Galactic Observer
John J. McCarthy Observatory

Volume 17, No. 5 May 2024



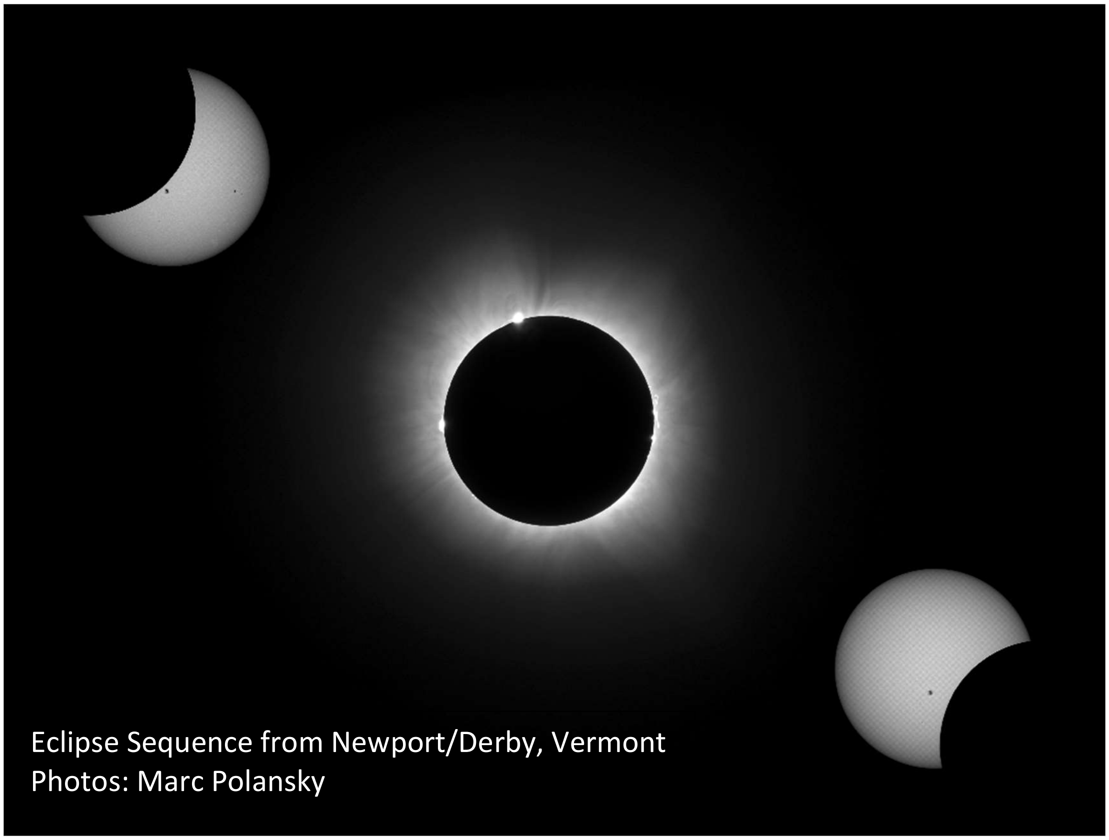


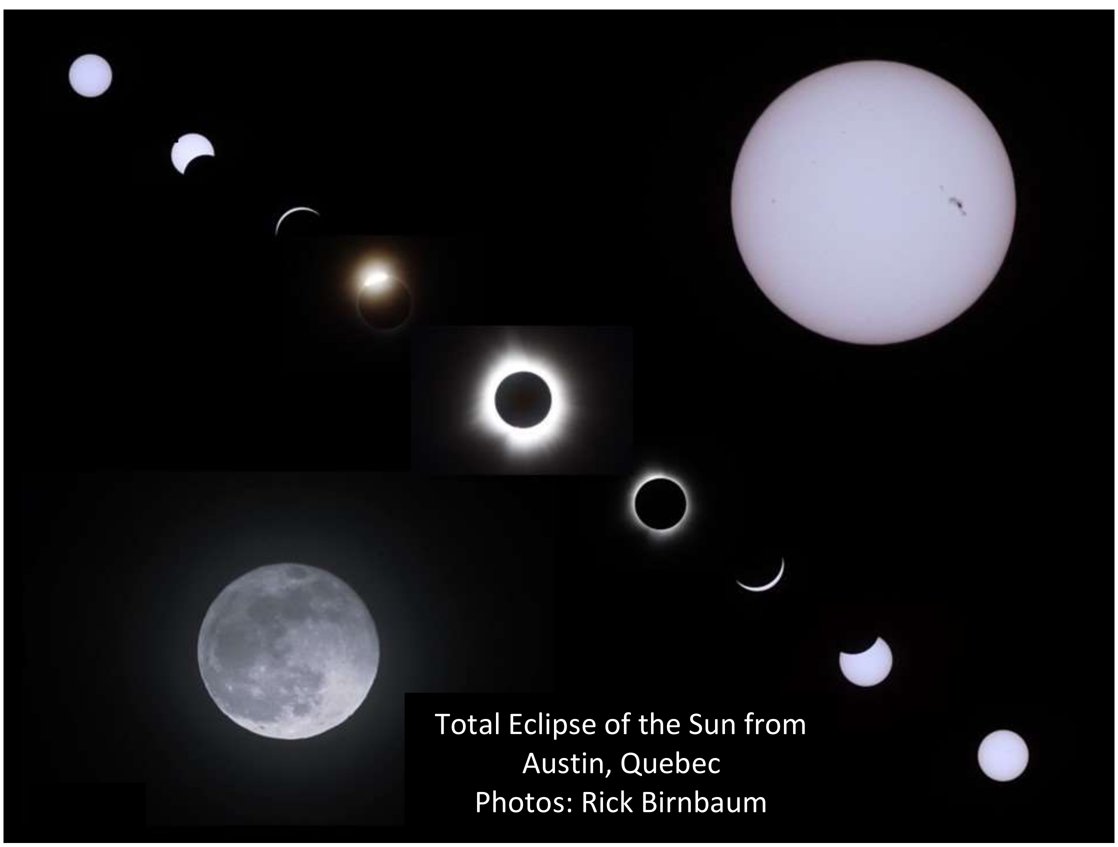
Solar Eclipse Viewing at the McCarthy Observatory

The volunteers of the Observatory hosted a viewing party for the students of New Milford High School during the April 8th eclipse

Photos: John Gebauer and Roger Moore

May Astronomy Calendar and Space Exploration Almanac





In This Issue

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McCarthy Observatory
New Milford, CT

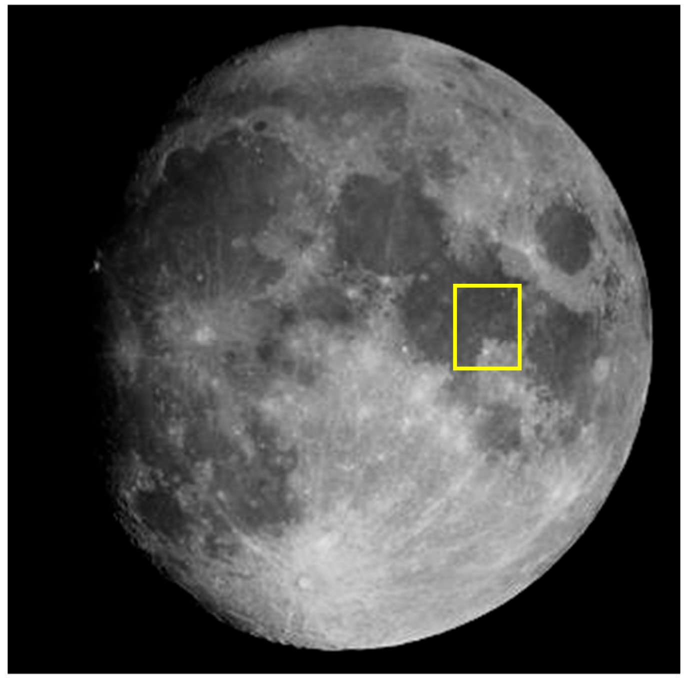
"Out the Window on Your Left"

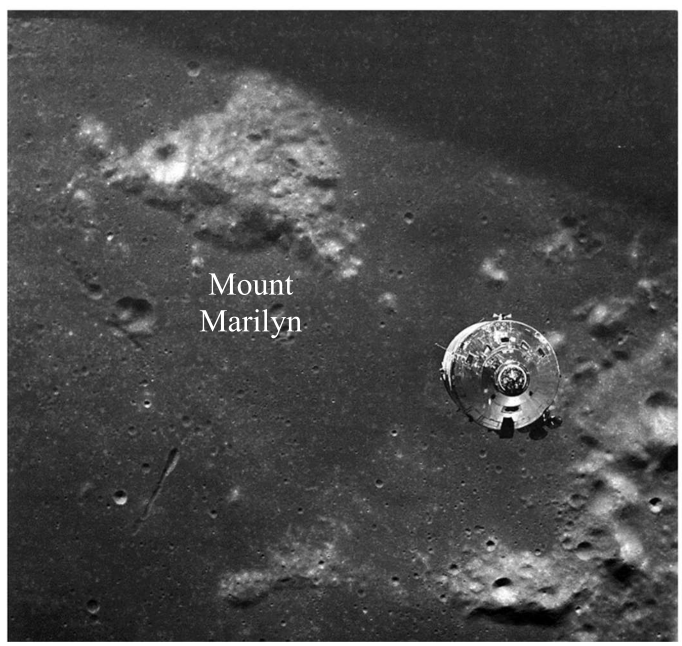
It's been more than 51 years since Gene Cernan left the last boot print on the lunar soil. As a nation founded on exploration and the conquest of new frontiers, today's commitment to return to the Moon has been as fleeting as the funding. But what if the average citizen had the means to visit our only 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).

Launched in May 1969, Apollo 10 was a dress rehearsal for Apollo 11, with astronauts Thomas Stafford and Eugene Cernan flying the Lunar Module down to within 9 miles (14 km) of the surface. Along the way the Apollo 10 crew identified dozens of informal landmarks that could be used by Armstrong and Aldrin as waypoints to check their progress against the nominal descent timeline (Mount Marlyn had been named by Jim Lovell for his wife during the Apollo 8 mission). The names appear on the charts used by the astronauts, in technical reports, and in the transcripts of communications between the astronauts and mission control.

By February 1968, the Apollo Site Selection Board had identified five landing sites under consideration for the first Moon landing. The sites were central to the near side and within five degrees of the lunar equator. Sites 1 and 2 were located in the Sea of Tranquility (Site 1 was eventually rejected as being too far east).

