

OKLAHOMA SPACE ALLIANCE

OUTREACH – January 2023

102 W. Linn #1, Norman, OK 73069

Oklahoma Space Alliance will meet at the
McMurray residence at 2:00 p.m.
on January 14, details inside

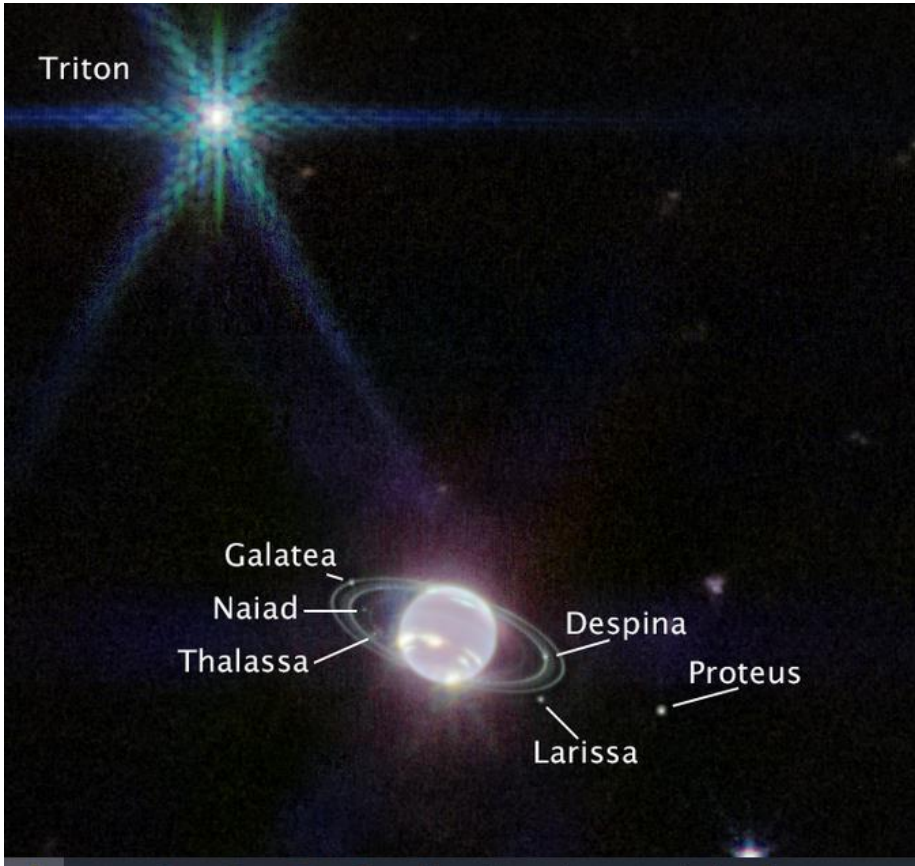


Figure 1 Neptune, Its Rings and Satellites (infrared image from James Webb Space Telescope)

OKLAHOMA SPACE ALLIANCE OUTREACH January 2023

January Meeting

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, January 14, at the McMurray's house. Prospective members are welcome. Their house is at 2715 Aspen Circle in Norman. To get to the meeting either: (1) Take the Lindsey Street east exit from I-35, turn right at Berry, and proceed to Imhoff Road. Turn right at Imhoff, right at Poplar Lane, left at Aspen Lane, and right at Aspen Circle. or (2) Take the Highway 9 east off I-35, turn left at Imhoff Road, left at Poplar, left at Aspen Lane, and right at Aspen Circle.

We will have this meeting on Zoom for those who cannot attend in person: To join the meeting, go to <https://ti-nyurl.com/y2qtab28>. If the link doesn't work, call Clifford McMurray, President 405-329-4326 (H), 405-863-6173 (C) (e-mail cliffmcmurray@hotmail.com) or Syd Henderson at 405-365-8983 (C) (e-mail sydh@ou.edu) and we will send you updated information.

Saturday January 14, 2023, 2:00 p.m. (tentative)

1. Introductions and review of Space events this past month
2. What's Happening in Space, News, Pictures, and Videos approximately one hour. See <http://osa.nss.org> before the meeting for items to be discussed.
3. Break
4. Oklahoma Space Alliance Chapter Business Discussion
 - a. Review OSA treasurer's report
 - b. Minutes of November meeting
 - c. Annual Report
 - d. Presentations from ISDC
5. Video (to be announced)
6. Chat

Minutes of December Party

OSA had its annual Christmas Party on December 10. OSA members attending were our hosts Tom and Heidi Koszoru, Russ Davoren, Claire and Clifford McMurray, Dave Sheely, and Syd Henderson. Tom and Heidi's daughter Jenny also attended. Only business was the re-election of all our officers.
Secretary Syd Henderson

Notes by OSA

Minutes to November 12 Oklahoma Space Alliance Meeting

Oklahoma Space Alliance met November 12, 2022, at the McMurray's house in Norman, Oklahoma. Attending were Clifford and Claire McMurray. Dave Sheely, and Syd Henderson. OSA President Clifford (Kip) McMurray presided over the meeting He did an Update discussing links to material covered in the meeting and this is online at <https://osa.nss.org/Update2211.pdf> so I'll cover the details that aren't covered there. This was a shorter meeting than usual since our October meeting was postponed until October 22 (which also made the October meeting unusually long).

It looks like in a few years Long March will be making controlled reentries much to the relief on nations under the flight path. We watched the launch of the Mengtian module of the *Tiangong* space station. We also watched a video of China astronauts moving modules around *Tiangong*.

Dennis Tito, who with his wife Akiko have purchased two of the 12 seats on SpaceX's second commercial lunar flight, will be at 82 years old the oldest astronaut to reach Earth orbit (surpassing John Glenn) let alone the oldest to fly to the Moon. (William Shatner is the oldest to reach space but that was on a suborbital flight. He was 90.)

