

OKLAHOMA SPACE ALLIANCE

OUTREACH –November 2019

102 W. Linn #1, Norman, OK 73069

Oklahoma Space Alliance will meet
at Clifford and Claire McMurray's house
2715 Aspen Circle in Norman
2:00 p.m. on November 9, 2019
Directions are inside.



Figure 1 Apollo 12 Badge (Wikipedia)

OKLAHOMA SPACE ALLIANCE OUTREACH November 2019

November Meeting:

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, November 8. at Claire and Clifford McMurray's house. Prospective members are also welcome. Their house is at 2715 Aspen Circle in Norman. An agenda is forthcoming.

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. The turns at Poplar, Aspen Lane and Aspen Circle are the first you can take, 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, December 14 at the McMurrays.

Saturday November 8, 2019 2:00 p.m.

Place: McMurray Residence

1. Introductions and review of Space events this past month
 - a. What's Happening in Space, News, Pictures, and Videos approximately one hour.
2. Break
 - . Oklahoma Space Alliance Chapter Business Discussion
 - a. Review OSA treasurer's report
 - b. Summary of August meeting minutes
 - c. Officer nominations
 - d. Christmas Party
3. Video (to be announced)
4. Chat

Minutes of October Meeting

Oklahoma Space Alliance met at the McMurrays' house in Norman, Oklahoma on October 12. In attendance were Clifford and Claire McMurray, Dave Sheely, Mike Hopkins, Adam Hemphill and Syd Henderson. OSA President Clifford McMurray presided over the meeting. He also did an Update with links to the videos he presented. This can be found at <http://osa.nss.org/Update1910.pdf> so I'll cover the highlights.

We went through an article on a NASA agreement with Australia. Australia is a big mining country which will be helpful when we start developing resources on the Moon and Mars. The Australian Space Agency only formed last year.



We watched a video of NASA Administrator Jim Bridenstine explaining Artemis Phase 1. (Artemis 2 is the mission that will actually land people on the Moon.)

We went through an article on China's plans for lunar spacecraft.

NASA wants to enable commercial free-flying platforms to provide destinations for commercial companies.

We watched a video of Axiom Space's modules for commercial users of the ISS. Axiom plans to eventually have a commercial space station. Nanoracks has a more modest ambition.

We went through an article and video on Northrop Grumman's satellite servicing mission, MEV, which will extend the life of Intelsat 901, which is in geostationary orbit. MEV will remain attached to Intelsat 901 for five years, then move it to a graveyard orbit,

The Senate Appropriation Committee would like to see a five-year budget profile of NASA's plan to return to the Moon.

The SLS could launch four Mars sample return missions on one flight.

We went through an article on meat-growing in space using a 3-D printer.

Mike informed us that cosmonaut Alexei Leonov died on October 11.

We went through several episodes of This Week at NASA.

The Hubble Space Telescope has detected water in the atmosphere of an exoplanet.

TESS detected the tidal disruption of a star by a black hole. This event takes place only once every 10,000 – 100,000 years in a galaxy the size of the Milky Way.

Business: We're hoping to arrange a meeting with Oklahoma City's congresswoman Kendra Horn. Dave, Clifford and Adam will attend.

Tom and Heidi Koszoru are both laid up, so the Christmas Party will probably be at the McMurrays.

In January it will be time to decide again about meetup.

We watched Elon Musk's presentation of Starship. This will be 50 meters long, 9 meters in diameter, and have a dry mass of 85 tons. Raptor has three sea-level engines and three vacuum engines. Superheavy has 37 engines total.

We also watched a conversation with Elon Musk from the web show "Everyday Astronaut."

--Minutes by OSA Secretary Syd Henderson

Minutes of September Meeting

Oklahoma Space Alliance met the McMurrays' house in Norman, Oklahoma on September 13. In attendance were Clifford and Claire McMurray, Adam Hemphill, Mike Hopkins, Tim Scott, Dave Sheely, Steve Swift, Brian Swift and Syd Henderson. OSA President Clifford McMurray presided over the meeting. He also did an Update with links to the videos he presented. This can be found at <http://osa.nss.org/Update1909.pdf>, so I'll cover the highlights.

