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JEFFREY N. WILLIAMS
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is July 22, 2015. This interview is being conducted with Jeffrey Williams in Houston, Texas, at the NASA Johnson Space Center for the International Space Station [ISS] Program Oral History Project. Interviewer is Rebecca Wright. Thank you for taking time out of your very busy schedule to meet with us today.

WILLIAMS: Good to be here.

WRIGHT: Colonel Williams, you became a member of the Astronaut Corps in 1996, and since that time you have served in a number of capacities for the space agency, including being a member of STS-101, which was the third [Space] Shuttle mission devoted to Space Station construction. Then, in 2006 you served as the flight engineer for [ISS] Expedition 13 for six months, followed three years later by another increment, Expedition 21, where in 2009 you were the flight engineer. Then you moved into commander for Expedition 22.

You've trained extensively for these assignments. You have been a backup for Expeditions 12, 19, and 20; for a number of EVAs [Extravehicular Activities]; and as the backup for the current one-year flight that spans Expeditions 43 through 46. Currently you're in training for flights scheduled for early next year, for the prime crew of Expeditions 47 and 48.

During this time that you've been here with NASA, you've also worked in the branches of EVA, Space Station, on the Russian Soyuz vehicle for the astronaut office, supported test and evaluation of ISS lab [laboratory] modules, along with commanding a nine-day coral reef expedition operation with NOAA's [National Oceanographic and Atmospheric Administration] Aquarius undersea habitat.

You've really been busy and in a constant mode of training, but you've been involved in so many different areas involved in the Space Station, so I'd like for you, if you would, to share with us some of the significant challenges that you've encountered working through these years as part of the Space Station Program activities.

WILLIAMS: Well, what comes to mind, initially, is the Space Station itself. I think it's easy to argue that it is the most complex technological achievement of mankind, ever, and there are several aspects to that. One, obviously, is just the space technology in getting the pieces to orbit, and all of the challenges with that. On top of that is the international flavor of it and the integration of the different partner contributions.

I would put on the top of the list of the international challenges the challenge of working with the Russians, from a technical point of view, from a cultural point of view, from a language point of view. That found its genesis, really, in the integration of what would have been Mir II and Space Station Freedom.

When you consider the amount of launches it took to put [the Space Station] up, when you consider the complexity of the technology in each piece that went up, and then [the design teams] had to integrate each of those pieces preflight, on paper. Sometimes you did it by attaching the hardware together on the ground and doing testing, but in many cases you couldn't do that because [the Station components] were launched from different places in the world, and we didn't have the luxury to do that on-the-ground preflight integration.

There were many challenges over the years, and putting it together. A very large team of people doing many different aspects of the design had to be integrated. The challenges and some setbacks, now and then, were met by the teams, but ultimately, what is most amazing to me is the net success, if you will, in the assembly and the integration of the Space Station.

WRIGHT: Your first Shuttle mission was one of the very first missions that began the assembly. Walk us through what that was like for you to see it in its infancy, and then what it was like for you to go back several times to see it toward its completion.

WILLIAMS: Yes, I was on STS-101, and on the Station manifest that was [assembly mission] 2A.2. It started out as 2A.2; it was an added mission to the manifest. It wasn't in the original plan, but I think the reason that it was added, primarily, was because in the original plan we hadn't appreciated the work that was required to get the [Zvezda] Service Module ready for the arrival of Expedition 1. If the Service Module would have launched and docked automatically to the [Zarya] FGB [Functional Cargo Block] and the [Unity] Node [1], there would have been some risk, shortly after that—it would have been after 3A, I think—to launch Expedition 1 without doing some of the integration of the Service Module, so they added STS-101 to the manifest.

There was a very unique aspect in that mission. In some respects it's the "lost mission," because sometimes you will see documentation of the build of the Space Station, and it doesn't even exist in the manifest. It was sort of added last minute, and [at the time] there was a great deal of] focus on subsequent missions (3A through 7A), I think. At least, that was our perspective. [STS-101] was unique in that it was focused on the Russian Service Module.

In the end we didn't execute that mission as [originally] intended, because the Russian Service Module then suffered a long delay. There were failures on the FGB and the Node that the program was worried about, so they ended up splitting STS-101, or 2A.2, into two missions. We became 2A.2a, and then there was a 2A.2b, which was STS-106. With the delay in the Service Module they decided we needed to go there to address some of the failures that were going on prior to the Service Module, so we launched in May of 2000.

Another little tidbit of that uniqueness—in the early training, because it was dedicated to the Service Module, and in the NBL—in our Neutral Buoyancy Laboratory—we didn't have a Service Module mockup to train on for spacewalks, and there were two spacewalks scheduled for that mission, we had to go to Russia to do the EVA training. It was unique because it was in U.S. spacesuits, and that's the only time in history that U.S. spacesuits have been integrated into the facility in Star City [Moscow, Russia], to do EVA training.