We watched a video of the November 1 Falcon 9 launch and the landing of the two side boosters on a foggy day. They landed about a hundred yards and a few seconds apart.

We watched video of the launch of India's GSLV Mark III rocket. Although this is currently being used to launch geosynchronous satellites, it will also be used to launch people into space.

The Stratolaunch carrier plane is called the Roc. We watched it do a captive carry of a Talon A hypersonic aircraft, although the first free flight of the Talon A won't be until next year.

Asteroid AP7's orbit crosses the Earth's on the other side of the Sun [and is in a 5-1 resonant orbit with the Earth, so it doesn't pose a threat to the Earth at present. Still, at a little more than a kilometer in length, it would produce quite an impact if its orbit shifts and it hits the Earth.

We went through an article on space warfare.

We went through several weeks of *This Week at NASA*. A Marsquake detected by *InSight* was caused by a meteor impact.

Lucy flew by Earth on its way to Jupiter's Trojan asteroids and snapped shots of the Earth and the Moon.

We have \$907.41 in our bank account and presumably the usual \$267 in cash.

The postal address of the National Space Society is changing to Florida on January 1. This needs to change in the newsletter and on our mailing list. Also, Syd needs to put the logo for ISDC 2023 on the website. This will be in Dallas-Frisco.

We renominated our officers for 2022 to serve in 2023: Clifford McMurray for President, Dave Sheely for Vice-president, Syd Henderson for Secretary, and Tim Scott for Treasurer (pending his approval).

--Minutes by OSA Secretary Syd Henderson

Minutes to December 12 Chapters Assembly Meeting Via Prathmesh Barapatre

1. Roll Call

1. Bennet Rutledge - Denver NSS
2. Prathmesh Barapatre - NSS Mumbai Chapter
3. Larry Ahearn - NSS VP Chapters
4. Perri Doutré - Colorado
5. Jan Roston - CA - Sacramento L5 Society
6. Bill Kranz - St. Louis Space Frontier Society
7. Mario Anzalotti - NSS Phoenix
8. George - (NA)
9. Gerald Mclaughlin - (NA)
10. David Stuart - NSS Seattle
11. Frank Graza - Phoenix Chapter
12. David Stuart - NSS Seattle
13. Christine Nobbe - St Louis Space Frontier
14. Joseph Bland - CA - Sacramento L5 Society
15. Jerome Glasnovic - (NA)
16. Bruce Mackenzie -

2. Approval of Minutes

Minutes for November 14th, 2022, were accepted.

3. Old Business

a. Committee Report: Chapter Resources (Kulis, Doutré) -

Perri Doutré - Need to decide on January, February and March Meeting Dates
Will be working on upcoming newsletter and blog for Chapter Resources list.

b. Status of relocation of NSS HQ to NASA KSC Visitor Center -

Bennett - KSC is not yet open for visitors for quite a while.
It's difficult to visit without paying visit to KSC Visitor Center.

c. Status of NSS Outposts with respect to the Chapters Assembly -

David - There are few people who discussed becoming outpost but majority of them haven't returned the paperwork back again.

Larry - Haven't received any paperwork back yet, but has been promised to be submitted from Baltimore, middle Tennessee, long Island and Few more places.

David - Some other contacts from International Contacts are willing to start outpost.

Larry - On international once, we are trying to get hold of Robert Ahearn, (International Chapters Coordinator) he has not been available for quite a long time.

Joseph - NSS Chapter Assembly should be making an attempt do an outreach. As these are nascent chapters, we should be making sure that they get a warm invitation to attend Chapter assembly and help them according to their requirement.

Suggestion - Chapter Assembly can consider having major outreach program for outpost.

****Motion Made by Joseph -**

"I move that the CA place on the agenda the creation of an invitation to NSS Outpost representatives and potential outpost representatives to attend and speak of themselves at a future CA meeting."

4. New Business -

a. Scheduling Upcoming Meetings -

Dates for next meetings:

- a. January 9th Monday 5pm PT
- b. February 13th Monday 5pm PT.
- c. March 11th Saturday 7am PT.

b. Update on Breakfast on the Moon -

Joseph - There were problems during the event. However, we created foundational tapes, these tapes had multiple messages in it, premise of it is to deliver message the message can be about apollo 17 and represents the final of the apollo mission.

Expecting messages from Larry, David Stuart and from Tony and other people messages as well who wanted to give out messages for the same.

****Motion by Joseph Bland -**

"I move that the subject of the NSS Discussions list be put on the agenda for the next meeting."

Seconded by Mario Anzalotti

****Motion by Bennett -**

Over dates of upcoming meeting - seconded by Prathmesh Barapatre

Space News

We'll have to wait a bit longer for the first orbital flight from the United Kingdom. "Start Me Up" was lifted by Virgin Orbit's carrier plane, and the LauncherOne rocket was dropped at 5:09 p.m. (CDT). The two stages of the launch rocket separated but the upper stage failed to deliver the payload to orbit. Nine satellites were lost in the failed mission. Virgin Orbit has had five successful launches from Mojave Space Port in California, but the first orbital launch from the UK was big deal.

Two other sites in the UK, both in Scotland, are hoping to see their first launches this year: SpaceHub Sutherland in the northern part of mainland Scotland and SaxaVord Spaceport on Unst, the northernmost Shetland Island. Unlike Virgin Orbit, these host vertical launches. Several of their contractors are orbital space companies, so Scotland may beat England to orbit.

Artemis 1 finally launched on November 16 on a 25-day mission, six of which were spent orbiting the Moon in a for half of a distant retrograde orbit. It had been delayed several times since the end of August, but the launch went off without a hitch; indeed, the entire mission had only very minor glitches, none of which caused serious problems. On its way to the Moon, Orion separated from the ICPS (Interim Cryogenic Stage), the upper stage of the Artemis spacecraft. The ICPS deployed ten cubesats on its own loop around the moon on its way to solar orbit.

