Galactic Observer

John J. McCarthy Observatory

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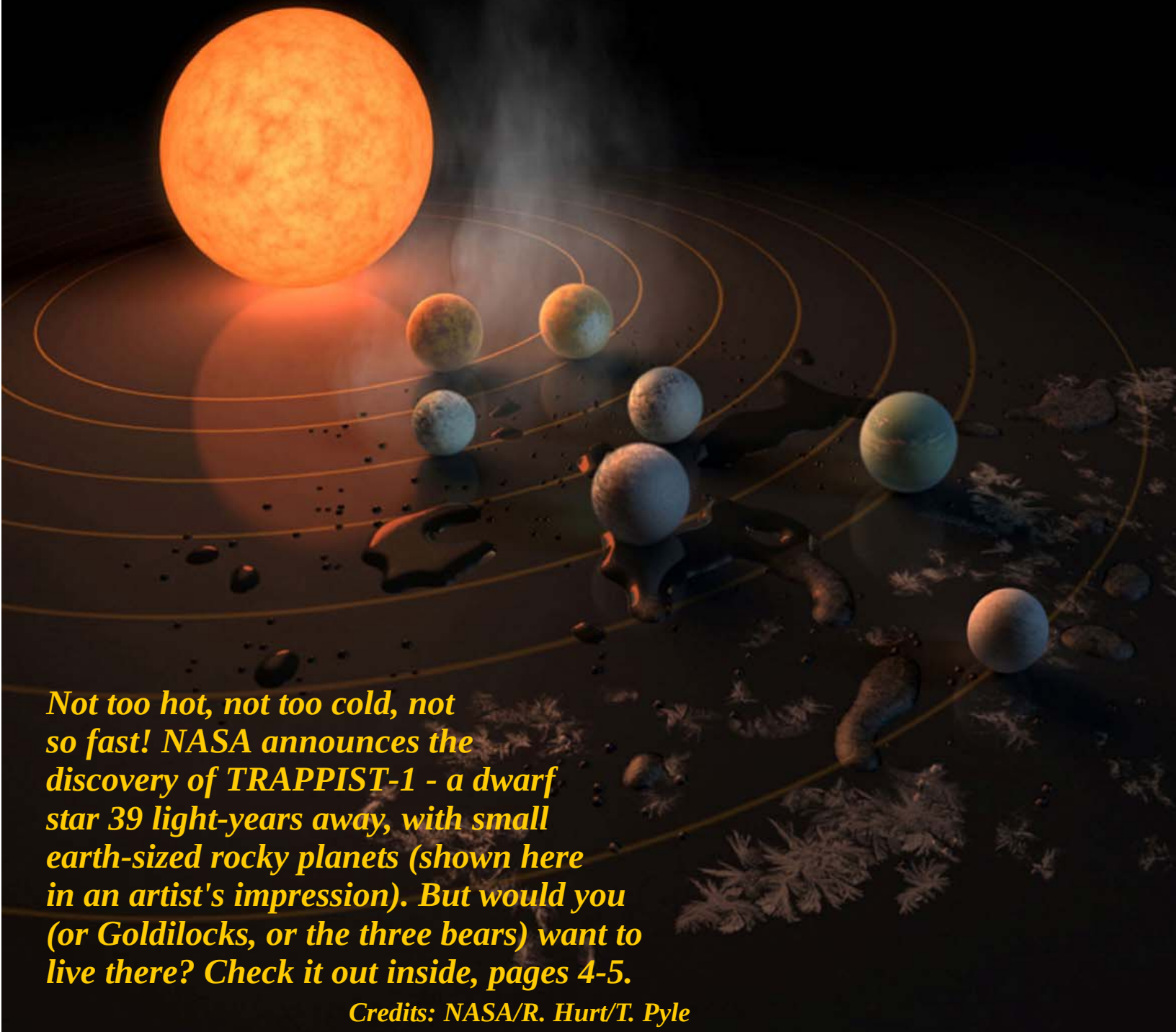

Not too hot, not too cold, not so fast! NASA announces the discovery of TRAPPIST-1 - a dwarf star 39 light-years away, with small earth-sized rocky planets (shown here in an artist's impression). But would you (or Goldilocks, or the three bears) want to live there? Check it out inside, pages 4-5.

Credits: NASA/R. Hurt/T. Pyle

The John J. McCarthy Observatory

New Milford High School
388 Danbury Road
New Milford, CT 06776

Phone/Voice: (860) 210-4117
Phone/Fax: (860) 354-1595
www.mccarthyobservatory.org

JJMO Staff

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

Steve Barone
Colin Campbell
Dennis Cartolano
Mike Chiarella
Jeff Chodak
Bill Cloutier
Doug Delisle
Cecilia Detrich
Dirk Feather
Randy Fender
Louise Gagnon
John Gebauer
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Tina Hartzell
Jim Johnstone
Carly KleinStern
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Parker Moreland, PhD
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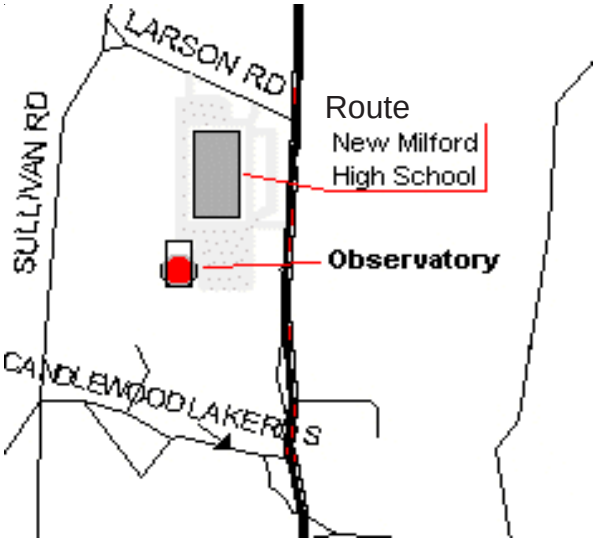


In This Issue

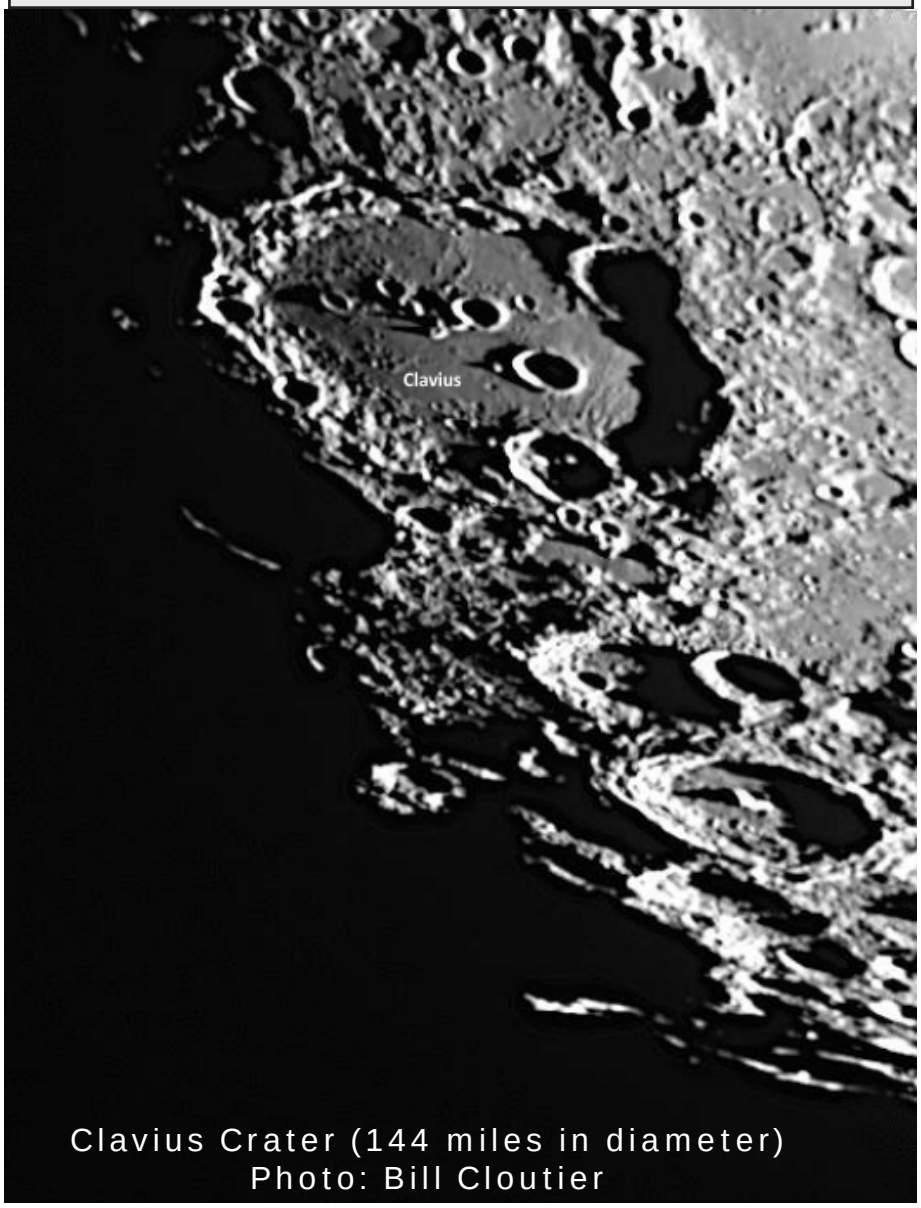
April Astronomy Calendar and Space Exploration Almanac