That year, in 1999, we had four trips to Russia. They were two or three weeks long, each one of them, and in part they were dedicated to the EVA training. So, it was a very unique chapter in history that is sometimes lost.

We ended up going, as I said, earlier than the Service Module because of its delay. We did one of those two originally planned EVAs, arrived to the Space Station when it had been on orbit but not visited at all for about a year. I remember when we docked, and the hatch was open—actually we did the EVA first, out of the Shuttle airlock, on the day after the docking. Then the day after that, we got the hatches open and came in. The temperature inside was in the mid-90s [degrees Fahrenheit], and it had a really strong smell because of some outgassing of some equipment that had been stored onboard. It took a while to get the air cleaned up so it could be somewhat tolerable to work inside there. Then we had several days of working inside, transferring a lot of stowage in preparation for Expedition 1, as well as doing some repairs on the systems that I mentioned earlier.

WRIGHT: Based on what you're sharing with us, it sounds like so many things have an opportunity not to go as planned, but yet you're able to find the answers to what you need to move forward. Can you share with us some of the areas in training, or some of the skills that you have picked up along the way that help you prepare for walking into these challenges that you encounter, when things aren't exactly going as planned?

WILLIAMS: Well, boy, that's a broad question. Of course, the training gets you proficient in understanding the systems and the operations, as planned. You train on how you plan to execute, but frankly, the majority of the training is addressing failures and issues that might come up that we try to pre-plan for to respond to them. Then go through the contingencies of those failures, those emergencies, or whatnot.

Just in the scope of doing that, it prepares you, I think, for the flight and what may come along that's not planned. Thankfully, in flight experience it's nothing like the training in that most of the elements of the flight go as planned, but not everything goes as planned. The flight crew is able to respond to contingencies as well as the ground crew, because we train and prepare for that.

WRIGHT: When you went back to the Station as flight engineer on your first Expedition, you weren't there for a visit. You were there to stay. Talk to us about entering the Station and becoming a resident there, and what you felt you wanted to accomplish at the time period, and then some of the experiences that you did encounter while you were there.

WILLIAMS: You're right, an expedition to the Space Station is much different than a Space Shuttle flight. Shortly after STS-101 was executed, I was asked to start working on another Shuttle assembly flight—specifically, the EVAs for 13A. I worked on the development of those EVAs for about a year, and then we had some changes in the crew availability in Russia for upcoming expedition flights.

There was somebody that had to drop out of the [training] flow for a medical issue, as I recall, so I was asked to come off that Shuttle flight and head to Russia. That was in the summer of 2002. My first trip over to Russia was in December of 2002, and I spent the subsequent years going back and forth. The Russia piece ended up taking up almost 50 percent of my time in the years leading up to Expedition 13. Prior to that I was backing up Bill [William S.] McArthur on Expedition 12, with a plan to fly as the commander of Expedition 14. I would launch a year after Bill launched.

When we were in Baikonur, in Kazakhstan, for just a few days prior Bill's launch, I got a call and said, "Hey, we've got another change." STS-114 had flown, and it was the first flight after the [STS-107 Space Shuttle] *Columbia* accident, and of course the *Columbia* accident was a big factor in the changes that occurred. Because 114 did not prove that we had successfully addressed the problems [with foam being shed from the external tank (cause of the *Columbia* accident)], the crews were still going to be on the Soyuz.

That resulted in a change in crew assignments, and I was asked, while I was in Baikonur, if I could move up to [Expedition] 13 and launch six months later, as opposed to a year later. So, that's what I ended up doing. We launched as an expedition of two. Because we wanted to reduce the logistics requirements after the *Columbia* accident, we dropped from a crew of three to a crew of two: one Russian and one American.

I launched with Pavel [V.] Vinogradov, and with us was Marcos [C.] Pontes, who was a Brazilian astronaut. Brazil had arranged for his flight directly with Russia, so it was an agreement between those two countries. He launched with us. We had about a week handover period with Bill McArthur and Valery [I.] Tokarev onboard. After that handover period Marcos returned to Earth with them, and Pavel and I began our expedition.

Backing up a little bit—I remember, on the way to the launchpad in Baikonur to climb onto the Soyuz rocket, feeling like it was a one-way ticket, because the [completion date of the] six months was way over the horizon. It was much different than walking to the Shuttle at the Cape [Canaveral, Florida], when you knew you were going to be back in 10 days or so. It was much different in that way. Of course, it was a completely, literally foreign environment in Russia [and Kazakhstan]; a very historic place. We launched from the same launchpad as most expeditions have to date, and at the same pad that Yuri [A.] Gagarin [first human in space] launched from, so a lot of history there. A very rewarding experience.

You may ask what is the biggest challenge in all of this. If you take any one element of the job, it's not that great of a challenge. Of course when you add them all up and consider the scope of it, that becomes a big challenge, but if I was to be pinned down to say what was the biggest challenge of the entire thing, it's the Russian language. Most of us in this business, we're inclined toward math and science and engineering, and we avoided the [study of] languages and that type of thing. That's been the most challenging aspect for me. Also though, like all things, it brings the most reward.

