OKLAHOMA SPACE ALLIANCE

OUTREACH - November 2022

102 W. Linn #1, Norman, OK 73069

Oklahoma Space Alliance will meet at the
McMurray residence at 2:00 p.m.
on November 12, details inside

OKLAHOMA SPACE ALLIANCE OUTREACH
November 2022

November Meeting

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, November 12, 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.

This is the meeting at which we nominate officers. If you wish to serve as an officer of Oklahoma Space Alliance, please let us know at the meeting or contact Syd by e-mail at sydh@ou.edu. Syd will be sending out election ballots around the beginning of December by both e-mail and snail mail. If you wish to be an officer, please contact him by December 1. Note that officers must be members of the National Space Society, though you can join at the Christmas party. Elections will be held at the Christmas Party, tentatively December 10 at the McMurrays'

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

Saturday November 12, 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.
3. Break
4. Oklahoma Space Alliance Chapter Business Discussion
   a. Review OSA treasurer's report
   b. Nomination of Officers
   c. Minutes of October meeting
   d. Presentations from ISDC
5. Video (to be announced)
6. Chat

Minutes of October 22, 2022, Oklahoma Space Alliance Meeting

Oklahoma Space Alliance met October 22, 2022, at the McMurray's house in Norman, Oklahoma. Attending were Clifford and Claire McMurray. Adam Hemphill, Tim Scott, Dave Sheely, and Syd Henderson. OSA President Clifford (Kip) McMurray presided over the meeting He did an Update discussing links to material covered in the meeting and this is online at https://osa.nss.org/Update2210.pdf so I'll cover the details that aren't covered there.

The October meeting would normally have been held on October 8, but it was postponed because several of our members tested positive for COVID-19. Fortunately, none were seriously ill.

The reason that DART overperformed was because Dimorphos is essentially a rubble pile. This moon of the asteroid Didymos is a hundred meters across and has a mass of a billion tons. We watched videos of the impact taken from ground-based telescopes and the Hubble and Webb Space Telescope, not to mention video that DART sent before impact showing an egg-shaped asteroid covered with small boulders and, from the results, also boulders and pebbles inside. To my eye, Didymos looks more solid. The brightness of the Didymos/Dimorphos system brightened three times from the impact, which produced jets of material that surprised the mission team.

There was an anomaly on a New Shepard launch which resulted in its destruction although the capsule was recovered intact. The FAA is checking whether debris fell outside the safe zone. We watched a video. There have been two failures out of 22 flights. Adam: The G-forces on the capsule may well have harmed any passengers if humans had been aboard.

Firefly will launch at least once more this year and six times next year. We watched a Firefly launch.

The Indian Mars probe *Mangalayaan* died after two long eclipses so may have run of solar power. It was supposed to last six months and lasted eight years, so it had a very good run.

Looks like Astrobotics will retain all of Masten's employees after buying the company's assets. Masten expanded too rapidly and exhausted funding. Will NASA transfer its Masten contracts to Astrobotics? [One of these is Masten Mission One, which will carry a lander to the Moon as well as an Astrobotic lunar rover. It's unclear what will happen to this mission.]

Without a boost, there is a 50% chance the Hubble Space Telescope would re-enter the Earth's atmosphere by 2037. Some method of robotically refueling it are being investigated.

InSight heard a meteorite impact Mars.

There is a James Webb Space Telescope postage stamp! See https://store.usps.com/store/product/buy-stamps/james-webb-space-telescope-stamps-S_482704.

NASA is "blowing up" inflatable space habitats to test their reactions to pressure.

Our video for the month was "Apollo 11: What We Saw" hosted by Bill Whittle.

Minutes by OSA Secretary Syd Henderson

Minutes to September 10 Oklahoma Space Alliance Meeting

Oklahoma Space Alliance met September 10, 2022, at the McMurray's house in Norman, Oklahoma. Attending were Clifford and Claire McMurray. Adam Hemphill, Tim Scott, Dave Sheely, and Syd Henderson. OSA President Clifford (Kip) McMurray presided over the meeting He did an Update discussing links to material covered in the meeting and this is online at http://osa.nss.org/Update2209.pdf so I'll cover the details that aren't covered there.

There were 11 privately owned commercial Earth-observing satellites in 2006, but 500 in 2022. These could become targets if Russia gets more aggressive in space.

