Oklahoma Space Alliance OUTREACH
July 2016

July Meeting:

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, July 9, 2016 at Earl's Rib Palace, 920 SW 25th St, Moore, OK. This is between the 1-35 West Frontage Road and Telegraph Road, a couple of blocks south of Harry Bears. Telephone number is 793-7427.

We were hoping that Congressman Bridenstine would speak at this meeting, but it now looks like that make take place in September or October. OSA president Steve Swift is undergoing medical treatment and won't be able to preside, so OSA VP Dave Sheely will lead the meeting.

Place: Earl's Rib Palace
Moore Oklahoma
2:00-5:00 PM

1) Introductions
2) Space News Pictures and Videos by David Sheely
3) Break
4) Possible update on the July 4th Jupiter mission
5) Discuss Business
    a. Review OSA Accounts
    b. Summary of June Meeting
    c. Discuss September Visit by Congressman Bridenstine
6) Chat

Minutes of June Meeting

Oklahoma Space Alliance met at Earl's Rib Palace in Moore on June 11, 2016. Attending were Steve, Karen and Bryan Swift, Russ Davoren, Kay Fiel, Jasmine Kendricks, Claire and Clifford McMurray, Dave Sheely, Rosemary Swift, Rebecca Tate, Sue Taylor, Stephanie Thibodeau, Dennis Wigley and Syd Henderson.

There was a launch of the Delta IV rocket on the morning of June 11, too late to make last month's *Update*. This is the most powerful rocket we have, at least until SpaceX launches its Falcon 9 Heavy in a few months. We watched video of the Delta Launch.

The Lynx spacecraft is being shelved by XCor, which will result in employees being laid off. They will be building rocket engines for the United Launch Alliance.

We watched the Falcon 9 launch of Thaicom satellite and the subsequent landing of the first stage on a platform at sea. This was their third sea landing and fourth landing overall.

The Bigelow Expandable Module attached to the International Space Station has indeed expanded. There was some delay at first. This module has the advantage that it is covered with several layers of Kevlar, which protects it from micrometeorites.

Antares flights resume on July 6.

Claire and Clifford McMurray went to the International Space Development conference in Puerto Rico. Oklahoma Space Alliance won a special merit award for outreach. The next ISDC is in St. Louis.

NSS Chapter coordination is being reorganized so each organizer has about the same number of chapters to correspond with. [I hope this takes into account the physical size of each region.]

We have $1078.83 in the checking account and $267 in cash.

Steve is undergoing medical treatments that will leave him incapacitated for a while, so Dave Sheely will have to preside over the next meeting.

We watched a video on Economic Basis of Interstellar Flight by Robert Zubrin. Since the cost is a thousand times that of the Apollo program, he estimates we would need a GNP 200 times that we currently have.

Syd Henderson and Clifford McMurray will be on space panels at Soonercon. Claire McMurray will also be on panels, but they won't be on space. Syd suggested we might consider a space track on Mars at the next Soonercon.

--Minutes by OSA Secretary Syd Henderson

Between-Meeting Activities

Claire and Clifford McMurray and Syd Henderson attended Soonercon and were on some of the panels. Clifford and Syd were on "Colonies by the Canals: is a Martian colony even a good idea?" with about a dozen people in the audience (which is why I'm writing about Mars later in the newsletter). Clifford also gave his slideshow on asteroids to an audience of five, and Syd was on "Space in 50 Years" with an audience of eight (not counting the four panelists). Claire was on a couple of panels on filksinging (which is the sf fan's equivalent of folk singing).

"Space in 50 Years" was rather free-form, since we were moved into a room without tables, so that the panelists were mixed among the audience. My fellow panelists were planetologist John DeLaughter (moderator); Karl Gallagher who worked on satellite orbits and trajectories (and also wrote a novel *Torchship*) and Joey Rodman who is a writer and astronomy geek. My belief was that we will probably have intermittently manned scientific stations on Mars but likely not permanent settlements and permanently manned outposts on the Moon (possibly speaking Chinese). We will be exploiting near-earth asteroids, and likely will have sent astronauts to the asteroid belt but probably not settled there due to problems of radiation and adapting to zero-gee. This, however, does make some of the larger asteroids appealing, especially if you can increase their rate of spin so that you can live on the inside and substitute centrifugal effects for gravity. See the Syfy channel show *The Expanse* on what this might look like.

