Oklahoma Space Alliance OUTREACH
July 2017

July Meeting:

Oklahoma Space Alliance will meet at 2:00 p.m. on Saturday, July 8, 2017 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.

Saturday July 8, 2017
Program

Place: Earl's Rib Palace

Moore Oklahoma

2:00-5:00 PM

1) Introductions
2) What's Happening (Steve Swift)
    (1) (Pictures, Videos & Links)
3) Discuss Business
    a) Review OSA Accounts
4) Summary of June Meeting
5) OSIDA Meeting Report
6) New Business
7) Feature Presentation – ***SpaceX***
    (1) (Review of history and accomplishments with pictures, videos and links)
8) OSA Member Presentations/Discussions
9) Chat

Minutes of June Meeting

Oklahoma Space Alliance held its regular monthly Meeting on June 10 at Earl's Rib Palace in Moore, Oklahoma. Attending were Steve and Karen Swift, Chris Crawford, Ross Davoren. Tom Koszoru, Claire and Clifford McMurray, John Northcutt, Norman (didn't get last name), Dave Sheely, Brian Swift, Rosemary Swift, and Syd Henderson. OSA President Steve Swift presided over the meeting.

This was the first meeting after the International Space Development Conference in Saint Louis. Claire, Clifford, Dave, Syd and Tim Scott went to the conference and the first four shared their experiences. I'll be going through my experiences in some detail later on, but I mentioned a Japanese student experiment to launch a ring-shaped solar power collector that would light up a ring-shaped satellite in time for the Tokyo Olympics. [Ed Strickland and I worked out that this would be visible as a tiny ring, not a point of light. This talk was actually part of a student contest on designing and using solar power satellites, and what the Japanese are doing are modular SPSs.] I also attended plenary sessions by Professor Johann-Dietrich Wörner, the Director-General of the European Space Agency, by Space Pioneers, one on high altitude ballooning, and dinner talks by Professor Wörner, by representatives of the Kepler Team,

and the Awards banquet. I also commented on METI, a relative of SETI in which we deliberately broadcast to other civilizations so they can come eat us (or make friends).

Dave went to the Space Medicine track, which considered questions as to how exposure to 25 seconds of zero-G affects plants. Robert Zubrin and a Dr. Rhodes have diametrically opposed views on the magnitude of the radiation threat in long-term space travel and colonization.

Claire took "Greening the Galaxy."

One person wants to build a ring around the Pacific Ocean, then expanding it by running a current through it so it surrounds the planet (apparently fixed through magnetic support).

Two people from Japan are running the Japanese equivalent of the Zero-G corporation.

Claire's reading a book on the Universe as a Hologram. The entire Universe is a giant hologram because on the atomic level every bit contains information about the rest.

Kip went to the Space Solar Power track on Friday. Gary Barnhard is trying to get a cubesat as a technology that would beam power to a module. We could have a mothership taking a bunch of cubesats to explore asteroids. We will be using 100 gigawatts of Space Solar Power by the end of the 21st Century.

One speaker on METI wants to beam out the structure of our DNA to the stars so we can be constructed.

On the Public/Private panels. There are six hundred million tonnes of water at the North Pole of Mars. [Syd: this is the mass of six hundred billion liters.]

Public/Private collaboration has less regulation but some oversight.

We can have people on the moon in five to seven years for a tenth of NASA's cost. Estimate to construct a Lunar base is 10 billion dollars

One speaker (Wingo?) wants a 25 year tax holiday for items produced in space.

China is spending a trillion dollars on something called the New Silk Road, and now effectively owns the Greek port of Piraeus.

Kip was running the Space Business track on Saturday so didn't see much else.

Exos Aerospace has reassembled the Armadillo Aerospace team back and much of the equipment.

Soon 1500 satellites will be launched per year.

If you assemble your satellite in orbit, you don't have to overbuild it to survive the stresses of launch. A suggestion is to do modular construction of satellites on the Space Station.

A 40 by 80 kilometer box in geosynchronous orbit now holds seven satellites.

Buzz Aldrin's son is a college professor working on an MBA program to promote space startup companies. This would compete with the International Space University.

Michael Snyder from Made in Space 3-D manufacturer said 82% of failures on the Space Station were of parts that can probably be manufactured through 3-D printing on the Space Station.

Fiber optics manufactured in space are notably faster than those manufactured on Earth.

On Sunday, Kip went to the Asteroid Track. First talk was on the OSIRIS-REx mission to the carbonaceous asteroid Bennu. Bennu is one of the darkest asteroids; we want to collect sixty grams of material, searching for amino acids, which are the building blocks of proteins.

Joel Sircel wants to build a bag to surround an asteroid so he can bake off ice.

Bob Zubrin had a talk on the radiation and planetary protection rackets. Any biological hazards from Mars would already have affected Earth from Mars rocks. [Given the number of mass extinctions in Earth's history, this may not be comforting as it sounds, though there are simpler explanations.]

OSA Business: Craig Crawford paid for a membership for two years.

Oklahoma Space Alliance member Peggy McBride passed away.

Land and uranium weren't resources until we found ways to use them. People create resources.

NASA could create a base on Mars, but how do you create a civilization? How does it support itself?

We looked at bios of the twelve newly selected astronauts.

Update has a link to space launches.

--Minutes by OSA Secretary Syd Henderson

Syd's ISDC Report

Five members of Oklahoma Space Alliance went to the International Space Development Conference in Saint Louis May 25 - 29. I think most of us spent Memorial Day going home. I drove both ways by myself, which are the longest drives I've ever taken, but it was a pleasant trip. The section from Rolla, Missouri to Saint Louis was particularly beautiful.

The conference was held at the Union Station Hotel, which, as its name implies, is the hotel associated with an old train station. There is an Amtrak parking lot a couple of blocks away, which I parked at since it's a third the price of the hotel parking lot. Thanks to Clifford McMurray for the alert.