"Out the Window on Your Left"

IT'S BEEN ALMOST 45 years since we left the last footprint 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 beans 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).

On April 2, 1968, Metro-Goldwyn-Mayer (MGM) released the now classic science fiction film "2001: A Space Odyssey." The film, premiered shortly before the first manned missions to the Moon, was based on a screenplay co-developed by producer Stanley Kubrick and author Arthur C. Clarke and inspired by a short story that Clarke had written in 1948 called "The Sentinel." The storyboard assumed that mankind would establish a permanent colony and research base on the Moon by the year 2001. In reality, since 1972, U.S. astronauts have not left low-Earth orbit (venturing only as far as 350 miles to service the Hubble Space Telescope), and since 2011 have relied upon Russian rockets for rides to and from the International Space Station.

Clavius Crater
(location of the fictional Clavius Base in the movie 2001: A Space Odyssey)



Clavius Crater (144 miles in diameter)
Photo: Bill Cloutier

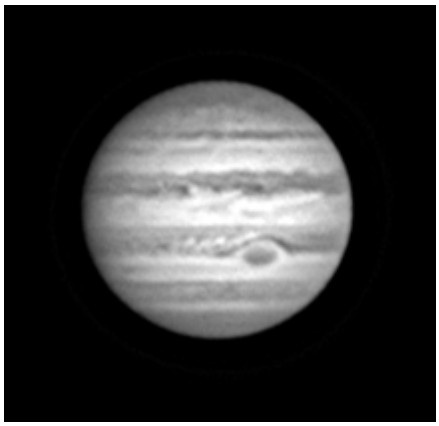
There is renewed interest in returning to our celestial neighbor. On Feb. 3, 2017, a bill was referred to the U.S. House of Representatives Committee on Science, Space, and Technology that would direct NASA to "return to the Moon by 2023 and to develop a sustained human presence there in order to promote exploration, commerce, science, and U.S. preeminence in space as a stepping stone for future exploration of Mars and other destinations."

In the private sector, SpaceX announced that it will send two private customers on a circumlunar flight in 2018 in a crewed version of the Dragon capsule and its Falcon Heavy booster. Jeff Bezos' Blue Origin rocket company has been promoting its New Glenn booster, including a potential adaptation that could deliver up to 10,000 pounds of supplies to a future moon base (with Amazon reliability). Bigelow Aerospace has been developing a lunar lander that could deliver its 12,000 cubic foot inflatable modules to the Moon's surface and designing a moon base that would integrate three of its modules.

China's goal of a manned mission to Moon by 2032 is predicated on the development of its Long March 9 booster, which will be the world's most powerful rocket when it flies. In the interim, the Chinese have been testing the landing gear for a future lunar landing module. While Russia has floated plans for a manned mission in the 2029-2030 timeframe, it has also expressed interest in establishing a cislunar habitat or waystation.

Jupiter at Opposition

The Earth comes between the Sun and Jupiter in its orbit on April 7th (an arrangement known as Opposition with Jupiter opposite the Sun as viewed from Earth). On that day, Jupiter will rise with the setting Sun and be visible all night, appearing highest in the south at



midnight. Jupiter will remain in the evening sky until late October when it passes behind the Sun (superior conjunction).

Jupiter can be found in the constellation Virgo. At magnitude -2.3, it will be one of the brightest star-like objects in night sky. On April 7th, the gas giant will be 414.2 million miles (4.455 AU) from Earth or 37 light minutes.

Jupiter reaches Opposition every 399 days (on average), about a month later each successive year. It is one of the only planets that displays surface (atmospheric) details through a moderately sized telescope. With its rapid rotation (approximately every 10 hours), the planet's cloud belts and storms provide the observer with an ever-changing, dynamic display.

Jupiter's four Galilean moons (discovered by Galileo in 1610) appear as stars along the planet's equatorial plane. Their motion is discernable over the course of a single night. The three inner moons, Io, Europa and Ganymede, are tidally locked with one hemisphere always facing Jupiter. In their synchronistic orbits, Io completes four orbits of Jupiter (in 1.77 days) and Europa two orbits of Jupiter (in 3.55 days) in the time Ganymede completes one orbit (in 7.2 days). Furthest from Jupiter, Callisto, the fourth Galilean moon, is tidally locked but not in orbital resonance with the inner three Galilean moons.

Ganymede is Jupiter's largest moon, with a diameter greater than the planet Mercury. Callisto has the oldest and most heavily cratered surface while Io has one of the youngest being the most volcanically active world in the solar system.

Three of the four Galilean moons (excluding Io) may have subsurface oceans. Europa will be the target of several future missions, including ESA's *Jupiter Icy moons Explorer* and NASA's *Europa Clipper*.

Since Europa is embedded in Jupiter's magnetosphere, the Europa Clipper will spend a majority of its time outside the high radiation regions, diving in for brief flybys of the icy moon. If the mission includes a lander, it could park in a safe, low radiation orbit until a suitable landing area on Europa can be identified or follow the orbiter with a separate launch.

A Mini Solar System

In May 2016, astronomers, using the Transiting Planets and Planetesimals Small Telescope (TRAPPIST) in Chile, announced that they had discovered three planets orbiting an ultra-cool dwarf star in the constellation Aquarius, approximately 39 light years from Earth. Several large ground-based telescopes confirmed the existence of two of the TRAPPIST discoveries and detected five additional planets around the Jupiter-sized star.

In the fall of 2016, the Spitzer infrared space telescope observed the newly discovered solar system

for almost 500 hours as the seven planets paraded in front of (transited) the star. The near-continuous observation campaign allowed the Spitzer team to develop estimates of the size and masses of six of the worlds (estimates for the outermost world have not been completed). With size and mass, estimates of each planet's density was possible.

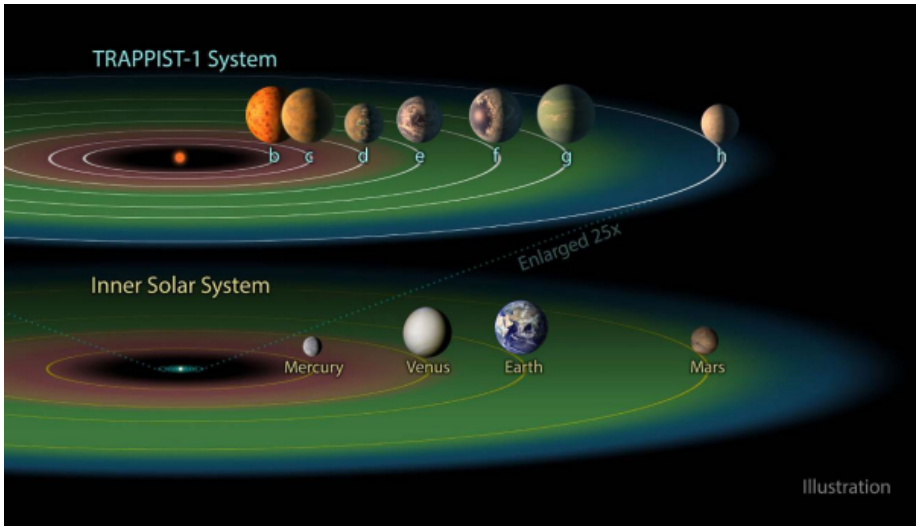
The seven planets are all Earth size, with the largest 1.13 times the size (relative to Earth), and the smallest .76 times the size. The worlds are thought to be rocky based on their density, and after preliminary observations by the Hubble Space Telescope failed to detect extended, hydrogen-dominated atmospheres, typical of a gas or ice giant like Neptune.