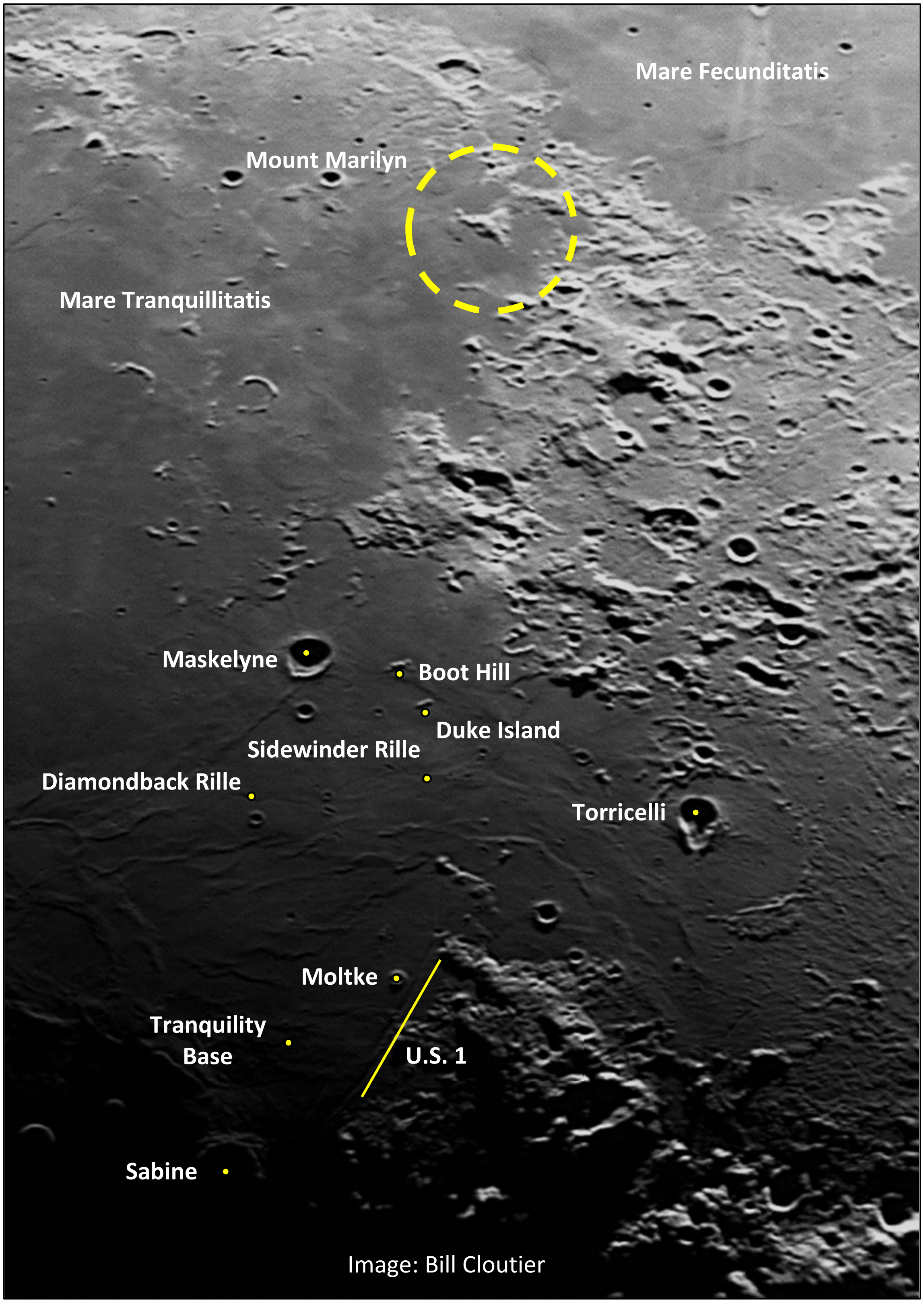
Sites appraised for the first landing (from ground-based telescope observations, robotic spacecraft photographs, and Apollo 10 astronaut assessments) were relatively level and free of boulders and large craters. NASA preferred to land shortly after dawn, approaching the target from the east so that the crew could view the terrain with the sun at their backs. This restricted the availability of a particular landing site to just one day in a lunar month. Launch delays would move the landing site west for more favorable lighting.



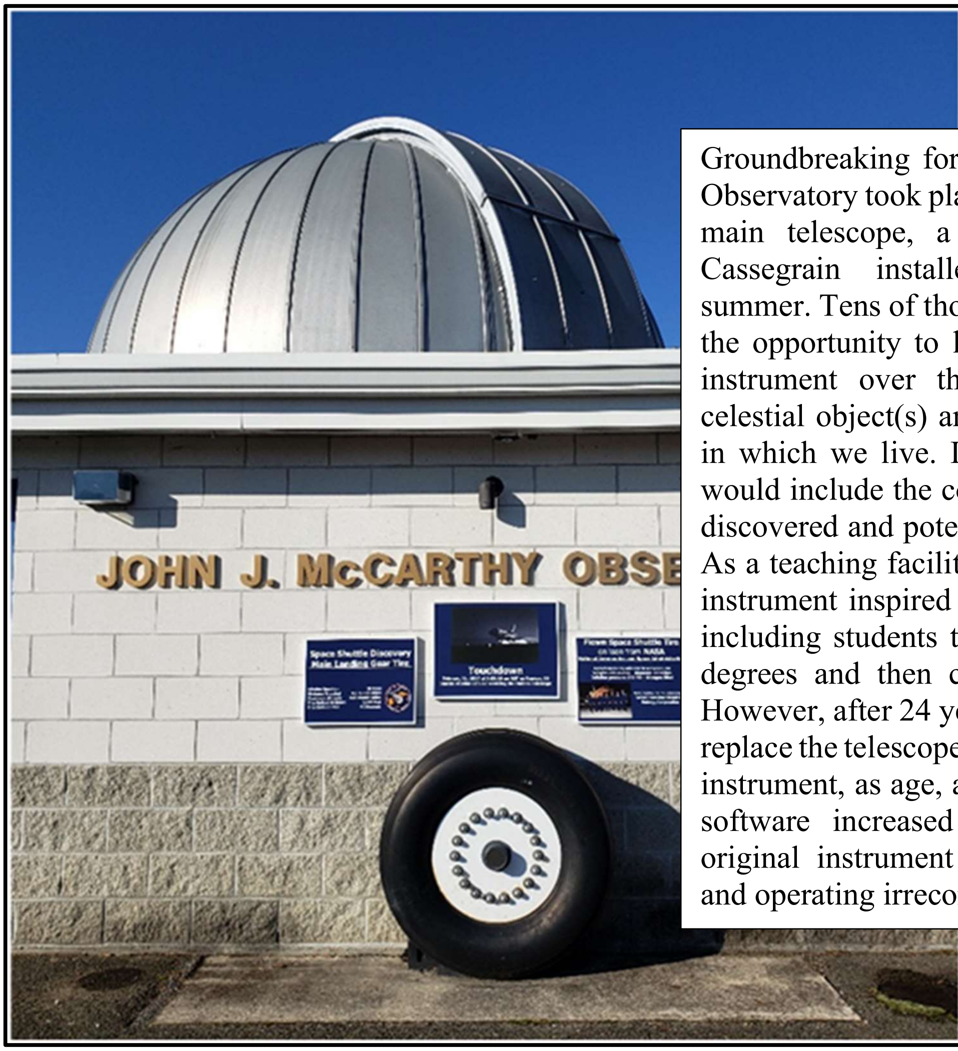


NASA Photo: Apollo 10 Command Module as seen from the Lunar Module with Mt. Marilyn visible in the background

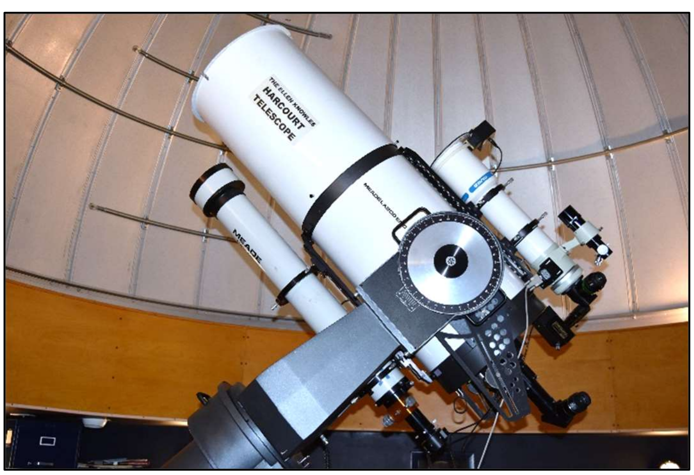
The Approach



Next Generation Telescope

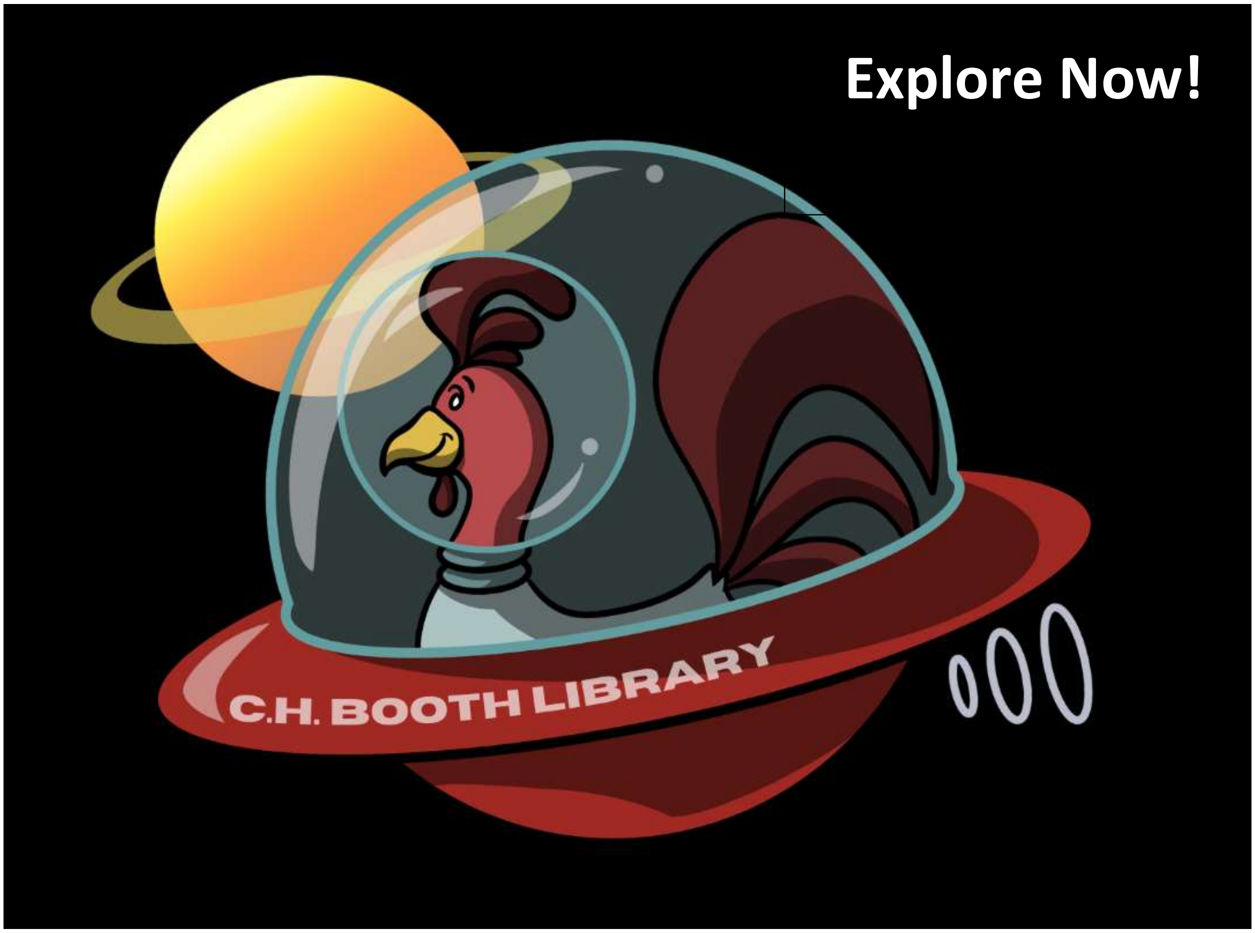


Groundbreaking for New Milford's McCarthy Observatory took place on May 6, 2000, with its main telescope, a 16-inch Meade Schmidt Cassegrain installed over the following summer. Tens of thousands of visitors have had the opportunity to look through the venerable instrument over the years at their favorite celestial object(s) and learn about the universe in which we live. Its contributions to science would include the confirmation of many newly discovered and potentially hazardous asteroids. As a teaching facility, access to such a capable instrument inspired many who worked with it, including students that would go on to pursue degrees and then careers in scientific fields. However, after 24 years a decision was made to replace the telescope with a new, state-of-the-art instrument, as age, advances in technology and software increased the vulnerability of the original instrument to increased maintenance and operating irreconcilabilities.

