NORTHWEST EARTH AND SPACE SCIENCES PIPELINE

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"Meet a NASA Engineer" #2 — John Gruener (May 14, 2019)

SPEAKER: you want to ask ques-- there we go. If you want to ask questions, put them on the chat room and we'll try and answer them as we have time. So John is an engineer here, working on Apollo and Beyond. And he's going to give us his discussion about what it means.

JOHN GRUENER: All right. Well, I will share my screen. So everybody can see that OK? How do I get rid of this page?

PAIGE: It just kind of disappears.

JOHN GRUENER: Or this-- can I minimize this?

PAIGE: Yep.

JOHN GRUENER: All right. So you introduced me as an engineer, and that's certainly how I started out here at NASA. I got my bachelors of science in aerospace engineering from the University of Texas because when I was in high school and I talked to my high school counselor about careers and jobs, we didn't really know a lot about the space program. But I wanted to work in this space program, and we thought aerospace engineering sounded like a good job to get if you wanted to work in the space program.

But when I was a little kid and going through school, my favorite subjects were science and history. And I love being in the outdoors. And sometimes I wish my high school counselor would have known about planetary science and planetary geology, and maybe I would have gone into that straightaway. But I did discover that when I started working here at the Johnson Space Center as an engineer working with scientists on what they wanted to do on the Moon, and it was so cool I started to go to night school.

So I worked during the day as an engineer. I went to night school to learn planetary geology. At the time, I was married. We had two kids. So it was kind of a crazy time in my life. But it's been an awful lot of fun.

These pictures on the bottom-- the one where I'm in the work red flannel shirt, that's out at Los Alamos. And those are big volcanic pyroclastic flows behind me, really, really thick. And then in the middle on the bottom, that's me standing in front of a big crater out in Arizona. But that's a big volcanic crater. It's called a maar volcano where magma coming up from below hits water, and then that waters get turns into steam, and then all that pressure creates an explosion. So we call those maar craters. So that's a big maar crater behind me. It's not an impact crater.

And so some of the things-- Paige asked me to put these little three things down, these three attributes of what has been important to me to make my career successful, both as an engineer and a scientist. And of course, number one is be really flexible on what you can do and what you're are open to doing. You can't really have a fixed mindset that I'm only going to do this and nothing else. You want to be flexible in everything you do, and a good way to allow that flexibility is to get a really good basic

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education in math and science and English, history. You get a good basic education and that allows you to be more flexible.

And then what's really helped me here at NASA, and got me in trouble when I was a little kid in elementary school, is I have quite an imagination. So I talk a lot and I think a lot of crazy things, but turns out that's pretty a nice thing to have here at NASA, to be creative and imaginative, and in any career, really. If you're trying to come up with something new for the very first time, whether it's space stuff or whether you're coming up with a new electronic gizmo to connect to the Wi-Fi or whatever, that imagination and creativity will carry you a long way. So you can get a good basic education, be real flexible, have a lot of imagination and creativity.

But if you don't work hard, you don't really ever get anywhere. So you always have to work hard no matter what you're doing in life, whether it's schoolwork, whether it's a sport you're playing like soccer or baseball, or you get a job. Like, here we are at NASA being a planetary scientist. So you've always got to work hard to make meaningful accomplishments because if you're just going through the motions and you're not really accomplishing anything, well, then what's the point, right? We all want to do something special in our lives.

So how do I--

PAIGE: If you click on your slide, you should be able to get to the-- click on it. Oh, there you go.

JOHN GRUENER: Oh, so I don't have to do the Return button?

PAIGE: I don't think so.

JOHN GRUENER: All right. So when I was a little kid in elementary school, this is what I got to watch on TV. Now, at the Gruener house, it was a black and white television. We didn't see the colorful gold foil on the bottom of the lander-- that's for thermal reasons, that's like insulation-- and the red, white, and blue of the American flag on our black and white TV. It was all gray. But as a kid, this was really, really cool stuff. And people my age are all over the space program, and so it was Apollo that really inspired us to do this.

So here I am in the red tennis shoes with the arrow pointing at me. I'm about five years old, and this was my first day on the job at the Johnson Space Center. Well, not really, but it was a family visit because-- I don't know. Can you see my picture?

So this was my uncle Don and he worked at NASA during the Apollo program, and he would bring us down to the Johnson Space Center and show us all sorts of cool stuff. And what we're standing in front of, this big, dark room back there, is a huge thermal vacuum chamber where we could put spacecraft. So you kind of see this spacecraft in there. You can put spacecraft in this big room, shut the door, and suck out all the air to make it a vacuum of space. And then you can make it either really, really hot like the

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Sun shining on it, or really, really cold to see if your spacecraft or your hardware can actually survive in that environment.

And as a matter of fact, here's a picture me at five years old. And today I'm 58, and I'm probably sitting about 200 yards away from this very building. So I'm in the last five years of my career, and it's ending just about where it started back when I was a little bitty kid.

So next slide. So like I said, when I talked to my high school counselor about what to work at NASA, we thought aerospace engineering. And when you go to aerospace engineering, you learn how to build spacecraft, rockets. If you'd stay atmospheric, you learn about airplanes and helicopters. The middle graphic there is trajectories from the Earth kind of going out to Mars, and there's the Sun in the middle. So you learn how to calculate these kind of trajectories from a circular orbit of the Earth, an elliptical orbit of Mars, and then you can calculate a trajectory.

So you learn all that stuff in aerospace engineering, and so I was well prepared to come to work at NASA. But when I started working on missions to the Moon or Mars, I also worked with mechanical engineers who design things that would work on the surface, such as these cars. These are pressurized rovers, so kind of like submarines that would actually drive around on a surface of the Moon or on Mars where you don't have much atmosphere, so it all has to stay contained in that vehicle. They build spacesuits. Of course, they build robots, all sorts of robots.

