

OKLAHOMA SPACE ALLIANCE

OUTREACH -July 2022

102 W. Linn #1, Norman, OK 73069

Oklahoma Space Alliance will meet at the
McMurray residence at 2:00 p.m.
on July 9, details inside



Artemis 1 Mission Patch (NASA)

OKLAHOMA SPACE ALLIANCE OUTREACH

July 2022

July Meeting

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, July 9, 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 try to have this meeting on Zoom for those who cannot attend in person: To join the meeting, go to <https://tinyurl.com/y2qtab28> If for some reason 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 365-8983 (e-mail sydh@ou.edu) and we will send you updated information.

Saturday July 9, 2022, 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. (The impact of the Russian invasion of Ukraine on space will undoubtedly be part of it.)
3. Break
4. Oklahoma Space Alliance Chapter Business Discussion
 - a. Review OSA treasurer's report
 - b. Minutes of April meeting
 - c. Chapters Assembly (Syd)
 - d. Presentations from ISDC
5. Video (to be announced)
6. Chat

Minutes of June 2022 Oklahoma Space Alliance Meeting

Oklahoma Space Alliance met June 18, 2022, at the McMurray's house in Norman, Oklahoma. Attending were Clifford and Claire McMurray. Adam Hemphill, Tim Scott, Dave Sheely, and Syd Henderson. Since Cliff and Claire had just gotten back from ISDC and other travels, Dave Sheely presided over the meeting He did an Update discussing links to material covered in the meeting and this is online at <http://osa.nss.org/Update2206.pdf> so I'll cover the details that aren't covered there.

Starship is not going to immediately launch from Cape Canaveral because of the time it would require constructing a new launchpad. [The first *Starship* launch will be from Texas.]

We watched a video of the delay of FAA's final environmental review of Starship. However, it looks like SpaceX must have passed since Starship is nearing its first orbital test flight.

We watched a video on a European Spaces conference. Space is now a strategic, economic and security battlefield.

We watched a video from Collins Aerospace on their new spacesuits.

We watched a video of Blue Origin's fifth peopled launch and landing.

We read an article watched a video on the Modular Artificial-Gravity Orbital Refinery Spacecraft, which is a response to NASA's Technology Transfer Program. This relies on counterrotating rings to simulate gravity (and incidentally balancing the angular momentum of the whole spacecraft. I've seen this proposed for providing artificial gravity for deep space missions.

Musk presented a video on the launch the UKs new (solar) Power station to create limitless energy. This would go up around 2035. Adam mentioned that the organization producing the video is not a real channel but includes a lot of speculation, and the narrator's voice is computer-generated, which apparently is a thing now. The craft presented certainly seems to be highly speculative/

We watched a video on building large structures in space.

We watched a video on possible legislation to give a National Guard component to the Space Force. This is the second attempt and has bipartisan support.

We always watch episodes of This Week at NASA. This week we saw the Europa Clipper being assembled, the new supersonic aircraft QUESST, NASA grow plants in soil from the Moon. The shock wave from the great Tonga volcanic eruption reached the ionosphere as well as the lower atmosphere.

We watched Adam's video of the First Point-to-Point flight in Honduras, 27 miles test flight to a small village over rough terrain taking thirty minutes. It ended in a controlled (and apparently intentional) crash. It looks like the next step is to have a soft landing.

Minutes by OSA Secretary Syd Henderson

Minutes of May 2022 Oklahoma Space Alliance Meeting

Oklahoma Space Alliance chapter of National Space Society had its regularly scheduled meeting on May 9, 2022, at the McMurray residence in Norman, Oklahoma. Attending were David Sheely, Clifford and Claire McMurray, John Northcutt, Tim Scott, and Syd Henderson. OSA president Clifford McMurray presided over the meeting. He did an Update discussing links to material covered in the meeting and this is online at <http://osa.nss.org/Update2205.pdf> so I'll cover the details that aren't covered there.

The Russian kinetic collision test that produced so much debris was conducted in polar orbit which means the debris trajectory intersects everything (and at orbital velocity from the side).

The US has adopted a moratorium on such tests. South Korea applauds the moratorium but China is more skeptical.

We watched a video on debris from the tests.

Michael López-Alegría holds the current record for most space walks.

