

# OKLAHOMA SPACE ALLIANCE

## OUTREACH –March 2020

**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 March 14, 2020 Directions  
are inside.



**Apollo 13 Patch (NASA image)**

### **OKLAHOMA SPACE ALLIANCE OUTREACH March 2020 March**

#### **Meeting:**

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, March 14. at Claire and Clifford McMurray's house. Prospective members are also 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. 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.

**Saturday March 14, 2020 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. Minutes of February Meeting
  - c. Yuri's Night
  - d. Apollo 13 anniversary
3. Video (to be announced)
4. Chat

**Minutes of February 2020 Meeting**

Oklahoma Space Alliance met at the McMurrays' house in Norman, Oklahoma on February 8, 2020. In attendance were Clifford and Claire McMurray, Adam Hemphill, Tim Scott, Dave Sheely, Rosemary Swift, Steve Swift, Joe (didn't get last name) and Syd Henderson. OSA President Clifford McMurray presided over the meeting. He also did an Update with links to the online videos he presented. This can be found online at <http://osa.nss.org/Update2002.pdf> so I'll just cover the highlights.

We watched a video of the sections of the State of the Union address on the new Space Force and the Artemis project.

The House of Representatives authorization bill would extend ISS to 2028 rather than 2024.

Companies involved in commercial space don't like NASA keeping control of the Moon Landing.

We watched the SpaceX abort test and the landing of the capsule. Since the abort test was successful, SpaceX is on track to start sending astronauts to the International Space Station.

We watched a video on Space Debris.

We watched several episodes of This Week at NASA.

The first class of Artemis astronauts has graduated.

The Hubble Space Telescope has confirmed that IC 1101 is the largest known galaxy. It is a billion light years away and has a radius of two million light-years and a mass of 100 trillion suns. [In comparison, the Milky Way has a radius not more than a hundred thousand lightyears and a mass no more than 1.5 trillion times that of the Sun.] The giant galaxy has been nicknamed the Godzilla Galaxy. I was going to say that Hubble discovered it, but IC 1101 was discovered in 1790 by William Herschel, although it wasn't revealed to be a galaxy until sometime around 1932. We watched a video on the history of Chinese launch vehicles.

We currently have \$936.93 between the cash box and the bank account.

--Minutes by OSA Secretary Syd Henderson

**Minutes of January 2020 meeting.**

Oklahoma Space Alliance met at the McMurrays' house in Norman, Oklahoma on January 11, 2020. In attendance were Clifford and Claire McMurray, Adam Hemphill, John Northcutt, Tim Scott, Dave Sheely, and Syd Henderson. OSA President Clifford McMurray presided over the meeting. He also did an Update with links to the online videos he presented. Since we did not do videos at the Christmas Party, he had two months of space events to present, and did not do another video at the end of the meeting. Kip presented These can be found at <http://osa.nss.org/Update2001.pdf> so I'll cover the highlights.

Dave visited the OSIDA meeting. Boeing will be testing at Space Port Oklahoma.

We watched a video of the Starliner launch and the landing. It was the first time a human-rated space capable American space capsule has landed on land.

Employees of the Air Force Space Command, some 2000 people, will be transferred to the US Space Force. John “Jay” Raymond, the head of Space Command will be the head of the Space Force. A number of Air Force bases will be transferred to Space Force.

We watched a video of New Shepherd capsule landing, then Blue Origin itself taking off and landing.

We watched a video of Long March 5’s return to flight. There will be a test flight of Long March 8 around the middle of 2020.

We watched a video of *Hayabusa 2* picking up samples from asteroid Ryuku.

We watched a video of Gordon Cooper on UFOs.

We have \$659.96 in our checking account and \$267 in our cashbox, for \$926.96 total.

The ISDC is in Dallas from May 28 – 31.

Clifford asked a bunch of questions of what will happen in space this year.