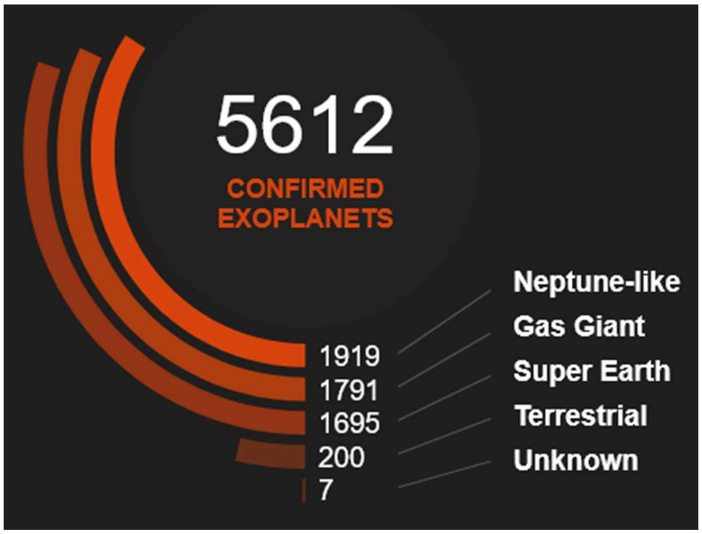


Original telescope (above) as compared to the new, next generation telescope (right) - a PlaneWave CDK17, a 17-inch (0.43 m) f/6.8 Corrected Dall-Kirkham Astrograph telescope

Local Exoplanet Exhibit



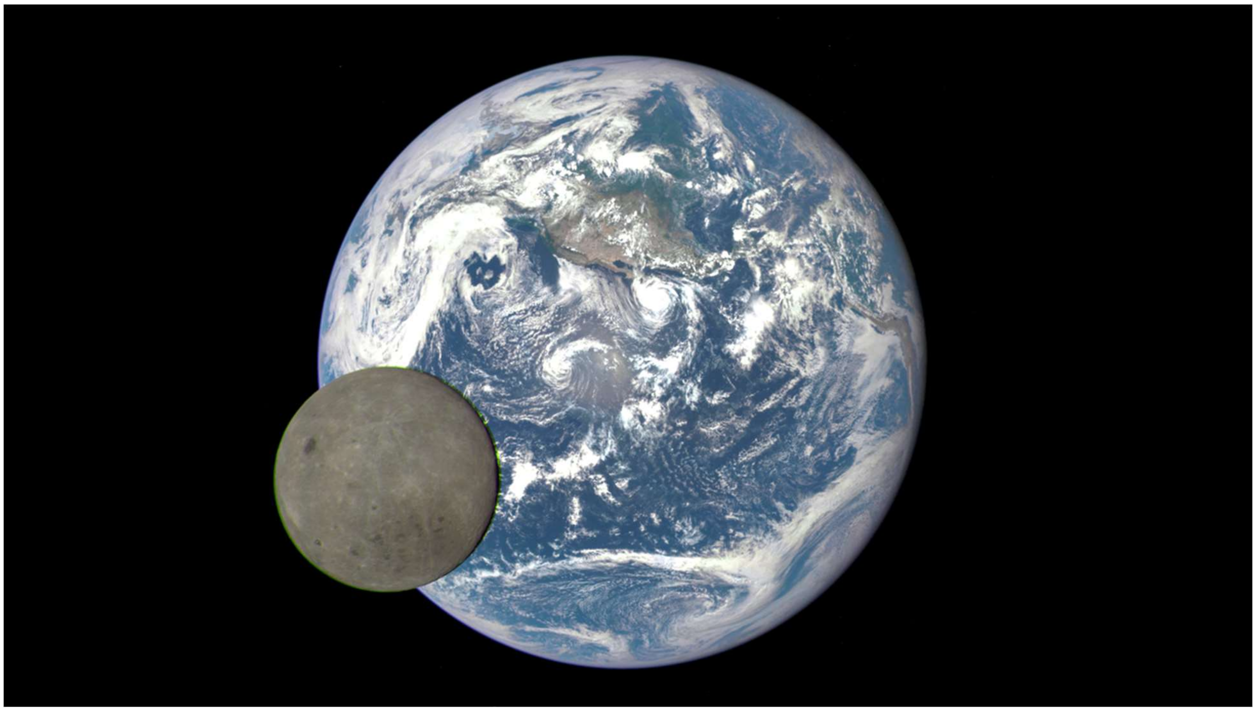
The C.H. Booth Library in Newtown will be hosting NASA's traveling exhibition *Discover Exoplanets: The Search for Alien Worlds* through May. The library is one of only ten libraries in the country selected to host the exhibit and the only site in the Northeast and Tristate area.



The exhibit, in partnership with NASA's Space Science Institute, is a free, hands-on, multimedia experience that brings the excitement of exoplanets (planets outside of our solar system) to patrons and visitors to the library through a series of interactive exhibits and fun activities.

It was only 30 years ago when the first exoplanet was discovered. Since then, with an exponential leap in detection technology and machine learning, the count of confirmed exoplanets now tops 5,600, as astronomers continue to find smaller and more Earth-like worlds, including those with habitable biospheres.

Lunar Time Zone



View of the far side of the Moon and the Earth from the DSCOVR satellite which orbits between Earth and Sun at the L1 Lagrangian point in space

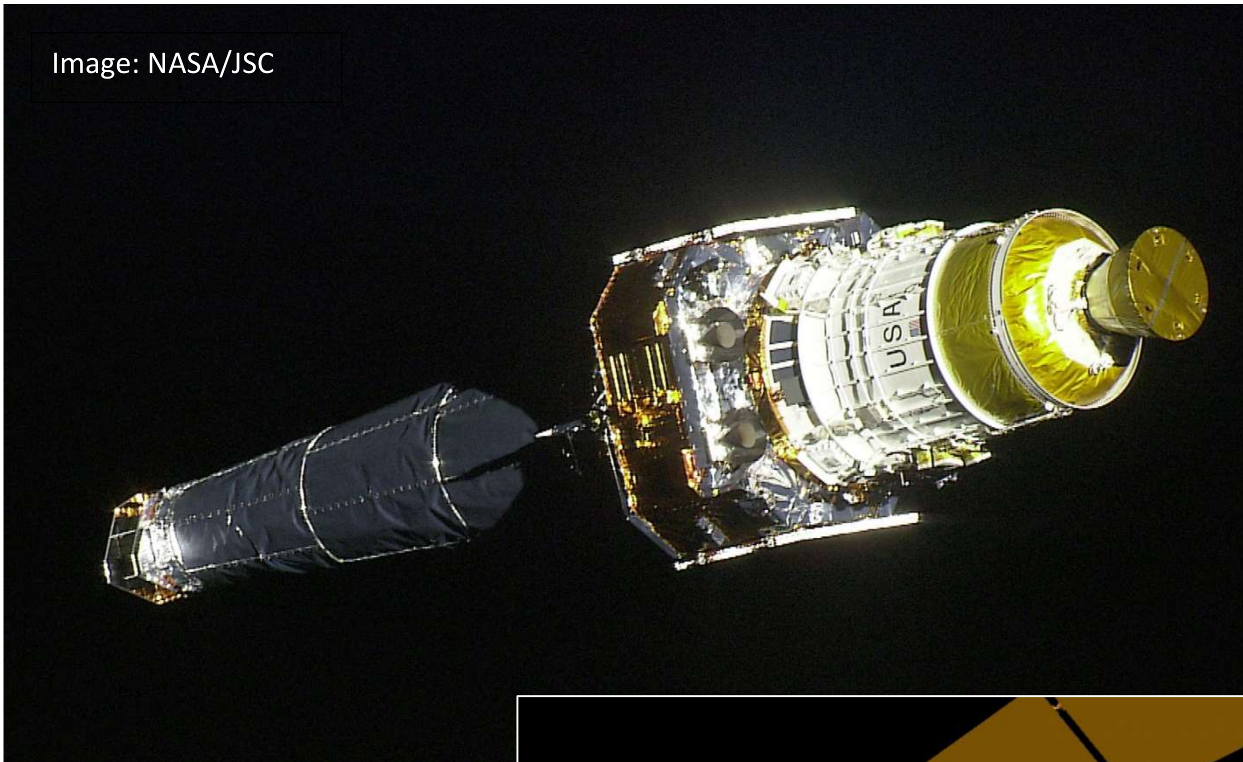
Credit: NASA's Goddard Space Flight Center/NASA/NOAA

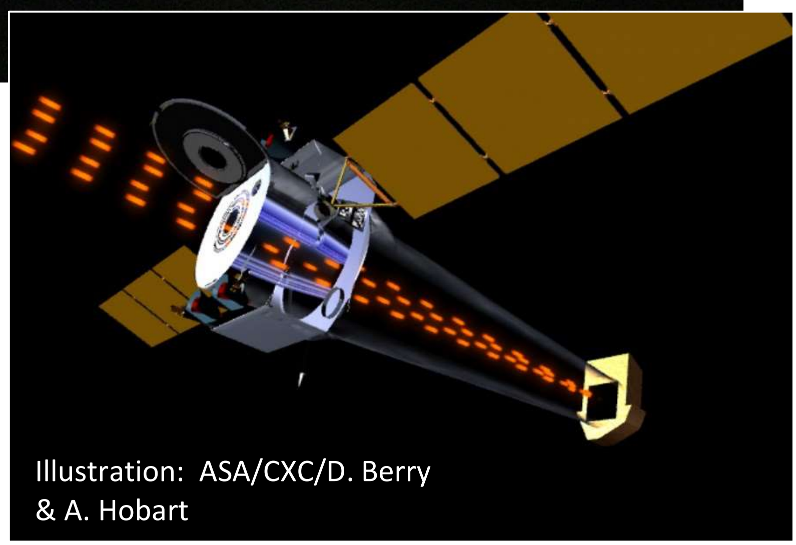
The Apollo missions to the Moon in the 1960s and early 1970s used "mission elapsed time" for timekeeping. The clock started when the Saturn V rocket lifted off from the pad. Astronauts also set their watches to Houston time where mission control was located. The longest mission, Apollo 17, was only 12 days, and Earth-centric timekeeping worked well for a short-term excursion.