You can make lenses out of liquid polymers using a process that doesn't require gravity and which are much bigger than mirrors made on Earth.

We watched the launch of the Axiom-1 mission to the ISS. We watched a split screen of stage one and stage two, and the landing of stage one. Axiom will eventually have their own three-module space station.

We watched the separation and return of the Axiom-1 mission.

We watched a RocketLab launch and the attempt to catch the returning booster by helicopter. They don't land the same way as SpaceX since their booster is so much smaller [i.e., less fuel for landing]. The helicopter did catch the booster temporarily but had to release it because the helicopter pilots were concerned about aerodynamic stability. The booster was eventually recovered from the ocean.

We watched a video of the launching of Shenzhou 13 crew to the Tiangong Space Station, and a video of the crew, as well as a video by Wang Yiping addressing International Women's Day.

We watched a video of the docking of the Tianzhou 4 cargo module with the Tiangong Space Station.

China's proposed lunar contact orbiter will fly a highly elliptical orbit to allow longer contact with its Lunar South Polar landers.

We watched a video of a Phobos transit of the Sun as seen from the Perseverance rover on Mars [It occurred to me that Phobos and Deimos must both transit the Sun frequently, and probably sometimes do it simultaneously—from opposite directions since Phobos orbits faster than Mars rotates and Deimos slower.]

Spaceport Cornwall will have its first launch this year.

We watched images from the Lucy spacecraft.

We now have \$918.82 in the checking account and \$267 in cash, for a total of \$1188.72. This is after Syd was reimbursed for renewing the mailbox.

Minutes by OSA Secretary Syd Henderson

Some notes on the May 28th Chapters Assembly meeting

This was a combined live/Zoom session with many more people on Zoom. I have 35 names listed, but since I don't know how many people were attending at each location, it was probably well over 40. Among these were people from several chapters in India but I didn't notice people from other NSS International Chapters. Main action was to vote for a new Executive Secretary for the Executive Secretary, and the candidates were Kris Cerone from Sacramento L5, and Prathmesh Barapatre (I believe from the Mumbai chapter). We voted by chapter (which caused some confusion when some chapters started voting by individual) I cast OSA's vote for Ms. Cerone, but I'm informed that Ms. Cerone has resigned, though she was still in place on June 13, and Mr. Barapatre is now Executive Secretary, His first meeting will be on Saturday morning.

The deadline to vote for the Board of Directors is June 24.

NEOSM (the Near-Earth Object Surveillance Mission, aka NEO Surveyor) is in danger of being cancelled. Dale (Dale Grant?) is working to save it. [See News]

Space News: Space Probes

Continuing from that last item in the Chapters Assembly notes: The NEO Surveyor is a satellite under development dedicated to finding near Earth objects (comets and asteroids mostly, unless there are derelict alien spacecraft) large enough to cause serious damage if they happen to strike populated areas or oceans on the Earth. NEO Surveyor will be able to detect more than 90% of near-Earth objects

Congress set this goal in section 321 of the NASA Authorization Act of 2005. This section is also known as George E. Brown, Jr. Near-Earth Object Survey Act. NASA was given 15 years at the time, but I guess the deadline was extended since NEO Surveyor is supposed to go up in the first half of 2026 assuming it is properly funded. In any case, many near Earth objects were detected during the NEOWISE mission starting in 2013. Hundreds of thousands of asteroids and comets have been discovered by NEOWISE and its previous identity, WISE, but most of them were not near-Earth objects. NEOWISE, by the way is still operational, although its coolant, which was essential to the WISE infrared survey, was exhausted a decade ago.

In any case, the NEO Surveyor mission will cost \$500 – 600 which I presume includes development costs to date, and to be completed for launch in 2026 requires adequate funding. NEO Surveyor's expected cost for 2023 was \$170 million, but NASA requested only \$40 million, which would delay the mission until at least 2028. The House Appropriations Committee has since raised the funding to \$94.9 million.

The overall allocation for NASA for 2023 would be \$25.446 billion, an increase of \$1.4 billion over FY 2022, but \$527 million less than NASA requested. This includes \$1.486 billion for the Human Landing System which is part of the Artemis program.

Note that the budget process is still ongoing. Fiscal Year 2023 doesn't begin until October 1, 2022, so there's still some more haggling to go.