I also worked with chemical engineers who want to take the dirt on Mars or the dirt on Moon and chemically break it up, and then collect things like oxygen and hydrogen and water and metals like iron and aluminum that we can build stuff. So I worked with a whole bunch of engineers on what would we want to do on Mars some day or at the Moon, using the Moon as a proving ground or how to work and live.

And one of the things we had to do, of course, was talk to the scientists and say, well, what is it like on the Moon? Because our engineering systems are going to have to work in that environment. What is it like on Mars? And once you kind of get an idea of the environment, then you start talking to the scientists about, well, what do you want to do there? Because it's not so much the engineers that are going to really do anything on Mars. They're designing the things to work on Mars. It's going to be the scientists or the people who are trying to use these natural resources that want to do something there.

So that was-- oh, and one more engineer we worked with, so civil engineers. And of course, they do a lot of mining here on Earth. So we're going to do mining on the Moon or Mars to get to those resources so that we can use them. But I came across this quote as I was going through my career at NASA, where the crossing of interplanetary space is a huge technical problem, but it's not an end in itself. It's just the beginning. And then there's no point in going somewhere unless you do something when you get there, and that doing something was all of what the scientists were talking about when I was talking to them about engineering things.

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So this was kind of where I changed my career to where I didn't really care to be an engineer anymore because we had about 10,000 or 12,000 engineers at the Johnson Space Center. What I really wanted to do is talk about more of what are we going to do on the Moon or Mars and why. And so this led me to my career as a scientist, and so the career field I work in is planetary geology. These are some of our co-workers here where we will spend our time in the labs, like at the bottom.

Andrea here is actually holding a Moon rock in our curation facilities because when the Apollo astronauts went to the Moon, they brought back lots of rocks and dirt. And so we saved those in special cabinets full of nitrogen gas so they don't change from the way they were on the Moon. And then people like Kelsey right here, Kelsey Young, and Stephanie-- Stephanie is actually an astronaut. We go out in the field and practice on how we might explore the Moon again with new technologies, or how we might explore Mars someday.

But geology is only one of the sciences. We work with astronomers, and I think one of the cool things is finding all these planets out there around other suns and other stars. And now we've found about 3,000 planets outside of our solar system. And of course, the real fun part is are these potentially habitable planets, and maybe people could live on these things or other life forms are living on these things. So we work with astronomers and of course, we work with biologists because we've got to keep our astronauts up here healthy and happy.

We will grow plants in our life support system so we'll have food to eat. And of course, through photosynthesis, plants give us oxygen to breathe and through transpiration they give us water to drink. So plants are going to be a big part of our life support systems.

And then, intriguingly, down here in the bottom, you see this little worm-looking thing. Some people in our building thought that was fossilized bacteria in a meteorite that came from Mars. And so if a rock that came from Mars has fossilized bacteria in it, what is that telling us about life elsewhere in the solar system or elsewhere in the universe? So the biologists have some pretty cool things they're working on.

So we're going to focus now on the Moon because that's what we're working on in a big way right now, getting back to the Moon to do different things. But here you are, in 30 seconds and all one slide, what we learned from the Apollo missions. First, we found out that the Moon likely formed when a Mars-size planetary body was flying through space and it smashed into the Earth. Part of the Earth was flung out into space, and then that kind of accumulated. All those bits and pieces accumulated in orbit around the Earth, and then all those bits and pieces kind of came together to make our Moon. And all of that happened about 4.5 billion years ago.

And this very old surface of the Moon has been beat up by constant impacts from meteorites. Well, meteorites fall on the Earth, but meteors, asteroids, comets, all those things that have smashed into the Earth have also smashed into the Moon, making big round craters like this guy right there. There's a big impact crater, big impact crater. There's a smaller one, but they're all over the Moon. Here's a bright one, so that's a lot younger because you can see all the stuff that came out of this crater is laying on top of the older stuff.

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So this one here, that's a bright new crater because, look, all of the ejecta that came out of the crater is laying on top of the dark surface. So the lighter stuff came after the darker stuff. So it turns out that darker stuff on the Moon is lava. It's just good old basalt. Covers our ocean floors, comes out of the ground in Hawaii, eastern Washington, all over the place. Matter of fact, basalt's the most common rock in the inner solar system. It's on Mercury, Venus, Earth, the Moon, Mars. It's all over the place. So those are the dark areas of the Moon.

So big lava flows filled up some of these holes and created the maria regions. Maria is Latin for seas, and a long time ago when people would look through the Moon with little telescopes, they kind of thought those dark areas were like seas just like they're here on the Earth. So the brighter areas are what we call the highlands. And it's a different rock, so maybe if you've done geology in your science class, you've done Mohs' scale and rock hardness, and you know there's a mineral out there called feldspar. It's very hard. It's, like, nine on Mohs' scale. 10 would be diamond, so it's really, really hard stuff. But we think this bright area is, like, the original crust of the Moon right, and really, really old.

So when you look up at the Moon at night, you see the old, bright highlands. You see the younger, smoother mare. You see the craters all over the place that have battered the Moon, and what that constantly impacting and beating up of the Moon has done to all the rocks is it's turned it into dirt or soil. We call it regolith. So the whole Moon is covered with anywhere from 3 or so meters to maybe 15 meters deep of this dirt, or this regolith.

