

OKLAHOMA SPACE ALLIANCE

OUTREACH –January 2021

102 W. Linn #1, Norman, OK 73069

Oklahoma Space Alliance will have
a Zoom meeting online at 2:00 p.m.
on January 9 details inside



Apollo 14 Mission Patch

OKLAHOMA SPACE ALLIANCE OUTREACH

January 2021

January Meeting

We are once again delaying the restart of in-person meetings for Oklahoma Space Alliance for another month or two. This month we'll have our online chapter meeting via Zoom.

The meeting will begin promptly at 2 PM on Saturday, January 9. Please sign into the meeting as close to this time as you can. The free Zoom account allows only 40-minute meetings for 3 or more people, and the timer starts when the third person joins the meeting. Once that meeting times out, we can restart using the same link after 15 minutes have elapsed, so the plan will be to take a break at about 2:40 and resume for part two of the meeting at 3 PM.

To join the meeting, , contact Dave Sheely at 821-9077 (email sheely at sbcglobal.net) or Syd Henderson at 365-8983 (e-mail sydh at ou.edu) and we will send you updated information. Please note if you are on our e-mail list, the url is in your meeting announcement and also in your newsletter.

Saturday January 9, 2021 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
3. Break
4. Oklahoma Space Alliance Chapter Business Discussion
 - a. Review OSA treasurer's report
 - b. Minutes of December meeting
5. Video (to be announced)
6. Chat

Minutes of December Meeting

Oklahoma Space Alliance chapter of National Space Society had its regularly scheduled meeting on December 12, 2020. However, due to the ongoing Covid-19 pandemic, we held the meeting online via Zoom. (Because of Covid-19 we decided to postpone our holiday celebration until people had a chance to get vaccinated.) Attending were Clifford and Claire McMurray, Russ Davoren, Ron Lajoie (by phone), Robin Scott, Tim Scott, David Sheely, 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/Update2012.pdf>, so I'll cover the highlights that aren't covered there.

We elected officers for the year 2021. David Sheely is President, Clifford McMurray Vice-President, Syd Henderson Secretary and Tim Scott Treasurer.

Our Quote of the Month was by Dr. A. P. J. Abdul Kalam. Dr. Abdul was head of India's space program and from 2002 until 2007 was President of India. He died in 2015 at the age 83.

Hayabusa 2 sample capsule landed in the Australian outback on December 5, bringing 100 milligrams from the asteroid Ryuku back to Earth. It is now going to asteroid 98943 2001 CC21 in 2026 and 1998 KY26 in 2031. The latter is spinning so fast nothing can land on it.

We watched videos of the *Chang'e 5* launch and landing on the Moon. Space.com also has a video of the lander separation. We watched a video of the robotic docking (which was the first robotic docking in lunar orbit). *Chang'e 5*'s lunar sample is much larger than any returned by Russia.

Astronaut Kate Rubins, who is currently aboard the ISS, was one of the eighteen astronauts chosen for the first batch of Artemis astronauts. [Other familiar names included Joe Acaba, Victor Glover, Christina Koch, Nicole Mann, Anne McClain and Jessica Meir. Also note Michael Hopkins, who is also aboard the ISS, is now a member of the Space Force.]

There is a long tradition of using dolls as gravity indicators, which is one of the reasons a glittery stuffed dinosaur was carried aboard SpaceX's demo flight. This also explains why we watched video of Baby Yoda aboard the Crew-1 mission.

We watched a video of launch and separation of Rocket Lab's "Return to Sender" mission.

We looked at the first group of Artemis astronauts, which consist of nine men and nine women. Stephanie Wilson, age 54, is the oldest member, and from NASA's 1996 astronaut class, while several are from NASA's 2017 astronaut class, the youngest being Jessica Watkins at age 32. One member who got her name in the papers a while back was Anne McClain, who went through a nasty divorce which evolved into a fraud case involving her ex-wife.

We watched a video of Starship 8's launch maneuvers and spectacular explosion on landing. The term used was "Rapid Unscheduled Disassembly."

We watched a video of Dragon Cargo Ship docking with ISS.

We now have \$627.26 in the checking account and \$267 in cash, for a total of \$894.26. We also had several people renew their memberships, which is not reflected in this total.

--Minutes by OSA Secretary Syd Henderson

Minutes for November 2020 Oklahoma Space Alliance Meeting

Oklahoma Space Alliance chapter of National Space Society met via Zoom on November 14, 2020. Attending were Cliff and Claire McMurray, Seth Potter, Robin Scott, Tim Scott, Dave Sheely 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/Update2011.pdf>, so I'll cover the highlights that aren't covered there.