Space X will go to the station this year. (Yes from all)

Boeing's Starliner will go to the station this year. (Yes from all)

Virgin Galactic launches commercial flight. 5 no 2 yes.

Blue Origin flying (something, can't read own handwriting) all yes.

SLS launches test launch (4 no, 3 yes. Adam, John and Dave are the yesses)

We watched a video on commercial space habitats. We watched a SpaceX video on companies pursuing space habitats.

The “Down to Earth” video celebrates 20 years of continuous human presence in Space.

We watched a video of astronauts on the Space Station celebrating the holidays. Mostly Christmas and New Year’s but also Hanukkah.

April is the 50th anniversary of *Apollo 13*, which was launched on April 11, 1970 and had its famous accident on April 13, returning on April 17, Note that April 12 is the 59th anniversary of Yuri Gagarin’s space flight., so we’ll be commemorating both.

--Minutes by OSA Secretary Syd Henderson

## **Apollo 13**

I am doing a series of articles on the Apollo missions, and have now reached what is now the second most famous of them and the one that came closest to tragedy since *Apollo 1*, whose astronauts died in a fire in their capsule before it got a chance to take off. That it didn’t tested the ingenuity of the ground crew and the perseverance and intelligence of the astronauts. It also made for high drama and a film that was nominated for nine Oscars, winning two.

*Apollo 13* was our fifth mission to the Moon and was supposed to be the third to land astronauts on the Moon. *Apollo 8* and *Apollo 11* had received the most attention but all the manned missions starting with *Apollo 7* had been highly successful, and some had had their own kind of drama. In a way, they may have been too successful, and the public was getting complacent.

Commander of *Apollo 13* was Jim Lovell, who had earlier orbited the moon in *Apollo 8*. Fred Haise was lunar module pilot, and Jack Swigert was command module pilot. Swigert replaces Ken Mattingly who was grounded after he was exposed to German measles and NASA didn’t want to take a chance that he might get sick

There were a couple of oddities about how this crew came to be on *Apollo 13*. Lovell, Haise and Mattingly were the backup crew for *Apollo 11*, and under normal procedures would have been the crew for *Apollo 14*. However, Alan Shepherd hadn’t flown since 1961 and had recently had surgery, so the crews were exchanged. Also, the crew would have been exchanged with the backup crew since Mattingly was grounded, except the person who exposed Mattingly was Charles Duke, who was one of the backup crew. Thus, Swigert was promoted from backup crew. (The third member of the backup crew was John Young, who got the usual rotation and commanded *Apollo 16*.)

*Apollo 13* was Lovell’s fourth and final trip into space. He had earlier been pilot on *Gemini 7*, with Frank Borman as Command Pilot, On *Gemini 12*, he was the commander and Buzz Aldrin his pilot. And on *Apollo 8*, he was Command Module Pilot, with Frank Borman the commander and William Anders the Lunar Module Pilot. Lovell was 42 years old at

the time of *Apollo 13*. He was a naval aviator from 1954 and test pilot from 1958. He was one of the test pilots who became candidates for Project Mercury along with his classmates Pete Conrad and Wally Schirra, but only Schirra was chosen. Lovell and Conrad were both chosen as part of the second group of astronauts and became part of the Gemini and Apollo programs. On the *Apollo 8* mission, he named a mountain between Mare Fecunditatis and Mare Tranquillitatis for his wife Marilyn, and Mount Marilyn became official in 2017.

Fred Haise was 38 years old at the time of *Apollo 13*, and had been a fighter pilot for the Marines. He was a civilian research pilot for NASA when he was selected as part of the fifth group of astronauts in 1966. *Apollo 13* was his first mission into space. He and Lovell would have been the fifth and sixth men to walk on the Moon if not for the accident which aborted the Moon landing. If the later Apollo missions hadn't been cancelled in 1970, he would have been the commander of *Apollo 19* and had another chance to walk on the Moon. He also was part of the Space Shuttle program, piloting the Space Shuttle *Enterprise* to three test landings, but never flew in space after *Apollo 13*. He and Lovell are still alive, being 86 and 91 years old, respectively.

