Thomas Smith (00:14):

Good morning. And what would you do? The Adelaide Festival of Ideas? My name is Thomas Smith. I'm from Kings College, London originally from Adelaide and our session this morning is Human space exploration. It gives me great pleasure to welcome you and beautiful Adelaide. First of all, I'd like to acknowledge that today we get it on the traditional company of the garner people or the headlight flights, where you recognise and respect the cultural heritage, beliefs, and relationships with the land. We acknowledge that they are of continuing importance to people living today, and we respect their elders past and present.

Thomas Smith (00:53):

May I ask you to switch off your mobile phones and also ask that there'd be no recording of the session this morning, a photo or video we'd like to remind people that you're welcome to connect with the festival on Twitter and Instagram. And now I have a great pleasure of introducing our speaker. Pamela Melroy. Pam is a former NASA astronaut and space shuttle commander, a retired Colonel in the us air force and military test pilot currently working and living in Adelaide for Nova Systems as director of space technology and policy. And rather than taking any more time, I'd like to hand straight

Pamela Melroy (01:41):

[Inaudible]. Can you hear me okay. All right. Great.

Pamela Melroy (01:44):

Good, good morning. Thank you so much for coming out on this. Well, it's hard for me to say bitterly cold cause I live in the United States. Most of it, but it is a little fresh this morning. So thanks for coming out early. On a chilly, chilly morning here in Adelaide, I'm very excited to have the opportunity to share some of my stories with you today. And I'm going to tell some stories about my experience in space. But then I'm going to talk about a couple of big ideas because this is the festival of ideas. And I want to talk about what my experience has given me from that perspective. What are the big ideas in this space? So one of the interesting things about being an astronaut is that people sort of seem to think you just like watched into the world fully formed as an astronaut.

Pamela Melroy (02:33):

They never think about the fact that you were actually once a kid. And so this is me. I was about two and a half years old and my mother caught me in the garden wearing my father's air force flight, cath impersonating an air force officer, which isn't wrong instead of punishing me, my parents encouraged me and they always told me from as long as I can remember that I can do anything that I wanted. Well, believe me, growing up as a girl in the sixties and seventies, what that meant to them was that I could actually be a doctor someday or a lawyer, or maybe get a PhD and be a scientist. They never in their wildest dreams thought that I'd become an astronaut, but they supported me and they never backed off that position. And because they believed in me, I believed in me.

Pamela Melroy (03:30):

So I was really interested in the sky from a very early age and I wanted to study astronomy specifically planetary science, but that was not close enough for me not just to study it at university, I wanted to actually go visit if I could. So I was also very fascinated with weather and I wanted to get into the sky. And so I became an air force pilot and then eventually a test pilot. Now when I was a kid and I decided I

wanted to be an astronaut, the only astronauts that I knew about were military jet test pilots that is not true anymore. About two thirds of astronauts around the world are scientists and engineers. And only about one third are from have a military background and in particular and ancient background. But I was particularly excited to go that way because I, again, I've just really loved being a pilot.

Pamela Melroy (04:25):

And of course I had an opportunity after being a test pilot to have my dream come true in flying in space three times each of my three flights to the international space station. So let's talk about what what I did my era was about the space shuttle. So the space shuttle flew for about 30 years from 1981 to 2011. So that Spanish my career and a critical part of the space shuttle was to do science in micro gravity. So what is micro gravity? Well, we tend to call it zero gravity, but in fact, that's not really true. It's not accurate. Gravity is everywhere. It's the law. You can't get away from it. There's no such thing as zero gravity, but as you accelerate fast enough and go around and around the earth, you're essentially continually in free fall and the earth is falling away from you.

Pamela Melroy (05:24):

So if I could throw a ball, it will eventually do the force of gravity, hit the earth. But imagine if I was the best ball player in the world and he couldn't throw it at 28,000 kilometers an hour, it would actually just go into orbit around the earth. The arc of in falling actually would match the earth curvature and it would always stay in space. So all the forces balanced out in the sensation that you have is that there is no gravity. We call it micro gravity. What's interesting about micro gravity is that it's a major parameter. So if you remember from science experiments, which you try and do is change one thing at a time and then see what happens as a result of that. That's a key part of a scientific experiment. Well, changing the force of gravity on what you're doing is a huge thing to change.