Of the cubesats, the OMOTENASHI lunar lander failed, but several lunar orbiters deployed. Not all cubesats were destined for the Moon. The Near-Earth Asteroid Scout is a solar sail probe that would have visited an asteroid, but communication was not established, and the probe is considered lost. The other eight seem to be successful. ArgoMoon followed the ICPS into heliocentric orbit. Lura IceCube is orbiting the Moon searching for ice deposits. The Lunar Polar Hydrogen Matter is looking for hydrogen, which also means water, and the spectroscopic mission LunIR will also be able to detect water and other substances.

Artemis and its cubesats weren't the only spacecrafts going to the Moon last month. On December 11, SpaceX launched three lunar probes via a Falcon 9 rocket. These are NASA's Lunar Flashlight (which was to have been launched aboard *Artemis 1* but apparently missed a deadline), ispace's *Hakuto R Mission 1 Lander* and the United Arab Emirates Rashid lunar rover. All three of these will coast on long looping paths that will take them far from the Moon to save fuel. Although the *Hakuto R* lander was built by a private Japanese space company, it should, if successful, take some of the sting out of losing OMOTENASHI (which was a JAXA project). But the landing is up to five months away, so plenty can happen. *Hakuto* and *Rashid* are designed to work together. *Hakuto* is designed to demonstrate landing techniques and carries a tiny rover for ispace. The *Rashid* rover is more ambitious and will study the lunar regolith.

Incidentally, the *Hakuto* project was one of the five contestants for the Lunar-X-Prize, and, though it missed that deadline, shows that that X-Prize contest still influences lunar exploration. Indeed, another finalist was SpaceIL, which launched *Beresheet* to lunar orbit, but the lander crashed and was lost. Astrobotics was also hoping to enter the contest but has developed the *Peregrine* lander which they hope to launch later this year.

NASA's Lunar Flashlight cubesat will eventually assume a near-rectilinear orbit of the type first done by CAPSTONE. This is a ridiculously eccentric orbit that will take it 43,500 miles above the lunar surface at the farthest and 9 miles above the lunar surface at perigee. Its mission is to peer into craters near the lunar South Pole which in their permanently shadowed bottoms may contain water ice. It will do this by shining near-infrared lasers into the craters, hence the mission's name. Hopefully the lasers will not touch any spot long enough to vaporize the ice, assuming it exists.

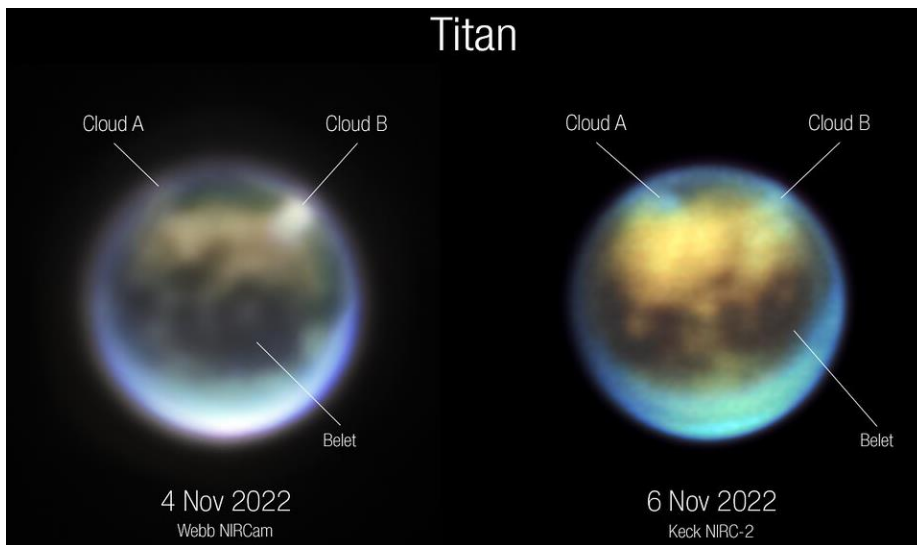
Walter Cunningham, who died January 3 at age 90, was the last survivor of *Apollo 7*, the first crewed Apollo flight. *Astronomy* has a lengthy memorial here: <https://astronomy.com/news/2023/01/walter-cunningham-last-surviving-apollo-7-astronaut-dies-at-age-90> I did a brief report on *Apollo 7* in the September 2018 *Outreach*, which is online at <https://osa.nss.org/Out1809.pdf>, but didn't go into sufficient detail on Cunningham, so you're better off with the *Astronomy* report.

All good things must come to an end, and now we say goodbye to NASA's InSight Lander, which last phoned home on December 15. This was expected, since InSight's solar panels had been covered by a dust storm which cut its power in half, to a level insufficient to keep it alive.

Last May 4, InSight detected a Marsquake the waves from which were detectible for ten hours. The estimated magnitude of the quake has been upped to 4.7, which is a record for Mars, although I've felt more powerful earthquakes in Oklahoma.

The James Webb Space Telescope has been imaging planets as well as galaxies. The cover, from last September, is an infrared image of Neptune's rings and seven of its moons (out of 14 known; Nereid isn't shown). I think Triton appears the way it does is because it is so bright at these wavelengths. Neptune's atmosphere absorbs infrared radiation at this wavelength, so Neptune appears dark. This is fortunate because in visible light the rings tend to be washed out by the planet.

In addition to imaging Neptune and Jupiter, the James Webb Space Telescope is capable of imaging Saturn's moon Titan. The first image is from Webb's Near Infrared Camera, the second from the corresponding NIRC-2 at the Keck Observatory on Mauna Loa in Hawaii, the highest resolution camera at these wavelengths on the surface of the Earth. Webb's camera has higher resolution, but Keck's is also impressive.