The dwarf star is much smaller and cooler than our Sun. The planets are also much closer to their star (well within the orbit of Mercury) with orbital periods ranging from about 1.5 days to 20 days). The planets are so close to one another that geologic features could be visible on the nearest ones as viewed from the surface of an adjacent world.

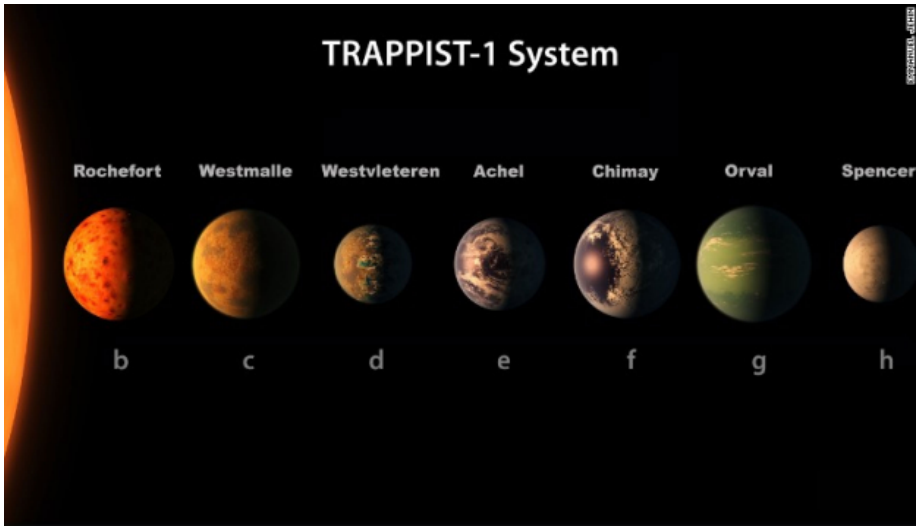
Three of the worlds are located in the star's habitable zone – at a distance where liquid water could exist on the surface. Several of the planets could be tidally locked, presenting only one hemisphere to the star. If liquid water pooled on the surface of the illuminated hemisphere, it might well be frozen on the side in perpetual darkness.

With the launch of the James Webb Space Telescope in 2018, astronomers will be able to assess the potential for the TRAPPIST-1 solar system to support life. The increased sensitivity of the telescope and its instruments can be used to study the atmospheres of the exoplanets, detecting chemical components that relate to habitability (e.g., water vapor, methane, oxygen and ozone).

On a lighter note, researchers have informally named the new planets after Trappist breweries. Six of the planets are named after monastery breweries in Belgium, the seventh after a Trappist brew produced by a monastery in Spencer, Massachusetts.



Artist conception of the view from TRAPPIST-1f (the fifth planet from the dwarf star). Image Credit: NASA/JPL-Caltech

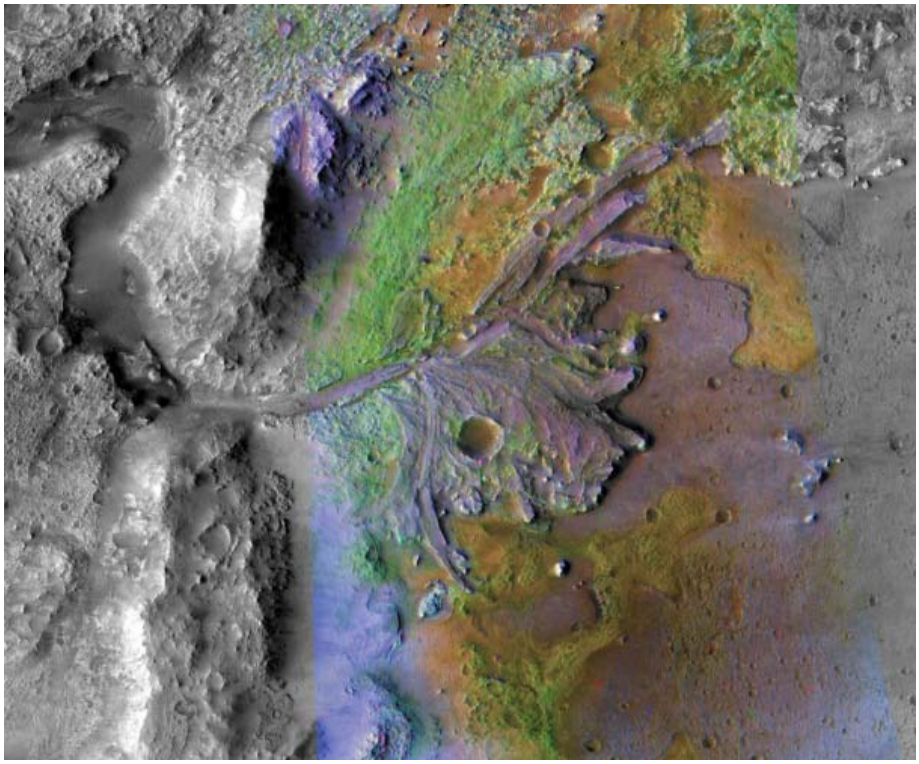


Final Selections for Mars 2020 Landing Sites

In February, NASA held its third Mars 2020 Landing Site Workshop. Participants reviewed the eight candidate sites selected at the previous workshop (culled from an initial list of 30). Sites considered were the Columbia Hills (explored by the Spirit rover between 2004 and 2010), Eberswalde crater (ancient river delta), Holden crater (ancient alpine lakes), Jezero crater (ancient river delta), Mawrth valley (ancient water-carved channel), Melas (canyons), NE Syrtis, and Nili Fossae (methane detected?). The 200+ scientists and engineers assessed the eight sites against criteria that included:

- astrobiologically-relevant (probability of past habitability and potential that the biosignature(s) would be preserved)
- sample diversity (rocks and regolith with potential to yield fundamental scientific discoveries if returned to Earth in the future)
- traversability (confidence that the site can be adequately investigated within the prime mission)
- environment (conditions, including temperature, that would affect rover and equipment operations as well as maintain and preserve indicators of ancient life)
- water-rich (potential for significant water resources available for future exploration)

Since the Mars 2020 rover may be tasked with caching a limited number of samples to be returned to Earth by a future mission, the selection of a site based upon the collective experience from exploring Mars and the interpretation of the data that meets those criteria is critical to mission success. As a result of the deliberations, five of the eight sites were eliminated, leaving Jezero Crater and NE Syrtis as the top candidates, with the Columbia Hills needing further evaluation.



A false color image of the delta emptying into Jezero Crater
Credit: ASA/JPL/JHUAPL/MSSS/Brown University

The Jezero site includes a well-defined delta that empties into a crater that had been flooded with water (possibly on multiple occasions). The crater, which may contain sediments from ancient rivers, dates back to the Noachian age (4.1 to 3.7 billion years ago). The crater is approximately 30 miles (49 km) in diameter and located at a latitude of approximately 19° N in the Syrtis Major region. It is the oldest of the three candidate sites and orbital surveys have indicated the presence of clay minerals in the lakebed sediment.

The nearby NE Syrtis region (just to the south of Jezero) is home to several large shield volcanoes. Volcanic activity could have heated subsurface water, which in turn would have reacted with minerals in the surrounding rock to provide an environment comparable to that found around geothermal hot springs. Warm and mineral rich conditions would have been suitable for propagating microbial life.

The discovery of suspected hydrothermal deposits in the exploration of the Columbia Hills by the Mars Exploration Rover Spirit and the diversity of volcanic rocks kept the site in contention. However, since the site had already been explored by arover,workshop participants raised concerns on whether revisiting the site would yield additional fundamental scientific discoveries, particularly if the hot spring hypothesis turned out to be incorrect.