We watched a Linkspace video of a test launch of a Chinese commercial launch, then a video of the semi-commercial launch of Smart Dragon-1, which launched three satellites to low-Earth orbit

We watched a video on ArianeSpace's reusable launcher, the Themis. This is being developed by ArianeWorks, which is sort of the ESU version of "Skunk Works." CNES and ArianeSpace are creating the Prometheus engine which uses methane and oxygen and will be used aboard Themis.

We watched a video of the fourth and last Starhopper test flight. Starhopper has one Raptor engine. Starship will have at least three.

We watched a video on Virgin Galactic.

Australia, Canada, New Zealand and China are all establishing their own space resources policies.

We watched a video on the Chandrayaan 2 landing. The lander lost contact before landing (or crashing), but the orbiter will last seven years.

TESS has discovered an exoplanetary system which has a hot Earth-sized and two mini-Nep-tunes. It's not clear how such a planetary system could have formed.

Kip: They're finding an awful lot more lava tubes on the Moon.

Business meeting:

We have \$655.36 in checking account and \$267 in cash, for a total of \$922.36. (This was before I have Tim a check from a new membership.)

Kip went to the Tripoli LDRS meeting. Kip thinks it's the most amazing space-related experience he's had except for meeting Neil Armstrong. Someone did a full-scale V-2 replica and someone else a 1/10 scale Saturn V replica. (These were flown in previous years.) The LDRS event is held every Labor Day weekend at the Argonia, Kansas, Rocket Pasture.

During the exploration of the Northwest Passage, privately funded explorers did better than the government sponsored ones.

We watched a video the acceptance speech of Jeffrey Manber, the CEO and co-founder of NanoRacks receiving the NSS Space Entrepreneur award at ISDC. He had a video about terpenes in microgravity. These occur in whiskeys and wines. Aging a beverage in microgravity for two years is equivalent to doing it for five years on Earth.

In 2009, NanoRacks entered a contract to increase the exploitation of the ISS. NanoRacks has been on 35 launches, with 750 payloads, including 230 satellites deployed.

Should we have a display for the opening of the movie *Ad Astra*, since it uses the name of the NSS magazine? [Apparently not.]

--Minutes by OSA Secretary Syd Henderson

Apollo 12 Anniversary

Over the last couple of years, we've been commemorating the 50th anniversary of the *Apollo* missions. This month, we're remembering *Apollo 12*, the second mission to land on the Moon.



Figure 2 Astronauts Conrad, Gordon and Bean in front of Apollo 12's Saturn V (NASA photograph)

Just under four months after *Apollo 11* and the first crewed landing on the Moon, and five months before the dramatic and thankfully non-tragic *Apollo 13* mission, *Apollo 12* is less well remembered than either. The Commander on this mission was Charles "Pete" Conrad, the Command Module Pilot was Richard Gordon, and the Lunar Module Pilot was Alan Bean.

Pete Conrad was born on June 2, 1930, the same year as all three of the *Apollo 11* crew. (Aldrin was born in January, Armstrong in August, and Collins in October.) He was named Charles Conrad, Jr., but his mother wanted him to be named Peter, and that's why he's almost always called Pete. He served in the Navy as a fighter pilot shortly after the Korean War and became a test pilot in 1958. He attempted to join the first group of NASA astronauts but rebelled at the training and wasn't accepted. Conrad was encouraged to apply for the second group of astronauts and passed a saner bunch of tests and was accepted.

Conrad's first space mission was *Gemini 5* from August 21 – 29, 1965, on which his commander was Gordon Cooper. (This, incidentally made Cooper the first person to orbit the Earth on two occasions.)

They were supposed to rendezvous with a space pod, but electrical problems forced them to do a “phantom rendezvous.” Most of this mission was spent photographing the Earth, and medical experiments determining whether an eight-day mission was feasible. The prior record flight was a Russian five-day mission.

Conrad’s second space mission was *Gemini 11* from September 12 – 15, 1965, on which his pilot was his future *Apollo 12* crewmate Dick Gordon, who was on his first flight. This mission was briefer than *Gemini 5*, but successfully docked with an Agena target vehicle, which then boosted *Gemini 11* to a then-record 850 miles. (This is still a record for the apogee of a crewed spacecraft in Earth orbit, though of course, the Apollo moon missions went higher; they just weren’t in Earth orbit at the time.) They also experimented with artificial gravity using a tether to join the two spacecraft. They eventually achieved a force of 0.00015 g, so they each weighed about half an ounce.

