Speaker 1 (00:14):

Chris Hansen grew up in Los Alamos, New Mexico and he joined NASA at the Johnson Space Center as a cooperative education student in 1991 where he worked on several projects as a structural analyst and designer. After graduating from University of California Irvine in 1993, with a degree in mechanical engineering, he joined NASA full-time as a structural analyst. In 1999 Chris earns his master's of mechanical engineering degree from Rice University. And he has held multiple positions with the space shuttle and International Space Station programs. In 2007 he became chief engineer for the International Space Station. In 2015 he became the manager of the EVA Office, which makes him responsible for integrating all spacewalks activities for NASA. Today Chris will be talking all about the Artemis Program spacesuits. Without further ado, Chris Hansen.

Chris Hansen (01:15):

Excellent. Thank you so much for the introduction. I'm super, super happy to talk to you guys here. I love talking to college students. You guys are really the future of NASA and the future of our country. Today before I get started though something really exciting happened. Today I woke up really earlier this morning and spent the day working on a spacewalk. We call those EVAs, extravehicular activities. You know them as spacewalks. This morning we actually did a spacewalk with two astronauts. I'm getting a ton of feedback from somebody who has their mic open. Those two astronauts, Victor Glover, this was his first EVA. The other astronaut, however, was a astronaut named Mike Hopkins. He actually graduated from the University of Illinois. He was outside this morning doing his third ever spacewalk. They did about a six hour and 56 minute spacewalk. Did lots of good work installing some science on the outside of the space station and got back in safely, which is what we love most of all. So congrats to you guys for bringing Mike Hopkins to us and he did a great job this morning, so thanks for that.

All right, let's hop back to the presentation. You're going to find out really quick I love talking about spacesuits. And I can no longer see my charts Patty, so I don't know where they went. There we go, you're good. Got it. So I could talk for hours on spacesuits. I'm really getting ... Oh my gosh, getting a ton of feedback from somebody. If everybody would mute their mics? I'll fight through it. I love talking about spacesuits. I'm only going to be able to ... I'd really like to give you guys some time to ask questions, so I'm going to just hit the highlights of this, so let's go to the next slide.

Really the last time that NASA built a spacesuit to walk on the surface of another planet was 50 years ago back during the Apollo Program. Today we use what's called the EMU, the extravehicular mobility unit. You see it on the right there. These are the suits that we use on the space station today to do spacesuits on what we call microgravity out in lower Earth orbit. But these suits aren't going to work when we go back to the Moon, so we need a different suit. So we are working on a new suit that we call the exploration extravehicular mobility unit or we call it the xEMU. So we have a couple videos just to introduce you to this suit and then I'll give you some more details.

Speaker 3 (04:38):

Moon walkers, working in 1/6th Earth's gravity, will need spacesuits that let them use their hands and feet, walking to destinations, and bending and reaching as they explore. For this new type of work NASA has been testing prototype planetary suits, culminating in a new suit design, the xEMU.

Amy Ross (04:59):

The xEMU is exploration extravehicular activity mobility unit. So it is an exploration spacesuit. So it's a spacesuit that you're going to use as we move forward on gateway missions and on the lunar missions with Artemis. And then we're using all that to test the suits you would want to use to go to Mars. And so eventually you're going to have to be very independent and very confident in your hardware, when you go and do a mission that far away from Earth.

The new suits, the planetary walking suits we're working on now, we really hope to provide improved mobility and comfort, along with reduced injury potential. And really, like I said, provide the best tool to the crew member that we can provide. Then we want to be able to provide them the ability to kneel down and pick up a rock, like they're going to want to do in their geology science that they're working on. We want this to be a very reliable and durable suit, so they can use it day after day in a dusty environment and not have to do a lot of maintenance with it while they're needing to do their mission. So there's a lot of those kinds of aspects that go into improving the suit that we're going to provide for the lunar missions.