Pamela Melroy (06:16):

And so we can do all kinds of really interesting science in space. And my friend Khaleeji Macata here demonstrating that fluids in the absence of gravity, the strongest forces acting on them as surface tension. So that is a ball of water just floating completely formed in front of him, but it is still liquid fat. You can drink it if you want to. Some other really interesting science that we discovered is that flames burn differently in space. In fact, what we found is you can get incredibly kind of flames that are burning with extremely high efficiency at very low temperatures. So what's exciting about that is that it's so efficient that it consumes all the fuel and there's very little by-product and it, and so when we hope from this kind of science experiment, we can have more effective and combustion engines that produce less pollution.

Pamela Melroy (07:14):

Another interesting thing about micro gravity is that in the absence of gravity, you can form larger and more perfect crystals in suspension. So who cares about crystals? Well, it turns out that people were studying human bodies, use crystals, proteins, and crystals, and x-ray spectrography to try to understand the formation of that, that protein, that kind of experiment is done to learn how to design new drugs and medications for people. And so you can see a huge difference here between let's see if I can get it right. Yeah. Here, there we go. Between crystals that are grown is in space versus all, any round. And so they're much, much better at doing that kind of experiment. And when I was on board and most of the shuttle and the station, we literally would carry suitcases of protein crystals to grow in space and then bring them back for this kind of experimentation.

Pamela Melroy (08:15):

Another wonderful way to do science from space is looking at the earth and in, even in my career spanning 14 years as an astronaut, I was able to look down at the earth and see changes that were occurring lake Chad Africa having a huge impact as it dries up creating food scarcity migration of animals and of the people. Now, when I talk about the negative aspects, I always want to bring up the positive ones to Mount St. Helen's is a volcano in the United States that erupted in the eighties and created a huge dust cloud that's bred for kilometers around what we found though, by looking at space is that the area around it is recovering much faster. The flora and fauna is recovering from that eruption much faster than anyone anticipated. So sometimes you do see really good things too, not just the bad ones.

Pamela Melroy (09:13):

So the idea behind the international space station was looking at the space shuttle and recognizing, yeah, we were doing great science on the shuttle, but the shuttle only flied applies about six to seven times a year. So imagine if you had a major national laboratory that you could only operate for about a week at a time, six or seven times a year, and then the rest of the time you had to shut everything down. So we were getting some really tantalizing science, but the idea behind the international space station was to build a place that we can do science 24 hours a day, seven days a week, 365 days a year, a major engineering enterprise. And it is the international space station partnerships with countries all over the world. A few points that I'd like to make about the ISS. This is actually an artist concept from the year I arrived at NASA in 1995.

Pamela Melroy (10:10):

So in the area in the center here, this is the pressurized living quarters. And then at this end is where all the labs are. This is a large trust, which hosts the radiators they're ready, heat of the electronics and the people on board to space. And then of course the solar rays. So that's the primary way of generating electricity in space is usually through solar race. Now on the space shuttle, we used fuel cells, but we had to carry our own propellant to run those fuel cells. If you want to operate for 365 days a year, you want to take the rays of the sun, which are continually providing, convert them to electricity. So a very important part of the space station. So my career as an astronauts spanned three flights, my first flight was in 2000. And if this is the way a space station looked at the time, there were just three different elements to it.

Pamela Melroy (11:10):

And no one was living on board and on our mission, we attached two new pieces, a sort of utility switching box and a high gain antenna, and then a side door, because you never want just one way to dock because if you've got a problem, then you got to go home, right? So aside door very important. One of the very early missions to the station in 2002, just two years later, this is the way the station looked quite a bit of activity going on here. We had an airlock that got added and we were able to add this first segment of the trust. You can see there's one solar array on top here. There was one solar Ray delivered early, and it sat on top of that utility switching box that I showed you in the previous chart. And you'll see how the station grew after that.