Conrad would go a fourth time into this space, this time as Commander of the first mission on a space station, *Skylab* in May through June 1973.

Alan Bean, born in 1932, was on his first flight. He became a test pilot in 1960, and his instructor was Pete Conrad. He was part of the third group of astronauts selected but didn’t go into space for six years. Pete Conrad specifically asked for Bean to be assigned to his crew when astronaut Clifton Williams was killed in a plane crash.

Bean would go into space once more, as commander of *Skylab 3* from July through September 1973. Their 59-day mission was by far the longest in space at the time.

Bean retired from NASA in 1981 to become a noted space artist. He’s famous for including lunar dust in his paintings.

Dick Gordon was born of October 5, 1929. He joined the Navy just after the Korean war and was a test pilot from 1957 through 1960 (so all three *Apollo 12* astronauts were Navy test pilots with thousands of hours flying jet aircraft). As mentioned, he was aboard *Gemini 11*. *Apollo 12* was his second and last spaceflight.

After his flight, he became an executive for the New Orleans Saints, and later became president of Astro Sciences Corporation.

All three of the *Apollo 12* astronauts have passed on: Pete Conrad on July 8, 1999 following a motorcycle accident, Dick Gordon on November 6, 2017, and Alan Bean on May 26, 2018. They were 69, 88 and 86, respectively.

Apollo 12 was launched at 11:22 EST on November 14, 1969 on a rainy day and encountered hurricane-force winds of up to 175 mph as it ascended through the clouds. It was struck twice by lightning during the first minute, which knocked out all three fuel cells on the Command Module. Not surprisingly, this also caused power problems in the instrument panel, which Alan Bean fixed by switching to a backup power supply, reactivating the fuel cells and saving the mission.

Apollo 12 entered Lunar orbit late in the evening of November 17, and the LEM, *Intrepid* separated from the Command Module, *Yankee Clipper*, at 11:16 p.m. on November 18. Astronauts Conrad and Bean landed in the Oceanus Procellarum (Ocean of Storms) at 1:56 a.m. EST on November 19. The Ocean of Storms is the largest of the lunar maria, covering over ten percent of the surface of the Moon, and is the only one of the Maria called an Ocean. The landing site was 950 miles almost directly west and 47 degrees across the near side of the Moon from the *Apollo 11* site. Unlike the *Apollo 11* landing, there was no last-minute drama.

The landing site was less than a thousand feet of that of *Surveyor 3*, which landed on the Moon in 1967. One of the missions of *Apollo 12* was to retrieve parts of *Surveyor 3*, including its camera and scoop and bring them back to Earth to analyze long-term exposure of spacecraft on the lunar surface.

Conrad became the third man to step on the Moon, saying "Whoopie! Man, that may have been a small one for Neil, but that's a long one for me." (He'd made a bet with Oriana Fallaci that he would say that.) I don't know what Alan Bean's first words were. They set up an ALSEP (Apollo Lunar Surface Experiments Package), which would become a feature of the future manned Moon landings. Unlike the package left by *Apollo 11*, this was nuclear powered and in fact would operate until 1977 when they were

turned off. Conrad and Bean made two moon walks, each lasting just under four hours. *Intrepid* stayed on the Moon for 31 ½ hours, lifting off at 9:26 a.m. on November 20. They redocked with *Yankee Clipper* at 12:58 p.m. The Lunar Module ascent stage was released two and a half hours later to impact with the Moon. Seismographs, including those aboard ALSEP, detected the seismic waves from the impact.

Yankee Clipper continued to orbit the Moon for 24 hours so they could photograph the Moon and other objects. Gordon spent 89 hours in orbit around the Moon.

Apollo 12 returned to Earth at 3:58 p.m. EST on November 24. During the landing, Alan Bean was knocked unconscious by a camera and required six stitches.

[Sources: Wikipedia, NASA and *Astronomy*, which did a commemoration of the mission.]