Space-Related Articles

The Alternate View: “Pulsars Ride Neutrino Rockets,” by John G. Cramer, *Analog*, pp.126 – 128. This is a fun article about a discovery that may just have explained a long-standing mystery: why do so many pulsars move so darn fast? The average velocity of a pulsar is 0.15% of the speed of light, and five have velocities 0.33% of the speed of light. Even the first is 15 times the orbital velocity of the Sun around the galactic center.

The usual answer, that they were thrown out by supernova explosions, doesn’t seem to fit the data, especially since the direction of motion of the Crab Nebula pulsar aligns with its spin axis. What a team of Chinese scientists led by Zheng Li propose is that the neutron stars are being propelled by a jet of neutrinos emitted by the neutron star.

This may seem counterintuitive given the low mass of neutrinos, but they are produced in neutrino-antineutrino pairs by vortexes within the neutron star. Since the particles (even neutrons) are aligned with the star’s strong magnetic field and parity violation in weak interactions, both the neutrinos and antineutrinos are emitted in the same direction along the star’s axis, which produces a tiny acceleration of the neutron star in the opposite direction. This “neutrino rocket” is still incredibly weak, but as we see with ion rockets, a small constant acceleration adds up, especially since this can go on for hundreds of thousands of years. I suspect the velocities can get much higher than what we’ve seen, but by the time the star reaches those velocities, it’s far outside the galaxy.

Incidentally, this process also lowers the rotational velocity of the neutron star. Shades of the Dean Drive!

Cramer proposes that science fiction writers might want to figure out how to use this as a space drive, but the beings that use it would have to be extremely patient.

The paper by Zheng, *et. al.*, “Neutrino Rocket Jet Model: An Explanation of High-Velocity Pulsars and their Spin-Down Evolution,” was published in the *Astronomical Journal* 931, 123.

Sky Viewing

A highlight this month is actually a rerun of an event that occurred last month, but which was not visible from Norman because the skies were overcast. On the night of January 30 – 31, the **Moon occults Mars** as seen from Oklahoma. This will occur around 10 – 11 p.m., so will be perfectly placed. This is actually the third such occultation in two months. The third was visible in north Africa on January 3.

The Moon also occults Venus a couple of times this year as seen from various places on Earth but not from Oklahoma.

Mercury went through inferior conjunction on January 7 hence is lost in the Sun’s glare. It will be theoretically visible by February 1 but will be only four degrees above the horizon an hour before sunrise and is only magnitude -0.1, so seeing it will be a challenge. This is about as good as it gets for this apparition.

Venus has returned to the evening sky after its October 22 superior conjunction with the Sun. Venus will get brighter during the first half of 2023 as it gets closer to Earth (the increase in apparent diameter more than makes up for less of its surface being lit), only starting to fade when its crescent becomes too thin in July.

At the moment, Venus is low in the west during twilight and sets about the end of twilight. Still, at magnitude -3.9, it is easily visible in twilight if your horizon is clear. Venus and Saturn will be only 11 minutes of arc (a third the apparent width of the Moon) apart on January 21, but since Saturn is magnitude 0.8 it may be difficult to see. However, they are setting two hours after the Sun, so maybe not.

In February Venus will brighten slightly and as the month goes on, she and **Jupiter** will get closer and closer as they approach a conjunction on March 1 when Venus will be a half-degree north of Jupiter.

Also check February 22, when Jupiter and the Moon will be one degree apart and Venus seven degrees below them.

Continuing with **Jupiter**, it is magnitude -2.4 and easily visible in high in the western sky at sunset. Jupiter will be getting lower in the evening sky, but not much dimmer, and will remain easily visible into March. It will not be in conjunction with the Sun until April 11.

Mars was in opposition with the Sun on December 7 and is still brilliant at about magnitude -0.8 and visible for most of the night. It seems even brighter since this opposition it was about as high as it gets—more than 70 degrees above the horizon (!) and objects almost overhead look brighter than those low in the sky. The previous opposition Mars was in Sagittarius, which is as low as it gets, and, though technically brighter than this time, looked less bright from Oklahoma.

Mars is in Taurus forming an approximate isosceles right triangle with Mars at the right angle and Aldebaran and the Pleiades at the other vertices. Mars and Aldebaran make a pleasant pair since both of them appear red. (Aldebaran is a red giant.) Mars is currently about 1.5 magnitudes brighter, which is substantial, but is also growing dimmer as it moves away from us.

Mars won't set until 3:30 a.m. even on January 31, but it will have dimmed to magnitude -0.2. Mars moves across northern Taurus through February as it dims to magnitude 0.3, which still makes it brighter than any visible star currently in the night sky other than Sirius.

Saturn is gradually disappearing from the night sky, but still manages a conjunction with Venus on January 21. It is currently only fifteen degrees above the horizon at 6:30 p.m. and down to magnitude 0.8. By the end of the month, it will be setting during twilight and will be very difficult to see. In February, Saturn will mostly be invisible since it has a conjunction with the Sun on February 16.

Uranus is still in a dim part of Aries, which may actually make it easier to find with binoculars. Since at magnitude 5.7 it isn't much dimmer than the few stars nearby and should appear a bit fuzzy. Uranus doesn't move rapidly across the star field and will be in Aries for a couple more years.

Neptune is still at the border of Pisces and Aquarius and is moving back and forth across the boundary when it is in retrograde motion. At magnitude 7.8, it requires binoculars or a small telescope. If you can find the Circllet that forms one of the fishes in Pisces and look below it at a distance of the approximate width of the Circllet, you will be looking in the vicinity of Neptune.

Data on the planets come from the January and February issues of *Sky and Telescope* and *Astronomy* and from their websites. I also used *Starry Night* to verify data and the times of the lunar occultation of Mars. The Quadrantid meteor shower has already passed, and we don't have any bright meteor showers until the Lyrids in late April. We may have a comet barely visible to the naked eye this month, but that's nothing compared to the -2 magnitude comet imaged by the *Perseverance* rover on Mars.