Mr. DeLaughter asked us what we thought the priorities might be among the Moon, Mars, asteroids and oceans. I think in the short run, it's the Moon, near-earth asteroids, Mars, oceans and the asteroid belt, but in 50 years, the asteroids will be first because we will be exploiting them for raw materials.

DeLaughter posited the next space race will be China vs. India, but I'm a little skeptical about the scale of that race. I think that there's going to be a rivalry among commercial space companies such as SpaceX and Blue Origin for actually getting people and robots to places where they may actually make a profit.

I'll be discussing the Mars panel later. The panelists for that were Clifford McMurray (moderator), Mr. Delaughter, sf writers Cary Osborne, Gorg Hugg and Jackie Kramer.

Larry Nemecek had a presentation on the Enterprise in Space project, which is to launch a small space satellite packed with experiments created by high school kids. This project also includes a virtual personal tutor Ali (as in Alison, I think). The idea is to inspire kids' interest in science through hands-on projects, and having your experiment sent into space should certainly do it. For information, visit http://www.enterpriseinspace.org. The National Space Society has agreed to be part of this this and you can find information on their blog.

This was the largest Soonercon since its 2005 revival and possible altogether. There were conservatively eight hundred people there and likely more.

More on Enterprise in Space from an NSS press release:
National Space Society's EIS mission includes many important 'firsts:'

- The first spacecraft bearing the name Enterprise to orbit Earth
- The first Sci-Fi inspired design of a spacecraft.
- The first to converse with student teams in natural language while in orbit using an artificial intelligence, just like the Star Trek™ computer assisted their crews with experiments and analyses.
- The first non-profit organization to launch and return student experiments free of charge, allowing children of all socio-economic levels to participate. Students work in cross-cultural teams to convince judges that their experiment should earn the right to be among the 100+ experiments flown.
- Likely the first 3-D printed spacecraft (aero-frame and skin) to orbit and return to Earth.
- The first to promote and encourage liberal and fine arts as part of the experimental design.

Space News

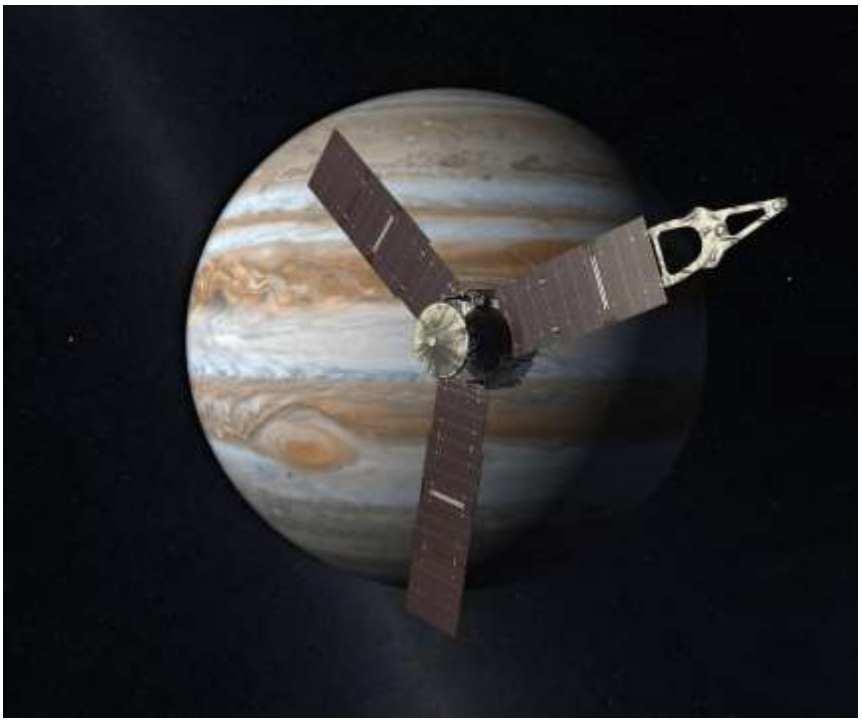

Figure 1 Juno at Jupiter (Artist conception, from NASA)

