

OKLAHOMA SPACE ALLIANCE

OUTREACH –September 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 September 14, 2019
Directions are inside.



**Figure 1 Apollo 11 Comemorative Anniversary Cakes
(from OSA July 20 Event—Syd Henderson)**

OKLAHOMA SPACE ALLIANCE

OUTREACH

September 2019

September Meeting:

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, September 14. 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.

Saturday September 14, 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. Kip visited LDRS (Large Dangerous Rocket Ships) 38 in Argonia, Kansas. This is the Tripoli Rocketry Association's annual event. For more information, visit www.ldrs38.org/Default.aspx.
 - d. Discuss proposal to sponsor an international sister chapter
3. Video: Jeffrey Manber, the CEO and co-founder of NanoRacks received the NSS Space Entrepreneur award at ISDC and we will watch his acceptance speech. He was also an official part of the Russian space corporation, RSC Energia, during their privatization period of the 1990s.
4. Chat

Minutes of July Meeting

Oklahoma Space Alliance met at the McMurrays' house in Norman, Oklahoma on July 13. In attendance were Clifford and Claire McMurray, Russ Davoren, Steve Galpin, Adam Hemphill, Mike Hopkins, 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 videos he presented. This can be found at <http://osa.nss.org/Update1907.pdf>, so I'll cover the highlights.

We watched a video of the June 25 Falcon Heavy launch by Space X, and the subsequent booster landing. They also covered half the fairing, which was the first time they had recovered any of it. SpaceX first stages have now flown twice, and some may have flown five times by the end of the year. SpaceX believes they are capable of flying ten times before retirement.

Chris Hadfield has a Masterclass that we watched an ad to.

We watched a video on Chandrayaan 2, which is scheduled to launch on July 14.

The US Government is getting concerned with lunar landing contenders which are partnering with foreign governments.

We watched a video of Hayabusa 2's second touchdown on asteroid Ryuku. Hayabusa 2 is now heading back to Earth.

We watched a video about Dragonfly, the newly approved spacecraft that will fly through Titan's atmosphere. It will weigh about 300 kg and is about the size of a sedan,

What about commercial copyright for commercial users of the Space Station? NASA won't be able to get commercial users to rent space if the users don't have rights to what they discover.

Farouk Al-Baz was an Egyptian-American space scientist who trained NASA astronauts as geologists.

Kip mentioned that in the early part of the launch of a Saturn V, the fuel was going down more rapidly than the rocket was going up.

There's a new documentary *Armstrong* coming out that has been approved by Neil Armstrong's family. We listened to a video of the theme song "Flight of Fancy."

Science has an article on Cassini's flyby of Saturn's rings.

We watched a video about the ULA (United Launch Alliance). The ULA got a Von Braun Award.

Business: We now have 809.23 in checking and 267 in cash.

Apollo 11 event preparations: we can serve beverages, as long as they're not red (and are non-alcoholic).

Claire reserved a TV. Does it have an internet connection?

We will have an easel on which to put up a poster. We need to bring a clipboard or two. Syd has several.

Mike has been putting together a bunch of posters commemorating the Apollo missions and earlier related flights.

We also have a large poster showing Moon landing sites.

We have models of a Saturn V, including a large one to put in a display case, and one of the command module attached to the LEM.

We will bring the Moon globe.

Mike, John and Syd will be there at 10:00 a.m.

--Minutes by OSA Secretary Syd Henderson

Apollo 11 Commemoration

Oklahoma Space Alliance hosted a 50th Anniversary commemoration of the *Apollo 11* moon landing on July 20 at the Norman Pioneer Library. Ten people attended from Oklahoma Space Alliance and at least 40 non-members visited, although we never had more than 16 at one time, which was enough for a lively discussion. We had refreshments, and two sheet cakes, each of which had two pictures from *Apollo 11*. We refrained from decapitating the astronauts.