I was late to this meeting because my computer decided to update fifteen minutes before the meeting started and didn't complete it for more than forty minutes. However, Robin Scott covered the meeting for NSS Downlink, so I'm quoting her for that part:

“On November 14, 2020, OSA’s members gathered online via Zoom to informatively share recent space news. On its way to Mars and in deep space, China’s Tianwen-1 spacecraft ejected a small camera, which took images, “space selfies,” every second and then transmitted these images to the parent spacecraft that transmitted them to Earth. NASA has announced its first human-tended suborbital payload — a Virgin Galactic SpaceShipTwo will carry Alan Stern, a planetary scientist and Associate Vice President at Southwest Research Institute to test a camera, which was designed to work at low light levels for astronomical imaging. NASA purchased its last seat on the Russian Soyuz spacecraft for astronaut Kate Rubins, which arrived at the International Space Station (ISS) on October 14, 2020. General John “Jay” Raymond is looking to swear NASA astronaut Michael Hopkins, a U.S. Air Force colonel and commander of the SpaceX Crew Dragon mission, into the space force while he is on the ISS. CEO of United Launch Alliance Tory Bruno has pitched the idea of a two-year propellant reserve for transportation to Mars to the Users’ Advisory Group of the National Space Council. NASA’s Tipping Point program gave 15 awards worth 372.2 million to 14 companies.... Tea leaves were used to find the small crack on the ISS, which was patched with Kapton tape until a more permanent patch is applied.”

Kip hasn't met Mike Kelly, the former astronaut who was elected Senator from Arizona, but his twin brother Scott's autobiography is one of the best Kip has read.

We saw a photograph the launch of a Soyuz manned spacecraft as taken from the ISS. This was the last Soyuz to take an American astronaut to the ISS under the current agreement.

New Shepard is a suborbital craft but will launch high enough to simulate lunar gravity.

Ice has been found on as much as 15,000 square miles of the lunar surface. This is more than twice as much as thought before.

Vector had a trial of a new engine using liquid oxygen and propylene but didn't get the performance they wanted. The revived company will use the more conventional liquid oxygen and kerosene.

SpaceX was going to launch astronauts to the ISS a few hours after our meeting, but the launch got postponed to the next day because of weather.

We held officer nominations for 2021. Clifford McMurray is stepping down to run for vice-president and Dave Sheely is running for president. Syd Henderson is running for another term as Secretary and Tim Scott for another turn as Treasurer, Claire will attend Chapters Assembly.

It's possible that if Dave hosts Zoom meetings, he may have to create a new URL starting in January since the link we're current using is to Kip's free account.

We now have \$627.26 in the checking account and \$267 in cash for a total of \$894.26.

Claire brought up a motion to sponsor an NSS chapter in Colombia with a recommended amount of \$50 for the first year, and several members agreed to send donations to the treasury to pay for the cause.

Since Covid-19 is having a resurgence with Oklahoma and many other states setting new records, it was decided to cancel the Christmas party year and have a virtual meeting (which can double as a Christmas Party).

--Minutes by Oklahoma Space Alliance Secretary Syd Henderson

Apollo 14

After the accident aboard Apollo 13 that required extreme innovation to save the lives of its three astronauts, the launch of Apollo 14 was inevitably delayed while the causes of the failure were investigated. Consequently, there was a gap of nine months between the launches of Apollo 13 and Apollo 14. (note, though, that the time between missions increased after Apollo 12, with gaps nearly as long between Apollo 15 and 16 and Apollo 16 and 17.

Whereas the previous manned Apollo missions had each featured at least one astronaut who had flown in the Gemini program, none of the Apollo 14 had ever been in orbit before (and, as it turned out, after). This was partly compensated for by the fame of its commander, Alan Shepard, the first American in space. Shepard was supposed to have flown on the first Gemini flight, but was grounded due to Ménière's disease for the duration of the Gemini program. Because of this (and possibly the *Apollo 1* fire), Shepard became the only one of the Mercury 7 astronauts to walk on the Moon. In 1968, Shepard underwent surgery which corrected the problem and allowed him to return to space. During the interval when he was grounded, he served as Chief Astronaut.

Accompanying Shepard on this mission were Command Module Pilot Stuart Roosa and Lunar Module Pilot Edgar Mitchell. As mentioned, this was the only spaceflight for either of them. The entire crew's space experience going in amounted to 15 minutes. It's worth noting that the *Apollo 14* crew was originally supposed to have launched on *Apollo 13*, but the crews were switched since Shepard had not been in space since 1961 and Deke Slayton thought Shepard needed more training time. Probably a lucky decision considering what happened aboard *Apollo 13*. As it happened, they had more training time for their specific mission than any other Apollo crew.