The *Juno* Spacecraft arrived at Jupiter on the evening of July 4, and successfully achieved Jupiter orbit after skimming the top of Jupiter's cloud. During the approach, *Juno* achieved a velocity of 165,000 mph relative to Earth, making it the fastest spacecraft in history by that measurement (though the velocity relative to Jupiter seems more relevant). Aerobraking and insertion burn slowed *Juno* enough to put it in a highly elliptical 53 day orbit around Jupiter, with closest approach about 3000 miles from Jupiter's clouds. After a couple of such orbits, *Juno* will be placed in a 14-day polar orbit which will approach Jupiter at a distance of 3000 miles from the top of the clouds at the near point, and more than a million miles (beyond Callisto) away at the most distant. It will be in that orbit for at least 420 days, enabling it to cover most of Jupiter's surface and probe its interior, maybe finding

out whether Jupiter has a solid core. Since *Juno* passes through Jupiter's intense radiation belts, its lifespan depends on how many times it can do that and survive. When done, it will plunge into Jupiter's atmosphere to avoid contaminating Europa.

Instruments were turned off a few hours before the approach and will be turned back on over the next few days, which will give us an idea whether they are intact, but Juno appears to be in good health.

On September 30, *Rosetta* will end its mission by landing on Comet 67P/Churyumov-Gerasimenko. It will send information during its descent, but is expected to die after the landing due to loss of solar power. *Rosetta*'s entire mission lasted twelve years, including two in orbit around its target comet

On June 15, the LIGO team announced that it has detected a second merger of black holes. These were considerably smaller than those in their first detection. The black holes had masses respectively 14.2 and 7.5 times that of the Sun, and the merger took place 1.4 billion light-years from Earth. The new, enhanced, black hole has a mass less than 21.7 solar masses since the merger converted more than a solar mass into gravitational waves. (Source Astronomy.com).

Earth has a newly discovered quasi-satellite, 2016 HO_3, which will be orbiting Earth for centuries to come. A previous quasi-satellite, 2003 YN 107, orbited Earth for a while about a decade ago, but now has gone on its way. 2016 HO3 never approaches closer than about ten million miles, or further than 25 million miles. It appears our new quasi-moon has a diameter of less than 300 feet. It was spotted in April by the Pan-STARRS1 asteroid survey telescope in Hawaii. 2016 HO_3 isn't considered to be truly captured by the Earth; it has an orbital period of a year so is a co-orbital. (Source: Astronomy.com, June 16, 2016; skyandtelescope.com, June 24, 2016.)

Earth and the outer planets t probably have many quasi-satellites. Indeed Venus, which has no true satellites, has a quasi-satellite 2002 VE_{68}.

Some Notes on Mars Colonization

I was part of a panel on Mars colonization at Soonercon in which the general consensus was that yes, Mars colonization is something we should do. Coincidentally, I've been reading some articles about the problems we will face, some of which double as opportunities.

One of the biggest problems we will face is the long exposure to radiation, both from solar wind and flares and cosmic rays. Oddly enough, these are to some extent complementary, in that the solar wind tends to protect us to a certain extent from charged cosmic rays. This makes it a bit ominous that at the moment there is not a single sunspot on the surface of the Sun, and the last couple of sunspot cycles have been weak, prompting speculation that we are due for a repeat of the Maunder Minimum, which coincided with the middle of a period called the Little Ice Age. (The Sun tends to be cooler during sunspot minima because increased flare activity more than makes up for the sunspots.) What this means is that in the near future, astronauts going to Mars will have little shielding from cosmic rays. The radiation exposure on a single trip to Mars is enough to keep them grounded for the rest of their lives.

One proposal I've recently seen is to have a strong magnetic field surrounding the ship, which would do wonders to deflect charged particles emanating from the Sun. I'm not sure that it would protect that much from cosmic rays since they are travelling close to the speed of light and would probably go right through the spacecraft before they had time to be deflected. (It also wouldn't protect against neutral particles such as the energetic neutrinos I mentioned in the last *Outreach*, but those seem to be rare.

There are various proposals involving using ice as a protection (as well as a source of drinking water. I'm wondering if a huge shuttle spacecraft such as we saw in *The Martian* is the solution. It might provide enough protection to prevent nerve damage and cancers from the radiation.

Note that we not only have the radiation problem on the trip to Mars but also when we get there, since Mars has no global magnetic field. There are local magnetic fields fossilized from the days when Mars had a liquid metal core but they don't seem to be very strong. (*The Martian* solved this problem by ignoring it.) This means that long-term settlement on Mars will require some sort of shielding and a really good health plan.

