

OKLAHOMA SPACE ALLIANCE

OUTREACH – March 2024

102 W. Linn #1, Norman, OK 73069

Oklahoma Space Alliance will meet at the
at the room next to Norman Computer
at 2:00 p.m. on March 9, details inside



Total eclipse of the Sun showing corona. See "Space Viewing". This particular eclipse is last year's from East Timor via Wikipedia commons.

(Public domain from Direção Nacional Meteorologia e Geofísica.)

OKLAHOMA SPACE ALLIANCE OUTREACH March 2024

January Meeting

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, March 9, at the location next to Norman Computers on West Main. Prospective members are welcome.

The meeting room is in the Cyber Hall and Gaming Lounge at Norman Computers. Norman Computers is at 916 W Main St, opposite Norman High School. The phone number is (405) 292-9501. To get to the meeting space from points north, take the Highway 77 exit off I-35, and continue south until you reach Main Street. Norman Computers is about a block and a half west of this on the south (left) side of a small mall.

Saturday March 9, 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 February meeting
 - c. Annual Report
 - d. Posters
5. Video (to be announced)
6. Chat

Minutes of February 10 Oklahoma Space Alliance

Oklahoma Space Alliance met February 10, 2024, at the Cyber Hall and Gaming Lounge at Norman Computers in Norman, Oklahoma. Attending Adam Hemphill, Dave Sheely, Tim Scott, and Syd Henderson. OSA President Adam Hemphill presided over the meeting He presented an *Update* put together by Clifford McMurray discussing links to material covered in the meeting and this is online at <https://osa.nss.org/Update2402.pdf> so I'll cover the details that aren't covered there.

NASA did a report on Space-Based Solar Power that was a bit pessimistic. Cost was estimated at \$.60 per kilowatt hour which is much more than solar and hydroelectric power (\$.02 and .05 per kilowatt-hour, respectively). Note that launch costs (a good part of the expense) are dependent on our not improving on SpaceX's current launch cost. [Launch costs were seventy percent of the estimated costs. It also didn't take into account using electric propulsion. Still, a lot of improvement has to be done to make it competitive.]

SLIM was SUPPOSED to rotate to land on its side. It looked to me like it rotated a bit too much but is still operational [and woke up after lunar night].

Northrop Grumman is coming up with more capable space serving satellites. Looked at their patent application.

SpaceX's Moon plans are so ambitious that Blue Moon may succeed with a simpler profile.

The Artemis 2 delay is partly due to extra erosion on its heat shields and partly due to components of the life-support systems.

Tracking capability has to be able to grow exponentially [to keep up with increase in space debris and small satellites].

January 25 is annual Remembrance Day for astronauts who died in the space program.

Axion 3 arrived at the ISS on January 20.

The deadline for Oklahoma Space Alliance's annual chapter report to the ISS is March 1. We have \$823.48 in the checking account and \$267 in cash for a total of \$1010.48.

--Minutes By OSA Secretary Syd Henderson

Minutes of January 2024 Oklahoma Space Alliance Meeting

Oklahoma Space Alliance met January 13, 2024, at the Cyber Hall and Gaming Lounge at Norman Computers in Norman, Oklahoma. Attending in person were Clifford McMurray, Mark Deaver, Dave Sheely, Tim Scott, and Syd Henderson. Robin Scott attended by phone. OSA President Adam Hemphill couldn't make the meeting, so OSA Vice-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/Update2401.pdf> so I'll cover the details that aren't covered there. Adam also got a partial newsletter done which Kip presented, and that is online at [https://osa.nss.org/Update2401\(Simple\).pdf](https://osa.nss.org/Update2401(Simple).pdf).

There were 228 total launched into space in 2023, 116 from the United States (with 96 by SpaceX alone) and 67 from China. The latter is fewer than 2022.

SpaceX lost a lander when high winds knocked it over. This was the first SpaceX lander to carry people into space and had been launched many times since. The engines were saved but not the booster.

Artemis II is now scheduled for September 2025 and Artemis III for September 2026.

The Beta Pictoris system sports a structure [presumably natural] that is shaped like a cat's tail.

The *Juno* Jupiter orbiter passed within 930 miles of Io, the closest pass in more than twenty years. [I'm guessing the previous encounter was by *Galileo*.]

MEPs (Mission Extension Pods) can extend a space mission by up to six years by providing fuel.

