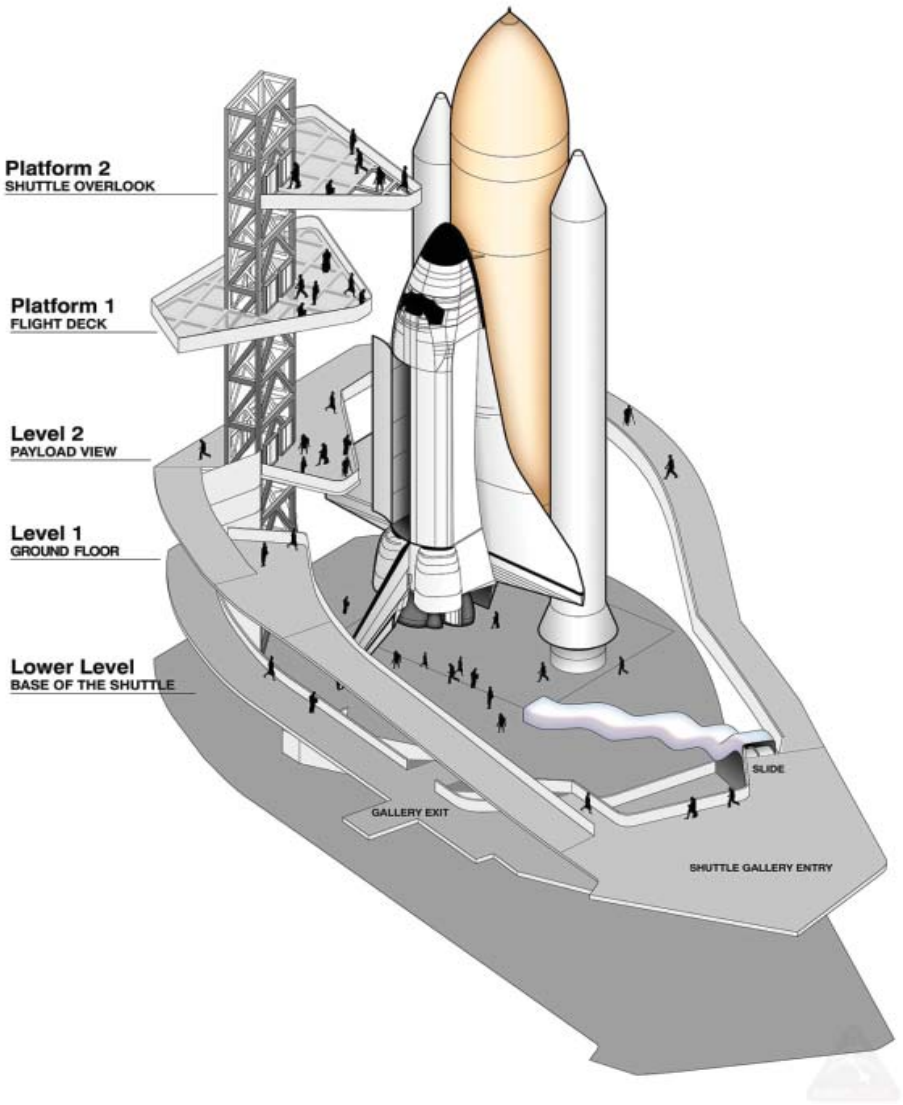
If not for the political support of the Air Force, the shuttle would have met the same fate. The Air Force, after having several of its own space programs canceled in the 1960s, including Dyna-Soar and the Manned Orbiting Laboratory, was interested in a low-cost means of launching reconnaissance satellites and military hardware. Air Force support on Capitol Hill, however, did not come without a cost. The price of their support was the redesign of the shuttle from a straight wing to a delta wing for greater cross-range capability (for example, to execute a one-orbit mission from Vandenberg Air Force Base, polar orbit and short-duration capture missions (capturing Soviet satellites in flight)). The change in flight profile and wing configuration would significantly increase the reentry temperature - and therefore the demands on the shuttle's thermal protection system - which would one day have disastrous consequences.

The space shuttle that flew was a compromise, designed to meet Air Force requirements and the Office of Management and Budget's constraints. It was likely a much different (and more expensive) vehicle than if NASA had been allowed to pursue its fully reusable, potential hot-metal, straight-wing, initial design.

Photo: Bill Cloutier

The space shuttle (or orbiter) is only one component of the Space Transportation System (STS). The three main engines of the reusable orbiter, carrying crew and cargo into orbit, are powered by 143,000 gallons of liquid oxygen and 385,000 gallons of liquid hydrogen contained within an expendable external tank during the first 8½ minutes of flight. Two solid rocket boosters (recoverable) provide an additional 2.6 million pounds of thrust during the first two minutes of flight. The solid rockets return to Earth (ocean) by parachute. The orbiter returns in an unpowered glide to a runway landing.

Six orbiters were built at Rockwell International's facility in Palmdale, California. The first, Enterprise, was used for atmospheric testing, the other five for travel to, and for long-duration stays in, low-Earth orbit. Between April 12, 1981 and July 21, 2011, the five spaceworthy orbiters (Columbia, Challenger, Discovery, Atlantis and Endeavour) completed a total of 135 missions, carried 355 men and women, flew over 500 million miles, and spent more than 1,300 days in orbit.



The orbiters rendezvoused with Russia's Mir space station nine times, the International Space Station more than 35 times, and the Hubble Space Telescope five times. They carried to orbit satellites, space station components, space telescopes, laboratories and laboratory experiments, and spacecraft to explore the solar system.

Unfortunately, the STS never delivered as a low-cost transportation system. The greater concern, however, was the loss of two shuttles and crew. The loss of the Columbia upon reentry on February 1, 2003 prompted a comprehensive reevaluation of the program. The Columbia Accident Invstigation Board concluded that: "*Because of the risks inherent in the original design of the Space Shuttle, because that design was based in many aspects on now-obsolete technologies, and because the Shuttle is now an aging system but still developmental in character, it is in the nation's interest to replace the Shuttle as soon as possible as the primary means for transporting humans to and from Earth orbit*." Shortly after the release of the Board's findings, President Bush announced the remaining space shuttle fleet would be retired once the construction of the International Space Station was complete.

The landing of Atlantis on July 21, 2011 signaled the end of the shuttle program and the beginning of the effort to prepare the orbiters for a new life on public display. Toxic fuels were drained, hazardous materials and toxic chemicals neutralized, pyrotechnics disarmed, the main engines removed and preserved for future use and the shuttle's control systems placed in a safe configuration.

The Smithsonian requested the Discovery as the oldest and most traveled orbiter for display at its National Air and Space Museum, Udvar-Hazy Center in Virginia. The Enterprise, which had been on display at the Udyar-Hazy Center, was moved to the Intrepid Sea, Air & Space Museum in New York City.

NASA awarded Endeavour to the California Science Museum in Los Angeles, close to the Palmdale facility where it was built. Atlantis stayed close to home and put on display at the Kennedy Space Center.

Enterprise

The Enterprise, designated Orbital Vehicle (OV)-101, was a test vehicle. It was not intended for spaceflight but provided critical test data on the orbiter's handling within the atmosphere, needed for a successful return from flight. It flew several captured flights (attached to the top of a Boeing 747) and five free flights at the Edwards Air Force Base. The orbiter was originally to be named Constitution; however, a write-in campaign by viewers of the Star Trek television show persuaded the administration to christen OV-101: Enterprise.

Once the Smithsonian acquired Discovery, the Enterprise was transported by barge to the Intrepid Sea, Air & Space museum where it went on display on July 19, 2012.

Discovery

Discovery was NASA's third orbiter (OV-103) and flew more missions than any of the other orbiters - 39 flights between 1984 and 2011. It was the workhorse of the fleet and the orbiter that flew the "return-to-flight" missions after the Challenger and Columbia accidents. Discovery delivered the Hubble Space Telescope to orbit and flew two of the follow-on servicing missions in 1997 and 1999. The orbiter made two flights to the Russian space station Mir and 13 flights to the International Space Station. The name Discovery was chosen to honor historic sailing ships of the past.

Discovery was delivered to the Smithsonian (near Dulles Airport) in April 2012 mounted atop NASA's Shuttle Carrier Aircraft, a modified Boeing 747 jumbo jet. It is displayed in a landing configuration with its gear deployed.