Chris Hansen (06:06):

All right, good. That's just a quick intro. One of the important things I want to point out to you was that a lot of you have heard about the Artemis Program. So back in 2019 NASA decided that we are going back to the surface of the Moon. The plan was in 2024. With the new administration change that might move a little bit but we still ... The Moon is definitely in our sights and we plan to go back. And when we go back to the Moon the astronauts that we bring back with us, the first woman to walk on the Moon and the next man, will be wearing this spacesuit. So let's kind of see what's inside this suit.

Now the other thing ... There's a lot of words on this chart, I don't want you to read them all, but what I want to ... the thing I want to point out most is that this suit is really part of a bigger system. It's not just a suit. We're actually building tools for the astronauts to work, to do geology on the surface of the Moon. The reason we want to go back is to do science and so we need to give the astronauts the tools to do that with. We have vehicle interface equipment, so we're going to go in a lander and the astronauts put the suit on inside. And they're hooked to an umbilical to the lunar vehicles. That umbilical actually provides them oxygen, and water, and power. We recharge the batteries through it. So we have to build all the hardware that fits inside that vehicle that knows how to connect to our suit and we can replenish that suit with consumables as we go.

The suit itself is made up of a couple different systems. The most complicated part is called the life support system. We call it the Portable Life Support System. It's the backpack that you see on the back. It's what keeps the astronauts alive, one of the things. It provides them thermal control, it provides them oxygen, ventilation. It's got the battery system in it. It's got the radio in it, so we can talk to the crew members. The Pressure Garment is the part that looks like the human, it's the part that their body's in that keeps them pressurized. It allows them to move around and walk on the surface of the Earth. And then the Informatics System is the computer inside that helps run this whole system. It also includes high definition videos and cameras, and in-suit displays. Our goal is to make it look a lot like what you guys have all seen in Iron Man in the movie, that computer that talks to Iron Man inside. The Tony Stark computer, the Jarvis. We're trying to create a system that works similar to that for this suit.

So what's different about this suit? It's got high speed data comm. The avionics are a lot more advanced than we had 40 years ago when we built our current EMU. We've got high definition video and lights. We've got advanced automated suit checkout systems onboard. The computers onboard can actually checkout the system before the crew members even get in. We've got much better mobility. The crew members can move their arms, they can walk, they can bend down. They can do a lot of things that we can't do in our current suit and that we really couldn't do back in Apollo. If you remember seeing the Apollo videos the crew members were stumbling around and if they wanted to pick up a rock they almost had to fall down on their face, pick up a rock, and do a pushup. A little bit easier in 1/6th gravity to get back up. Those suits were not very mobile at all. This suit's designed to allow them to bend down, to reach things, and to really do science and act like a geologist on the surface of the Moon.

We have advanced dust protection. The dust on the Moon is really nasty, it gets in joints, gets into the system. So we have to protect our systems from that. We've got an hour emergency oxygen system. We have variable pressure. That allows us to do a lot of different things. We can go out at the beginning of a spacewalk at higher pressure, which means we spend less time pre-breathing. In the suits, since we run them with pure oxygen, the astronauts actually have to purge all that nitrogen out of their body. So we have to pre-breathe with pure oxygen. If we can do that at a higher pressure we can get out the door faster. And then as the EVA goes on we can actually lower the pressure in the suit to allow them to move around easier.

Right now the way the suits work today we have a system that will absorb carbon dioxide, which is one of the most important functions of the suit. But once that system is full we have to end the EVA and bring the crew members back in. This suit has a much different system. It's a vacuum regenerable system, so that it's continually absorbing carbon dioxide from inside and dumping it into vacuum. So that will no longer be a consumable, it will not be a limitation to how long we can spend outside anymore. That's a big advance.

We've got a completely different cooling system. The cooling system that we use today uses a Sublimator, so we actually have water, it creates ice, we expose that ice to vacuum. That ice actually sublimates off and creates cooling that we use to cool the astronauts, and the systems inside. This system uses an evaporative system, which is very different. We've done a lot of testing to show that it works. What we like about it is it's much less sensitive to water quality, it's much more robust. We can use it for many, many more hours than we can use our system. This suit you actually get into it a different way, it's a rear-entry suit. And we'll talk about on another chart why that's important.