Jack Swigert was 38 years and a former test pilot before joining Haise in the fifth group of astronauts. *Apollo 13* was also his first flight. He was supposed to fly on an Apollo-Soyuz mission but was removed as part of the postal covers scandal of the 1970s and never flew again. In 1982 he ran for Congress and won the election but died of cancer before he could serve.

*Apollo 11* was mostly intended to prove we could land on the Moon, and *Apollo 12* was to retrieve part of *Surveyor 3*, and both retrieved Moon rocks, but *Apollo 13* was the first mission on which the Moon walkers were trained in geology. The intention was to land near the crater Fra Mauro, which has material from the impact that formed Mare Imbrium. This crater is actually farther south between two small maria, Mare Insularum and Mare Cognitum not far from the *Apollo 12* landing site, and became, in fact, the *Apollo 14* landing site.

For this mission, the Command Module was named *Odyssey* after the Greek epic and *2001: A Space Odyssey*. The LEM was *Aquarius* after the constellation but was not named after the song. The mission patch shows the three golden horses that draw the chariot of Helios (Lovell thought Apollo) and show the Sun, Moon and Earth. It was the only patch from Lovell's missions that he didn't draw and the only Apollo badge that doesn't show the astronaut's names, which was fortunate due to the late crew replacement. The motto, *Ex Luna, Scientia* ("From the Moon, Knowledge) was derived by Lovell from the motto of the Naval Academy, *Ex trident, scientia*, "From the sea, knowledge." The patch was designed by Lumen Winter.

*Apollo 13* was launched at 1:13 p.m. CST on April 11, 1970.<sup>1</sup> The second stage engine shut down two minutes early, but the other engines had enough fuel to reach the planned orbit. Two hours later the spacecraft left Earth orbit on the way to the Moon. At this point, it was in a free return trajectory, which meant that if the mission had to be aborted, it would simply fly around the Moon and return safely to Earth. This was changed mid-flight to a trajectory that would allow them to reach Fra Mauro at a time when the landing site had better contrast. This change almost proved fatal, because on the third day of the mission, a short circuit in one of the oxygen tanks set fire to the insulation, exploding that tank and fatally damaged the second. As Lovell later learned, this also blew out one of the panels of the Service Module. This shut down all the fuel cells on the Service Module, leaving just battery power. Since the batteries didn't have enough power to keep the Service Module running through the entire mission, the crew had to shut down the Command Module and move into the Lunar Module, which was designed to house two astronauts for two days, not three for four days. But the LEM had power and oxygen for the crew.

At this point there were several options being considered to return the crew. One was a Direct Abort, which meant using the Service Module engines to turn the craft around. This would, however mean jettison the LEM, which was the crew's lifeboat, so it was a non-starter.

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Second possibility was to jettison the Service Module and use the Lunar Module's engines to return directly to Earth. However, this would have meant re-entry without a heat shield, which is a very bad idea.

The third idea, which was adopted, was to allow the spacecraft to go around the Moon and return to Earth. At the time of the accident, *Apollo 13* was on the altered trajectory, which would put the spacecraft in a long elliptical orbit that might have returned the crew every few months after they were dead. However, it was possible, using just the LEM's engines, to return the spacecraft to the free-return trajectory and bring the crew back to earth. Since the Service Module

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<sup>1</sup> This was when Daylight Savings Time still The started on the last Sunday in April.

had lost mass, the center of gravity of the combined spacecraft had shifted and Lovell had to learn to fly the new configuration. Fortunately, there were three test pilots on board.

The main problem was time, which required shutting down inessential systems, and finding a way to scrub carbon dioxide from the atmosphere to keep the crew from suffocating. Both the Command Module and Lunar modules had canisters to do this, but the Lunar Module just had one that was designed for a crew of two using it for two days, and it was round while the ones in the Command Module were square. So, Ground Control had to figure out how to fit a square peg into a round hole. If you've seen *Apollo 13* or were around at the time, the answer to this engineering problem was, of course, duct tape.