So these Apollo missions that I watched as a kid brought back about 840 pounds of rocks and soils. And of course, they were looking at them intensely in those early 1970s, but even today people are still looking at these very same Moon rocks but with new technology, new instruments that didn't exist during the Apollo days. And so even though these rocks were brought back to the earth over 50 years ago, we're still looking at them today with brand new technologies and new science instruments, and making new discoveries. So we always talk about these rocks and these samples brought back from the Moon as the gifts that keeps on giving because as our technology improves, we keep looking at the same rock and find out new stuff about it

On all of the missions, two astronauts went down to the surface of the Moon, and one astronaut stayed up in orbit and lived in this little capsule. And on the last three missions, on this capsule there was a big bay, or like the back of a pickup truck, full of science instruments. And these science instruments look down on the surface of the Moon. So as the spacecraft orbited the Moon, it was collecting science data. And so you can see-- and during the Apollo era, we only stayed close to the middle of the Moon or the equator of the Moon, and so we had very limited knowledge. This is the near side, and I'm going away to show you where we landed. But you can see we had very limited knowledge of the Moon up mainly around the equator.

So here's where we landed, all on the near side of the Moon, that face of the Moon that we see all the time. And we did that so we could have line of sight communications. We couldn't land on the far side of

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the Moon and talk to our Apollo astronauts back then, so we landed on the near side so we could see them from the Earth and we could talk to them straightaway.

And Apollo 11, of, course were getting ready to celebrate the 50th anniversary of Apollo 11. And here it landed in Mare Tranquillitatis, or the Sea of Tranquility. And then there was 12, and then-- oops. 13 is missing. I hope you all know the story of Apollo 13. They didn't land on the Moon, but we got the people back safely so that was a great triumph. And then 14-- 11, 12, 14, all the astronauts had to walk on their feet. By the time we got around Apollo 15, 16, and 17, the astronauts had little cars to drive around. So that was really cool because we could get a lot farther.

Now, some people think just because we've been to the Moon that we've already done the Moon. We don't need to go back to the Moon. Been there, done that. So I want to dispel that myth really quickly. Turns out the Moon's surface is about 90% of North and South America combined. So think about all of North and South America, and maybe get rid of Florida, maybe the Baja Peninsula, pull off a little bit here and there. Most of the surface of the Moon is equal to most of North and South America.

So let's say you are in charge of understanding North and South America. And there's where we landed on the Moon. This is where you would have landed. We'll start here in Houston. So those stars are now being transposed onto the map of North and South America, but this is United States because Apollo 16 would be, say, right here at the Johnson Space Center in Houston. Well, the farthest we would have sampled and visited would be Apollo 12, out by El Paso. The farthest north, Apollo 15 right in the middle of Kansas, the farthest east where Apollo 17-- Memphis, Tennessee. And then Apollo 11, the first landing somewhere here in the swamps and forests of Arkansas and Louisiana.

So if you keep the geometry of the landing sites on the Moon the same and you bring it to the Western hemisphere, this is where you would have landed. And if this is where you would have landed, what could you tell me about the Appalachian Mountains over here or this big thing called the Rocky Mountains, the Great Lakes, or these mountains here over in Washington where you have the smoked coming out them, volcanoes. We know there are volcanoes all along the West Coast of the United States and Mexico, and also down here along South America. We now know those volcanoes are created by plate tectonics.

And maybe you've heard about the Ring of Fire or the Pacific Rim, the Ring of Fire? Well, we're part of it over here on the west side. We would not know about plate tectonics if this is all we studied.

And say you don't really care about rocks and geology. You're kind of bored of that, but you really love biology. So look, you've got a lot of mosquitoes in Houston, maybe some swamp creatures there. But what about the Florida Everglades or the Okefenokee Swamp? I don't know if you've ever been to Olympia Peninsula up in Washington, absolutely fabulous. And way down here in South America, the Amazon rain forest, so much biology diversity you wouldn't have a clue about if this is where you were only confined to. So the whole idea of been there, done that to the Moon is-- I just don't believe that.

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So after the Apollo guys, we sent a bunch of astronauts to the Moon. Robots are cool because they're not large, so we don't spend a lot of money on them. They don't require air, food, water, and they don't have a family they have to come home to, so they're a great bargain. And a lot of people don't realize that before Neil Armstrong even stepped on the Moon, we sent 13 robots to the Moon first to make sure it was safe. We used cameras from orbit to figure out where to land, and then we used a surveyor to make sure we can land there safely.

And then all through the '90s and up until now-- oh, I've got to put Chang'e 4 on there. There's been a renaissance of robotic missions to the Moon by all sorts of nations. And look, we put these robots in polar orbits-- and remember those Apollo orbits right at the equator, and we had very limited knowledge? Now look. The orbits go from the North Pole to the South Pole, around and around the Moon, and now we're getting global maps of what the Moon is made out of. And we're finding out that that area where we landed with Apollo is very unique and different from the rest of the Moon. So it's really good that we're getting a global understanding.

Before we went to the Moon, we had three main theories about how the Moon formed, or the Moon fissioned, where the Moon split off from the Earth because it was spinning fast, capture theory because the Moon was flying through space and Earth's gravity pulled it in, condensation theory where the earth and the Moon kind of condensed together in the same neighborhood. Daniel Osborne was a student that did this. I think it's really clever.

But again, we're pretty sure-- we don't know exactly, but we're pretty sure a Mars-sized thing smashed into the Earth and created the Moon, and that comes from all the data and the rocks that we brought back right. We think the Moon had a magma ocean of several hundred kilometers thick. And eventually, the magma ocean cooled on top and cooled on bottom to create the crust, mantle, and core, just like we have here on the Earth

And another thing we're finding out now is there are meteorites from the Moon right here on the Earth. NASA goes out to the South Pole every year and we look for meteorites on the white hot snow or the blue ice, and these meteorites are teaching us about other parts of the Moon that we didn't land with Apollo. Problem is you never know where any particular meteorite came from, but the data itself is valuable. And so these are our databases you can go to to find out more about all of these lunar meteorites. There are several hundred of them now.