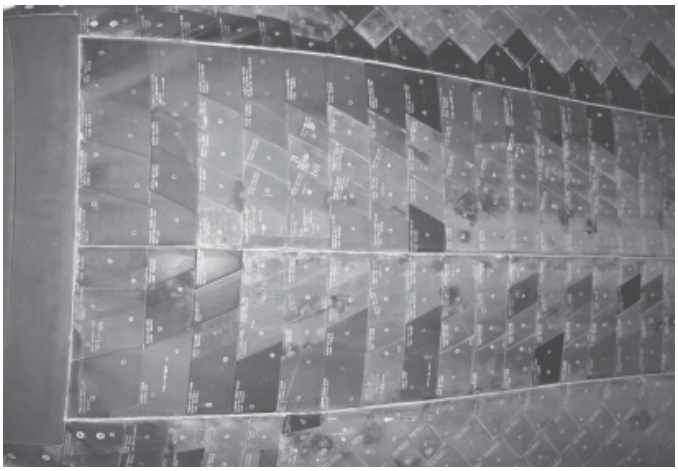
Endeavour

Endeavour (OV-105) was the last orbiter to join the fleet, built to replace the Challenger. Its maiden flight was on May 7, 1992 - the first of 25 missions. Endeavor carried the "corrective optics" in the first servicing mission to the Hubble Space Telescope. The orbiter also delivered the first U.S. component, the Unity Module, to the International Space Station. The orbiter is named after the British HMS Endeavour, the ship commanded by Captain James Cook on his first expedition to Australia and New Zealand between 1769 and 1771.

The California Science Center was selected to display the Endeavour, based, in part, on its proximity to Palmdale. The orbiter was deliv-

Enterprise

Discovery



ered to the Los Angeles International Airport by the Shuttle Carrier Aircraft on September 21, 2012. Three weeks later, the orbiter was towed 12 miles through the streets of Los Angeles to the museum. Endeavor is on temporary display until a permanent home can be constructed. It is currently mounted in an elevated horizontal position, allowing visitors to walk beneath the orbiter. The orbiter will eventually be displayed in a vertical, launch configuration.

The California Science Center also acquired two solid rocket boosters from the Kennedy Space Center in 2012 (currently in storage at NASA's Armstrong Flight Research Center). The museum had planned to use a replica for the external tank, since the tanks used for flight were not recovered. However, by happenstance, one tank was never used (it was too heavy to be used for ISS construction). Instead, the tank became a test article and even considered for future use on the Space Launch System. Ultimately, it was recently decided not to repurpose the tank, making it available to the California Science Center. The tank was transported from NASA's Michoud Assembly Facility in Louisiana by barge, through the Panama Canal to Los Angeles, arriving on May 18, 2016. Once the new 188,000 square foot addition to the California Science Center is complete (the Samuel Oschin Air and Space Center), the tank will be joined to the orbiter and solid rocket boosters and lifted into place. The exhibit is scheduled to open in 2019.

Atlantis

Atlantis was NASA's fourth orbiter (OV-104), named after the two-masted boat that served as the primary research vessel for the Woods Hole Oceanographic Institute from 1930 to 1966. It benefited from the lessons learned in the construction of its predecessors, being completed in half the hours spent on Columbia and weighing in at 3.5 tons lighter (allowing it to carry more payload).

Atlantis was the first orbiter to dock with the Russian Mir space station. It carried to orbit planetary probes that would explore Venus (Magellan) and Jupiter (Galileo) and the Compton Gamma Ray Observatory. Atlantis delivered the U.S. laboratory module Destiny and the Joint Airlock Quest to the International Space Station, as well as sections of the Integrated Truss Structure (the structural backbone of the ISS).

Atlantis is on display at the Kennedy Space Center's Visitor Center. It is displayed as in flight, with payload doors open and its Canadarm (robotic arm) extended.

Lost Orbiters

Columbia

Columbia (OV-102) was NASA's first space-worthy orbiter. It lifted off on its maiden voyage on April 12, 1981, piloted by mission commander (and former Gemini and Apollo astronaut) John Young and pilot Robert Crippen. The orbiter was named for the first American ship to circumnavigate the globe in 1790 as well as the Apollo 11 command module. Among its many accomplishments, Columbia carried the Chandra X-ray Observatory into orbit in July 1999.

The orbiter and crew were lost during reentry on February 1, 2003 when hot gases entered a hole in the orbiter's left wing. The hole had been created by a small piece of foam shed by the external tank on takeoff. The hot gases melted the airframe, causing the vehicle to break up in the atmosphere.

Challenger

Challenger (OV-099) was originally built as a test vehicle. In 1979, Rockwell International received a contract to convert the orbiter for space flight (NASA believed Challenger to be a less complex conversion than Enterprise). Challenger arrived at the Kennedy Space Center in 1982, joining the Columbia.

The orbiter was named after the British Naval research vessel HMS Challenger that sailed the Atlantic and Pacific oceans during the 1870s.

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

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

The orbiter and crew (including high school teacher Sharon Christa McAuliffe) were lost when a seal failed in the right rocket booster. The open joint allowed burning fuel to escape from the rocket booster and breech the external tank. Seventy-three seconds after liftoff, the orbiter was destroyed in an explosion from the failure of the hydrogen and oxygen fuel inner tanks.

Space Shuttle Memorial

Last year (June 2015), a permanent memorial, "Forever Remembered," opened at the Kennedy Space Center Visitor Complex. The memorial honors the crews lost on the Challenger (1986) and Columbia (2003) space shuttles. Personal items from the crew members are included, as well as debris from both orbiters never before displayed in public.

Planning Your Visit

Space Shuttle	Enterprise	Discovery	Endeavour	Atlantis
Location	Intrepid Sea, Air & Space Museum, NYC	Smithsonian Udvar-Hazy Center, Chantilly, Virginia	California Science Center,[1] Los Angeles	Kennedy Space Center, Florida
General Admission[2]				
Adult	$33.00	Free	Free [3]	$50.00
Seniors	$31.00	Free	Free [3]	$46.00
College Students	$31.00	Free	Free [3]	-
Child	$24.00	Free	Free [3]	$40.00
Child (under 5)	Free	Free	Free [3]	-
Retired Military	Free	Free	Free [3]	-
Active Duty	Free	Free	Free [3]	$46.00
Museum Members	Free	Free	Free [3]	-
Parking	-	$15.00	$12.00	$10.00
Summer Hours (M-F)	10:00 am - 5:00 pm	10:00 am - 6:30 pm	10:00 am - 5:00 pm	9:00 am - 6:00 pm
Summer Hours (Weekends)	10:00 am - 6:00 pm	10:00 am - 6:30 pm	10:00 am - 5:00 pm	9:00 am - 6:00 pm

[1] Endeavour is on temporary display while its permanent home is under construction

[2] Best available information and subject to change. Does not in clude special attractions, tours or access to traveling exhibits

[3] $2 timed reservation is required on weekends, holidays, and the high attendance periods

Reference Websites for Additional Information:

Enterprise	http://www.intrepidmuseum.org/
/Discovery	https://airandspace.si.edu/visit/udvar-hazy-center/
Endeavour	http://californiasciencecenter.org/
Atlantis	https://www.kennedyspacecenter.com

Summer Activities

Summer is a great time to enjoy the night sky. Some suggestions for this summer:

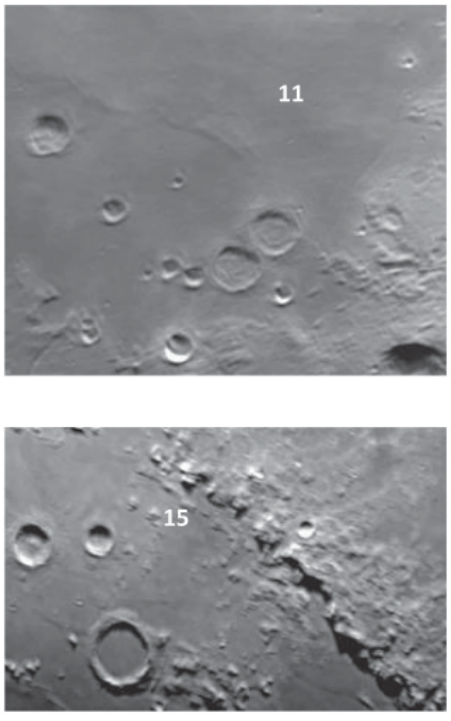
1. Attend a star party. Star parties are gatherings of amateur astronomers where the general public is invited to share the wonders of the night skies with skilled observers and through telescopes of every size and shape. A calendar of dates and locations across the United States is available at www.skyandtelescope.com. Closer to home, the McCarthy Observatory hosts a star party on the second Saturday of each month. Please join us on July 9th and August 13th with your family and friends for a memorable evening under the stars.