WRIGHT: So you've been able to increase your vocabulary in Russian?

WILLIAMS: I've been focused on Russian since 2002, so I continue to take lessons. I'm pretty proficient in the language right now, which pays off in great dividends of course, and makes the experience that much more rewarding. I've really enjoyed working with the Russians over the years, both from a crew point of view as well as with the training team, the engineers, the flight control teams, and the management over there as well. It has been a very rewarding aspect.

WRIGHT: I remember reading some things that you've talked about there were points when you have been on the Station where you really have felt the international partnerships, because of the diversity of the crewmembers and the diversity of the cultures that were being shared during that time. Can you give us some memories of those times that seem to come to mind, of special moments where you felt not like you were in the world by yourself, but yet you were sharing the world with them on the Station?

WILLIAMS: Well, halfway through Expedition 13, STS-121 launched—that was the successful return to flight after the *Columbia* accident—and they brought along with them Thomas Reiter from Germany, and he joined Expedition 13. So now we had a Russian, a German, and an American onboard this magnificent orbital outpost, as I like to call it, working as a crew, as a team, supported by the flight control teams on the ground from those countries and beyond, across the partnership.

I spent 27 years as an active Army officer, and when I was commissioned in 1980 after graduating from [the United States Military Academy at] West Point [New York], that was still in the height of the Cold War. My first assignment after flight school was in West Germany near Frankfurt, and we were responsible for the defense of the Fulda Gap [border area between East and West Germany], and protecting the West against the Soviet Union and the Soviet Bloc countries. Having gone through that—and I spent a little over three years there—the irony of, years later, being partners with the Russians in particular, and working with them. The way we have been walking around Red Square [Moscow, Russia] on a weekend, taking pictures, as an Army colonel I've never gotten over the irony of history in all of that.

Other examples later, in Expeditions 21 and 22, I got the opportunity to fly with a Canadian crewmate, and then later a Japanese crewmate, and if you add up all those flights, many other Russian cosmonauts as well. It really highlights the international flavor of this program. Hopefully, the ISS will have many aspects of its legacy, but certainly one of them will be the visible example to all of the world of countries working together in a very unique and challenging environment. It's an environment that, thankfully, stays below and, in a sense, transcends political challenges among the countries of the world. Hopefully we will be able to maintain that example to the world.

WRIGHT: It seems like the world has gotten a lot smaller in that capacity.

WILLIAMS: That's right.

WRIGHT: As the anniversary of 15-year continual human presence in space approaches, it does remind us that it seems so far away for those of us on Earth, but it's not. We have so many ways now to connect with the Station, whereas we didn't when the first expedition crews were there. I know a couple of the changes that happened while you were onboard—I think it was on Expedition 13 you helped connect us with high-definition [HD] video cameras. Talk about what a difference that has made, and how you were involved with making that change, that the links in the video images that were coming from the Station now brought an even more clear and exact capture of what was going on from your view.

WILLIAMS: I became convinced—and it was only reinforced later—early in my career that when it's all over, what you have largely consists of still pictures and video. I also know that if you want to share the experience with those on the ground, particularly after the flight, you need to do it with good photography and good video. Because we're always constrained by budget and other things, of course we can't have everything we want. So in the early years of the Station Program, the video that we had available from the Station was not very good quality. It certainly wasn't HD, and it was even worse quality than the Shuttle, ironically.

When I got up there for Expedition 13, we know that there had been, by that time, multiple spaceflight participants that had flown with the Russians on short flights during the handover periods. Marcos Pontes—I would call him a professional astronaut, not a spaceflight participant—but he was also in that same category of a short flight. Greg [Gregory H.] Olsen, particularly, had flown up with Bill McArthur. He paid for, himself, an HD camera and left it onboard.

It's easier to get stuff up there than it is to get it back, so Greg and others brought up good video equipment. Marcos brought up an HD camera as well, and they couldn't get it back down to the ground, so it was left there. I learned that the tapes we were using with standard definition at the time also could be used for HD. The folks here on the ground helped me work out a system where I could use those old HD cameras with the tapes and still send down the normal, standard definition video, but preserve the HD.

When STS-121 arrived halfway through [Expedition] 13, of course that was my first opportunity to return things to Earth, so I sent a bunch of tapes back. That I think was essentially the first exposure that the wider audience had to HD, and it showed everybody how important it is. Since then, of course, HD and beyond have taken over, and it has really opened up the world of life on the Space Station to the population on Earth.

WRIGHT: Yes, it certainly changed how we saw things, and I don't think anybody wants to go back, that's for sure. On a related, but different note, you were there as part of Expedition 21, when the first live Twitter [social media] connection came from the Space Station. You had a tweet up, but now NASA has more than 11 million followers. People are watching what NASA is doing on this continual basis. I'm going to assume that when you first started training for space, these pieces were not part of what you were training for, how to do Twitter and how to use HD cameras, but you're seeing the impact. Share with us why you feel that people here on Earth want such a connection with what's going on up there, and how you guys feel like this is such an important contribution to what you're doing, to make that connection through these types of media.