On June 28, a Rocket Lab Electron rocket launch from New Zealand carried the CAPSTONE cubesat into orbit. CAPSTONE is the Cis-Lunar Autonomous Positioning System Technology Operations and Navigation Experiment, which is a big name for a satellite that weighs 55 pounds. However, it is a harbinger for a more impressive satellite, the Lunar Gateway station which is part of the Artemis mission.

CAPSTONE is destined for a halo orbit around the Moon but will take its own time getting there. The apogee of its orbit is gradually being increased until it is finally released to go to the Moon—or actually past the Moon to a point 810,000 from the Earth (and 570,000 miles above Lunar orbit. This makes it easier for CAPSTONE to fall back and be captured into a Lunar polar orbit. (I believe this kind of capture orbit was pioneered by the Japanese, but this is more extreme.)

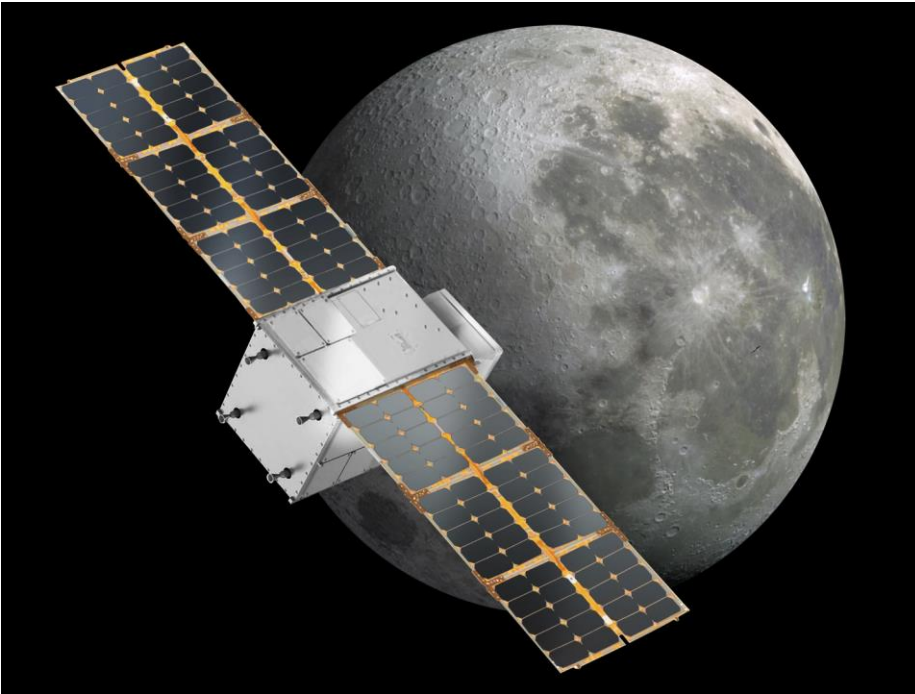
This orbit, the same that Lunar Gateway will eventually use, is highly elliptical, with the periapsis¹ about a thousand miles above the Lunar North Pole, and the apoapsis 43,000 miles above the Lunar South Pole. This makes sense because our lunar explorations will be in the south polar regions of the moon, and we want our communications relay to be above the horizon as much as possible. The Chinese space program is planning the same thing, and I bet the Russians are too.)

In any case, to ease such a small probe into such an object, we sacrifice time for fuel, and CAPSTONE will not go into orbit around the Moon until November 13. It's expected that Artemis 1 will reach the Moon two months earlier

The primary purpose of CAPSTONE is to test the stability of the halo orbit around the Moon, which has never been tried before and may turn out to have complications. Note, though, we already have satellites in halo orbits around the Earth-Sun L1 and L2 points. Indeed, the James Webb Space Telescope is in a halo orbit around L2.

The CAPSTONE launch also tested RocketLab's HyperCurie engine, which will also be used in a 2023 launch to Venus and a 2024 launch to Mars.

¹ It's probably also perilune or periselene, but that sort of thing is really only useful when you're talking about perigee or perihelion. Otherwise, periapsis is nice and generic. It's the closest point to the center of mass of what its orbiting around. Apoapsis is the farthest point.