The rest of the trip was mostly a matter of surviving, though there was also drama when Fred Haise developed a urinary infection, and when the crew started running short of water. (Normally water would have been supplied by the fuel cells, which, of course, were dead.) Finally, they had to power the Command Module back up after it had been dead for several days. They also had to figure out a way to separate the LEM from the Command Module. Finally, they just pressurized the tunnel connecting the LEM to the Command Module and let the air pressure push them apart. The Command Module separated from the Lunar Module at 10:43 a.m. on April 17 and returned to earth 80 minutes later. During the re-entry, there was a six-minute blackout just to provide a final moment of drama.

By the time of *Apollo 13*, the freshness of lunar voyaging was fading, and a broadcast by Lovell on the way to the Moon wasn't covered by any network. The explosion six minutes later got the networks' attention and much of the world was riveted for the next four days. However, interest in the Apollo program by the Nixon Administration had disappeared and he was interested in finding a way to put his stamp on the space program than promoting a project initiated by his rival. Originally there were supposed to be Apollo missions up to #20, but that had already been cancelled and 18 and 19 would be cancelled later in 1970, with Skylab and the Apollo-Soyuz missions taking the place of the later missions. Thus, we haven't sent men to the Moon in more than 47 years.

## Space News

With coronavirus outbreaks starting to occur in the United States, various events are being cancelled and some businesses are converting to telecommunicating. This includes NASA's [Ames Research Center](#), whose employees will be working from home after one worker tested positive for the [coronavirus](#) responsible for COVID-19. NASA Administrator Jim Bridenstine issued a statement: "Limiting personnel at the center will allow Ames medical personnel and public health officials to determine potential contacts and assess areas that may require additional cleaning and mitigate potential exposure to center personnel. Working with county officials, Ames leadership and medical personnel are working to trace the contacts of the employee and notifying individuals who may have had significant contact with that person."

In the addition, the American Physical Society's March Conference in Denver was cancelled. This is one of the largest physics conferences of the year. Many of the presentations will be done online.

**Betelgeuse** looks like its dimming has finally bottomed out and it is slowly getting brighter. At its low point it was actually a bit dimmer than Bellatrix, which is a bright second magnitude star. Betelgeuse has several periodic variations in its brightness, and two of them coincided. It appears that this time it emitted a large cloud of dust containing titanium dioxide which was blocking a lot of light. Interferometric images showed a bright spot which I suspect was one of the places with less dust between Betelgeuse and us.

NASA has selected a name for their next Mars Rover: **Perseverance**. They'd received 28,000 essays supporting various names, the other eight finalists being Endurance, Tenacity, Promise, Vision, Clarity, Ingenuity, Fortitude, and Courage. Four of the names, including the winner, will be appropriate if the mission lasts a long time. One of the judges was Clara Ma, who named *Curiosity*. The winning essay was submitted by Alexander Mather at Lake Braddock Secondary School in Burke, Virginia. Presumably he'll be on the panel for the next Mars rover contest.

*Perseverance* (the *Mars 2020* rover) will launch on July 17 and arrive at Jezero Crater on February 18, 2021. Jezero Crater once contained a deep lake and there was a river delta opening into it, making it a prime spot for *Perseverance*'s main mission, which is to search for signs of past life on Mars.

The *Mars 2020* mission also includes a drone to scout the vicinity of the landing spot. The drone is called the Mars Helicopter Scout. Apparently, there is no contest to rename it. I think the current name is good enough.

Earth has a newly discovered, if temporary, mini-moon orbiting about 180,000 miles from the Earth. 2020 CD<sub>3</sub> is between six and twelve feet across, and apparently has only been orbiting the Earth since 2016 or 2017 and may be leaving Earth orbit within the next couple of months, though it will return in the future.

