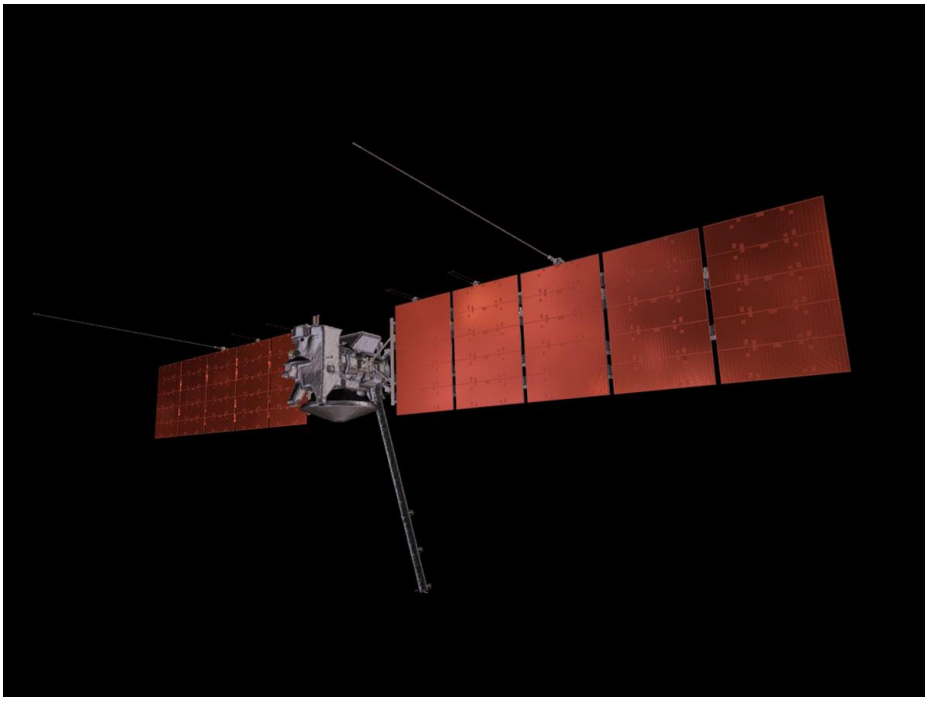
OKLAHOMA SPACE ALLIANCE

OUTREACH – September 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 September 14, details inside



Europa Clipper

OKLAHOMA SPACE ALLIANCE OUTREACH
September 2024

September Meeting

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, September 14, 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 September 14, 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 July and August meetings
    c. Posters
    d. Membership Business
    e. ISDC 2024
5. Video (to be announced)
6. Chat

Minutes of August 10 Oklahoma Space Alliance Meeting

Oklahoma Space Alliance met August 10, 2024, at the Cyber Hall and Gaming Lounge at Norman Computers in Norman, Oklahoma. Attending were Adam Hemphill, Mark Deaver, Steve Marino, Kip and Claire McMurray, Jackson O'Neal (from OU-SEDS), Dave Sheely, and Syd Henderson. OSA President Adam Hemphill presided over the meeting Adam presented an update containing links to material covered in the meeting and this is online at **https://osa.nss.org/Update2408.pdf** so I'll cover the details that aren't covered there.

At the time of the meeting, *Starliner* (the Boeing Crew Flight Test vehicle) was still attached to the ISS and its two-person crew still aboard the International Space Station. We had a vote on whether we thought they would come back to Earth aboard *Starliner*, and whether there would be any more *Starliner* flights, and voted no on both. [Well, *Starliner*'s crew capsule returned to Earth without them, and the second will be probably be true although Boeing has another flight scheduled for next year.] Steve Marino mentioned that if they make any change in software (which they did so *Starliner* can operate without astronauts), they have to recertify the whole thing.

The order to have six people return aboard a Dragon capsule would require delaying revisions, so they'll probably send a regular Dragon up with two free seats and return Butch and Suni in February.

The June failure of a Falcon Block 9 was the first for that configuration,

Adam thinks Boeing should concentrate on their commercial side and getting their 737 fixed while working on the inevitable replacement. Boeing's pay in Seattle is not competitive there (but might be elsewhere, such as Oklahoma).

SpaceX is going to build the deorbit vehicle for the ISS, but NASA will operate it. Russia has already said they'll cease support in 2028.

We looked at the stock market histories for Intuitive Machines and Rocket Lab.