As was traditional for Apollo missions, the Command Module and Lunar Module got their own callsigns when separated in orbit. They became respectively *Kitty Hawk* and *Antares*. The names of the Apollo craft after *Apollo 10*'s *Charlie Brown* and *Snoopy* tend to be more traditional until *Apollo 16*'s *Casper*, named for Casper the Friendly Ghost. Kitty Hawk is, of course, where the Wright Brothers conducted their first flight. Antares was chosen by Edgar Mitchell because the equatorial star was used for astral orientation.

Apollo 14 was originally supposed to land in Mare Serenitatis near features thought to be volcanic. However, after *Apollo 13*'s landing was aborted, *Apollo 14*'s landing site was transferred to Fra Mauro where the other mission was to have landed. This site is thought to contain ejecta from the Mare Imbrium impact, hence possibly material from the interior of the Moon. [I believe the landing site for *Chang'e 4* was chosen for similar reasons.] Thus, the geological training had to be switched from volcanoes to craters. Although the site in Mare Serenitatis was never used, *Apollo 17* would land not far from it.

After the change of crew aboard *Apollo 13* necessitated by Ken Mattingly's exposure to rubella, NASA initiated a 21-day protocol to limit possible exposure to disease. *Apollo 14* was the first mission on which the protocol was used. Something similar is used today since we don't want astronauts getting sick on the ISS or on the Moon.

Apollo 14 launched on at 4:03 p.m. EST on January 31, 1971, after a forty-minute weather delay. The launch window was four hours, after which the launch would have been delayed till March. This was partly due to *Apollo 12* having been struck by lightning on its way to orbit. There was a bit of alarm in orbit when the lunar module was repositioned to dock with the command module. The docking mechanism would not activate for two hours, so finally the crew tried it with the docking mechanism retracted, and this activated the latches that joined the two modules. (I think of it as hitting the side of an old tv to get it working.) If this hadn't worked, the mission would have had to been aborted. As it was, the two craft were firmly docked, and the third stage was allowed to separate to crash on the Moon where it caused seismic tremors that were detected by instruments left by *Apollo 12*. This planned destruction was echoed on all the Apollo missions to the moon starting with *Apollo 13*. The third stages for Apollos 8 through 12 went into heliocentric orbit and, as far as I know, are still there.

The trip from Earth orbit to Lunar orbit lasted around three days, and the mission settled into Lunar orbit at 2:00 a.m. on February 4. The spacecrafts separated a few hours afterward, after which *Antares* experienced two potentially serious problems. First, a short in the abort switch started it sending "abort" messages though the craft was not in trouble. This was finally solved by making the software believe that the abort had already occurred. This solved the problem, but also meant the astronauts would, if an abort had proved necessary, have to do it manually. Then during the descent, the radar started acting up, not locking onto the lunar surface until *Antares* was about 3.5 miles above the Moon. If it hadn't locked, the landing might have been aborted (though I think Shepard probably would have tried to land anyway). As it was, *Apollo 14* landed less than a hundred feet from its target, the closest of any Apollo mission.

The Fra Mauro highlands lie near the sixty-mile crater, also Fra Mauro, named after a 15th century Venetian monk and mapmaker. The highlands, however, are thought to composed of ejecta from the deep impact that produced Mare Imbrium. Shepard and Mitchell landed a couple of miles from the more recent Cone Crater, which also produced ejecta for the astronauts to investigated (some of which would, in turn, have been originally produced by the impact that produced Mare Imbrium). Because of the success of this mission, scientists have been able to determine the Mare Imbrium is about 4 - 4.25 billion years old, which also gives scientists a good idea of when the other Maria were created.



Crew of Apollo 14. From left: Stuart Roosa, Alan Shepard, and Edgar Mitchell(Photo from NASA archives.)

Shepard and Mitchell conducted two Moon walks, the first lasting four and three-quarters hours on February 5, the second four and a half hours the next day (early morning Houston time). Altogether, they collected a hundred miles of Moon rocks and nearly made it to Cone Crater but were unable to find its rim. Due to unexpectedly rough terrain. The rocks from the vicinity of Cone Crater tend to be breccias, a metamorphic rock formed by meteor impacts. However, rocks collected from another locations contained basalt, which is a more volcanic rock. Most important were granite samples, which contain zircons. Zircons are extremely stable and useful for radioactive dating since uranium's decay products tend to stay put. Thus, scientists were able to estimate the time of the granite's formation to more than four billion years ago. Interestingly, the granite seems to have come from Earth from an impact that long ago.