Pamela Melroy (12:03):

And the next flight was in 2007. This is my crew, a very diverse crew from all around the world. A mix of rookies who'd never flown in space before and highly experienced astronauts. And our responsibility was to bring up the hub of all the labs. How do you call it? No two. And it's sort of like the hub of a tinker

toy set. So all the labs attached to it. So we were bringing it up to put it into place. The us lab was already in place, but the Japanese lab chemo and the European lab Columbus were sitting on the ground in Florida ready though on the next two missions. So we needed to attach this and we had another responsibility as well. And that was to relocate that original solar way. So I pointed it out to you in the earlier picture, it's sitting in pack on top of the space station, the crew ahead of us, folded it up and it put it into place.

Pamela Melroy (13:03):

And our responsibility was to use a combination of the robotic arms of the show and a space station to relocate that out to the end of the trust and then unfurl it. And that was actually very important because not only did it a known, provided a place for chemo in Columbus to attach this solar array was needed in that place for the wiring to provide the power to those laboratories. So how do you get ready for a mission like that while you spend a lot of time practicing? Of course we have to study our books, but that's actually the simplest part. It's harder when you get the crew together into the cockpit and practice all the things that you're going to do. And this is the cockpit and the shuttle training cockpit that we practiced for law, gosh, for degree. And if rendezvous turns out the shuttle is so hot allocated and you can't simulate everything in a single simulator, but this simulator had one extra special feature, which was really nice.

Pamela Melroy (14:05):

It would actually link up with mission control. So we could have mission controllers and we're in the cockpit. And then you have a group of really evil individuals who are trainers who think of malfunctions. And then they put the malfunction in the system and we get the correct signature for that malfunction. And so does mission control. And that allows us to work together, to figure out how to solve those problems. And that that's a key point part of the training I missed the robotic arm. So I'd like to point them out because they're incredibly capable of a Porter. This is the robotic arm of the space show. It is Canada's contribution to the human space flight program called Kennett or one. And if you think of Canadarm one like a human arm, it's attached to the shoulder and rotates it rotates at the elbow and at the wrist, and it can grab hold of things.

Pamela Melroy (15:02):

So in this case, it's grabbing hold of another part of the robotic system, which is just a long boom with a camera on the end of it that we use to inspect the space shop. So as the space station was being billed Canada as the world expert in space, robotics contributed of course, Ken on to, to the international space station. Now in kindergarten to had a lot of extra features that we learned from operating Canada, one that we really wanted it. So if you try to think of it like a human arm, you can get confused pretty quickly because it actually is double jointed. It goes all the way around and you can actually operate it kind of in a plane where you can walk it into position. It also has another really cool feature. It has a river at both ends, and that's really important because the space station is about a hundred meters in all three dimensions.

Pamela Melroy (15:58):

And so the shell are, there was no way that it could reach all the places that it needed to reach, but even the station arm, although a little bigger, wasn't long enough to get to all the places you needed to get to. So it can literally rappel and then release from the other end and walk itself out to another place on the space station and provide the flexibility that we needed. Now we use the robotic arm to lift big, heavy,

heavy things, or to get astronauts into tight spots where they needed to operate. But just because you've attached a new piece to the space station doesn't mean you're actually ready to start using it yet. So for those very fine dexterous tasks, we use space walkers. Now, space walkers go out and essentially what is a fabric spacecraft. So it was really other than launching entry, the most dangerous thing that has done in space because they're out there all by themselves with several layers of fabric and that's it between them and the space.

Pamela Melroy (17:02):

They carrying tools, including the largest cordless drill you have ever seen in your life. And their job is to go out and make the connections right, and to drill things into place. So they use the cordless drill to bolt pieces of the space station together. They use their hands to connect fluid connectors and electrical connectors, and essentially to do any kind of task that simply you couldn't do with the capability in the robotic arm, you have to pull back a blanket and look at a system underneath a thermal blanket. That's what only a space Walker can do, how we prepare and practice for that is actually in a pool. So it's the closest that we can get here on earth to microgravity just for the purpose of training. So if you're a scuba diver, you know that you can use it hominization of air and weights to get yourself neutrally buoyant, what does that mean?