We watched a video of ADRAS-J's inspection flyby of its intended target, a Japanese upper stage.

Naro-1 was South Korea's first orbital vehicle in 2013. Their current orbital vehicle is *Nuri*. [Unlike *Naro-1*, all of *Nuri* is built by South Korea.]

The planet Mercury has patches of graphite on its surface, and it is suspected that deeper in the crust, this becomes diamond.

We watched a video of the ISS Olympics.

In contrast with the Chinese booster that was destroyed, the SpaceX booster broke up in a much lower orbit and no debris was produced.

We currently have $797.67 in the checking account and $267 in cash.

After the meeting, we watched a 2018 ISDC video of a talk on Moon Direct by Robert Zubrin

--Minutes By OSA Secretary Syd Henderson

Minutes of July 13 Oklahoma Space Alliance Meeting

Oklahoma Space Alliance met June 8, 2024, at the Cyber Hall and Gaming Lounge at Norman Computers in Norman, Oklahoma. Attending were Adam Hemphill, Mark Deaver, John Northcutt, Kevin Sampson, Tim Scott, Dave Sheely, and Syd Henderson OSA President Adam Hemphill presided over the meeting Adam presented an update containing links to material covered in the meeting and this is online at **https://osa.nss.org/Update2407.pdf** so I'll cover the details that aren't covered there.

Why is China doing static rocket tests within a building? [This refers to the static test of Long March 10 in June. 'Tis still a mystery.]

Ariane 6 did have problems reducing the orbit of the second stage so it will stay in orbit and will be doing an uncontrolled reentry quite a while in the future.

If NASA does mothball ISS, as has been proposed, there could be a potential problem with space debris hitting the mothballed space station.

We watched a video of Tianlong 3's accidental launch, brief burst of freedom, and subsequent crash. The private company that created it had previously successfully reached orbit with Tianlong 2.

Only a small part of the pallet of batteries from the ISS dropped through the roof of the man who is suing NASA. The whole pallet weighed over a ton but thankfully most of it burnt up on reentry.

Space piracy could include taking control of orbiting satellites.

SpaceX had a second stage failure while launching twenty Starlink satellites. These communications satellites were released, and they will try to boost them to a higher orbit. Rockets on Starlink satellites are low-thrust. [It looks like the satellites were allowed to burn up.] For the moment the United States has no capacity to launch people to the ISS. [SpaceX has resumed launches and will launch a crew to the Space Station at the end of August.]

This Week @ NASA apparently stopped on May 31 so we had to look elsewhere for space news.

The upper stage of a Long March 6A is creating orbital debris. This is not due to the upper stage breaking up. The pieces of debris are tiny and may be insulation.

--Minutes by OSA Secretary Syd Henderson

Space News

The cover this month is the *Europa Clipper*, which is currently scheduled to launch on October 10 via a Falcon Heavy. This will follow *JUICE*, the Jupiter Icy Moons Explorer, to the moons of Jupiter. Although *JUICE* will visit Europa, its primary mission is to investigate Callisto and Ganymede, eventually going into orbit around the latter. *Europa Clipper*, on the other hand, will be flying by Europa more than fifty times, mapping its surface and looking for signs that it might support life under its frozen exterior. It is certain that there is a subsurface ocean, and occasionally water from beneath the crust will reach the surface through cracks. The spacecraft carries deep radar to search for the subsurface ocean, as well as a magnetometer and instruments to examine Europa's atmosphere, which is thin but present. Between these and the general gravitational environment, we should get a better idea of what lies inside Europa. And, of course, we'll be looking for organics that have come up through the cracks in the ice.

As with *JUICE*, *Europa Clipper* will be using gravitational slingshots to get it to Jupiter orbit. After its launch, it will fly by Mars in February 2025 and Earth in December 2026, arriving at Jupiter in April 2030. It will not actually orbit Europa *per se*, since the heavy radiation there would shorten the spacecraft's lifetime too much, which is why the Europa Orbiter became the *Europa Clipper*. Instead, it will have an elliptical orbit, transmitting its data after each encounter with Europa. (Since Ganymede is farther from Jupiter, *JUICE* will be able to orbit it.) In order to get into its resonant orbit, *Europa Clipper* will use Ganymede and the other moons of Jupiter to adjust its orbit. I don't think either spacecraft will be going by Io because the radiation intensity is even higher there.