Mike Hopkins had made up a bunch of 8 by 11 posted detailing the history of missions to the Moon, including the main Apollo missions. We also had posters of lunar landing sites, and one of the famous photographs of Earth in the lunar sky. Adam brought a disk of the documentary *Apollo 11*, as did Syd, but neither worked with the keyboard he was using, so he downloaded it off the Web and we watched it that way.

Syd took photographs which he will put on the web site, and in the September *Outreach*.

We had a clipboard for people to sign up and thirteen did, about half of whom left contact information.

--Notes by OSA Secretary Syd Henderson



Figure 2 Apollo 11 Celebration: History of Apollo Missions (Photo: Syd)



Figure 3 Apollo 11 Cabinet Display with Saturn V Model (Photo: Syd)

Minutes of August Meeting

Oklahoma Space Alliance met at the McMurrays' house in Norman, Oklahoma on August 10. In attendance were Clifford and Claire McMurray, Dave Sheely, Mike Hopkins and Syd Henderson. OSA President Clifford McMurray presided over the meeting. This meeting was abbreviated because of a power failure, though Clifford did go over the stories in *Update*. The stories we covered are online at <http://osa.nss.org/Update1908.pdf>, together with attached videos we were unable to play.

One of the stories dealt with protection of space satellites, and Kip observed that the Russians tested a cannon on one of their satellites, and the vibrations produced were dangerous to the satellite itself.

There is a big rocketry convention in southern Kansas on Labor Day weekend. Claire and Clifford are planning to go. [Claire didn't make it, but Cliff will be reporting on it at the September meeting.]

--Minutes by OSA Secretary Syd Henderson

Space News

India's *Chandrayaan-2* orbiter entered orbit around the Moon on August 20, with the Vikram lander and Pragyan Rover to land on September 6. Release of the lander was successful, but the Indian Space Research Organization (ISRO) lost contact with Vikram 1.2 miles above the lunar surface. *Chandrayaan-2* spotted the lander on the lunar surface, and ISRO are attempting to contact it, which makes me think it may have been able to make an automated soft landing. If so, India would be the fourth nation to achieve a soft landing on the Moon, but without communications, it will be hard to be sure. They have two weeks to get in contact before lunar night arrives.

India has big plans for space exploration, including a *Chandrayaan-3* mission to the Moon around the year 2023. That would be a collaboration with Japan and feature a rover that would explore the Lunar south pole. India is also planning a second Mars mission, *Mangalyaan 2*, tentatively scheduled for 2022, and that would include a lander and rover. India's Aditya-L1 mission, scheduled to launch in 2020, will study the Sun's corona from a halo orbit around the Earth-Sun L1 point, hence the name—Aditya is Sanskrit for the Sun. *Shukrayaan-1*, which may be launched in 2023, would orbit Venus.

Gaganyaan is India's manned space program, with first flights optimistically scheduled for December 2021, in time for the 75th anniversary of modern India's independence. Astronaut selection has already begun. Unmanned tests of the capsule begin next year.

China's *Yutu-2* lunar rover has discovered an unusual “gel-like” substance in a lunar crater, of a color that differs from the rest of the lunar surface. It's been suggested that it might be glass formed from the heat of meteor impacts. Of course, science-fiction scenarios have also been suggested.

Last May, *Yutu-2* discovered evidence of what appears to be lunar mantle material on the lunar surface, possibly from the huge impact that formed the South Pole-Aitken Basin.

The Mars Helicopter Scout has been under development since 2014 and has now been approved for launch with the Mars 2020's Rover. The helicopter has counterrotating rotors each around 44 inches in diameter and will carry a high-resolution camera which will point down at the Martian surface. It will be attached to the underside rover for the first two or three months on Mars until it is ready for test flights.