However, with several countries planning to establish a long-term presence on the lunar surface, there is a need for timekeeping specific to the Moon, for example, a lunar time zone. Coordinated Lunar Time (LTC) is desirable because, on the Moon, time moves slightly faster than on Earth. This is due to a concept called "gravitational time dilation." As predicted by general relativity, massive objects like planets create a gravitational field that slows down time in the immediate vicinity. With the Moon's lower mass, and higher velocity relative to Earth, time passes around 58.7 microseconds faster each Earth day (24 hours) on the Moon. This imperceptible difference to humans represents a significant challenge in areas of scientific study, data transfer, mapping and spacecraft navigation, including dockings and landings.

Initially presented by the European Space Agency as a prerequisite for international coordination of lunar surface activities, the White House's Office of Science and Technology has tasked NASA with creating the lunar standard by the end of 2026. Recommendations could be adopted by the International Astronomical Union to facilitate acceptance by other space agencies. Among the requirements are traceability to Coordinated Universal Time (UTC), the global system that regulates all Earthly time zones. Unlike on Earth, the Moon will have just one time zone and no daylight saving time.

Defunding a "Great Observatory"





Chandra telescope shortly after deployment from the space shuttle's payload bay

Light Path - X-ray photons entering the telescope, deflected by grazing mirrors and focused onto an electronic detector

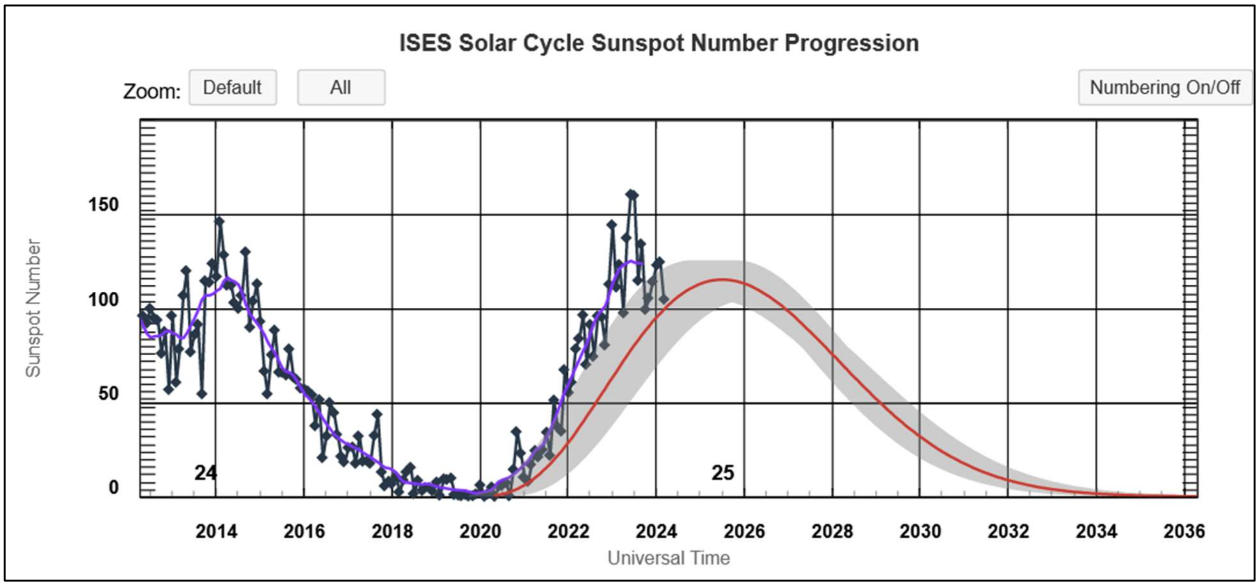
Carried into low-Earth orbit by the space shuttle Columbia on July 23, 1999, the Chandra X-ray Observatory was one of NASA's four Great Observatories (only the Hubble Space Telescope and Chandra remain operational). The telescope is designed to detect X-ray emissions from exploded stars, clusters of galaxies, and infalling matter around black holes. An integrated solid-fuel rocket was used to boost the telescope in an elliptical orbit that carries the observatory to a maximum altitude of 86,500 miles (139,000 km), almost 200 times higher than Hubble's orbit.

Despite its pioneering work, and recent collaborations with Hubble, as well as the James Webb Space Telescope, Chandra's days may be numbered. Budget allocations for telescope operations, as currently proposed, would be reduced from $68.3 million in 2023 to $41.1 million in FY25 (which starts this October) and $26.6 million in FY26. By 2029, only $5 million is allocated. With NASA's flagship X-ray astronomy mission winding down, funding is expected to shift to the Nancy Grace Roman Space Telescope (infrared spectrum), scheduled for launch in 2027.

Space Weather Guide

The Sun's magnetic field reverses, or completely flips, every eleven years (on average). This periodicity, known as the solar cycle, is associated with the waxing and waning of solar activity and accompanied by the appearance of sunspots. These dark blemishes on the solar disk are cooler and less dense than the surrounding photosphere. They appear as the intense magnetic flux erupts from within the solar interior. When activity is low, the Sun's photosphere can appear blank while, at the height of activity, the surface can be peppered with dark spots many times the size of the Earth. The more complex the magnetic structure, the more likely the sunspot will produce solar flares. (Mount Wilson classifies each sunspot into one of eight magnetic categories.)

The Sun in currently in Cycle 25 (cycle number assignments began in 1755) and is expected to reach peak activity sooner than originally predicted - as early as this year.



Space Weather Prediction Center
National Oceanic and Atmospheric Administration

The National Oceanic and Atmospheric Administration (NOAA's) Space Weather Prediction Center is a comprehensive resource for monitoring space weather. The following nomenclature and "yardsticks" may be helpful in interpreting the data published by NOAA, for assessing the risk of high latitude travel, and/or for gauging the probability of aurora manifestations.

Solar Wind

The solar wind is a continuous stream of protons and electrons in a plasma state flowing outward from the Sun and throughout the solar system. Embedded in the plasma is the solar magnetic field.

The Earth's magnetic field deflects the solar wind with a majority of the charged particles channeled around the planet. Other worlds, like Mars without a global magnetic field, are not so fortunate and the solar wind is believed to be largely responsible for the loss of the planet's atmosphere. (Follow NASA's Mars Atmosphere and Volatile Evolution Mission or MAVEN mission for additional information on the processes involved in atmospheric erosion.)

Solar Flares

Solar flares are large eruptions of electromagnetic radiation originating from areas with strong magnetic fields, typically associated with sunspots. The energy from the flares travels at the speed of light and therefore reaches Earth in a matter of minutes. Scientists classify solar flares according to their X-ray brightness in the wavelength range of 1 to 8 Angstroms. Flares classes are: A, B, C, M, and X, with A being the weakest and X the strongest. Each category has nine subdivisions, for example, C1 to C9, M1 to M9, and X1 to X9. These are logarithmic scales, much like the seismic Richter scale, so an M flare is 10 times as strong as its counterpart C flare.

Coronal Mass Ejections

Coronal Mass Ejections (CMEs) are large eruptions of plasma originating from within the Sun's corona. A CME can contain billions of tons of coronal material and carry an embedded magnetic field. They travel much slower than flares. The fastest CMEs can reach the Earth in as little as 15-18 hours while the slower CMEs can take several days to arrive. Strong flares (M and X-class) are likely candidates to launch coronal mass ejections.

Solar Radiation Storms

Solar radiation storms occur when a large-scale magnetic eruption accelerates charged particles (for example, protons) in the solar atmosphere to very high velocities (large fraction of the speed of light). When they reach Earth, the protons penetrate the magnetosphere that shields Earth from lower energy charged particles and follow the Earth's magnetic field lines into the atmosphere near the north and south poles.

The NOAA Solar Radiation Storm Scale is used to indicate the severity of a radiation storm by considering the energy level of the particles heading towards Earth. The level is denoted by a "S" followed by a number from 1 to 5, with 1 being a minor event, and 5 an extreme event. An S2, or Moderate storm, has an elevated radiation risk to passengers and crew in high-flying aircraft at high latitudes. Health effects become more acute in a S3, S4 or S5 storm.

Geomagnetic Storm (G and Kp Indices)

Energy from the stream of particles from the Sun (even the solar wind) disturbs the Earth's geomagnetic field. The level of disturbance is measured by ground-based magnetometers at 13 geomagnetic observatories around the globe. A K-index scale, with a range from 0 to 9, is used to measure the fluctuation (relative to a quiet day) in the geomagnetic field over a three-hour interval. A value greater than 5 is indicative of a geomagnetic storm.

NOAAS Geomagnetic Storm Scale indicates the severity of geomagnetic storms (with a Kp value greater than 5). It is denoted by a G followed by a number from 1 to 5, with 1 being a minor event, and 5 an extreme situation.

Aurora

The aurora is a manifestation of geomagnetic activity or geomagnetic storm. The Aurora Borealis (Northern Lights) and Aurora Australis (Southern Lights) result from electrons colliding with oxygen and nitrogen atoms in Earth's upper atmosphere. In these collisions, the electrons transfer their energy and excite the oxygen and nitrogen atoms to a higher energy state. As the atoms return to a lower energy state, they release energy in the form of light.

Halloween Superstorm Aurora
from New Milford
Photo: Bill Cloutier

Despite being well past solar maximum, the Sun erupted in late October and early November 2003, unleashing a series of massive solar storms. Seventeen major flares exploded over a two week period, including perhaps the most intense flare ever measured - a huge X28 flare from sunspot 486.

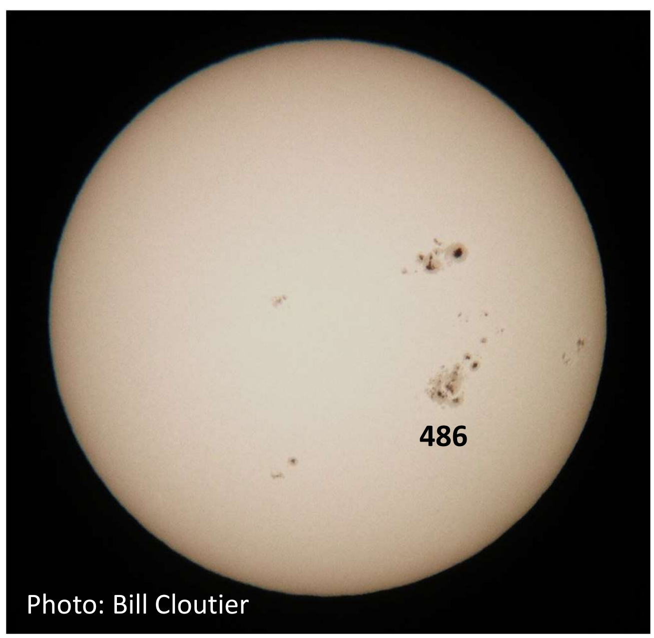


Photo: Bill Cloutier

Auroras were seen as far south as Texas and almost every flight over Earth's poles was rerouted to lower latitudes to avoid the radiation storm (astronauts on the ISS were directed to sheltered areas). Goddard's Space Science Mission Operations Team estimated that 59% of NASA's Earth and space science satellites were affected by the storm, with a large percentage of the instrumentation damaged beyond repair.