Polaris Dawn launched from Cape Canaveral at 4:23 CDT September 10 on a SpaceX Falcon 9 This is a four-person mission with Jared Isaacman, Scott Poteet, Sarah Gillis and Anna Menon. The last two will be the first two SpaceX employees to orbit the Earth.

Among other features, the one that's getting attention is the first private spacewalk. Since the Dragon Capsule lacks an airlock, the interior of the spacecraft will be evacuated of air and the two astronauts who stay inside will also have to wear spacesuits. The spacecraft will also reach an altitude of over 850 miles, which means it will pass through a bit of the Van Allen belts. This will be the highest any astronaut has reached since the *Apollo* missions more than fifty years ago.

On July 24, NASA announced that the James Webb Space Telescope had directly images a "cold Jupiter" planet orbiting Epsilon Indi, which is only twelve lightyears away. The planet is actually several times more massive than Jupiter and hence has retained its heat better. It is estimated to have a temperature of about two degrees Celsius (35 degrees Fahrenheit) despite Epsilon Indi being a type K5 star and the planet orbiting no closer that Saturn does the Sun. The orbit is also pretty elliptical, but I don't know if that's enough to preclude Earthlike planets in stable orbits. They would be closer to Epsilon Indi than Earth is to the Sun, so maybe.

Incidentally, the reason this planet is Epsilon Indi Ab is because Epsilon Indi has a binary brown dwarf companion denoted Epsilon Indi Ba and Bb. Since these orbit about 135 billion miles from Epsilon Indi A, they are not going to affect any planets further in. These are the second closest known binary brown dwarf and the fourth and fifth closest known brown dwarfs period.

Well, *Starliner* (technically the Boeing Crew Flight Test spacecraft) is back, sort of, after three months attached to the ISS and leaving its two-person crew on the ISS until February. What is actually back is the crew capsule *Calypso*, the rest of the vehicle burning up in space as planned. This, unfortunately. means they don't have the malfunctioning thrusters available to analyze although they've had three months to check them in space and have been trying to duplicate the malfunctions on the ground. Under the circumstances, NASA made a (wise) decision not to risk bringing Barry Wilmore and Sunita Williams back on *Calypso*. I was wondering if Suni Williams would set a record for most accumulated time in space, but Oleg Kononenko, who is returning on September 24, has that record safely in hand. He currently is approaching 1100 days in space over five missions, more than twice Williams. Peggy

Whitson has the most for an American, at 675 days, which is also a record for a woman in space and that's safe.

The continued stay of Wilmore and Williams aboard the space station has resulted in some shifts to accommodate their eventual return. Crew-Dragon 9 was delayed August 18 to September 24, and will carry only two astronauts, making it possible to return Wilmore and Williams on the next flight in February. This means Nick Hague and Alexandr Gorbunov will fly to the ISS, but Zena Cardman and Stephanie Wilson will not, at least on this flight. Gorbunov was required to fly by agreement with Roscosmos, and Hague was the only one of the three Americans who has been to space.

To my surprise, the *Starliner* capsule executed a landing at White Sands in New Mexico. (I was expecting a water landing.) There were a couple of problems on re-entry, including a thruster failing to ignite. This was a different kind of thruster than the ones that caused problems in June and is apparently a different issue. (The other problem was a minor glitch in the navigation system which was quickly fixed.)

Although I've been carelessly calling this *Starliner 1*, that name properly belongs to the first operational mission, which is currently slated for next August. I suspect that will be delayed for a lot more testing if it happens at all.

In addition to *Starliner*, Boeing is also involved in building the Block 1B version of SLS which will be used on *Artemis 4*. In particular, they are building the fuel tank and are having problems with that which are reminiscent of the problems with *Starliner*. In this case, they are having persistent problems with leaks that could delay the 2028 launch.

On the other hand, *Artemis 4*, which is much taller and heavier than the previous three *Artemis*'s, requires a new Mobile Launcher which is under development and experiencing cost overruns that may quintuple the initial estimated cost. This is being built by Bechtel, not Boeng, and should be ready by 2026, but delays will delay *Artemis 4*.

We'll have to wait a while for the first orbital launch from the United Kingdom. During a static fire test of the RFA One first stage at SaxaVord Spaceport on Unst in the Shetland Islands, the stage exploded, causing considerable damage. This delays the launch until sometime in 2025. This also delays the UK Pathfinder launch, which will probably be the third RFA One launch.

