EXPEDITION 42/43 CREW INTERVIEW
TERRY VIRTS – FLIGHT ENGINEER 6/COMMANDER

Q: Why did you want to be an astronaut?

A: The first book I read in kindergarten was about the Apollo moon landings, so from my youngest days I just wanted to be an astronaut. I didn't see Apollo as it was going on but there were books about it and I heard about it and it just looked really cool. And there is something about me, naturally, that I just love flying and space. When I was a kid I had space pictures and airplane pictures, all four walls of my room were completely covered with posters of that kind of thing. My family all worked at NASA. My mom and stepdad worked at NASA Goddard and my dad also worked at NASA Goddard, so the space industry was just in my DNA.

Let's find out about your story back from the beginning. Tell me about your hometown. Tell me what it was like growing up there.

I grew up in a town called Columbia, Maryland. It is in between Baltimore and Washington, right in the suburban beltway universe there. It was a great place to grow up, very middle class America, a very diverse community, great education, great schools. And I grew up with a good group of family and friends so I was very lucky to have lots of support and a great community to grow up in.

Were you able to pick it out from orbit, flying over?

You know, one of the very first experiences I had on the space shuttle, just a few minutes after launch, the space shuttle did a roll to heads up maneuver and, looking out the window, I could see the entire east coast of America from South Carolina up to Boston. So one of those white dots down there was Columbia, Maryland. But the orbital mechanics were such that I couldn't ever see it during the day when I was on the space shuttle, so that is one of the cool things about the six-month flight. There will be times when I will get to see it, so I am looking forward to that. I saw it at night. The east coast of America is amazing at night as there are a lot of lights down there.

Give me the thumbnail sketch of your education in Columbia on through college and through the service that led you to become an astronaut.

I went to the Howard County public school system in Maryland, a great, amazing public school system, and went to Oakland Mills High School which was a great high school. I can think back on so many teachers. I can remember almost all their names, the classes, the things I learned in each one of these classes. That was such an amazing foundation for the rest of my life. And, by the way, I'm not done going to school. As you know, in many professions, maybe most, you have to learn in some capacity for your whole career, so it's important to learn what subjects you are good at and where your gifts are and then continue to learn because it will help you throughout your career. From Oakland Mills High School I went to the Air Force Academy. I showed up there as a 17-year-old, never really been away from home, and spent four years at the Air Force Academy and then went to fly jets after that. I thought about trying to go to graduate school but what I really wanted to do was fly airplanes so I became a pilot in the Air Force.

What kind of assignments did you have?

During my first 11 years in the Air Force I had 11 different mailing addresses as I moved around a lot. I became an F-16 pilot and was at Williams Air Force Base in Arizona, Luke Air Force Base in Arizona, MacDill in Florida, Homestead in Florida, Moody in Georgia, Korea Osan Air Force Base, Spangdahlem in Germany—that was an awesome place to live—moved to Edwards Air Force Base where I went to Test Pilot School becoming an F-16 test pilot there. So my first 11 years I was moving constantly. From there I came to NASA and I have been here ever since. So it was this Air Force career where move, move, move, move, move, and then boom, you are here forever. But it is great. Both phases of my career have been really good and enjoyable.

Was the application to be an astronaut something that you always had in mind to do or did it just come up?

As a kid I wanted to be an astronaut but I didn't think it was possible. I mean, to a kid, that is kind of a crazy dream, but I always had it in my mind and I would ask, "Hey, what do you need to be an astronaut?" and someone would say, "Well, you need a technical degree. You need to get some kind of math or science or engineering degree." So I did that and then I thought being a pilot would probably be a good thing and somebody told me about being a test pilot. It wasn't until I was at Spangdahlem in Germany that I was trying to decide, you know, what I want to do when I grow up. I realized that I wanted to be an astronaut and that I probably was not going to be able to because that is just crazy and nobody ever gets to do that. But I decided I was just going to try and do it and put in an application for Test Pilot School. While I was at Test Pilot School they announced the Astronaut Class of 2000 and everybody said, "Don't apply. You're too young. You're still a student at Test Pilot School. You've got to be experienced. Just wait for the next class. Wait until you get some experience." And I thought that I would apply, I'll apply and let them tell me no. I'm not going to tell myself no. There were other guys who were much smarter and better looking than I was but they decided to wait to apply later and I didn't. I applied and it worked out. I got lucky and got picked. So a lesson I learned from that was don't ever tell yourself no. Put the application in, go for it. Go try and see what happens.