Sky Viewing

The big sky viewing event this month is a transit of **Mercury** across the Sun on the morning of November 11. This Veteran's Day transit begins at 6:35 a.m. CST and ends at 12:04 p.m. Eastern Time zone sees it an hour later, and Rocky Mountain time an hour earlier, which means they don't see the beginning of the transit. (Actually, Oklahoma and Texas don't either since we're so far west in the Central Time Zone.) You should use some sort of indirect projection that blows the image of the Sun up, especially since Mercury is near perihelion and appears at its smallest relative to the Sun. <https://www.skyandtelescope.com/astronomy-news/observing-news/how-to-look-at-the-sun/#projection> has some suggestions on how to project the Sun. One method even uses a refracting telescope to project the image. (DO NOT look directly at the Sun through the telescope.)

Transits of Mercury are not as rare as those of Venus, but tend to occur in clusters. There were transits in 1999, 2003, 2006 and 2016, but the next one won't occur until November 13, 2032. (And the next visible in the US is in 2049.) There are generally thirteen or fourteen in a century, and always in May or November.

Of course, since Mercury is transiting the Sun's disk, it is in inferior conjunction and not visible except as a black dot during the hours of transit. Mercury will, however, be visible around the end of November, reaching greatest elongation on November 28, at which point it will be shining at magnitude -0.5 and rise 75 minutes before the Sun. It will be slightly brighter in early December, rising up to 90 minutes before the Sun, but will start to disappear in the twilight by December 16.

The **Geminid Meteor Shower** peaks on December 14, but the gibbous Moon will interfere with viewing it. This is, however, one of the year's big meteor showers, and you should be able to see quite a few if you do what *Sky & Telescope* suggests and turn your back on the Moon: Geminids can appear all over the sky.

The **Ursid Meteor Shower** peaks on the night of December 22 and 23, and the Moon won't interfere. It generally only produces 10 meteors per hour, but has produced major outbursts, and some predictions are more than thirty per hour.

Venus is currently just possible to see low in the west at sunset, but you'll need a very clear horizon devoid of trees. (The planet two fist-widths above the horizon is Jupiter, not Venus.) Venus and Jupiter are heading in opposite directions and pass each other on the night of November 23 and 24, when they'll be 1.5 degrees apart. By that time, they'll be about ten degrees above the horizon in mid-twilight, so once again you need to get away from the trees. Venus is getting higher and brighter each night, reaching magnitude -3.9 in early December. On December 10 it will be about two degrees from Saturn, and both set about two hours after the Sun so will be easily visible. On December 12, Venus is only 1.3 degrees south of Pluto, which you can't see without a large telescope, but it's still a triple conjunction. Venus will continue to brighten through the first half of 2020, eventually getting up to magnitude -4.7.

Mars is rising near the middle of morning twilight, and at magnitude 1.8 is probably not visible. From November 8 – 12, it passes Spica, which is considerably brighter this time of year. By late November, Mars will be easier to see because it will be rising three hours before the Sun but will still be magnitude 1.6.

Jupiter is still easy to see in the western sky after sunset, but as mentioned it will be getting lower in the sky each night. It will get hard to see in early December as it approaches a conjunction with the Sun on December 27.

Saturn is about twenty degrees higher than Jupiter and shines at magnitude 0.6, making it the brightest object in that part of the sky. On November 30, Saturn will be setting almost three hours after the Sun, but by late December will be in twilight at sunset and be in conjunction with the Sun on January 13. It's not an accident that the planets are in conjunction with the Sun only 16 days apart, because they are approach a Great Conjunction on December 27, 2020.

If you're feeling ambitious, **Uranus** is just past opposition and is magnitude 5.7. It's in the southern part of the constellation Aries, which is not a particularly conspicuous constellation, so it may be hard to find.

Neptune was at opposition on September 10, and is still high in the south after sunset, but at magnitude 7.8, requires strong binoculars or a telescope. It's located near the fourth magnitude star phi Aquarii, in the northeastern part of that constellation not far from the border with Pisces.

Sky & Telescope has finder charts online for Uranus and Neptune through the rest of 2019 and early 2020. The URL is <https://s22380.pcdn.co/wp-content/uploads/UrNep-2019-2020.pdf>

Information from the November and December issues of *Sky & Telescope* and *Astronomy*, their websites, and Wikipedia.