WILLIAMS: We're [humankind] all fascinated with the new. We're all fascinated with the unusual. We all like adventure. If you look at our history, we want to know what's going on in the frontiers of the world, and beyond the world now. It's important to bring that back to people, because of the interest, because we do it for a wider population. We don't do it for ourselves. We don't do it for NASA, even. We do it for the greater good of the people on Earth, so it's very important to have that connection, to bring those products back, to let people vicariously participate.

Most people won't have the opportunity, obviously, to go there, but it is so fascinating. I will say that I miss being home when I'm up there. Thomas Reiter and I used to joke about how most astronauts, when they're on Earth they want to be in space. When they're in space—at least for long-duration flights—they want to be back on Earth, with their family. One of the things that you never get tired of up there is the view of Earth and seeing the wonder of all of the details of this planet that we call home.

WRIGHT: I know your days are full, and sometimes probably your nights, too. Some of the times that you spend are with experiments, life science experiments or Earth science. Give us some examples, and describe some of the ones that you feel very fortunate that you were involved with. And/or if some of the ones that, when you first were being assigned to, maybe you didn't particularly want to do those, but as you got more involved in them you felt that the science that's being done on the Station can benefit so many.

WILLIAMS: Yes, we do a wide scope of science up there, across all of the disciplines. From a crew point of view, some of it is very interesting. Some is less interesting. Some I would put in a category of a pet rock—you hook it up, and you turn it on, and it does its thing, and then eventually you turn it off, and the data gets sent home. I'm sure it's good science for the principal investigators and the teams on the ground that are going to do things with the data, but it's less interesting for us.

But there are many things that we do that are very interesting. Anything that has to do with life sciences is naturally interesting. One of the things I personally enjoy is anything that has to do with growing plants up there, because it brings a little aspect of life on Earth onboard when you see green. We even like to have plants in our home, and we grow gardens and things like that, so it has the same psychological impact onboard. It's very interesting to see how things like that behave in a weightless environment, and how they're different, how they're the same as that on Earth.

Material science—a variety of those things have been done. Most of the more advanced things that we're doing now, like we have a furnace onboard—that was not active when I was onboard last time, but I will participate in that in the coming flight. There's another topic, fluid dynamics. There is an experiment called CFE [Capillary Flow Experiment]. It's a fluid-related experiment, and they've had different apparati that have been designed differently. It's just a transfer of fluid inside these transparent vessels of different shapes that take advantage of capillary flow.

It was a lot of fun, because it's hands-on. You're watching how the fluid reacts as you changed the geometry internal to this container. There was live video going down in some of those experiments, and I did a variety of them. I could sense the awe and the wonder of the experiment team on the ground as I showed them the live video and how the fluid was behaving, which, of course, just added to my enthusiasm. It was just a lot of fun. It turned out there were some great results that came from that experiment that have already had applications far beyond what the team originally thought. That was a very personally rewarding experiment.

Another one called SPHERES [Synchronized Position Hold, Engage, Reorient, Experimental Satellites], which was developed at MIT [Massachusetts Institute of Technology, Cambridge], which is a series of volleyball-sized little satellites, you might call them. They look like little robotic satellites, and they're charged with a CO_2 [carbon dioxide] high pressure with thrusters. They've got a computer inside, and you can program it from a laptop, and it goes via RF [radio frequency] and programs the computer, and then you set it off to do a series of maneuvers.

You might have an experiment where you have one that does a series of rolls and pitch maneuvers and maybe translations back and forth, inside the cabin. Then, the second one, it watches what [the first] does and tries to follow it and duplicate its maneuvers. We did many experiments using that system. The initial intent was to develop flight control systems for satellites that might fly in formation, because there's many applications for that. It has expanded to other applications, as well as an educational outreach. There have been schools across the country now that have developed their own series of experiments with that facility and have flown onboard Station multiple times.

Those are just some of the examples of some of the experiments, but probably the most significant, in terms of what we do in space exploration, is the study of the human body. So not only are we executing experiments up there, we are the guinea pigs as well. We spend a lot of time participating in experiments that have us wired up, or we're drawing blood or other samples to return to Earth. Sometimes wired up with EKG [electrocardiogram], and you're running at max [maximum] effort on the cycle ergometer and breathing on a tube.

That's a big part of what we're doing, in terms of the science, primarily to develop countermeasures for those adverse effects that the human body suffers in a weightless environment. We've seen progress in that area already. I would say that during Expedition 13, for example, the effects on my bones were in family with the average, but it was a bone loss.

Between [Expeditions] 13 and 21 and 22, we had put up what we call ARED, or the Advanced Resistive Exercise Device, which improved the ability to do the equivalent of heavy weightlifting, particularly with squats and focused on the lower body. After that flight, I had virtually no measurable bone loss, so that was a great advance in the development of countermeasures.