Pamela Melroy (18:01):

It means you won't sink to the bottom, or you won't float to the top. You stay right where you are. That's about as close as we can get. And so we put our space walkers into their suits and then with Dockers, with scuba tanks, attach weights and air into the system to get them neutrally buoyant. And then we have a giant mock-up of a space station in a huge pool where they can practice and prepare. So that's not all we have to practice and prepare for. When we go to space, it's not like going we're school. We lived together. We don't go home at the end of the day to our families. So we have to live in a very, very small area right here. You see my crew on the middle deck, we're sleeping behind Palo's head is the kitchen. The toilet is behind that door.

Pamela Melroy (18:53):

This is our living room with lockers, and this is our gym, our workout equipment. So we have very, very tight quarters that we have to live in. And how do you prepare for that? No, I took the crew camping. That's how I'm preparing for it. We went sea kayaking in Alaska through the national outdoor leadership school program. The idea was that this is like a space analog for us. Every morning we would wake up, we would pack all her equipment into our kayaks and we wouldn't paddle 15 to 25 kilometers per day. We set a target. We would work together and make decisions. So you're dealing with risk decisions, physical risk people with different physical capabilities, summer which you might call city boys. And some are country gals. So I'm really love the outdoors and some don't everyone has different levels of experience, but the idea is that we would work together in this risk decision and environment.

Pamela Melroy (19:55):

At the end of the day, we wouldn't unpack all of our equipment set up our tents and our sleeping bags. We prepare a meal together. And then at the end of the debate ended of the meal, we would critique our team performance for the day. I have to tell you it's one of the most exhausting things I've ever done in my life to sit and rehash every single decision that we made as a team for the entire day, with as much candor as possible, you really have to figure out, you know, how people think, how they work together, how they act when they're tired and cold and hungry, who gets really crappy. If she's not fed

three times a day, those kinds of things, very, very important. This is what bonded us and helped us to go beyond a team environment, beyond a family in ways because our lives depended on each other.

Pamela Melroy (20:50):

And it's very, very important to have that knowledge and that ability to respect and work well together. So we had a very, very successful first half of the mission. We watched a lot of time for the first time for me on my third flight. We finally got off on the right day. We successfully docked to the space station. We got known to put into his position. We had three tremendous spacewalks to get known, to admitted out we moved the solar array from the top position on the top, out to the end, and then our space walkers bolted it down. And then they started to hit back in. And at that point, the commander of the space station, Peggy Whitson, and I began to unfurl the solar array and we were pretty successful. Actually. We got half of it out.

Pamela Melroy (21:44):

Okay. But about two thirds of the way through the other path, this is what I saw on the camera. So I called her to board. We put the brakes on, and then we floated over to the space shuttle where we could get a better view into our total horror. This is what we saw, not just one, but you can just barely see it. There. Two rips in a solar Ray, what had happened was the solar rays have long cables that it provided the tension to for the solar array when it's fully deployed really, really important. Because those solar rays are really floppy and they need to have tension because as you fire the thrusters of any visiting vehicles, spatial, or anything else, they hit those solar rays and caused them to wobble. So you need some load bearing attention on solar race. So we were in a really nasty position here because one of those cables had caught in the pins of the fed, the fold and the hinge point for the solar array.

Pamela Melroy (22:51):

I have to say as much time as we spend practicing for every single thing that we could think of, this was not one of them. No one had planned for this. In fact, the solar rays are only electrified all time. And our space walkers are told, nevermind here, those things cause they'll Friday electronics in your suit that are keeping you alive. So stay as far away from a solar array as possible. So we had a really serious problem though, because the solar array is not fully deployed. It was two thirds of the way out. We had one of these cables snarled. If that cable snapped and starting to wander around the space station, it could cause other kinds of damage to the space station. So we either had to fix this, or we were going to have to jettison the solar Ray, but you might remember then that solar rain is required for the energy, for the UN, for the European and the Japanese laboratories.