Vulcan Centaur's third lunar mission will be outside of NASA's aegis; that is, it is independent of NASA's Commercial Lunar Payload Service (CLPS) that is part of the Artemis project.

NASA requires two successful launches of Vulcan Centaur. The first was the *Peregrine* launch. [The Vulcan Centaur performed perfectly but *Peregrine* did not.] The second launch will be in April.

We watched "Space Race" featuring launches in first quarter of 2024. This included a discussion of Dream Chaser (Sierra Space). Dream Chaser's mission is now scheduled for April.

SpaceX is going for fuel propellant transfer test.

We looked through the *Celestis* list of people whose cremains and/or DNA were aboard the Vulcan Centaur that launched *Peregrine*. Most of these cremains, including *Star Trek* actors and NSS Executive Director Mark Hopkins, were launched into heliocentric orbit, not to the Moon.

We have \$843.48 in the checking account and \$267 in cash.

Russ Davoren. Adam Hemphill and Kip McMurray renewed memberships.

--Minutes by OSA Secretary Syd Henderson

Space News

The April 8 Total Solar Eclipse is covered at length in "Sky Viewing."

Intuitive Machines' NOVA-C lander *Odysseus* made a soft landing on the Moon on February 22, the first private spacecraft to do so, but not quite in the manner expected. Communications took a while to be established and it was realized that it had tipped over when it landed. In fact, the first photos released on February 29 revealed that it had broken one of its six legs upon landing and is now lying at a thirty-degree angle to the horizontal. It appears that a laser guidance system underestimated its height above the surface and the spacecraft made a harder landing than expected. It apparently also had some sideways motion,

and the ground was not level. It's estimated that it is at a twelve-degree slope. The landing site is about a mile from the intended landing site and in a small crater.

Despite the clumsy landing, the spacecraft seemed to be in good health with all instruments functioning and was beaming data to Earth during the entire week. However, the life of *Odysseus* is short, and it has already shut down after six days with the coming of lunar night, about four days early since the solar panels were at an awkward angle for generating maximum solar power.

I don't think this is expected to survive the Lunar night, but, on the other hand, *SLIM* woke up after Lunar night [see below] so there is hope.

Odysseus is notable for relying on liquid methane and oxygen for its engine. These boil at less than 250 degrees Fahrenheit under atmospheric pressure, and, although they are pressurized, present a major challenge to keep refrigerated. (But nowhere near the challenge liquid hydrogen would present.) Methane/oxygen engines will be playing a major role in the Artemis program. This is not only the first methane/oxygen engine to land on the Moon, it is the first to operate beyond low-Earth orbit.

I'm having a bit of trouble keeping names straight. Nova-C is a class of lunar landers developed by Intuitive Machines, and there will be more in the future. The mission itself is IM-1. The IM-1 lander is *Odysseus*, after the Greek hero famous for his wandering. To the Romans he was Ulysses, hence the name of the famous Solar probe. There are two asteroids named for him, one under each name. *Mars Odyssey* is a spacecraft orbiting Mars and was also the callsign of the *Apollo 13* command module. *Neptune Odyssey* is a proposed Neptune orbiter. *Odysseus* certainly gets around.

The *SLIM* lander on the other hand, is also nicknamed Moon Sniper since it landed within a hundred meters of its target.

The Japanese *SLIM* lander has woken up after the Lunar night and contact was re-established on February 25. Since this was around high noon at the landing site, operations are being postponed a bit until it gets a chance to cool off. The landing of this mission on January 25. This spacecraft made a soft landing on January 19, and made Japan the fifth nation to make a soft landing on the Moon. There was a complication because *SLIM* was supposed to tip to land on its side, but landed on the wrong side, which caused problems generating power. However, it did deploy two small rovers, and these operated as expected. I haven't heard if they survived the lunar night.

The *Peregrine* lunar lander which I wrote about in January did not make it to the Moon and was deliberately burnt up in the Earth's atmosphere. There was some confusion in the media (including me) about the cremains on the mission. Some of these were on *Peregrine*, hence returned to Earth, but Celestis was the company carrying ashes of Star Trek cast Nichelle Nichols, James Doohan and Deforest Kelley as well as Gene Roddenberry and Majel Barrett (and the late NSS Board member Mark Hopkins) and they were launched from the Vulcan Centaur into heliocentric orbit. They only send a few grams of each person's ashes which is why James Doohan and Gene Roddenberry are on their second flight. Roddenberry also had ashes aboard *Peregrine*, which may have been part of my confusion. I haven't seen any mention of cremains aboard *Odyssey* and don't believe there were any.