We watched a video of the Russian satellite *Kosmos* buzzing a US satellite.

We watched a video of the launch of a classified satellite by SpaceX and of a Russian spy satellite.

The lunar landing sites for the US have to be capable of accommodating *Starship*. We watched a video on possible landing sites.

Britain's proposed Solar Power Satellite would require 300 *Starship* launches and build something a mile in diameter.

The Sutter Ultra telescopes can potentially detect three hundred times as many asteroids as currently known. [This is for finding potentially exploitable asteroids, but also should detect a lot of 'Earth grazers.]

Axiom will start launching its modules to the ISS in 2024. These modules will eventually separate and become part of an Axiom space station.

Would SpaceX want to do is round the Moon mission before *Artemis 2* when this could embarrass NASA, which is SpaceX's biggest customer?

We watched a video taken from the ISS (apparently by Samantha Cristoforetti) of the Aurora Australis. [A still of this graced the cover of the September *Update*.]

We listened to a transposed audio of sound waves from the supermassive black hole at the center of a galaxy in the Perseus cluster (transposed 57 octaves, to be exact). Not sure how you can get soundwaves from so far; maybe we can see the vibrations in the gas clouds, or they're from radio waves. We also heard the same from M87.

The space probe *Lucy* has discovered a moon around the (Jupiter) Trojan asteroid Polymele. [This is only the second moon ever discovered around a Trojan. The first was in 2020.]

After the meeting we watched an interview by Tucker Carlson with a UFO specialist.

--Minutes by OSA Secretary Syd Henderson\

Apollo 17

I've been doing a series on the Apollo flights starting with *Apollo 7*, on the 50th anniversary of each, and now we've reached the final Moon mission. I haven't decided whether to commemorate *Apollo-Soyuz*, though it has an Oklahoma connection.

By 1972, support of the *Apollo* program by the Nixon administration was foundering, partly because the media had moved on, and partly because Nixon was reluctant to keep supporting an expensive flagship program of his predecessors, despite getting his name on the Moon. Instead, the Nixon administration began to look at accomplishments that they could

take primary credit for themselves, such as the diplomatic success of *Apollo-Soyuz*, the space station *Skylab*, and eventually the Space Shuttle (although that program had been gestating for a few years. As a result, the proposed *Apollo 18* through *20* Missions were cancelled and no human has gone beyond low-Earth orbit in fifty years. Fortunately, that does appear certain to change in the next few years with the *Artemis* program, Elon Musk's space tourist flights, and China's manned space program.

According to how NASA assigned crews on previous mission, the backup crew of *Apollo 14* would be expected to be the crew of *Apollo 17*. These were Gene Cernan, Ronald Evans and Joe Engle. However, Joe Engle was a former X-15 pilot, and when the later Apollo missions were cancelled, scientists wanted a professional geologist. Harrison Schmitt, who was on the backup crew for *Apollo 15* (hence in line for *Apollo 18*), fit the bill. Although there was talk of selecting the rest of the *Apollo 15* backup crew (Dick Gordon and Vance Brand), Deke Slayton decided to keep Cernan and Evans. Engle would go on to command two Shuttle Missions. Dick Gordon was the Command Module Pilot for *Apollo 12* and also was on *Gemini 11* and would have gotten to walk on the Moon for *Apollo 18*. He never went into space again. Brand would go on to be the Apollo Command Pilot on the *Apollo-Soyuz* mission, and commanded three Shuttle missions, including the first fully operational Shuttle mission. Thus Schmitt, Brand and Gordon didn't get to star in the awful movie *Apollo 18*.

Of the three astronauts who were actually chosen, Schmitt and Evans were on their first space flights, although as noted they were on the backup crews for previous *Apollo* missions. Cernan, in contrast, had been in space twice, first as the pilot of *Gemini 9A*, and more famous as the lunar module pilot of *Apollo 10*, the first spaceflight to test the lunar module in orbit around the Moon in preparation for the *Apollo 11* Moon landing. He was also on the backup crews for *Apollo 7* and *Apollo 14*. I'm not sure why he wasn't on the backup crew to *Apollo 13*, which would seem the usual rotation. Apparently, he wanted to command his own mission and John Young was going to do that for *Apollo 16*. Cernan would have walked on the Moon if he had gone on that mission since he would have been Lunar Module Pilot, but he had already done that.