So let's talk about the life support system. It's the most complicated part of this. We've built several generations of this system. In the lower part of the system you see what call our 2.0 test unit. This was about six years ago when we built that first one. It was a little bigger than we liked it, so we had to then ... But this was the first suit where we actually packaged it ... First life support system we packaged in a thing small enough that we thought we could carry it. We decided to make it even smaller and so if you look to the right that's what the current generation looks like. We are actually in the process ... In fact I was just in a lab this morning looking at this. We are putting the first fully functional unit, what we call our design verification test unit, today in a lab right now, so in about a month we'll be ready to start testing that thing.

And you see there's various components, you see their oxygen regulator up there in the upper right-hand corner. The carbon dioxide removal system is up there as well. And then you see the backplate that it all mounts to. What's in there? We talked about this. The primary heat rejection system, that's the Spacesuit Water Membrane Evaporator. We call it the SWME, that's what cools the system and cools the astronauts. That big gray box in the middle is what we call the Rapid Cycle Amine, the RCA. That's how we continually dump carbon dioxide overboard. We have fans that have to circulate oxygen around the suit to help pull carbon dioxide from the crew members' faces and help bring them oxygen so they can continue to breathe. We have pumps in the system that pump cooling water all around the system. We have a backup, what we call an Auxiliary Heat Rejection system. It's a smaller backup system in case the primary system fails the auxiliary system will keep in and it will run long enough for us to get the crew members back inside.

We have distributed control systems all over this, it's very much computer controlled, that will monitor the functions of this suit, the life support system, and make sure that it's working the way it's supposed to be. We've got high power lithium ion batteries inside that we can recharge in suit, so you'll actually just plug the whole suit in. With our current suit we actually have to take the batteries out, charge the batteries, put the batteries back in. This is a much more modern system. And we have a radio, you see down there as well, so that we can communicate with them.

So there's other parts of it, there's a display and control unit. This is the unit on the front of the suit, it's kind of mounted on the crew member's chest on the outside, that they use to control the suit, to turn it on and off. There's pressure gauges so they can make sure the pressure's working. There's an interface for an umbilical that when they get back in the vehicle they can plug in and that will start feeding the suit oxygen, and power, and water, and those kinds of things that they need to stay alive. We have a Trace Contaminant Control system that takes out contaminants out of the air that they're breathing. There's a water tank in there, the Feedwater Supply, that's the water we use to cool the suit. There are various relief valves throughout the system. Next slide.

The Pressure Garment too we've actually been testing this Pressure Garment for a couple of years. You see in the left-hand there that's actually astronaut Kate Rubins, she's onboard the International Space Station today. She's done a couple of spacewalks, so we try to get our very experienced crew members in this suit and in the pool, what we call the big Neutral Buoyancy Laboratory, and they can move around. And she gave us lots of really good feedback that this suit is much, much easier to move around in than our current suit. She wanted us to launch it for her. We weren't quite ready for it, so she's got to use our older suit onboard when she does a spacewalk, probably in about a month she'll go out the door.

So you see various versions of this. Our latest version you see there on the right, that's one of our engineers Kris Davis demonstrating the suit. The fact that she can bend down and pick things up even in this suit, and she's one of our smaller female crew members. And so this suit was designed from the beginning to fit a much larger range of people, including some of our smaller female astronauts all the way up to our larger male astronauts. This suit is designed to fit all of them.

This is a reentry suit. In our current suit the way you get into it, it's a little complicated, the suit breaks apart at the waist, and you actually have to climb underneath and stick your arms up. And we've actually hurt some of the astronauts, some of the shoulders. For those of you guys that are getting old you know we have shoulder problems, and some of our older astronauts have trouble getting in and out of the suit, so it's a little complicated. So it's actually a much better system if we can come in from the back. So this suit actually has a hatch. It's a hatchback on the back. The back opens up and the crew members actually crawl down from the back. It's a much easier, better way to get in the suit. You can see that there.