Sky Viewing

We have two eclipses in the time span covered by this newsletter, but the second, of course, is the important one. However, there is a deep **penumbral lunar eclipse** on March 24, Penumbral lunar eclipses are usually inconspicuous, and I don't report them, but the Moon should appear visibly darker from about 1:45 to 2:45 a.m.

However, the main event this newsletter is the **total eclipse of the Sun** on April 8, and, short of the path of totality crossing the Oklahoma City area which it will do in the August 2045 eclipse—only twenty-one years to wait!--this is the closest we will get till then. And it is total in southeastern

Oklahoma, or really on a path from the west coast of Mexico to the east Coast of Newfoundland (and a bit on the ocean before and after). In short, it compares favorably with the 2017 eclipse and comes much closer to us.

The eclipse comes ashore at 11:08 a.m. local time (12:08 p.m. CDT) Mazatlán (population 500,000), a resort city on the west coast of Mexico that is almost on the center line, the location of longest totality. Gómez Palacio (population 330,000 in the city but over a million in the metro area) is the other sizable city in Mexico near the center line. Totality crosses into the United States at 1:28 p.m. at Eagle Pass, Texas and shortly after brushes San Antonio (which was also in the path of last October's annular eclipse), Austin and Fort Worth, with Dallas being closer to the central line. The center line just clips the southeastern corner of Oklahoma, but totality will be visible. The center line of the eclipse reaches the Red River at 12:27 p.m. with totality beginning at 1:45 CDT and lasting about four minutes at the center line. The eclipse won't be total in Oklahoma City, but the Moon will still cover 93% of the Sun.

After Oklahoma, the path goes diagonally across Arkansas with Texarkana and Little Rock being within the edge of the path of totality. After crossing southeastern Missouri, it crosses into western Kentucky, coincidentally crossing the path of the 2017 eclipse.

The eclipse then passes into the Midwest, with Indianapolis, Cleveland and Buffalo all being near the center line, then through northern New York, Burlington in Vermont, Montreal (barely) and then into western Maine where it visits my mother. After that it passes into central New Brunswick and Newfoundland. Alas it misses Sydney, Nova Scotia.

The eclipse is partial throughout the 48 states, with Houston, St. Louis, Memphis, Tulsa, Chicago, Cincinnati, Detroit, Pittsburgh, and Boston all getting more than 90 percent totality, as do Guadalajara and Monterrey, Mexico, and Toronto, Ontario. New York gets exactly 90 %.

If you plan to view this eclipse, be sure to get eclipse glasses. It is especially dangerous when the Sun first pops out of totality since your eyes are adapted to darkness.

[A lot of information for this comes from the April *Sky and Telescope* but also from various online sources and my *Starry Night* program. *Astronomy* hasn't arrived yet this month but will also be devoted to the eclipse. MyScienceShop offers wrap-around eclipse glasses. (You can link to these through www.astronomy.com, but I'm sure many other sites are offering them.)

Mercury is currently lost in twilight at sunset since it was at superior conjunction last week. However, Mercury will become relatively highly visible in a couple of weeks as it moves toward greatest elongation on March 24. It is brightest before that date. By March 11, Mercury will be 15 degrees above the horizon a half hour after sunset. It will be about four degrees southwest of the crescent Moon and shining at magnitude -1.5. On March 24, it will be at greatest elongation, nineteen degrees from the Sun, and, because the ecliptic is almost perpendicular to the western horizon this time of year, also is pretty visible up to an hour after sunset. However, it will also be down to magnitude -0.3 and less than fifteen degrees above the horizon. Mercury will rapidly become lower and dimmer after that as it approaches inferior conjunction on April Fools Day. It will return to the eastern sky toward the end of April, but the ecliptic is at a shallow angle to the horizon in April and it will not get very high.

Venus is now getting low in the eastern sky at sunrise (shallow angle of the ecliptic again) but you may be able to see it just before sunrise, since it is still magnitude -3.8. It will not be visible at all in late April or all May or June since it is in superior conjunction with the Sun on June 4. Expect to see it in the west in mid-July.