2. Take in a meteor shower. With no telescope required, this naked-eye activity can be enjoyed in a lawn chair and a warm blanket. While an occasional meteor can be spotted at anytime, August 12th is the night to catch the Perseids meteor shower. A meteor shower occurs when the Earth passes through a cloud of debris usually left behind by a comet. Comet Swift-Tuttle is the source of the small grains of dust that create the Perseid shower. As one of the most famous showers, the Perseids meteor shower usually delivers an impressive display. Expect dark skies as moonlight will not be a problem this year.

3. Locate the Summer Milky Way. Our solar system resides in one of the outer arms of a very large, rotating pinwheel of 200-300 billion stars called the Milky Way Galaxy. During the summer, we can see the inner arms of the pinwheel in the direction of the galactic core. Unfortunately, a dark sky is required, as excessive lighting is ruining the natural inky black of the celestial sphere. However, it can be seen from parts of New Milford, late at night and once the moon has set. If you have never seen the Milky Way:Locate the Big Dipper (the most prominent asterism in the northern sky). The last two stars in the bowl of the Dipper point to the North Star.

- Imagine a line extended from the two Dipper stars, through the North Star and an equal distance beyond. You should now be between the constellations Cepheus and Cassiopeia. Cassiopeia is shaped like a W or and is the starting point for our journey down the Milky Way.
- The Milky Way flows from Cassiopeia south to Cygnus (the Swan or Northern Cross). Cygnus can be recognized by its brightest star Deneb (at the tail) and the three bright stars that form the wing.
- Continuing south, the bright star Altair provides the next navigation aid, directing us to Sagittarius, an asterism shaped like a teapot. On a dark night, the star clouds of the Milky Way appear like steam from the spout of the teapot. The spout is also in the general direction of the center of our galaxy (26,000 light years away).

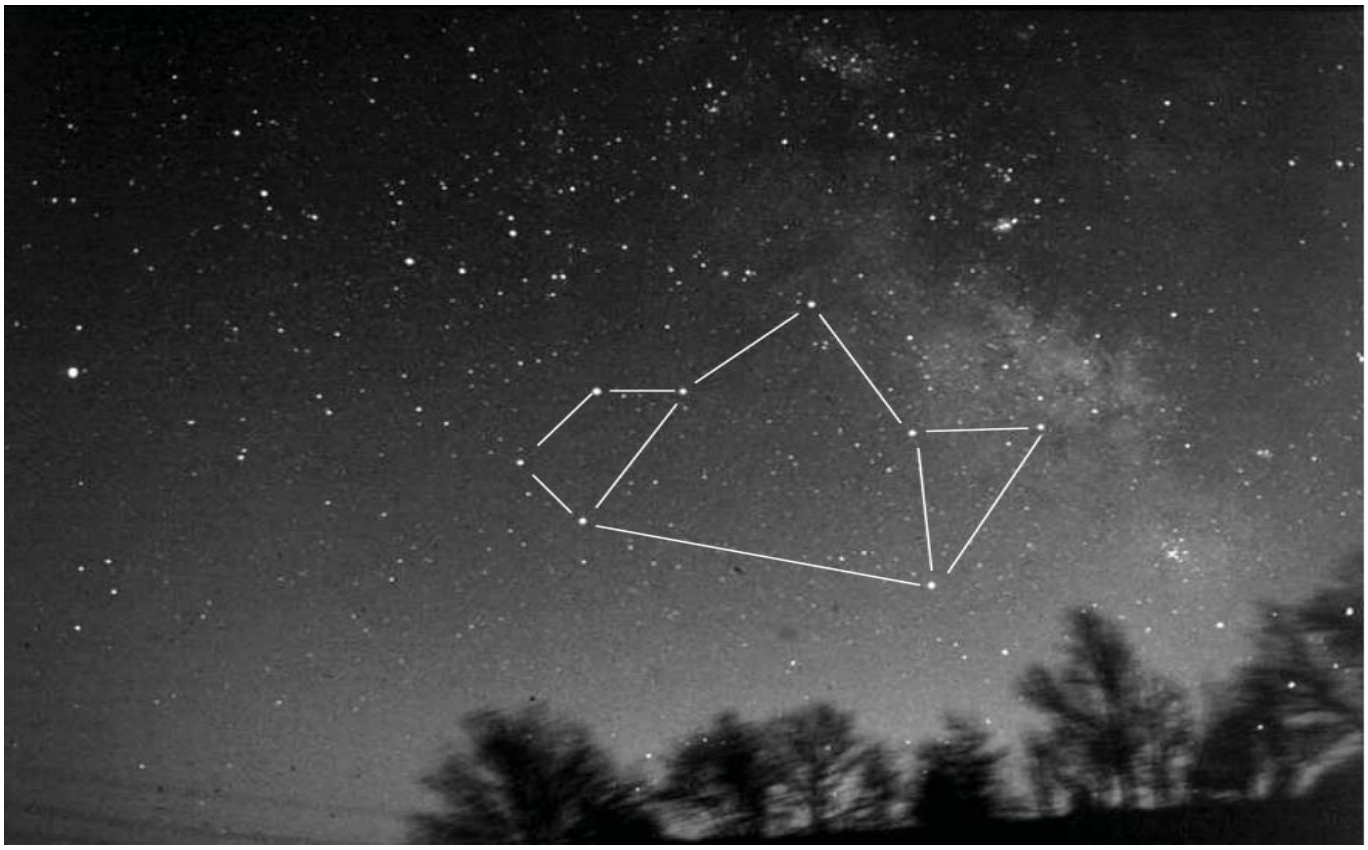
Sea of Tranquility and Apollo 11 landing site



Apennines Mountains and Apollo 15 landing site

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

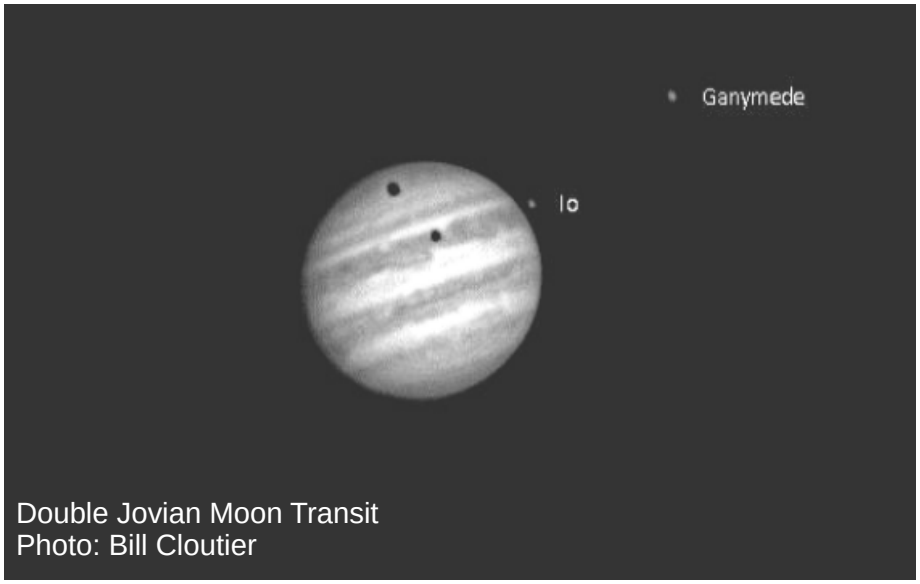
4. Find the Apollo landing sites. July marks the anniversaries of two moon landings. Apollo 11 landed on the southwestern shore of the Sea of Tranquility on July 20, 1969. Apollo 15 landed in the foothills of the Apennine Mountains on July 30, 1971. The southwestern shore of the Sea of Tranquility is visible 5 days after a New Moon. The Sun rises on the Apennine Mountains around the First Quarter Moon.



"Teapot" asterism in Sagittarius and star clouds of the Milky Way. Photo: Bill Cloutier

Jupiter and its Moons

Jupiter reached Opposition in early May when the two planets were at their closest. During the months of July and August, Jupiter is still well placed in evening sky after sunset. Jupiter will be at its highest approximately 30 minutes after sunset on July 1st (9 pm) and almost two hours earlier by month's end. As the Earth moves ahead of Jupiter on its inside orbit, Jupiter will diminish slightly in brightness and apparent size. As one of the brightest star-like objects in the night sky, Jupiter can be found in the constellation Libra.