One possibility of reducing radiation exposure to and from Mars is to use something faster than a Hohmann Transfer orbit. The latter is the most fuel efficient method of transferring spacecraft from one orbit to another and requires two burns, one to place the spacecraft into the transfer orbit and one to take place it in its new orbit. The spacecraft coasts in between. The transfer orbit is an ellipse which is tangent to both orbits. A spacecraft taking a Hohmann transfer orbit from Earth to Mars takes 8.5 months to get there, and the same time to get back. However, while on Mars, a crew would have to wait for the next launch window, which would be 500 days later. Thus a Mars mission using Hohmann transfer orbits would take nearly three years including travel time. Using some sort of propulsion such as an ion drive would cut the travel time considerably and open new launch window opportunities.

Spending two prolonged trips in zero-gee would have serious effects on health for the astronauts, so various methods for spinning the spacecraft to simulate gravity. My personal favorite is to have the spacecraft in two components attached by a long cable, so that it spins like bolas.

Of course that is just for the trip. Mars itself has a surface gravity 37.6 percent that of Earth, and we're not sure how that will affect human development. One talk I attended many years ago indicated we should be able to adapt to Mars gravity, but we would have many more problems on the Moon. We really need to run experiments in partial gee before sending people to Mars.

How sustainable a Mars colony would be depends on what materials we find there and how easy they are to process and how dangerous they are. Mars had tectonic activity early in its history, and there should be metal deposits near the former volcanoes, deposited both by cooling of magma and hydrothermal activity. A third method of concentrating minerals depends on life (which is how coal and iron ores were concentrated on Earth--the latter from the oxygenation of Earth's atmosphere).

When we start thinking about the necessities of life, things get interesting. There appear to be substantial amounts of ice deposited beneath Mars surface and the poles. It's not a lot compared with the oceans of Earth, but should be enough to sustain Mars colonies. Some of the water appears to be saturated by salt and seeps out on warmer Martian days.

The soil of Mars appears to contain both hydrogen peroxide and perchlorates. Perchlorates in particular occur in concentrations on the order of a half-percent or more (see http://www.space.com/21554-mars-toxic-perchlorate-chemicals.html). This means that the soil of Mars is extremely oxidizing, which would destroy organic materials (which is why the search for life is now looking below the surface), In addition, perchlorates suppress thyroid function, to the point that they are used to treat hyperthyroidism. In addition, perchlorates in Martian dust would cause lung disease. Thus a Mars colony would have to be very careful about toxic dust.

On the other hand, perchlorates and hydrogen peroxide are excellent sources of oxygen and will likely be used as such by Martian colonists.

I'll mention here how the perchlorates are produced in the first place. It's been found that they are produced when ultraviolet light hits titanium dioxide (and possibly other oxides) and chloride. However, another interesting method involves the dust storms for which Mars is famous. These raise a lot of static electricity, and sparks from that also produce perchlorates and peroxides. Over several billion years, you get quite an accumulation.

Nitrogen might be a problem since Mars has such a thin atmosphere, but there is a good possibility that the same processes that produced perchlorates also produced nitrates, as happens on Earth, and indeed the Curiosity rover has detected nitrates on Mars. If these are present in substantial enough amounts, we already have a presence of "fixed" nitrogen on Mars. Concentrations in some soils are up to

one percent. Phosphates have been found on Mars (in a more soluble form than on Earth—see http://phys.org/news/2013-09-phosphate-soluble-mars.html), as have sulfates. Carbonates have been found by several Mars landers, including the Phoenix lander and the Spirit rover, and also detected by the Mars Reconnaissance rover. (See the Wikipedia article on Carbonates on Mars). Finally, iron oxide is abundant, which is a major reason Mars is the Red Planet.

None of this is really surprising, since life tends to use common elements (excluding those whose compounds are not water soluble, such as aluminum and silicon), and we'd expect them to be in an oxidized form. Other essential elements such as sodium, potassium, calcium and magnesium are also present and indeed form salts with the perchlorates, sulfates, nitrates and carbonates.

In fact, I have to think one of the problems a colony would face on Mars is that the soil is so full of soluble salts. It's a similar problem faced on Earth in regions that depend on irrigation. On the other hand, it's good that essential elements are present in forms life finds accessible.