WASP-12 is a type G0 (i.e. Sun-like star) 1300 lightyears away with a planet, WASP12b, with a mass 1.4 times that of Jupiter and an orbital period of 1.1 days. Since the companion orbits its star at a distance of two million miles, it is a “Hot Jupiter” indeed. It's been observed since 2008, and its orbital period is known with great precision, and recently it has been discovered by a team led by Kishore Patre (UC Berkeley) that the orbital period is decreasing at a rate of 29 milliseconds per year. This translates to WASP 12b falling into its sun in 3 million years, which is a remarkably short time in cosmic terms. I suspect the planet will be disintegrating well before the crash and get eaten quicker than that.

It's long been predicted that stars with very close planets eat their young, but this looks like the first time we've observed the process.

If 1.1 days sounds like a fast orbital period, consider the double star in “General Relativistic Orbital Decay in a Seven-Minute-Orbital-Period Eclipsing Binary System” (Burdge *et al.*, *Nature*, 25 July 2019, pp. 528 – 531). The two stars here orbit closer than the diameter of the planet Saturn, which is only possible because they are white dwarfs, one of which has a mass of 60% percent of the Sun, and the other 20%. The heavier one has a temperature of 49,000 ° C, and the lighter less than 10,000° C. Because of white dwarf physics, this means the cooler star has a larger diameter and is darker, which makes the eclipse particularly dramatic. It also makes the cool, light star apparently a few hundred million years older than its companion. Given how close the two stars are, they are severely distorted by tidal forces, and I suspect a lot of material has gone from the lighter to heavier star in the astronomically recent past. In addition, tidal forces would synchronize the stars' rotation with their orbits so they spin once every seven minutes.

The pair are expecting to collide into each other in about 210,000 years since they are losing orbital energy due to the emission of gravitational waves through Einstein's General Theory of Relativity. Incidentally, a close pair of neutron stars provided the first evidence of the existence of gravitational waves back in the 1990s and won a Nobel Prize. The actual detection of such waves had to wait till a few years ago.

Sky Viewing

The **Orionid meteor shower** is always one of the more prominent of the year, and this year peaks on the night of October 21-22. There are about twenty meteors per hour in most years, with the radiant northeast of Betelgeuse in the direction of Gemini. The main problem this year is that the radiant peaks at 11:30 p.m., and the crescent Moon around 12:30 a.m. I'd still expect you'd be able to see quite a few meteors while the Moon is low in the sky. It's even better if you look in the northwestern sky, where you'll be looking well away from the Moon. The shower lasts a week centered around the October 21 peak.

The Orionids are one of the two meteor showers associated with Halley's Comet, the other being the Eta Aquariids in May.

There are also two lesser showers, the **Taurids**, which are divided into northern and southern components. The Southern Taurids peak on October 10, and, though they peak at only five meteors/hour, are also noted for producing spectacular fireballs. Unfortunately, this is close to the date of the Full Moon. The Northern Taurids peak around November 12 and are somewhat similar, including the production of fireballs. Both of these are associated with the short-period Encke's comet, which is also thought responsible a couple of daylight meteor showers earlier in the year. The Taurids are really one shower with two peaks because they encountered Jupiter.

Mercury, Venus and Mars were all recently in conjunction with the Sun, with Mercury having been in superior conjunction on September 3, Venus in superior conjunction and August 14, and Mars in conjunction on September 2, so none of them can be seen this week. However, all of them will become visible again by the end of October.

Mercury will begin to become visible after sunset around the end of September and will reach greatest elongation on October 19. This is not a particularly good elongation, and Mercury will set within an hour of the Sun. However, Mercury will still be around magnitude 0 most of October. It will disappear as it approaches inferior conjunction on November 11, but this conjunction is special, because Mercury will transit the Sun.

Venus may be visible just after sunset at the end of September, but it will be very low in the sky. Even by the end of October it will only be setting an hour after the Sun, and will be magnitude -3.9, which is almost a magnitude less bright than peak, but is still brilliant. It also helps you find Mercury, which is about two degrees below it on October 31.