VERITAS Resurrected

An illustration of the VERITAS spacecraft. - NASA/JPL-Caltech

NASA's VERITAS mission (an acronym for Venus Emissivity, Radio Science, InSAR, Topography, and Spectroscopy), delayed and defunded as a result of the reallocation of resources to other projects at the Jet Propulsion Laboratory, has been given a new life in the agency's latest budget. With funding and a proposed launch date, the project can now get back on track.

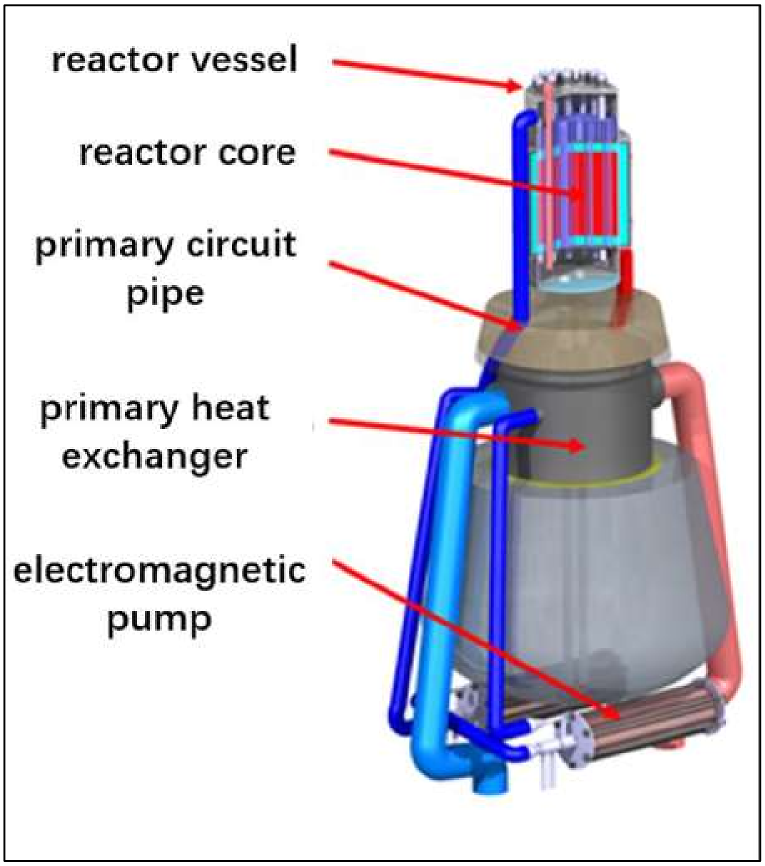
VERITAS was selected in 2021 as a Discovery mission, a lower cost, highly focused mission (similar to the Lucy and Psyche missions) rather than the more expensive and multifaceted Frontier or Flagship missions. The mission was originally slated for launch in 2027.

The newly proposed schedule for VERITAS would have the solar-powered orbiter launch in 2031. Arriving at Venus about seven months later, the spacecraft would be placed in a near-polar orbit, at a final science altitude of 250 miles (400 km). Among the mission objectives are the acquisition of global, high-resolution topographic and radar images of the planet; mapping the regions where geologic processes are actively changing the surface of Venus; generating a near-global map of surface rock composition; and determining whether the planet's core is a solid or liquid. The data collected by VERITAS would also be used to gather evidence for current volcanic activity. The science phase(s) of the mission are expected to last 3 Earth-years, or four Venus days.

While Venus in similar in size and mass to Earth (roughly 95% of Earth's diameter and 82% its mass), it evolved much differently. Shrouded by thick clouds, the planet is the hottest in our solar system with a surface temperature high enough to melt lead. With a day longer than its years, this slowly rotating world spins backwards compared to Earth. Any water that might once have existed on its surface has been vaporized long ago.

Chinese Nuclear Space Reactor

Chinese scientists have built a prototype engine for a nuclear-powered spaceship that could travel to Mars. The 1.5 megawatt-class, lithium-cooled fission reactor is designed to deploy from a container-sized package after launch to its final form, extending as tall as a 20-story building. If successful, it would be seven time more powerful than NASA's current design for a reactor that would operate in cis-lunar space (defined by the region bounded by Moon's orbit).



Schematic diagram of the ultra-small lithium-cooled space nuclear reactor (Song et al., 2021)

Development of the space reactor is a collaborative effort of more than 10 research institutes and universities across China. Liquid lithium was chosen as the coolant/ heat transfer medium due to the element's high thermal conductivity and low mass. A scale model has already passed several ground tests, according to a paper recently published in a Chinese Academy of Sciences' peer-reviewed journal.

Nuclear thermal propulsion is about twice as efficient as from chemical-fueled rockets and a power source of this magnitude would shorten the transit time between the Earth and Mars to as little as three months (less than half the time by current chemical propulsion means). Less time in space means less radiation exposure to the crew and less time in a weightless environment (and its adverse health effects on the human body).

The proposed reactor will operate at much higher temperatures than most commercial nuclear plants (operating in excess of 2,300°F or almost 1,300°C), necessitating the use of high-temperature and corrosion resistant alloys. China plans to use its Tiangong space station and other spacecraft to flight test and verify the emergent technologies and hardware. The current reactor design is anticipated to be able to provide continuous power for at least ten years.

One of the challenges of deploying a space-based reactor is ensuring public safety during launch and deployment. It is not clear if China has enacted such safeguards in their design at this time (NASA plans to keep its reactor inert until well after launch and conduct any demonstrations at a sufficiently high enough orbit to preclude reentry of the reactor until any fission products have substantially decayed to pre-launch levels).

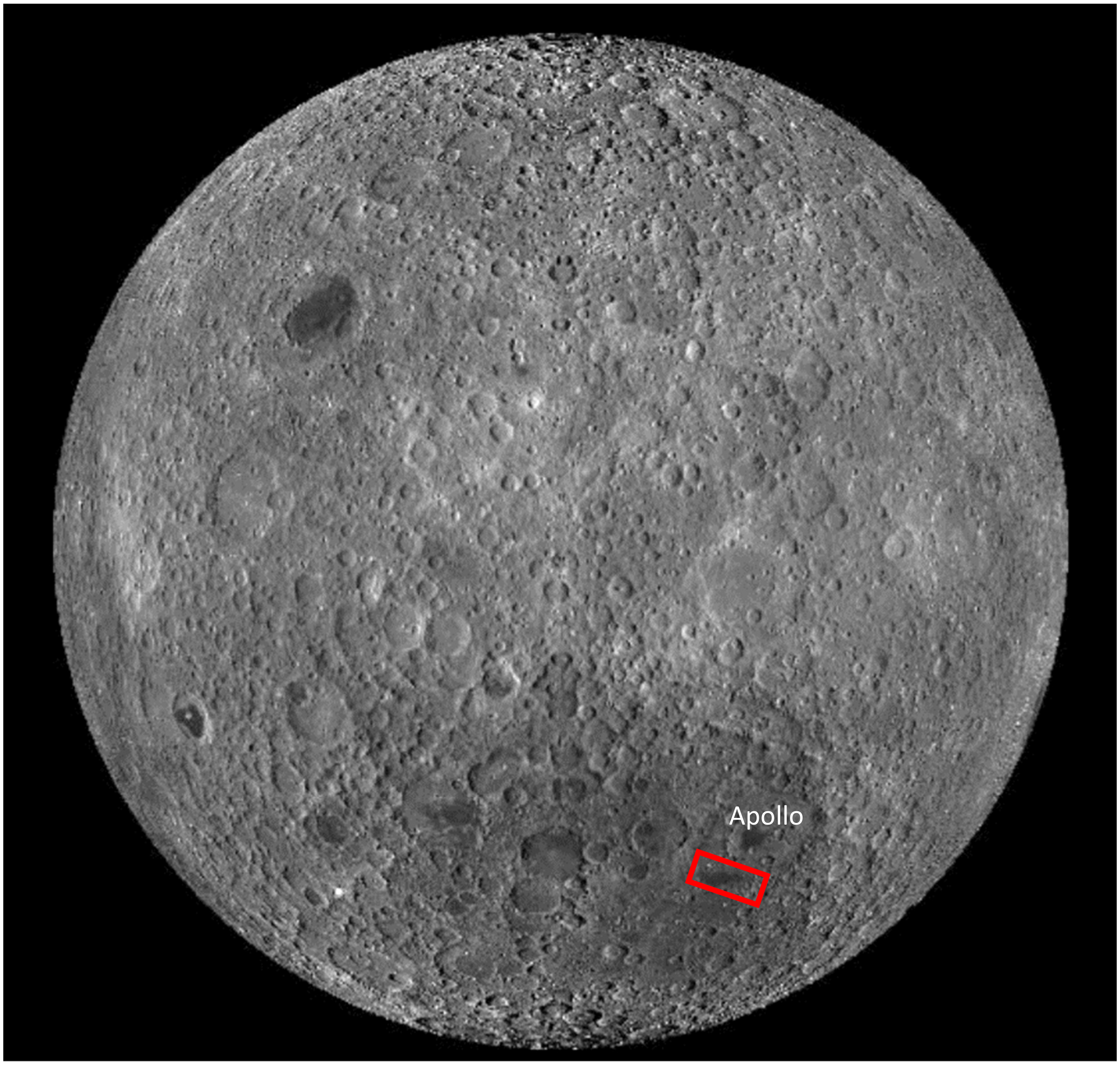
Chinese Lunar Relay Satellite Launched

China has launched a new relay satellite into lunar orbit to support its upcoming missions on the far side of the Moon and south polar region. Queqiao-2 or "Magpie Bridge-2" was launched on a Long March 8 rocket from China's Wenchang spaceport on March 20th.

The 2,645 pound (1,200 kg) communications satellite is equipped with a 13.8-foot (4.2 meter) parabolic antenna. Its orbit is designed to maintain a line of sight with both Earth ground stations and the future Chang'e-6 mission, which is destined for Apollo crater on the Moon's far side.

Queqiao-2 also carries three science payloads for studying near-Earth space, including an Energetic Neutral Atom Imager to image Earth's magnetotail, an Extreme Ultraviolet Camera for Earth's plasmasphere observations, as well as very-long-baseline interferometry measurement and observation experiment to improve the accuracy of determining the orbits of spacecraft in deep space. (The spacecraft's orbit will create a 250,000 mile or 400,000 km baseline between Queqiao-2 and radio telescopes on Earth.)

Chinese Far Side Sampling Mission



The far side of the Moon and the site (Apollo crater) targeted for the Chang'e 6 sample return mission. Red box indicates likely landing area.