Mars has such a thin atmosphere that colonists will have to live in habitats and concentrate what atmosphere there is, which is mostly carbon dioxide (another source if oxygen once plants get growing). The next two most common substances in the Martian atmosphere are nitrogen and argon, comprising 1.89% and 1.93% percent of the atmosphere, so the air in the habitats is going to be different than on Earth, with maybe 40 percent of it being argon and 38 percent nitrogen, and the rest oxygen from Earth, Martian soil and, eventually, plants. Argon, fortunately, is an inert gas, and, outside of being forty percent denser than nitrogen, should be harmless. (It can be an asphyxiant in circumstances where it's concentrated since it is denser than air, however, it normally just mixes with the rest of the atmosphere.)

One problem we're going to have to deal with if we go to Mars is that it's much colder than Earth, and Robert Zubrin has proposed warming it up, possibly by releasing methane tetrafluoride into the Martian atmosphere. The latter, CF_4, is the fluorine equivalent of carbon tetrachloride, and is a cousin of the chlorofluorocarbons that wreak havoc with the ozone layer. Carbon tetrafluoride doesn't do that, but is a very potent greenhouse gas, 6500 times more effective than carbon dioxide, and is very stable. Once the atmosphere starts warming up, carbon dioxide and, eventually, water will be released from the polar caps and, since carbon dioxide and water vapor are also greenhouse gases, compound the warming effects of the carbon tetrafluoride.

This, also, will add more oxygen to the atmosphere as liquid water starts disintegration perchlorates. This will take some time, since perchlorates are pretty stable (at least compared to chlorates and chlorites) since the perchlorate ion is tetrahedral in shape and difficult for water to attack. On Earth, some microbes get energy by breaking perchlorates into oxygen and chlorides, but I'm not sure we want to contaminate Mars enough to use them there.

Actually, although Zubrin thinks this could make it possible to breathe on Mars unassisted in maybe a thousand years (less if we use creative bioengineering on plants), I have to wonder what he's using for a neutral component in the atmosphere. Humans can't breathe pure oxygen forever (or more than eighty percent either), carbon dioxide is not a suitable major component, and, though Mars has enough nitrogen and argon for space habitats, they would be a tiny component of an atmosphere built from Martian materials. We'd probably have to ship in nitrogen from the outer solar system, which would get really expensive.

Sky Viewing

The **Perseid Meteor Shower** peaks on the morning of August 12. This could be a very good year for the Perseids, with a peak of 150 meteors per hour. There is a gibbous Moon during the evening, but it sets around 1:00 a.m. and the Moon will be far away from the radiant in any case.

Mercury and **Venus** are both hidden behind the Sun in early July, but it still is a pretty good month for viewing planets.

Mars was closest to the Earth on May 30, but is still magnitude -1.4, which is about as bright as Sirius, and is visible most of the night. It's in the south at sunset, and is the brightest object in that part of the sky. Mars will be becoming dimmer through July and August but will still be in negative magnitudes. It's currently in Libra not far from the head of Scorpius. (Not surprising since Libra was originally the claws of the Scorpion.) In late August, it moves into the southern part of Ophiuchus, the Serpent Bearer. Ophiuchus is not counted as one of the twelve signs of the Zodiac, although the Sun and planets spend much more time within it than neighboring Scorpius. However, the part of Scorpius (its head) that the ecliptic passes through is conspicuous, while the part of Ophiuchus it passes through is not. On August 23, Mars passes only two degrees north of Antares, which is in Scorpius but just south of the boundary with Ophiuchus. Since Mars and Antares are both red, this makes for an interesting juxtaposition. (The name Antares, incidentally, means 'rival of Mars.' The reason I keep referring to "Scorpius" is because that's its astronomical name, while Scorpio is the corresponding astrological sign.)

Saturn is also bright, at magnitude 0.0 and considerably brighter than Antares, which is between and to the south of it and Mars. Saturn is about 15 degrees east of Mars and is already in southern Ophiuchus. Indeed Saturn and Mars are going to have a conjunction on August 25, with Mars passing four degrees south of Saturn.

Jupiter is the brilliant planet in the western sky at sunset. It's currently setting about three hours after the Sun, but by the end of July this will be less than two hours, and Jupiter will be setting during twilight at the end of September. **Venus**, meanwhile, will be becoming visible in the evening sky in August, and on August 27, the two planets will be having a spectacularly close conjunction during which they will be separated by an eighth of the diameter of the full Moon. The closest approach will actually occur during late afternoon, but the planets will still be close enough that they may appear to you as a single object.

Mercury will also be visible shortly after sunset in early August. On August 16, it will be four degrees below Jupiter.