Could it collide with the Earth when it returns? JPL estimates a 3% probability in the next century. However, 2020 CD<sub>3</sub> is so tiny it likely would either burn up in the atmosphere or become a small meteorite.

These temporary space visitors are probably common. Another one orbited the Earth in 2006 and 2007. Since 2020 CD<sub>3</sub> never got brighter than 20<sup>th</sup> magnitude, we were lucky to detect it.

A couple of notable passings: Katherine Johnson died February 24 at the age of 101. She's most famous for her calculation of orbital mechanics during early space missions, as portrayed in the movie *Hidden Figures*. She worked for the Guidance and Navigation Department at the NACA starting in 1953, and thus became part of NASA when NACA was dissolved and its personnel transferred in 1958. [The movie fudges this point, giving the impression that the three "hidden figures" all started with NACA/NASA at the same time, but Dorothy Vaughan started working for NACA in the 1940s and Mary Jackson in the early fifties.] In one famous episode, John Glenn refused to fly on his mission until Katherine Johnson verified the computer's calculations.

Johnson received many honors, especially in her later years when the role of African American women in the early space program became known. She received the Presidential Medal of Freedom in 2015, and the Katherine G. Johnson Computational Research Facility at the Langley Research Center in Hampton, Virginia was dedicated in 2017. In 2019, she was awarded the Congressional Gold Medal, thus she received the two highest civilian awards issued by the United States. [Mary Jackson and Dorothy Vaughan were posthumously awarded the Congressional Gold Medal at the same ceremony, and another "hidden figure," Christine Darden received one as well. She wasn't portrayed in the movie probably because she didn't join NASA until 1967 but is still alive at the age of 77.]

Freeman Dyson died February 28 at the age of 96. He made contributions to many areas of mathematics, physics and astronomy, including his and Hugh Montgomery's discovery that there is connection between quantum mechanics and the zeroes of Riemann's Zeta function. The distribution of the zeroes of said function is the subject of the Riemann Hypothesis, the most celebrated unsolved problem of mathematics. He was also the first person outside of Richard Feynman to use Feynman diagrams in quantum electrodynamics and systemized the renormalization procedure that eliminates the infinities in calculations in QED.

Dyson was also one of the people who worked on Project Orion, the proposal to build a spacecraft propelled by nuclear bombs. This project was terminated by another proposal Dyson supported, the first nuclear test ban treaty. Dyson is probably best known outside of hard science for his speculations, the most well-known of which is the Dyson Sphere, which a space civilization would build around its star to completely harness its energy. This is well-known in science fiction, including Montgomery Scott's return in *Star-Trek the Next Generation*, and one of the hypotheses about the possible artifact surrounding Tabby's Star.

Dyson was personally shy and modest, but not being afraid to speculate. He is survived by the Dyson series, Dyson operator, Dyson tree (another speculation), Dyson's theorem, several generations of Dysons, and tons of books and articles, including *Disturbing the Universe* and *Infinite in All Directions*. He was a recipient of the NSS's Heinlein Award and the Gerard K. O'Neill Memorial Award. He was also a member of the NSS Board of Governors and attended ISDCs, though I never got to meet him.

## Sky Viewing

The **Lyrid meteor shower** peaks on the night of April 21 and 22 and this time viewing conditions should be about perfect, weather permitting, with no moon in the sky. This shower typically produces about twenty meteors an hour and will do this for several days around the peak.

Oddly the radiant of the Lyrids (that is, the point they appear to come from) is in the constellation Hercules. The reason the meteor shower is called the Lyrids is that before the current constellation borders were defined, the radiant was in Lyra and still is barely outside it. In any case the radiant is eight degrees from Vega, which is the fifth brightest star in the night sky, and far more conspicuous than anything in Hercules.