Image: NASA/GSFC/Arizona State University

China's latest sample return mission (scheduled to launch in May) is targeting the southern portion of Apollo crater, located in the South Pole-Aitken (SPA) basin on the far side of the Moon. The massive ancient impact basin, roughly 1,600 miles (2,500-km) in diameter, was created over 4 billion years ago. Samples from this massive excavation could include material from the lunar mantle, providing insight on the composition and state of the Moon's interior.

This challenging mission could last as long as 53 days and require the support of a relay satellite for communications. Much like Chang'e-5, the goal is to return 2,000 grams (4.4 pounds) of material that may help explain why the two sides of the Moon are so dissimilar.

Virtual Flyby

Virtual reality image of Callisto as it would appear to the JUICE spacecraft in 2031
CREDIT: ESA/Airbus

The European Space Agency's (ESA) Jupiter Icy Moons Explorer (JUICE) still has another seven years to go before it arrives at Jupiter, including three flybys of the Earth (in August 2024, September 2026, and January 2029) for gravity assists. Despite being in the early stage of flight, the team at ESA is using the time to model, diagnose and solve potential issues that could be experienced by the spacecraft when it arrives in the Jovian system (when the great distance will preclude real-time communications).

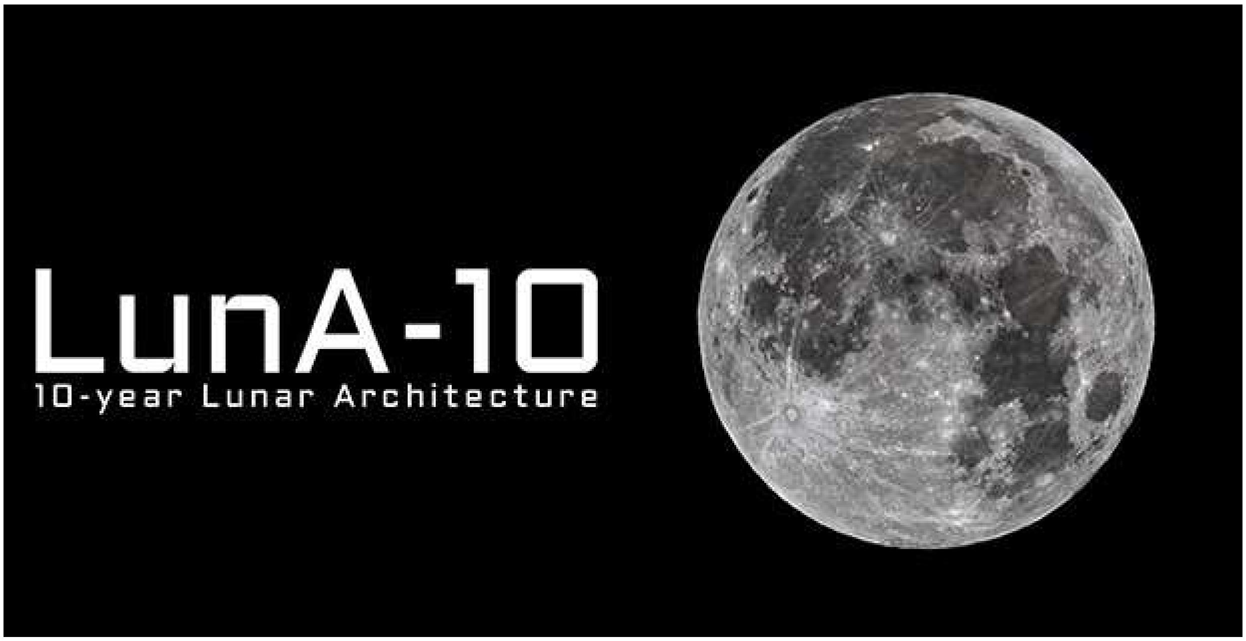
In April 2031, JUICE will fly past Jupiter's moon Callisto. To simulate the encounter, the team in Germany "tricked" its engineering model, with an exact copy of the spacecraft's software, electrical systems, and instruments that were sent into deep space, into thinking it had already arrived to put the spacecraft's autonomous navigation software to the test.

Computer-generated and high-resolution images of Callisto were used in the test, depicting the moon in the exact orientation and phase that JUICE will see when it arrives seven years from now. While Callisto's position in 2031 is well known, JUICE's instruments need to be pointed to a high degree of precision to make their measurements. To do so, the navigation camera needs to be able to identify specific features and make the necessary corrections for maximum scientific return.

Despite the challenges, JUICE's navigation software locked on to the correct regions of Callisto on the first attempt and safely maintained the correct trajectory throughout the simulated flyby. The team now has to confirm that the flight model will behave accordingly.

Lunar Railroad Evaluation

The Defense Advanced Research Projects Agency (DARPA) is a research and development agency of the Department of Defense. It identifies and promotes emerging technologies for use by the military (for example, developing an AI autonomously-flying F-16), although it has also partnered with NASA and commercial companies to bring those technologies to fruition (for example, on the development of nuclear-powered rocket engine that could be used to power spacecraft in cis-lunar space).



DARPA recently selected Northrop Grumman Corporation to further develop the concept of building a moon-based railroad network (as part of the broader 10-year Lunar Architecture Capability Study or LunA-10). In concept, the lunar railroad would transport humans, supplies and resources across the lunar surface.

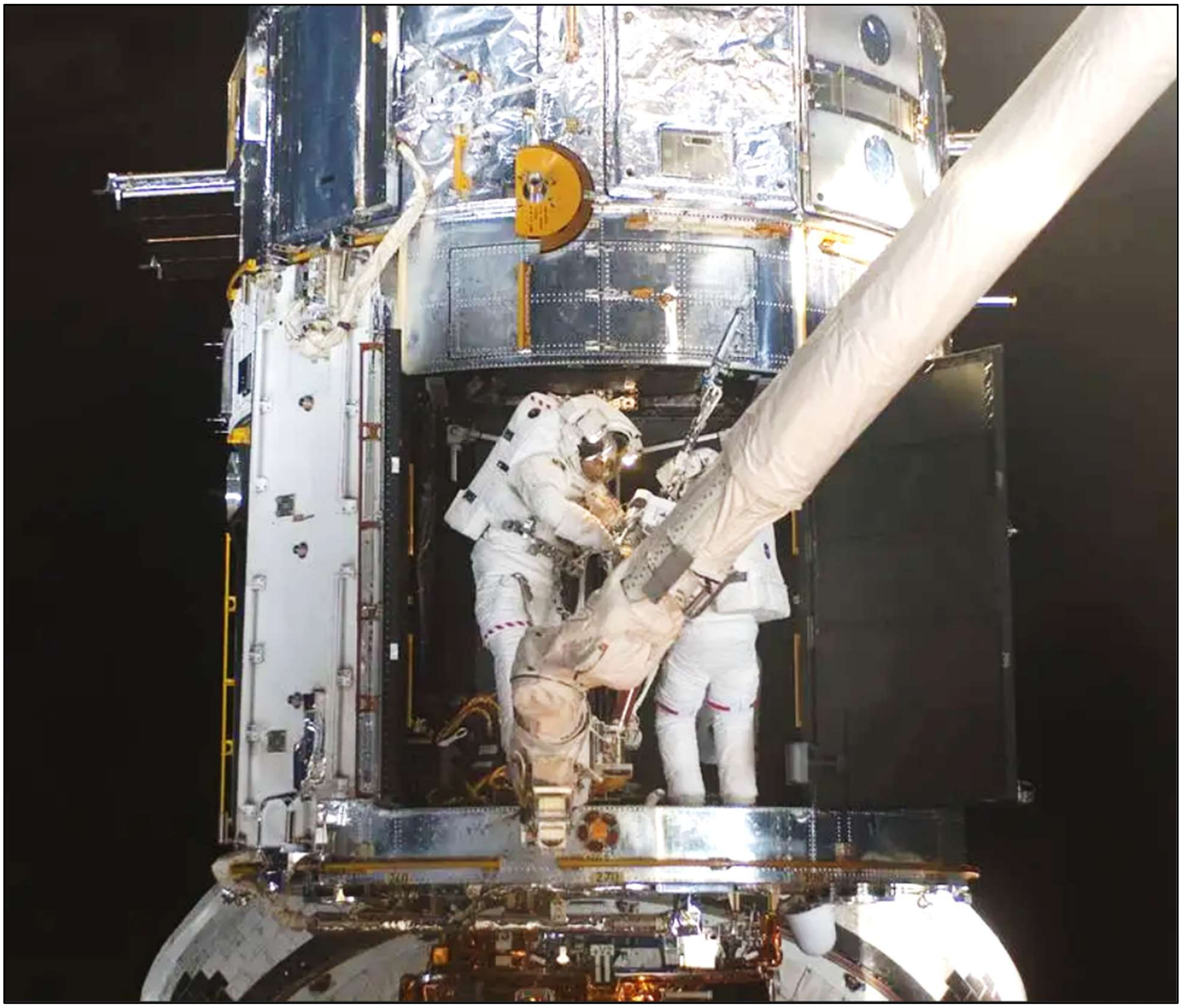
According to DARPA, the intent of the LunA-10 initiative is to "explore the rapid development of foundational technology concepts designed to move away from individual scientific efforts within isolated, self-sufficient systems and toward a series of shareable, scalable, resource-driven systems that interoperate – minimizing lunar footprint and creating monetizable services for future lunar users."

Northrop Grumman's charge is to:

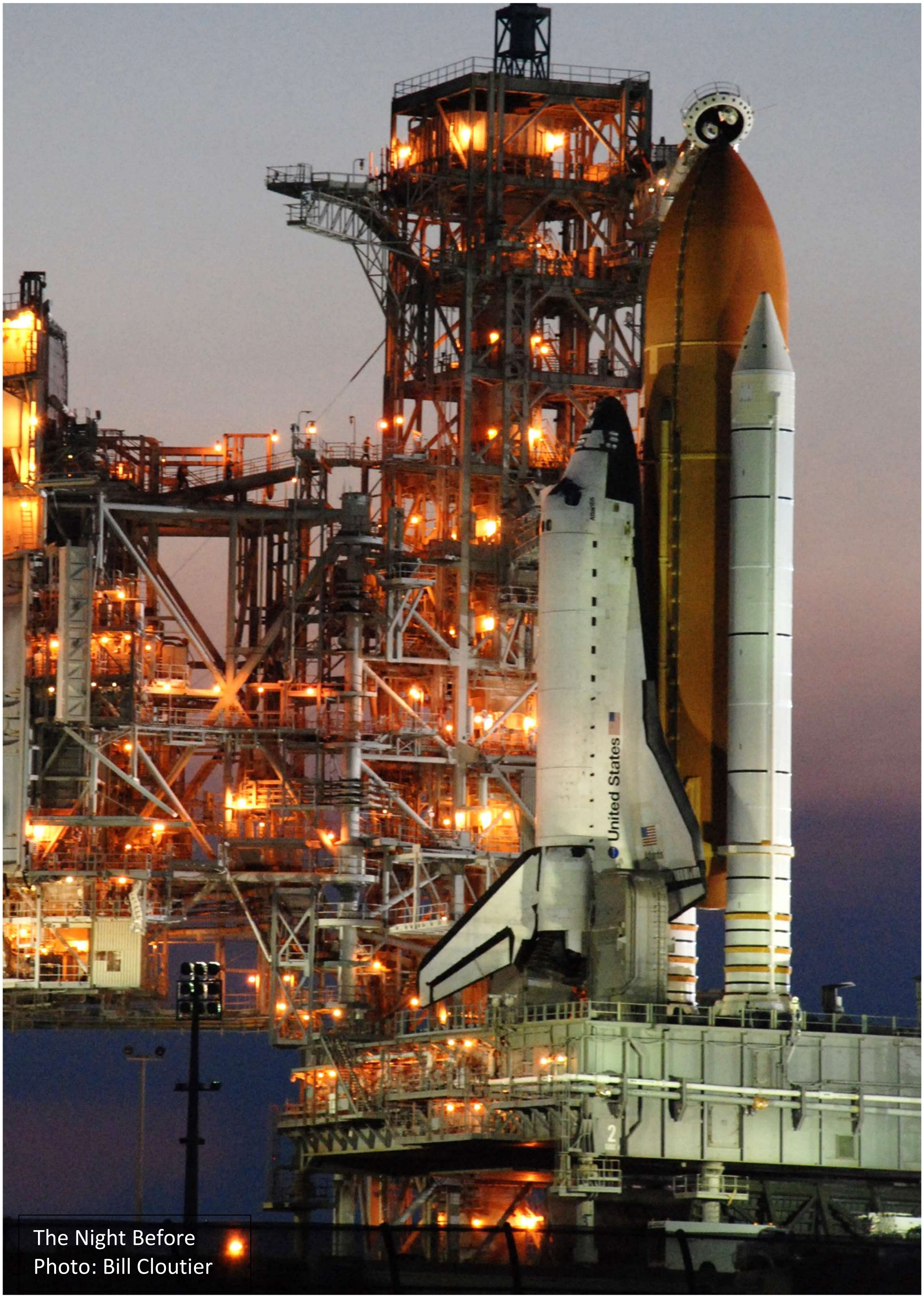
- "Define the interfaces and resources required to build a lunar rail network.
- Establish a critical list of foreseeable cost, technological and logistical risks.
- Identify prototypes, demonstrations and analyses of a fully operating lunar rail system's concept design and architecture.
- Explore concepts for constructing and operating the system with robotics, including grading and foundation preparation, track placement and alignment, joining and finishing, inspection, maintenance and repair."

Final Servicing Mission

Fifteen years ago, on May 11, 2009, the space shuttle Atlantis lifted off from Pad 29A at the Kennedy Space Center for its first visit to the Hubble Space Telescope and the telescope's last servicing mission. Atlantis ferried two new instruments to the telescope - the Cosmic Origins Spectrograph and the Wide Field Camera 3. The Atlantis crew repaired the Space Telescope Imaging Spectrograph (STIS) and the Advanced Camera for Surveys (ACS), replaced a Fine Guidance Sensor, six gyroscopes, and batteries. A new science computer was installed along with new insulation on three electronic bays. A soft-capture mechanism was added to the telescope's base to facilitate its de-orbiting at its end of operational life. The Atlantis crew included three astronauts that had visited Hubble on previous repair missions - Scott Altman (STS-109), John Grunsfeld, (STS-103 and STS-109) and Mike Massimino (STS-109).



Mission Specialists Michael Good (left) and Mike Massimino continued repairs and improvements to the Space Telescope Imaging Spectrograph during the mission's fourth spacewalk while the telescope is parked in the shuttle's cargo bay.
Photo credit: NASA



The Night Before
Photo: Bill Cloutier

Apollo 10

Apollo 10 was the second mission to orbit the Moon (Apollo 8 being the first) and the first lunar mission to include the Lunar Module (LM). The Saturn V rocket, carrying the Command Module (CM) named Charlie Brown and LM, named Snoopy, was launched on May 18, 1969.

Astronauts Thomas Stafford and Eugene Cernan flew the LM to within 47,000 feet (14,326 meters) of the lunar surface. The LM made two passes over the designated Apollo 11 landing site before jettisoning of the LM's descent stage (in preparation for the rendezvous with the CM). At that time, the ascent stage began to wildly gyrate and for three harrowing minutes, the spacecraft went into a near-fatal roll before Stafford could gain manual control. The cause was eventually traced to a switch being in the wrong position.

Mission commander Stafford pats the nose of Snoopy, the mission's mascot, held by Jamye Flowers, astronaut Gordon Coopers' secretary. Credit: NASA

Apollo 10 LM "Snoopy" Credit: NASA

Liftoff of Apollo 10 on May 18, 1969
Credit: NASA

Public Astronomy

Eighty-nine years ago, on May 14, 1935, the Griffith Observatory opened to the public and its ownership transferred to the City of Los Angeles. Located on the southern slope of Mount Hollywood in Griffith Park, the public facility is operated by the city's Department of Recreation and Parks, and has welcomed over 76 million visitors since opening.

A public observatory was the brainchild of Griffith J. Griffith, a Welsh immigrant who made his fortune in Mexican silver mines and California real estate. In 1896, he purchased and donated 3,015 acres to the city for a public park after visiting grand open spaces in Europe. In 1912, after a visit to the Mount Wilson observatory, Griffith offered the city $100,000 for a public observatory to be built on Mount Hollywood in Griffith Park. Griffith was quoted as saying "Man's sense of values ought to be revised. If all mankind could look through that telescope, it would change the world!"

Unfortunately, Griffith would not live to see his vision realized. Mired in political debate, work on the observatory didn't begin until 1933. However, guided by leading astronomers and scientists of the day, including astronomer George Ellery Hale, physicists Edward Kurth and Rudolph Langer, Adler Planetarium Director Philip Fox and Russell Porter, leader of the amateur telescope making movement, an observatory was constructed and dedicated two years later. The facility also included a planetarium. The planetarium was only the third of its kind in the United States; the technology was not even invented until four years after Griffith's death.

The Griffith Observatory is visible from many parts of Los Angeles, being located at an elevation of 1,134 feet above sea level. It is one of the most popular attractions in Southern California.

May Showers

The *Eta Aquarids* meteor shower peaks in the early mornings of the 5th and 6th. The dust producing the shooting stars is from *Comet Halley*. As with all meteor showers, the Aquarids are named for the constellation (Aquarius) from which they appear to radiate. Typically, you can expect to see up to 20 meteors per hour. An almost New Moon will provide dark skies for viewing the shower this year.

Sunrise and Sunset (from New Milford, CT)

	Sunrise	Sunset
May 1st (EDT)	05:49	19:52
May 15th	05:33	20:06
May 31st	05:22	20:21

May Nights

For those who do their stargazing early in the evening, a myriad of spectacular objects appear out of the twilight, winking into view as the Earth turns away from the Sun. Leo dominates the southwestern sky with its reverse question mark arrangement of stars, punctuated by the star Regulus, forming the front of the lion, and a triangular arrangement of stars forming the back or tail of the creature. To the west of Leo is an open star cluster called the Beehive (M44) in the constellation Cancer. On a dark night it can be seen with the naked eye. East of Leo, towards the constellation Boötes is the globular cluster M3. Boötes is easily identified by its bright star

Arcturus. Follow the arc in the handle of the Big Dipper to find Arcturus, at the base of the kite-shaped constellation. M3 is located further away than the center of our galaxy, the Milky Way, and is one of the many outstanding globular clusters that will grace the late spring and summer skies.

Astronomical and Historical Events

1st Last Quarter Moon
1st History: Goddard Space Flight Center established (1959)
1st History: discovery of Saturn's moon *Daphnis* by the Cassini spacecraft (2005)
1st History: discovery of the Mars meteorite *Dar al Gani 476* (1998)
1st History: discovery of Neptune's moon *Nereid* by Gerard Kuiper (1949)
2nd Close approach of Apollo class asteroid and Near-Earth Object 2022 AA5
2nd History: discovery of the first binary star (Xi Ursae Majoris) by William Herschel (1780)
4th Star Wars Day
4th History: launch of the AQUA satellite to study precipitation, evaporation, and the cycling of Earth's water (2002)
4th History: launch of the Magellan/Venus radar mapping spacecraft and attached Inertial Upper Stage from the space shuttle Atlantis (STS-30) (1989)
4th History: launch of Lunar Orbiter 4 for photographic evaluation of Apollo and Surveyor landing sites (1967)
5th Moon at perigee (closest distance from Earth)
5th *Eta Aquarids* meteor shower peak (best viewing: early morning on the 5th and 6th)
5th History: launch of NASA's InSight spacecraft (Mars lander) from the Vandenberg Air Force Base, California (2018)
5th History: launch of Freedom 7 and astronaut Alan Shepard aboard a Mercury-Redstone rocket, first American in space (1961)
6th Scheduled launch of Boeing's CST-100 Starliner spacecraft on its first mission with NASA astronauts Butch Wilmore and Suni Williams to the International Space Station. The spacecraft will launch on a United Launch Alliance Atlas 5 rocket from the Cape Canaveral Space Force Station, Florida
6th History: groundbreaking for the John J. McCarthy Observatory, a world-class observatory in New Milford, CT., with a mission to promote science literacy (2000)
7th New Moon
9th History: launch of MUSES-C (Hayabusa), Japanese sample return mission to asteroid *Itokawa* (2003)
9th History: first Earth-based laser aimed at the Moon: crater Albategnius (1962)
9th History: launch of first production model of the Project Mercury capsule from Wallops Island, Virginia to test the escape system (1960)
10th Close approach of Apollo class asteroid and Near-Earth Object 2021 JG9
10th History: OSIRIS-REx departs asteroid Bennu for Earth (2021)
10th History: President Truman signs Public Law 507, creating the National Science Foundation (1950)
10th History: Estherville Meteorite Shower: a 455-pound meteorite fell to earth in Emmet County, just north of Estherville, Iowa, where it buried itself 15 feet in the ground - largest meteorite known to have fallen in North America (1879)
11th **Second Saturday Stars - Open House at McCarthy Observatory**

Astronomical and Historical Events (continued)