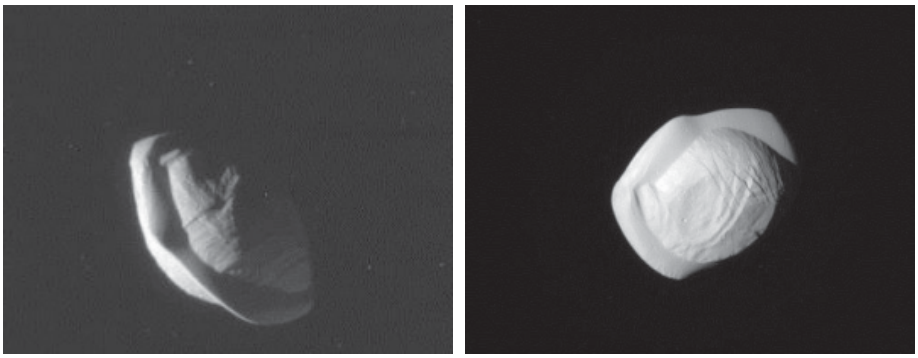
Pan

The Cassini project is heading for a September 15th conclusion and grand finale encounter with Saturn's atmosphere. The spacecraft, which arrived at Saturn in 2004, is currently traveling in a polar, outer ring-grazing orbit. On April 22nd, the spacecraft will use a flyby of Saturn's largest moon Titan to modify its orbit to one that

dives between the planet and the rings. The first pass through this gap is scheduled for April 26th (at 2 am PDT). Twenty-two orbits later, if the spacecraft survives multiple transits of the gap (using its high gain antenna as a dust and particulate shield), Cassini will plunge into Saturn's atmosphere.

Cassini's camera recently captured a close-up view of Pan, Saturn's innermost moon. The flying saucer shaped moon is only 16.6 miles (28.2 km) across and orbits Saturn at a distance of 83,000 miles (134,000 km) within the Encke Gap of the A-ring.

Pan orbits Saturn every 13.8 hours and acts as a shepherd moon, keeping the Encke Gap open (the gap is 200 miles (325 km) wide). Images captured on March 7, 2017, from a distance of 15,268 miles (24,572 km), are the closest taken to date of the diminutive moon.



Saturn's moon Pan
Image Credit: NASA/JPL-Caltech/Space Science Institute

Portraits of Jove

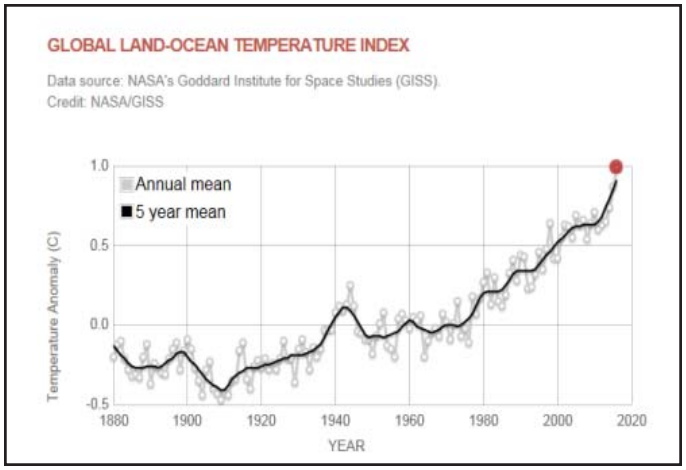
The Juno spacecraft completed its fifth close encounter with the planet Jupiter (Perijove 5), on March 27th. The image (below) of a "dark spot" on Jupiter was captured by the spacecraft's JunoCam instrument on a previous pass and processed (color enhanced) by a citizen scientist (Roman Tkachenko). The spacecraft was approximately 9,000 miles (14,500 kilometers) above the cloud tops when the image was taken. The camera, which can capture full color views of the planet's atmosphere during close approaches, was designed for public outreach (the public can suggest points of interest for targeting by the camera on each pass) and images from the camera are available to the public for review and processing at *www.missionjuno.swri.edu/junocam*.

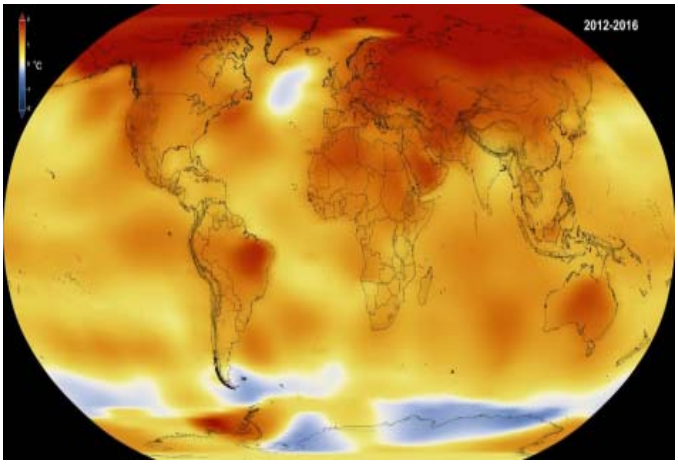
Earth Day 2017

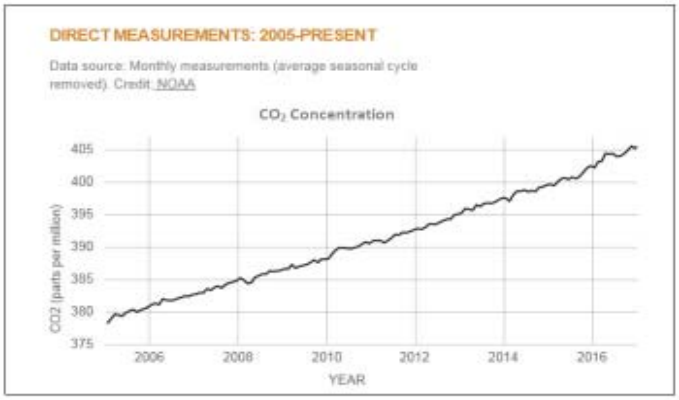
Setting aside a day to focus on spaceship Earth, its natural environment and the impact that humans have had on its fragile biosphere, was the idea of U.S. Senator Gaylord Nelson after witnessing the aftermath of the 1969 Santa Barbara oil spill (a well blowout in an off-shore drilling platform that spilled an estimated 80,000 to 100,000 barrels along the southern California coastline). In the first Earth Day, on April 22, 1970, 20 million Americans participated in country-wide events. The public awakening was credited for the establishment of the Environmental Protection Agency and the passage of important clean air and water legislation.

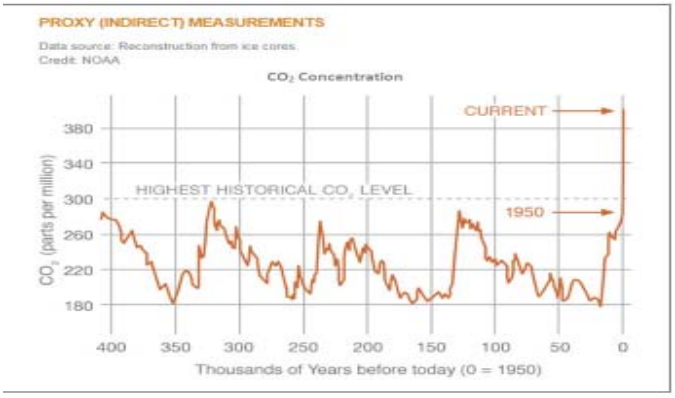
Earth Day 2017 finds the threats to the environment infinitely more challenging than an oil spill and their consequences potentially irreversible. Unlike a breached oil well, there are no quick fixes or easy answers if we do decide to address the source(s) of Earth's rapidly changing climate. Earth's health report is presented in the following graphs. It's not that the climate is changing — change is inevitable in such a complex, dynamic system over eons - it's the rate of change over such a short period of time that should be reawakening public consciousness.