CAPSTONE Lunar Orbiter (NASA)

Since the Artemis 1 mission is still on for late August, perhaps I should write about that for a while. Artemis 1 is the first test flight of the Artemis moon program, the first flight of the Space Launch System (SLS) superheavy-lift launch vehicle, and the first flight of the Orion spacecraft. It is, naturally, unmanned, but will be carrying a bunch of small satellites, including two cubesats that will orbit the Moon, and one small lunar lander, JAXA (Japan Aerospace Exploration Agency)'s OMOTENASHI. (I'll spare you what that's an acronym for). Also aboard is Japan's *EQUULEUS* spacecraft, which will investigate the Earth-Moon L2 point from a halo orbit around that point. In fact, China's *Queqiao* relay satellite is already in such an orbit.

The original plan was for *Artemis 1* to have a free Lunar trajectory—that is, it would simply loop around the Moon and come back without entering orbit but plans change. The entire mission will last four to six weeks with six days spent in a distant retrograde orbit around the Moon. Such an orbit passes above the L1 and L2 points of the Moon and can be fairly long. Both points are some 37000 miles above the surface of the Moon. China's Chang'e 5 orbiter is in such an orbit, and Lunar Gateway can put satellites into DROs.

Even if *Artemis 1* gets up in time, it still will be a while before people walk on the Moon again. *Artemis 2* in May 2024 is a lunar flyby (I think of it as *Apollo 8* version 2). *Artemis 3*, currently scheduled for 2025, is the next Moon landing. However, the Moon will not be left alone during that time. See the long list of landers and orbiters in "Calendar of Events" below.

Other Space News

We've been getting hints from the alignment tests, but the James Webb Space Telescope beginning its actual mission and the first set of full-quality images will be released on July 12. I don't say "color" since it is, after all, an infrared telescope and any images have to be translated to the visible spectrum, so they must be false-color. (On the other hand, it should be possible to cancel out the red shift for a single galaxy.) Webb can actually image exoplanets.

Not all instruments are up yet. This one is the MIDI (Mid-Infrared Instrument), which had to cool down to 7° K using cryogenics. The rest of the telescope operates at 50° K, or -370° F.

Although we have detected supermassive black holes at the center of galaxies and even imaged two, and found many black holes in stellar systems, we've had a hard time detecting black holes wandering by themselves. Until now. Using images from the Hubble Space Telescope over a period of years, scientists led by Kailash Sahu (Space Telescope Science

Institute) and Casey Lam (University of California, Berkeley) report the discovery of the first stellar-mass black hole wandering solo through the Milky Way. Sahu's team says it's seven solar masses, and Lam's says 1.6 – 4.4 solar masses. It was detected through gravitational lensing of background stars. [If the mass is less than 2.16 solar masses, it could still be a neutron star; if greater, it can't be.] I'm not sure how the teams decided the black hole didn't have a stellar companion. Perhaps it's from details of the gravitational lensing, or because we don't see the companion. (See <https://ti.nyurl.com/5n7ajh85> for the *Sky & Telescope* article by Colin Stuart). Or an abstract from Sahu *et al* at <https://arxiv.org/abs/2201.13296> (I note the abstract was submitted in January, but it's been undergoing revisions.)

On May 4, the *Mars InSight* lander detected the most powerful quake ever detected on another planet (wouldn't that just be Mars?). It registered 5.0, which is weaker than some that have occurred in Oklahoma. Moonquakes this strong have also been detected.

The detection is kind of bittersweet since *Mars InSight* is probably failing due to Mars dust accumulating on its solar panels. Three days after the Marsquake was detected *InSight* went into safe mode due to low power. When *InSight* landed four years ago, its solar panels produced 5000 watts of power, by May it was a tenth that. At this point the team is hoping for a dust devil to clear the panels,

It was expected that the seismometer may fail in June but shutting down other instruments and the fault protection system may buy it a couple more months. That also means any error is more likely to shut down the seismometer for good, but that seems to be happening anyway.

Sky Viewing

For a brief while last month all five bright planets (not counting the one below your feet) were visible before dawn, though I confess I couldn't see Mercury. Either light pollution near the horizon, or it was below the tops of trees. On the other hand, I was easily able to find Fomalhaut, which was due south, and has the advantage of having no right stars anywhere near it (and was due south of Saturn the day I looked). It's a lonely looking star.