BepiColombo made its fourth flyby of Mercury on September 4, passing only 100 miles above Mercury's surface and flying over the planet's south pole. *BepiColombo* has several more of these to make to slow it down near Mercury so it can eventually go into orbit. Since there was a problem getting power to the thrusters, mission control made this into a closer encounter than previously planned. Although this means it will still achieve Mercury orbit, that will be a year later, in November 2026. There will be two more flybys, in December 2024 and January 2025. The mission is actually two orbiters currently joined together, the Mercury Planetary Orbiter (MPO) and *Mio* (Mercury Magnetospheric Orbiter, MMO).[I]

BepiColombo will not be the first spacecraft to orbit Mercury; that was MESSENGER from 2011 to 2015. However, will be the second to orbit it and only the third to visit it, the first being *Mariner 10*.

In case you're wondering, *BepiColombo* is named after Giuseppe Colombo, nicknamed "Bepi", who came up with the gravitational assist idea that got *Mariner 10* to Mercury, so it is truly appropriate if a bit odd looking I'm glad they didn't choose another strained acronym.

Sky Viewing

The only meteor shower in September or October is **Orionid Meteor Shower**, which peaks on October 21. Unfortunately, this is only four days after the full Moon. The Orionids are a respectable meteor shower with up to twenty meteors per hour radiating from a point between Betelgeuse and Alhena, which I always think of as the third star in Gemini.

The Orionids are one of two meteor showers shed from Halley's Comet. The others are the Eta Aquariids in May, which, despite having to share their constellation with other meteor showers, are more impressive than the Orionids.

The second major eclipse of 2024 is an **annular eclipse of the Sun** that few people will get to see without a lot of travelling. This one is almost entirely over the South Pacific Ocean, and barely over the southwestern Atlantic, touching land in Easter Island and the 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. I've seen ads advertising sea trips to the area around Easter Island. No word on whether they'll be supplying eclipse glasses to the Moai statues.

By early October, we should have a good idea whether **Comet C/2023A3**, aka **Comet Tsuchuinshan-ATLAS**, is a wonder or a bust, or more likely something in-between. This comet has a period of millions of years, and this could even be its first trip to the inner solar system. Such comets are prone to disintegrate while passing the Sun, which is around September 27, but if they don't, can get very bright. In this case it could get as bright as Venus, but most likely won't. Still, if it approaches magnitude 0, it will be memorable. During mid-October the comet or its remnants will be passing through Virgo north of Spica (but south of Arcturus), Serpens (both head and tail) and the middle part of Ophiuchus, north of Scorpius and Antares, then into Hercules..

Even if it doesn't disintegrate, this might very well be the last (and perhaps only) passage of Comet C/2023A3 around the Sun since planetary perturbations may throw it out into interstellar space.

Mercury was at greatest western elongation on September 4 so is still visible in the morning. By September 14, it will be very low in the east, but will also be at magnitude -1.0, so may be visible a half-hour before sunrise, but only with a totally clear horizon. Mercury will be in superior conjunction with the Sun at the end of the month. In October, it will be an evening star but sit very low to the horizon due to the shallow angle of the ecliptic on fall evenings, and even at greatest eastern elongation will be difficult to spot.

Venus is still low in the western sky at sunset (shallow angle of ecliptic again), but at magnitude -3.8 may be possible to see even a half-hour after sunset. Venus will dominate the evening sky starting in October as it moves away from the Sun, growing brighter each night into next February. It still is on the far side of its orbit, so is about a magnitude less bright than it is at its peak, but still is brighter than any other star or planet.

Mars is currently magnitude 0.6 and in the constellation Gemini below and to the left of Jupiter (which is still in Taurus) with Aldebaran on the opposite side of Jupiter. By the end of September, Mars will be halfway across Gemini and outshining Pollux by half a magnitude and Castor by a full magnitude. During October, Mars will brighten to magnitude 0.1. making it a full magnitude brighter than Pollux and brighter than any other object in that part of the sky except Jupiter.

Jupiter is in Taurus right now near the tip of the horns of the Bull. At magnitude -2.3, it is easy to spot starting about one in the morning. Jupiter is also getting brighter and will reach magnitude -2.7 by the end of October, still between the horns of the Bull. Jupiter will be in retrograde motion starting on October 9, which is why it's staying in Taurus.