To help them carry their tools and samples, the astronauts had a handcart called the MET (Modular Equipment Transporter). This debuted the use of tires on the Moon. *Apollo 14* was the only mission to use a handcart, since the Lunar Rover debuted with *Apollo 15*.

The end of this second Moon walk is famous because Alan Shepard attached a golf ball head to the handle of a lunar excavation (i.e shovel) and hit several golf balls, thereby introducing sports to the Moon. The images of this are the most famous of the mission.

Roosa, meanwhile, was photographing the Moon's surface from orbit, including the Descartes Highland which would be the target of the *Apollo 16* mission.

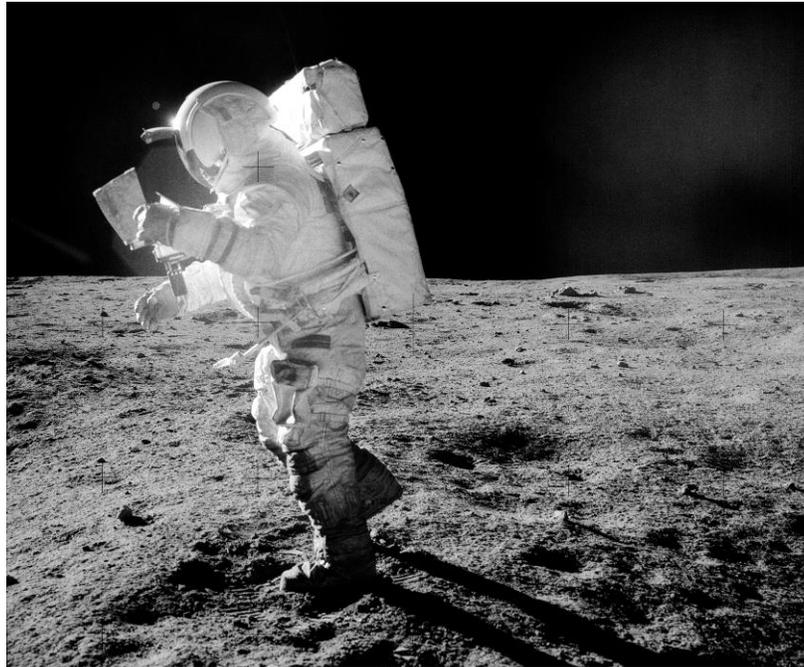
After thirty-three and a half hours on the Lunar surface, *Antares* lifted off at 1:48 p.m. EST on February 6 and docked with *Kitty Hawk* less than two hours later. Compared with the first docking this one was largely uneventful. Once the astronauts and samples were aboard, the ascent module was intentionally crashed into the Lunar surface, creating shockwaves detected by Seismometers left by *Apollo 12* and *Apollo 14*.

Apollo 14 returned to Earth at 4:05 p.m. on February 9 and the crew promptly went into quarantine for eighteen days. They were the last *Apollo* crew to be quarantined upon landing.

After the mission, Shepard once again became Chief Astronaut, a position he held until 1974 when he retired from NASA at age 50. He remains the oldest person to have walked on the Moon. He became a successful businessman, and founded the Astronaut Scholarship Foundation. He died of leukemia in 1998 at age 74.

Edgar Mitchell got interested in the paranormal and theories of consciousness, founding the Institute for Noetic Sciences. He was also certain that many UFOs were in fact alien spacecraft. He also was early into green technology. He died at 85 in 2016, just short of the 45th anniversary of his Moon walk.

Stuart Roosa also became a businessman and retired from NASA in 1976. To tell you the truth, I don't have much information about his later life. He died of pancreatitis in 1994 at the age of 68. He is buried at Arlington National Cemetery.



Apollo 14 Astronaut Edgar Mitchell as photographed by Alan Shepard (NASA Archives)

Sky Viewing

Jupiter and Saturn had their spectacular great conjunction just before Christmas. At their closest, they could be seen through the same telescope, as well as the Galilean moons and Titan. In fact, since Jupiter was 2.5 magnitudes brighter than Saturn, it tended to drown it out (though Saturn itself was magnitude 0.5, which is brighter than all but a handful of stars). I used my cheap binoculars to see both.