So here's how we see the Moon at night. Well, we see the near side. We never see the far side. And this is kind of how the geologists will map the Moon, where all these different colors represent eras or times, from the oldest times going back 4.5 billion years ago, to the youngest times, even happening today. So you can see all the bright yellow craters are brand new craters, and then the greens are less old. And when you look at the browns, you'll see the oldest parts of the Moon. So that's kind of how a geologist looks at the Moon.

And even though he went to the Moon with Apollo, look at all these places that scientists still want to get back to with either robots or people. And we have so many questions. Over here on this side are different types of rocks that we would like to sample, and you can see they're both on the front side and the far side.

So the latest visit to the Moon-- I can talk till 3:10. OK, great. The latest visitor to the Moon was China's Chang'e 4 mission. It actually landed on the far side of the Moon. You guys can watch this on YouTube or go to their websites. But that is a lander, landed in January. It's still active. So they go to sleep at nighttime because the Sun goes down, it gets very, very dark. So the lander and the rover, called Yutu-2-- because Yutu-1 and a lander identical with this one was the Chang'e 3 mission that landed about five years ago. So both the rover and the lander are working really well, and this is the first robotic mission to the far side of the Moon. So the Chinese beat everybody else to the far side the Moon, so great for them.

But they're not the only ones. Look at all these other countries talking about going to the Moon. So we're going to go back and we're going to talk about that later, but Russia and Europe are talking missions. India, Canada has some robots they would like to drive around. South Korea, Japan. A lot of this space-faring nations have their sights set on the Moon in the next 10 years or so with robots.

So in the US, the approach we're taking is work with commercial companies. Just like Amazon delivers things to your house or UPS in the big brown trucks brings packages to your house, we have companies that are set up now that are going to deliver things to the Moon for us so NASA doesn't have to design the lander itself anymore. We have companies that like to do that. And not only will NASA fly to the Moon on these landers, but any customer can do that. If your schools have something you want to fly on the Moon and you happen to have the money to do it, you could fly something to the Moon on these commercial companies. So it's a great partnership between our government agency of NASA and these private companies in developing these systems. And you can see, if one lander doesn't quite work so well, we'll have several to choose from. So hopefully, it's going to be very competitive, and we're going to have lots of companies making money and getting to the Moon, but also lots of workers learning how to do this for all these companies.

So this is the United States Space Policy, and what we're following right now is called Space Policy Directive 1. And the important parts is commercial-- we're going to build with commercial and international partners. I just talked about the commercial partners, and then, as you saw in those other slides, a lot of other countries want to go to the Moon. So we're going to work with partners to get back to the Moon. And we're not just going like an Apollo, stay for a couple of days and come home. We're actually going to go to the Moon for long term exploration and utilization of the natural resources there. So Space Policy Directive 1 kind of gives us our marching orders.

And just recently, Vice President Mike Pence, who leads the National Space Council, really put a challenge to us because he said, we want the first American woman and the next American man to land at the South Pole of the Moon by 2024. Well, that's only five years away. So we're working pretty hard to get the plans together to allow this, and we're also working with our commercial partners because they may be able to do this. And then our American astronauts ride to the Moon in commercial vehicles, just like even though I work at NASA here at the Johnson Space Center, I don't fly a NASA jet to NASA

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headquarters. I fly commercial airlines. And hopefully, that's the way we'll get to the Moon with our commercial partners.

The challenge will be just because a president says something, Congress doesn't always agree. So throughout the history of NASA the presidents have given us our strategic direction, but then it's up to Congress to pay for this and write the bills that become law and give us our budget. And if the president and the Congress are agreeing on something, we move pretty well. If the president and Congress don't agree, well, things then get kind of stopped.

So we're going to have to see if Congress is really behind what the presidential administration right now is trying to do because it's been a mixed bag throughout history of the president and Congress working together, or the president Congress not so much seeing eye-to-eye. But it's up to the politicians to do all this. NASA would love to be in charge of its own destiny, but we're not. It's the politicians in this country who are in charge of NASA's destiny, and kind of tell us what we're supposed to do and how much money we have to do those things.

So this focus on the South Pole-- well, why the South Pole? Well, most of the Moon gets to see Sun for about two weeks, and then you have darkness for about two weeks. And so to try to make it through a lunar night of two weeks long is really hard to do because you have to have batteries or fuel cells or something to keep you warm and keep you going electrically. But at the poles of the Moon, there are areas that see the sunlight almost 90% of the time. You can see these bright areas of highly illuminated place and at the poles of the Moon, and this is the South Pole. And the reason that happens is, you look over on this chart, the Moon's axis of rotation is only tilted by 1 and 1/2 degrees.

Now, you know that our axis of rotation is 23 and 1/2 degrees, so that's why we have seasons. When your hemispheres-- so we're here in the United States. When the Northern Hemisphere is pointing at the Sun like it is now, we get hotter and hotter and it's summer. But when the Northern Hemisphere is pointing away from the Sun, it cools down and we go through our winter. Well, the Moon doesn't really have that.

But what this does do is, at the poles of the Moon, the sunlight is almost going right across to the surface or parallel to the surface. So if you have a crater on the Moon, you have a hole on the Moon, like this guy right in the middle. That's Shackleton crater. That sunlight is going right across the top of your hole, and it never gets there. So we have permanently dark, permanently shadowed craters in the polar regions of the Moon right next to areas where there's lots of sunlight, like, 90% of time sunlight, where we can have solar rays to generate power for us and our systems.