This hotel is about three miles west of the Gateway Arch and Eads Bridge, two landmarks I made a point of visiting and photographs. Alas, I copied the photos to my hard drive which failed, and deleted them from the camera, so I can't share them with you. The Eads Bridge was the first bridge across the main part of the Mississippi River, is was a legendary engineering feat and is still in use. (Speed limit is 25 mph.) At the time, it was the longest arch bridge ever built. It's also the only bridge ever built under the guidance of James Eads, who I guess had nothing more to prove.

I walked to the park that houses the Arch. Downtown Saint Louis is very pretty and, of course, very historic.

The hotel has a huge gallery where you can buy drinks, and where they have a light show each night. The exhibition hall is on the bottom floor and equally large, and the exhibitors occupied a fraction of the space although there were a lot of them. There was a student contest to design space colonies which included several teams from Romania, and we had short talks from various team representatives preceding some of the speakers.

I spent much of Thursday morning at the METI talks. METI stands for Messaging Extra-Terrestrial Intelligence, and proposes to augment the passive listening of SETI by beaming information of our presence to likely stars. Earth, of course, has been broadcasting radio signals since the early 20th century, and broadcast television signals since mid-century, although those signals would soon attenuate. Since the rise of telecommunication satellites and cable television it would be even harder for aliens to detect broadcasts from Earth. This also suggests that there might be a limited period in a civilization's life during which it emits broadcast signals to space. If alien races all had SETI, they might be unable to detect each other.

In any case, it's doubtful Earth radio could be detected from light-years away without antennas on the astronomical scale unless the signal is boosted and directed, and this is where METI comes in. It proposes announcing our presence to alien worlds by beaming information.

This obviously could be hazardous we contact a hostile civilization, and Cixin Liu's *The Three-Body Problem* and its sequel *The Dark Forest* argues that the default reaction to a technological civilization announcing itself is that some other more advanced civilization would destroy it. One of the speakers (Lucianne Walkowicz according to the program, but I think it was a man) speculated that, sure, broadcasting our presence might be dangerous, but there might also be fastidious civilizations that clean up technologically advanced civilizations that refuse to announce themselves. [I think the logic is that if you are technologically advanced and secretive, you must be assumed to be dangerous.] Thus, since we don't know whether it is more dangerous to do METI or not to do METI, we should do METI. I'm not sure I agree with the logic here,

In any case, METI would be a long and expensive effort that with current technology might take thousands of years to pay off. But really it would only require a 200-year startup, since then we would be more technologically advanced and have better ways to communicate.

William Kitchen of Interstellar Beacon.org followed. He's the one who wants to create an interstellar capsule to preserve our civilization (but wouldn't you need a series of such capsules?), then an interstellar Noah's Ark (more of a seed bank), and eventually transmit our DNA so aliens can construct people.

I spent my first half of Thursday afternoon taking in the sights in Saint Louis. When I got back, I attended some of the talks on "Public/Private Partnership for Moon Missions." Among the topics discussed were the increase in the number of cubesats launched (145 anticipated in 2018), and traditional planetary surface markets, which would also be developed on the Moon and Mars.

Jeff Bezos (Blue Origin) is talking about regular flights to the lunar South Pole.

In the evening, the conference presented *Fight for Space*, which asked the questions, "Why haven't we gone back to the Moon, or sent humans to Mars? Weren't we supposed to be there in the 1980s? What led to the decline of NASA's budget and why is it stuck in low Earth orbit?" The movie goes through the rise of the manned space program, and gives much blame to the Nixon administration, who were favoring the cutting of the number of Moon missions from the moment of the first landing, and possibly before. Nixon didn't see the benefit of continuing to send Apollo-type missions after the first one, and wanted to put his own stamp on NASA's direction in space, including cutting out deep-space manned missions. Memos from the Nixon administration are included. But it's worth noting that Nixon resigned in 1974, and we're still stuck in low-earth orbit more than forty years later, despite several presidents proposing missions to Mars or asteroids.

The Friday morning plenary doesn't seem to have happened and turned into a discussion of what NSS is. More interesting was the 10:00 a.m. student plenary featuring Johann-Dietrich Wörner, the Director-General of the European Space Agency, who spoke to hundreds of students about the ESA, which includes 20 members, including several which are not part of the European Union, such as Norway and Sweden. He played a video of the seven planets orbiting TRAPPIST-1, and notes corresponding to each orbit, showing how the resonant orbits produce harmonies. A music of the spheres, so to speak.

Professor Wörner then did a multiple-choice quiz on Kahoot.it, asking questions such as "What destination do you want to go to" (LEO 21, Mars 83, Moon 25, Other 39) and where do you expect us to go (LEO 17, Mars 102, Moon 38, Other 8)? How should exploration be managed (primarily public 23, primarily private 9, parallel 38, mixed 90) and how will it be managed (primarily public 16, primarily private 28, parallel 40, mixed 80). The audience was primarily international students with large contingents from India and China, which may reflect why 80 of the respondents thought the public side should be organized globally, and only six nationally.

I have a recording of Professor Wörner's talk if anyone is interested.

There was a presentation of Current Lunar Missions by Dr. Bradley Joliff. Among these are GRAIL (Gravity Recovery and Interior Laboratory), which is actually a past mission; ARTEMIS, a two-probe mission which has been orbiting the Moon since 2011; and LADEE, which is studying the lunar atmosphere, which is an excellent vacuum, but has found the atmosphere is mostly helium with argon and neon also present. The helium and neon come mostly from the solar wind, argon presumably from potassium 40, a radioactive isotope which has a half-life of more than a billion years. Sodium and potassium ions are indeed present. The Lunar Reconnaissance Orbiter has been orbiting the Moon since 2009; it's best remembered for crashing the LCROSS probe into a crater near the Lunar South Pole and detecting water.