They are slowly separating and now are about a degree and a half apart (or three times the diameter of the Full Moon, which is smaller than people generally think). They are also setting earlier and are well into twilight at Sunset. They are both nearing conjunction with the Sun, Saturn on January 23, and Jupiter on January 28. Thus, neither will be visible again until mid-February when they will be morning “stars.” This, incidentally, makes it easy to find Mercury, since during the last week in February, Jupiter, Saturn and Mercury will be close together in the morning sky. Mercury will be to the left of Saturn (which is higher than Jupiter) and slightly brighter. Jupiter and Saturn are in Capricornus, which is the dimmest of the Zodiacal constellations.

Mercury is currently an evening star and actually is within a couple of degrees of Jupiter and Saturn from January 9 – 13, so if you can still see Jupiter on those days, you can easily find Saturn and Mercury. Mercury is the highest of the three by January 13 and quite a bit brighter than Saturn. This starts a very good evening appearance of Mercury, which by January 23 will be setting 90 minutes after the Sun and will be magnitude -0.6. After that, Mercury will get quickly more difficult to see as it approaches inferior conjunction with the Sun on February 8. As mentioned above, it will accompany Jupiter and Saturn at the end of February.

Venus is also leaving the night sky, but in the opposite direction from Jupiter and Saturn. Venus is currently low in the morning sky and has fallen to magnitude -3.9 (which still makes it easily the brightest object in the night sky after the Moon). Venus will fade into twilight later in January, and not be visible at all from early February through most of April, after which it will dominate the evening sky for the rest of the year.

Mars is growing dimmer as it moves away from us, but is still magnitude 0.0 and noticeably red. It is just inside the constellation Aries and will be moving across that constellation until February 23, when it moves into Taurus. It also moves slowly across the sky with respect to the Sun, so it will be visible in the evenings at least through mid-summer, with conjunction with the Sun not until October.

Uranus is in the southern sky early in the evening but is only magnitude 5.7 and in an inconspicuous part of Aries. However, it will become much easier to find from January 18 through 22 since it will be only two degrees from Mars. Closest approach is on January 20, when it is 1.5 degrees south east of Mars. Although Uranus will probably require binoculars, it should be fairly easy to find because there literally is nothing brighter that near it.

Neptune is in the southwest after sunset and may not be that difficult to locate although at magnitude 7.8 because it is about a degree east of Phi Aquarii, a fourth-magnitude star and will stay in that approximate position through January. By mid-February, Neptune will be setting too early to be visible even with a telescope as it nears its conjunction with the Sun in March

You can find sky charts for Uranus and Neptune at https://in-the-sky.org/findercharts/09uranus_2020_2.png and https://in-the-sky.org/findercharts/10neptune_2020_2.png, and at https://skyandtelescope.org/wp-content/uploads/UranusNeptune2020_BW_WebFinder.pdf.

Viewing Opportunities for Satellites (January 9 – February 12, 2021)

You can get sighting information at www.heavens-above.com, which allows you to get satellite-viewing data for 10-day periods and gives you a constellation map showing the trajectory of the satellite. The times below are from the NASA site <https://spaceflight.nasa.gov/realdata/sightings/SSapplications/Post/JavaSSOP/JavaSSOP.html>. It gives coordinates at 20-second intervals from when the satellite rises, not from when it peaks. (This program requires Java. I'm currently using Internet Explorer to run it and making an exception for the site in the Java Control Panel.) I'm using its information for the International Space Station and Hubble Space Telescope, interpolating when necessary. 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 -3.8 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. However, there are no good passes of the Hubble Space Telescope during this time period. Missions to and from the International Space Station can change its orbit. However, there are no missions to the ISS until the Northrup Grumman resupply mission on February 20.

ISS 9 January 2021

Time	Position	Elevation
6:41 a.m.	284°	18°
6:42	265	28
6:43	228	34
6:44	191	28
6:45	171	18

ISS 17 January 2021

Time	Position	Elevation
6:36 p.m.	186°	17°
6:37	167	26
6:38	132	32
6:39:21	97	26
6:40:01	83	20

Vanishes into Earth's Shadow

ISS 19 January 2021

Time	Position	Elevation
6:38 p.m.	239°	22°
6:39	250	41
6:40	321	68
6:41	28	41
6:42	38	22

ISS 4 February 2021

Time	Position	Elevation
6:51 p.m.	342°	17°
6:52	2	25
6:53	36	30
6:54	69	25
6:55	89	17

ISS 5 February 2021

Time	Position	Elevation
7:40 p.m.	289°	19°
7:41	270	31
7:42	227	41
7:43	183	31

Vanishes into Earth's shadow

ISS 6 February 2021

Time	Position	Elevation
6:52 p.m.	309°	23°
6:53	306	43
6:54	208	83
6:55	140	42
6:56	137	22

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 International Space at 7:40 p.m. on February 5. measure just under two fist-widths north from due west and just under two fist-widths above the horizon (and a minute later it is due west).