Viewing Opportunities for Satellites (November 8 – December 14)

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 NASA site that I was using for 20 second observation times doesn't appear to be working anymore, so all data is from Heavens Above. 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, although, since it is lower in the sky, it is more difficult to see.

Missions to and from the International Space can change its orbit. A Cygnus cargo ship was launched to the ISS on the morning of November 2. A Progress cargo craft will be launched to the ISS on the morning of December 1. A SpaceX cargo mission will be launched on December 4. Boeing will launch an Orbital Flight Test of Starliner to the ISS on December 17. The next possible manned mission to the ISS would be the manned test flight of SpaceX's Dragon 2 Test Capsule which is certain to be pushed to early 2020 since SpaceX is doing an abort test in December (and I believe they're also working on their parachutes.)

ISS, 11 November 2019			ISS, 12 November 2019		
Time	Position	Elevation	Time	Position	Elevation
6:32 a.m.	303°	10°	Appears from Earth's Shadow		
6:35	226	54*	5:45:46 a.m.	321°	31°
6:38	148	10	5:46:14	41	75
*Passes very close to Procyon			5:50	128	10

ISS, 21 November 2019		
Time	Position	Elevation
6:17 p.m.	214°	10°
6:21	135	58
6:22:38	62	22
Vanishes into Earth's Shadow		

ISS, 23 November 2019		
Time	Position	Elevation
6:17 p.m.	249°	10°
6:20	322	41
6:22:17	30	15
Vanishes into Earth's Shadow		

HST, 22 November 2019		
Time	Position	Elevation
5:52 p.m.	229°	10°
5:56	171	27
5:59	112	10

ISS, 10 December 2019		
Time	Position	Elevation
6:59 p.m.	298°	10°
7:02	227	41
7:03:55	173	25
Vanishes into Earth's Shadow		

HST, 23 November 2019		
Time	Position	Elevation
5:41 p.m.	234°	10°*
5:45	173	29
5:49	113	10
*Rises close to Jupiter and Venus		

ISS, 11 December 2019		
Time	Position	Elevation
7:10 p.m.	311°	10°
7:13:30	226	85*
7:17	135	10
*Passes very close to Deneb		

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 5:52 p.m. November 22, measure a little less than four fist-widths south of due west, then one fist-width above the horizon.

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: All times are CST.

December 1, 5:00 a.m. Launch coverage of Progress 74 cargo craft to the ISS. Actual launch is 5:30 a.m.

December 3, 7:00 a.m. Rendezvous and docking of Progress 74 with the USS. Actual docking is scheduled for 7:40 a.m.

December 4: NASA TV will certainly show the launch and docking of the SpaceX CRS-19 cargo mission if that goes as scheduled. Launch would be at 11:48 a.m., so coverage would probably begin at 11:00 a.m.

Calendar of Events

November: Maiden orbital flight of LauncherOne by Virgin orbit.

November 8: Oklahoma City Astronomy Club meets at Science Museum Oklahoma (formerly the Omniplex). 7:00 p.m., followed by a talk at about 7:45 p.m. See <http://www.okcastroclub.com/> for details.

November 9: Oklahoma Space Alliance meeting, 2:00 p.m., McMurray Residence.

November 11: Mercury transits the Sun. The transit pretty much lasts all morning.

November 11, 9:00 a.m.: SpaceX launches the second 60-satellite cluster of Starlink communications satellites. The third cluster will be launched later in November.

November 14 – 24, 1969: 50th anniversary of *Apollo 12* lunar mission. The moon landing was 12:54 a.m. on November 19, with return launch at 8:25 p.m. on November 20.

November 28: Mercury is at greatest western elongation, 20 degrees from the Sun (hence is visible before sunrise.)

December: Atmospheric test flight of the Crew Dragon 2 abort system and parachutes.

December 13: Oklahoma City Astronomy Club meets at Science Museum Oklahoma (formerly the Omniplex). 7:00 p.m., followed by a talk at about 7:45 p.m. See <http://www.okcastroclub.com/> for details.

December 14: [Tentative] Oklahoma Space Alliance Christmas Party and elections, time TBA, McMurray residence.

December 14: Peak of the Geminid meteor shower.