Upcoming is the Chang'e 5 lunar sample return mission due to launch in November. This will land in the Oceanus Procellarum, the only lunar "sea" to be so large as to be called an ocean. It will thus join Luna 9 and 13 and Surveyor 1 and 3, as well as the Apollo 12 lander.

My first panel of Friday afternoon was the "Lunar Power & Light Company" by Daniel Faber, Brad Blair and Gary Barnhard. This is a proposal to create solar power stations in orbit or on the Moon (and eventually, it turned out, around Mars) with the purpose of beaming power to satellites so they don't have to generate so much power on the spot. Their projected power production would be 3-6 kilowatts in 2018 (an ISS experiment), 100 kw in 2020, 100 megawatts in 2024, 2 gigawatts in 2029, 10 gigawatts in 2038 and 50 gigawatts in 2049, by then being from a full-fledged space solar power satellite. (Kip said it would get up to 100 gigawatts by 2100.)

This would require a long-term government commitment to space solar power, and a commitment to developing cislunar space that would require that much power. Among these are to hydrolyze water to produce propellant from lunar ice. [An aside: this seems a bit wasteful of a scarce resource. I would think a lunar base would more likely be taking water in than sending it out. On the other hand, this might be more useful on Mars, which has much more water, or in the asteroid belt.]

Then came the Space Solar Power International Student Competition. This was one of the most interesting presentations of the conference as groups from the US, Netherlands and Japan participated, and two teams from China would be participating through Skype a few days later.

One group was using a mixture of perovskite and quantum dots to produce solar power. Perovskite has a theoretical efficiency of 31% conversion, but the record achieved so far is 22% (which is still pretty good). Quantum dots are theoretically capable of 63% conversion, but at the moment is only 12%. Perovskite has the disadvantage that it tends to sublime at 185 – 234 degrees Centigrade, so the cells must be kept from heating up. I gather the quantum dots are embedded somehow in the perovskite since they would seem to require a matrix.

A second group was doing a comparative study of power generation for Mars missions, and the potential for space solar power systems. There are several problems with generating solar power on the Martian surface, such as dust storms, dust coating the solar panels, and the light intensity varying by 20% due to the elliptical orbit. Thus, the proposal to put a solar power satellite in areostationary orbit and beam power to a rover on the surface. Gaseous attenuation of microwaves would be negligible since carbon dioxide produces much less attenuation that oxygen molecules or water, but they also have to allow for attenuation by dust.

The third group was considering how space solar power can serve the military by supplying power from space to troops in the field. This can potentially save lives since in 2007, three thousand soldiers and support personnel were killed or injured on fuel convoys. Side effects to consider are skin burns and cataracts when the amount of power beamed is 1000 watts per square meter at ten gigahertz.

The Japanese team presented the SACULA project, which I found most interesting. They want to create solar power satellites through a modular design using cubesats, each of which are 50 cm to a side and weigh fifty kilograms. The idea is to fold your solar panels into cubesat and have it unfold in space. These can unfold into squares, hexagons or rings which can then be assembled into a larger satellite. They hope to have a demonstration model working by the 2020 Olympics. What they are proposing is to launch a cubesat that will unfold into a 300-meter ring lined with LEDs. (They showed a video of solar panels unfolded. The solar power collected will light the LEDs, producing a "star" as bright as Sirius. Five rings would make the Olympic rings (though I imagine the black ring would be hard to see at night.) I asked Ed Strickland about this and we figured out that the structure would indeed be visible as a small ring when viewed from the surface of the Earth.

This strikes me as the one of these proposals that has a real chance of happening and people I asked seemed either interested or appalled, the latter thinking what the sky would look like if everybody did this. I'd like to see it happen, though, since it clearly would serve as a demonstration project everybody could see.

Fifth proposal was using solar power generation for station-keeping control, using electric propulsion and solar pressure. With proper orientation, part of the electric thrust could be replaced by solar radiation thrust. (Emission of microwaves itself generates thrust.)

Sixth proposal was "Flexible Adjustment Model for SPS-ALPHA Optical Solution," and I confess I didn't understand it at all. Oh, it had something to do with dynamic distortion of reflecting surfaces, which I can see would be useful, but the details escaped me.

Our speaker on Friday night was Professor Wörner of the ESA on the "ROI of Exploration." Some of this was presented earlier at the student plenary and considered various space programs, but unfortunately, I didn't take notes.

Evening film presentation was a series of student-produced shorts, some of which were pretty good.

Saturday morning's plenary was "Space Pioneers Forum with MAC's Old Team," which was a historical panel including Gemini/Apollo Astronaut Tom Stafford and moderated by Amy Shira Teitel, who is a spaceflight historian. This was in two parts, but, since I was having trouble hearing the panelists in the big hall, I bailed out at ten to the thread on "Space Settlement and the Human Experience." First talk was "Biological Requirements of Sustainable Space Settlements," by John Mankins. Among the questions are what is the minimum scale requirements for such a settlement, and what are the integrated biological requirements.

A sustainable settlement must be sufficient and resilient. Air and potable water must be available indefinitely. There must be sufficient nutrition. And finally, to be a true settlement, there must be children and genetic variety. [I've read that fifty breeding pairs are needed to prevent excessive inbreeding.]

Biological implications of self-sufficiency: (1) there must be fauna (e.g. worms) and fungi to create viable soil, (2) internal and external microbiota, (3) enough viral and bacterial preparation to keep immune systems healthy (i.e., a certain amount of illness must be tolerated to keep the immune system from attacking the body.) (4) Genetic diversity—not only of humans, but plants, fungi, animals and microbiota. This will require monitoring of genetics of all species brought to the settlement. He has 40 people of breeding age originally, up to 120 for steady state. In a steady state, he would require 480,000 square meters of soil to a depth of at least half a meter and ideally a meter. The whole colony would require 720000 kg living mass, not counting the crops and the humans themselves. Over thirty days, over ten million kilograms of water would be requited (ten million liters since a liter has a mass of a kilogram), much of which would be recycled.