You are one of only a little over 200 different human beings who have ever been on this space station. How do you hope to use this mission to inspire future space explorers?

One of the best parts of the mission is going to be talking to kids. While in space, we will have opportunities to call down to schools, colleges, universities, middle schools, different-aged kids, and that is really fun. People are really excited. They don't normally get to talk to astronauts in space so that is going to be one of my favorite things to do. And then when I get back, for the rest of my life, I will have an opportunity to tell people about the space mission, and more than just tell them about what I did in space, I can tell them what we as people can do and are going to be doing in space and share some of

the motivation with them. Everybody is not going to be an astronaut but everybody has gifts that they have been given and just to have the opportunity to inspire people to use their gifts, to go for it. And just because you don't get to be the astronaut or you don't become whatever, there are still lots of good things that you can do with your own gifts that God has given you.

To fly in space is to take on a job that has some unique risks, but I am guessing that you think these risks are worthwhile since you are going ahead and doing it. Tell me what is it that we are learning by sending people to space that makes it worth doing.

There is a lot of risk in space exploration. The way we explore space is twofold. We have robots. We send probes to Mars and Jupiter and telescopes so we are sending these robots out in space. They are amazing and I am very interested in them and like to talk to the people that are doing these things. Then we send people into space and people are obviously where the risk is, particularly from an astronaut's point of view, but what humans can do is think and repair things and make modifications and, you know, think on the fly. The amount of work that you can do as a person is tremendous. But, more than that, it is the fact that we are actually sending people to live in space. I tell people, you can read about it and you can see a lot. You can see the islands and look at that pretty sunset, that's a nice picture. Or you can go there and I would much rather go there. It's a lot easier to look at the pictures. You can look at pictures from places all over, but there is something about actually going there that allows us to really be there. Ultimately, if we are going to have people living off the planet, people need to go live off the planet and it is a risk that we need to take. There is a lot we can learn from robotics, so it is a great partnership as they can do things that people cannot do, but people can do things that robotics cannot do. Ultimately it is about us being there and living there and if we are going to do that we have to go there and live there.

Terry, you and your crewmates are next in line to launch to the International Space Station. Tell me what the goals of your mission are and what your jobs are going to be.

The main goal is to fly a safe mission and keep the space station running in good order. The operational mission that we have is to do science and there are all different kinds of science: life science, materials science, astronomy. Basically every discipline of science is going to have some piece of the pie while we are up there. Primarily we are going to be keeping ourselves safe, keeping the station safe, and then doing science.

You have been to the station once before, but it has changed since then. What are you most looking forward to seeing when you get back there?

I think the answer that everybody would have to that is going to the Cupola which I had the chance to install on STS-130. The views of Earth from there are just amazing. When I was there the first time I only had a few chances to look out the Cupola because we were so busy and then we had to leave right after we installed it. So I am looking forward to being able to live in space for six months and see Earth, see space. But I am really

looking forward to not just seeing but experiencing space. I am looking forward to floating again. It was just fun floating and I have not been able to do that for years so I am really looking forward to that.

Is there really a difference between living in space and visiting?

Yes, it is kind of like visiting Hawaii for a week on your honeymoon or moving to Hawaii, or visiting Colorado, going skiing for a week, or moving to Colorado and living there. You are in the same place and you kind of know what it is like. But I think when you live in space you need to learn how to float, how to move around and just be there to live in space. My shuttle flight was only two weeks long so the learning curve was still going up, I had not peaked out. Most guys say that after six weeks you kind of level off and you are as good as you are going to get and I could tell that I was not as good as I was going to get, that I still had more to learn. So there is definitely a learning process that happens. When you are a new human on Earth, when you are born, you have a few years to learn how to walk and do all the things that you have to do on Earth. When you get into space it is like the second the engines shut off you have to learn how to do it, so the learning curve is a lot steeper because there is a lot more to learn.