**Mercury** is returning to view after being in inferior conjunction with the Sun last month. By March 20 and 21 it will rise an hour before the Sun and will have a conjunction with the crescent Moon that night. Mercury will be shining at magnitude 0.2. However, Mercury will also be at low altitude because the ecliptic will be meeting the horizon at a shallow angle. It will actually get up to magnitude -0.2 on April 10 but will still be barely visible before morning twilight. **Venus** is still the only bright planet in the evening sky but makes up for it by shining at magnitude -4.4 and staying up for three hours after sunset. In late March, Venus will enter Taurus, where it will pass through the southern part of the Pleiades on April 3. Venus has recently been having a conjunction with the Pleiades every eight years on April 3, and each one has been getting closer. The one on April 3, 2028 will have Venus finally passing through the Pleiades, passing very close to Merope. The 2036 and 2044 events will see Venus passing through the bowl of the Pleiades. In late April Venus skirts the other famous star cluster in Taurus, the Hyades, passing about three degrees north of Aldebaran.

The reason that these conjunctions happen so precisely every eight years is that Venus makes thirteen orbits around the Sun in almost exactly the time Earth makes eight orbits, so it shows in the same position in the sky every eight years. **Mars, Jupiter** and **Saturn** are almost in a straight line in the morning sky, with Mars the highest, Saturn the lowest and Jupiter by far the brightest. They are respectively magnitudes 1.0, -2.0 and magnitude 0.7. Mars is getting closer to Jupiter in the sky and they will be separated by only three degrees on March 14. They are approaching a March 20 conjunction with Mars passing 0.7° south of Jupiter. Mars will continue past Saturn, passing 0.9° south of Saturn on the morning of March 31. The three planets are all rising before 6:15 a.m. CDT and are easy to spot. On April 9, Saturn will be about 5.5 degrees from both Mars and Jupiter. Jupiter will be rising about 3:20 a.m. on April 1, and 1:30 a.m. on April 30, with Saturn gradually getting closer as they approach their Great Conjunction in December.

**Uranus** just had a conjunction of its own, passing only 2.2 degrees from Venus on March 7. Since Venus shines ten magnitudes brighter than Uranus, this is a study of sorts in the extremes of nighttime visibility. Uranus (and Venus, of course) is in the constellation Aries. Unlike Venus, it will be there for quite a while. Uranus is getting lower in the sky each night and will be in conjunction with the Sun on April 26.

**Neptune** was in conjunction with the Sun on March 8 and isn't visible except through pretty strong binoculars at the best of times. If you want to try, you'll have to look for it just before morning twilight in late April.

With Uranus nearing conjunction with the Sun and Neptune already past it, the planet finder charts are down at [skyandtelescope.org](http://skyandtelescope.org). Presumably there will be a new one after Uranus passes conjunction.

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

### Viewing Opportunities for Satellites (March 14 – April 14, 2020)

You can get sighting information at [www.heavens-above.com](http://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 <https://spaceflight.nasa.gov/realdata/sightings/SSapplications/Post/JavaSSOP/JavaSSOP.html> is back up. It gives coordinates at 20second 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](http://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. Missions to and from the International Space Station can change its orbit. SpaceX launched a Dragon cargo mission on the evening of March 6 to arrive at the ISS on March 9. Expedition 63 launches from Baikonur Cosmodrome in Kazakhstan on April 9.

6:25	216	64
6:26	160	40
6:27	148	22

## ISS, 17 March 2020

Time	Position	Elevation
8:41 p.m.	189°	18°
8:42	170	28
8:43	132	34
8:44:00	105	31

Vanishes into Earth's Shadow

## ISS, 19 March 2020

Time	Position	Elevation
8:43 p.m.	243°	22°
8:44	256	39
8:45	319	62
8:46	22	39
8:47	36	22

## HST, 22 March 2020

Time	Position	Elevation
6:22 a.m.	220°	20°
6:23	201	26
6:24	174	30
6:25	165	26
6:26	129	20

## HST, 23 March 2020

Time	Position	Elevation
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## Appears from Earth's Shadow