Well, what's so cool about those-- cool, no pun intended-- about these dark places at the poles of the Moon? Well here's a map of them so maybe you can seem a little better, so the North Pole here on the left, the South Pole on the right. So you can see all these red permanently dark craters. The cyan color or turquoise, those are smaller permanently shadowed regions, so they're all over the place. And we have evidence from orbit that inside of some of these permanently shadowed craters there's water ice, both at the South Pole and the North Pole. But we're focusing on the South Pole. Matter of fact, Shackleton

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crater, the rim of it is kind of right on the South Pole there. But you can see there are areas where we see water ice in these permanently shadowed craters.

So what a great resource for us, water in this lunar desert. We have these oases at the poles of the Moon with water ice. And just like the oases in deserts here on the Earth, on the hot deserts of the Earth, travelers for centuries have seeked out these oases for water to sustain them. Well, this water on the Moon can also sustain us. And so that's why we're going to the South Pole. We have the highly illuminated ridges and crater rims where we get lots of Sunlight, and they happen to be next to deep dark holes full of water ice that we hope to mine and turn in the water. So we can drink the water, we can split the hydrogen from the oxygen, we can breathe the oxygen. And then hydrogen and oxygen can be used as rocket propellants, so what a great resource for us.

So the main goal of going back to the Moon is to learn how to work and live on another planet. Here's a polar region where there's not a lot of sunlight. You can see lights lit up by electricity, by tall solar arrays, mining going on with people and robots. We're going to be using the natural resources on the Moon to live off the land so we don't have to bring everything with this from the Earth. It's very expensive to launch things from the Earth because of our gravity. So if we can learn how to use the resources on the Moon and live off of the land, we now can do it in a more economically sustainable way. So living off the land, using the resources is critical for any long-term presence there.

And finally, we're going to use the Moon as a proving ground. So if we can learn how to work and live on the Moon, we can take all those technologies and all that knowledge to then work and live on Mars or other places in the solar system. So the Moon is kind of our training ground. And the cool thing is it's only about three or four days away by rocket travel, so we can go there any time we want. And if something breaks down, we just come home and figure out a way to fix it, and then go back to the Moon. It's not like Mars where it takes months and months to get there, and you can only travel back and forth between the Earth and Mars once every couple years. The Moon is there all the time. So it's a great proving ground for us.

So that's it. I don't do a very good impression of Yoda, but I think of Yoda from Star Wars was talking to us about the Moon, he would tell us close, interesting, and useful the Moon is. And so that's it. I hope you all enjoyed that.

PAIGE: And you can do stop sharing.

JOHN GRUENER: And we're going to do stop sharing so I can see everybody, and we can take questions.

SPEAKER: you so much. That was really interesting. Appreciate it. I'm going to let Tedrick take over the questions, so he's going to start reading them out. Tedrick?

TEDRICK: Yeah. Can everyone hear me?

SPEAKER: And I'm going to leave the show, and hopefully I don't kill everything.

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TEDRICK: All right. So we had some pretty good questions so far. So if anyone has more, feel free to ask. But I want to start off with actually a jumble of questions because there are a lot of them right along the same line. So do you love your job? And what's the scariest, most entertaining, and weirdest parts of your job?

JOHN GRUENER: Yeah, I do love my job because I started out as an engineer, I became a scientist, and I learn something every day when I come to NASA to work because I work with so many different people, so many different backgrounds, and read so many different science papers, I'm always learning something new. Someday I think my head's going to explode, but it's a great place to work.

So I don't know about weird. I'll have to think about that one. Well, one of my most fun projects was back in the '90s we were working-- I talked about growing plants. And we were working on developing a slow release fertilizer substrate that we would take with us to the Moon or Mars, so we not only use them as soils to grow plants, but also we use the slow release fertilizer to kind of kick it off. So we called it [INAUDIBLE] substrate. So for about eight years I was a space farmer, learning how to grow food in a life support system where everything is recycled and reused. So that was a lot of fun.

And if I can think about weird-- well, maybe it was the alien-- oh, can't talk about that one. OK, next question.

TEDRICK: Let's see. How long is considered long-term exploration?

JOHN GRUENER: Well, that's a good question because there are a lot of people at NASA and also in this country that want to just forget the Moon. Yeah, we went to the Moon. We have Moon rocks. We can send robots to the Moon, but we want to send people to Mars. That's what we really want to do. So the more time we spend on the Moon, the more we push Mars further out into the future. And so different people have different definitions of long-term exploration and utilization of the Moon.

For me, it's forever. I mean, you think you think about how mankind has spread all over this planet, from continent to continent. And once people got to a place, they pretty much stayed there, and they learned not to live off the land. They learn how to trade with partners, whatever. So I think of long-term as indefinitely. Some people think of long-term as 10 years because, boy, we really want to get to Mars. But if mankind or humankind is ever going to expand off of the Earth, we're going to have to learn how to use the resources. The private companies are going to have to get involved so they can make money and generate economy, and that will spur things on.

You think about how the United States has grown over the centuries, it's because of the economic engine that has been driving it all. So long-term can be different things to different people. But I hope, once we go, we're always there.

TEDRICK: Thank you. So next, sounds like we have a question from Elizabeth, and then we'll have a question from Quincy. So Elizabeth, go ahead and unmute yourself and ask your question.

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ELIZABETH: So I was wondering, how do you build your rocket ships?

JOHN GRUENER: How do I build my rocket ships? Well, that's a good question. So if you look behind me-- Paige, will you-- that rocket that I built didn't go so well. It's bent. It's kind of crushed. So building a real rocket, building real spacecraft requires lots of different people because it turns out these things are very complex, have lots of moving parts, and lots of systems. So you have to have a team of people to work on the structures to hold the thing together, or the propellant experts to figure out which propellants you're going to use, what kind of tanks those propellants go in, how cold they have to be retained to keep the propellant in a liquid form. The electronics people have to design things so the astronauts can talk back to the Earth, the spacecraft can talk to itself. So it's very complex.