Most years, the two best meteor showers are the Geminids in December, and the **Perseids**, which peak on the night of August 12 -13. (Some years the Leonids rival them.) This year's Perseid meteor shower unfortunately occurs only one day after the Full Moon, which will mean you'll only see half the number of meteors as under a dark sky. Since the meteor shower is at its best between 2:00 and 5:00 a.m., you may be able to put the Moon at your back. The Perseids usually top off at 100 meteors/hour (without a Full Moon) but have been known to double that rate.

A less well-known meteor shower, the **Southern Delta Aquariid**, has an advantage over the Perseids this year, in that the Moon will two days past New and won't be a factor. Aquarius is a mostly southern constellation but not too far south (Fomalhaut, which I mentioned above, is south of it and easily visible), so many of the meteors should be visible. The peak is about 25 meteors/hour but some of those will be heading south, and you'll get only have half at their maximum brightness. A bonus is that Saturn, Mars and Jupiter will be bright in the sky at the same time.

The last few months we've had planets strung along the ecliptic in the morning. Presently they are in the west-east order Saturn, Jupiter, Mars and Venus (with Neptune somewhere between Saturn and Jupiter and Uranus between Mars and Venus). At the end of June, **Mercury** was supposedly visible below Venus, but I was unable to see it, and it is getting lower anyways so it's getting even more futile. Mercury actually gets brighter on the far side of its orbit (since its showing more of its face which compensates for it being farther away, which is the opposite of Venus, where the difference in the amount of the face that is seen is largely compensated by its crescent having a much larger diameter.) However, Mercury is also getting lower in the sky and will be in superior conjunction on July 16 and be visible in the evening sky in late July. Yeah, right.

The other planets are easier to spot. **Venus** is now at magnitude -3.9, which is about a magnitude below its peak brightness, and is getting low in the morning sky, but is still instantly visible and will be for another month or two. As mentioned above, Venus is brighter when its close to us (until we see too much of its night side) and it is now on the far side of its orbit. However, it is not in superior conjunction with the Sun until October 22. It will become visible in the western sky after sunset late in the year and get gradually brighter all the way into July 2023.

Next highest in the sky (ignoring Uranus) is **Mars**, which is gradually growing brighter and is currently magnitude 0.4. That may not seem impressive but it's brighter than all the morning summer stars except Arcturus and (barely) Vega. It's maybe twenty degrees from Jupiter but is moving away, and forty degrees from Venus, which is moving away in the eastern direction. Since Mars takes two years between oppositions, it brightens slowly for a long time, but does move

eastward across the constellations. It's about to pass from Pisces into Aries. (It's also approaching Uranus, which is already in Aries, and they will have a not-very close conjunction on August 1.)

Jupiter is next, and is instantly visible at magnitude -2.5, and high in the sky before sunrise. Jupiter, surprisingly, is not in any constellation of the Zodiac, but in Cetus the Whale. The ecliptic just grazed the northwest corner of Cetus and a planet south of the ecliptic can find itself in Cetus. It's going to be there for quite a while, too: if Starry Night is correct, Jupiter is in Cetus until the end of August. This is probably because it is stationary on July 28. [Astrological sites claim Jupiter is in Aries, but that's because precession has put astrologers 2000 years out of date.) Jupiter is also brightening a bit as it approaches opposition on September 26.

Finally (ignoring Neptune), **Saturn** is now rising in the east before midnight, and is due south a couple of hours before dawn. At magnitude 0.7, it's not as bright as Mars, but is still brighter than all the stars at that hour except Arcturus and Vega. Saturn is also near peak brightness since it is at opposition on August 14. It's in the dim constellation Capricornus and will be until February,

Finally, **Uranus** is magnitude 5.8 in Aries and as mentioned will be 1.4 degrees north of Mars on August 1. Oddly, despite all the planets being in the morning sky, this is the only conjunction in July or August. All the other planets are separating themselves and we may not get another till Mercury passes Venus again.

Neptune is just moving into Pisces after eleven years in Aquarius and is about 12 degrees from Jupiter in the direction of Saturn. Neptune is at opposition on September 16, at which time it will still be magnitude 7.8 and require strong binoculars or telescope to see it. Since it is also in retrograde motion, it will go back into Aquarius for a while before it finally goes into Pisces for good.