The hard upper torso is the part that holds all of these pieces together. You see the hemi-ellipsoid helmet, that actually gives the crew members much better visibility. They can actually see a much wider range around them, they have much better situational awareness. Again the idea is that our astronauts are scientists and when we go back to the Moon we want them to be able to experience the environment as much as they can. You see the front where the ... That's where the display and control unit will go. This is actually a picture of our DVT unit there on the right that we're putting together to begin testing, in about a month we'll have that going.

The Informatics System we will have lights mounted on. One of the things that we want to do when we go back to the Moon this time we want to go to a different place than we went back in the Apollo Program. We want to actually go to the southern poles of the Moon, primarily because one of the most important things we're looking for is ice, water ice. If we can get water ice and we can find it on the surface of the Moon it actually provides ... Because it's hydrogen and oxygen we can actually make rocket fuel out of that. We can make breathing oxygen out of that. Water itself is useful. So if we can find that resource on the Moon it's very important for exploration, so we want to go look for it. And we think that there's water ice there very near the surface in the south poles. One of the downsides though is the south pole is really, really dark. And so we have to have lighting systems that allow the crew members to see what they're doing, to see the workplace they're in.

The other thing is we want to take the whole world with us when we go back this time, so we're putting high definition cameras on. I'm working on a conceptual 360 degree camera that hopefully the whole world can be sitting on the shoulder of the astronauts when they're walking around on the surface of the Moon this time. We also have antennas, avionics, batteries, radios so the crew members can talk back to the lunar vehicle and then back to Earth. And then ultimately, when we bring these suits to father out, when we take them to Mars and other locations like that, this system will basically work the same way this one does that we're using on the Moon when we go back.

We also have lots of really unique facilities, training facilities. We have a vehicle called the Advanced ... Or a facility called the Advanced Reduced Gravity Offload System called ARGOS. We can actually see the second picture from the left there on the bottom, we can actually ... It's a system that simulates being in different gravity fields. In this case we generally simulate 1/6th gravity since that's the surface of the Moon. We can do a lot of training in that system so the astronauts can learn. We do other kinds of EVA training too. We actually can weight the astronauts down in the bottom of our pool to 1/6th G, so we can do some practicing in the bottom of our Neutral Buoyancy Laboratory. The fourth picture from the left there that's another picture of one of our crew members inside of a suit in the ARGOS facility training and practicing. We are building a bigger facility to allow the crew members to practice getting in and out of the landers, and walking around the lander area, to begin practicing what it's going to be like going back to the Moon.

So this is a picture, we brought the suit out, we unveiled it at Washington D.C. This is our administrator there Jim Bridenstine in the middle. Kris Davis is one of the suit engineers that actually works on the Pressure Garment, so we got her inside the suit and brought it to headquarters, and had a pretty good event.

So as you can see there's a lot of really cool things that are happening in the spacesuit world. The spacesuit that we fly today to space station was designed in 1979. I suspect that was before a lot of people on this call were even born. I was alive but I wasn't very old. So our suit that we're flying today with is almost 40 years old and it was a beautiful machine. It works really well, but it's time for us to build the next generation suit. We want a suit that's more functional, that's significantly safer than our current suit. And again, as I said a couple times, it allows our astronauts to really do exploration like scientists. That's really why we're going back is to do science. And this is really just a tool that allows our astronauts to behave like scientists. And really that's the goal for going back.

So I think that's all I got. Let's go to the next slide. Yeah, questions. So I wanted to save some time, so it looks like we have about 10 minutes. I'd love to answer your questions. Any questions you guys have. Again, I love talking about spacesuits.

Speaker 1 (18:44):

So, first of all, I wanted to say thank you Chris for that excellent talk and great videos. We really do appreciate you giving a talk. So now we're going to open the room for discussion for questions.