All times are rounded off to the nearest minute except for times when the satellite enters or leaves the shadow of the Earth. The highest elevation shown for each viewing opportunity is the actual maximum elevation for that appearance.

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>.

Highlights (times are Central Standard Time):

Not much going on this month with no crewed launches or landings. I'm sure we'll be seeing a lot on February 18 with the 2:43 p.m. landing of the *Perseverance* rover on Mars.

January 11, 8:00 a.m. Coverage of undocking of SpaceX Cargo Craft from the ISS. Actual undocking is at 8:25 a.m.

NASA also has a weekly podcast, This Week @ NASA, which you can watch online at

<https://www.youtube.com/playlist?list=PL1D946ACB21752C0E>

. You can also get the most recent episodes at NASA.gov.

Calendar of Events

Sometime in 2021: China launches the first module of their space station.

Sometime in 2021 [Moved from 2020].: ALINA, the Autonomous Landing and Navigation Module will be launched aboard an Ariane rocket, and land near the Apollo 17 landing site in the Taurus-Littrow valley. It will carry two Audi lunar rovers which will try to locate Apollo 17's Lunar Rover. For more information, see <https://ptscientists.com/products/alina>.

Sometime in January: First Firefly launch carrying 26 small satellites, mostly cubesats to low-Earth orbit.

First Quarter of 2021: First flight of India's Small Satellite Launch Vehicle (or SSLV).

First half of 2021: Launch on *Tianhe*, the first element of the Chinese space station.

January 9: Oklahoma Space Alliance meeting, 2:00 p.m., via Zoom.

January 14: Launch of a slew of small experimental satellites by a SpaceX Falcon 9 from Cape Canaveral, all into low-earth orbit with many going to sun-synchronous orbit.

January 23: Mercury is at greatest eastern elongation, 18.6 degrees from the Sun (so can be seen after sunset).

January 23: Saturn is in conjunction with the Sun.

January 28: Jupiter is in conjunction with the Sun.

January 31 – February 9: 50th anniversary of Apollo 14.

February: Hope (*Al Amal*), aka Emirates Mars Mission, arrives at Mars. For more information,, see [//en.wikipedia.org/wiki/Emirates Mars Mission](https://en.wikipedia.org/wiki/Emirates_Mars_Mission)

February 8: Mercury is at inferior conjunction with the Sun.

February 11: China's *Tian-wen-1* achieves Mars orbit. (See April 23.)

February 13: Oklahoma Space Alliance meeting, 2:00 p.m., probably via Zoom.

February 18, 2:43 p.m.: Mars rover *Perseverance* (formerly Mars 2020) lands at Jezero Crater on Mars. It will be carrying the Mars Helicopter Scout aka Ingenuity, which will deploy in two or three months.

February 22: Launch of *Amazônia-1*, the first Earth observation satellite developed by Brazil. It will be launched from Satish Dhawan Space Center in India.

March 4: The asteroid Vesta is at opposition. Vesta is the brightest asteroid and will get up to magnitude 6.2. Since the Moon isn't in the sky till midnight and Vesta will be high in the sky, it will be on the threshold of naked eye visibility, but more likely will require binoculars.

March 6: Mercury is at greatest elongation, 27.3 degrees west of the Sun (hence can be seen before sunrise).

March 10: Neptune is in conjunction with the Sun.

March 13 [Tentative]: Oklahoma Space Alliance meeting, 2:00 p.m., location to be announced.

March 20: Launch of many minisatellites from many countries via a Soyuz 2.1 from Baikonur. This includes Tunisia's first satellite, as well as satellites from Argentina, Hungary, Thailand, Saudi Arabia, and more usual suspects such as the US, Russia, Canada and Japan.

March 26: Venus is at superior conjunction with the Sun.

March 29: Second uncrewed orbital test flight of Boeing's CST-100 *Starliner*.

March 30: SpaceX's Dragon Crew-2 mission to the ISS.

April 9 [Moved from April 1]: Launch of three cosmonauts by Soyuz from Baikonur to the ISS.

April 8: [Tentative]: Oklahoma Space Alliance meeting, 2:00 p.m., location to be announced.

April 17: Mars is 0.1 degrees north of Moon. This is an occultation in India, Indochina, and western Indonesia.

April 18: Mercury is at superior conjunction with the Sun.

April 22: Peak of Lyrid meteor shower.

April 23: Landing of China's *Tianwen-1* on Mars.