Mars is about eight degrees to the upper right of Venus and only around magnitude 1.2. It was in conjunction with the Sun back on November 17 and, since it takes two years to go from conjunction to conjunction, takes a while to separate from the Sun. It is, however, moving in the opposite direction from Venus and will be getting gradually brighter for the rest of 2024. By April 6, it will be rising about 5:15 EDT and playing tag with **Saturn**. The two planets will be separated by half a degree on April 10, and will both be around magnitude 1.2. Mars is the higher (and redder). Over the next day or two, Mars passes to the left of Saturn, but the two planets will still be close. The constellation is Aquarius, by the way.

Jupiter is still visible for about three hours after sunset, and at magnitude -2.2, is easily visible. It is in Aries, if you want to find that rather small constellation. By the end of March, it will be setting at 9:30 p.m., a couple of hours after the Sun, and at the end of April, in late twilight at 8:00 p.m. as Jupiter approaches its May 18 conjunction with the Sun.

The conjunction with Mars is also about when **Saturn** is starting to become visible in the morning sky. It was in conjunction with the Sun on February 28. It should be visible around April 1, rising maybe twenty minutes after Mars, and by the end of April will be rising about 3:30 a.m. It still will be around magnitude 1.0.

Uranus is about eight degrees above Jupiter on March 9, but at magnitude 5.8 is a difficult object even with binoculars. The constellation is also Aries. Jupiter and Uranus actually have a conjunction of sorts on April 20, or at least Uranus passes Jupiter. Since the two planets are so close in the sky, it's not surprising that Uranus is in conjunction with the Sun on May 13, only five days before Jupiter. To search for Uranus, try <https://lovethenightsky.com/see-uranus-through-a-telescope/>

Neptune is in conjunction with the Sun on March 17, hence is not visible even with binoculars. It may be visible with binoculars low in the eastern sky an hour before sunrise in a dark sky, but at magnitude 7.8 is still difficult to find. It is in an inconspicuous part of Pisces near the border of Aquarius.

Viewing Opportunities for Satellites (March 8 – April 13, 2024)

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. 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 is more likely. *Tiangong* is the Chinese Space Station. It currently gets up to magnitude -2.2 after the addition of the Wentian module last July and will do so several times below.

The “mag.” beside the date indicates the brightest magnitude the satellite gets during the pass. All the ISS passes get between -2.9 and -3.9, 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. The Crew 8 mission arrived on March 5. There is a Soyuz crew launch to the ISS on March 21. The Expedition 70 mission returns in March, but I have no firm date. There are no launches to *Tiangong* this month. There will be no launches to Hubble in the foreseeable future. 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. I have no good Hubble viewing opportunities this month.

ISS 3/8 mag. -3.8			Tiangong 3/9 mag. -2.1		
Time	Position	Elevation	Time	Position	Elevation
Appears from Earth's shadow.					
5:24:23 a.m.	215°	47°	7:21 p.m.	299°	10°
5:25:15	47	88	7:23:51	21	66
5:29	132	10	7:25:50	102	20
			Vanishes into Earth's shadow.		

Tiangong 3/11 mag. -2.0		
Time	Position	Elevation
7:54 p.m.	292°	10°
7:57	206	74
8:00	121	10

ISS 4/2 mag. -2.9		
Time	Position	Elevation
8:39 p.m.	311°	10°
8:42	226	46
8:45	152	10

ISS 3/13 mag. -3.9		
Time	Position	Elevation
8:38 p.m.	225°	10°
8:41:21	137	86
8:43:36	49	19

Vanishes into Earth's shadow.

Tiangong 4/8 mag. -2.2		
Time	Position	Elevation
6:38 a.m.	296°	10°
6:41	23	83
6:44	113	10

Tiangong 3/30 mag. -1.9		
Time	Position	Elevation
Appears from Earth's shadow.		
6:30:11 a.m.	339°	17°
6:32:22	59	55
6:35	64	10

Tiangong 4/10 mag. -2.2		
Time	Position	Elevation
Appears from Earth's shadow.		
6:07 a.m.	286°	17°
6:09	208	61*
6:12	124	10

*Passes just above Arcturus

Although the Hubble Space Telescope passes just above Venus at the close of its passes in early February, it is also very low in the sky and probably can't be seen (though Venus should be visible with a clear horizon.)