Saturn was at opposition at midnight on September 7-8 and is currently visible all night long at magnitude 0.6. The constellation is Aquarius, and there are no first magnitude stars any closer than Fomalhaut, which is a full magnitude dimmer and twenty degrees to the south. Since there are no bright stars near Fomalhaut, this is a good opportunity to find it. Saturn doesn't really move that fast, so expect to find it in Aquarius for a while yet.

Uranus is currently in a dim region in western Taurus about five degrees south of the Pleiades. It's currently rising around 10:00 p.m., but about an hour earlier every two weeks. Don't expect it to move much against the stars over the rest of the year. Since it is magnitude 5.8, it is theoretically visible to the naked eye in really dark skies, but you would probably need binoculars or a small telescope. To search for Uranus, try https://lovethenightsky.com/see-uranus-through-a-telescope/

Neptune is at opposition on September 20, hence is above the horizon all night. At magnitude 7.9 it definitely requires a strong pair of binoculars or a telescope. It's also in an inconspicuous part of Pisces below the Circlet asterism about fifteen degrees to the left of Saturn. It's a difficult object to search for, but https://lovethenightsky.com/see-neptune-through-a-telescope/ should be a help. Neptune has the advantage that if you find it at all, it will be in about the same place for the next year or two.

Viewing Opportunities for Satellites (September 14 – October 14, 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. Now that the *Starliner* capsule has returned, operations are back on track. A Soyuz carrying three astronauts to the ISS is scheduled for September 11, after this went to press. Crew Dragon 9, with two astronauts, launches to the ISS on September 24. (The other two seats will go to the Starliner crew when they come back in February. A *Tianzhou* cargo craft will dock with Tiangong on October 15. 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.

Tiangong 9/17 mag. -2.2

Time	Position	Elevation
8:36 p.m.	234°	10°
8:38:53	153	63
8:40:08	81	31

Vanishes into Earth's shadow.

Tiangong 9/19 mag. -2.1

Time	Position	Elevation
8:05 p.m.	249°	10°
8:08	336	79*
8:11	64	10

*Passes just above Vega

Tiangong 9/28 mag. -1.8

Time	Position	Elevation
8:07 p.m.	310°	10°
8:09:32	20	51
8:11:18	89	21

Vanishes into Earth's shadow.

HST 9/29 mag. 2.0

Time	Position	Elevation
6:50 a.m.	239°	10°
6:53:30	177	30*
6:57	115	10

*Passes below Sirius

HST 9/30 mag. 1.9

Time	Position	Elevation
6:30:35 a.m.	234°	14°
6:32:18	178	30
6:36	116	10

Tiangong 9/30 mag. -2.2

Time	Position	Elevation
7:33 p.m.	292°	10°
7:36	24	74
7:39	109	10

ISS 9/30 mag. -2.9

Time	Position	Elevation
7:56 p.m.	329°	10°
7:59:02	37	37
8:01:16	97	16

Vanishes into Earth's shadow.

ISS 10/2 mag. -3.6

Time	Position	Elevation
7:55 p.m.	308°	10°
7:58	231	72
8:01	139	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 spans about ten degrees. "Elevation" is elevation above the horizon in degrees. So, to view the Tiangong Space Station at 8:09:32 p.m. on September 28, measure two first-widths east of due north, then five fist-widths above the horizon.

Programming Notice: NASA+ on the Web

NASA-TV has become NASA+ https://plus.nasa.gov/

NASA+ live event schedules are available at https://www.nasa.gov/live/ or https://plus.nasa.gov/scheduled-events/.

The current schedule only goes up to September 16. However, there will be coverage of the September 24 Crew-9 launch to the ISS. There should also be coverage of the *Europa Clipper* launch on October 10.

Calendar of Events

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

Sometime in 2024 [Moved from July]: First flight of *Eris*, from Bowen Spaceport at Abbot Point in Queensland, Australia. If successful, this will give Australia the ability to launch its own satellites.

September: Flight test of *Tianlong-3*, Space Pioneer's orbital launch vehicle. The first test launch in early July ended in a spectacular fireball.

September: Fifth *Starship* orbital test flight. This may get moved to October.

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

Mid-September: ULA will launch a *Mass Simulator* mission with an inert payload and some experiments. This is the second certification mission of the Vulcan launcher, but its scheduled cargo has been delayed and ULA wants Vulcan certified now.

September 13: 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.

September 14: Oklahoma Space Alliance meeting, 2:00 p.m., Norman Computers. Meeting information will be posted at http://osa.nss.org.

September 20: Neptune is at opposition.