But basically, it starts off with an idea right or a sketch, and you think, OK, I want to build this thing. And you have to think, well, what does it need to do? So we call those functional requirements. So what are we trying to do? What functions or capabilities do my spacecraft have to have?

And then once you write down what you want your spacecraft or rocket to do, then you start saying, OK, well, how much? How much do you want this rocket to lift off in the Earth? How fast do you want your spacecraft to travel to Mars? So once you know your functional requirements of what you want to do, then you start getting in your design requirements to say, well, how much do you want? How fast you want to go? How many people, all those kind of things.

So it starts off with an idea, and your functional requirements turn into design requirements. And then somewhere in there you have to develop what we call a concept of operations of how you would even use all this stuff. So usually, it's what do you want to do, how are you going to do it with a concept of operations, and then a design process. So those are the three basic steps in system engineering.

TEDRICK: I think next we have a question from Quincy.

QUINCY: Hello. My question is, if you had to choose only one item from the ISS that is most important--not the ISS itself, and not the wires-- what would you choose?

JOHN GRUENER: The one item, so that's tricky because I love the high-definition cameras that are on ISS that look down on the Earth, so we get fabulous images of what's going on here on the Earth. But without those big solar rays generating electricity, our astronauts couldn't live there. So my engineer half loves the solar rays. My science half loves the cameras. How's that?

TEDRICK: That's good. All right. Next I think we have a question from-- I will try to say this right, but I think it's [INAUDIBLE] Elementary. [INAUDIBLE]?

STUDENT: What is the coolest rock you've ever found?

JOHN GRUENER: The coolest rock? Oh man, there's so many of them.

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PAIGE: On Earth or the Moon?

JOHN GRUENER: OK, well, I've never been to the Moon.

STUDENT: Moon.

JOHN GRUENER: So I think one of the neatest rocks we brought back from the Moon was on Apollo 15, and it was called the Genesis rock, right? Wasn't that Apollo 15?

PAIGE: Yep.

JOHN GRUENER: Yeah, Apollo 15 Genesis rock, and that was the first real big sample that was from the bright highlands of the Moon. Remember in the talk I talked about the old highlands and the young maria lava flows? Well, that Genesis rock really gave us an idea of how old the highlands are. So if I had to pick my favorite Moon rock, it would be that.

But I never give one answer, so my favorite dirt or soil on the Moon was from Apollo 17. They actually found orange-colored soil. So you look at the Moon, it's all gray. But they actually found orange soil on the Moon. And it turns out orange stuff was actually small glass spheres that were created in a volcanic fire fountaining eruption.

I don't know if you all watched in Hawaii last year when the eruptions were going off and, unfortunately, the lava was covering up the neighborhoods, but boy, was it beautiful to watch at nighttime when all that stuff would go up into the air. Well, we had those same kind of eruptive fire fountainings going on on the Moon, and that orange soil is really cool stuff.

TEDRICK: And next I think we have a question from Seth.

SETH: When would you say your next Apollo mission would be?

JOHN GRUENER: Well, Seth, the vice president and the National Space Council have challenged us to get there in 2024, so that's only five years away. It's going to take money to do it because you just have to hire people and work really hard to get something built in five years. But certainly, we'll have the next people on the Moon within the next 10 years. So before the vice president challenged us with 2024, we were looking at the year 2028. So within the next decade, I think you'll see the first people walking on the Moon.

Now again, that only goes if Congress agrees with this presidential administration to do that. But whether the United States goes to the Moon or not, those other countries are going to go to the Moon. China's going to be on the Moon. Europe is going to be on the Moon, probably either with us or with China. I don't know that Europe will do it by themselves. But there will be some kind of humans on the Moon within the next decade. I hope they're Americans.

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TEDRICK: Next I think we have another question from-- I believe we have a question from Quincy. Or did I skip Liam?

QUINCY: No, I'm going since it was Seth and then-- yeah. What is the grossest thing that astronauts have to eat in space?

JOHN GRUENER: Boy, I don't know because I've tasted some of that food over in the food lab, and it's actually not that bad. So one of my hobbies is taking taekwondo. I started that when I was 53 years old. I sure wish I would've started sooner because my old body doesn't like to kick and bend and punch like a little youngster. But the guy that teaches us, our master in our taekwondo studio, Stan Love, is an astronaut. I never really asked him what the grossest thing he had to eat.

But just like you at home, you probably wouldn't eat it if it was gross. You'd probably just kind of shove it aside and tell mission control, yeah, we eat ate our kale. All is good. So I can't really tell you because I only eat the astronaut food that I can buy at the gift stores and what I've tasted at the food lab. And I know one thing they do like to do is they like to spice it up. So the shrimp cocktail, really tasty. But they bring up M&M's and all sorts of candies and stuff.

Before astronauts go into space, they work with the food lab so that the food lab gives them the kind of food they like to eat. We're not going to send an astronaut up there and then make them eat gross food. They're going to eat food that they chose.

TEDRICK: Thank you. So yeah, now we have a question from Liam.

LIAM: Have you planted plants with the Moon soil?

JOHN GRUENER: No, Liam. I never got to do that yet. In some of our tests in the 1990s, when I was a space farmer, we used what we call simulants-- simulated lunar soil. So we know, bringing the rocks back from the Moon, we know what they are, and they're very similar to rocks here on the Earth. So you can take rocks on the Earth and smash them up into powder to make it fine like a lunar soil, and then grow plants in that simulant.

The same thing with Mars. We know from our robots on Mars, and also the meteorites that have fallen on the Earth that have come from Mars, we know how to make simulants of the Martian dirt or soil. So we can grow plants in that also. But back during Apollo, that was one of the scary things. They weren't sure if this dirt and these rocks coming back from the Moon was going to infect anybody or do something really bad to the biosphere on the Earth.