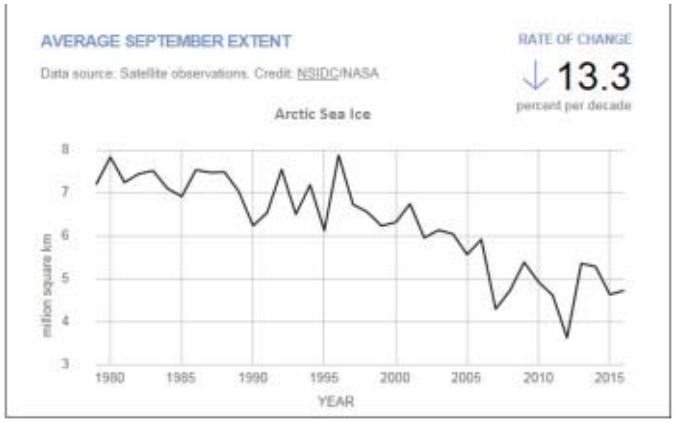
Sunset image of the Earth's limb taken from the International Space Station showing several layers of the Earth's atmosphere (the Earth's atmosphere has several distinct layers). The majority (75% by mass and 99% of the water vapor) of the atmosphere (troposphere), highlighted in yellows and oranges, extends 5 to 10 miles above the surface (wider at the equator). Above the troposphere (pink and white region) is the stratosphere which extends to an altitude of 31 miles. Overlying layers - the mesosphere, thermosphere and exosphere become progressively thinner as the Earth's atmosphere transitions to the vacuum of space

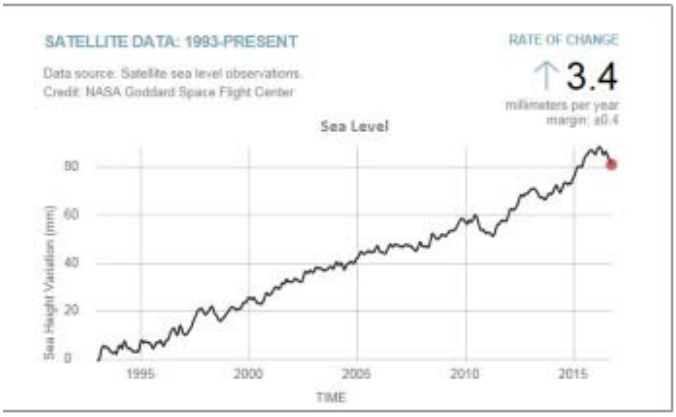












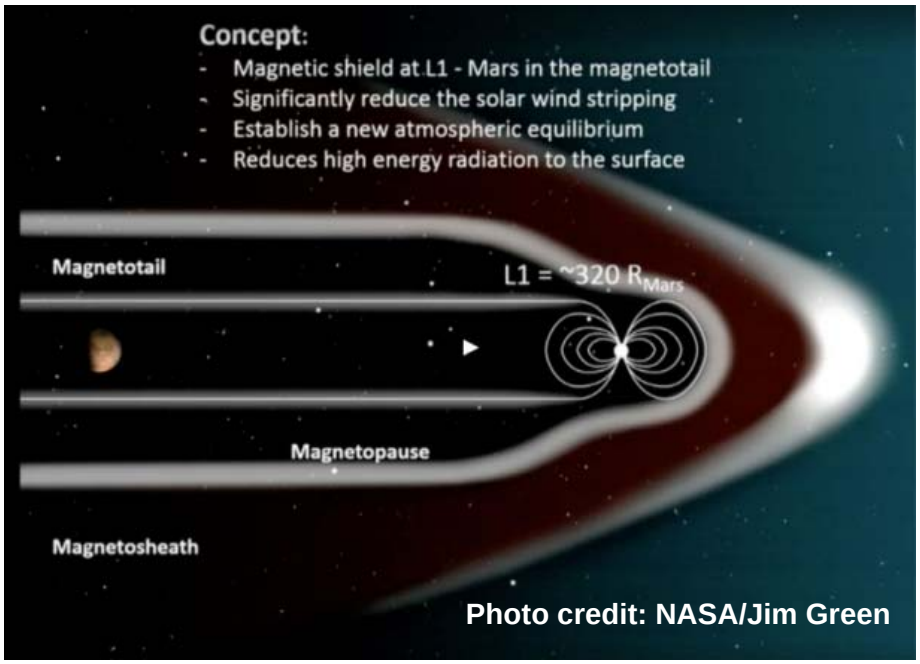
Based on independent analyses by NASA and NOAA, 2016 was the warmest year on record (since record keeping began in 1880). While El Niño contributed to the warmer temperatures in 2015 and first third of 2016, 16 out of the 17 warmest years on record have occurred since 2001. Average global temperatures in 2016 increased by 0.22 degrees Fahrenheit (0.12 Celsius) from the 2015 values, the third year in a row that a new record has been set.

Terraforming Mars

One of the more intriguing ideas presented at this year's Planetary Science Vision 2050 workshop involved the (partial) restoration of the Martian atmosphere. The workshop, held at NASA's headquarters in Washington DC, is a forum for long-range, ambitious projects that could be undertaken sometime in the near future.

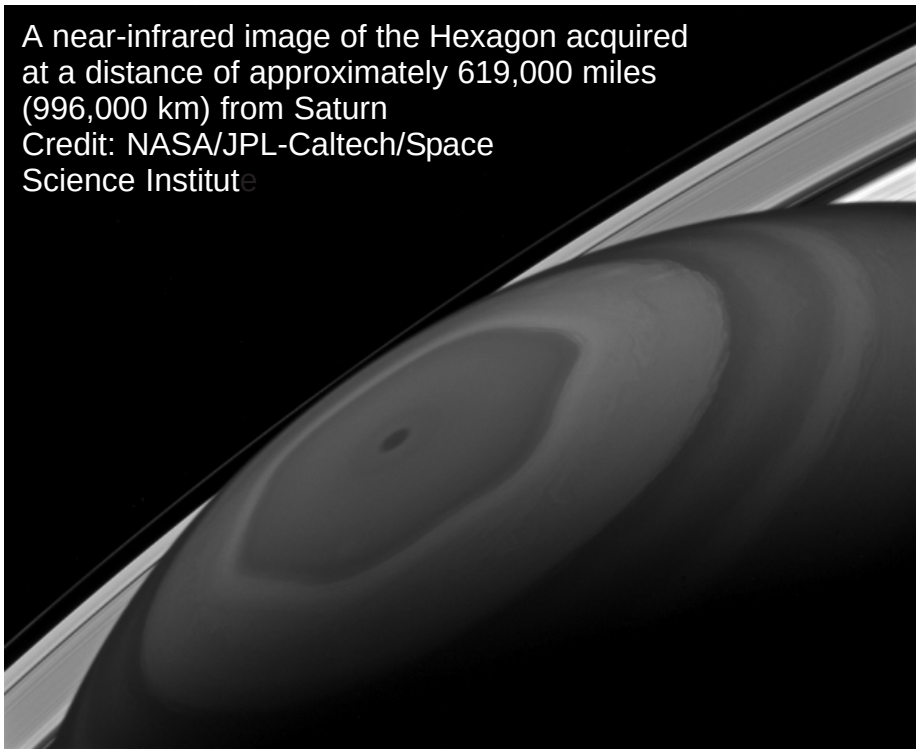
Jim Green (Director of NASA's Planetary Science Division), presentation entitled "A Future Mars Environment for Science and Exploration," proposed placing a magnetic shield between Mars and the Sun (at the Mars L1 Lagrange Point) to create an artificial magnetic field and divert the solar wind around the planet. Computer simulations suggest that (absent the solar wind) sublimation of the frozen carbon dioxide at the poles would eventually create a greenhouse effect at the equator and melt subsurface ice. The models also suggest a relatively rapid rise in the atmospheric pressure which would increase surface temperatures. The concept allows for the remote terraforming without having to modify the planet.

NASA's MAVEN spacecraft has been studying the Martian atmosphere since it arrived on orbit in 2014 and has confirmed the erosion of the planet's upper atmosphere by the solar wind. Scientists believe that the planet's magnetic field gradually disappeared more than 4 billion years ago, leaving the atmosphere exposed. Since then, 90% of the original atmosphere is believed to have been lost to space, contributing to the cold and dry conditions found on the planet today.



The Hexagon

The unusual atmospheric artifact was first observed at Saturn's north pole in images captured by the Voyager spacecrafts during their high-speed flybys in the early 1980s. Since the Sun is currently illuminating the planet's north pole, Cassini (in its current inclined orbit) has had the opportunity to study the phenomenon up close and over multiple orbits. The spacecraft's observations have allowed scientists to model the Hexagon and simulate conditions under which such a structure would form and persist.



The Hexagon is believed to be an artifact of a jet stream moving at more than 220 mph in the easterly direction and following the outline of the hexagon. The rotation rate of the Hexagon (vertices) is approximately the same as the rotation rate of the planet.

Computer simulations have produced similar appearing structures by introducing small perturbations to a polar jet. Once established, the meandering jet settles into a stable hexagonal shape with the proper rate of rotation. The longevity and geometry of the feature is dependent upon the assumed depth of the jets in the upper atmosphere (cloud level) and the presence of lower winds (below cloud level) for stability.