Double Jovian Moon Transit
Photo: Bill Cloutier

Jovian Moon Transits

One of the more interesting and easier events to observe through a telescope is the projection of a shadow from one of Jupiter's moons on the Jovian disk as the moon passes in front of (or transits) the planet. On nights of good visibility the following events should be visible through a moderately-sized telescope.

Date	Moon	Transit Begins	Transit Ends
July 1st	Io	7:42 pm	9:51 pm
July 8th	Io	9:37 pm	11:46 pm
July 15th	Europa	8:07 pm	10:23 pm
	Io	11:31 pm	1:40 am (16th)
July 22nd	Europa	10:45 pm	1:01 am (23rd)
July 24th	Io	7:55 pm	10:04 pm
July 31st	Io	9:49 pm	11:58 pm
August 7th	Ganymede	8:53 pm	10:37 pm
August 7th	Io	11:44 pm	1:53 am (8th)
August 16th	Europa	7:56 pm	10:12 pm
August 16th	Io	8:07 pm	10:17 pm
August 23rd	Io	10:02 pm	12:11 am (24th)
August 23rd	Europa	10:34 pm	12:50 am (24th)
August 30th	Io	11:57 pm	2:06 am (31st)

Red Spot Transits

The Red Spot is a large cyclone in the upper Jovian atmosphere. The rapid rotation of this gas giant (10 hours) may be responsible for the longevity of this storm, which has been observed for over 300 years. The Red Spot 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
June 30th	8:10 pm	August 2nd	10:21 pm
July 2nd	9:48 pm	August 5th	12:00 am
July 4th	11:27 pm	August 7th	9:31 pm
July 7th	8:57 pm	August 9th	11:10 pm
July 9th	10:36 pm	August 12th	8:40 pm
July 12th	8:06 pm	August 14th	10:19 pm
July 14th	9:44 pm	August 16th	11:58 pm
July 16th	11:23 pm	August 19th	9:20 pm
July 19th	8:53 pm	August 21st	11:08 pm
July 21st	10:32 pm	August 24th	8:38 pm
July 24th	8:02 pm	August 26th	10:18 pm
July 26th	9:41 pm	August 28th	11:57 pm
July 28th	11:20 pm	August 31st	9:27 pm
July 31st	8:42 pm		

Saturn - Jewel of the Summer Sky

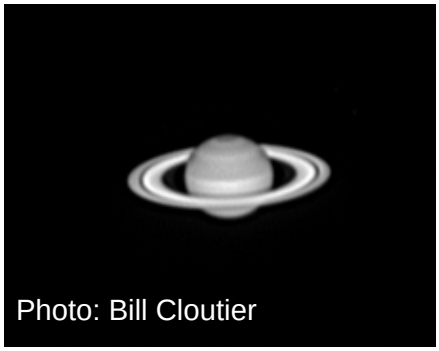
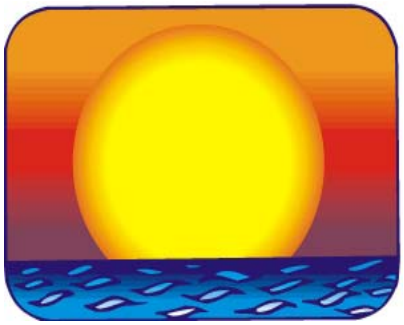


Photo: Bill Cloutier

The Earth and Saturn were closest on June 27th when only 841.1 million miles (1.35 billion km) separated the two worlds. Saturn can be found in the constellation Sagittarius. During the months of July and August, Saturn is still well placed in evening sky after sunset. Saturn will be at its highest just after midnight on July 1st (12:38 am) and almost two hours earlier by month's end.

Saturn's axial tilt is almost 27° (as compared to Earth's 23.5° or Jupiter's 3°). The axial tilt produces seasons which last more than 7 years, since it takes Saturn almost 29½ years to complete an orbit around the Sun. It was summer in the southern hemisphere when the Cassini spacecraft arrived in 2004, with the planet's north pole in perpetual darkness. Saturn's Vernal equinox occurred in August 2009 with both hemispheres experiencing equal amounts of sunlight (at equinox, the rings appear almost edge on). Since that time, our view of the rings has improved. With the northern summer solstice in May 2017, the rings are wide open with the planet's north pole sunlit and tipped towards Earth. This year the ring tilt is one of the best at 26° (slightly less than in 2017).



Sunrise and Sunset (from New Milford, CT)

Sun	Sunrise	Sunset
July 1st (EDT)	05:23	20:32
July 15th	05:33	20:26
July 31st	05:47	20:12
August 1st	05:48	20:11
August 15th	06:02	19:53
August 31st	06:19	19:28

Astronomical and Historical Events

July

1st Centaur Object 10370 Hylonome at Opposition (23.011 AU)

1st History: opening of the Smithsonian National Air & Space Museum (1976)

1st History: NASA officially activates the Launch Operations Center on Merritt Island, Florida; later renamed the Kennedy Space Center (1962)

1st History: 100 inch diameter mirror for the Hooker Telescope arrives on Mt. Wilson (1917)

1st History: discovery of asteroid 6 Hebe by Karl Hencke (1847)

2nd Amor Asteroid 1916 Boreas closest approach to Earth (0.657 AU)

2nd History: launch of European Space Agency's Giotto spacecraft to Comet Halley (1985)

3rd Aten Asteroid 2005 MF5 near-Earth flyby (0.083 AU)

3rd Kuiper Belt Object 307261 (2002 MS4) at Opposition (45.689 AU)

3rd History: launch of the ill-fated Nozomi spacecraft to Mars by Japan (1998)

3rd History: launch of the Solar Anomalous and Magnetospheric Particle Explorer (SAMPEX) by a Scout rocket (1992)

4th Aten Asteroid 2016 NB1 near-Earth flyby (0.068 AU)

4th History: Juno enters orbit around Jupiter (2016)

4th History: impact of Comet Tempel 1 by Deep Impact's impactor (2005)

4th History: Pathfinder spacecraft, with rover Sojourner, lands on Mars (1997)

4th History: Chinese astronomers record a "guest star" (supernova) in the constellation Taurus; visible for 23 days and 653 nights (1054); the remnant (Crab Nebula) later catalogued by Charles Messier as Messier 1 or M1

5th Apollo Asteroid 2018 AJ2 near-Earth flyby (0.091 AU)

5th Aten Asteroid 2340 Hathor closest approach to Earth (0.532 AU)

5th Centaur Object 55576 Amycus at Opposition (19.831 AU)

5th History: Isaac Newton's "Mathematical Principles of Natural Philosophy" published, describing the laws of motion (1687)

6th Last Quarter Moon

6th Earth at Aphelion, furthest distance from the Sun (1.017 AU or 94.5 million miles)

6th History: discovery of Jupiter's moon Lysithea by Seth Nicholson (1938)

7th Amor Asteroid 1915 Quetzalcoatl closest approach to Earth (2.248 AU)

7th History: launch of the Mars Exploration Rover B (Opportunity) (2003)

8th Atira Asteroid 418265 (2008 EA32) closest approach to Earth (0.589 AU)

8th Atira Asteroid 2010 XB11 closest approach to Earth (0.726 AU)

8th Kuiper Belt Object 486958 (2014 MU69) at Opposition (42.237 AU)

8th Kuiper Belt Object 2014 PN70 at Opposition (42.932 AU)

8thh History: launch of the Space Shuttle Atlantis (STS-135) to the International Space Station; final space shuttle flight to low-Earth orbit (2011)

9th Centaur Object 10199 Chariklo at Opposition (14.913 AU)

9th History: closest pass of Jupiter's cloud tops by the Voyager 2 spacecraft (1979)

Astronomical and Historical Events for July (continued)