Viewing Opportunities for Satellites (July 9 - August 13, 2022)

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 0.9 (as on March 27) but will get brighter as more modules are added. 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. The only mission to the ISS is a cargo mission on July 14. The Chinese are launching the Laboratory Core Module to *Tiangong* on July 23 (after which *Tiangong* may get brighter).

The information below is from Heavens Above. There are no visible passes for the Hubble Space Telescope, and all for *Tiangong* are in the morning (but they're pretty good.) The ISS makes up for it with lots of passes.

ISS 7/11/22 mag. -2.1				ISS 7/13/22 mag. -3.8			
	Time	Position	Elevation		Time	Position	Elevation
	5:46 a.m.	326°	10		5:46 a.m.	306°	10°*
	5:50	37	39		5:50	225	61
	5:53	108	10°		5:53	144	10

*Passes very close to Vega

ISS 7/11/22 mag. -4.0				ISS 7/14/22 mag. -3.1			
	Time	Position	Elevation		Time	Position	Elevation
	10:27 p.m.	222°	10°		9:38 p.m.	239°	10°
	10:33	137	76*		9:42	319	60
	10:36	51	10		9:45	41	10

*Passes very close to Vega and Deneb

ISS 7/12/22 mag. -3.3			
	Time	Position	Elevation
	9:39 p.m.	201°	10°
	9:42	133	37
	9:45	64	10

Tiangong 7/29/22 mag. 1.3			
	Time	Position	Elevation
Appears from Earth's shadow			
	5:33:49 a.m.	225°	21°*
	5:35:50	152	58*
	5:41	72	10

*Passes very close to Saturn, Jupiter and Mars (along the ecliptic)

Tiangong 7/31/22 mag. -1.1			
	Time	Position	Elevation
	5:12:55 a.m.	260°	40°
	5:13:53	336	75
	5:17	63	10

ISS 8/1/22 mag. -3.8			
	Time	Position	Elevation
	9:41 p.m.	314°	10°
	9:44:40	43	83
	9:46:15	128	28

Vanishes into Earth's shadow

ISS 8/2/22 mag. -3.1			
	Time	Position	Elevation
	8:53 p.m.	325°	10°
	8:56	38	43
	8:59	147	10

ISS 8/3/22 mag. -3.2			
	Time	Position	Elevation
	8:52 p.m.	304°	10°
	8:56	225	55
	8:59	147	10

Tiangong 8/9/22 mag. 1.0			
	Time	Position	Elevation
	5:59 a.m.	230°	10°
	6:02	208	68
	6:05	124	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. Thus, to find the ISS at 9:42 p.m. on July 14, measure four fist-widths west from due north, then six fist-widths above the horizons. Although finding Tiangong on July 29 is also easy since it goes almost straight down the ecliptic encountering planets (including Venus just 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>.

Times below are Central Daylight Time.

July 12, 9:30 a.m.: First images from the James Webb Space Telescope

11:00 a.m.; Media briefing on the JWST's first images

Presumably if Artemis 1 goes up in August, goes around the Moon and returns, NASA TV will have extensive coverage.

Calendar of Events

Second half of 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.

Second half of: 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.

Second half of 2022: first test of flight of the full-scale version of Perigee Aerospace (South Korea) *Blue Whale 1* from Whalers Way in Australia.

Third quarter of 2022: Maiden flight of Taiwan's Hapith V from Whalers Way in Australia. For more information, see https://en.wikipedia.org/wiki/TiSPACE#HAPITH_I.

Third quarter of 2022: Launch of first commercial small satellite to Mars, built by the Polish company SatRevolution and air-launched by Virgin Orbit.

Third Quarter of 2022: First flight test of SpaceX starship spacecraft, to be launched from SpaceX Starbase in Boca Chica, Texas,

July: First launch of India's Small Satellite Launch Vehicle (SSLV),

July 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.

July 9 [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence. Meeting information will be posted at <http://osa.nss.org>.

July 12: first full (false-) color images expected from the James Webb Space Telescope as well as the first spectroscopic data.

July 14: Launch of SpaceX CRS-25 cargo supply mission to the ISS. This mission also carries a lot of cubesats including one from Moldova. ELaNa 45 will launch on this flight.

July 16: Mercury is in superior conjunction with the Sun.