Uranus and **Neptune** are inconspicuous in the morning sky before dawn. *Sky & Telescope* has charts online at http://www.skyandtelescope.com/wp-content/uploads/WEB_UrNep16_Finders.pdf

Pluto was at opposition on July 7, and was only 14th magnitude. There's a very nice finder chart on pp. 48 – 49 in the July *Sky & Telescope*.

[Material for this section of *Outreach* derives from the July and August issues of *Astronomy* and *Sky & Telescope*, and the *Sky & Telescope* and *Astronomy* web sites]

Viewing Opportunities for Satellites (July 9 to August 14, 2016)

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.

http://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. I'm using its information for the International Space Station and Hubble Space Telescope, interpolating when necessary. It doesn't give you information for Tiangong 1, so I'm using Heavens Above for that. The *Sky & Telescope* web site carries International Space Station 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 -3.5, 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. China's Tiangong 1 space station can get up to magnitude -0.6, which is brighter than all the night stars except Sirius and Canopus.

Missions to and from the International Space Station may change its orbit. The next launch to the ISS will be a Progress resupply mission on July 16, followed by a SpaceX mission on July 18. However, there is also a manned mission scheduled to dock with the ISS on July 8.

Station July 10, 2016

Time	Position	Elevation
Appears from Earth's shadow		
5:00:56 a.m.	259°	27°
5:01:23	269	35
5:02	321	50
5:03	14	35
5:04	30	20

Tiangong-1 July 11 2016

Time	Position	Elevation
9:40 p.m.	290°	10°
9:43	211	57
9:44:50	135	17
Vanishes into Earth's shadow		

Station July 26, 2016 morning

Time	Position	Elevation
5:27ap.m.	325°	21°
5:28	339	38
5:29	39	59
5:30	102	38
5:31	115	21

Station July 26, 2016 evening

Time	Position	Elevation
10:04 p.m.	233°	21°
10:05	238	41
10:06	313	79
10:07	38	42
10:08	43	22

Station July 27, 2016

Time	Position	Elevation
9:11 p.m.	199°	19°
9:12	181	32
9:13	133	44
9:14	86	32
9:15	68	19

Station July 29, 2016

Time	Position	Elevation
9:01 p.m.	242°	21°
9:02	254	38
9:03	317	63
9:04	24	39
9:05	37	21

HST August 4, 2016

Time	Position	Elevation
6:15 a.m.	223°	20°
6:16	205	27
6:17	178	30
6:18	150	27
6:19	132	20

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HST August 5, 2016

Time	Position	Elevation
6:05 a.m.	226°	20°
6:06	207	27
6:07	180	31
6:08	154	27
6:09	134	20

HST August 6, 2016

Time	Position	Elevation
5:55 a.m.	229°	20°
5:56	210	27
5:57	183	30
5:58	156	27
5:59	137	20

HST August 7 2016

Time	Position	Elevation
5:46 a.m.	230°	19°
5:47	211	26
5:48	185	29
5:49	159	26
5:50	141	19

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 see the Hubble Space telescope at 5:55 a.m. on August 6, you would measure a little bit less than five fist-widths west of due south, 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:

July 8: 10:30 p.m.: Docking coverage of ISS Expedition 48/49 (actual docking is 11:12 p.m.)

July 9: 1:00 a.m. Hatch opening coverage for new crew on ISS. Actual hatch opening is 1:50 a.m.

July 16: 4:30 p.m. Launch coverage of Progress Cargo Craft from Baikonur Cosmodrome. Actual launch is 4:41 p.m.

July 18, 6:30 p.m. Docking coverage of Progress Cargo Craft at the ISS. Docking scheduled for 7:22 p.m.

Calendar of Events

July 8: Oklahoma City Astronomy Club meets at Science Museum Oklahoma (formerly the Omniplex). There will be a novice session in the planetarium at 6:45 p.m., followed by a club meeting at 7:30 p.m. See http://www.okcastroclub.com/ for details.

July 9: [Tentative]: Oklahoma Space Alliance Meeting, location to be announced.

July 2016-2020: The *New Horizons* probe visits the Kuiper Belt. For details, visit https://en.wikipedia.org/wiki/New_Horizons or http://pluto.jhuapl.edu. (Also see January 1, 2019.)

July 18: Launch of a SpaceX resupply mission to the International Space Station, 11:45 a.m.

July 20: Moon Day: anniversary of the Apollo 11 landing on the Moon.

August: Launch of an Orbital ATK resupply mission to the International Space Station,

August 12: Peak of Perseid meteor shower.