WRIGHT: That's pretty interesting. I'm just sitting here, thinking about how many years from now will people that are working towards the long-duration flight for Mars be studying what you guys did here, so that they can apply those lessons and move forwards.

WILLIAMS: Yes, well, that's what's one of the biggest drivers of all of this, to prepare us to go beyond Earth orbit, whether it's back to the Moon or eventually on to Mars.

WRIGHT: You're laying that foundation and that groundwork. Are you planning on repeating some of the measures that you've done in your first expeditions to your future one? Do you find yourself repeating different levels?

WILLIAMS: In terms of the human body? Yes, there will be. Like I said, we're guinea pigs up there, so there will be measurements preflight, in flight, and postflight. From an operational medical point of view, as well as from an experimental point of view. There's both research and there's what we call med ops, or medical operations. But certainly there will be a lot of data available to see what has changed over the years, in terms of the reaction to the environment.

WRIGHT: When you return, is there a place that you plan to return first to the Station? This will be your fourth visit, third expedition. You were talking about the changes within your body through these years. I just was curious if there's a place that you'll go back to look, or a specific area of the world that you want to look at that you might have been watching through these years that you've seen changes happen through the windows.

WILLIAMS: Oh my goodness. Well, one of the places I look forward to going back to is the Cupola. We added the Cupola, which I call the "window on the world," because it was—outside of being outside on EVA—the first place that we got added to the Station where we could see the entire globe from one vantage point. All of the other windows, you can only see part of the Earth at a time. So, I look forward to getting back to that spot on Station and viewing the Earth.

In terms of places on the Earth—of course, all the places that I've lived, our current home here, I look forward to seeing that from up there again. In terms of changes, I see changes up there primarily in the seasonal aspect. The first long flight was over the summer, the second long flight was over the winter, so I tried to document seasonal changes in many different places. I think they said that I've taken 200,000 pictures up there, around the world, so I can't get it down to one or two favorite places. There are many, many favorite places.

WRIGHT: Speaking of being outside, you've had the opportunity to do EVAs, and I'm sure that they're planning for you to do or be prepared to do additional ones. Share with us not just about the training, but how your participation in EVAs has changed, and maybe the changes that have occurred on the Station. Because first we were using EVAs to assemble, and now we're using EVAs for other purposes, including maintaining.

If you can help us understand what you, as a participant in that amazing technical adventure. Everything that we watch on television looks always so much easier than what you guys have to go through. Maybe you could just explain to us one of the most significantly challenging ones that you had to do, or maybe one that you're training for that you know you're going to have to do in your upcoming mission, to give us an idea about what it really takes and how much time it takes to prepare and to do those EVAs.

WILLIAMS: EVA certainly is a big part of the Space Station history. It was very intimidating, I think for all of us ahead of time, to anticipate the number of EVAs required just to put the thing together, and the challenges in the content of those EVAs. Thankfully, we got through it all pretty successfully. There were a couple minor setbacks, where we had to go out the door subsequent unplanned times, but there was obviously a big effort made—particularly through the assembly years—in executing those EVAs.

One of the advantages that we had during that time was most of the EVAs were done by Shuttle crews, and you had the advantage of getting a lot of iterations of a training run in the NBL in the months leading up to a flight. Plus, the content of the EVA was very well defined, so you could hone every little hand movement of the 6 ½ or 7 hours that you were outside, and be very efficient in it, and develop new techniques to make a task even more efficient.

With the expedition EVAs and now, within a current environment, we don't have that luxury. We don't know what we're going to do preflight, exactly, because the content of an EVA is defined closer to the EVA. So we're more dependent on the ground teams to develop those efficiencies for the time that we're going to go outside, and we have less time to prepare for it.

Most of the preparation is inside, in your head, using some computer tools, and then relying on the skills that you developed in preflight training, doing generic tasks.

EVA has always been the most challenging activity that we do, but as I mentioned earlier, it also is the biggest reward, to be able to go outside—I call it "the ultimate skydive"—and be outside for that period of time—6 ½, 7, sometimes longer hours.

I also had the opportunity, thankfully, early in the program to do a Russian EVA in an Orlan [spacesuit], during Expedition 13. Completely different system, different language. When we're doing the EVA, we're working with Moscow mission control, and it's all in Russian—a little bit more challenging working in that suit than a U.S. suit. The tasks are a little bit different. In that EVA, Pavel [Vinogradov] and I went outside, and we did some Russian segment tasks, and then we also went all the way to the front end of the Station and did some tasks—specifically, changing out a failed video camera—on the front end of the Station. So to be able to go outside and span the length of the Station or the width of the Station and do those tasks has definitely been a reward.

WRIGHT: All the times that you've been there and have safely returned, did you have some suggestions or some recommendations on possibly ways to enhance procedures, or improve ways that events or activities or day-to-day procedures were being done? If so, could you give us some ideas of how that process works? Those that are returning, and how they come back, and how you try to help make it better for the next people going up?