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 spans about ten degrees. "Elevation" is elevation above the horizon in degrees. So, to view the International Space Station at 8:42 p.m. on April 2, measure four-and a half fist-widths west of due south (i.e., look southwest), then four and a half 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>.

March 9: 835 a.m. Change of command ceremony on the ISS.

April 8: noon: Live-stream coverage of total solar eclipse.

Calendar of Events

Sometime in 2024: Maiden flight of the Aurora rocket. This will be the first orbital launch from Spaceport Nova Scotia.

Sometime in 2024: *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.

March: Launch of *Eris*, the first Australian rocket to launch an Australian payload, and the first launch from Bowen Orbital Spaceport in Queensland, Australia. *Eris* is the launch vehicle for Gilmour Space. For more information, visit en.wikipedia.org/wiki/Gilmour_Space_Technologies#Eris.

March 8: Oklahoma City Astronomy Club meets at Science Museum Oklahoma. 7:00 p.m., followed by a talk at about 7:45 p.m. See www.okcastroclub.com for details. Lecture is “The Last Stargazers” by astronomy Professor Emily Levesque of the University of Washington.

March 9: Oklahoma Space Alliance meeting, 2:00 p.m., Norman Computers. Meeting information will be posted at <http://osa.nss.org>.

March 14 (moved from March 11): Final launch of the Delta IV Heavy rocket, and the final launch of a Delta rocket, period. This ends nearly 64 years of flights of the Delta Rocket family.

March 17: Neptune is in conjunction with the Sun.

March 20: Launch of China’s *Queqiao-2*, the relay satellite for the *Chang’e-6* mission to the far side of the Moon.

March 21: Launch of Expedition 70/71 by Soyuz to the ISS.

March 24: Mercury is at its greatest eastern elongation, 18.7 ° east of the Sun (hence can be seen after sunset).

April: Launch of *Polaris Dawn* flight carrying Jared Isaacman and four other civilians into space. https://en.wikipedia.org/wiki/Polaris_Dawn

April 1: Mercury is at inferior conjunction.

April 6: 3:20 a.m.: Conjunction of the Moon and Saturn. This will be an occultation from some locations.]

April 8: 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.

April 8: Peak of Lyrid meteor shower. Note that this is happening at the same time as the eclipse.

April 12: Oklahoma City Astronomy Club meets at Science Museum Oklahoma. 7:00 p.m., followed by a talk at about 7:45 p.m. See www.okcastroclub.com for details.

April 13: Oklahoma Space Alliance meeting, 2:00 p.m., Norman Computers. Meeting information will be posted at <http://osa.nss.org>.

April 22 [Moved from April 14]: First crewed test launch of *Boeing Starliner-1* to the ISS. For more information, see https://en.wikipedia.org/wiki/Boeing_Starliner.

May: Launch of *Chang’e 6*, China’s second lunar sample return mission, this time to the Apollo Basin on the far side of the Moon. For more information, see https://en.wikipedia.org/wiki/Chang%27e_6

May 3: Peak of Eta Aquariid meteor shower.

May 9: Mercury is at greatest western elongation, 26.4° from the Sun (hence can be seen before sunrise).

May 11: Oklahoma Space Alliance meeting, 2:00 p.m., Norman Computers. Meeting information will be posted at <http://osa.nss.org>.

May 13: Uranus is in conjunction with the Sun.

May 18: Jupiter is in conjunction with the Sun.

May 23 – 26: International Space Development Conference 2024 in Los Angeles, California.

June: First (uncrewed) *Gaganyaan* flight test. For more information, see https://en.wikipedia.org/wiki/Gaganyaan_1

June (moved from April): First ISS Cargo Resupply mission for *Dream Chaser*.

June: Maiden flight of the Tianlong reusable launch vehicle.

June 4: Venus is in superior conjunction with the Sun.

June 8: Oklahoma Space Alliance meeting, 2:00 p.m., Norman Computers. Meeting information will be posted at <http://osa.nss.org>.

June 14: Mercury is in superior conjunction with the Sun.

Late June: Maiden flight of Ariane 6. More precisely, Ariane 62.

Third quarter of 2024: First launch of Firefly's *Blue Ghost* lunar lander delivering payloads to Mare Crisium. For more information, see https://en.wikipedia.org/wiki/Firefly_Aerospace#Blue_Ghost_lunar_lander.

July 22: Mercury is at its greatest eastern elongation, 26.9 from the Sun (hence can be seen before sunset).