April 30: Uranus is in conjunction with the Sun.

May 4: Peak of the Eta Aquariid meteor shower.

May 13 [Tentative]: Oklahoma Space Alliance meeting, 2:00 p.m., location to be announced.

May 17: Mercury is at greatest elongation, 22 degrees east of the Sun (hence is visible after sunset).

May 26: Total eclipse of the Moon, visible from all the Pacific Ocean and lands on its rim. In Oklahoma, totality will be occurring just before moonset

June: First crewed flight of Boeing's *Starliner* space craft on a voyage to the Space Station.

June 10: Annular eclipse of the Sun. The eclipse passes through the Arctic from Russia just north of Kamchatka, almost to the North Pole, back through northwestern Greenland, Baffin Island, and Hudson Bay. Until terminating in central Ontario north of Lake Superior. In other words,

few people will be able to see the annular eclipse, though a partial eclipse will be visible in the northeastern United States, and eastern and central Canada.

June 10: Mercury is in inferior conjunction with the Sun.

June 10 [Tentative]: Oklahoma Space Alliance meeting, 2:00 p.m., location to be announced.

July 4: Mercury is at greatest elongation, 21.6 degrees west of the Sun (hence can be seen before sunrise).

July 8 [Tentative]: Oklahoma Space Alliance meeting, 2:00 p.m., location to be announced.

July 13: Conjunction of Mars and Venus. Venus will be half a degree north of Mars, the diameter of a Full Moon.

July 17: Pluto is at opposition.

July 26 – August 7: 50th Anniversary of Apollo 15.

July 27: Peak of Delta Aquariid meteor shower.

July 30: *Juno* ends its mission to Jupiter with a fiery death in Jupiter's atmosphere.

August 1: Mercury is in superior conjunction with the Sun.

August 1: Saturn is at opposition.

August 12: Peak of Perseid Meteor shower.

August 19: Jupiter is at opposition.

September: SpaceX's Dragon Crew 3 to the ISS.

September 13: Mercury is at greatest elongation, 26.8 degrees east of the Sun (hence can be seen after sunset).

September 14: Neptune is at opposition.

Fourth quarter of 2021 [Moved from July]: Maiden flight of the Vulcan Centaur, ULA's new heavy launch vehicle. which will carry the Peregrine lunar lander. For more information, visit [https://en.wikipedia.org/wiki/Vulcan_\(rocket\)](https://en.wikipedia.org/wiki/Vulcan_(rocket)) and https://en.wikipedia.org/wiki/Astrobotic_Technology#Peregrine_lander.

Fourth quarter of 2021: Launch of *Axiom Space Mission 1* which will carry a commercial crew of four to the ISS via SpaceX Crew Dragon.

Fourth quarter of 2021: SpaceX launches of *Space Adventures Crew Dragon* which will carry up to four tourists to orbit. For more information, see https://en.wikipedia.org/wiki/Space_Adventures_Crew_Dragon_mission.

October [Moved from February]: Maiden flight of KSLV-II (aka Nuri), the first South Korean indigenous orbital launch vehicle.

October 1: Launch of the Luna 25 lunar lander, the first mission of Russia's Luna-Glob lunar exploration mission. For more information, visit en.wikipedia.org/wiki/Luna_25 and en.wikipedia.org/wiki/Luna-Glob.

October 7: Mars is in conjunction with the Sun.

October 9: Mercury is in inferior conjunction with the Sun.

October 11: The first Nova-C mission will carry the IM-1 lander and Moon Mark lunar rover to the Moon. To be launched by SpaceX.

October 16: Launch of Lucy, a mission to explore Jupiter's Trojan Asteroids. See [https://en.wikipedia.org/wiki/Lucy_\(spacecraft\)](https://en.wikipedia.org/wiki/Lucy_(spacecraft)) for details.

October 21: Peak of Orionid meteor shower.

October 24: Mercury is at greatest western elongation, 18 degrees west of the Sun (hence is visible before sunrise).

October 29: Venus is in greatest eastern elongation 47 degrees from the Sun (hence is visible after sunset.)

October 31: [Postponed from April] Launch of the James Webb Space Telescope. For more information, see https://en.wikipedia.org/wiki/James_Webb_Space_Telescope

Late 2021 or early 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.

November: [Moved from 2020] Launch of Artemis 1 the first launch of the Space Launch System. On this 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 NearEarth Asteroid Scout cubesat (https://en.wikipedia.org/wiki/Near-Earth_Asteroid_Scout) and a bunch of other satellites.