December 17, 2:54 a.m.: Launch of the CHEOPS exoplanet telescope satellite from Kourou, French Guiana. See <https://en.wikipedia.org/wiki/CHEOPS> for details.

December 17, 6:45 a.m. Orbital test flight of Boeing's CST-100 to the ISS. This is a robotic mission. See https://en.wikipedia.org/wiki/CST-100_Starliner for details.

December 26: Annular solar eclipse visible in Saudi Arabia, Qatar, India, Sri Lanka, Indonesia, the Philippines and Guam.

December 27: Jupiter is in conjunction with the Sun.

Late 2019: Launch of the Lunar Scout mission to the South Pole of the Moon. This includes a lunar lander, an optical telescope, and a laser reflector.

2020: India begins unmanned tests flights for its *Gaganyaan* manned spacecraft.

First quarter of 2020: SpaceX's Dragon 2 space capsule will take a two-man crew to the ISS.

First quarter of 2020: Boeing's first crewed flight of Starliner to the ISS.

Early 2020: ALINA, the *Autonomous Landing and Navigation Module* will be launched aboard a Falcon Block 5, 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://ptsScientists.com/products/alina>.

Sometime in 2020: India launches *Aditya-L1* to the Earth-Sun L1 point, on a mission to study the Sun's corona.

January 13, 2020: Saturn is in conjunction with the Sun.

February 6, 2020: Launch from Cape Canaveral of the European Space Agency/NASA Solar Orbiter (SolO), which will orbit the Sun at a distance closer than Mercury. Not to be confused with NASA's *Parker Solar Probe*. Web site is sci.esa.int/solarorbiter.

March 8, 2020: Neptune is in conjunction with the Sun.

March 24, 2020: Venus is in greatest eastern elongation, 46 degrees from the Sun (hence is visible after sunset.)

March 20, 2020; Launch of Expedition 62/63 from Baikonur Cosmodrome in Kazakhstan to the ISS.

April 11 – 17, 2020: 50th anniversary of *Apollo 11* lunar flight.

April 26, 2020: Uranus is in conjunction with the Sun.

May 2020: SpaceX will launch its first crew rotation to the Space Station.

June 2020: [Moved from 2019] Maiden flight of the Space Launch System. On this launch NASA launches the Lunar IceCube, Lunar Polar Hydrogen Mapper, and Lunar Flashlight lunar orbiters. 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

June 2020: Launch of Japan's OMOTENASHI cubesat lunar lander.

June 2020: Launch of the earth observation satellite Amazônia-1 by an Indian rocket. Amazônia-1 is the first satellite built entirely within Brazil See <https://en.wikipedia.org/wiki/Amaz%C3%B4nia-1> for details.

July 2020: United Arab Emirates launch the Mars Hope, aka as *Al-Amal* or the *Emirates Mars Mission*, from the Mohammed bin Rashid Space Center in Dubai. For more information, visit https://en.wikipedia.org/wiki/Hope_Mars_Mission.

July 14, 2020: Jupiter is at opposition

July 16, 2020: Maiden flight of Ariane 6 from Kourou, French Guiana.

July 17, 2020, 8:00 a.m.: Launch of the *Mars 2020* space rover, which will arrive on Mars at the beginning of 2021. For more information, see https://en.wikipedia.org/wiki/Mars_2020 or <https://mars.jpl.nasa.gov/mars2020/>.

July 20, 2020: Saturn is at opposition.

July 23, 2020: Launch of *Huoxing-1*, the Mars Global Remote Sensing Orbiter, Lander and Small Rover by China. For more information, see https://en.wikipedia.org/wiki/Mars_Global_Remote_Sensing_Orbiter_and_Small_Rover. (China really needs to work out an acronym for this.)

July 25, 2020: ESA launches the *ExoMars Mars Rover*, which has been christened *Rosalind Franklin*, and the *Exomars 2020 surface platform*. For more information, visit en.wikipedia.org/wiki/Exomars.

August 13, 2020: Venus is in greatest western elongation 45 degrees from the Sun (hence is visible before sunrise.)

September 11, 2020: Neptune is at opposition.

October 13, 2020: Mars is at opposition, 39 million miles from Earth.

October 31, 2020: Uranus is at opposition.

December 2020 Test flights begin for India's *Gaganyaan* program, which will eventually launch people into orbit.