July 23: Pluto is at opposition.

July 27: Peak of Delta Aquariid meteor shower.

August 6 – 15: *ESCAPADE Blue* and *Gold* Mars Orbiters launch by New Glenn. This is the maiden flight for Blue Origin's New Glenn rocket. For more information, see en.wikipedia.org/wiki/EscaPADE.

August 12: Peak of the Perseid meteor shower.

Mid August: Ninth *Crew Dragon* mission to the ISS.

August 18: Mercury is at inferior conjunction with the Sun.

September 4: Mercury is at greatest western elongation, 18.1° from the Sun (hence can be seen before sunrise).

September 7: Saturn is at opposition.

September 11: Launch of Expedition 71/72 to the ISS by Soyuz.

September 20: Neptune is at opposition.

September 30: Mercury is in superior conjunction with the Sun.

Fourth quarter of 2024: China launches its *Xuntian* space telescope, which will orbit close to orbit close to *Tiangong* for easy servicing. For more information, visit <https://en.wikipedia.org/wiki/Xuntian>

Fourth quarter of 2024: Maiden flight of Perigee Aerospace *Blue Whale 1* reusable launch vehicle from Jeju Space Center in South Korea.

Fourth quarter of 2024 [Moved from second quarter]: Second (uncrewed) *Gaganyaan* flight test. This one will carry the Vyommitra humanoid robot. For more information on the *Gaganyaan* program, see <https://en.wikipedia.org/wiki/Gaganyaan>.

Fourth quarter of 2024 [Moved from second quarter]: 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. This is the second NOVA-C mission.

Fourth quarter of 2024: *Hakuto R* Mission 2 carrying iSpace's Resilience lunar lander and a Luxembourg (!) iSpace Europe lunar mini-rover. [*Hakuto R* mission 1 was the one that crash landed with a UAE rover aboard.]

October 2: Annular eclipse of the Sun. This one is almost entirely over the South Pacific Ocean, touching land in Easter Island and southern tips of mainland Chile and Argentina. It will be partial in Hawaii, southern South America, and a bunch of small South Pacific islands as well as Western Antarctica.

October 8: 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. For more information, visit [https://en.wikipedia.org/wiki/Hera_\(space_mission\)](https://en.wikipedia.org/wiki/Hera_(space_mission)).

October 10: Launch of *Europa Clipper* orbiter to Jupiter's moon Europa. For more information, https://en.wikipedia.org/wiki/Europa_Clipper,

October 21: Peak of the Orionid meteor shower.

Late October: Launch of *Axiom-4 (Ax-4)* mission to the ISS, via Falcon 9. This carries one professional astronaut and three private astronauts, including the winner of the *Space Hero* reality show. For more information, see https://en.wikipedia.org/wiki/Axiom_Space.

November: Maiden flight of *Pallas-1* by Galactic Energy company in China.

November: Launch of NASA's *VIPER* lunar rover, which will hunt for ice near the Nobile Crater at Moon's South Pole. *VIPER* is landing aboard Astrobotic's *Griffin* lunar lander. They leave Earth on a Falcon 9. For information, see [en.wikipedia.org/wiki/VIPER_\(rover\)](https://en.wikipedia.org/wiki/VIPER_(rover))

November 16: Uranus is at opposition.

November 16: Mercury is at greatest eastern elongation, 22.5° from the Sun (hence can be seen after sunset) .

December 5: Mercury is at inferior conjunction with the Sun.

December 7: Jupiter is at opposition.

December 13: Peak of Geminid meteor shower.

December 22: Peak of Ursid meteor shower.

December 24: Mercury is at greatest western elongation, 22.0° from the Sun (hence can be seen before sunrise).

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

December 30: Launch of the *Venus Life Finder Probe and Photon* relay satellite to Venus by RocketLab's Electron Booster. For more information, visit https://en.wikipedia.org/wiki/Venus_Life_Finder

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

Sometime in 2025: Israel launches its *Beresheet 2* lander and orbiter to the Moon. For more information, see en.wikipedia.org/wiki/Beresheet_2.

Sometimes in 2025: Launch of Skynet 6A by Airbus and the UK Ministry of Defense, which will catapult us into the Terminator universe./

Sometime in 2025: JAXA launches *DESTINY+*, an asteroid flyby mission to Phaethon, the parent of the Geminid meteor shower. It will arrive there in 2029. For information, see en.wikipedia.org/wiki/DESTINY%2B.