11th History: launch of the space shuttle Atlantis (STS-125), final Hubble Space Telescope servicing mission (2009)
12th History: first planetarium (Adler Planetarium in Chicago) opens in United States (1930)
13th Close approach of Apollo class asteroid and Near-Earth Object 2015 KJ19
13th History: launch of first Project Bumper rocket from White Sands, NM; the two stage rocket was a combination of a German V-2 and American WAC Corporal rocket (1948)
14th Close approach of Apollo class asteroid and Near-Earth Object 2014 WF6
14th Close approach of Aten class asteroid and Near-Earth Object 2021 JN10
14th Close approach of Amor class asteroid and Near-Earth Object 2021 JJ
14th History: Griffith Observatory, one of the first institutions in the U.S. dedicated to public science, opens in Los Angeles (1935)
14th History: launch of the Herschel infrared telescope and the Planck microwave observatory (2009)
14th History: launch of Skylab, the United States' first space station (1973)
14th History: the American Interplanetary Society (later renamed the American Rocket Society) launches its first liquid fueled (liquid oxygen and gasoline) rocket from Staten Island, N.Y. (1933)
14th History: German Society for Space Travel (Verein für Raumschiffahrt or VfR) launches the Repulsor-1, a liquid fueled (liquid oxygen and gasoline) rocket (1931)
14th History: Orgueil meteorite shower: large carbonaceous chondrite that disintegrated and fell in fragments near the French town of Orgueil; presence of organics renewed the debate on spontaneous generation as the origin of life; fragments analyzed by the French chemist Louise Pasteur for indigenous microorganisms (1864)
15th First Quarter Moon
15th History: discovery of Pluto's moons *Nix* and *Hydra* by Hal Weaver, et al's (2005)
15th History: sixth docking of a space shuttle (Atlantis) with Russian space station Mir (1997)
15th History: launch of Faith 7 and astronaut Gordon Cooper aboard a Mercury-Atlas rocket, final Mercury mission (1963)
15th History: Soviet Union launches Sputnik IV containing a self-sustaining biological cabin and dummy astronaut (1960)
16th History: launch of the space shuttle Endeavor to the International Space Station on its final mission (2011)
16th History: Soviet spacecraft Venera 5 returns 53 minutes of data while descending by parachute through the atmosphere of Venus and before impacting the surface (1969)
17th Moon at apogee (furthest distance from Earth)
17th Close approach of Apollo class asteroid and Near-Earth Object 2022 WN2
17th History: Soviet spacecraft Venera 6 returns 51 minutes of data while descending by parachute through the atmosphere of Venus and before impacting the surface (1969)
17th History: discovery of Jupiter's cloud belts by Italian Jesuit, astronomer, and physicist Niccolo Zucchi (1630)
18th History: launch of Apollo 10 with astronauts John Young, Tom Stafford and Gene Cernan; the lunar module Snoopy was flown within 50,000 feet of the lunar surface while the command module Charlie Brown orbited the Moon (1969)
19th History: launch of the Mars 2 orbiter/lander (which subsequently crashed) (1971)
19th History: launch of the first Army Hermes A-1 rocket from White Sands, NM (1950)

Astronomical and Historical Events (continued)

19th History: oldest recorded meteorite fall, a 472-gram, ordinary chondrite, falls in Nogata, Japan (861 AD)
20th History: launch of the Japanese Venus Climate Orbiter Akatsuki or Planet-C spacecraft and the Ikaros solar sail (2010)
20th History: launch of the Pioneer Venus 1 spacecraft (1978)
21st Close approach of Apollo class asteroid and Near-Earth Object 2019 VB5
22nd History: launch of the GRACE Follow-On spacecraft from the Vandenberg Air Force Base, California. The tandem satellites tracking Earth's water movement and changes in sea level.
22nd History: launch (and recovery) of monkeys Patricia and Mike on an Aerobee rocket, reaching a record altitude of 30 miles (1952)
23rd Full Moon (Full Flower Moon)
24th History: discovery of Neptune's moon Larissa by Stephen Synnott, Harold Reitsema, and David Tholen (1981)
24th History: launch of Aurora 7 and astronaut Scott Carpenter aboard a Mercury-Atlas rocket; second American to orbit Earth (1962)
24th History: launch of Midas 2; first Experimental Infrared Surveillance Satellite (1960)
24th History: Russian civil engineer Ivan Yarkovsky born. Proposed idea that heat radiated from rotating bodies, such as asteroids, would generate a small force which over time could change the orbit (1844)
25th Towel Day - Annual Tribute to Douglas Adam
25th History: Phoenix spacecraft lands in the Martian arctic (2008)
25th History: launch of first Skylab crew; astronauts Pete Conrad, Paul Weitz and Joseph Kerwin (1973)
25th History: President John F. Kennedy's Moon goal speech to Congress (1961)
25th History: science fiction writer and futurist Arthur C. Clark proposes communication satellites in geosynchronous orbit (1945)
25th History: first recorded perihelion passage of comet Halley by Chinese astronomers (240 BC)
26th Main belt asteroid 253587 Cloutier, discovered by the McCarthy Observatory, closest approach to Earth (1.497 AU)
26th History: launch of the first "Navaho Missile," a pilotless aircraft consisting of a missile and a booster; program goal was to determine the feasibility of an intercontinental missile (1948)
28th Close approach of Aten class asteroid and Near-Earth Object 2008 LD
28th Close approach of Apollo class asteroid and Near-Earth Object 2021 LV
28th History: launch of Mars 3 (USSR) lander and rover; lander became the first spacecraft to attain soft landing on Mars, although transmissions ceased after 15 seconds (1971)
28th History: launch of an Army Jupiter missile carrying two primates (Able and Baker) to an altitude of 300 miles; monkeys survived the flight (1959)
28th History: Frank Drake born - radio astronomer devised the "Drake Equation" as an attempt to estimate the number of worlds in our galaxy that might harbor intelligent life (1930)
29th History: Solar Eclipse observations (specifically, positions of stars in the vicinity of the Sun) used to confirm Einstein's General Theory of Relativity (1919)

Astronomical and Historical Events (continued)

29th History: launch of Luna 22 (USSR), lunar orbiter mission that included imaging as well as studying the Moon's magnetic field, the composition of lunar surface rocks, and the gravitational field (1974)
29th History: measurements during solar eclipse agree with predictions based on Einstein's General Relativity theory (1919)
30th Last Quarter Moon
30th History: launch of SpaceX's Crew Dragon with astronauts Doug Hurley and Bob Behnken to the International Space Station from the Kennedy Space Center. Designated Demo 2, it was the first launch of the spacecraft with astronauts aboard. (2020)
30th History: launch of Mariner 9, Mars orbiter and first artificial satellite of Mars; mapped Martian surface and imaged moons *Phobos* and *Deimos* (1971)
30th History: launch of Surveyor 1, Moon lander; transmitted over 11,000 images from Oceanus Procellarum (1966)
31st History: European Space Agency's birthday (1975)

Commonly Used Terms

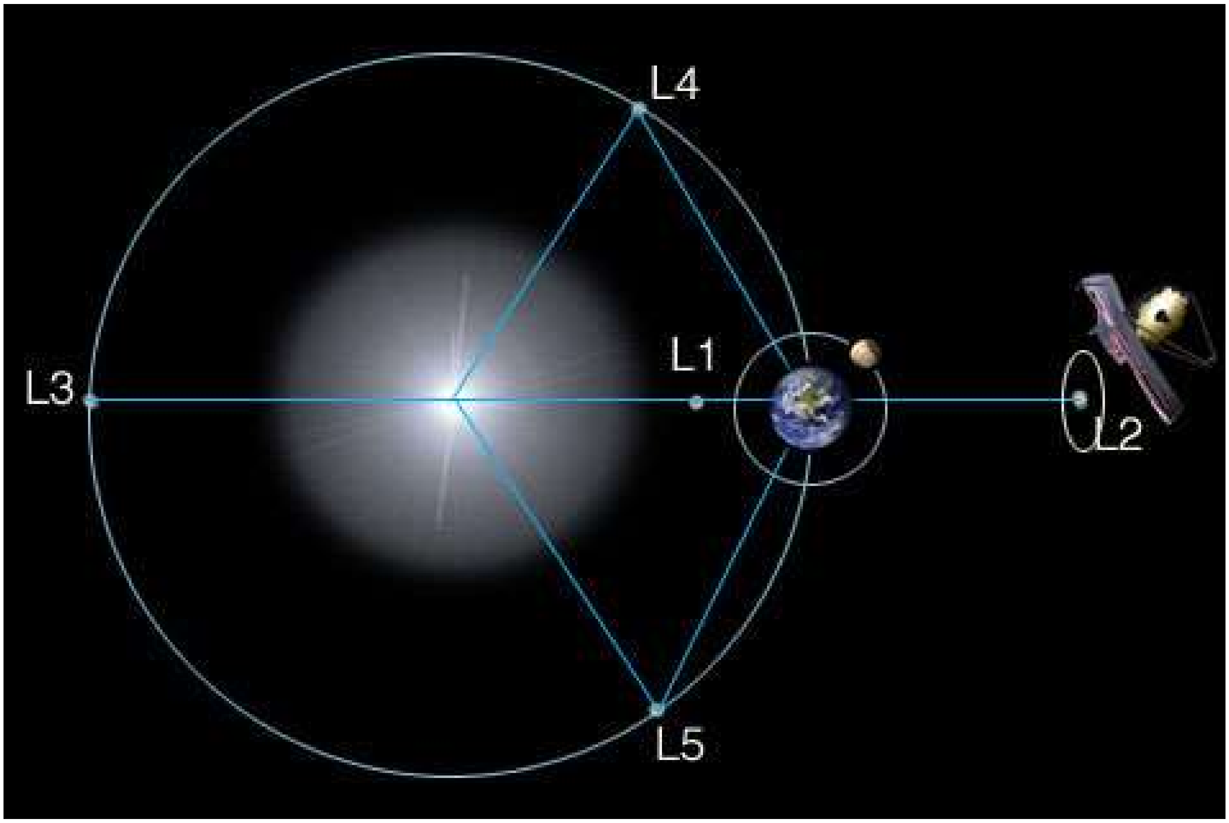
- Apollo: a group of near-Earth asteroids whose orbits also cross Earth's orbit; Apollo asteroids spend most of their time outside Earth orbit.
- Aten: a group of near-Earth asteroids whose orbits also cross Earth's orbit, but unlike Apollos, Atens spend most of their time inside Earth orbit.
- Atira: 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

Lagrange Points

Five locations discovered by mathematician Joseph Lagrange where the gravitational forces of the Sun and Earth (or other large body) and the orbital motion of the spacecraft are balanced, allowing the spacecraft to hover or orbit around the point with minimal expenditure of energy. The L2 point (and location of the Webb telescope) is located 1 million miles (1.5 million km) beyond the Earth (as viewed from the Sun).



James Webb Space Telescope

https://webb.nasa.gov/index.html

Euclid Space Telescope

https://www.esa.int/Science_Exploration/Space_Science/Euclid

International Space Station and Artificial Satellites

- www.heavens-above.com for the times of visibility and detailed star charts for viewing the International Space Station and other manmade objects.

Solar Activity

- For the latest on what's happening on the Sun and the current forecast for flares and aurora, check out www.spaceweather.com

NASA's Global Climate Change Resource

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

Mars – Mission Websites

- Mars 2020 (Perseverance rover): https://mars.nasa.gov/mars2020/
- Mars Science Laboratory (Curiosity rover): https://mars.nasa.gov/msl/home/
- Mars Atmosphere and Volatile EvolutioN (MAVEN): https://science.nasa.gov/mission/maven/

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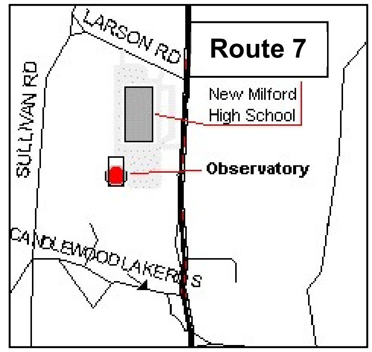

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