6:12:10 a.m.	215°	24°
6:12:41	204	27
6:14	177	31
6:15	149	27
6:16	130	20

## ISS, 4 April 2020

Time	Position	Elevation
9:03 p.m.	337°	18°
9:04	357	30
9:05	37	38
9:06	78	30

Vanishes into Earth's Shadow

## ISS, 6 April 2020

Time	Position	Elevation
9:05 p.m.	200°	22°
9:06	286	39
9:07	223	61
9:08:05	183	38
9:08:30	159	30

Vanishes into Earth's Shadow

## ISS, 7 April 2020

Time	Position	Elevation
8:18 p.m.	321°	22°
8:19	331	41
8:20	44	70
8:21	112	41
8:22	122	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 Hubble Space Telescope at 6:16 a.m. on March 23, measure four fist-widths south of due east, then two fist-widths 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>

April 9: 2:00 a.m. Live coverage of the launch of Expedition 63 to the Space Station. (Actual launch is at 3:05 a.m.) 8:30 a.m.: Coverage of docking. (Actual docking is at 9:16 a.m.) Hatch opening coverage at 10:15 a.m., with actual opening around 11:00 a.m.

April 16, 8:30 p.m. Coverage of Expedition 62 undocking of their Soyuz capsule from the Space Station. Actual undocking is at 8:53 p.m. 11:00 p.m.: Coverage of de-orbit burn and landing of Expedition 62. Landing is at 12:17 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

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.

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

March 14: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., location to be announced.

March 24: Mercury is at greatest western elongation, 27.8 degrees from the Sun (hence can be seen before sunrise). March 24: Venus is in greatest eastern elongation, 46 degrees from the Sun (hence is visible after sunset.)

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

April 9, 3:04 a.m.: Launch of Chris Cassidy, Anatoly Ivanishin and Ivan Vagner to the Space Station.

April 10: Oklahoma City Astronomy Club meets at Science Museum Oklahoma. 7:00 p.m., followed by a talk at about 7:45 p.m. See <http://www.okcastroclub.com/> for details.

April 11: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., location to be announced.

April 11 – 17: 50<sup>th</sup> anniversary of *Apollo 11* lunar flight.

April 17, 1:23 a.m.: landing of Andrew Morgan, Jessica Meir and Oleg Skripochka returning from the Space Station.

April 21-22: Peak of Lyrid meteor shower.

April 26: Uranus is in conjunction with the Sun.

May: SpaceX will launch its first crew rotation to the Space Station. May 4: Mercury is in superior conjunction with the Sun

May 4: Peak of Eta Aquarid meteor shower.

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

May 9: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., location to be announced.

May 28 – 31: International Space Development Conference, Hilton-Dallas-Frisco Hotel & Convention Center. Web site is <https://isdc2020.nss.org>

June: 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.

June 3: Venus is in inferior conjunction with the Sun.

June 4: Mercury is at greatest eastern elongation, 23.6 degrees from the Sun (hence can be seen after sunset).

June 12: Oklahoma City Astronomy Club meets at Science Museum Oklahoma. 7:00 p.m., followed by a talk at about 7:45 p.m. See <http://www.okcastroclub.com/> for details.

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

June 30: Mercury is in inferior conjunction with the Sun.

July: 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](https://en.wikipedia.org/wiki/Hope_Mars_Mission).

July: Maiden flight of South Korea's *Blue Whale 1*.

July 11: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., location to be announced.

July 14: Jupiter is at opposition

July 17, 8:00 a.m.: Launch of *Perseverance* (formerly *Mars 2020*) space rover, which will arrive on Mars in February 2021. For more information, see [https://en.wikipedia.org/wiki/Mars\\_2020](https://en.wikipedia.org/wiki/Mars_2020) or <https://mars.jpl.nasa.gov/mars2020/>.

July 20: Saturn is at opposition.