- 9th Scheduled launch of a Russian Progress cargo-carrying spacecraft to the International Space Station from the Baikonur Cosmodrome, Kazakhstan
- 10th Apollo Asteroid 65803 Didymos closest approach to Earth (1.296 AU)
- 10th History: flyby of Comet Grigg-Skjellerup by the European Space Agency's Giotto spacecraft following its close encounter of Halley's Comet (1992)
- 10th History: flyby of asteroid 21 Lutetia by the European Space Agency's Rosetta spacecraft (2010)
- 10th History: launch of Telstar 1, prototype communication satellite designed and built by Bell Telephone Laboratories (1962)
- 10th History: Alvan Graham Clark born, optician and telescope maker (1832)
- 11th History: launch of the Soviet Gamma Observatory (1990)
- 11th History: Skylab re-enters into the Earth's atmosphere (1979)
- 12th New Moon
- 12th Mercury at its greatest eastern elongation - apparent separation from the Sun in the early evening (26°)
- 12th History: launch of the High Energy Astronomical Observatory (HEAO-1), designed to survey the entire sky for x-ray emissions (1977)
- 12th History: launch of Soviet Mars orbiter Phobos 2 (1988)
- 13th Moon at Perigee (closest distance to Earth)
- 13th Dwarf Planet 134340 Pluto at Opposition (32.584 AU)
- 13th History: Soviet Union launches Luna 15, a lunar lander and sample return mission, in an attempt to upstage Apollo 11; crashed during landing (1969)
- 13th History: Langley Research Center's birthday (1917)
- 14th Second Saturday Stars - Open House at the McCarthy Observatory
- 14th History: flyby of the dwarf plant Pluto by the New Horizons spacecraft dwarf planet and its largest moon Charon (2015)
- 14th History: flyby and first close-up view of Mars by the Mariner 4 spacecraft (1965)
- 15th History: the Dawn spacecraft enters orbit around the asteroid 4 Vesta (2011)
- 15th History: Pioneer 10 becomes the first spacecraft to enter the main asteroid belt (1972)
- 16th Scheduled flyby (13th science pass) of Jupiter's cloud tops by the Juno spacecraft
- 16th History: over twenty fragments of comet Shoemaker-Levy 9, with diameters estimated at up to 2 kilometers, collide with Jupiter between July 16th and the 22nd (1994); the comet had been discovered a year earlier by astronomers Carolyn and Eugene Shoemaker and David Levy
- 16th History: launch of Badr-A, first Pakistan satellite (1990)
- 16th History: launch of Apollo 11, with astronauts Neil Armstrong, Edwin "Buzz" Aldrin and Michael Collins, first manned lunar landing (1969)
- 16th History: first launch of a Proton rocket by the Soviet Union (1965)
- 16th History: first photo of a star other than our Sun (Vega) taken at the Harvard College Observatory (1850)
- 17th Apollo Asteroid 9162 Kwiila closest approach to Earth (0.831 AU)
- 17th History: docking (and crew handshake) of an Apollo spacecraft with astronauts Thomas Stafford, Vance Brand, and "Deke" Stayton with a Soyuz spacecraft with cosmonauts Alexei Leonov and Valeri Kubasov (the Apollo-Soyuz Test Project (ASTP)) (1975)

Astronomical and Historical Events for July (continued)

17th History: William Bond and John Adams Whipple take the first photograph of a star (Vega) at the Harvard College Observatory (1850)

18th History: John Glenn born, first American to orbit the Earth in 1962 (1921)

18th History: launch of Rohini 1, India's first satellite (1980)

18th History: launch of Gemini X, with astronauts John Young and Michael Collins (1966)

18th History: launch of Soviet Zond 3 spacecraft; first successful flyby of Moon; transmitted photographs that included the far side (1965)

18th History: Allan Sandage born, astronomer specializing in observational cosmology (1926)

19th First Quarter Moon

19th Apollo Asteroid 5011 Ptah closest approach to Earth (1.450 AU)

19th History: launch of the Explorer 35 spacecraft into an elliptical lunar orbit; designed to study interplanetary plasma, magnetic field, energetic particles, and solar X-rays (1967)

20th History: discovery of Jupiter's moon Callirrhoe (2000)

20th History: Gus Grissom's Mercury capsule (Liberty Bell 7) retrieved from the Atlantic Ocean floor at a depth of 15,000 feet, 38 years after it had sunk after splashdown (1999)

20th History: Viking 1 lands on Mars (1976)

20th History: Apollo 11 lands on Moon at 4:17 pm EDT; first step onto the lunar surface at 10:56 pm (1969)

21th Apollo Asteroid 2012 BV26 near-Earth flyby (0.053 AU)

21th Atira Asteroid 413563 (2005 TG45) closest approach to Earth (0.236 AU)

21th History: launch of the Soviet Mars mission Mars 4 (1973)

21th History: launch of Mercury-Redstone 4 with astronaut Virgil (Gus) Grissom; second suborbital flight by the United States (1961)

21th History: discovery of Jupiter's moon Sinope by Seth Nicholson (1914)

22th History: first dogs (Dezik and Tsygan) to make a suborbital flight aboard a Soviet R-1 rocket (wore pressure suits and acrylic glass bubble helmets) (1951)

22th History: landing of Soviet spacecraft Venera 8 on Venus (1972)

23rd Apollo Asteroid 2135 Aristaeus closest approach to Earth (1.507 AU)

23rd History: launch of Space Shuttle Columbia (STS-93) and the Chandra X-ray Observatory (1999); first mission commanded by a woman, Eileen Collins

23rd History: discovery of Comet Hale-Bopp by Alan Hale and Tom Bopp (1995)

23rd History: discovery of Neptune's rings (1984)

23rd History: launch of Landsat 1 into a near-polar orbit to obtain information on Earth's resources, environmental pollution, and meteorological phenomena (1972)

24th History: launch of the Geotail spacecraft, a joint JAXA/NASA mission to study the magnetic environs of Earth (1992)

24th History: first rocket launch from Cape Canaveral (Bumper/V-2 rocket) in 1950

25th Apollo Asteroid 2014 WO371 near-Earth flyby (0.060 AU)

25th Aten Asteroid 2018 GR4 near-Earth flyby (0.098 AU)

25th History: Svetlana Savitskaya becomes the first woman to walk in space (1984)

25th History: launch of Soviet Mars orbiter Mars 5 (1973)

Astronomical and Historical Events for July (continued)

26th History: launch of the Space Shuttle Discovery (STS-114) "Return to Flight," 907 days after the loss of Space Shuttle Columbia (2005)

26th History: launch of Apollo 15 with astronauts David Scott, James Irwin and Alfred Worden; fourth lunar landing (1971)

26th History: launch of Syncom 2, first geosynchronous satellite (1963)

27th Full Moon (sometimes called Buck Moon)

27th Moon at Apogee (furthest distance from Earth)

27th Mars at Opposition

27th Atira Asteroid 1998 DK36 closest approach to Earth (0.594 AU)

27th Kuiper Belt Object 2017 OF69 at Opposition (42.791 AU)

28th History: launch of Skylab-3 astronauts Alan Bean, Jack Lousma and Owen Garriott (1973)

28th History: launch of Ranger 7; Moon impact mission (1964)

29th South Delta-Aquarids Meteor Shower peak

29th Apollo Asteroid 439313 (2012 VE82) near-Earth flyby (0.068 AU)

29th History: deorbit and destruction of the Salyut 6 space station; first of the Soviet's second-generation space station design (1982)

29th History: Deep Space 1 flyby of asteroid Braille (1999)

30th History: discovery of the asteroid 951 Gaspra by Grigory Neujmin (1916); the Galileo spacecraft passed within 1,000 miles (1,600 km) of Gaspra on October 29, 1991 on its way to Jupiter

30th History: the Cassini spacecraft arrives at Saturn after a seven year journey (2004)

30th History: launch of the Wilkinson Microwave Anisotropy Probe (WMAP); mapped the Cosmic Microwave Background radiation and determined the age of the universe to be 13.73 billion years old to within one percent (2001)

30th History: Apollo 15 lands on Moon at 6:16 pm EDT (1971)

30th History: discovery of Jupiter's moon Carme by Seth Nicholson (1938)

30th History: Galileo observes Saturn's rings (1610)

31th Asteroid 55 Pandora closest approach to Earth (1.588 AU)

31st History: impact of the Lunar Prospector (1999)

31st History: flyby of Mars by Mariner 6 (1969)

August

1st Peak of the Alpha Capricornids meteor shower

1st Apollo Asteroid 420591 (2012 HF31) near-Earth flyby (0.072 AU)

1st History: discovery of Martian meteorite (shergottite class) SAU 051 in Oman (2000)

1st History: launch of Lunar Orbiter 5, last of the Lunar Orbiter series; photographed potential Apollo and Surveyor landing sites and captured the first image of a nearly full Earth from space (1967)

1st History: Maria Mitchell born, first woman to be elected as an astronomer to the American Academy of Arts and Sciences (1818)

2nd Kuiper Belt Object 2013 AT183 at Opposition (63.748 AU)

3rd Amor Asteroid 1580 Betulia closest approach to Earth (1.620 AU)