Apollo 17 launched at 12:33 a.m. (EST) on December 7, 1972, the only night launch of the Apollo Moon program, The flight had the only launchpad delay of the Apollo program due to a hardware problem: the liquid oxygen tank didn't automatically pressurize. This was done manually, and the launch software had not realized this. Thus, the computers had to be rewired to get around the software glitch, and the launch occurred normally after a two hour and forty-minute delay. A half million people watched the launch from Cape Canaveral, and, since it was a night launch, it was visible from 500 miles away.

Given that this was going to be the last manned mission to the Moon for the foreseeable future, the mission was heavily biased on the side of science even for a J-class mission. Thus, the destination was a lunar valley called Taurus-Littrow on the southeastern edge of the Sea of Serenity. This valley is bordered by two massifs (high mountain regions) called the North and South Massifs. The depth from the top of these to Taurus-Littrow is greater than that of the Grand Canyon on Earth. It was hoped that this region would be volcanic in nature. However, Mare Serenitatis was formed by a huge impact which produced a lot of ejecta, much of which would have landed around the landing site. Since there is also an East Massif and the Sculptured Hills near the landing site, this may have been the most difficult landing spot for any of the Apollo Missions.

In addition to the three human astronauts, five pocket mouse astronauts flew on *Apollo 17* to investigate any tissue damage from cosmic rays. Thus, they were implanted with radiation detectors under the scalps. Although the mice did develop scalp and liver lesions, these weren't attributed to cosmic rays, and I wonder if they were due to the radiation detectors. No other significant damage was found. The mice were named Fe, Fi, Fo, Fum and Phooey. Along with Ronald Evans, the five mice hold the record for most time orbiting the Moon, 75 orbits. One mouse died during the mission for unknown reasons. The other mice were dissected on return to Earth. (Evans was not.) The mouse who died in space was a male with the designation A3352 and really deserves a memorial though we don't know his nickname.

The three astronauts themselves were part of an experiment to determine the cause of the light flashes astronauts experienced even when their eyes were close. It was suspected these were due to cosmic rays, so two of the astronauts wore blindfolds to better observe them while Evans wore a device over his eyes to detect the particles producing the flashes. The experiment confirmed the suspicions.

Unlike several earlier missions, there weren't serious issues during the launch or on the way to the Moon. Due to the launch delay, NASA chose a faster trajectory to the Moon. One of the latches connecting the Command and Lunar modules was unlatched and Evans fixed it.

Apollo 17 reached lunar orbit at 2:54 p.m. EST on December 10. The lunar module separated the next day and landed at 2:55 p.m. EST on December 11, almost precisely 24 hours after the astronauts had entered lunar orbit. The Command Module was christened *America* and the lander *Challenger*.

There were three moonwalks on the expedition. The first began at 6:54 p.m. when Cernan left the spacecraft, followed by Schmitt. Thus, although Cernan is well known as the last man to stand on the Moon, Schmitt is the last man to stand on the Moon for the first time. After setting up the Apollo Lunar Surface Experiments Package (ASLEP), the astronauts started drilling a deep core sample. Since this took longer than expected, the geology expedition was cut short.

However, their second moonwalk, on December 12, was also a moonride on the lunar rover that took them five miles to the South Massif. They found the remains of a landslide, which enabled them to sample materials of different colors and compositions, some originally from high up the massif. Since Cernan was drilling another sample core, Schmitt was busy taking samples from the service, but kept knocking over the sample bag and having to repack the samples. In the course of this he even fell over once.

However, the astronauts now went to the 100-meter-wide Shorty Crater just north of the South Massif, which is where Schmitt made a surprising discovery. He discovered that the soil around him was orange, which was unheard of on the monochromatic surface of the Moon. The question now was what this could be. The first thought was rust formed from iron in the rocks by steam from a volcanic vent, which would have meant not only vulcanism, but past water, so the astronauts happily took samples. It turned out that the orange soil was glass beads from a volcanic eruption billions of years before, and unearthed (unmooned?) by the formation of Shorty Crater by an impact twenty million years ago.