Pamela Melroy (23:53):

And we did not have a spare waiting for this on the ground. So we had to fix this problem as quickly as we possibly could. So a very complicated problem. And I should add in addition to the fact that we didn't really want our space walkers anywhere near here, the robotic arm was also not long enough to reach out there. So we had to figure out how to get out there and face it with all of these constraints. So for about three days the ground and improve the space station crew in Margaritaville, the space shuttle all worked together to come up with solutions. So there were people working on the ground trying to figure out how to repair the solar Ray, if you could, then we had the robotics specialists. My, these are my two astronauts that were our robotics specialists working on, trying to figure out how they could use the robotic system to get someone out there.

Pamela Melroy (24:46):

Anything that we needed to use for the repair had to be constructed, onboard the space station of spatial kind of line when there's Apollo 13 moments where you dump the stuff on the table and say, okay, what is, what is, what do we have that allows us to, to construct or repair? And then of course, we had to prepare any of the tools and a space walking suits for what would likely be a really epic space walk. So the first solution was to develop the capability to stitch up and provide structure structural integrity to the solar array. So what, what the ground came up with was an idea they call it cufflinks. So the idea there was to cut literally out a sheet of aluminum, a strip of aluminum cover with insulating tape and then attach it to a cable. And in it, it could slide through a hole in the solar array, just like a cufflink does it locks into place.

Pamela Melroy (25:47):

So five of these to span across the solar array. So we needed to get an in the holes top and bottom and get them put into place. We also had to construct them on board. So the next problem was how to get a space water out there. I should mention Scott Parazynski is one of the tallest astronauts. He was my lead space Walker, and he's the one who actually performed the repair. And you can see him out here. This is a meter long footstool, and Scott is well over two meters in height. He's like 2.2 is extremely tall. So the solution here was actually to take the Canadarm to the space station arm, and match it with that pole. You got extra poll that we had as a part of the shuttle bike system and includes those two things together, put them at the end and get them out there.

Pamela Melroy (26:40):

So the tremendous challenge was to weave our way through the inner solar array and get, get it out there. Now his responsibility was to get the cufflinks in place without ever touching the solar array. So he had, he kind of needed three hands, but he only had two. So he had one tool to help him pull the solar array closer to him, fully insulated. And then with his other hand, he could stuff the coupling through the hole. And then he had a third tool, which we call the hockey stick and it was an L-shaped tool that was very blunt and it was grafted insulating tape. And that was to push the solar array away from him if he needed to do that. So he had to juggle all three of those tools as he was doing this. So we had a little bit of excitement as Scott got ready to put in the first complaint.

Pamela Melroy (27:35):

He slid the cufflink through the hole and many things. He didn't want any one of us would've done. If in that kind of situation, he jiggled it a little bit to make sure that the flipper bar and locked into place. And then it gave him a good tub just to make sure it was in place. So then what happened with something and we weren't really expecting, and there was only one person on the crew who can see it. And that was Doug peel-off, who was sitting at the very base of the solar Ray looking up at Scott. And he was in the only, the only person on the whole crew in a position to see this freezing cold. He was in the shade is really, really cold. His hands were really cold. He didn't have anything to do, but watch Scott, he could be forgiven for looking the other way and getting a little bored, but instead he stayed very focused on Scott's safety.

Pamela Melroy (28:25):

And after Scott gave that tug, Doug shout out to him, Scott, look out, of course, I'm in a spacial. I'm going look out what I'm looking straight on. And I have no idea what he sees. So Scott looked down, what he saw was when he gave it to the tug, a big below, went down to the bottom of the solar rain.

And then in microgravity, it started to come right back up. And so a huge wave of solar array coming up again. So he took the hockey stick. He's held it out in front of him and he leaned back as far as he could on a step stool. And Doug actually lost sight of Scott's hands as the big below. And the ripple went by when all the ways top went back down again, went back up again, and finally frictional forces caused you to damp down.