Astronomical and Historical Events for July (continued)

3rd Centaur Object 83982 Crantor at Opposition (17.832)

3rd History: launch of the MESSENGER spacecraft to Mercury (2004)

4th Last Quarter Moon

4th Earliest scheduled launch of NASA's Parker Solar Probe aboard a Delta 4 Heavy rocket from the Cape Canaveral Air Force Station

4th Apollo Asteroid 428694 Saule closest approach to Earth (0.806 AU)

4th Apollo Asteroid 4183 Cuno closest approach to Earth (1.743 AU)

4th History: launch of the Phoenix polar lander spacecraft to Mars (2007)

5th Aten Asteroid 398188 Agni near-Earth flyby (0.060 AU)

5th Amor Asteroid 6456 Golombek closest approach to Earth (0.341 AU)

5th History: launch of the Juno spacecraft to Jupiter (2011); scheduled to arrive on July 4, 2016

5th History: flyby of Mars by the Mariner 7 spacecraft (1969)

5th History: astronaut Neil Armstrong born (1930); Commander of Apollo 11 and first person to step out on the lunar surface

6th Southern Iota Aquarids meteor shower peak

6th Aten Asteroid 2011 FQ6 near-Earth flyby (0.094 AU)

6th History: the Rosetta spacecraft and her robotic lander companion Philae arrive in orbit around Comet 67P/Churyumov-Gerasimenko after a 10-year journey (2014)

6th History: landing of the Mars Science Laboratory (MSL or Curiosity) at the base of Mount Sharp inside Gale Crater (2012)

6th History: launch of Vostok 2 and cosmonaut Gherman Titov; second man in Space (1961)

6th History: Chinese astronomers first observe supernova in Cassiopeia; remained visible for more than 6 months (1181)

7th Apollo Asteroid 6063 Jason closest approach to Earth (2.795 AU)

7th Kuiper Belt Object 2008 OG19 at Opposition (37.703 AU)

7th History: Brett Gladman, et al's discovery of Saturn moons Ymir, Paaliaq and Kiviuq (2000)

7th History: announcement of possible microfossils found in Martian meteorite ALH84001 (1996)

7th History: Viking 2 arrives at Mars (1976)

8th History: launch of Genesis spacecraft, solar particle sample return mission (2001)

8th History: launch of Pioneer Venus 2 (1978)

8th History: launch of the Soviet Zond 7 Moon probe (1969)

9th Apollo Asteroid 2008 HU4 closest approach to Earth (1.236 AU)

9th History: launch of the Soviet Luna 24 spacecraft, third attempt (and only successful attempt) to recover a sample from Mare Crisium (1976)

9th History: Henry Draper obtains the first spectrum photograph of a star (Vega) to show distinct lines (1872)

10th Moon at Perigee (closest distance to Earth)

10th 83nd Convention of Amateur Telescope Makers (Stellafane), Springfield, Vermont (through the 12th), see https://stellafane.org/convention/2018/index.html

10th Apollo Asteroid 11500 Tomaiyowit closest approach to Earth (0.462 AU)

10th Apollo Asteroid 1566 Icarus closest approach to Earth (0.551 AU)

Astronomical and Historical Events (continued)

- 10th Amor Asteroid 3352 McAuliffe closest approach to Earth (1.531 AU)
- 10th History: launch of TOPEX/Poseidon Earth-monitoring satellite, joint venture between CNES and NASA that measured ocean surface topography to an accuracy of 4.2 cm (1992)
- 10th History: launch of Mars Reconnaissance Orbiter to Mars (2005)
- 10th History: launch of Kitsat A, first South Korean satellite (1992)
- 10th History: the Magellan spacecraft enters orbit around Venus; radar mapped 98% of the planet over the following two years (1990)
- 10th History: launch of the Lunar Orbiter 1 spacecraft; photographed smooth areas of the lunar surface for assessing future landing sites and captured iconic image of the Earth rising above the lunar surface (1966)
- 11th New Moon
- 11th Second Saturday Stars - Open House at the McCarthy Observatory
- 11th History: Asaph Hall discovers Martian moon Deimos (1877)
- 12th Peak of the Perseids meteor shower (into the morning of the 13th)
- 12th Apollo Asteroid 306367 Nut closest approach to Earth (3.399 AU)
- 12th Centaur Object 52872 Okyrhoe at Opposition (9.793 AU)
- 12th History: launch of the International Sun-Earth Explorer-3 (ISEE-3) satellite into a heliocentric orbit. Renamed International Comet Explorer, (ICE), it became the first spacecraft to visit a comet, passing through the plasma tail of comet Giacobini-Zinner in 1985 (1978)
- 12th History: launch of the High Energy Astronomical Observatory (HEAO-1) to monitor x-ray sources (1977)
- 12t History: Soviet spacecraft Vostok 4 launched one day after Vostok 3 - first time multiple manned spacecraft in orbit, although they did not rendezvous (1962)
- 12th History: launch of Echo 1, the first experimental communications satellite (1960)
- 13th Apollo Asteroid 2008 AG4 near-Earth flyby (0.094 AU)
- 13th Aten Asteroid 2013 ND15 (Venus Trojan) closest approach to Earth (0.143 AU)
- 13th Kuiper Belt Object 2015 UH87 at Opposition (80.788 AU)
- 13th History: discovery of Mars' south polar cap by Christiaan Huygens (1642)
- 13th History: discovery of long-period variable star Mira, (Omicron Ceti) by David Fabricius (1596)
- 15th Amor Asteroid 2011 UA near-Earth flyby (0.081 AU)
- 15th Apollo Asteroid 85585 Mjolnir closest approach to Earth (1.273 AU)
- 16th Scheduled launch of a Japanese H-2 Transfer Vehicle (unmanned cargo vehicle) to the International Space Station from the Tanegashima Space Center
- 16th History: launch of Explorer 12 spacecraft, measured cosmic-ray particles, solar wind protons, and magnetospheric and interplanetary magnetic fields (1961)
- 17th Venus at its Greatest Eastern Elongation (46°), apparent separation from the Sun in the evening sky
- 17th Aten Asteroid 2016 JJ17 near-Earth flyby (0.065 AU)
- 17th Apollo Asteroid 4341 Poseidon closest approach to Earth (1.912 AU)
- 17th History: launch of Venera 7; Soviet Venus lander (1970)
- 17th History: launch of Pioneer 7 (1966)

Astronomical and Historical Events for July (continued)

17th History: Asaph Hall discovers Martian moon Phobos (1877)

18th History: launch of Suisei; Japan's Comet Halley mission (1985)

18th First Quarter Moon

19th Apollo Asteroid 5786 Talos closest approach to Earth (0.766 AU)

19th History: launch of first Philippine communications satellite Agila 2 (also known as Mabuhay 1 or ABS 5) (1997)

19th History: launch of Soviet Sputnik 5 spacecraft with dogs Belka and Strelka (1960)

19th History: discovery of S Andromedae (SN 1885A), supernova in the Andromeda Galaxy and the first discovered outside the Milky Way Galaxy; discovered by Irish amateur astronomer Isaac Ward in Belfast on the 19th and independently the following day by Ernst Hartwig at Dorpat (Tartu) Observatory in Estonia (1885)

19th History: Orville Wright born (1871)

19th History: John Flamsteed born; English astronomer known for his accurate astronomical observations and first Astronomer Royal (1646)

20th Aten Asteroid 2017 FR63 near-Earth flyby (0.099 AU)

20th History: launch of Voyager 2 to the outer planets (1977)

20th History: launch of Mars orbiter/lander Viking 1 (1975)

20th History: Ernst Hartwig's discovery of S Andromedae Supernova (1885)

21st History: launch of the Orbiting Astronomical Observatory-3, Copernicus, with a UV telescope and X-ray detector (1972)

21st History: launch of Gemini V with astronauts Gordon Cooper and Charles Conrad (1965)

22nd Aten Asteroid 2015 QM3 near-Earth flyby (0.063 AU)

23rd Moon at Apogee (furthest distance from Earth)

23rd History: Lunar Orbiter 1 takes first photo of the Earth from the Moon (1966)

24th History: Pluto reclassified as a Dwarf Planet (2006)

24th History: launch of the Soviet Luna 11 spacecraft to analyze the Moon's chemical composition, study gravitational anomalies and measure radiation levels (1966)

25th Northern Iota Aquarids Meteor Shower Peak

25th Apollo Asteroid 2005 QQ87 near-Earth flyby (0.089 AU)