Launches Resume from Historic Pad 39A

The launch of SpaceX's Cargo Resupply Service mission (CRS-10) on February 19th marked the first time Launch Complex 39A had been used since the end of the Space Shuttle program (Atlantis flew the final shuttle flight from the pad on July 8, 2011). The 39A complex was original built for the Apollo program. The Dragon spacecraft carried 5,500 pounds of supplies and experiments to the ISS, staying on station for a month, before returning on March 19th.

The first stage successfully returned eight minutes after launch, setting down on a pad at the Cape Canaveral Air Force Station, nine miles to the south of pad 39A.

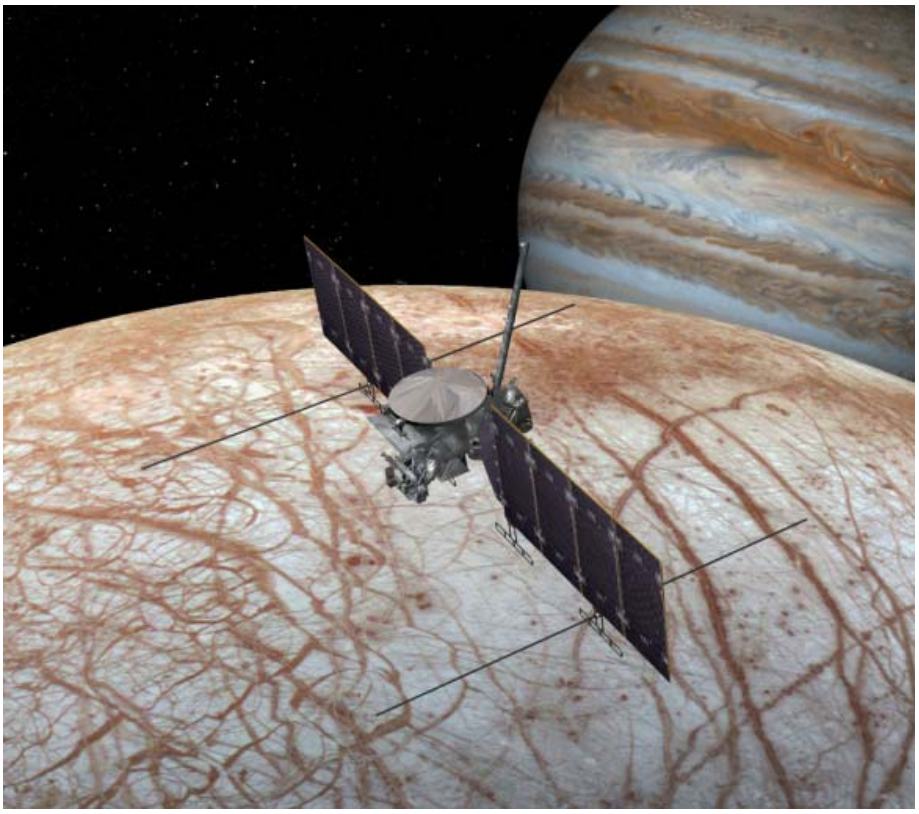
Europa in the News

The President's budget request for 2018 includes additional funding for a mission to Jupiter's moon Europa. As currently envisioned, an orbiter would conduct detailed surveys of the moon's icy surface, analyze the composition and thick-


Photo: SpaceX


Photo: SpaceX

First stage of the Falcon 9 rocket returns to Earth after a successful launch



Artist's rendering of a flyby of Europa by NASA's Europa Clipper spacecraft. Image credit: NASA/JPL-Caltech

ness of its icy shell and probe the moon's subsurface ocean. The orbiter, formally named the Europa Clipper, would execute 40 to 45 flybys of the moon during its primary mission in long looping orbits so as to minimize the time spent in Jupiter's radiation belts. Surveys would be conducted at altitudes ranging from 1,700 miles to just 16 miles (2,700 km to 25 km) above the icy terrain.

NASA completed Phase A of the design phase, highlighted by the selection of ten instruments that would be carried by the orbiter, as well as testing of some of the spacecraft's components. With the recent project review completed, the project is moving forward into Phase B. During this phase (continuing through September 2018), the preliminary design of the spacecraft and its subsystems will be finalized, with vendors selected for the proposed hardware. Readying the Europa Clipper for launch is budget dependent, but tentatively planned for some time in the 2020s,

The Congressional budget deal for 2016 included funding for the orbiter and a stipulation for a lander. While the President's budget request for 2018 does not fund the lander, NASA had assembled a Science Definition Team for the purpose of assessing the scientific value of such a mission, establishing goals and conceptualizing the design and function of a lander. The team formally issued its report on February 7th. It is available on the internet at *http://solarsystem.nasa.gov/docs/Europa_Lander_SDT_Report_2016.pdf*.

The Team identified three primary goals for the lander:

- search for evidence of life on Europa,
- assess the moon's habitability (by characterizing non-ice material on the surface and evaluating environmental factors), and
- characterize the moon's surface and subsurface for future exploration (e.g., determining the proximity of liquid water).

Future missions to Europa would likely probe deeper into the crust and, depending upon its accessibility, the ocean beneath (e.g., with submersibles).

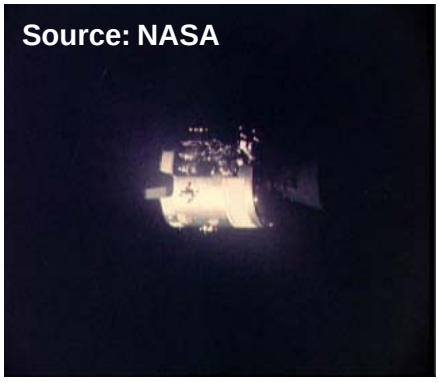
April History

Apollo 16 wasn't the only lunar mission launched in the month of April. Two years earlier, on April 11, 1970, Apollo 13 lifted off from Cape Canaveral in what was intended to be the third manned mission to the Moon. The crew of James Lovell, Fred Haise and Jack Swigert never got their chance.

Two days later and almost 200,000 miles from Earth, the No. 2 oxygen tank exploded, cracking the feed pipe to the No. 1 oxygen tank and crippling the fuel cells providing the electrical power to the Command Module. The next four days would become the greatest human drama in space history.

With failing power and a cloud of debris surrounding the space craft, the three astronauts shut down the Command Module and moved into the Lunar Module (LM). The LM was designed to support two astronauts for a maximum of 45 hours. The LM needed to support the three astronauts for 75 to 100 hours for a safe return to Earth. To conserve supplies, almost all the spacecraft's systems were turned off. The temperature dropped to just above freezing, water condensed on all the internal surfaces and instruments and the level of carbon monoxide

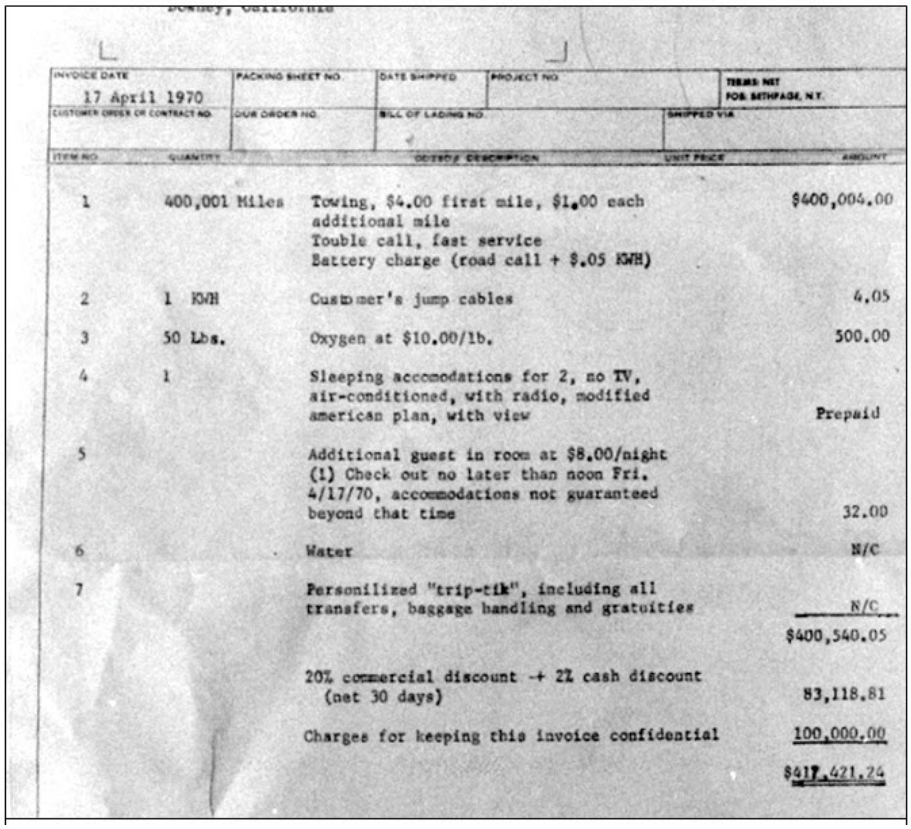
increased to life-threatening levels. Fluids and gases being expelled from the crippled Command Module acted like small rockets, continually pushing the spacecraft off course. The debris



View of damaged Apollo 13 Service Module from the Lunar/ Command Modules.

cloud prevented anything more than rudimentary navigation. The astronauts became dehydrated (fuel cells also provide water) and the conditions inside the spacecraft became increasingly unsanitary when the crew, through a misunderstanding, began to accumulate human waste inside the spacecraft (instead of discharging it).