[It was pointed out to me at the OSA meeting that this analysis ignores hydroponics, which would indeed reduce the amount of soil required, but I'm not sure it could meet all needs, such as a healthy microbiota and immune systems. And you'd still want some animal species around.]

Dr. Behrokh Khosnevis spoke on construction lunar bases, using sulfur concrete molding and 3D fabrications, including tiling with modified hexagons, which fit together much like jigsaw puzzle pieces. This can create a flat surface for landers.

Mike Snyder spoke on 3D Printing for Space, which I mentioned in the minutes for the June meeting.

James Logan spoke on the seven essential criteria for the perfect space settlement site. What he wants is (1) low Delta V to get there, (2) lots of resources, (3) little or no gravity well, (4) near-Earth gravity, (5) natural radiation protection, (6) ability to have large redundant ecosystems, and (7) a staging area for further expansion. He's looking at the Martian moon Deimos, with the colony inside and presumably spun up to produce gravity. (Why not Phobos?) I think he's too pessimistic on (4); we don't really know how much gravity is required (though it isn't 0), and Martian gravity may be enough. However, Mars does present radiation problems.

I skipped the noon lunch and discovered a sandwich truck outside, which did reduce my lunch expenses. Then I went to Jaime Yarbrough's talk, "Space Fungi, Off Earth," which unfortunately was not about mutant space fungi, but about fungi on Earth, and how we use them, and what uses we will put them to in space. He didn't really have anything to say about the effects of space on fungi. He did talk of using mycostructural materials (i.e. fungus tissue), soil enhancement, and fuel.

I missed the initial talks on space elevators, but eventually did attend one on materials we can use for their construction. (This was probably Dr. Dennis Wright's.) One question to be considered is whether

carbon nanotubes are slippery, and, if so, how can we increase friction. What do we use for braking, and can we recover energy from slowing down? A mass of six tonnes are recommended for the climber, with fourteen tonnes of payload. He wants to beam lasers to power the climber, which sounds dangerous. We don't know if carbon nanotubes are good conductors, but if they are, we could use them as a power cord.

Space elevators would have to go through several different radiation regimes, which include cosmic rays, the Van Allen Belts, and the solar wind. The ascent to geosynchronous orbit might take a week. Without shielding, the radiation might prove lethal. Hard electronics are also necessary.

What effects does radiation have on space elevator material? This would depend on the material, and the next talk by Mark Haase was on that. Materials for space elevators must have a high specific strength, chemical stability, radiation resistance, be repairable and maintainable, and allow industrially viable production.

Carbon nanotubes are usually proposed. Their density is one or two grams per cubic centimeter (i.e. one or two times that of water), and they have a strength of 10 – 100 gigapascals. They have variable conductivity, are pretty chemically stable, and can heal themselves. Nanotubes start to burn at 600° C, and once they start burning, they also crumble.

Graphenes are similar. They're strong in a planar direction, fairly flexible, are good conductors, and about as reactive as carbon nanotubes. It's easy to repair serious defects. Since they are planar, I assume the plan is to roll them up.

An intriguing possibility is boron nitride nanotube. These have a strength of 30 gigapascals, are very chemically stable, have about the same density as carbon nanotubes, act as electric insulators, and are radiation resistant. Since one form of boron nitride is similar to graphite, it should also form sheets like graphene, but those are still theoretical.

The Saturday dinner talk was "NASA and the Ingenuity of a National Space Exploration Program" by William Gerstenmaier, who received the NSS Pioneer Award, but I don't remember anything about his talk. This was also the NSS Chapter Awards banquet, and Oklahoma Space Alliance got an award for space outreach.

The Sunday Plenary was "Exploring the Space Frontier in a Revolutionary Vehicle with a Storied History," with Jane Poynter, the CEO of World View Enterprises. This was a little offbeat for a plenary, because World View specializes in building helium balloons that carry people to an altitude of twenty miles, and sometimes people jump out of them. One of these jumpers, Baumgartner, became famous a few years ago by jumping from an altitude of 24 miles and breaking the sound barrier as he fell.

Poynter was talking about designing a capsule that will go above 99.95% of the Earth's atmosphere. They want a platform that can stay over an area for weeks or months.

Although she didn't go into it, Space View is also a near-space tourist organization who plan to offer passengers a chance to view the curvature of the Earth and a black sky during the daytime.

Dr. Pascal Lee talked on going to Mars via the Martian Moons Deimos and Phobos. There are numerous questions about these satellites, including whether they are natural moons or captured asteroids. It's not even known whether they are related. When compared with largest near-earth asteroids, the largest in order are Ganymed>Eros>Phobos>Don Quixote>Deimos. The first two are D Type asteroids (i.e. stony), while Don Quixote a D type, is reddish and dark, probably from organic compounds, as well as carbon compounds and silicates. These are more usually in the outer asteroid belt as well as Jupiter's collections. Phobos and Deimos resembles Don Quixote, and, if they are captured asteroids, are D-type.

Why go to Phobos and Deimos? First, it takes minimal delta-V to get to them from Earth. They are excellent posts from which to monitor Mars. It's a very short time to communicate with robot landers. It would advance our understanding of small bodies in space. Finally, they might contain water and other resources.

The other Space Pioneer Award went to the Kepler Team, which was accepted by Kepler Project Manager Charles Sobeck and project scientist Natalie Batalha. MC was Dr. Shawna Pandya, who we'll

meet again below. This was a particularly lively presentation and one of the most enjoyable at the conference.