So they did-- they grew plants in real Moon dirt back in the early '70s. And they actually fed Moon dirt to rats and all sorts of things, and everything lived. No dead rats, no dead plants. So they found out there's nothing toxic on the Moon, so we don't have to keep our astronauts in quarantine every time they come back from the Moon. So that was probably the last time anybody ever grew plants in real Moon soil.

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Hopefully, we send our robotic missions to the Moon with our commercial partners. We bring back materials from the Moon, and we can do that again with new plants and new people like you guys.

TEDRICK: So next up. I think we have another question from Quincy

QUINCY: I was a part of the FLL, and our project was, basically, calming astronauts with the color pink. We heard that you painted the walls of the ISS a salmony color to calm astronauts down. Have you guys thought of doing anything further with trying to calm them down?

JOHN GRUENER: Well, I do have some friends that work in what's called human factors. And so it's the human factor people that make sure you design something that's livable. Now, sometimes you look at the space station and you wonder if it's really livable because you have wires everywhere and instruments are everywhere. But yes, they tried to pick those calming colors or warmer colors.

Now, matter of fact, the Gruener household is a mess right now because we're redoing everything. And we're picking-- my wife's a school counselor, so we want warm, nurturing colors, and we do the same thing inside of our spacecraft. So I'm not an interior designer, so I can't tell you which are the best colors to make people the happiest and calmest. But know you can look at my wall here and it's just kind of a beigey color, but I think they went with more blues and grays on Space Station versus the good old beiges that have been around forever.

TEDRICK: Next we have another question from Elizabeth.

ELIZABETH: So do you know when you've going to be launching your next rocket ship?

JOHN GRUENER: When are we launching our next rocket ship? No, I don't really keep up with that on a daily basis. You can go to the Kennedy Space Center or Cape Canaveral website, and they have a listing of all the rockets that are coming up because there are so many of them going up now. It used to be when I was a kid that everything that launched was a government mission, whether it was NASA or the Department of Defense. It was all government missions. And then the private industry started getting involved.

So maybe some of you guys have satellite TV in your house. Well, that's a private company that's beaming those satellite TV channels to your house. Telephone communications, weather forecasting and images of the weather, all of those are done by commercial businesses and companies. And it was about, , I think maybe eight or nine years ago or 10 years ago where the number of commercial missions to space actually got higher than the number of government missions. So now we're launching more commercial stuff in this country than we are government stuff, and it's really hard to keep up with when the next communications satellite goes up or what.

But you can go to Cape Canaveral. They have a schedule of launches at NASA. Paige, I'm trying to think, when do we have a mission coming up? And I'm scratching my head and coming up blank. We always

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supply the space station, so every three months or so another rocket goes up to bring food and groceries and air to the space station, every three months or so. And that's on SpaceX or Cygnus.

PAIGE: And I think it was, like, May 5 where we just sent up our latest SpaceX resupply mission, including one of our--

JOHN GRUENER: That's right. Yeah, yeah.

PAIGE: --our Hermes experiment [INAUDIBLE] as well.

JOHN GRUENER: So we have co-workers who sent an experiment up to Space Station on the launch that was just a week ago. So if you like to watch launches, go live in Florida because then you get to watch all sorts of stuff going to space.

TEDRICK: Thank you. Next up, I think, Quincy's brother had a question. Did you want to ask his question for him?

QUINCY: Yeah. How is the Wi-Fi situation, like, the internet stuff going on the ISS?

JOHN GRUENER: Pretty well. That's a challenge because you have knowledge modules, a long line of modules, and they go in different directions. And so you can't just keep a wire on everywhere you go. So they're finding out there's not a lot-- they design their systems correctly, number one. First, you have to understand what they call the electromagnetic environment. And once you understand that, you can design your systems to work well, and we've had a good response.

Now, when we get to the Moon-- we were just talking about that today, matter of fact, down the hall. Will Wi-Fi really work on the Moon? Because the Moon's a very harsh radiation environment. The space station is inside our magnetic field and Van Allen belt, so they're somewhat shielded from all the radiation that's really out there in space. But when you go to the Moon, man, you're getting hit hard by the radiation from the Sun and what's called galactic cosmic rays, which come from all over the universe.

And so we were talking about, well, how is Wi-Fi going to work on the Moon because you have that huge radiation environment, and is it going to disrupt your signal? And we decided, yeah, there's going to be a little bit of static. It's not going to be crisp and clean, but you're going to have to have your receivers and your transmitters really shielded so they work well with the signal. But as the signal goes from one place to another on the Moon, it's going to get a little bit messed up by all that radiation. But it works well on the Space Station.

TEDRICK: So let's see. I want to check around because I know we've had a lot of questions from a few people, and they've been really good questions. And I want to see if anyone else has any questions that hasn't piped up yet. I can't see everyone on my screen. So if I can't see you, go ahead and just put your question in the chat, and I can either ask it for you or I can call on you.

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JOHN GRUENER: Tedrick, Paige just told me in the chat room somebody asked how long I've been working at NASA.

TEDRICK: Yeah.

JOHN GRUENER: So I was just kidding when I showed you that picture of me when I was five years old. That really wasn't my first day on the job. I went to college, just like a lot of people do. And I started working here at the Johnson Space Center in 1986. So here we are in 2019, so I'm on my 33rd year, going on to 34, and then 35, 36, 37. And hopefully, by the time I get up to about 38 years at NASA, we're going to have people on the Moon. So it's been a while, but it's been fun, otherwise I wouldn't be around. I'd go find something else to do.

TEDRICK: And I think we have another question from Quincy and then a question from Seth.

QUINCY: Do the astronauts on ISS, as kind of a holiday thing, do they do anything special for Halloween? Like, do they dress up or do they have any candy? Do they just acknowledge it and not do anything?