Viewing Opportunities for Satellites (January 14 – February 15, 2023)

You can get sighting information at www.heavens-above.com, which gives you a constellation map showing the trajectory of the satellite. The Sky & Telescope web site carries ISS observation times for the next few nights at skyandtelescope.com/observing/almanac. You can also get data at <https://spotthestation.nasa.gov/sightings/>.

With the addition of the solar panels, the International Space Station can be as bright as magnitude -4.0 making it brighter than all the stars other than the Sun and all the planets other than Venus, although magnitude -2 to -3 is more likely. The Hubble Space Telescope can get up to magnitude 1.5, which is brighter than the stars in the Big Dipper, but magnitude 2.0 – 2.5 is more likely. *Tiangong* is the Chinese Space Station. It currently gets up to magnitude -2.3 after the addition of the Wentian module in July.

The “mag.” beside the date indicates the brightest magnitude the satellite gets during the pass. All the ISS passes get between -3 and -4, which is brighter than Jupiter ever gets, but not quite as bright as Venus.

Missions to and from the International Space Station and *Tiangong* can change their orbits. It looks like there will be a couple of crew launches to the ISS on February 19 and 20 which is after the dates below. I don't know of any flights to *Tiangong*, and there are none to Hubble. Also note that the ISS (and presumably *Tiangong*) sometimes have to alter orbits to avoid space debris. Hubble is high enough that this is less of a concern.

The information below is from Heavens Above. This month we have lots of evening viewings of all three satellites.

ISS 1/16/23 mag. -2.6			
	Time	Position	Elevation
	7:17 p.m.	250°	10°
	7:20:11	322	40
	7:20:46	351	36
Vanishes into Earth's shadow			

ISS 1/17/23 mag. -3.7			
	Time	Position	Elevation
	6:28 p.m.	232°	10°
	6:32	318	77
	6:35	224	13

Tiangong 1/17/23 mag. -2.0			
	Time	Position	Elevation
	7:09 p.m.	231°	10°
	7:11:14	152	57
	7:12:00	137	56
Vanishes into Earth's shadow			

Tiangong 1/19/23 mag. -2.1			
	Time	Position	Elevation
	6:47 p.m.	250°	10°
	6:50:15	336	75
	6:51:49	58	27
Vanishes into Earth's shadow			

Tiangong 1/21/23 mag. -1.4			
	Time	Position	Elevation
	6:25:32 p.m.	267°	10°
	6:28:34	342	45
	6:31:16	55	13

HST 1/25/23 mag. 2.2			
	Time	Position	Elevation
	7:07 a.m.	242	10°
	7:10	179	31
	7:14	116	10

HST 1/26/23 mag. 2.2			
	Time	Position	Elevation
	6:54 a.m.	245°	10°
	6:57	182	31
	7:01	118	10

HST 1/27/23 mag. 2.1			
	Time	Position	Elevation
	6:41 a.m.	246°	10°
	6:44	184	31
	6:48	121	10

HST 1/28/23 mag. 2.1			
	Time	Position	Elevation
	6:28 a.m.	242°	14°
	6:31	186	29
	6:35	125	10

Tiangong 1/29/23 mag. -2.1			
	Time	Position	Elevation
	6:35 p.m.	299°	10°
	6:38	22	67
	6:41	106	11

ISS 2/3/23 mag. -3.7			
	Time	Position	Elevation
	7:12 p.m.	310°	10°
	7:17:11	224	80
	7:19:15	139	21
Vanishes into Earth's shadow			

ISS 2/4/23 mag. -3.6			
	Time	Position	Elevation
	6:23 p.m.	322°	10°
	6:27	39	52
	6:31	117	10*
*Passes midway between Procyon and Betelgeuse			

Tiangong 2/13/23 mag. -1.9			
	Time	Position	Elevation
	6:51 a.m.	238°	10°
	6:54	153	73
	6:58	68	10

Tiangong 2/15/23 mag. -2.1			
	Time	Position	Elevation
	6:27 a.m.	258°	14°
	6:31	338	63
	6:34	61	10

Key: Position is measured in degrees clockwise from north. That is, 0° is due north, 90° is due east, 180° is due south, and 270° is due west. Your fist held at arm's length is about ten degrees wide. "Elevation" is elevation above the horizon in

degrees. So, to view the International Space Station at 6:27 p.m. on February, measure about four fist-widths east of due north then a bit more than five fist-widths above the horizon.

Programming Notice: NASA TV on the Web

Watch NASA TV (Public, Media and Education Channels) on your computer using Flash, Windows or QuickTime at <http://www.nasa.gov/multimedia/nasatv/index.html>.

NASA TV Schedules are available at <http://www.nasa.gov/multimedia/nasatv/schedule.html>.

At this time, NASA has no live broadcasts scheduled after January 11. However, with a couple of launches to the International Space Station scheduled in mid-February, we can assume NASA will have lots of live events. It's possible they may show SpaceX's orbital test flight of Starship since it's so relevant to the return to the Moon.

Calendar of Events

Sometime in 2023: [Postponed from 2022.] Launch of SLIM, the Smart Lander for Investigating Moon, a Japanese lunar lander. Another JAXA spacecraft, *XRISM*, the X-Ray Imaging Spectroscopy Mission (pronounced "krism") launches on the same flight. For more information, see https://en.wikipedia.org/wiki/Smart_Lander_for_Investigating_Moon and https://en.wikipedia.org/wiki/X-Ray_Imaging_and_Spectroscopy_Mission.

Sometime in 2023: launch of *#dearMoon*, which will carry Japanese billionaire, Yusaku Maezawa, two crew members, and eight artists on a lunar free-return mission. For more information, visit https://en.wikipedia.org/wiki/Dear-Moon_project

Sometime in 2023 [postponed from 2022]: Launch of *Eris*, the first Australian rocket to launch an Australian payload. *Eris* is the launch vehicle for Gilmour Space. For more information, visit en.wikipedia.org/wiki/Gilmour_Space_Technologies#Eris.