Only through the ingenuity of the engineers back in mission control, the backup crew and hundreds of contractors involved in the assembly and operation of the spacecraft was the crew returned safely to Earth. The crew and the spacecraft reentered the Earth's atmosphere not knowing whether the heat shield had been damaged in the explosion or whether the parachutes would still deploy after four days of extreme cold. While Houston lost contact with the spacecraft for a minute longer than expected, Apollo 13 splashed down right on target.



Downey, California

INVOICE DATE	PACKING SHEET NO.	DATE SHIPPED	PROJECT NO.	TERMS: NET
17 April 1970				FOB: BETHPAGE, N.Y.
CUSTOMER ORDER OR CONTRACT NO.	OUR ORDER NO.	BILL OF LADING NO.		SHIPPED VIA

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	AMOUNT
1	400,001 Miles	Towing, $4.00 first mile, $1.00 each additional mile Touble call, fast service Battery charge (road call + $.05 KWH)		$400,004.00
2	1 KWH	Customer's jump cables		4.05
3	50 Lbs.	Oxygen at $10.00/lb.		500.00
4	1	Sleeping accomodations for 2, no TV, air-conditioned, with radio, modified american plan, with view		Prepaid
5		Additional guest in room at $8.00/night (1) Check out no later than noon Fri. 4/17/70, accommodations not guaranteed beyond that time		32.00
6		Water		N/C
7		Personilized "trip-tik", including all transfers, baggage handling and gratuities		N/C
				$400,540.05
		20% commercial discount -+ 2% cash discount (net 30 days)		83,118.81
		Charges for keeping this invoice confidential		100,000.00
				$417,421.24

Post flight levity: an image of invoice sent to North American Rockwell (command and service module manufacturer) by Grumman Aerospace (lunar lander manufacturer) for services rendered in providing roadside assistance following the Apollo 13 accident and the use of the LM as a lifeboat.

The cause of the accident was eventually traced to damage the oxygen tank had sustained during its removal from Apollo 10. Due to a defective drain, internal heaters were used to empty the tank. Unfortunately, the pad power supply was not compatible with the spacecraft's power systems. The higher voltage melted the insulation leaving bare metal exposed to the pure oxygen environment. When Jack Swigert turned on the tank fan, the contents exploded. The story of Apollo 13 is detailed in astronaut Jim Lovell's book "Lost Moon," former Flight Director Gene Kranz's book "Failure is Not an Option," and recreated in the Ron Howard/Tom Hanks film "Apollo 13."

April Showers

The Lyrid meteor shower is expected to peak just before dawn on April 22nd. The dust producing the shooting stars is from *Comet Thatcher*. Expect to see 10 to 20 meteors per hour if light from an early morning moon doesn't interfere. As with all meteor showers, the Lyrids are named for the constellation (Lyra) from which they appear to radiate.

Sunrise and Sunset

Sun	Sunrise	Sunset
April 1st (EDT)	06:36 am	7:19 pm
April 15th	06:13 am	7:34 pm
April 30th	05:52 am	7:51 pm

Comet History

In the photo (right) *Comet Hale-Bopp* graced the evening sky on April 2, 1997, one day after perihelion (closest approach to the Sun). The comet was brighter than the brightest stars in the sky, with a dust tail that stretched almost 45 degrees across the sky. The photo shows the brighter, yellow dust tail and the dimmer, blue ion (gas) tail.

The orbital period of *Hale-Bopp* as it entered the inner solar system was 4,206 years. A close encounter with Jupiter in April of 1996 modified its orbit, shortening its orbital period to 2,380 years as it returned to the outer solar system.

Jupiter and its Moons

Jupiter reaches Opposition on April 7th, rising with the setting Sun and visible all night. By the end of April, it will be in the eastern sky almost 2 hours earlier and well placed in the evening for observers. As one of the brightest star-like objects in the night sky, Jupiter can be found in the constellation Virgo.

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. The photo on the right shows the shadow of Ganymede on the Jovian disk. On nights of good visibility the following events should be visible through a moderately-sized telescope.

Transit of Jupiter's Red Spot

Date	Moon	Transit Begins	Transit Ends
2nd	Io	11:32 pm	1:43 am (3rd)
4th	Io	6:00 pm	8:12 pm
9th	Europa	7:53 pm	10:21 pm
11th	Io	7:54 pm	10:06 pm
14th	Ganymede	6:29 pm	8:54 pm
16th	Io	10:29 pm	1:57 am (17th)
18th	Io	9:48 pm	11:59 pm
21st	Ganymede	10:27 pm	12:51 am (22nd)
25th	Io	11:42 pm	1:53 am (24th)

he 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 7 pm to midnight local time:

Date	Transit Time	Date	Transit Time
Mar 31st	10:10 pm	15th	7:31 pm
2nd	11:47 pm	17th	9:09 pm
3rd	7:39 pm	19th	10:47 pm
5th	9:17 pm	22nd	8:16 pm
7th	10:54 pm	24th	9:54 pm
10th	8:24 pm	26th	11:32 pm
12th	10:02 pm	27th	7:23 pm
14th	11:40 pm	29th	9:02 pm

Astronomical and Historical Events

1st Mercury at its Greatest Eastern Elongation (19°) – apparent separation from the Sun in the evening sky
1st History: Comet *Hale-Bopp* reaches perihelion – closest approach to Sun (0.914 AU) (1997)
1st History: launch of the first weather satellite, Tiros 1 (1960)
2nd Amor Asteroid 3552 *Don Quixote* closest approach to Earth (3.085 AU)
2nd History: U.S. release of the movie "2001 A Space Odyssey" (1968)
2nd History: launch of Zond 1, Soviet Venus flyby mission (1964)
2nd History: selection of the Mercury 7 astronauts (1959)
2nd History: French physicists Louis Fizeau and Leon Foucault take first photo of the Sun (1845)
3rd First Quarter Moon
3rd Apollo Asteroid 2015 BY310 near-Earth flyby (0.079 AU)
3rd History: Soviet spacecraft Luna 10 becomes the first artificial satellite to orbit the Moon (1966)
4th History: launch of Apollo 6, last test flight of the Saturn V rocket (1968)
5th Distant flyby of Saturn's moons *Atlas*, *Pandora* and *Epimetheus* by the Cassini spacecraft
5th History: launch of the Compton Gamma Ray Observatory (1991)
5th History: launch of the first Pegasus rocket (1990)
5th History: launch of Pioneer 11, Jupiter and Saturn flyby mission (1973)
6th Distant flyby of Saturn's largest moon *Titan* by the Cassini spacecraft
6th Aten Asteroid 2014 FN38 near-Earth flyby (0.064 AU)
6th Kuiper Belt Object 2014 FT71 at Opposition (46.794 AU)
6th History: launch of Intelsat 1, first commercial communications satellite (1965)
7th Jupiter at Opposition, rising with the setting Sun and visible all night
7th History: launch of Luna 14, Soviet Moon orbiter mission designed to test radio transmission stability, measure the lunar gravity field, solar wind and cosmic rays (1968)
8th **Second Saturday Stars - Open House at McCarthy Observatory**
8th Northeast Astronomy Forum and Telescope Show (NEAF), Rockland Community College, Suffern, NY (8th and 9th)
8th Aten Asteroid 2016 GH135 near-Earth flyby (0.088 AU)
8th Kuiper Belt Object 2013 FS28 at Opposition (84.431 AU)
8th History: launch of the Bigelow Expandable Activity Module (2016) aboard a SpaceX Dragon cargo vehicle - module was installed on the International Space Station for a two year long demonstration of the expandable habitat
8th History: discovery of Saturn moon's *Telesto* by the Voyager 1 spacecraft (1980)
8th History: meteorite hits house in Wethersfield, Connecticut (1971)
8th History: launch of the unmanned Gemini 1 (1964)
8th History: Project Ozma, the search for extraterrestrial intelligence, begins as Frank D. Drake, an astronomer at the National Radio Astronomy Observatory in Green Bank, West Virginia, turns the 85-foot Howard Tate telescope toward the star Tau Ceti (1960)
10th Aten Asteroid 3554 *Amun* closest approach to Earth (0.936 AU)
10th History: Japanese lunar probe Hiten impacts Moon; first non-U.S./Soviet lunar probe, also first to visit the Lagrangian Points L4 and L5 during its three year mission (1993)
11th Full Moon (Full Pink Moon)
11th History: ESA spacecraft Venus Express enters orbit around the planet Venus (2006)
11th History: launch of Apollo 13 with astronauts James Lovell, Fred Haise and Jack Swigert; mission aborted when oxygen tank explodes and cripples the Command Module (1970)
12th Distant flyby of Saturn's moons *Mimas*, *Aegaeon*, *Janus*, *Atlas* and *Prometheus* by the Cassini spacecraft
12th History: launch of the first space shuttle (Columbia) with astronauts John Young and Robert Crippen (1981)