Mars, like Venus appears to move slowly across the sky because their orbits are close to Earth. Thus, Mars will not be visible through September. At the end of September, it will be rising 50 minutes before the Sun, but it will also be at the far end of its orbit, and will only be magnitude 1.8, so not possible to see against twilight. (Its disk will appear to be about the same size as Uranus's.) However, it will be rising 90 minutes before the Sun by the end of October. Mars will be brightening for the next year, reaching opposition in October 2020, at which point it will also be well above the ecliptic and appear six times wider than Uranus.

Jupiter is still in the south-southwestern sky at sunset and ruling the evening but is getting slightly dimmer. Still, it is magnitude -2.2, which is brilliant. Since the Sun is now setting earlier each night, Jupiter is getting lower in the sky but still will be setting two-and-a-half hours after the Sun at the end of October. The bright star to the lower right of Jupiter is Antares in Scorpius, although Jupiter itself is in the far south of Ophiuchus.

Saturn is just about three fist-widths to the left of Jupiter and a bit higher. It is in the constellation Sagittarius above the handle of the Teapot asterism, but, at magnitude 0.4, is by far the brightest object in that part of the sky. In other words, it's more useful for finding the Teapot than vice-versa. In early October Saturn is about to halt its retrograde motion, so it will be near the Teapot for the next several weeks. It's also growing slightly dimmer, but only to magnitude 0.6 by the end of October. It's currently a bit to the east of due south at sunset but will become exclusively an evening planet in early October.

Uranus is well up in the eastern sky by mid-evening and is above the horizon most of the night. This will get better, since Uranus will be at opposition on October 27 and will be in the sky all night. It still will be only magnitude 5.7, and is in an inconspicuous part of Aries, so requires effort and probably binoculars to find.

Neptune was just at opposition on September 10, so it is above the horizon all night long, though, at magnitude 7.8 you'll need a telescope to see it. Surprisingly, it may be easier to find than Uranus because Neptune is near the 4th magnitude star Phi Aquarii. In fact, on September 9 Neptune and Phi Aquarii were only seven minutes of arc apart. (The Full Moon is about thirty arcminutes across.)

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 September and October issues of *Sky & Telescope* and *Astronomy*, their websites, and Wikipedia.

Viewing Opportunities for Satellites (September 14 – October 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.

<https://spaceflight.nasa.gov/realdata/sightings/SSapplications/Post/JavaSSOP/JavaSSOP.html> 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.

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. The next manned launch to the Space Station is that of Expedition 61 on September 25. There was also an unmanned cargo mission on September 10.

ISS, 13 September 2019

Time	Position	Elevation
6:19 a.m.	328°	21°
6:20	343	37
6:21	39	55
6:22	96	37
6:23	112	21

HST, 5 October 2019

Time	Position	Elevation
8:24 p.m.	227°	21°
8:25	208	28
8:26	180	32
8:26:40	152	28
8:27:00	141	24

Vanishes into Earth's shadow

ISS, 15 September 2019

Time	Position	Elevation
6:18 a.m.	289°	19°
6:19	270	32
6:20	226	41
6:21	183	31
6:22	164	19

HST, 6 October 2019

Time	Position	Elevation
8:13 p.m.	229°	21°
8:14	210	28
8:15	182	31
8:16	154	28
8:17	135	20

ISS, 18 September 2019

Time	Position	Elevation
8:32 p.m.	201°	20°
8:33	183	34
8:34	134	47
8:35	84	34
8:35:44	70	22

Vanishes into Earth's shadow

HST, 7 October 2019

Time	Position	Elevation
8:02 p.m.	231°	20°
8:03	212	27
8:04	185	30
8:05	158	27
8:06	139	20

ISS, 20 September 2019

Time	Position	Elevation
8:32 p.m.	260°	20°
8:33	272	34
8:34	322	47
8:35	11	34
8:36	29	20

ISS, 8 October 2019

Time	Position	Elevation
8:34 p.m.	308°	21°
8:35	303	40
8:36:16	219	79
8:36:23	190	77