JOHN GRUENER: No, you're a human. You're up there and-- so yeah, all the different holidays they try to do something fun. I know when they send up the modules with supplies, they always try to put some presents in there for them. But that's going to be the challenging thing for humans who are actually working and living on the Moon someday or traveling to Mars. Typically, a Mars mission requires three years. So you fly out to s in about six to eight months, you spend about a year and a half on Mars, and then you fly home in about six to eight months.

So you think about that, your little mission to Mars, there's going to be about four of your buddies with you. Well, hopefully, your buddies because you're stuck together. But for those three years, you miss three baseballs-- I love baseball. So you missed three baseball seasons and going to baseball games. You miss Halloween. You miss Thanksgiving and being with your family. You miss the Christmas holidays.

So they try to do all that as much as possible up in the Space Station to keep the spirits up, but the tour of duty-- most astronauts only spend six months up on Space Station right now. So if you plan your mission correctly, you're home in time for Halloween if you have a sweet tooth. Or you're home in time for Thanksgiving so you can spend it with your family. So right now, our astronauts on the station, they miss six months of what's going on down the Earth. But when we do get to the Moon for that long-term settlement and multi-year missions to Mars, it'll be interesting to see how people react from an emotional and psychological point of view.

TEDRICK: So real quick, because I think we are reaching the end of our time and I think Zoom actually might cut us off, so in case it cuts off, first of all, I want to thank everyone that was able to join us.

JOHN GRUENER: Yeah, this was a lot of fun.

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TEDRICK: I hope you were able to learn a few things along the way, learn some good stuff from John. And I hope your challenge is going well. Now, I did promise if we can fit you in before it cuts off, we'll have Seth ask a question, then we'll have Haley ask a question.

JOHN GRUENER: All right, speed round.

SETH: So when are you going to launch your next satellite?

JOHN GRUENER: Launch our next satellite. Well, Seth, somebody asked about our next launch, and I wasn't quite sure. So go to your browser on the internet, type Cape Canaveral launch schedule, and you'll see when we do that. Of course, the Europeans are launching things all the time, the Chinese, the Russians. a lot of stuff going into space these days, but I don't really know when we're launching on our next thing.

PAIGE: And our next, probably, mission that we'll be involved in is Mars 2020, which will launch next summer. I don't know if we have any missions we're involved in before that, but at least Mars 2020, maybe.

JOHN GRUENER: So hopefully you heard Paige. And Mars 2020, that's a new robot, kind of like Curiosity, heading to Mars to do more cool stuff.

TEDRICK: And also I think Christina put-- or Mary put a link to a space.com calendar that keeps track of all sorts of things going on in space, including a lot of this stuff.

JOHN GRUENER: All right, cool.

TEDRICK: All right. Let's have our last question from Haley.

JOHN GRUENER: What about Seth?

HALEY: So I was wondering, how long has one person been in space for?

JOHN GRUENER: So the longest somebody has been in space is a Russian, and I forget his name. And he spent over a year up there. Now, here in the United States there is-- we have these twin astronaut brothers, the Kelly's, Mark Kelly, and what's his--

PAIGE: Scott Kelly.

JOHN GRUENER: Scott Kelly. So Mark Kelly and Scott Kelly. And what a cool science experiment. You have twins. They're the same. Let's put one in space and see how he gets different from the buddy that stayed on the Earth, or the brother that stayed on the Earth. And Scott Kelly, he didn't quite make a year. It was more like 340-something days, but that's the longest an American astronaut has been in

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space, about 340-something days. But there has been a Russian that has been up there for just at a year, or a little bit longer than a year.

But that's one of these big challenges. I keep talking about how our missions to Mars are going to be multiple years in length, and so what happens to the human body when we don't have the gravity of the Earth? And what happens to our bones and our muscles? And is the gravity on Mars going to be enough to counteract all of that, or the gravity on the Moon? So the Moon's gravity is about 1/6 of the Earth's, so you feel like you weigh-- if you do weigh 100 pounds on the earth, you would feel like you weigh 16 pounds on the Moon.

Well, is that enough? Is that enough weight to work your muscles and to work your bones so the bones don't decalcify, the muscles don't atrophy? So that's why the Space Station is a pretty good test bed for human space flight, just like the Moon is going to be a test bed or a proving ground for living and working on planetary surfaces. And we hope to find out what happens to the human body as it spends years on the Moon, but we're not there yet.

TEDRICK: All right. Thank you, John.

JOHN GRUENER: [INAUDIBLE].

TEDRICK: So it is about time we should wrap up. I did see a question that led really well into when is the next one of these, so the next session we'll have like this is in two days, May 16. It will be at 1:30 PM Pacific time or 3:30 PM Central, and we'll be chatting with George Gorospe from NASA Ames. He's an engineer there.

So I guess if we can have everyone-- if you want to unmute yourselves and everyone say thank you to John.

STUDENT: Thank you

JOHN GRUENER: You bet. It's been fun.

STUDENT: Thank you.

TEDRICK: All right. And I don't know--

STUDENT: This was an amazing experience.

TEDRICK: --if you had any other words you wanted to sign off with.

STUDENT: This was a good experience.

TEDRICK: Thank you.

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STUDENT: [INAUDIBLE]

TEDRICK: And now everyone's unmuted, we're getting feedback. So we'll go ahead-- thank you so much.

SPEAKER: All right. I would definitely do that again. It was quite interesting.

STUDENT: Yeah, same.

JOHN GRUENER: Bye.

STUDENT: I would probably do that again.

Bye.

I'm saying it's improbable.

[INAUDIBLE] take you out.

We're slowly going to be removed, slowly but surely.

TEDRICK: Bye. Thank--