September 24: Ninth *Crew Dragon* mission to the ISS. This will have two empty seats to eventually accommodate Suni Williams and Barry Wilmore on their return next February.

September 27 – October 4: Okie-Tex Star Party, Camp Billy Joe, Kenton, Oklahoma. Hosted by the Oklahoma City Astronomy Club. For more information, visit https://www.okie-tex.com.

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

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

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 7: 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).

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

October 21: Peak of the Orionid meteor shower.

November 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.

November: Maiden flight of *Pallas-1* launch vehicle by Galactic Energy in China. For information, see en.wikipedia.org/wiki/Pallas-1.

November: Maiden flight of *New Glen.. National Security Space Launch* demonstration flight.

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 [Moved from July]: First (uncrewed) *Gaganyaan* flight test. For more information, see https://en.wikipedia.org/wiki/Gaganyaan_1.

December: *Fram2*, a four-passenger civilian flight by Crew Dragon. This will be the first crewed flight ever launched into polar orbit. For more information, visit https://en.wikipedia.org/wiki/Fram2.

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

December 7: Jupiter is at opposition.

Mid-December: 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.

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

Late December: *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.]

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

Sometime in 2025: Israel launches its *Beresheet 2* landers (two of them) 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: Uncrewed Starship lunar landing demonstration.

Sometime in 2025 [Moved from fall 2024]: 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.

Sometime in 2025: Third (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.

Sometime in 2025 [maybe]: India launches its first crewed orbital flight *Gaganyaan 4*. For more information, en.wikipedia.org/wiki/Gaganyaan.

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

Sometime in 2025 [moved from September 24, 2024]: Launch of Russia's Bion -M No. 2, to observe the effects of the Van Allen radiation belts on mice over a period of 30 days.

First half of 2025: In flight fuel transfer from Starship to a target.

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.

January 3, 2025: Peak of Quadrantid meteor shower.

January 9, 2025: Venus is at its greatest eastern elongation, 47.2 degrees east of the Sun (so can be seen after sunset).

January 15, 2025: Mars is at opposition, 60 million miles from Earth. In other words, this is a poor opposition.

February 2025: SpaceX launches SpaceX Crew-10 to the ISS. This is the mission that will allow the *Boeing Crew Flight Test* crew to finally come home (aboard Crew-9, which has been serving as a lifeboat).

March 2025: *New Glenn* will carry a prototype Blue Moon lunar lander to the Moon. This is known as Pathfinder Mission 1.

March 2025: Launch of South Korea's Hanbit-Nano from Alcântara Space Center in Brazil. This is the first private launch from Alcântara.

March 2025 [moved from December 2024]: First Dream Chaser cargo mission via Vulcan Centaur. This is the mission that was supposed to go up in July 2024.

March 7, 2025: Mercury is at its greatest eastern elongation, 18.2 degrees east of the Sun (so can be seen after sunset).

March 11, 2025: Saturn is in conjunction with the Sun.

March 14, 2025: Total eclipse of the Moon, visible throughout the Americas.

March 22, 2025: Venus is in inferior conjunction with the Sun.

Second quarter of 2025 [moved from September 2024]: *ESCAPADE Blue* and *Gold* Mars Orbiters launch by New Glenn. For more information, see en.wikipedia.org/wiki/EscaPADE.

Second quarter of 2025 [Moved from October 2024: 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.

April 2025 [Moved from February]: Launch of *IMAP* heliophysics probe and *Solar Cruiser* to the Earth-Sun L1 Lagrangian point (the one between us and the Sun). For more information, visit https://en.wikipedia.org/wiki/Interstellar_Mapping_and_Acceleration_Probe and https://en.wikipedia.org/wiki/Space_Weather_Follow_On-Lagrange_1

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, which will visit Earth's co-orbital asteroid Kamo'oalewa and comet 311P/PANSTARRS,. For more information, see https://en.wikipedia.org/wiki/Tianwen-2.

June 2025: Maiden flight of LandSpace's *Zhuque-3* orbital launch vehicle.

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 of 2025: First operational crewed mission of *Starliner 1* to the ISS. This now seems doubtful, with SpaceX's Crew-11 taking this spot. For more information, visit https://en.wikipedia.org/wiki/Boeing_Starliner-1.

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

September 2025: Astrobiotic's *Griffin Mission 1*, including lunar lander and CubeR over. They leave Earth on a Falcon Heavy. This was originally going to carry *VIPER*, which has been cancelled.