The purpose of the original Kepler mission was to determine what fraction of stars in the galaxy host potentially habitable planets. To do this, it viewed a small patch of sky for three years, looking for the tell-tale dips in brightness produced when a planet crosses its star's disk. It detected a lot of hot Jupiters at first, but longer observations detected smaller and smaller planets, some of which are smaller than Earth.

Kepler started with four gyros, one of which was lost in 2013 and another in 2014. This ended the original mission, so Kepler is now on a second mission, which is to examine fields of stars near the ecliptic for eight days. (The time limit is because its solar panels must point toward the Sun.)

In retrospective, before Kepler began its mission, there were 326 confirmed exoplanets, all of which were far larger than Earth and most larger than Jupiter. (This doesn't count pulsar planets.) Now there are 3483 confirmed exoplanets, 2482 from Kepler, with another 2400 candidates. (I think this was before the last announcement, which means there are several hundred more confirmed exoplanets. This changed the size distribution of exoplanets: the most common detected are between Earth and Neptune in size, no examples of which are in the Solar System. There are also quite a few smaller than Earth, and a few as small as Mars. (There are probably a lot more smaller than Earth since they're hard to detect.) There is a gap in size between 1.4 and 1.9 Earth radii; the latter presumably kept more of their hydrogen/helium envelopes.

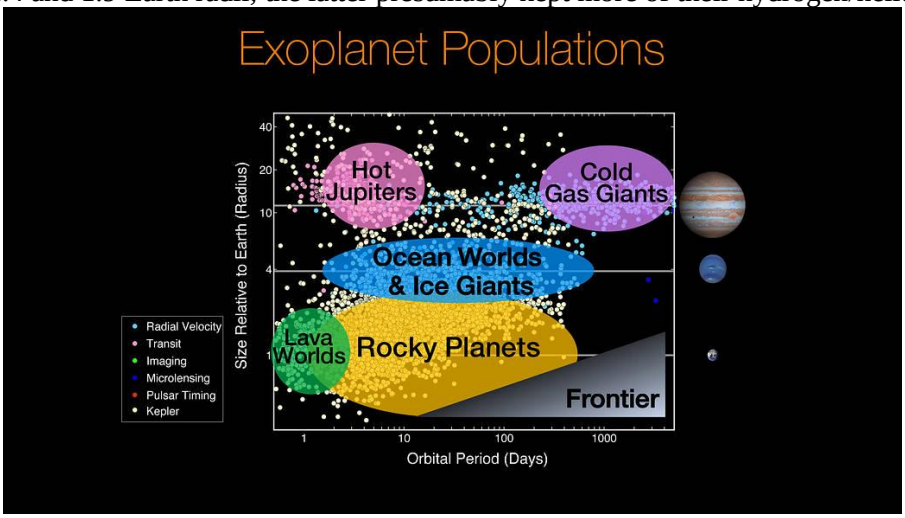

Figure 1 Exoplanet Populations Detected by Kepler and by other Methods

On average, every sun-like star has at least one planet, and the potentially habitable planet around a sunlike star is within 35 light-years. (Probably considerably closer since many haven't been thoroughly examined.)

Bode's Law doesn't seem to apply to exoplanetary systems.

One question that was expected was about Tabby's Star, which was detected by the Kepler team. Tabby's Star had a two-percent dip in brightness for the week of May 14 – 21. The team was expecting to make an announcement within a month.

Sunday afternoon, the conference wound down a bit. I went to the thread on "Perspectives on Space Medicine and Technologies," with James Logan, Shawna Pandya, and William Gardiner. Logan pointed out that the surface radiation dose on Mars is more than two hundred times that of Earth. Dr. Pandya spoke on "Reproduction and Sexuality in Space," According to one astronaut, fluid shifts produce a Viagra effect, but there's also speculation astronauts might become impotent in Space. Probably depends on

the astronaut. Rat embryos experienced growth retardation and higher rates of hydrocephalus and hemorrhage.

Both male and female astronauts have parented health offspring after spaceflight, but there is a higher rate of spontaneous abortion among female astronauts.

Dr. Gardner spoke of nutrition, including diabetes and metabolic disorders, but, as near as I could tell, never really connected it with space medicine.

Sunday night movie was Pascal Lee's *Passage to Mars*, which proved a pretty good cure for insomnia, so I decided to rest up for my return drive.

Attendance this year was about eight hundred, but I don't know if that includes the youth participants, which numbered a couple of hundred. Since many of these were from outside the US, the conference had a pleasant international feel.

Sky Viewing: Total Eclipse at Last

On August 21, 2017, the contiguous 48 states will experience its first total eclipse since February 26, 1979. For the southeastern US, it will be the first since March 1970. The most recent total eclipse seen in any part of the US was the July 11, 1991 total eclipse, which was visible in Hawaii.

This is a totally American total eclipse: that is, the only places where the path of totality crosses the land are in the contiguous 48 states. The last eclipse to do that was in 1257 A.D. This is also a partial eclipse over all of North America.

Although I've included a map of the eclipse path, I recommend the August 2017 issue of *Astronomy*, which has twelve pages of maps showing the path of totality, giving the time and length of totality for each location. Although the length of totality varies, it's two minutes on the West Coast, but two and a half minutes from eastern Wyoming through South Carolina. The longest period of totality is in southern Illinois near Carbondale (which also gets the 2024 eclipse; life is unfair), two minutes and 42 seconds. Really, though, totality is pretty much the same length anywhere east of the Rockies.

Since you'll have to travel, here are times totality begins for various locations:

Landfall near Lincoln Beach, Oregon, 10:17 a.m. PDT. Salem, Oregon, 10:18 a.m. PDT. Idaho Falls, Idaho, 11:33 a.m. MDT. Casper, Wyoming, 11:44 a.m. MDT. Grand Island, Nebraska, 12:59 p.m. CDT. Lincoln, Nebraska, 1:03 p.m. CDT. Kansas City, Missouri (northern part), 1:09 p.m.