Sometime in 2023: First flight of Blue Origin's *New Glenn* orbital rocket. For more information, see https://en.wikipedia.org/wiki/New_Glenn.

Sometime in 2023: *Axiom 3* and *Axiom 4* space tourist missions to the ISS. Presumably these will launch after *Axiom 2* in May.

First quarter of 2023 [moved from December 2022]: Launch of the *Peregrine* lunar lander by ULA's Vulcan Centaur for Astrobotic Technology. This is the maiden flight for Vulcan Centaur.

First quarter of 2023: UK Pathfinder Launch, from SaxaVord Spaceport on Unst in the Shetland Islands to low Earth orbit. This, amazingly, will be the first orbital launch from the ground in the history of the United Kingdom. [I.e., not counting air launching of LauncherOne.]

January: First orbital velocity test flight of SpaceX's *Starship*. It will travel three quarters of an orbit, landing northwest of Kauai in Hawaii.

January 29: Mercury is at greatest western elongation, 25.0° from the Sun (so can be seen before sunrise).

February [moved from January]: India launches Aditya-L1 to the Earth-Sun L1 point, on a mission to study the Sun's corona. For more information, visit <https://en.wikipedia.org/wiki/Aditya-L1>. "Aditya" is Sanskrit for the Sun, aka Surya.

February 16: Saturn is in conjunction with the Sun.

February 19: SpaceX's sixth Crew Dragon mission to ISS.

February 20: Launch of Soyuz-2.1a to the ISS. This is a replacement for Soyuz MS-22, which suffered a puncture in its radiator. Between this and the SpaceX launch, the MS-22 crew can be returned to Earth.

February 22: Jupiter and the crescent Moon are only one degree apart. Venus is 7.5 degrees below them.

March [Moved from December 2022]: Launch of *Polaris Dawn* flight carrying four civilians into space, led by Jared Isaacman.

March [Moved from December 2022]: Launch via Falcon 9 of the *Nova-C* lander and other cargos to the Lunar South Pole.

March 15: Neptune is in conjunction with the Sun.

March 17: Mercury is in superior conjunction with the Sun.

Second Quarter of 2023: Launch of the IM-2 South Pole Mission, including the Polar Resources Ice Mining Experiment 1 (PRIME-1), the IM-2 Lunar Lander, the Lunar Trailblazer orbiter, the Micronova Lunar Hopper, and the M1-

MAPP demo lunar rover. The last is a joint US/Finnish mission. Also on this flight is Tanker-002, an in-space refueling satellite from Orbit Fab.

April Maiden flight of Ariane 6.

April [Moved from December 2022]: First crewed launch of *Boeing Starliner-1* to the ISS.

April 4 – 30 : Launch of *JUICE*, the Jupiter Icy Moons Explorer, by the European Space Agency. The JUICE web site is sci.esa.int/web/juice. This will also mark the final launch of *Ariane 5*.

April 11: Jupiter is in conjunction with the Sun/

April 11: Mercury is at greatest eastern elongation, 19.5° from the Sun (so can be seen after sunset).

April 20: Hybrid solar eclipse. This goes from the south-central Indian Ocean north of Antarctica, touches north-western Australia, crosses central Indonesia, and western New Guinea before crossing the territory of small island nations in the western Pacific Ocean. This is total in the parts of Australia and Indonesia that it crosses, and annular along the rest of its path.

April 22: Peak of Lyrid meteor shower.

May: Launch of *Axiom-2* mission to the ISS, via Falcon 9. This carries one professional astronaut and three private astronauts. [Axioms 3 and 4 should also launch this year.]

May: Launch of Venus Life Finder atmospheric probe as well as the *Photon* relay satellite by RocketLab.

May 5: Peak of Eta Aquarid meteor shower.

May 9: Uranus is in conjunction with the Sun.

May 28: Mercury is at greatest western elongation, 24.9° from the Sun (so can be seen before sunrise).

June: India launches Chandrayaan-3, which will include a lander and a long-lived rover which will explore craters around the Moon's South Pole in search of ice. See <https://en.wikipedia.org/wiki/Chandrayaan-3>.

June 4: Venus is at greatest elongation, 45.4 degrees east of the Sun (so can be seen after sunset).

Third quarter of 2023 [moved from February 2023]: First ISS Cargo Resupply mission for Dream Chaser.

Third Quarter of 2023: Launch of the European Space Agency's *Euclid* space telescope. This will map the distribution of dark matter and search for evidence of dark energy. The Euclid website is <https://sci.esa.int/web/euclid>. This is one of the missions that had to find a new ride after the Russian invasion of Ukraine.

July: Launch of *Luna 25*, the first mission of Russia's Luna-Glob program, landing near Bogulswasky crater. For more information, see https://en.wikipedia.org/wiki/Luna_25.

July 30-31: Peak of Southern Delta Aquariid meteor shower. Moon, alas, will be almost full.

August 12 – 13: Peak of Perseid meteor shower. This may be good since the Moon is a thin crescent.

August 13: Venus is in inferior conjunction with the Sun.

September 24: *OSIRIS-REx* returns samples from Asteroid Bennu.

Fourth quarter of 2023: Second Nova C mission carrying the *Trailblazer* lunar orbiter, the Micro-Nova lunar hopper, and two lunar rovers for various companies. In addition, PRIME-1, the Polar Resources Ice Mining Experiment 1, flew on this flight.

Fourth quarter of 2023: First (uncrewed) *Gaganyaan* flight test.

Fourth quarter of 2023: China launches its *Xuntian* space telescope, which will orbit close to orbit close to *Tiangong* for easy servicing.