September 2025: *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.

Fourth quarter of 2025: *Mission Possible*, a demonstration flight of the Nyx reusable spacecraft by the Exploration Company a French-German enterprise.

Fourth quarter of 2025: *Axiom-4*, a four-person fourteen-day mission to the ISS.

Fourth quarter of 2025: Launch of CLPS mission to the Lunar South Pole, including PROSPECT. CLPS=Commercial Lunar Payload Services.

October 2025 [moved from first quarter of 2025]: A SpaceX Nova-C mission to the Moon takes Intuitive Machines' IM-3 lander, NASA's Lunar Vertex rover, and several NASA Cadre rovers.

Sometime in 2026: Launch of ispace's Mission 3. First flight of ispace's APEX 1.0 lunar lander.

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).

Sometime in 2026 [moved from 2024]: India launches *Mars Orbiter Mission 2* (MOM 2 or *Mangalyaan 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: Launch of MIT's Venus Habitability Mission.

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 which failed launch in 2024, Intuitive Machines GEO Pathfinder , which is a variant of SHERPA, or Pathfinder Mission 1, which is part of the Blue Moon program.)

Sometime in 2026: *Gaganyaan-6*, India's first resupply mission to the ISS.

Sometime in 2026: Maiden flight of *Volans*, the first orbital launch vehicle developed in Singapore.

Sometime in 2026: Launch of Canadensys lunar rover, the first for Canada.

May 2026: The *Psyche* probe flies by Mars.

Mid-2026: Uncrewed *Starship* mission to Lunar South Pole, carrying Astrolab's FLEX lunar rover and Starship HLS lunar lander.

Second half of 2026: ClearSpace-1 will capture PROBA-1 and deorbit it.

July 2026: *Hayabusa 2* flies by asteroid 2001 CC_{21}.

September 2026: 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 includes an orbiter, a lander and a hopping probe. For more information, see https://en.wikipedia.org/wiki/Chang%27e_7.

Fourth quarter of 2026 [Moved from 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

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.

November 2026 [postponed from December 2025 due to a thruster problem]: *BepiColombo* arrives at Mercury orbit.

Sometime in 2027 [moved from 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.

Sometime in 2027: Launch of the Axiom Power Thermal Module. This will complete the Axiom segment to separate from the ISS and operate as its own space station.

Sometime in 2027: First flight of Long March 10, which will be China's vehicle for crewed Moon missions.

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. For more information, see en.wikipedia.org/wiki/Demonstration_Rocket_for_Agile_Cislunar_Operations.

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 2027[moved up from 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.

September 15, 2027: *Lucy* flies by Trojan 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: Launch of *Chang'e 8*, which will include a lander, rover and a 3D printing experiment using lunar resources. This will be the last Chang'e mission before China sends a human crew to the Moon.

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. [There's a very good chance that this will be delayed for up to a decade.]

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).

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.

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 2028: Launch of ESA's *Ramses* spacecraft, which will fly by Apophis.

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

July 2028: Launch of *Dragonfly*, the Titan helicopter mission. For information, see 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.

October 2028: ESA launches the *ExoMars Mars Rover*, which has been christened *Rosalind Franklin*. For more information, visit https://en.wikipedia.org/wiki/ExoMars.

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 to the Sun-Earth L_2.point,where the Interceptor will wait for a long-period comet to come by.

Sometime in 2029: Launch of *VERITAS* orbiter and Venus Atmosphere Sample Return Mission to Venus. For more information, see https://en.wikipedia.org/wiki/VERITAS_(spacecraft).

April 21, 2029: *OSIRIS-APEX* rendezvous with the asteroid Apophis. Note: *OSIRIS-APEX* is the same spacecraft as *OSIRIS-REx;* it is 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).

September 2029: Launch of Artemis 5 to the Moon. This mission carries the ESPRIT Refueling Module to the Lunar Gateway, and a crew and the crewed Lunar Terrain Rover.

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

Sometime in 2030: China will land a crewed mission on the Moon.

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.

Sometime in 2030: Launch of ESA's *EnVision* Ven
us orbiter.

April 2030: *Europa Clipper* arrives at Jupiter.

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

Spring 2031: *Europa Clipper*'s first flyby of Europa.

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 build in Japan.

Sometime in 2032: 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 first South Korean lunar lander.

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.

Sometime in 2035: Launch of LISA gravitational wave observatory.

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 is 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) 980-0890Their 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.

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