Pamela Melroy (29:15):

And we point we all together, deep breath, Scott was okay. He hadn't touched a space station or a solar Ray, neither had a robotic arm touch the solar Ray. So he was safe and then he had to go do it nine more times. So he was successful in doing that. You can see the view after he had gotten the vibe cufflinks in, this is a picture that Doug took looking straight up the solar Ray and then pulled him away from the array and then in the unfurled it, and the amazing thing is on a regular look, it's right there. A little wrinkle spot. It is producing 99% of its designed power. And no one has come up with a better solution. So this is exactly the way the space station is today. So the space station now is hadn't been completed. It was completed in 2011.

Pamela Melroy (30:06):

You can see all four solar rays or any position, the Japanese laboratory here with their porch, the European laboratory and the us lab. And of course no to which we delivered all in place. And we're doing science just as we envisioned on the space station and then keeping up on changes in modern science, Kate Rubins, Siemens DNA in space for the first time, we're beginning to actually understand how our DNA expresses differently in microgravity to have insights, not just to have and how to keep our astronauts safe, but why certain things happen to our bodies in space and why certain things don't that we expect them to. We also have had to develop a tremendous amount of equipment just to keep humans alive on the space station. Most importantly, water and CO2 reclamation. And that's really important technology that has filtered out and spread out to remote regions across the earth.

Pamela Melroy (31:11):

And of course, we continue to take pictures of the earth from space, provide them for free around the world to scientists, to study the earth. I shouldn't stop for a moment and tell you about my personal experience, looking at the earth from space. It's absolutely amazing. And during the day, it's actually very hard to see people. You see oceans, you see clouds, you see rivers pouring out into those oceans. You see K the grand canyon and beautiful stretches of islands and hurricanes and all kinds of things. You have to actually know right? Where to look. If you're looking for people, you have to know right. Where to look because cities are actually more defined except at night. So the big change that happens at night is you suddenly no longer see me, or if anywhere, it wouldn't be completely dark. The only thing you see are people on my first flight, I was not busy.

Pamela Melroy (32:13):

We had just waved off and landing. So I had about three hours free and I'm looking out the window and I see these a series of beautiful cities underneath me, like diamonds on black velvet things myself. I wonder where we are because I hadn't been keeping track. So I looked over at the computer and instead of we were over in China, China is a place I'd never visited. I didn't know anybody there didn't ever expect to visit there. But I thought for a moment and I said, well, you know, they can actually see me up here. You can go on the internet and see when the shuttle was coming overhead. And in fact, I'd done it myself in Houston and stepped outside and ways of as the space shuttle flew by. So I thought to

myself, Hey, maybe there's some kid down there and China he's out there and he stepped outside and he's playing, sorry.

Pamela Melroy (33:05):

I made it back. It was amazing to me. This still is amazing to me. Technology is what brought human beings together at that moment. Isn't that amazing. We think of technology as something that separates us. It is not in this case. I could have seen them et cetera for the lights and they hadn't seen me except I was floating around and probably the pinnacle of what human attendant technology can achieve. This is the thing, extraordinary experience to look at the diversity very well. We're looking at going beyond for human space flight. So there's an international consortium that is discussing going back to the moon to build an orbiting station around the moon. That's a temporary way point that allows us to build on a moon village and have everyone participate in developing the moon. But I think our real goal is to move on to the Mars.

Pamela Melroy (34:03):

We're very excited about whether we'll have the opportunity to find life on Mars. The way I think about Mars is the way I think about a scientific experiment. We only have one planet that we know pretty well. Right? So think of the insights that we can get by comparing our biology to a biology that was developed on a completely different planet with completely different chemistry and completely different processes. So I think there's so much to be gained, especially if we can find life on Mars. So the well to point out that my generation of astronauts build the international space station, but right now, somewhere in school today is the first person who will set foot on Mars. And I'm always excited, especially when I see kids in the audience. Cause I wondered if maybe I'll come back in 20 years and here you get your talk about Al-Anon or on Mars. So cold, I'll just finish up with a couple of the big ideas that I hope that I was able to pass through. My experiences. And then the first one is that scientific exploration is actually about life on earth. It's about human beings. We are improving the human condition. And someday when we permanently go off the surface of the planet, it will be life on other planets as well.