The third and last expedition was also the last of the Apollo program, and the last by people on the Moon to date. The destination this time was to the North Massif, the Sculptured hills and a crater known as Van Serg. There the two astronauts collected nearly 150 pounds of samples, including a fine-grained rock, sample 70215, which massed eight kilograms.

Gene Cernan was the last person to date to stand on the Moon's surface and knew it might be a long time before people returned, so he got to say the last words yet spoken on the Moon's surface:

"Bob, this is Gene, and I'm on the surface; and, as I take man's last step from the surface, back home for some time to come – but we believe not too long into the future – I'd like to just [say] what I believe history will record. That America's challenge of today has forged man's destiny of tomorrow. And, as we leave the Moon at Taurus–Littrow, we leave as we came and, God willing, as we shall return, with peace and hope for all mankind. 'Godspeed the crew of *Apollo 17*.'"

The Lunar Module lifted off at 5:54 p.m. EST on December 14 and docked with the Command Module two hours later. After transferring equipment and the lunar samples, the Lunar Module was separated and sent to a crash landing on the Moon to be detected by seismometers, some of which had been placed by *Apollo 17*. At 6:35 p.m. on December 16, the Command Module headed back to Earth. On the way back, Evans performed the last EVA (so far) beyond Low Earth Orbit as he retrieved film canisters from the Service Module. *Apollo 17*'s capsule landed in the Pacific Ocean at 2:25 p.m. on December 17.

None of the *Apollo 17* astronauts flew in space again. Cernan retired from NASA in 1976 and died in 2017. (I think I met him once at an ISDC.) Evans retired from NASA in 1977 and died in 1990. Harrison Schmitt retired in 1975 to enter a brief career in politics: He was elected Senator from New Mexico in 1976, winning 56.8% of the vote, defeating Democratic incumbent Joseph Montoya. He was defeated after one turn by Democrat Jeff Bingaman, who would go on to serve for thirty years. Schmitt is still alive at age 87, the most recent person to walk on or orbit the Moon.

[Sources: the December *Astronomy*, Wikipedia, NASA and a response on Stack Exchange to a question on the mice.

Space News

A meteor that burnt up in a spectacular fireball on February 22, 2021, arrived in an orbit that indicates that it came from the Oort Cloud despite being a rocky object rather than a cometary fragment. This appears to be the second rocky object from the Oort Cloud. In 2016, Karen Meech and colleagues at the University of Hawaii detected an unusual dark object from the Oort Cloud that lacked a tail. (Meech calls it a Manx comet by analogy of the breed of tailless cat.) There was also a 1979 rocky meteor the orbit of which tracked back to the Oort Cloud. The origin of these rocks is a mystery so far, whether they formed in place or were expelled to the Oort cloud by Jupiter in its early days when one theory has it moving toward the inner solar system before settling in its current orbit.

Sky Viewing

We have two major meteor showers and one minor one over the next two months.

The **Leonid Meteor Shower** peaks on November 17 and the Moon is rising well after peak visibility. Although there will be only 10 – 15 meteors per hour on the 17th, the shower last from November 14 through 21, and is unusually clumpy.

Predictions are that one of these clumps will produce a lot more meteors on November 19, with about 50 meteors per hour. Since Leonids often produce bright fireballs, it may be worth getting up to see them. There is a lesser peak on November 18. The best time is in the morning, since Leo rises about midnight. The radiant is right in the middle of the curve made by the blade of the Sickle asterism in Leo. The Sickle is easy to find since the first-magnitude star Regulus is in its handle.

The **Geminid Meteor Shower** is active from December 4 through 17, peaking on the morning of December 14. Unfortunately, a bright gibbous Moon will be shining much of the morning, so the best time to look might be around midnight before the Moon rises. The Geminids are one of the more prolific and dependable meteor showers of the year with peak rate of 100 meteors per hour being usual. The radiant is, of course, in Gemini, just above Castor. Since Gemini is north and a bit east of Orion, Castor and Pollux are easy to locate. Pollux is noticeably the brighter of the two, but Castor is a bright second-magnitude star.

The **Ursid Meteor Shower** is less impressive, peaking at about ten meteors/hour, but has the advantages that (1) the radiant is above the horizon all night and (2) the shower is peaking on December 22-23, the night of the New Moon. The Ursids do occasionally produce minor outbursts, but none is expected this year: the last was in 2014, and the one before that in 1986.