October 10]: Launch of *Psyche*, which will orbit a large metallic asteroid also named Psyche. See [en.wikipedia.org/wiki/Psyche \(spacecraft\)](https://en.wikipedia.org/wiki/Psyche_(spacecraft)). The *Janus* mission, which will send twin probes *Serenity* and *Mayhem* to separate asteroids (yet to be determined), will launch on the same flight. For more information, see [en.wikipedia.org/wiki/Janus \(spacecraft\)](https://en.wikipedia.org/wiki/Janus_(spacecraft))/

October 14: Annular eclipse of the Sun. The path where it is annular extends from the coast of Oregon, northern Nevada, Utah, central New Mexico, and southwestern Texas (including Austin and San Antonio), thence lengthwise through Yucatan and Central America, then Colombia and northern Brazil. This will be partial from Oklahoma with 80% of the Sun covered. This makes a good prelude to the total eclipse the following April.

October 20: Peak of Orionid meteor shower.

October 23: Venus is at greatest western elongation, 46.4 degrees from the Sun (so can be seen before sunrise).

November 2023: Launch of Masten Mission One lander and Moon Ranger rover on the Moon via Falcon 9. They will land at Haworth Crater near the South Pole of the Moon. For more information, see https://en.wikipedia.org/wiki/Masten_Space_Systems#Masten_Mission_One. Note: Masten recently went bankrupt and was acquired by Astrobotic (see osa.nss.org/Update2208.pdf). The mission is still on, but the launch date is less certain.

November 11 – 12: Peak of Northern Taurid meteor shower.

November 17 – 18: Peak of Leonid meteor shower.

December 13 – 14: Peak of the Geminid meteor shower. Often the best shower, the Geminids will be even better since the Moon is practically New.

December 21 – 22: Peak of the Ursid meteor shower.

Sometime in 2024: Launch of *Hakuto-R* mission 2, Japan's lunar lander and rover. For more information, see <https://en.wikipedia.org/wiki/Hakuto>. Sometime in 2024: First launch of Firefly's *Blue Ghost* lunar lander. For more information, see https://en.wikipedia.org/wiki/Firefly_Aerospace#Blue_Ghost_lunar_lander.

Sometime in 2024: JAXA launches *DESTINY+*, an asteroid flyby mission to Phaethon, the parent of the Geminid meteor shower. It will arrive there in 2028. For more information, see en.wikipedia.org/wiki/DESTINY%2B.

Sometime in 2024: India launches Mars Orbiter Mission 2.

Sometime in 2024: China launches the *Chang'e 6* sample return mission.

Second quarter of 2024: A SpaceX Nova-C mission to the moon takes Intuitive Machines' IM-3 lander, NASA's Lunar Vertex rover, Lunar Outpost's M2 MAPP rover, and several NASA Cadre rovers.

Second quarter of 2024: Launch of the Mission Robotic Vehicle (MRV) which carries the RSGS (Robotic Servicing of Geosynchronous Satellites) to attach jet packs to remove dying satellites from orbit.

April 8, 2024: Next total eclipse of the Sun visible in the United States. This one will be visible on a path through northern Mexico (making landfall opposite the tip of Baja California), passes through Texas (including Dallas, Arlington, and Waco), touches the southeastern corner of Oklahoma, then crosses Arkansas, eastern Missouri, Illinois, western Kentucky, Indiana, Ohio (including Cleveland), Erie in Pennsylvania, upper New York (including Buffalo and Niagara Falls), Burlington in Vermont, New Hampshire, and Maine, then into Canada.

May 2024: *Artemis 2*, the first crewed test flight of SLS and Orion. This will be a free-return mission: that is, it will loop around the Moon without landing.

May 2024 [Maybe]: Commercial Lunar Payload Services mission delivers a lunar lander in Schrödinger Basin.

September 2024: Launch of Japan's *Martian Moons Exploration* (MMX) which includes a Phobos lander and sample return. For more information, see [https://en.wikipedia.org/wiki/Martian_Moons_eXploration_\(MMX\)](https://en.wikipedia.org/wiki/Martian_Moons_eXploration_(MMX)).

Late 2024: India launches its first crewed orbital flight *Gaganyaan-3*

Fourth quarter of 2024: Impulse Space sends the Terran R lander to Mars. For more information, see https://en.wikipedia.org/wiki/Terran_R.

October 2024: Launch of the *Hera* asteroid orbiter by the ESA, which contains the *Juventas* and *Milani* asteroid probes. Destination is the binary asteroid Didymos/Dimorphos to evaluate the results of the DART asteroid impact mission.

October 2024: Launch of *Europa Clipper* orbiter. For more information, https://en.wikipedia.org/wiki/Europa_Clipper.

October 2024: *ESCAPADE Blue* and *Gold* Mars Orbiters launched.

November 2024: Launch of the first two modules of the Lunar Orbiter Platform- Gateway. These were originally going to be launched on separate spacecraft but are now bunked together.

November 2024: Launch of NASA's *VIPER* lunar rover, which will hunt for ice near the at Nobile Crater at Moon's South Pole. VIPER is landing aboard Astrobotic's *Griffin* lunar lander. They leave Earth aboard a Falcon 9.

December 2024: Launch of India's *Shukrayaan-1* Venus orbiter. For more information, see <https://en.wikipedia.org/wiki/Shukrayaan-1>.

December 2024: Launch of the Space Entertainment Enterprise's SEE-1 inflatable space habitat docked to the Ax-iom segment of the ISS.

December 24, 2024: Parker Solar Probe (formerly Solar Probe Plus) makes its first pass through the outer corona of the Sun. For more information, see <http://parkersolarprobe.jhuapl.edu>.

Sometime in 2025: first uncrewed test launch of *Orel*, Russia's new crewed spacecraft, with first crewed launch later in the year. For information, [https://en.wikipedia.org/wiki/Orel_\(spacecraft\)](https://en.wikipedia.org/wiki/Orel_(spacecraft)). This is the first flight for Russia's *An-gara A5P* spacecraft.

Sometime in 2025: Launch of *Artemis 3*, which will be the first crewed lunar landing since 1972.