July 23: Launch of Wentian, the first laboratory module of the *Tiangong* space station. For information, en.wikipedia.org/wiki/Wentian_module.

July 28: Peak of the Delta Aquariid meteor shower.

August: Earliest launch date for *Artemis 1* the first launch of the Space Launch System, on a test flight around the Moon. On this uncrewed launch NASA launches the Lunar IceCube, Lunar Polar Hydrogen Mapper, and Lunar Flashlight lunar orbiters, in addition to Japan's OMOTENASHI cubesat lunar lander. For more information, see https://en.wikipedia.org/wiki/Lunar_IceCube, the Near-earth Asteroid Scout cubesat (https://en.wikipedia.org/wiki/Near-Earth_Asteroid_Scout) and a bunch of other satellites.

August 2: Launch of the *Korea Pathfinder Lunar Orbiter* (KPLO) and lunar impactor from Naro Space Center in South Korea. For more information, see https://en.wikipedia.org/wiki/Korea_Pathfinder_Lunar_Orbiter.

August 12: Peak of the Perseid meteor shower.

August 13 [Tentative]: Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence. Meeting information will be posted at <http://osa.nss.org>.

August 14: Saturn is at opposition.

August 27: Mercury is at greatest eastern elongation, 27.3° from the sun (so it can be seen before sunset.)

September [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>.

Sometime in September: Launch of LauncherOne from Mojave, carrying the ELaNa 46 mission. This is a Virgin Orbit flight carried by a plane named *Cosmic Girl*

September 1: Fifth Crew Dragon mission to the ISS.

September 8: Launch of *LauncherOne* from Spaceport Cornwall, England. This launch will place six satellites in low-Earth orbit, including the first for Oman. This is a Virgin Orbit flight carried by a plane named *Cosmic Girl*. [This is not a duplicate: Orbit has two launches this month.]

September 10: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence. Meeting information will be posted at <http://osa.nss.org>.

September 23: Mercury is in inferior conjunction with the Sun.

September 26: Jupiter is at opposition.

September 26 – October 1: DART will impact with the asteroid Dimorphos in an effort to change its orbit. [See October 2024 for the follow-up mission, *Hera*.

Late September [postponed from August]: Launch of the Luna 25 lunar lander, the first mission of Russia's Luna-Glob lunar exploration mission. This will land near Boguslawsky Crater about 77 degrees South on the Moon. For more information, visit en.wikipedia.org/wiki/Luna_25 and en.wikipedia.org/wiki/Luna-Glob.

October: Launch of *Hakuto-R* mission 1, Japan's lunar lander. (Hakuto is Japan's Moon rabbit, so is equivalent to China's Jade Rabbit). For more information, see <https://en.wikipedia.org/wiki/Hakuto>. The same Falcon rocket will launch the *Rashid* lunar rover for the United Arab Emirates.

October: [Moved from August]: Launch of *Mengtian*, the second laboratory module to the *Tiangong* space station.

October 8: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence. Meeting information will be posted at <http://osa.nss.org>.

October 8: Mercury is at greatest western elongation, 18.0° from the Sun (so can be seen before sunrise).

October 21: Peak of the Orionid meteor shower.

October 22: Venus is at superior conjunction with the Sun.

October 25: Partial eclipse of the Sun visible from Europe, western Asia (including India) and northeastern Africa.

November: Launch of *Polaris Dawn* flight carrying four civilians into space, led by Jared Isaacman.

November 5: Peak of the South Taurid meteor shower.

November 8: Total lunar eclipse over all of the Pacific Ocean. Oklahoma will get most of this eclipse.

November 8: Mercury is in superior conjunction with the Sun.

November 9: Uranus is at opposition.

November 12: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., McMurray residence. Meeting information will be posted at <http://osa.nss.org>.

November 17: Peak of Leonid meteor shower.

December: Launch via Falcon 9 of the *Nova-C* lander and other cargos to the Lunar South Pole.

December: Launch of the *Peregrine* lunar lander by ULA's Vulcan Centaur for Astrobiotic Technology. This is the maiden flight for Vulcan Centaur.

December: First crewed launch of *Boeing Starliner-1* to the ISS.

December: Launch of fourth crew to the *Tiangong* space station.

December 7: Mars is at opposition.

December 7 – 19: 50th anniversary of Apollo 17. This, to date, is the last manned mission to the Moon.