The station assembly that you helped with is all but complete so the emphasis now is on the science that is being done on the station. How do you explain to people the potential for what we can learn on this space station?

Potential is an interesting word because we don't know. If you are learning something, you do not know just what you are going to learn, so the potential is really infinite there. The station really has two purposes and one of them is doing the science that can benefit life on Earth. Every type of science that you took in high school or college, we are doing that in space. But the other big reason why we have a space station is to start going into the solar system, for people to live in space and work in space, and that is a more profound thing. If we are going to actually live off the planet and colonize Mars eventually and even beyond that, the space station is a steppingstone. It is a very primitive one. Hundreds of years from now, hopefully we will look back and say, "Wow! It was great that we did that but that was just a baby step and look how far we have come." Hopefully that is what the station really will mean hundreds of years from now. We will definitely have scientific discoveries that we have made from it, but it will be the first steppingstone into living in space.

In the process are we learning things that have application for those of us who do not get to go to space?

There have been lots of applications from space science that we have done. On my space shuttle flight we did some work on vaccinations that were actually applied to Earth vaccinations. On this flight we are doing several different life sciences experiments. We will be doing an interesting one using rodents to learn about immunology and how the immune system works and maybe how to fix problems with that and learning about muscle and bone loss that has potential for drugs to be used by people on Earth. I will

be doing an experiment with airways, learning about how to help people who have asthma or other airway diseases or even how to improve the equipment that we use to monitor those things. I will be using an ultrasound machine to look at my brain and my eyeball to see how increased pressure affects eyesight and also affects blood flow in the brain. So there are a lot of different life sciences things that we are going to be doing on our flight that can help people on Earth. We are also doing several different combustion experiments. We have a couple of different racks, basically boxes, where we can do these combustion experiments. We are burning different fuel mixtures and, if we can learn about the fundamental physics behind combustion and improve gasoline engines on Earth by just a little bit, that would be worth every dollar ever spent on the space station. One of the coolest experiments is something called AMS, Alpha Magnetic Spectrometer. It is a big 10,000-pound box that sits on the outside of the station and is looking for cosmic rays and intergalactic particles. Basically antimatter is what it is looking for, so it is sitting there for years just detecting those particles flying in from different parts of the galaxy and even beyond the galaxy. Astronomers over time can look at these particles and hopefully learn more about what the universe's composition. So that is another kind of fundamental science there, there are a lot of different sciences that we are doing.

Let me ask you a couple more questions about the human life sciences because that is one of the real areas of concentration for the science program, trying to find out how people are affected in that environment and how to counter the bad effects. In March the station program is sending two crew members to go there for a full year to learn more about these effects on people. What do you think about that mission? In fact, you are going to be there to greet those year-long crew members when they arrive.

Yes, we are going to welcome Scott Kelly and Misha Kornienko when they show up for their one-year flight. There are negative effects from space flight that happen to astronauts when we are in space. The weightlessness can cause bone loss and muscle loss because we are not fighting gravity constantly. We have really learned how to combat that pretty well with some exercise techniques, basically running on a treadmill. We also have a bike and some weight-lifting types of machines. Some guys come back in amazingly good shape, so we have really learned how to combat that. It will be interesting to see how those guys do on their one-year flight. We will see what the effect is from radiation. So there are definitely negative effects from spaceflight and hopefully we can learn how to prevent those. This will be the first time on the space station that folks have flown for this long. The Russians flew back in the '80s and '90s, I believe, four cosmonauts flew on Mir for a year-long stay. A big reason for the space station is to learn how to live and work in space for longer periods of time.

Would you like to go back for a year?

For now I am happy with my six-month flight and we will see how that works out. Eventually, when we get an American vehicle flying again, we will be able to make the increments shorter so that astronauts will be able to fly more often. They will get their

science done and let another guy come up as, hopefully, we can move to maybe shorter increments in the distant future.

Now you have been to space and you have experienced the effects on the body of getting there and being there and then of coming home. From your point of view, what aspects of that adaption to space and re-adaptation to gravity do you think are really key to maximizing our successful human exploration beyond Earth?