WILLIAMS: The teams on the ground have done a great job of anticipating, of coming up with a procedure, for example, and maybe how to train for a task, what needs to be done on a future flight.

We've learned over the years, too, you can only anticipate something ahead of time to a limited degree. Then when you go execute it, actually do it in the environment, sometimes you get some surprises, you get some challenges that you didn't anticipate. Sometimes you have to change the way you're doing business, that the original assumptions didn't work at all.

The teams—both the collective flight and ground teams—over the years have grown in their ability to anticipate preflight, and also to adjust in flight. In every crew that comes back, you spend several weeks or longer debriefing specifics of the flight with the teams that are responsible for each of those activities, so that provides some feedback into the process, to continue to improve those processes. That feedback is very important.

It's also very important, at the front end, to have the different interests, or the different expertise represented in the process to develop it. That includes, of course, the people that had designed—say if it's a piece of hardware—designed that hardware, understand its original intent, understand how it fits into the big picture; as well as the flight controllers that are essentially the operators, to help integrate that into the operation; as well as the flight crew, who are actually going to do the hands-on stuff.

It's important to have the right people in the room, if you will, to develop that preflight, and then to have those same people back in the room after a flight to capture the lessons learned, so everybody understands them, and then apply them to future applications. And that has happened over and over and over again.

WRIGHT: When you were talking about those processes, it reminded me that while you've been involved with the program, the main part of transportation that you were going to be on was the Shuttle. Of course, it has been retired. We have incorporated commercial cargo to Station, as well as other international partners providing cargo transports. As you're training now for this next expedition, you may be involved with all those facets, because you will be there for another six months.

Are there other areas that you have to train in for that? For instance, do you have to know specifics many months ahead, to train for each one of those cargo transports? Or are these things that you learn along the way, that when you prepare—whether the SpaceX [Dragon cargo spacecraft] comes or what if the [Orbital ATK, Inc.] Cygnus [cargo spacecraft] comes or so forth—it's a different aspect of what we've done at the early part of the Station, compared to what we're doing now.

WILLIAMS: Right. Of course, the legacy that we had coming out of the Shuttle Program was short-duration flights, where the content of the flight was very well defined. Every minute was carefully choreographed. You could train the actual tasks that you were going to do in the flight. Early in the Space Station Program, although we said we couldn't afford to do that, we largely did that, as opposed to developing skills that can be applied to a variety of specific tasks. Then you don't have to train each task; you develop the skills to be able to apply those tasks.

I think that was part of the growing pains early on in the Station Program, because you physically cannot train task-based, if you will. The scope is far too great, so you have to train skill-based. You have to develop the skill base for the crew to be able to take the task of the day and be able to execute it efficiently. I think that has been the obvious change in how we approach things.

Using the example of cargo vehicles and whatnot, I would put that in the same category. Although they all differ, they're essentially common in their intent. They're common in that they have a system that cargo is stowed in it, that may include how that cargo is secured so it's not rattling around after launch, how you find things, the sequence of events to get stuff out of there and un-stow it and transfer it to the Station, as well as repacking what ends up being mostly trash to come back, but also some return cargo on SpaceX.

The integration of the vehicle on the Space Station—of course, the big thing for the crew is the Dragon capture, using the robotic arm—I would call that a generic skill. There are some unique aspects to each vehicle, but it's a generic skill that you can refresh your mind on the unique aspects in the days leading up to a particular operation and then execute it just fine. That has been, philosophically, the big change that we've gone through.

WRIGHT: That has to somewhat help you, as many missions that you've trained for—as part of the backup crew, as part of the prime crew, and then, the last many months, you were the backup to the one-year mission. Talk about the whole aspect of what you thought when you heard about that opportunity, and your participation in that and what you believe is going to be the value of this current mission.

WILLIAMS: That's a good question. I don't think I'd be flying anymore, except for the one-year mission. The idea to do the one-year mission, of course, came about perhaps from a variety of reasons, but one of those reasons is, can we answer all the questions that we need to know for future exploration with six-month durations, or are there changes still out there, beyond six months—to the human body, specifically—that we need to identify? So, that's kind of the question out there that's behind the one-year mission.

Frankly, from a personal point of view, when I was first asked to do it, I said no. I could not do it to my family, to my wife. She, in particular, wasn't ready for it, and if she's not ready for it, I wasn't going to be ready for it. It actually took close to a year—ten months or a year—where I would be approached, periodically, if I would be willing. After that time, I finally said, "If you need me to do it, then I'll be willing to do that." Part of the reason was they made the criteria to include previous experience in EVA and in all of those things a prerequisite to the one-year mission, so that whittled the list of contenders or candidates down pretty small.

I agreed to do it, and Scott [J. Kelly] is up there now, and he's doing a great job. Psychologically, it's a huge challenge. Six months is a huge challenge in itself, so one year becomes twice that. There are a lot of things that happen in our lives on Earth in six months. There are a lot more that happen in a year. You just think about the practical things of paying monthly bills, and then you have those things that come up once a year—doing your income taxes, things like that. It presents significant challenges to being away and largely out of touch with all those kinds of details for a year, not to mention the separation from family and friends.