Sometime in 2025 (most likely September): End of *JUNO* mission to Jupiter.

Sometime in 2025 [moved from 2024]: Israel launches its *Beresheet 2* lander and orbiter on the Moon. For more information, see en.wikipedia.org/wiki/Beresheet_2.

Sometime in 2025: Launch of NEM-1, the core module of the Russian Orbital Service Station. For more information, see https://en.wikipedia.org/wiki/Russian_Orbital_Service_Station.

September 2025: First crewed flight of Russia's *Orel* (formerly called *Federatsiya*), destined for the ISS.

December 2025: *BepiColombo* arrives at Mercury orbit.

Sometime in 2026: Launch test of China's Long March 5DY, which will eventually carry Chinese astronauts to the Moon.

Sometime in 2026: China launches the lunar mission *Chang'e 7*, which include an orbiter, a rover and a hopping probe.

First half of 2026: Launch of the *NEO Surveyor* which will be able to detect more than 90% of near-earth objects greater than 460 feet in diameter. For more information, see https://en.wikipedia.org/wiki/NEO_Surveyor.

July 2026: *Hayabusa 2* flies by asteroid 2001 CC₂₁.

October 2026 [Maybe]: Launch of the *Nancy Grace Roman Space Telescope* [formerly known as WFIRST]. For more information, see https://en.wikipedia.org/wiki/Nancy_Grace_Roman_Space_Telescope.

Sometime in 2027 [moved from 2026]: Launch of *Artemis 4*, a Lunar Gateway expedition.

Sometime in 2027: Launch of the ESA's *Earth Return Orbiter* to Mars. This is the vehicle that will bring the *Perseverance* Mars samples to Earth.

Sometime in 2027: First flight of the ESA's HERACLES lunar Transport System. This is uncrewed and will carry cargo both to and from the Moon (including sample returns and lunar landers). For more information, see [https://en.wikipedia.org/wiki/HERACLES_\(spacecraft\)](https://en.wikipedia.org/wiki/HERACLES_(spacecraft)).

June 2027: Launch of *Dragonfly*, the Titan helicopter mission.

August 12; 2027: *Lucy* flies by asteroid 3548 Eurybates in its first encounter with a Trojan asteroid. It will fly by at least 3 more Trojans in 2027 and 2028.

Sometime in 2028: [tentative, postponed from 2022]: ESA launches the *ExoMars Mars Rover*, which has been christened *Rosalind Franklin*. For more information, visit <https://en.wikipedia.org/wiki/ExoMars>. Note: this is the mission most affected by Russia's invasion of Ukraine, since they were supposed to supply the landing platform.

Sometime in 2028: Launch of *VERITAS* orbiter to Venus.

Sometime in 2028: First flight of the Long March 9 super-heavy launch vehicle. This looks like it will be able to carry 53,000 kg to the Moon and 44,000 kg to Mars and will probably carry Chinese astronauts to the Moon.

Sometime in 2028: Launch of the *Sample Retrieval Lander* to.

First quarter of 2028: Launch of the *Emirates Asteroid Mission*.

November 2028: Launch of China's *Tianwen-3* Mars sample return mission.

Sometime in 2029: Launch of the *ARIEL Space Telescope* and the *ESA/JAXA Comet Interceptor* mission via Ariane 62.

Sometime in 2029: The *Psyche* asteroid probe arrives at the asteroid 16 Psyche. [This is assuming a 2023 launch.] For more information, visit [https://en.wikipedia.org/wiki/Psyche_\(spacecraft\)](https://en.wikipedia.org/wiki/Psyche_(spacecraft)).

Sometime in 2029 [tentative]: Launch of the *Yenisei* lunar flyby mission. This will be the first Russian manned mission to the Moon (though it's not a landing).

April 21, 2029: *OSIRIS-APEX* rendezvous with the asteroid Apophis. Note: *OSIRIS-APEX* is the same spacecraft as *OSIRIS-REx*; it gets renamed "Apophis Explorer" for this part of its mission.

June 2029: Launch of *DAVINCI+* to Venus.

October 2029: *JUICE* achieves Jupiter orbit. [See 2022.]

Sometime in 2033: *JUICE* achieves Ganymede orbit. [See 2022.]

December 2034: *Dragonfly* arrives at Titan.

August 12, 2045: The next total solar eclipse visible in Oklahoma City. This one is also visible in Salt Lake City, Denver, Little Rock (again), Tampa Bay and New Orleans.

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Other Information

Oklahoma Space Industrial Development Authority (OSIDA), 401 Sooner Drive/PO Box 689, Burns Flat, OK 73624, 580-562-3500. Website is <http://airspaceportok.com/#home>,

Science Museum Oklahoma (former Omniplex) website is www.sciencemuseumok.org. Main number is 602-6664.

Tulsa Air and Space Museum, 7130 E. Apache, Tulsa, OK 74115.

Web Site is www.tulsaairandspacemuseum.com. Phone (918) 834-9900.

The Mars Society address is The Mars Society, 11111 West 8th Avenue, Unit A, Lakewood, CO 80215. Phone: (303) 980-0890 Their web address is www.marsociety.org.

The National Space Society's Headquarters Executive Director e-mail nsshq@nss.org. The Chapters Coordinator is Bennett Rutledge 720-641-7987, rutledges@chapters.nss.org. The address is: National Space Society, 1300 I Street NW, Suite 400E, Washington, DC 20005. Phone (321)452-2448. Web page is space.nss.org.

The Planetary Society phone 626-793-5100. The address is 60 South Los Robles Avenue, Pasadena, California, 91101, and the website is www.planetary.org. E-mail is tps@planetary.org.

NASA Spacelink BBS 205-895-0028. Or try www.nasa.gov .

Congressional Switchboard 202/224-3121.

Write to any U. S. Senator or Representative at [name]/ Washington DC, 20510 (Senate) or 20515 [House]

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