June 21: Annular solar eclipse visible on a path including the Democratic Republic of the Congo, Sudan, Ethiopia, Eritrea, southern Arabia, Pakistan, India southern China and Taiwan. The biggest cities on this path are New Delhi and Chongqing.

July 22: Mercury is at greatest western elongation, 20.1 degrees from the Sun (hence can be seen before sunrise).

July 23: 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](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: 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](https://en.wikipedia.org/wiki/Exomars).

July 27: Peak of Delta Aquarid meteor shower.

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

August 12: Peak of Perseid meteor shower.

August 13: Venus is in greatest western elongation 45.8 degrees from the Sun (hence is visible before sunrise.)

August 17: Mercury is in superior conjunction with the Sun.

September 11: Neptune is at opposition.

Last quarter of 2020 (postponed from July): Maiden flight of Ariane 6 from Kourou, French Guiana.

October 1: Mercury is at greatest eastern elongation, 25.8 degrees from the Sun (hence can be seen after sunset).

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

October 20 – 21: Peak of Orionid meteor shower.

October 23: Mercury is in inferior conjunction with respect to the Sun.

October 30: Uranus is at opposition.

November: [Moved from June] Maiden flight 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](https://en.wikipedia.org/wiki/Lunar_IceCube), the Near-Earth Asteroid Scout cubesat ([https://en.wikipedia.org/wiki/Near-Earth\\_Asteroid\\_Scout](https://en.wikipedia.org/wiki/Near-Earth_Asteroid_Scout)) and a bunch of other satellites.

November 10: Mercury is at greatest western elongation, 19.1 degrees from the Sun (hence can be seen before sunrise).

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

December (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 13-14: Peak of Geminid meteor shower.

December 14: Total eclipse of the Sun visible in southern Chile and Argentina, Kiribati and a long path across the wastes of the southern Pacific and Atlantic Oceans.

December 20: Mercury is in superior conjunction with the Sun.

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

December 22: Peak of Ursid meteor shower.

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: 50<sup>th</sup> anniversary of *Apollo 14*.

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

February 18, 2021: Mars rover *Perseverance* (formerly *Mars 2020*) 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.

May 26, 2021: 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.

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](https://en.wikipedia.org/wiki/Luna_25) and [en.wikipedia.org/wiki/Luna-Glob](https://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](https://en.wikipedia.org/wiki/Astrobotic_Technology#Peregrine_lander).

July 26 – August 7, 2021: 50<sup>th</sup> 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: 50<sup>th</sup> 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](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: 50<sup>th</sup> 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 Benu.

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 Japans *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, 2020 (Area Code 405)

Clifford McMurray, President & *Update* Editor 329-4326 (H) 863-6173 (C)

Dave Sheely, Vice-President 821-9077 (C)

Syd Henderson, Secretary & *Outreach* Editor 321-4027 (H) 365-8983 (C)

Tim Scott, Treasurer 740-7549 (H)

#### 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](mailto: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](http://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](http://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](http://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](http://www.marsociety.org).

The National Space Society's Headquarters phone is 202-424-2899 (new as of May 2019). Executive Director email [nsshq@nss.org](mailto:nsshq@nss.org). The Chapters Coordinator is Bennett Rutledge 720-641-7987, [rutledges@chapters.nss.org](mailto:rutledges@chapters.nss.org). The address is: National Space Society, PO Box 98106, Washington DC 20090-1600 Web page is [space.nss.org](http://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](http://www.planetary.org). E-mail is [tps@planetary.org](mailto:tps@planetary.org).

NASA Spacelink BBS 205-895-0028. Or try [www.nasa.gov](http://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](http://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. 8<sup>th</sup> Ave, Unit A, Lakewood, CO 80215.

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OSA Memberships are for 1 year, and include a subscription to our monthly newsletters, *Outreach* and *Update*. Send check & form to **Oklahoma Space Alliance, 102 W. Linn, #1, Norman, OK 73071.**