Pamela Melroy (35:33):

Any other thought that I'd like to leave you with is that when you look at the earth from space, you begin to realize that earth is our spaceship. And just like my crew had to protect and repair our spacecraft to keep us alive. We, as the crew of spaceship earth have the same obligation to take care of our spaceship. It's the only one we've got and it's, what's keeping us alive. So there are no political borders that you see in space. We all are a part of this. We're all connected. So the use of water, the use of our precious resources you might think that what we do in Australia, what we do in the United States doesn't have impact. In fact, it is all one earth and it is all deeply connected and it is our spaceship together. And it's my hope that with the advent of commercial space flight, you know, Australian space agency, things going forward, that more people will have a chance to get at this perspective. And I think it's going to have an enormous impact on our culture and society when we have more people who are able to be in this way. Thank you.

Pamela Melroy (37:00):

[Inaudible]

Thomas Smith (37:00):

Thank you so much. [inaudible] And we do have some time for questions, actually, a few minutes, rather than take time to have a few more. We thought it might be best just to ask people to speak up. Raise your hand. If you got a question.

Pamela Melroy (37:23):

Oh, mine

Speaker 4 (37:25):

Couldn't have. Yes, [inaudible]

Pamela Melroy (37:40):

Sure.

Pamela Melroy (37:40):

So I'd like to point out that we've added virtual space. We're hoping to see maybe 15 or 20 years from now. Price has to come down a little bit, but I hope that all of you would have the opportunity to buy a ticket and at least have an experience the way you could on an airplane today. However astronauts will still continue to explore go to the moon, go to Mars and have some of those official responsibilities. And so if you want to be that kind of Explorer there's two things that I tell everyone, the first one is studying any kind of math, science, or engineering, any kind, whatever you'd like for me, I love planetary science, but there are computer scientists, doctors, geologists, you name it. And just about every single kind of science and math and engineering. The second piece is to think about the kind of that she would want to spend six months on the space station with or two years going to Mars. So we all know that there are people around us who we prefer to work with, right. They're easier to work with. They are friendly, they're helpful, they're cooperative, they're not selfish. And that's just as important is to practice being a kind of person. So I often tell kids one way that you can do that is through sport or other team MIS. And so practice being a part of a team and working with [inaudible]

Pamela Melroy (39:20):

Doing something on comparing the solar panels or the recipes in addition to defeat. Yeah.

Pamela Melroy (39:29):

So the question was, how do you get over the fear of after? Well, and so fortunately before I became an astronaut, I had about 12 years of experience as a military jet test pilot. And so pilots base a lot of those same issues. And what you learn how to do is compartmentalize. You have to be able to do that. You have to be able to put your emotions in a box, put it away and say, it's not a solid problem. Now it doesn't mean that after you land, you don't freak out on the side a little bit. You take out those emotions and that's actually very important to you to recover. It's something I think the doctors understand very well as well especially surgeons and those kinds of things. I think it's, there is no really great answer. We also go back to what people in combat say, which is that you don't want to let your mains down. And, and that's really, if you can get a sense of what it's like to go to space, that is one of the most critical parts is that you go far beyond a work team into family and territory. And I just don't want to let people down and it's wonders whatever [inaudible]

Pamela Melroy (40:52):

That's correct. Since the show was retired we are going sending humans exclusively on the Russian Soyuz. However, the us has three vehicles in development to work commercial. And one is a government vehicle called a Ryan. That's the one that's going to be the deep space vehicle, but both space X and Boeing are developing the capability to take astronauts to and from the space station. And in fact I think we're going to be pretty excited when we have more than one way to the space station in the next year. [inaudible]

Pamela Melroy (41:33):