Adapting to space takes most people two or three days. For me, a big effect that I had was just a headache. Your head is full of fluid because all the blood and water float from your body up into your head so you kind of have a big puffy face the first couple days and rotating your head is hard. You have to move it real slowly because your inner ear is not used to it yet. So I had a headache the first two days and then, on the morning of flight day three, it was like a light switch went off and I was completely fine, felt normal. Some people have back pain. There are aches and pains that you get the first couple days in space and then they pretty much go away, so I don't think adapting to space is the problem. The problem is adapting back to gravity. Interestingly, we had a crew a few years back in the Soyuz whose landing profile changed and they ended up landing a couple hundred miles from where they were expected, so the crew had to get out of Soyuz, set up the radio and do a lot of work on their own in a vehicle that is not really designed for that to happen. They had just spent six months in space so they were deconditioned, yet they were able to do it. So kind of inadvertently, we got the data point that you can live in space and you can come back to a gravity environment and then you can work and get tasks done. So that is the challenge, I think. If you go to Mars, for example, and spend a few months in space, there will not be a ground crew there to meet you—that we know of—so it is going to be a big design challenge to make the spaceship such that the crew will be able to get all their work done having come back to gravity.

You have mentioned a couple of examples of the different kinds of experiments or investigations that are countering the negative effects on the human body from being in that space environment. What things are you going to be involved in?

There are a couple specific ones about the vestibular system, the balance system. They are looking at what kind of degradation occurs, how long it takes to get back to normal. In the first moments after coming back how's your balance and a day after coming back how's your balance, and five days after coming back, how's your balance. There are some simulators where I do flying tasks or driving tasks and then we will see what my abilities are like to do those things, how far they have degraded and then how long it takes for them to come back. That is an interesting question because if you land on Mars, you have to actually land on Mars so somebody has to at least be able to back up an automatic landing in case you have take over manually. So that is a good question. Then if you have to drive a rover around or whatever, you know, those are good questions and I think we will find that we will be able to do it.

And you also made some reference to the exercise equipment that has really been having some positive effects.

Some of the astronauts come back in really good shape. It is like they just went to a health club because they generally give us two-and-a-half hours a day for exercise and that includes a treadmill, a bike-type device and a weight lifting-type of device. So, in some ways, you can actually come back in pretty good shape if you have that much time to work out. But there are still some muscle groups and bone groups that have a little bit of degradation, but they measure that very carefully. There are all kinds of scanners and measurements that they do to see how we do. In most ways we have found that astronauts are coming back in pretty good shape, and in a few ways they degrade a little, but they can still walk around and function and then, over time, that recovers. I think a giant positive story from the space station has been that we have shown that we can live in weightlessness for an extended period of time and then come back and function on Earth, which is great. Functioning on Mars will be a little bit easier because the gravity is less. It is less than half of what it is on Earth so the ability to walk around on Mars, we would think (we have never actually done it) that it should be easier than it would be coming back to Earth and adapting here.

Human life sciences experiments are one focus, but there are a lot of other science experiments that the crew members are busy with on an almost daily basis in the several well-outfitted laboratories that are on orbit right now. Give me some examples of some of that other kinds of science that you will be doing.

There are lots of science equipment and labs that we have on the station. There is the U.S. Lab. The Europeans and Japanese both have really amazing labs and the Russians, of course, have science equipment on their segment, too. There is a lot of science available to be done. One that I think is really interesting and promising is something called protein crystal growth. We have been doing this on the shuttle and on the space station for several decades now. The body has lots of proteins in it and understanding the structure of a protein, first of all, can help you design drugs and help you understand how the body biology is working. So it is important to understand the exact three-dimensional molecular structure of a protein. In order to do that you have to grow a crystal. The bigger this piece of protein grows the easier it is to analyze using X-ray machines or different types of radiation. On Earth you can only grow small crystals but in space, because there is no weight, you can grow big crystals which give you a better view of what it is you are trying to look at. It lets the scientists understand the molecular structure better, so we are doing protein crystal growth. It is one of the experiments that help people understand the human body and also potential medical treatments for various conditions. So that is an important one. Other science that we are doing is combustion. Flames burn differently in space so, on one hand, it helps us understand fires in space and how to prevent them. We have a new fire extinguisher that is going to be coming up next year on the space station, so just how to put out fires in space is very interesting. There is no convection so flames burn differently and burn out more quickly. You can see the fundamental physics behind combustion in some ways in space that you just physically cannot see on Earth. This helps scientists understand how fuel and oxygen burn and could lead to huge, huge advances on Earth. The thing about science is you never know what you are going to get and the really easy discoveries were all made 500