The process to prepare for the one-year was different only in that everybody was trying to understand, potentially, what might be different. What needed to be different in training and preparation for a one-year flight over a six-month flight. We spent a lot of time trying to evaluate that. In the end, I don't think it's a whole lot different. You train for a three-month flight, four-month flight, six-month flight, one-year flight—again, the focus is developing the skills, with the assumption that you can maintain those skills or get some refresher training just prior to an activity onboard the Station.

We'll see, after Scott comes home, if there's anything that has been found that suggests there are questions that go beyond six months, but we'll just have to wait until he gets done. He's about three and a half or four months into it now, so it's really no different than the previous six months. We haven't even gotten far enough into it to be able to answer any potential questions that are out there.

WRIGHT: The next time you're up there, if you put all the days together, you will spend more than a year of your life in space. Is that correct?

WILLIAMS: Yes, I think it will. Well, I've got about a year up there now, so it'll be 530 or 540 or 550 days, something like that. It has been an amazing privilege to be able to do that, and to be able to span the career from the third Shuttle flight to the Station—when it was just a Node and the FGB, before Expedition 1 got there, all the way through Expedition 13, where it was about half done and the Shuttle was grounded.

Then, during [Expedition] 13, we resumed the assembly with STS-115 bringing up another truss segment. Then, going back to [Expedition] 21 to 22—which was essentially the end of the assembly. There was a couple of things added. There was a [Leonardo] PMM [Permanent Multipurpose Module] that was added after that, but essentially we integrated [Tranquility] Node 3 and the Cupola, and that was close to assembly complete. Now, to go back when it's in its full utilization mode, I consider it quite an honor.

WRIGHT: I was thinking, you have spent this much time in space, yet you were also underwater as commanding part of that Aquarius group. Did you find similarities in being so far under the water and so far above the Earth?

WILLIAMS: Absolutely. The Aquarius mission was nine days, I think, so it was in the short-duration category, but it was in a frontier environment, on the bottom of the ocean, so it had a lot of similarities to spaceflight: You were isolated, you were in a hazardous environment. We were scuba diving six hours every day, and you couldn't go to the surface. If you had an emergency that took you to the surface, you would likely suffer the bends and have some severe medical problems. We used redundant systems. We went to great lengths to have operational control so that we reduced the risk of somebody having to go to the surface when they were out scuba diving, you needed to find your way back to the habitat.

The habitat in itself was about the size of the laboratory module on the Space Station. We were a crew of six, so relatively confined quarters for those nine days. The food preparation, sleeping, free time, interaction with friends and family on the surface through the limited resources we had, all of those things were analogues to spaceflight. That's why we do that.

WRIGHT: You had mentioned that learning skills that you can apply to numerous tasks was one of the lessons learned. Are there other areas that you can think of that you can put your finger on, that when you first became involved with the Space Station Program and its activities, that you feel like we might have done one thing one way, but now we've learned that this way is a better or more useful or maybe just the right way of doing something, compared to what we thought, because we have learned so much in these last 15 years?

WILLIAMS: Yes. I alluded to this in a different way earlier, but at the front end of something we don't know what the challenges are, so we want to be exhaustive in our preparation. We did that. The teams did that, and that included training. That included preparation for operations, backup systems, all of that. We wanted to maximize the opportunity to succeed and accomplish the mission, to get it put together, to make sure it worked, to make sure it was safe. If we had a problem, that we had the right spare parts onboard.

Naturally, when you do that, if everything works out fine in the end, you find that you overdid it in some areas. Training was one example of that, and there were certainly other areas as well that we perhaps overdid it, spent more time than necessary. Since then we've become a little bit more efficient. We've sorted out the things that weren't necessary so much in preparation or in the operation, and streamlined things to make it more efficient. That's a normal process.

I think one example of that is operating the Station itself. In the beginning, in just running the Station, all of the systems, and being able to respond to—nothing can be called minor—but the less significant failures that could occur onboard. We spent a lot of time preparing the crews to respond to those things. Not emergencies, not what we put in the warning category, but things that are lower level, lower significance if they occur.

We learned very quickly that, from a practical point of view, the ground is best to focus on that. There's a control team in the [Mission] Control Center made up of a variety of flight controllers, each one specializing in their system or systems. They have all the data in front of them, so it's more appropriate for them to respond to those failures or contingencies that might happen on Station, and if we have communication with Station, they'll do that as a matter of course.

In fact, we'll have an alarm, even a warning, go off on the Space Station periodically. If it didn't take out the communication system, we'll very quickly get a call from the ground, from Houston, to say, "Disregard. We've got it." That allows us to go about our business, and that has been a natural evolution. That has been driven by learning how to operate the Station over time. It also has been driven by virtually continuous communication coverage now, where the ground always is in communication, and they always are getting the telemetry down to the ground, and they're able to send up commands to the system. As well as just becoming smarter, from a practical point of view of operating the system.