December 14: Peak of Geminid meteor shower.

December 21: Mercury is at greatest eastern elongation, 20.1° from the sun (hence can be seen after sunset.)

December 22: Peak of Ursid meteor shower.

Sometime in 2023 [Postponed from August 2022]: 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>

Sometime in 2023: launch of *#dearMoon*, which will carry six to eight artists on a lunar free-return mission.

Sometime in 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.

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

First quarter of 2023: Launch of *Axiom-2* mission to the ISS, via Falcon 9. This carries one professional astronaut and three private astronauts.

First quarter of 2023: UK Pathfinder Launch, from SaxaVord Spaceport on Unst in the Shetland Islands.

February 2023: First ISS Cargo Resupply mission for Dream Chaser.

March 2023: SpaceX's Sixth Crew Dragon mission to ISS

March 2023: First orbital Starliner Mission to ISS, launched by Boeing.

April 2023 [Postponed from 2022]: Maiden flight of Ariane 6.

April 5, 2023: Launch of *JUICE*, the Jupiter Icy Moons Explorer, by the European Space Agency. The JUICE web site is <https://sci.esa.int/web/juice>. This will also mark the final launch of *Ariane 5*.

May 2023: Launch of Venus Life Finder probe as well as the *Photon* relay satellite by RocketLab.

June 4, 2023: Venus is at greatest elongation, 45.4 degrees east of the Sun (so can be seen after sunset).

Third Quarter of 2023 [Tentative, postponed from August 2022]: Launch of *Psyche*, which will orbit a large metallic asteroid also named Psyche. For more information, visit [https://en.wikipedia.org/wiki/Psyche_\(spacecraft\)](https://en.wikipedia.org/wiki/Psyche_(spacecraft)).

August 13, 2023: Venus is in inferior conjunction with the Sun.

September 24, 2023: *OSIRIS-REx* returns samples from Asteroid Bennu.

Fourth quarter of 2023: Launch of *Hakuto-R* mission 2, Japan's lunar lander and rover. For more information, see <https://en.wikipedia.org/wiki/Hakuto>.

Fourth quarter of 2003: Second (uncrewed) *Gaganyaan* flight test.

Fourth quarter of 2003: China launches its *Xuntian* space telescope, which will orbit close to orbit close to *Tiangong* for easy servicing.

October 14, 2023: 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 23, 2023: Venus is at greatest western elongation, 46.4 degrees from the Sun (so can be seen before sunrise).

November 2023: 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 Astrobiotic's *Griffin* lunar lander. They leave Earth aboard a Falcon 9.

November 2023: Launch of Masten Mission One lander and MoonRanger rover on the Moon via Falcon 9. They will land at Haworth Crater near the South Pole of the Moon.

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: Launch of the Hakuto-R Lunar Lander and Rover by SpaceX for ispace (Japanese company)

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

Sometime in 2024: India launches Mars Orbiter Mission 2.

First half of 2024: Israel launches its *Beresheet 2* lander and orbiter on the Moon.

First half of 2024: uncrewed test launch of *Orel*, Russia's new crewed spacecraft. For information, [https://en.wikipedia.org/wiki/Orel_\(spacecraft\)](https://en.wikipedia.org/wiki/Orel_(spacecraft)).

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: 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: 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)).

September 2024: Launch of the first Axiom Hub Module, probably on a New Glenn rocket.

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 to evaluate the results of the DART asteroid impact mission.

October 2024: Planned date of *Artemis 3*, which will land astronauts on the Moon for the first time since 1972.

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.

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

Sometime in 2025 [moved from 2024]: India launches its *Mangalayaan-2* Mars mission, which includes an orbiter, lander, and rover.

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.

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.

July 2026: Launch of the *Sample Retrieval Lander* to Mars. This is the lander which will bring take the samples taken by *Perseverance* to orbit.

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

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)).

May 2027: 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.

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.

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

November 2028: Launch of China's *Tianwen-2* 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).

Fourth quarter of 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.
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 The Mars Society address is Mars Society, Box 273, Indian Hills CO 80454. 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, PO Box 98106, Washington DC 20090-1600 Web page is space.nss.org.
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 NASA Spacelink BBS 205-895-0028. Or try www.nasa.gov .
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