December 2020 (Postponed from December 2019): Launch of China's *Chang'e 5* lunar sample return mission. This will be the first such mission since 1976.

December 21, 2020: Great conjunction between Jupiter and Saturn. The two planets will be separated by six minutes of arc.

Sometime in 2021: *Hope*, aka *Emirates Mars Mission*, arrives at Mars (see July 2010).

Sometime in 2021: The *ExoMars* Mars landers land on Mars. These in the Russian Kazachok surface platform and the ESA's *Rosalind Franklin* Mars rover.

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

January 31 – February 9, 2021: 50th anniversary of *Apollo 14*.

February 2021: Maiden flight of KSLV-II (aka *Nuri*), the first South Korean indigenous orbital launch vehicle.

February 18, 2021: The *Mars 2020* rover lands at Jezero Crater on Mars. It will be carrying the Mars Helicopter Scout, which will deploy in two or three months.

March 30, 2021: Launch of the James Webb Space Telescope.

April 2021: Launch of the IXPE X-Ray Telescope by Falcon 9.

July 2021: 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.

July 2021: 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.

July 26 – August 7, 2021: 50th Anniversary of *Apollo 15*.

August 2, 2021: Saturn is at opposition.

August 19, 2021: Jupiter is at opposition.

September 2021: First Dream Chaser cargo mission to the ISS.

October 2021: 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 2021: Launch of *Hakuto -R*, Japan's lunar lander. (Hakuto is Japan's Moon rabbit, so is equivalent to China's Jade Rabbit.)

October 29, 2021: Venus is in greatest eastern elongation 47 degrees from the Sun (hence is visible after sunset.)

December 2021 [VERY 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.]

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

June 2022: Proposed launch date of JUICE, the Jupiter Icy Moons Explorer, by the European Space Agency. The JUICE web site is <http://sci.esa.int/juice>.

June 2022: First crewed launch of an *Orion* space capsule.

June 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 <http://sci.esa.int/euclid>.

July 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.

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)).

September 26, 2022: Jupiter is at opposition.

December 2022 (Tentative): Launch of the first module of the Gateway Lunar Orbiter Platform.

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

Last quarter of 2022: Launch of NASA's VIPER lunar rover, which will hunt for ice near the Moon's South Pole.

Last quarter of 2022: Launch of the Einstein X-Ray Probe from China's Xichang Space Center.

Last quarter of 2022: Launch of RSGS (Robotic Servicing of Geosynchronous Spacecraft).

March 2023: Launch of *Hakuto – R Mission 2*, Japan's lunar lander and rover.

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]: India and Japan launch *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.

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

Sometime in 2024: First crewed flight of Russia's *Federatsiya*.

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>.

December 2025: *BepiColombo* arrives at Mercury orbit.

Sometime in 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))

Sometime in 2030: JUICE achieves Jupiter orbit. [See 2022.]

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

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.

Oklahoma Space Alliance Officers, 2019 (Area Code 405)

Clifford McMurray, President & <i>Update</i> Editor	329-4326 (H) 863-6173 (C)
Dave Sheely, Vice-President	821-9077 (C)
Syd Henderson, Secretary & <i>Outreach</i> Editor	321-4027 (H) 365-8983 (C)
Tim Scott, Treasurer	740-7549 (H)
Claire McMurray, Communications	329-4326 (H) 863-6173 (C)

OSA E-mail Addresses and Web Site:

sheely at sbcglobal.net or david.sheely.1 at us.af.mil (David Sheely)
 cliffmcmurray at hotmail.com (Claire & Clifford McMurray)
 sydh at ou.edu (Syd Henderson)
 sswift42 at aol.com (Steve Swift)
 ctscott at mac.com (Tim Scott)
 t_koszoru01 at cox.net (Heidi and Tom Koszoru, new address)
 john.d.northcutt1 at tds.net (John Northcutt)
 lensman13 at aol.com (Steve Galpin)

E-mail for OSA should be sent to sydh@ou.edu. Members who wish their e-mail addresses printed in *Outreach*, and people wishing space-related materials e-mailed to them should contact Syd. Oklahoma Space Alliance website is osa.nss.org. Webmaster is Syd Henderson.

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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A Chapter of the National Space Society
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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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