Astronomical and Historical Events (continued)

12th History: launch of Vostok 1 with cosmonaut Yuri Gagarin, first person to orbit the Earth (1961)
12th History: Edward Maunder born; studied solar cycle and sunspots. Analyzed period between 1645 and 1715 when almost no sunspots where recorded - known as the "Maunder minimum" or "Little Ice Age" because of the severe winters (1851)
12th History: discovery of Asteroid 10 *Hygiea* by Annibale de Gasparis (1849)
13th Dwarf Planet 136108 *Haumea* at Opposition (49.693 AU)
13th History: launch of Transit 1B, first experimental navigation satellite (1960)
14th Atira Asteroid 2014 FO47 closest approach to Earth (1.418 AU)
14th History: Christiaan Huygens born, Dutch scientist and discoverer of Saturn's rings and largest moon *Titan* (1629)
15th Moon at apogee (furthest distance from Earth)
16th Easter Sunday
16th History: launch of Apollo 16 with astronauts John Young, Ken Mattingly and Charles Duke, the only mission to the lunar highlands (1972)
16th History: Leonardo Da Vinci born, first to correctly explain Earthshine (1452)
17th History: closest flyby of the Sun by a spacecraft, Helios 2 (1976)
17th History: launch of Surveyor 3, Moon lander, first to experience a lunar eclipse from the Moon's surface during which the temperature fell 250° F; Apollo 12 would later land near Surveyor 3 in 1969, retrieving pieces of the lander for return to Earth and analysis of the effects of the harsh lunar environment (1967)
18th Apollo Asteroid 143404 (2003 BD44) near-Earth flyby (0.056 AU)
18th Apollo Asteroid 2006 HE2 near-Earth flyby (0.063 AU)
19th Last Quarter Moon
19th Distant flyby of Saturn's moons *Methone*, *Aegaeon*, *Atlas*, *Pandora* and *Daphnis* by the Cassini spacecraft
19th Apollo Asteroid 2014 JO25 near-Earth flyby (0.012 AU)
19th Aten Asteroid 2014 UR near-Earth flyby (0.048 AU)
19th History: launch of the last Soviet Salyut space station, Salyut 7 (1982)
19th History: launch of the first space station, Soviet Salyut space station, Salyut 1 (1971)
20th Scheduled launch of a Russian Soyuz spacecraft from the Baikonur Cosmodrome, Kazakhstan, to the International Space Station. The Soyuz will ferry members of the next Expedition crew to the station.
20th Amor Asteroid 4957 Brucemurray closest approach to Earth (1.141 AU)
21st Apollo Asteroid 2016 UW80 near-Earth flyby (0.072 AU)
22nd Flyby of Saturn's largest moon *Titan* by the Cassini spacecraft
22nd Aten Asteroid 2016 JP near-Earth flyby (0.065 AU)
22nd Lyrids Meteor Shower peak
22nd Earth Day
22nd History: launch of the Air Force's X-37B prototype space plane from Cape Canaveral, Florida; first orbital mission (2010)
24th Asteroid 951 *Gaspra* closest approach to Earth (1.583 AU) - first flyby of an asteroid when visited by the Galileo spacecraft on 29 October 1991 on its way to Jupiter
24th History: launch of space shuttle Discovery (STS-31) and deployment of the Hubble Space Telescope (1990)
24th History: launch of Mao 1, first Chinese satellite (1970)
24th History: cosmonaut Vladimir Komarov dies during re-entry of a prototype Soviet lunar spacecraft (Soyuz 1) when parachute lines become entangled (1967)
25th Apollo Asteroid 11066 Sigurd closest approach to Earth (1.008 AU)
26th New Moon
26th Distant flyby of Saturn's moons *Janus*, *Atlas*, *Daphnis* and *Epimetheus* by the Cassini spacecraft

Astronomical and Historical Events (continued)

26th History: Ranger 4 impacts Moon (1962) - while the mission didn't return any scientific data due to an onboard computer failure, Ranger 4 become the first U.S. spacecraft to reach another celestial body when it crashed on the far side of the Moon
26th History: flyby of Venus (gravitational assist) by the Cassini spacecraft (1998)
26th History: launch of Sputnik 14 (Cosmos 4), first successful Soviet reconnaissance satellite – designed to study upper layers of atmosphere and monitor U.S. nuclear tests (1962)
26th History: discovery of Asteroid 9 *Metis* by Andrew Graham (1848)
27th Moon at perigee (closest distance from Earth)
28th Moon occults that star Aldebaran in the constellation Taurus
28th Aten Asteroid 2016 HF2 near-Earth flyby (0.090 AU)
28th Apollo Asteroid 469219 (2016 HO3) closest approach to Earth (0.139 AU)
28th Atira Asteroid 413563 (2005 TG45) closest approach to Earth (0.532 AU)
28th History: launch of the Cloudsat/Calipso cloud imaging and profiling satellites (2006)
29th Kuiper Belt Object 2014 FC69 at Opposition (83.543 AU)
30th Kuiper Belt Object 2010 EK139 at Opposition (35.763 AU)
30th History: the Surveyor 3 lander takes the first picture of Earth from the Moon's surface (1967)

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 un like 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°)
- One astronomical unit (AU) is the distance from the Sun to the Earth or approximately 93 million miles

Solar Activity

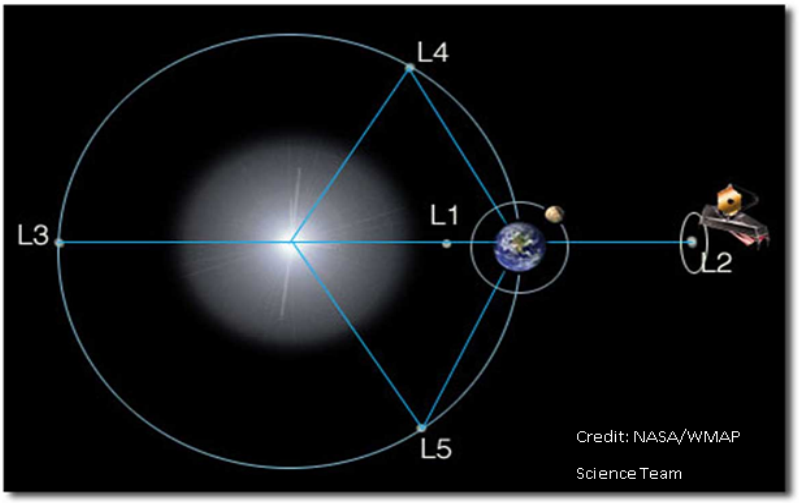
For the latest on what's happening on the Sun and the current forecast for flares and aurora, check out *www.spaceweather.com.*

International Space Station and Iridium SatellitesPnce Team

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.

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).



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Second Saturday Stars

FREE EVENT

Every Month at the
John J. McCarthy Observatory
Behind the New Milford High School
860.946.0312
www.mccarthyobservatory.org

April 8th
8:00 - 10:00pm

THE STATE OF OUR EARTH

Refreshments
Family Entertainment
Handicapped Accessible
ASL Interpretation Available with Prior Notice
Rain or Shine

Map