Vanishes into Earth's shadow

HST, 4 October 2019

Time	Position	Elevation
8:34 p.m.	224°	20°
8:35	205	27
8:36:06	177	31
8:36:55	154	29

Vanishes into Earth's shadow

ISS, 9 October 2019

Time	Position	Elevation
7:46 p.m.	329°	21°
7:47	345	36
7:48	58	52
7:49	94	36
7:50	110	21

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, the ISS at 7:46 p.m. October 9, measure a little less than three fist-widths west of due north (or six north of due west), 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>

Highlights:

September 14, 4:30 a.m.: Coverage of the capture of the Kounotori cargo craft by the ISS. Actual capture will be at 6:00 a.m. with installation around 7:30 a.m.

September 25, 8:00 a.m.: Coverage of the launch of Expedition 61-62 to the ISS. (Actual launch is 8:57 a.m. CDT). 2:00 p.m.: Coverage of docking with ISS. (Actual docking is 2:45 p.m., with hatch opening at 4:40 p.m.)

Calendar of Events

September 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.

September 14: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., Claire and Clifford McMurray's.

September 25: Expedition 61 Launch from Baikonur, Kazakhstan to the ISS. Aboard will be NASA astronaut Jessica Meir, cosmonaut Oleg Skripochka, and United Arab Emirates astronaut Hazzaa Ali Almansoori. (The last is listed as a "Roscosmos spaceflight participant" by NASA but is an astronaut, the first for the UAE. Their other astronaut is Sultan Al Neyadi. 'Sultan' here is his name, not a title.)

No earlier than October: Boeing's CST-Starliner makes its first (uncrewed) flight to the ISS. See https://en.wikipedia.org/wiki/CST-100_Starliner for details.

Sometime in October: First suborbital test flight of SpaceX's Starship.

October 3: Return of ISS Expedition 60 at Baikonur Cosmodrome in Kazakhstan. Returning are NASA astronaut Nick Hague, cosmonaut Alexey Ovchinin and UAE astronaut Hazzaa Aki Almansoori.

October 10: Launch of ICON, the Ionospheric Connection Explorer, aboard a Pegasus Rocket for Northrop Grumman.

October 11: 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.

October 12: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., location to be announced.

October 15: Launch of *CHEOPS*, the European Space Agency's exoplanet studier, from Kourou, French Guiana by a Soyuz rocket.

October 19: Mercury is at greatest eastern elongation, 25 degrees from the Sun (hence is visible after sunset.)

October 28: Uranus is at opposition.

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

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

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

November 30 (estimated): Boeing's CST-Starliner makes its first crewed flight to the ISS. See https://en.wikipedia.org/wiki/CST-100_Starliner for details. Either this or the December SpaceX mission will be the first manned orbital flight for an American spacecraft since July 2011.

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

December: Crewed flight of Dragon 2 to the ISS. If this goes as scheduled, it will be the first or second manned orbital launch by the US in eight years, depending on whether the CST Starliner flight on November 30 goes as planned.

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 meeting, 2:00 p.m., location to be announced.

December 14: Peak of the Geminid meteor shower.

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

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.

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.

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 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.

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.

July 2020: United Arab Emirates launch the Mars probe *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 16, 2020: Maiden flight of Ariane 6 from Kourou, French Guiana.

July 17, 2020: 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 23, 2020: Launch of 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*. 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.)

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

December 2020: Launch of the Korea Pathfinder Lunar Orbiter (KPLLO) and lunar impactor from Naro Space Center in South Korea. For more information, see https://en.wikipedia.org/wiki/Korea_Pathfinder_Lunar_Orbiter.

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.

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.

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 as part of the *Gaganyaan* program.

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

Sometime in 2022: India launches its *Mangalayaan-2* Mars mission, which includes an orbiter, lander and rover.

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>.

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

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.

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.

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 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)

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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.

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