years ago. The apple hits the ground—hey, there's gravity! You know that people have already picked all the low-hanging fruit, so to speak, so the science that we are doing now is really a link in a chain that may be a thousand links long. Sometimes the science just helps scientists design the next experiment or sometimes it rules out a path of thinking that they were looking at and sometimes it just helps validate something they already thought and that gives us more confidence that what we were thinking is correct. And sometimes it is just the "Eureka!" discovery, but that is pretty rare. For the most part it is a building-block approach. It is like detective work, you know. Most of it is not exciting, just sitting in an office going through paperwork and then every once in a while you solve a case, and that is kind of the way the science that we are doing is now. An interesting story that just came out recently was an experiment flown on *Challenger* in 1985 and now, several decades later, there is a company working with one of the astronauts that flew on that mission that is trying to develop some drugs that target specific chemicals in the body and they are hoping to come out with a diabetes treatment. That is one example of the science that was done a long time ago, fundamental physics, and then years and decades later people are using those results that may potentially lead to a big breakthrough.

A lot of times when crew members are working on combustion or protein crystal growth or something, we hear them talking to the scientists on the ground, the people who dreamed up these experiments and are the ones who sent them up there with a specific goal in mind. What is it like for you when you get to work with those experts in their fields?

That is fun because for the person who is doing the protein crystal growth or the person who is doing the material science to try and build better computer chips, that is their life and they have been working on this project for years and they have a Ph.D. in the subject and they know everything there is that people know about this thing. As an astronaut I have a million things on my mind, how to keep the station running and having to do exercise and doing public affairs events and we have these 30 different experiments going on, so this one experiment is just a small part of my life. It is really valuable to get a chance to talk to them because they are the experts in the field. Usually, when we call the ground, we talk to the capcom, who is a person here at Mission Control who we talk to about everything. But when it comes to science experiments they can tie us in directly with the scientists and that is very beneficial. As I said, they are the experts and they know everything about the experiment.

There is science that you guys work on inside the station. You mentioned earlier, there is also science going on on the outside of the station. The station is a platform for science inside and out. But the human crew members are responsible for keeping it operating. What other kinds of things does a station crew member have to do? What is a day like for you on orbit?

Yesterday I had training on that, on all the different things that we have to maintain, kind of the unique things we are doing on our experiments or on our increment. One of the examples is there is a recycling system on the station. We take oxygen and nitrogen and carbon dioxide and water and hydrogen and mix them back and forth between each other

to go from breathing air to drinkable water. So there are these machines doing this continuous recycling flow. The atmosphere and drinking water recycling are really complicated and there are a lot of moving parts, They do a great job and are actually very important for eventually going on to Mars because we are not going to be able to have resupply, we are going to have to recycle what you have. But just to maintain them, there is some new hardware that I am going to need to learn how to fill water and pump, so we were talking about the specific hoses. Where does this hose go? How does it get plugged in, that kind of stuff, only there are several thousand of those things. And that was just yesterday! Like you could spend every day, so the good news is you don't have to know everything before you launch into space. We have procedures like a short video clip: here is how you are going to repair this piece of equipment in a minute and then there are procedures and detailed steps. An astronaut in a Mercury capsule or in some small spaceship might have known every little switch and detail of the spaceship. The space station weighs a million pounds. There is way more than any one person could know, so we really depend on training, like generic skills, how do you fix stuff in general, and then any time one thing breaks, they will give us specific procedures that we go through.

It sounds, though, that it can be very interesting from the point of view that you never know what you might be getting to do today.

There are a couple of astronauts here who are like car mechanics. They race cars, they build cars. One of guys I flew with is Steve Robinson, who was a guy like this. He was just in heaven and I really enjoyed it, too, just because you get to work on things and there are air hoses and water hoses and electrical cables and new equipment and you are always building something or taking something apart. So, if you enjoy that kind of thing, it is a lot of fun.