The question was about physical changes when I return. Yeah, they're implanting when you're up there. Believe me. So we have learned fairly recently from having a lot of people stay up there for six months at a time that we are struggling with some issues. For example there's some astronauts, it seems to affect men more than women for some reason have a higher incidence of changing in their eyesight. And we think it has to do with the fact that in microgravity, all fluid pools in your thoracic cavity and roar, half of your body is spread throughout your whole body and creates intercranial pressure. We think we don't know yet. We're doing a lot of work around that right now. So the other effects tend to be much more short term there's dizziness. If you're really diligent about exercise on orbit, you won't lose bone mass, but that is a problem and a concern. But it is hard not to lose muscle mass in space because everything is so easy when you're floating around, you can literally move around the room just with a finger Busch. And so it's hard not to lose muscle mass that way. So that's usually the biggest thing that imbalance I had a lot of issues on all three flights for the first day or so out of balance

Pamela Melroy (42:56):

Recently. [inaudible]

Pamela Melroy (43:07):

Yeah. So cool. I mean, I thought this experiment is amazing. So there's this idea. It's actually about 15 years old now and it goes against everything that I learned in high school biology, which was your genes, your genes, you get insulin from your mom, you get someone from your dad and that's it right. All the, well, in fact, they can express differently. And what we learned is if you're in exposed to a different environmental condition, they can turn it on and off or express more strongly, less strongly. So the idea behind the Kelly twins marking stock one to space, identical twins, one stayed on earth, and then they looked at the, at their genes and how they were expressing differently. And what they discovered was sure enough, about 7% of Scott's genes in space expressed differently than they did here on earth. And it was around things like the suppressed immune system, which we know for a while, astronauts have recorded that anecdotally that we have a suppressed immune system in space, but now we've got some proof of that. For me that was one of the biggest findings, but there were several other areas too around bone expression and some other it's very, very interesting experiment. So I we've got a lot more work to do in that area.

Speaker 4 (44:33):

How much time [inaudible]

Pamela Melroy (44:37):

Okay. All the way back. All right. What are some, well, what are the risks of space travel? I mean, there are tons of it and obviously it's one of the riskiest things that you can do. But I think what's really cool is that with the admin and commercial space, we're starting to see the technology. They can keep people

alive in space, be commercially available off the shelf. I think that what we are looking at is very similar to where aviation was in the early 20th century. And the problem that we have is when we only said that a few people at a time we're just beginning to learn, right. Just because you've done something a few hundred times does not mean you're an expert in something like that. Imagine if there were only 200 takeoffs and landings in the history of airplanes, right.

Pamela Melroy (45:35):

How, how much you were there is to learn. One of the things I'm excited about is suborbital. It's much less dangerous because your exposure to space is what shorter the energy involved as much shorter. But I think we're going to get a better sense of the medical issues. And Tom is going to talk about that tomorrow. He's giving a talk on the impact of of space on the human body. It'll be a great talk and I hope you can listen to it. And of course when you're riding a rocket that's probably the biggest hazard, but there's also hazards coming back to the surface of the earth. I think those are all things that we do worry about. But we also feel like the payoff, what we have learned about our bodies about our earth about science are worth those risks.

Thomas Smith (46:30):

I have the pleasure of thank you very much. We actually need to get out of this free session. What that means is it's, it wouldn't be possible for autographs and that kind of thing, but [inaudible] will be available at that point. That we'll do ask that you go ahead, [inaudible]

Pamela Melroy (47:13):

Grab some water actually. [inaudible]

Speaker 5 (49:15):

I am actually, Chris, most of me is

Thomas Smith (49:19):

The mess up voice at the moment. Sorry, PowerPoint presentation.

Speaker 5 (49:25):

That's right. Have one. And it has a video.

Thomas Smith (49:28):

Should I just pop it in here? Absolutely.

Speaker 5 (49:31):

Okay. Good stage managers today. Oh, stage manager. Wow. For what it's worth Laura. Nice to meet you. We'll be coordinating the dancers. Yes. Excellent. Absolutely. There a [inaudible] okay. The cabaret festival still go all good. That was good. Oh, okay. No, no, I'm imagining what is this fee?