25th Apollo Asteroid 2012 BD14 near-Earth flyby (0.100 AU)

25th Apollo Asteroid 54509 YORP closest approach to Earth (0.704 AU)

25th History: flyby of Neptune by the Voyager 2 spacecraft (1989)

25th History: launch of the Spitzer Space Telescope (2003)

25th History: launch of the Advanced Composition Explorer spacecraft to study energetic particles from the solar wind, the interplanetary medium, and other sources (1997)

26th Full Moon (sometimes called Sturgeon Moon)

26th Mercury at its Greatest Western Elongation (18°), apparent separation from the Sun in the morning sky

26th Amor Asteroid 2016 RW17 near-Earth flyby (0.069 AU)

26th History: flyby of the planet Saturn by the Voyager 2 spacecraft (1981)

27th Kuiper Belt Object 225088 (2007 OR10) at Opposition (87.061 AU)

Astronomical and Historical Events for July (continued)

27th History: launch of the Mariner 2 spacecraft to Venus; first successful planetary encounter (1962)

28th Aten Asteroid 2016 GK135 near-Earth flyby (0.043 AU)

28th Apollo Asteroid 358744 (2008 CR118) near-Earth flyby (0.099 AU)

28th Apollo Asteroid 12711 Tukmit closest approach to Earth (0.652 AU)

28th History: flyby of the asteroids Ida and Dactyl by the Galileo spacecraft (1993)

28th History: discovery of Saturn's moon Enceladus by William Herschel (1789)

29th Aten Asteroid 1998 SD9 near-Earth flyby (0.011 AU)

29th Aten Asteroid 2016 NF23 near-Earth flyby (0.034 AU)

29th History: discovery of a bright nova in the constellation Cygnus (Nova Cygni 1975); visible to the unaided eye for about a week (1975)

30th Apollo Asteroid 2018 DE1 near-Earth flyby (0.039 AU)

30th Kuiper Belt Object 408706 (2004 NT33) at Opposition (38.293 AU)

30th History: discovery of first Kuiper Belt Object (1992 QB1) by David Jewitt and Jane Luu

30th History: launch of Japanese satellite Yohkoh (Sunbeam) to observe phenomena taking place on the Sun (1991)

30th History: launch of STS-8 and astronaut Guy Bluford; first African-American in space and first night launch and landing by a shuttle (1983)

31th Aten Asteroid 136818 Selqet closest approach to Earth (0.290 AU)

31th Kuiper Belt Object 307982 (2004 PG115) at Opposition (37.432 AU)

31th History: President Kennedy signs the Communications Satellite which created the Communications Satellite Corporation (COMSAT) and committed the U.S. to building a global communications system (1962)

31th History: first photo showing Moon's shadow on the Earth during Solar Eclipse taken by stratospheric balloonist Captain Albert Stevens (1932)

Tentatively Scheduled for August

?? Launch (first) of SpaceX's Crew Dragon spacecraft aboard a Falcon 9 rocket from the Kennedy Space Center (unmanned)

27th Launch (first) of Boeing's CST-100 Starliner spacecraft aboard an Atlas 5 rocket from the Cape Canaveral Air Force Station (unmanned)

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

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).

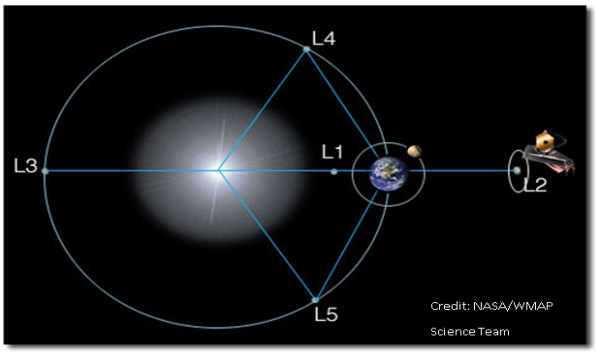


Image Credits

Front page design and graphic calendar: Allan Ostergren

Second Saturday Stars poster: Marc Polansky

All other non-credited photos were taken by the author: Bill Cloutier

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/Iridium Satellites

Visit www.heavens-above.com for the times of visibility and detailed star charts for viewing the International Space Station and the bright flares from Iridium satellites.

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.

On the Cover

An image of the restless cloud belts and vortices of Jupiter's northern hemisphere taken by the Juno spacecraft on May 24 this year. The view was from a position of 9,600 miles (15,500 kilometers) above the cloud tops and 56 degrees north latitude of the planet's restless atmosphere.

Ammonia and water, along with a mixture of other chemicals, likely make up the bright clouds of the upper atmosphere, while the darker shades originate from elements deeper within the planet's interior. Since Jupiter is a gas planet and devoid of solid matter, there is no physical land surface to tame and direct the endless dance of whirling gases bounded by its immense gravity. Scientists identify the "surface" of Jupiter as the layer where atmospheric pressure equals the pressure of the Earth at one bar.https://www.nasa.gov/image-feature/jpl/chaotic-clouds-of-jupiter.

Circulation in the Jovian atmosphere is driven by similar forces as on the Earth. However, the predominent flow (90 percent) is anticyclonic (clockwise) and is concentrated in zones more than 2000 km (1,242 miles) in diameter. and with an average duration ranging from a few days to hundreds of years.

Image Credits: NASA/JPL-Caltech/SwRI/MSSS/Gerald Eichstädt/Seán Doran

For more information, go to https://www.nasa.gov/image-feature/jpl/chaotic-clouds-of-jupiter; https://www.nasa.gov/juno and http://missionjuno.swri.edu.

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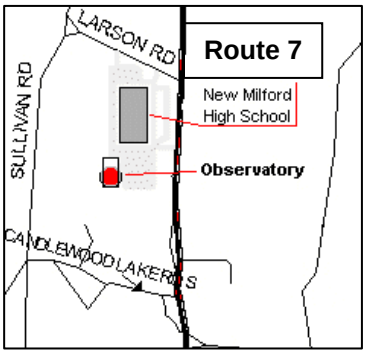

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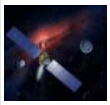
July 2018