Sometime in 2025: China will launch an asteroid impactor and flyby to asteroid 2019 VL5. For more information, see <https://spacenews.com/china-to-target-asteroid-2019-vl5-for-2025-planetary-defense-test/>.

Sometime in 2025: Uncrewed Starship lunar landing demonstration.

First quarter of 2025: India launches its first crewed orbital flight *Gaganyaan-3*. For more information, en.wikipedia.org/wiki/Gaganyaan.

First quarter of 2025 (moved from 2024): A SpaceX Nova-C mission to the moon takes Intuitive Machines' IM-3 lander, NASA's Lunar Vertex rover, and several NASA Cadre rovers.

First quarter of 2025: First crewed mission of *Starliner 1* to the ISS. For more information, visit https://en.wikipedia.org/wiki/Boeing_Starliner-1.

First quarter of 2025: 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. For more information, see https://en.wikipedia.org/wiki/Mission_Extension_Vehicle.

February 2025: Launch of *IMAP* heliophysics probe and *Solar Cruiser* to the Earth-Sun L1 Lagrangian point (the one between us and the Sun).

April 20, 2025: *Lucy* flies by asteroid 52246 Donaldjohanson.

May 2025: Launch of *Tianwen-2* (formerly *Zheng He*), China's asteroid sample return mission and comet orbiter. For more information, see <https://en.wikipedia.org/wiki/Tianwen-2>.

Second half of 2025 (not in July!): first crewed mission to Vast's *Haven-1* space station. For more information, <https://en.wikipedia.org/wiki/Haven-1>.

August 2025: launch of Vast's *Haven-1* space station. For more information, <https://en.wikipedia.org/wiki/Haven-1>.

Third quarter of 2025: First flight test of ESA's uncrewed Space Place *Vega-C*.

September 2025 [Moved from 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. For more information, visit https://en.wikipedia.org/wiki/Artemis_2.

November 2025: Launch of the first two modules of the Lunar Orbiter Platform Gateway by SpaceX's Falcon Heavy. These were originally going to be launched on separate spacecraft but are now bunked together.

December 2025: *BepiColombo* arrives at Mercury orbit.

Sometime in 2026: Launch and landing of Japan/India *LUPEX* (Lunar Polar Exploration) lander. For more information, see https://en.wikipedia.org/wiki/Lunar_Polar_Exploration_Mission.

Sometime in 2026: Launch of Japan's *Martian Moons Exploration* (MMX) which includes a Phobos lander and sample return. For information, see [en.wikipedia.org/wiki/Martian_Moons_Exploration_\(MMX\)](https://en.wikipedia.org/wiki/Martian_Moons_Exploration_(MMX)).

Sometime in 2026 [moved from 2024]: India launches *Mars Orbiter Mission 2* (MOM 2). For information, see https://en.wikipedia.org/wiki/Mars_Orbiter_Mission_2.

Sometime in 2026: Maiden flight of Terran R mission to Mars from Impulse Space. For more information, en.wikipedia.org/wiki/Terran_R.

Sometime in 2026: second *Blue Ghost* mission, carrying Lunar Pathfinder to the far side of the Moon. (Lunar Pathfinder is not to be confused with UK Pathfinder, to launch in 2024, or Intuitive Machines GEO Pathfinder, which is a variant of SHERPA.)

Sometime in 2026: Maiden flight of *Volans*, the first orbital launch vehicle developed in Singapore. May 2006: The *Psyche* probe flies by Mars.

Mid-2026: Uncrewed *Starship* mission to Lunar South Pole, carrying Astrolab's FLEX lunar rover. July 2026: *Hayabusa 2* flies by asteroid 2001 CC₂₁.

September 2026 [Moved from 2025]: Launch of *Artemis 3*, which will be the first crewed lunar landing since 1972. For information, see en.wikipedia.org/wiki/Artemis_3.

Fourth quarter of 2026: China launches the lunar mission *Chang'e 7*, which include an orbiter, a rover and a hopping probe. For more information, see https://en.wikipedia.org/wiki/Chang%27e_7.

October 2026: Launch of the *Nancy Grace Roman Space Telescope* [formerly known as WFIRST] to the Earth-Sun L2 point. For more information, see https://en.wikipedia.org/wiki/Nancy_Grace_Roman_Space_Telescope.