Mars is at opposition just before midnight on the night of December 7, a week after it was closest to Earth. Although this opposition isn't as close as the last couple, for observers in the United States it is in many ways even better, because Mars is near the horns of Taurus the bull, which is almost as far north as the Ecliptic gets. In other words, Mars is about 75 degrees above the horizon, or as near to directly overhead as it can get. Since Mars was much lower in the sky during the last opposition, this one look brighter even if technically it's not.

Anyway, Mars is already near peak brightness at magnitude -1.7. Mars is moving back and forth across the horns of Taurus due to the wonders of retrograde motion. On November 12, it's midway between the horn tips. The brighter horn tip is Beta Tauri (aka El Nath), and they make a nice pair. Mars will brighten to magnitude -1.9 at opposition and stay bright through December.

This opposition is especially interesting since the Moon is full on the night of December 7, which means that it is having a conjunction with Mars, which from much of the United States (including, I believe, Oklahoma) is actually an **occultation**. Start looking about 7:00 p.m.

Mercury and **Venus** are both currently just past conjunction with the Sun, hence are not visible. However, Mercury will become visible again at the end of the month and Venus a few days later. Mercury is at greatest elongation on December 21, at which point it will be eight degrees above the horizon at half-hour after sunset and magnitude -0.5. Venus, of course, is much brighter, but also low in the sky in December, and is on the far side of the Sun, so is "only" magnitude -3.9. Venus will grow brighter in the western sky until July of next year.

Jupiter is currently dominating the evening sky all evening. At sunset, it is already shining in the southwest at magnitude -2.8 and is actually visible near the beginning of twilight. Jupiter will be shining all evening long though November and December.

Saturn is only magnitude 0.7 but is easily visible if you trace the ecliptic east of Jupiter, since it is by far the brightest object in Capricornus. It's currently due south at sunset (which also makes it easy to sport) and is visible several hours after sunset. It will be setting about 10 p.m. at the beginning of December and 8 p.m. at the end of December. It will be in conjunction with the Sun in mid-February.

Uranus is just past its November 9 opposition and is at its peak brightness of 5.6. This is just at the limit of naked eye visibility in a very dark sky. It's best viewed with strong binoculars of a small telescope. Uranus is in a rather nondescript location in Aries north of the head of Cetus. You can find a location map at https://in-the-sky.org/news.php?id=20221109_12_100 or on page 49 of the November 2022 *Sky and Telescope*.

Neptune is magnitude 7.8 and at the border of Aquarius and Pisces, where it will be for a long time. It is approximately at the location shown in https://in-the-sky.org/news.php?id=20220916_12_100 south of the Circlet asterism in Pisces.

Data on the planets and meteor showers come from the November and December issues of *Sky and Telescope* and *Astronomy* and from their websites. I also used *Starry Night* to verify data and the times of the lunar occultation of Mars.

Viewing Opportunities for Satellites (November 12 – December 12, 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 -g2.3 after the addition of the Wentian module in July. We can expect it to get even brighter after the Mengtian module is added in October.

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. There is a cargo flight to *Tiangong* on November 12 followed by a crewed flight on November 26. SpaceX is sending a cargo flight to the ISS on November 18. Also note that the ISS (and presumably *Tiangong*) sometimes have to alter orbits to avoid space debris. Hubble is high enough that this is less of a concern.

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

HST 11/14/22 mag. 2.1

Time	Position	Elevation
6:49 p.m.	236°	10°
6:52:54	175	30
6:54:15	144	24

HST 11/15/22 mag. 2.1

Time	Position	Elevation
6:37 p.m.	239°	10°
6:40:16	177	31
6:42:25	128	19

Tiangong 11/16/22 mag. -2.2

Time	Posit6on	Elevation
Appears from Earth's shadow.		
5:57:38 a.m.	296°	29°
5:59:07	25	87*
6:02	10	10

*Passes very close to Capella and Spica

HST 11/16/22 mag. 2.1

Time	Position	Elevation
6:24 p.m.	242°	10°
6:28	179	31
6:31	121	14

HST 11/17/22 mag. 2.2

Time	Position	Elevation
6:11 p.m.	244°	10°
6:15	181	31
6:19	118	10

ISS 11/18/22 mag. -3.8

Time	Position	Elevation
6:36 p.m.	231°	10°
6:39:24	318	79
6:40:43	41	33
Vanishes into Earth's shadow.		