Chris Hansen (18:56):

All right, bring them on.

Speaker 1 (18:58):

I can get the ball rolling with a couple questions. So my research tends to be in the realm of sustainability, so what are some areas of sustainability that you have implemented into the suit itself?

Chris Hansen (19:12):

Wow, so that's a broad topic. So from a sustainability standpoint we think about maybe differently than when you use the term sustainability, maybe differently. One of the things that we're talking about is when we went back to the Moon the first time we went there, there were six trips to the Moon but we only spent a couple of days there at a time and then we came back. So we've only been on the surface of the Moon for 20 or 30 hours. We really ... This mission, Artemis, is designed to go back to the Moon for the long term. To have a very sustained presence there. And for us one of the keys to that is having a system that is very robust that we can reuse it over, and over, and over again. And so this system was designed to function for really thousands of hours in the long term, so we've spent a lot of time looking at reliability. How do we design systems that are reliable?

I talked about the cooling system. We use water. The current system is really, really sensitive to water quality. We've broken it a couple of times by having some very tiny, tiny amounts of contaminant in the water. This suit we've actually run really dirty water through it for hundreds and thousands of hours, and it continues to function properly. So it is allowing ... There's a [inaudible 00:20:26], let me get it out of the way. So it allows us really to have a much longer presence. The idea is to go back to the Moon this time to stay, so we have a much more sustained presence there on the surface of the Moon.

Speaker 1 (20:39):

Thank you.

Josh Rovey (20:39):

Hi, this is Josh Rovey, University of Illinois.

Chris Hansen (20:43):

Hi Josh.

Josh Rovey (20:44):

I wanted to ask a question about dust mitigation. You kind of talked about this a little bit but you also mentioned astronauts getting in and out of the lander, perhaps astronauts going in and out of a habitat. Are there things you do in terms of a suit that help to minimize or mitigate dust buildup inside those vehicles?

Chris Hansen (21:04):

Yeah, definitely. So one of the things we learned back in Apollo was that there was a lot of dust that we brought back in. It was a big problem. One of the big issues with dust on the surface of the Moon is because there's no atmosphere there is no erosion process of the dust, so the dust particles tend to be really sharp. They got lots of sharp points, which is really bad for mechanisms and moving things like our joints, and bearings, and those things.

We had plans ... The other thing is we had developed tools for Apollo to help clean the surface of those suits off before the astronauts got back inside. What we found when we went back and did some research on it is the astronauts were so tired. The suits that they were using back in the Apollo days were so difficult to use. They spent so much energy fighting the suits themselves that by the time they got to the end of the EVA they were so tired they really couldn't do an effective job of cleaning the suits off, so we brought a lot of that stuff back in.

So there's a couple things we do. By making the suit easier to use, by understanding how to minimize the amount of energy it takes for the crew members to move around in them, we're going to give them a lot more time and energy to deal with dust removal. We're also building tools to get dust off of the suits. We're looking at materials that are dust-resistant and dust-repellent. We're even looking at some electrical ways to perhaps charge the surface of the suits to keep the dust from sticking to it. All our bearings are very specially sealed. We spend a lot of time sealing the bearings that are particularly sensitive to dust. And then the landers themselves have to have systems that are designed to take dust of the air. We have requirements on them, as they're designing their landers right now, to try to deal with and minimize the amount of dust that we bring in.

It's not going to be perfect. It's a really, really dirty environment. But, again, we're looking at trying to build systems that are, A, robust enough to deal with it. And then spend a lot more time and effort trying to keep us from bringing dust back with us. So it's one of the biggest technical challenges we have going back but we've got a lot of work ... We think we kind of understand at least how to take a good shot at it at first. It's a good question.

Speaker 1 (22:58):

So we have a question from Raymundo Muro-Barrios. His question is, "What material is used for the suits face shield?"