Another thing that you get to do from time to time is to go outside—spacewalk. Now the plans for spacewalks, famously change, sometimes on very short notice, but as we sit here and talk today, what is the plan for spacewalks during your six months. Who is going outside and what are they going to do?

The one thing for sure, if I tell you who is going outside and what are they going to do, it is going to change. The very rough draft right now on Expedition 42 is that Barry Wilmore and I will be going outside to ready the new docking system for spacecraft. When we have American spacecraft coming to the station again, hopefully in a few years, these spaceships will need to dock and those docking areas need to be launched and installed. There is an awful lot of wiring that needs to be done, so Butch and I will be installing the cables. It is the most cables and the longest cables ever—in a 10-year long assembly sequence with lots of cables, this is the most that has ever been done. So we are going to be the cable guys on probably one or two different spacewalks. There is also a robotic arm that is very important: It helped build the station. It is how we moved all the modules around and now, when the visiting vehicles come, it grabs Cygnus and Dragon and then attaches them to the station. We also use the arm to do spacewalks. If there is a big piece of equipment that needs to be installed, the arm will grab it, move it, and hold it

while we install it. So this arm has been in space for almost 15 years now and some of the bolts are getting a little sticky so we need to go out and put some grease on it. That is one of the potential spacewalks that we are going to do and, of course we will be ready for any contingencies that pop up. During Expedition 43 Scott Kelly and I have a spacewalk scheduled. It is possible that we will install some more equipment for the docking ring that I talked about. Also I have Samantha Cristoforetti with me and she is qualified to do spacewalks also so we will have to wait and see if she does one also.

I don't want to make it sound like it is all work because I have got to think that going outside on a spacewalk has got to be fun.

You know what? I did not do a spacewalk. I was a pilot, and on the space shuttle program, the pilots did not do spacewalks. So I can't say from experience but it looks like a lot of fun. It has been a huge amount of training. I have spent several years getting ready in the pool here in Houston to do spacewalks, so I really hope that I get to do that. I hope all my crewmates get to do it because it is one of those things where there is nothing like it on Earth so we would all like to do it. But doing a spacewalk is a pretty serious business. There is risk involved. There is also a lot of effort. There are hours and hours and hours of preparation that you need to go through, so it will be fun but mostly it will be serious work. It is pretty serious business doing a spacewalk.

You are going to be in space on the 50th anniversary of the first spacewalk done by cosmonaut Alexei Leonov. What do you think the development of spacewalking as a technique has meant to our efforts to explore space?

Mr. Leonov is a great guy. During my backup flow he was there and he was chatting with Reid Wiseman, giving him some advice, and that was really cool being with this cosmonaut, the first man to walk in space, 50 years later. Spacewalking has come so far. Of course, in the '60s we were just learning the very basics of it. Americans learned how to spacewalk during the Gemini project. That led to the most famous spacewalks ever, and probably that ever will be, the moon landing when Neil Armstrong and Buzz Aldrin and then eventually ten other men walked on the moon. That was different. That was literally walking, they were bouncing but at least they were walking. The spacewalks we do now are different. The moonwalkers would eventually come back to the moon; if you push off the space station you won't necessarily eventually come back to the space station. So we spend a lot of effort tethering, being sure we have safety tethers and making sure that we are able to move around in weightlessness because you are not literally walking. You are holding on with your hands and that is how you do spacewalks, so that technique is a lot different. And without spacewalking we would not have a space station. It just required hundreds of spacewalks to go out and assemble all the cables and equipment and hoses that needed to be put together. There was a lot of work that had to be done outside to get the space station built and now to keep it running because occasionally a box or a piece of equipment or something will break and we need to go out and fix it. Without spacewalking there would be no space station.

This space station gets supplies delivered by a small fleet of uncrewed cargo vehicles. Tell me about the different international ships that are going to be bringing supplies to the station.