Sometime in 2027: 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.

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

Sometime in 2027: Launch of *Luna 26*, the Luna-Resurs-Orbiter. This mission is in tandem with next year's Luna 27 lander. For more information, see https://en.wikipedia.org/wiki/Luna_26.

Sometime in 2027: USSF's *DRACO* demonstration of a nuclear thermal rocket in low-Earth orbit.

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.

September 15, 2027: *Lucy* flies by Tronan asteroid 15094 Polymele.

Possibly in 2028 (moved from December 2024): Launch of India's *Shukrayaan-1* Venus orbiter. For more information, see <https://en.wikipedia.org/wiki/Shukrayaan-1>.

Sometime in 2028: Launch of *Luna 27*, the Luna-Resurs Lander which will land in the South Pole-Aitkin Basin on the far side of the Moon. This mission is in tandem with 2027's Luna 26 orbiter. For more information, see https://en.wikipedia.org/wiki/Luna_27#Science_payload.

Sometime in 2028: 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 *Chang'e 8*, which will include a lander, rover and a 3D printing experiment using lunar resources.

Sometime in 2028: Launch of the *Sample Retrieval Lander* to Mars. This is part of a joint NASA/ESA mission and will include Ingenuity class helicopters.

Sometime in 2028: 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)).

Sometime in 2028: Launch of the first module of India's *Bharatiya Antariksha* space station. For more information, see https://en.wikipedia.org/wiki/Bharatiya_Antariksha_Station.

First half of 2028: 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.

March 2028: Launch of the *Emirates Asteroid Mission* to the asteroid belt, where it will make at least seven flybys of asteroids, the largest of which are Chimaera and Justitia. [See May 2035.]

April 18, 2028: *Lucy* encounters asteroid 11351 Leucus.

July 2028 [Moved from June 2027]: Launch of *Dragonfly*, the Titan helicopter mission. For information, see [en.wikipedia.org/wiki/Dragonfly_\(spacecraft\)](https://en.wikipedia.org/wiki/Dragonfly_(spacecraft)).

September 2028: Launch of *Artemis 4*, a Lunar Gateway expedition which will also land four astronauts on the Moon.

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

November 11, 2028: *Lucy* flies by Trojan asteroid 21900 Orus.

Sometime in 2029: *DESTINY+* flies by asteroid 3200 Phaethon, the parent body of the Geminid meteor shower.

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

Sometime in 2029: Launch of *VERITAS* orbiter and Venus Atmosphere Sample Return Mission to Venus.

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. For more information, see <https://en.wikipedia.org/wiki/DAVINCI>

August 2029: The *Psyche* asteroid probe arrives at asteroid 16 Psyche. For more information, visit [https://en.wikipedia.org/wiki/Psyche_\(spacecraft\)](https://en.wikipedia.org/wiki/Psyche_(spacecraft)).

September 2029: Launch of *Artemis 5* to the Moon.

September 2029: Launch of *Tianwen 4* which will carry a Jupiter orbiter and a mission to Uranus. The Uranus spacecraft will eventually leave the solar system, something that only the US has achieved.

Sometime in 2030: Launch of the ESA's *NEOMIR* (Near-Earth Object Mission in the Infrared).

Sometime in 2030: Launch of Russia's *Luna 28* sample return mission.

September 2030: Launch of *Artemis 6* to the Moon.

July 2031: Hayabusa 2 arrives at asteroid 1998 KY26.

July 2031: *JUICE* flies by Ganymede then is inserted into Jupiter orbit.

September 2031: Launch of *Artemis 7* to the Moon. This will include the crewed Lunar Cruiser rover.

Sometime in 2032 [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).

Sometime in 2032: Launch of *Artemis 8* to the Moon, which includes the first component of the Artemis Base Camp.

Sometime in 2033: 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.

March 2, 2033: *Lucy* flies by the double Trojan asteroid 617 Patroclus-Menotius. I believe these are the largest asteroids it will encounter.

December 2034: *Juice* achieves Ganymede orbit.

May 2035: The *Emirates Asteroid Mission* touches down on Justitia.

Sometime in 2036: *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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To join the Mars Society, visit www.marssociety.org. One-year memberships are \$50.00; student and senior memberships are \$25, and Family memberships are \$100.00. Their address is Mars Society, 11111 W. 8th Ave, Unit A, Lakewood, CO 80215.

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