August 12: Oklahoma City Astronomy Club meets at Science Museum Oklahoma (formerly the Omniplex). There will be a novice session in the planetarium at 6:45 p.m., followed by a club meeting at 7:30 p.m. See http://www.okcastroclub.com/ for details.

August 13: [Tentative]: Oklahoma Space Alliance Meeting, location to be announced.

August 15: Launch of SpaceX's Dragon capsule on a resupply mission to the Space Station.

August 16: Mercury is at greatest elongation, 27 degrees east of the Sun (so can be seen after sunset).

September 1: Annular solar eclipse, visible in Africa on a path crossing Gabon the two Congos, southern Tanzania and northern Madagascar,

September 2: Neptune is at opposition.

September 8: 6:05 CST. Launch of *OSIRIS-REx*, the Origins Spectral Interpretation Resource Identification Security Regolith Explorer, which will orbit the near-earth asteroid 101955 Bennu and return samples. For more information, visit http://en.wikipedia.org/wiki/OSIRIS-REx or http://science.nasa.gov/missions/osiris-rex/.

September 10: [Tentative]: Oklahoma Space Alliance Meeting, location to be announced.

September 12: Mercury is at inferior conjunction with the Sun.

September 22: Launch of Expedition 49 to the Space Station.

September 26: Jupiter is in conjunction with the Sun.

September 28: Mercury is at greatest elongation, 20 degrees west of the Sun (so can be seen before sunrise).

September 30: The *Rosetta* space probe ends its mission with a descent to the surface of Comet 67P/Churyumov-Gerasimenko,

October 4 – 10: World Space Week. See http://www.worldspaceweek.org for details.

October 4: Seventh Orbital Sciences Commercial Resupply Mission to the Space Station launches from Cape Canaveral.

October 8: [Tentative]: Oklahoma Space Alliance Meeting, location to be announced.

October 15: Uranus is at opposition.

October 27: Mercury is at superior conjunction with the Sun.

November 12: [Tentative]: Oklahoma Space Alliance Meeting, location to be announced.

November 15: Launch of Expedition 50 crew to the International Space Station.

November 21: SpaceX launch to the ISS.

December: ESA's *ExoMars Mars Orbiter* arrives at Mars, together with the Schiaparelli lander. (The rover will be launched in 2018.) For more information, visit en.wikipedia.org/wiki/Exomars.

December: Test flight of SpaceX's Falcon Heavy.

December 10: Mercury is at greatest elongation, 21 degrees east of the Sun (so can be seen after sunset).

December 10: Saturn is in conjunction with the Sun.

December 10: [Tentative]: Oklahoma Space Alliance Christmas Party, location to be announced.

December 14: Peak of Geminid meteor shower.

December 19: Launch of SpaceX's Dragon capsule on a resupply mission to the Space Station.

December 28: Mercury is in inferior conjunction with the Sun.

December 30: Antares launch to the ISS.

Sometime in 2017 [tentative]: China launches the *Chang'e 5* lunar sample return mission.

Sometime in 2017: India launches *Chandrayaan 2*. This mission will include a lunar rover. For more information, visit http://en.wikipedia.org/wiki/Chandrayaan-2. [Moved from 2014.]

January 12, 2017: Venus is at greatest eastern elongation, 47 degrees from the Sun (so can be seen after sunset).

February 26, 2017: Annular solar eclipse touching the southern tip of South America, the south Atlantic Ocean, and Angola.

March 2017: Launch of the Green Propellant Infusion Mission (GPIM) by a SpaceX Falcon Heavy rocket. This mission is "green" because the fuel it uses, hydroxylammonium nitrate produces nontoxic gases when it burns, unlike hydrazine.

March 25, 2017: Venus is in inferior conjunction with the Sun.

May, 2017: First demo flight of SpaceX's Dragon 2 Spacecraft, which will be the first commercial spacecraft capable of carrying humans to orbit (as well as the first human-rated space vehicle capable of making a soft landing on Earth.)

June 3, 2017: Venus is at greatest western elongation, 46 degrees from the Sun (so can be seen before sunrise).

August, 2017: First crewed demo flight of SpaceX's Dragon 2 Spacecraft.

August 21, 2017: The next total solar eclipse visible in the United States, on a pretty straight path from Portland, Oregon to Charleston, South Carolina. St. Louis is the biggest city in-between.

September 15, 2017: The *Cassini* spacecraft will end its mission with a plunge into Saturn's atmosphere.