If we are lucky we will actually get a chance to see one of each of the different vehicles. That probably won't work out but I am hopeful that we will get a chance to do that. When we arrive there will be something called an ATV [Automated Transfer Vehicle] there. It is the European cargo ship and will be docked on the back side of the station in the Russian segment. There will also be the Progress vehicle, which is basically a Soyuz without people in it, an unmanned cargo ship. So we'll have Progress there and it has have pressurized cargo which means it is in air so you open the hatch and can pull things out and there are water tanks, air tanks and fuel tanks that can, through lines, resupply the station. The American vehicles that we have are Dragon and Cygnus and they are pressurized so you open the hatch and there is the equipment in there. You grab it and move it in the station and then you take your trash and pack it back in there. Dragon has this unique ability which we call trunk, so you can bring external stuff out in the trunk and you can grab it with the robotic arm and install it somewhere. For the spacewalks that I talked about, the docking ring will be brought up in the trunk of the Dragon. That is a good capability. The other thing the Dragon can do that the other vehicles do not do is that it can bring things back to Earth which is really important for the science. If we have, for example, blood samples or any kind of biology samples or materials science samples or any of the sciences that we have, we can bring a little bit back in the Soyuz but for the most part we use Dragon for that. So those are the two American vehicles. HTV [H-II Transfer Vehicle] is the Japanese vehicle, a really big spaceship. It carries a lot of cargo. So there is this fleet of Japanese, European, Russian and American cargo ships. The biggest lesson I think we need to learn for the future of exploration is we have a lot of resupply to the station, so we need to figure out how to live with *no* resupply. That is going to be the challenge and hopefully the station can teach us some of what we need for future, longer-duration exploration.

You are going to become commander of this vehicle for Expedition 43 after Butch Wilmore's crew departs in [March]. How does that change daily life in space for you?

Being the commander will change my daily life in space. My tasks will be the same. I will have the same work that I am doing but, when you are the guy in charge, there is a level of responsibility there that you feel. I am going to take time, probably out of my morning, to just go around and make sure everything is okay. I will take more time making sure my crewmates are doing all right. A big part of a long-duration flight is just the psychological aspect, making sure the crew stays together as a team, making sure everybody is doing okay. If something happens on Earth, making sure that they are okay. The car broke down. Yes, there are these cares that you have that most people would not think that astronauts have to worry about, but we have the same things. So the commander needs to just be concerned about those kind of things. I have probably the most experienced crew ever. Gennady Padalka has flown in space more than just about anybody and I think, by the end of his flight, he will have flown in space more than

anybody. He has been station commander before. Scott Kelly has been station commander before. Misha Kornienko has flown in space in a long-duration flight. Anton's [Shkaplerov] flown in space in a long-duration flight. I have Samantha Cristoforetti, who is the smartest of anybody. It is a very lucky time and the crew I have will be fine. They will be a self-running crew. It is going to be a good group.

We talked about a lot of details and a lot of different aspects of what is going on. I want to see if I can get you to sum it up from your point of view. Terry, what is it that we are learning from these missions to the International Space Station that is preparing us for human exploration of space beyond Earth orbit?

There is a long list of what we have learned from the space station. One of the things was that the space station was assembled in Earth orbit, so we have gotten very good at how to assemble things. We know how to make hardware that can automatically attach itself. We know how to make hardware that is usable by astronauts doing spacewalks to get it attached. So if we need to assemble components in space, we have 15 years of experience doing that with the space station. It may be better to not have to take all the time and effort required to assemble; it may be better just to launch one big spaceship pre-assembled on Earth. About the human aspect of things, we have already shown that people can live in space for a long period of time. We have really greatly improved some of the exercise protocols. There are some other effects, vision loss and some other problems that astronauts have, that we are trying to work on now to fix. So the human physiology aspect of things we are working on right now and we have shown to a large extent that we can live in space and survive and thrive. The psychological aspect is maybe the biggest challenge. If you look at Antarctic expeditions or around-the-world sailing ships in the 1700s, the psychology often is the limiting factor and the hardest problem to overcome. On the station I think we have done unbelievably well in that area. We take a lot of effort to make sure the astronauts and cosmonauts have some type of psychological support, that their families are taken care of, that they have contact with Earth. We try to give guys time off. There is a lot of work and it is not like normal time off from a normal job, but we try to keep Sundays pretty free from work when we can and Saturdays are not too bad usually. So there are the psychological aspects and the intercultural part since it is an international space station. My crew gets along great and it is just a great group of people. It is an amazing example of, yes, we can work together even though you are from, Japan, America, Russia; we all, we get along—Italy—all these different countries get along very well.