HST 11/18/22 mag. 2.3

Time	Position	Elevation
5:59 p.m.	246°	10°
6:02	184	31
6:05	121	10

ISS 11/18/22 mag. -3.4

Time	Position	Elevation
5:48 p.m.	211°	10°
5:50:50	134	51*
5:54:04	58	10

*Passes very close to Saturn and nor far above Jupiter.

HST 11/19/22 mag. -2.4

Time	Position	Elevation
5:46 p.m.	247°	10°
5:50	186	30
5:53	124	10

ISS 11/20/22 mag. -2.0

Time	Position	Elevation
5:47 p.m.	248°	10°
5:50	321	43
5:43	36	10

Tiangong 11/28/22 mag. -2.0

Time	Position	Elevation
6:41 p.m.	231°	10°
6:43:37	151	57
6:44:04	116	51*

Vanishes into Earth's shadow.
*Passes just above Jupiter

Tiangong 11/30/22 mag. -2.2

Time	Position	Elevation
6:18 p.m.	250°	10°
6:20:56	336	77
6:22:37	60	25

Vanishes into Earth's shadow.

Tiangong 12/2/22 mag. -1.5

Time	Position	Elevation
5:55 p.m.	246°	10°
5:58	266	46
6:01	342	12

ISS 12/5/22 mag. -3.6

Time	Position	Elevation
6:31 p.m.	322°	10°
6:34:15	39	50
6:35:16	35	35

Vanishes into Earth's shadow.

ISS 12/7/22 mag. -2.7

Time	Position	Elevation
6:29 p.m.	301°	10°
6:32	226	46
6:36	152	10

Tiangong 12/10/22 mag. -2.1

Time	Position	Elevation
5:58:p.m.	300°	10°
6:02	28	58
6:05	102	10

Tiangong 12/11/22 mag. -1.0

Time	Position	Elevation
6:35 p.m.	283°	10°
6:38	211	41
6:41	144	15

Key: Position is measured in degrees clockwise from north. That is, 0° is due north, 90° is due east, 180° is due south, and 270° is due west. Your fist held at arm's length is about ten degrees wide. "Elevation" is elevation above the horizon in degrees. So, to view the Hubble Space Telescope at 6:52:54 p.m. on November 14, measure half a fist-width east of due south, then three 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.

NASA will have several programs relating to the launch of *Artemis 1*. These dates are for a November 13 launch (our time):

November 13, 1:30 p.m.: coverage of fueling of *Artemis 1*. 8:30 p.m.: Coverage of launch of *Artemis 1*. Actual launch is at 11:07 p.m.

November 14, 7:50 a.m.: first imagery from *Artemis 1*.

Calendar of Events

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

Fourth 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.

November: Launch of first commercial small satellite to Mars, built by the Polish company SatRevolution and air-launched by Virgin Orbit via *LauncherOne* and the plane *Cosmic Girl*.

November: 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.]

November 11: 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.

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

November 14 – 27: Launch windows 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.

November 17: Peak of Leonid meteor shower.

November 22: 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. For information on that, see en.wikipedia.org/wiki/Emirates_Lunar_Mission.

November 26: Launch of fourth crew to the *Tiangong* space station.

November 29: Firefly Alpha launches with a lot of small satellites. ELaNa 43, which consists of eleven small CubeSats, launches on this flight.

December: First flight test of SpaceX Starship spacecraft, to be launched from SpaceX Starbase in Boca Chica, Texas. This will complete three-quarters of an orbit.

December 5: Launch of SWOT, the Surface Water and Ocean Topography mission, which will conduct the first global survey of the Earth's surface water and measure how they change over time.

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 9: 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.

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

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

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

Sometime in 2023: 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.

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

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

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

January 3, 2003: Peak of Quadrantid meteor shower.

January 7, 2003: Mercury is in inferior conjunction with the Sun.

January 29, 2003: Mercury is at greatest western elongation, 25.0° from the Sun (so can be seen before sunrise).