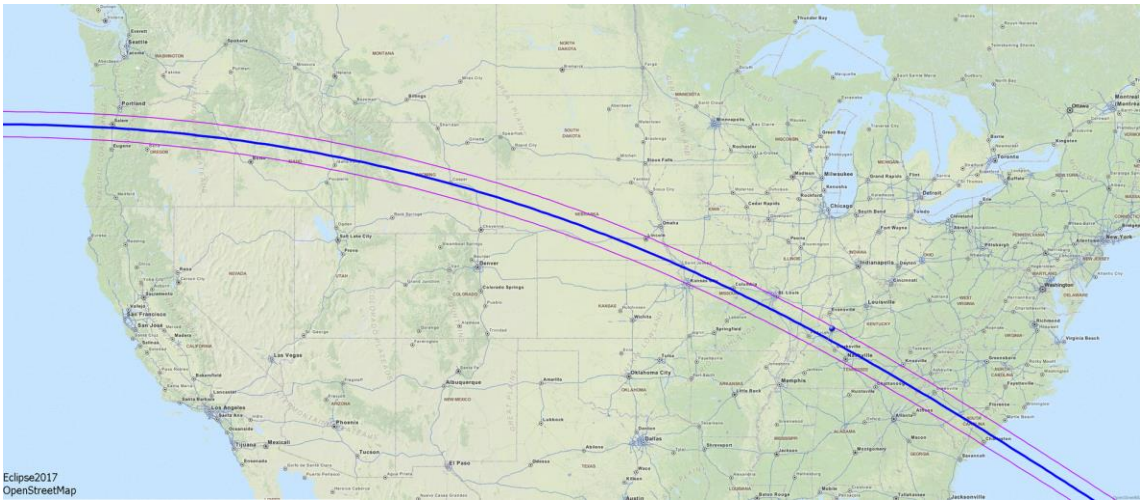

Figure 2 Path of August 21 total eclipse (Wikipedia)

CDT. Columbia and Jefferson City, Missouri, 1:13 p.m. CDT. Saint Louis (southern part of urban area), 1:18 p.m. CDT. Carbondale, Illinois, 1:21 p.m. CDT. Nashville, Tennessee, 1:28 p.m. CDT. Columbia, South Carolina, 2:43 p.m., EDT. Charleston, South Carolina, 2:47 p.m. EDT, where the path of totality enters the Atlantic. The largest city entirely within the path of totality is Nashville, but Columbia, South Carolina, Columbia and Jefferson City, Missouri, Casper, Wyoming, and Salem, Oregon are all closer to the central line of totality. The closest location to Oklahoma City appears to be Kansas City.

Although the eclipse won't be total in Oklahoma, the Sun will be almost 90% obscured, which will noticeably darken the sky. It should be dark enough to see Venus, and it's possible Jupiter might also be visible. I'm not sure any stars will be visible, though some bright stars such as Sirius, Procyon, Betelgeuse and Rigel will be above the horizon. (These will all be visible in places where the eclipse is total.)

After the August 21 eclipse the next total eclipse of the Sun visible from the US will be on April 8, 2024. That one will cross northern Mexico, Texas (including Dallas), Arkansas (including Little Rock), southeastern Missouri, southern Illinois, Indiana (including Indianapolis), northern Ohio, New York and Maine as well as part of the Atlantic provinces of Canada. (It looks to me like it might be total in Cleveland and Buffalo and nearly so in Detroit. It also just misses Hamilton, Toronto and Montreal, Canada. In other words, this will be easily accessible to tens of millions of people.) This will be the next total eclipse visible in Oklahoma: the path of totality just clips the southeastern part of the state. The path of the 2014 total eclipse crosses the path of this year's in southern Illinois near Carbondale, Illinois, and that city, Cape Girodeau, Illinois, and Paducah, Kentucky will all experience two total eclipses in less than seven years. There may be a lot of people getting married around the time of this eclipse since the path of totality passes over Niagara Falls.

The next total eclipse to cross the US after that one is that of August 12, 2045, which crosses the US a few hundred miles south of this year's, and whose path includes Norman and Oklahoma City. The 2045 eclipse will be a particularly long one. I can hardly wait.

Every place on Earth eventually gets a total eclipse, but some have to wait a long time. The area that is now Delaware hasn't had one since 1478 (its next is in 2144. The District of Columbia won't get one until 2444.

By the way, places in the Northern Hemisphere get a total eclipse on average once per 330 years and those in the Southern Hemisphere get one once per 540 years. I'll tell you why the difference later, but give you a chance to guess.

The eclipse gives you a chance to see planets during the daytime. Although **Mars** be about eight degrees east of the Sun and should be easily visible, although at magnitude 1.8, it won't be spectacular. **Venus** will be visible even in areas where the eclipse is not quite total, such as Oklahoma. **Mercury** will be nearing inferior conjunction with the Sun, hence will be dim enough to be drowned out by the Sun's corona. **Jupiter** will be low in the southeast. **Saturn** will be below the horizon.

The reason total solar eclipses are more common in the Northern Hemisphere is a combination of two factors: solar eclipses are obviously more likely when the Sun is in the sky, and most likely on the longest day of the year, which is June 21 in the Northern Hemisphere and December 22 in the Southern Hemisphere. However, the Earth is at perihelion in early January, so the Sun looks biggest and the eclipse would most likely be annular rather than total. The Earth reaches aphelion (farthest point from the Sun) in early July, so the Sun appears smallest and the eclipse is more likely to be total.