November [Moved from September]: Launch of the IXPE X-Ray Telescope by Falcon 9. For more information, see <https://en.wikipedia.org/wiki/IXPE>.

November 4: Uranus is at opposition.

November 5: Peak of South Taurid meteor shower.

November 12: Peak of North Taurid meteor shower.

November 17: Peak of Leonid meteor shower (unfortunately coinciding with the Full Moon).

November 19: Partial lunar eclipse, 3:02 a.m. peak, visible from Oklahoma. Since the moon is 97% covered, this is not far from being a total lunar eclipse.

November 28: Mercury is in superior conjunction with the Sun.

December: First operational *Starliner* mission to the ISS.

December 4: Total eclipse of the Sun. Unfortunately, this one is only visible from West Antarctica and the ocean around it.

December 8: Soyuz crew mission to the ISS from Baikonur.

December 14: Peak of the Geminid meteor shower.

December 22: Peak of Ursid meteor shower.

Sometime in 2022 [tentative]: India launches its first manned orbital flight Gaganyaan-3.

Sometime in 2022: SpaceX plans to launch a human crew around the Moon. [This is speculative, reflected by this mission being postponed from 2018.]

Sometime in 2022: Launch of several crews to the Chinese Space Station and the addition of the second lab module.

Sometime in 2022 [Moved from October 2021]: 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>.

January 2022: [Moved from 2020]: 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>.

February 4, 2022: Fourth Crew Dragon mission to the ISS.

March 2022: Launch of *Eris*, the first Australian rocket to launch an Australian payload. *Eris* is the launch vehicle for Gilmour Space.

April 16 – 27, 2022: 50th anniversary of Apollo 16.

May 2022: Second flight of South Korea's *Nuri*, and the first with a commercial payload.

May 22 - June 10, 2022: Launch window for JUICE, the Jupiter Icy Moons Explorer, by the European Space Agency. The JUICE web site is <https://sci.esa.int/web/juice>.

June 2022 [approximate]: First crewed launch of an Orion space capsule.

July to December 2022 [Moved from 2020.] 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>.

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 1, 2022 (postponed from December 2020): 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.

September 20, 2022 [postponed from 2020]: ESA launches the ExoMars Mars Rover, which has been christened Rosalind Franklin, and the Exomars 2020 surface platform. For more information, visit <https://en.wikipedia.org/wiki/ExoMars>.

Fourth quarter of 2022: [Tentative] Launch of the Israeli Lunar Surface Access Service (LSAS). Tentative because they are looking for a launch to hitch a ride on.

December 2022: Launch via Falcon 9 of Masten Mission 1, a Commercial Lunar Payload Services mission to the lunar South Pole.

December 21, 2022: Launch of the *Nova-C* lander to the Lunar South Pole.

December 7 – 19, 2022: 50th anniversary of Apollo 17. This, to date, is the last manned mission to the Moon.

Sometime in 2023: OSIRIS-REx returns samples from Asteroid Bennu.

Sometime in 2023 (tentative): 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.

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

Sometime in 2023: (Tentative): Launch of the first module of the Lunar Orbiter Platform- Gateway.

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

April – July 2023: The ExoMars Mars landers land on Mars. This includes the Russian Kazachok surface platform and the ESA's Rosalind Franklin Mars rover.

November 2023: Launch of NASA's VIPER lunar rover, which will hunt for ice near the Moon's South Pole.

Sometime in 2024: India launches its Mangalyaan-2 Mars mission, which includes an orbiter, lander, and rover.

Sometime in 2024: Planned date of Artemis 3, which will land astronauts on the Moon.

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.

September 2024: Launch of Japan's Martian Moons Exploration, which includes a Phobos lander.

December 19, 2024: Parker Solar Probe (formerly Solar Probe Plus) makes its first pass through the outer corona of the Sun. For more information, see <http://parkersolarprobe.jhuapl.edu>.

Sometime in 2025: First crewed flight of Russia's Orel (formerly called Federatsiya).

December 2025: BepiColombo arrives at Mercury orbit.

April 2026: Launch of Dragonfly to Titan.

January 31, 2026: The Psyche asteroid probe arrives at the asteroid 16 Psyche. For more information, visit [https://en.wikipedia.org/wiki/Psyche_\(spacecraft\)](https://en.wikipedia.org/wiki/Psyche_(spacecraft)).

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 phone is 202-424-2899 (new as of May 2019). 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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To join the Mars Society, visit www.marssociety.org. One-year memberships are \$50.00; student and senior memberships are \$25, and Family memberships are \$100.00. Their address is Mars Society, 11111 W. 8th Ave, Unit A, Lakewood, CO 80215.

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