February 2023 [moved from January]: India launches Aditya-L1 to the Earth-Sun L1 point, on a mission to study the Sun's corona. For more information, visit https://en.wikipedia.org/wiki/Aditya-L1. "Aditya" is Sanskrit for the Sun, aka Surya.

February 2023: SpaceX's Sixth Crew Dragon mission to ISS.

February 16, 2023: Saturn is in conjunction with the Sun.

March 2023 [Moved from December 2022]: Launch of *Polaris Dawn* flight carrying four civilians into space, led by Jared Isaacman.

March 2023 [Moved from December 2022]: Launch via Falcon 9 of the *Nova-C* lander and other cargos to the Lunar South Pole.

March 15, 2023: Neptune is in conjunction with the Sun.

March 17, 2023: Mercury is in superior conjunction with the Sun.

April 2023: Maiden flight of Ariane 6.

April 2023 [Moved from December 2022]: First crewed launch of *Boeing Starliner-1* to the ISS.

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

April 11, 2023: Jupiter is in conjunction with the Sun/

April 11, 2023: Mercury is at greatest eastern elongation, 19.5° from the Sun (so can be seen after sunset).

April 20, 2023: Hybrid solar eclipse. This goes from the south-central Indian Ocean north of Antarctica, touches northwestern Australia, crosses central Indonesia, and western New Guinea before crossing the territory of small island nations in the western Pacific Ocean. This is total in the parts of Australia and Indonesia that it crosses, and annular along the rest of its path.

April 22, 2023: Peak of Lyrid meteor shower.

May 2023: Launch of *Axiom-2* mission to the ISS, via Falcon 9. This carries one professional astronaut and three private astronauts. [Axioms 3 and 4 should also launch this year.]

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

May 5, 2023: Peak of Eta Aquarid meteor shower.

May 9, 2023: Uranus is in conjunction with the Sun.

May 28, 2003: Mercury is at greatest western elongation, 24.9° from the Sun (so can be seen before sunrise).

June 2023: India launches Chandrayaan-3, which will include a lander and a long-lived rover which will explore craters around the Moon's South Pole in search of ice. See https://en.wikipedia.org/wiki/Chandrayaan-3.

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

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

July 2023: Launch of *Luna 25*, the first mission of Russia's Luna-Glob program, landing near Bogulswasky crater. For more information, see https://en.wikipedia.org/wiki/Luna_25.

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

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

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

October 10, 2023 [Moved from July]: Launch of *Psyche*, which will orb
it a large metallic asteroid also named Psyche. For more information, visit https://en.wikipedia.org/wiki/Psyche_(spacecraft). The *Janus* mission, which will send twin probes *Serenity* and *Mayhem* to separate asteroids (yet to be determined), will launch on the same flight. For more information, see https://en.wikipedia.org/wiki/Janus_(spacecraft)/

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 Masten Mission One lander and Moon Ranger rover on the Moon via Falcon 9. They will land at Haworth Crater near the South Pole of the Moon. For more information, see https://en.wikipedia.org/wiki/Masten_Space_Systems#Masten_Mission_One.

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

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

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

Sometime in 2024: India launches Mars Orbiter Mission 2.

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

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

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

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

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

May 2024: 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).

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

September 2024: uncrewed test launch of *Orel*, Russia's new crewed spacecraft. For information, https://en.wikipedia.org/wiki/Orel_(spacecraft). This is the first flight for Russia's Angara A5P spacecraft.

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

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

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

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

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

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

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

December 2024: Launch of the Space Entertainment Enterprise's SEE-1 inflatable space habitat docked to the 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: India launches its *Mangalayaan–2* Mars mission, Sometime in 2025 [moved from 2024]: Israel launches its *Beresheet 2* lander and orbiter on the Moon. For more information, see en.wikipedia.org/wiki/Beresheet_2.

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

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

. December 2025: *BepiColombo* arrives at Mercury orbit.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

December 2034: *Dragonfly* arrives at Titan.

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

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Other Information

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

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

Tulsa Air and Space Museum, 7130 E. Apache, Tulsa, OK 74115.
Web Site is www.tulsaairandspacemuseum.com. Phone (918) 834-9900.

The Mars Society address is 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.

The Planetary Society phone 626-793-5100. The address is 65 North Catalina, Avenue, Pasadena, California, 91106-2301 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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