Celestial Calendar

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1  Smithsonian Air & Space Museum birthday (1976)  100-inch mirror for Hooker telescope arrives at Mt Wilson (1917)  NASA officially activates the Launch Operations Center on Merritt Island, Florida; later renamed the Kennedy Space Center (1962)	**2** 	**3**  Launch of ill-fated Japanese Nozomi spacecraft to Mars (1998)  Launch of the Solar Anomalous and Magnetospheric Particle Explorer (SAMPEX) by a Scout rocket (1992)	**4**  Crab nebula viewed by Chinese astronomers (1054) Mars Pathfinder landing (1997)   Henrietta Leavitt born; measured distances to far galaxies (1868)	**5**  A. E. (Andrew Ellicott) Douglass ,an American astronomer who discovered a correlation between tree rings and the sunspot cycle. (1867)	**6**  Isaac Newton's *Principia* published (1687) Discovery of Jupiter's moon Lysithea by Seth Nicholson (1938) 	**7**  Launch of Mars Exploration Rover B *Opportunity* (2003)
8  Alvan Graham Clark born, telescope maker (1832) Flyby of Asteroid 21 Lutetia by European Space Agency's Rosetta spacecaft (2010)   launch of Telstar 1, prototype communication satellite designed and built by Bell Telephone Laboratories (1962)	**9** Probe of comet Tempel 1 by Deep Impact impactor (2005)   Launch of Soviet Gamma Observatory (1990) Skylab re-enters into the Earth's atmosphere (1979) 	**10**  Soviet Mars orbiter Phobos 2 launched (1988)	**11**  Langley Research Center Birthday (1917) Soviet spacecraft Luna 15 launched, lander to crash on Moon (1969) 	**12**  First close-up view of Mars by Mariner 4 Spacecraft (1965)	**13**  Moon at perigee (closest distance to Earth) Launch of Apoll0 18 and Soyuz 19 in joint U.S./ Soviet mission (1975)   The Dawn spacecraft enters orbit around the asteroid 4 Vesta (2011)	**14** Launch of the Space Shuttle Atlantis (STS-135) to the International Space Station; final space shuttle flight to low Earth orbit (2011)   2nd Saturday Stars Open House McCarthy Observatory
15  Apollo 11 Moon mission Armstrong, Aldrin, Collins (1969) Schoemaker/ Levy Comet fragments impact Jupiter (July 16-22, 1994)   first photo of a star other than our Sun (Vega) by Harvard University (1850)	**16** Monsignor Georges Lemaître born; Belgian priest and astronomer was first to propose expanding universe and Big Bang theory (1894)   Docking and handshakes of Apollo 18 and Soyuz 19 crews (1975)	**17** Launch of Zond 5, 1st successful Moon flyby 1965)   Allan Standage born, cosmologist Rohini I, India's 1st satellite, failed at launch (1980)   Gemini X with John Young and Michael Collins (1966)	**18**  Launch of Explorer 35 spacecraft into an elliptical lunar orbit, to study interplanetary plasma, magnetic field, energetic particles, and solar X-rays (1967)  Edward Charles Pickering born - Harvard astronomer and physicist who discovered the first spectroscopic binary stars, later used to measure cosmic distances. (1846)	**19**  Apollo 11 lands on Moon (1969) Viking I lands on Mars (1976) Gus Grissom's capsule Liberty Bell raised after 30 years on ocean floor (1999)	**20** Moon at perigee (closest to Earth) Launch of Soviet Mars 4 mission (1973) Virgil (Gus) Grissom, 2nd U.S. suborbital flight (1961)	**21** Close pass of Jupiter's cloud tops by Voyager 2 spacecraft (1979)
22 Alan Hale and Tom Bopp announce discovery of comet Hale- Bopp (1995) Launch of Shuttle Columbia and Chandra X-ray Observatory; first mission commanded by a woman, Eileen Collins (1999) Launch of Landsat 1 into a near-polar orbit to study Earth's resources and meteorological phenomena (1972)	**23** Bumper V-2, first rocket launch from Cape Canaveral (1950) 78th Convention of Amateur Telescope Makers (Stellafane), Springfield, Vt (through the 27th), 	**24** Svetlana Savitskaya becomes first woman to walk in space (1984) Launch of Soviet orbiter Mars 5 (1973) 	**25** Shuttle Discovery (STS-114) "return to flight" (2005) Launch of Syncom 2, first geosynchronous satellite (1963) launch of Apollo 15, fourth lunar landing (1971) 	**26** Sir George Biddell Airy born - an English mathematician and Astronomer Royal who worked on planetary orbits, measuring the mean density of the Earth, and establishing Greenwich as the prime meridian (1801) 	**27** Moon at apogee (farthest from Earth) Launch of Ranger 7, Moon impact mission (1964) Launch of Skylab 3 (Bean, Pogue, Garriott) (1973)	**28** Landing of Soviet spacecraft Venera 8 on Venus (1972) South Delta-Aquarids meteor shower peak
29 Impact of the Lunar Prospector (1999) Launch of the Wilkinson Microwave Anisotropy Probe WMAP); mapped the Cosmic Microwave background radiation and determined the age of the universe 2001) 	**30** Impact of the Lunar Prospector (1999) Mariner 6 Mars flyby (1969) 	**31** Death of 3 cosmonauts in Soyuz 11 when capsule depressurizes in reentry (1971) Tunguska explosion event (1908) 				

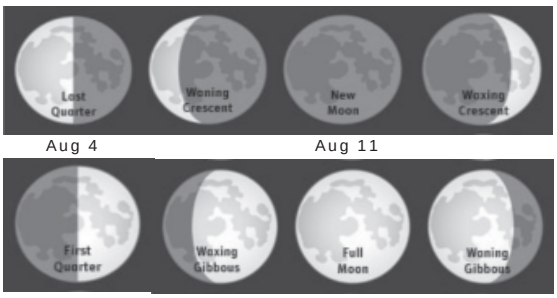
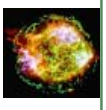
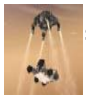
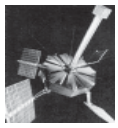
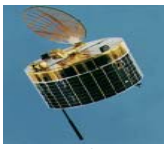
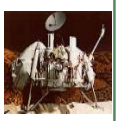
Phases of the Moon

July 6 July 12

July 19 July 27

August 2018

Celestial Calendar

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Phases of the Moon  			1 Peak of the Alpha Capricornids meteor shower   Launch of Lunar Orbiter 5, the last of the Lunar Orbiter series (1967) Maria Mitchell born, first woman elected as an astronomer to the American Academy of Arts and Sciences (1818) 	2  Valery Fyodorovich Bykovsky born: Soviet cosmonaut flew three manned space mission space flights, spending five days in orbit aboard Vostok 5 in 1963 - a record for a solo flight. (1934)	3  Launch of MESSENGER spacecraft to Mercury (2004)	4  Launch of Phoenix Spacecraft to Mars (2007)
5  Astronaut Neil Armstrong born (1930) Launch of the Juno spacecraft to Jupiter (2011)   Flyby of Mars by the Mariner 7 spacecraft (1969)	6  Gherman Titov, 2nd man in space (1961) Cassiopeia Supernova observed by Chinese (1181)   Landing of Mars Science Lab (MSL or Curiosity) inside Gale Crater (2012)	7  Viking 2 on Mars (1976)  Martian meteorite found to contain possible life (1996)	8  Launch of Pioneer Venus 2 (1978)  Launch of Genesis Spacraft (2001)  Launch of Soviet Zond 7 moon probe (1969)	9  Launch of Soviet Luna 24 spacecraft, third (and only successful attempt) to recover a sample from Mare Crisium (1976)	10  Launch of Mars Reconnaissance Orbiter (2005) Magellan spacecraft orbits Venus (1990) 	11  Asaph Hall discovers Martian Moon Deimos(1877) 2nd Saturday Stars Open House McCarthy Observatory 
12  Perseid meteor showers at peak Launch of the High Energy Astronomical Observatory (HEAO-1) to monitor x-ray sources (1977)   Launch of Echo 1A, communications satellite in 2ND attempt (1960)	13  Discovery of long-period variable star Mira, Omicron Ceti by David Fabricius (1596) Discovery of Mars' south polar cap by Christiaan Huygens (1642) 	14  Educator astronaut Barbara Morgan leads a Q&A session with children in Boise, Idaho from the space shuttle Endeavour, fulfilling legacy of Christa McAuliffe, who died in the 1986 Challenger disaster (2007)	15  President Reagan announced his support for the construction of an orbiter to replace Challenger (1986)	16  Launch of Explorer 12 spacecraft, measured cosmic-ray particles, solar wind protons, and magnetospheric and interplanetary magnetic fields (1961)	17  launch of Venera 7; Soviet Venus lander (1970) Asaph Hall discovers Martian Moon Phobos (1877)   Launch of Pioneer 7 (1966)	18  Launch of Suisei, Japan's Comet Halley mission (1985)
19  Launch of Sputnik 5, with dogs Belka and Strejka (1960) Birth of Orville Wright (1871)   Sir John Flamsteed born, English astronomer (1646) Dmitri Ivanovich Mendeleev rises to 11,500 feet (3.5 km) to observe an eclipse in Russia (1887) 	20 Launch of Mars orbiter/ lander Viking 1 (1975)  Launch of Voyager 2 to outer planets (1977)	21 Launch of Gemini V with astronauts Gordon Cooper and Charles Conrad (1965) Launch of the Orbiting Astronomical Observatory-3, Copernicus, with a UV telescope and X-ray detector (1972)	22 Neptune was found to have a continuous ring system by the Voyager 2 spacecraf (1989)	Moon at apogee (farthest from Earth) 23 Lunar Orbiter 1 takes first photograph of Earth from Moon (1966)	24 Pluto reclassified as a dwarf planet (2006) Launch of the Soviet Luna 11 spacecraft to analyze the Moon's chemistry, gravitation and radiation levels (1966) 	25 flyby of Neptune by the Voyager 2 spacecraft (1989) Meteor shower (Northern Iota Aquarids peak)
 26 Moon at perigee (closest distance to Earth) Flyby of Saturn by Voyager 2 spacecraft (1981)	27 launch of the Mariner 2 spacecraft to Venus; first successful planetary encounter (1962)	28 Discovery of Nova Cygni in the constellation Cygnus (1975)	29 Discovery of Saturn's moon Enceladus by William Herschel (1789) Flyby of asteroids Ida and Dactyl by the Galileo spacecraft (1993)	30 Discovery of first Kuiper Belt object, 1992 QB1, by David Jewet and Jane Luu Launch of STS-8 and astronaut Guy Bluford, 1st African-American in space (1983) First recorded occurrence - comet Howard Koomen-Michels impacts sun (energy of 1 million hydrogen bombs) (1979)	31 US Naval Observatory authorized by an act of Congress (1842)	