Chris Hansen (23:12):

Interesting. So the face shield is actually the ... What we call the helmet bubble, it's actually made out of a polycarbonate. It turns out that the original suits that we built for the shuttle and station that you see in the EMU have polycarbonate bubbles that are full bubbles. And that polycarbonate was a special blend that we built. And we thought we bought enough of it for the whole program. We just ran out of it about two years ago and they don't make it anymore, so we had to go through a whole big certification process to re-certify that polycarbonate, it's a plastic, for the current EMU. So at the same time we knew we also had to develop the new helmet bubbles for the current suits ... Or for the new suits, the xEMUs, so we actually went through a program together and re-certified a whole brand new kind of polycarbonate to use in those.

We like the polycarbonate, it's very tough. It's much less sensitive to damage. We actually have a double layer one to protect the inner part, which is keeping pressure inside the suit. We have like a shield, a screen, on the outside that helps protect that unit. But it's essentially plastic. It's really tough. It's a little easier to scratch than glass but it's a lot safer, it's not brittle like glass and so it's a much safer material for us to use.

Speaker 1 (24:24):

Thanks for that question. Good job. So we have another question from Jorge Hernandez. "Will NASA continue using Ortho-Fabric for spacesuits or has NASA looked into different exterior materials since you want to charge the exterior of the suit?"

Chris Hansen (24:43):

Well so it turns out we have a lot of experience with Ortho-Fabric. It works really well. And so the current plan right now is to continue using it because it's really effective. We are looking ... We're continually looking for other materials. We actually ... It's an interesting ... The Mars rover that's almost to Mars, we launched it about the middle of last year and it's on its way to Mars. We actually put some external spacesuit material on that vehicle, so it's going to sit in the Mars atmosphere for a while. It's got some new things on there. Again, looking forward to Mars, when we go back there, what different kinds of materials we can use. For now though the Ortho-Fabric works really well. It gives us good thermal properties and it's tough. And so for this first round at least we're likely to use Ortho-Fabric on the outside still. It's good stuff.

Patricia (25:27):

This is Patricia. I'm getting a few messages and questions as well. So Annu would like to know, "What's one feature of the suit you wish could be improved even more?"

Chris Hansen (25:40):

Of our current suit? That's a good question. To be honest with you it's mass. Mass is always the issue. The suit, while it's perfectly ... In 1/6th gravity it's easy to move around. It's pretty heavy. The current suit is about 350 to 400 pounds, which sounds like a lot. It would be difficult to walk around on the surface of Earth with that. On the surface of the Moon it's not too hard. But that's all mass that we have to get there and getting mass to the Moon is difficult. And so we are constantly looking at ways to make this system lighter, to make it less massive. We've done a really good job with it but it's still heavier than I would like it to be, so really a lot of our energy's going to go into trying to reduce the mass for this, especially when we go back to Mars. It's got a higher gravity field, so it's going to be even more important there. So that's the one thing I wish we could get more mass out of it and we're continuing to work on that challenge.

Patricia (26:33):

Awesome. And I've got one more in my chat. This is from ... And I don't know how to pronounce your name but I'm going to spell it. It's E-Y-O-B. And they'd like to know, "Are the suits also going to be used for the Mars missions or is that something entirely different?"

Chris Hansen (26:51):

Yeah, that's a good question. I wish Mars was closer to our horizon and I could spend more time worrying about that. Unfortunately Mars is quite a ways out. The Mars suits we can use a lot of this technology but one of the biggest differences is the surface of Mars is not a vacuum like the surface of the Moon and low Earth orbit. There it actually has a low pressure carbon dioxide environment. That messes with our cooling system and our CO_2 removal system. So there are some things we're going to have to do differently. Some of the technology parts of the life support system we will have to do differently. We're starting to think about that but it's far enough out that we haven't really tackled that problem yet. We know what challenges are out there, we haven't found a way to solve them yet. But a lot of the components we think we'll be able to use. And it gets back to the mass thing too, we need a suit that's lighter, so we'll be working on all of those things. Hopefully before my career's over we'll start tackling Mars.