By the way, the percentages of different kinds of solar eclipses are: partial, 35%, annular, 33%, total 27%, hybrid 5%. That surprises me; I would have thought a much higher percentage of partial eclipses. (A hybrid is an eclipse which is annular along part of its route and total during another part. This happens because the point of Earth directly beneath the Moon is 4000 miles close than a point where the Moon is on the horizon.)

[This and a lot of the trivia in this section come from the article "19 Big Eclipse Surprises" by Michael E. Bakich in the July issue of *Astronomy*.]

Sky Viewing

The big sky viewing event for this issue is the August 21 total eclipse of the Sun, which will be visible on a path that extends from Oregon to South Carolina. I have details above.

August is the month for the Perseid meteor shower, which peaks starting about 10 p.m. on the nights of August 11 and 12 and continuing into the early morning. The Moon will be nearing last quarter, and will interfere with viewing. Still, the brighter meteors should be visible at the rate up to thirty meteors per hour.

Mercury is currently lost in twilight at sunset, but is approaching a greatest elongation on July 30. However, it will only be eight degrees above the horizon a half-hour after sunset and magnitude 0.4, so it won't be easy to spot. (Mercury's actually brighter a week or so earlier, but also deeper into twilight.)

Venus is currently a morning star and, at magnitude -4.2 is easily visible in the east before, and even during, sunrise. In August, Venus will be rising more than two hours before the Sun and will be high in the sky during the eclipse.

Mars is in conjunction with the Sun on July 27 and will not be visible during July or August, except on August 21 to those experiencing the total eclipse. (See above.)

Jupiter is the bright planet you're seeing in the southwest after sunset. Currently it is magnitude -2 and will stay that bright through August.

Saturn is magnitude 0.1 and reasonably high in the eastern sky at sunset, and is the brightest object in that part of the sky. In fact, this is about as bright as Saturn gets. Saturn is still in an inconspicuous part of Ophiuchus, the Serpent Bearer. This constellation isn't one of the signs of the Zodiac although it contains much more of the ecliptic than Scorpio. The reason for this is because the part of Scorpius around the ecliptic is conspicuous (and because Libra used to be the claws of the Scorpion.)

By the way, Scorpio = astrological sign, Scorpius = constellation. Not sure why they're different, though the former is closer to the Greek and the latter is Latin. Similarly, Capricorn = sign, Capricornus = constellation.

[Information for this section from the July and August issues of *Astronomy* and *Sky & Telescope*, and www.skyandtelescope.com.]

Viewing Opportunities for Satellites (July 8 – August 14, 2017)

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, which causes problems with some web browsers. In fact, I'm currently using Microsoft Explorer until I can get it working in Firefox on my new computer. I also had to add the site to the security settings in the Java Control Panel, and discovered I also had to add the "s" to https to tell Java it's a secure web site. Writing newsletters is an education.) 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 or Tiangong 2, so I'm using Heavens Above for those. 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. With this issue, I'm also including data for Tiangong 2, which can get up to magnitude 0.4 at least.

Missions to and from the International Space Station or Tiangong-2 may change its orbit. The next manned flight to the Space Station launches on July 28. I know of no scheduled manned flights to Tiangong 2; however, China docked a Tianzhou unmanned cargo spacecraft with Tiangong 2 on April 22, and might be expected to do more such tests.

Tiangong-2 July 13, 2017

Time	Position	Elevation
10:35 p.m.	253°	10°
10:38	336	64
10:39	49	30

Vanishes into Earth's shadow

Tiangong-2 July 14, 2017

Time	Position	Elevation
9:38 p.m.	236°	10°
9:41	151	12
9:44	66	10

Tiangong-2 July 16, 2017

Time	Position	Elevation
9:22 p.m.	257°	10°
9:25	337	56
9:28	57	10

HST July 18, 2017

Time	Position	Elevation
9:18 p.m.	218°	19°
9:19	200	25
9:20	174	29
9:21	148	25
9:22	130	19

HST July 19, 2017

Time	Position	Elevation
9:08 p.m.	222°	19°
9:09	203	26
9:10	176	30
9:11	150	26
9:12	131	20

ISS July 21, 2017

Time	Position	Elevation
6:01 a.m.	338°	20°
6:02	347	35
6:03	39	50
6:04	91	35
6:05	108	20

ISS July 22, 2017

Time	Position	Elevation
9:47 p.m.	194°	18°
9:48	174	30
9:49	133	38
9:50	91	29
9:51	72	18

ISS July 23, 2017

Time	Position	Elevation
10:31 p.m.	266°	17°
10:32	285	27
10:33	334	34
10:34	2	27
10:35	21	17

ISS July 24, 2017

Time	Position	Elevation
9:38 p.m.	237°	21°
9:39	264	40
9:40	319	71
9:41	31	40
9:42	40	21

Tiangong-1 July 26, 2017

Time	Position	Elevation
6:01 a.m.	251°	10°
6:04	255	66
6:06	59	10

Tiangong-2 July 26, 2017

Time	Position	Elevation
9:36 p.m.	297°	10°
9:40	18	88
9:43	116	21

Vanishes into Earth's shadow

Tiangong-1 August 12, 2017

Time	Position	Elevation
9:04 p.m.	229°	10°
9:07	150	56
9:09	70	10

ISS August 12, 2017

Time	Position	Elevation
9:12 p.m.	322°	21°
9:13	333	39
9:14	40	a66
9:15	108	39
9:16	120	21

Tiangong-1 August 13, 2017

Time	Position	Elevation
9:22 p.m.	258°	10°
9:24	337	51
9:27	55	10

ISS August 14, 2017		
Time	Position	Elevation
9:03 p.m.	290°	18°
9:04	271	31
9:05	227	41
9:06	182	31
9:07	163	18

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 International Space Station at 9:40 p.m. on July 24, measure about four fist-widths west from due north, then seven 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

July 28: 9:30 a.m. Launch Coverage of the launch of mission 52-53 to the Space Station. Actual launch is at 10:41 a.m.