December 2017: Orbital test flight of Boeing's CST-100 Starliner, which will be capable of carrying humans to orbit. See https://en.wikipedia.org/wiki/CST-100_Starliner for details.

Figure 2 Boeing's CSC Starliner (from Wikipedia)

December 2017: Launch of the European Space Agency's CHEOPS space telescope, which will study exoplanets, which transit their star's disc. Project website is http://sci.esa.int/cheops.

December 2017: Proposed launch of TESS, the Transiting Exoplanet Survey Satellite. Unlike *Kepler*, TESS will (if approved) conduct a full sky search for exoplanets. For information, visit space.mit.edu/TESS.

Late in 2017: SpaceX launches the Google Lunar X Prize Moon landing. This includes a lander and a rover. See http://lunar.xprize.org/ and en.wikipedia.org/wiki/Google_Lunar_X_Prize for details.

Sometime in 2018: Launch of *InSight*, a lander that will probe the interior of Mars. For information, see http://insight.jpl.nasa.gov/. [Postponed from March 2016.]

Sometime in 2018: Possible unmanned SpaceX mission to Mars.

February 2018: Crewed orbital test flight of Boeing's CST-100 Starliner to the ISS. See https://en.wikipedia.org/wiki/CST-100_Starliner for details. April 2018: The European Space Agency/JAXA *BepiColombo* Mercury Orbiter is launched. [Postponed from January 2017.] Home page is http://sci.esa.int/bepicolombo.

May 2018: ESA launches the *ExoMars Mars Rover*. For more information, visit en.wikipedia.org/wiki/Exomars.

July 31, 2018: Proposed launch date for *Solar Probe Plus*, which will study the corona of the Sun from within four million miles. For more information, visit http://en.wikipedia.org/wiki/Solar_Probe_Plus or http://solarprobe.jhuapl.edu/. (This spacecraft will fly by Venus seven times to refine its orbit.)

October 2018: Earliest date for the launch of the James Webb Space Telescope.

October 2018: Launch from Cape Canaveral of the European Space Agency/NASA Solar Orbiter (SolO), which will orbit the Sun at a distance closer than Mercury. Web site is sci.esa.int/solarorbiter. [Moved from July 2017.]

January 1, 2019: *New Horizons* flies by the Kuiper Belt object 2014 MU_{69}.

September 2019: Arrival of OSIRIS-Rex at the near-earth asteroid 101955 Bennu to return samples. [See September 6, 2016.]

Sometime in 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 2020: First launches of the modules of the Chinese space station *Tiangong-3*. The station should be finished by 2022.

Sometime in 2020: Launch of ESA's *ExoMars Mars Rover*. For more information, visit en.wikipedia.org/wiki/Exomars.

July 2020: United Arab Emirates launch the Mars probe *Hope*.

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.

January 2022: *BepiColombo* arrives at Mercury orbit.

December 19, 2024: *Solar Probe Plus* makes its first pass through the outer corona of the Sun. [See July 31, 2018.]

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. This one is also visible in Salt Lake City, Denver, Little Rock (again), Tampa Bay and New Orleans.

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Other Information

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

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

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

The Mars Society address is Mars Society, Box 273, Indian Hills CO 80454. Their web address is www.marsociety.org.

The National Space Society's Headquarters phone is 202-429-1600. Executive Director e-mailnsshq@nss.org. The Chapters Coordinator is Bennett Rutledge 720-641-7987, rutledg-es@chapters.nss.org. The address is: National Space Society, 1155 15th Street NW, Suite 500, Washington DC 20005 Web page is www.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].

OKLAHOMA SPACE ALLIANCE
A Chapter of the National Space Society

MEMBERSHIP ORDER FORM

Please enroll me as a member of Oklahoma Space Alliance. Enclosed is:
_____ $10.00 for Membership. (This allows full voting privileges, but covers only your own newsletter expense.)
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National Space Society has a special $20 introductory rate for new members. Regular membership rates are $52, Student memberships are $36, Senior $42. Part of the cost is for the magazine, *Ad Astra*. If you choose to receive the magazine digitally, memberships are $40 for regular, $24 for students and $30 for seniors. Mail to: National Space Society, PO Box 98106, Washington, DC 20090, or join at www.nss.org/membership**.** (Brochures are at the bottom with the special rate.) Be sure to ask them to credit your membership to Oklahoma Space Alliance.

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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