July 28: 4:00 p.m.; Docking coverage of Soyuz carrying mission 52-53 with the Space Station. Docking is scheduled at 5:00 p.m.

July 28: 6:30 p.m.: Hatch opening coverage begins. Actual hatch opening will be approximately at 7:00 p.m.

Calendar of Events

July 8: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., Earl's Rib Palace in Moore, Oklahoma.

July 12: [tentative] Oklahoma Space Industry Development Authority [OSIDA] meets at 1:30 p.m. the Oklahoma Department of Transportation Building in Oklahoma. Call 580-562-3500 to verify.

July 14: Oklahoma City Astronomy Club meets at Science Museum Oklahoma (formerly the Omniplex). 7:00 p.m., followed by a talk at 7:45 p.m. See http://www.okcastroclub.com/ for details.

July 20: 48th anniversary of the *Apollo 11* landing on the Moon.

July 27: Mars is in conjunction with the Sun.

July 28: Randy Bresnik, Paolo Nespoli and Sergei Ryazanskiy will be launched to the Space Station via a Soyuz capsule.

July 30: Mercury is at greatest eastern elongation, 27 degrees from the Sun (so can be seen after sunset).

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

August 11: Oklahoma City Astronomy Club meets at Science Museum Oklahoma (formerly the Omniplex). 7:00 p.m., followed by a talk at 7:45 p.m. See http://www.okcastroclub.com/ for details.

August 12: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., Earl's Rib Palace in Moore, Oklahoma.

August 12: Peak of Perseid meteor shower.

August 21: 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.

August 26: Mercury is in inferior conjunction with the Sun.

September 5: Neptune is at opposition.

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

September 9: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., Earl's Rib Palace in Moore, Oklahoma.

September 12: Mercury is at greatest western elongation, 18 degrees from the Sun (so can be seen before sunrise).

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

September 30: [Moved from March.] 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

September 30: Launch of Expedition 53/54 to the Space Station.

October 4: 60th anniversary of the launch of *Sputnik 1*, the first spacecraft to orbit the Earth.

October 8: Mercury is at superior conjunction with the Sun.

October 11: Peak of Orionid meteor shower.

October 14: [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., Earl's Rib Palace in Moore, Oklahoma.

October 19: Uranus is at opposition.

October 26: Jupiter is in conjunction with the Sun.

November: China launches the Chang'e 5 lunar sample return mission. This will be the first spacecraft to return material from the Moon since 1976. (The Soviet Union's Luna 24.)

November: Launch of Expedition 54/55 to the Space Station.

November: First (unmanned) flight of SpaceX's Dragon 2 Spacecraft. Dragon 2 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.) This flight will take it to the Space Station.

November 11 [Tentative] Oklahoma Space Alliance meeting, 2:00 p.m., Earl's Rib Palace in Moore, Oklahoma.

November 17: Peak of Leonid meteor shower

November 24: Mercury is at greatest eastern elongation, 22 degrees from the Sun (so can be seen after sunset).

December: 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: 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.

December 13: Mercury is in inferior conjunction with the Sun.

December 14: Peak of Geminid meteor shower.

December 21: Saturn is in conjunction with the Sun.

December 22: Peak of Ursid meteor shower.

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: Possible unmanned SpaceX mission to Mars.

Early 2018: India launches *Chandrayaan-2* to the Moon. The mission consists of an orbiter, lander and rover.

April 12, 2018: Yuri's Night. 57th anniversary of the first man in space.

May 2018: SpaceX will launch a Dragon-2 capsule to the International Space Station. This mission will be the first American spacecraft to carry people to orbit since 2011. [See August.]

May 5, 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.]

June 2018: 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.

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.)

August 2018: Boeing's CST-Starliner makes its first crewed flight. If the May SpaceX mission is delayed, this will be the first American spacecraft to carry astronauts to orbit since 2011, otherwise it will be the second.

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

October 2018: The European Space Agency/JAXA *BepiColombo* Mercury Orbiter is launched. Home page is http://sci.esa.int/bepicolombo.

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.]

December 2018: Boeing's CST-100 Starliner carries two astronauts to the Space Station. See https://en.wikipedia.org/wiki/CST-100_Starliner for details.

Late in 2018: SpaceX plans to launch a human crew around the Moon.

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

September 2019: Arrival of OSIRIS-Rex at the near-earth asteroid 101955 Bennu to return samples. For more information, visit http://en.wikipedia.org/wiki/OSIRIS-REx or http://science.nasa.gov/missions/osiris-rex/.

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*.

July 2020: ESA launches the *ExoMars Mars Rover*. [Postponed from May 2018.] For more information, visit en.wikipedia.org/wiki/Exomars.

July 2020: Launch of the *Mars 2020* space rover, which will arrive on Mars at the beginning of 2021.

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.

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

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

Oklahoma Space Alliance Officers, 2017 (Area Code 405)

Steve Swift, President & *Update* Editor	496-3616 (H)
David Sheely, Vice President	821-9077 (C)
Syd Henderson, Secretary & *Outreach* Editor	321-4027 (H) 365-8983 (C)
Tim Scott, Treasurer	740-7549 (H)
Claire McMurray, Communications	329-4326 (H) 863-6173 (C)

OSA E-mail Addresses and Web Site:

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

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

Other Information

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

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

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

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

The National Space Society's Headquarters phone is 202-429-1600. Executive Director e-mailnsshq@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 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

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Please enroll me as a member of Oklahoma Space Alliance. Enclosed is:
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To join the Mars Society, visit www.marssociety.org. One-year memberships are $50.00; student and senior memberships are $25, and Family memberships are $100.00. Their address is Mars Society, 11111 W. 8th Ave, Unit A, Lakewood, CO 80215.

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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.**