One area that we've made great advances in in recent years is the robotic arm. Initially, every operation that involved the physical movement of the arm was done by the flight crew. Then, in about 2006, right before I arrived during Expedition 12, and then through my expedition there, we started developing the capability for the ground to do very small movements of the arm from the ground, where we weren't even involved. And that has grown now, to where we will do, for example, when a supply ship arrives, we'll do the track and capture of the supply ship and get it all safed and configured, and then the ground takes over from there, all the way to moving the thing to the berthing port and getting it ready to berth.

We've really evolved quite a bit in that, and of course that frees up crew time to be able to focus on other things, such as the hands-on research that takes place in the laboratory.

WRIGHT: Thanks for sharing those steps. As our time starts to close this morning, I wanted to ask if you could to just go back for a second. You were talking about what you thought probably would be the legacy of the Station. You had mentioned earlier about the international cooperation and the international understanding. You mentioned that that would probably be part of it, and I didn't know if you wanted to talk a little bit more about that aspect of what you feel that will be the legacy, or if there was something else that you wanted to add to that. When we have all moved on past the Station, what will you be glad that we remember the Station for?

WILLIAMS: A lot of times people will talk about it being a laboratory and the return of science and what you learned in the research programs onboard the Space Station. You can talk about that as a product of the Space Station itself, and certainly that is a product, but I think the legacy of the Space Station will be the Space Station itself. Many different aspects—as I alluded to earlier—just the technology and the scope of the technology that's integrated in this almost one-million-pound mass spacecraft assembled by way of almost 40 Shuttle launches. I think it's 37, 38 Shuttle launches, 180 EVAs or more, 40 or more launches from the Russian system to assemble it, and then the Russian launches are continuing to support it. Operating is for this many years, with multiple control centers, and all the integration that takes place there.

Being able to respond to failures that are onboard—it was designed to have replacement parts, so if something fails it was replaceable, and we have spares onboard. Originally it was assumed that the Space Shuttle would be available for the life of the Station, so a lot of the maintaining of the Station assumed the Space Shuttle to get the big parts up there on relatively short notice of, say, weeks or months. Then that went away, so the program and the partnership had to adjust to that reality, and we continue to evolve in our ability to support the requirements to maintain the Space Station.

The international partnership and the strength of the partnership—I go out and speak in public settings across the country and even internationally, regularly, and I always get the question about working with the Russians in particular, especially given the political context of today, with the political conflict surrounding the situation in Ukraine. I can say that the partnership, from an ISS point of view, from my vantage point, has never been better. We are working together as well as we have at any time in the program, and that has been dependent on the relationships built. We know each other personally. We can trust each other personally, and we know the constraints that each of us has, and we try to work together to manage those constraints. I think that will be the legacy of the Space Station program.

In 1984 Space Station Freedom was announced by [President Ronald W.] Reagan, and that was three years after the Shuttle had its first flight. The Shuttle was originally designed to put up a space station. It was conceived as early as the late ’50s to build something like the Space Shuttle to put up a space station, to go to the Moon, and then on to Mars. I read a report, and I think it was dated 1959 or so, that laid out that vision, so it hasn’t changed since then.

We did things in a little bit of a different order, but the Shuttle was designed in the ’70s, flew its first flight in ’81. Space Station Freedom was announced in ’84, went through multiple design iterations through the ’80s into the early ’90s without any reality of flying. The Soviet Union fell apart. Now, we’ve got this new Russia. There was a—rightfully so—political motivation to establish in a new way this fledgling democracy, as we envisioned it at the time, and that resulted in a proposal of partnering with the Russians, adding the Russians to what had been Space Station Freedom, with the Canadians, the Japanese, and the Europeans, and it became the International Space Station.

Prerequisite to that was the Shuttle-Mir Program through the ’90s, to learn how to operate with them, to learn how to integrate our systems and our way of thinking and the culture and the language and whatnot, and that’s why they called it Phase One of ISS. And that led up to, of course, the launch of the first element, the FGB, followed by [Space Shuttle] *Discovery* taking Node 1 up, and then the assembly of the Space Station.

I’m convinced that, and I think if you look at history, everything that NASA has done, historically, has been in the context of what could be politically supported at the time. We went to the Moon because it was a huge political objective in the ’60s. Once we landed after the first time, the motivation to continue to go back diminished rapidly. Of course, we know we only flew a few more flights to the Moon before the program was canceled.

Apollo-Soyuz [Test Project] happened. We just celebrated, this past week, the 40th anniversary of Apollo-Soyuz, and that was really the precursor to what became the ISS. Personally, I'm convinced that if the Russians were not brought onboard as partners in the ISS program, that we would not be flying today. As challenging as it has been through some seasons to get it to work, had they not been with us, we would not be flying today.

I think that that suggests that in the future, any major, next chapter of space exploration will undoubtedly be international in its flavor, and probably in an international partnership that maybe has some political and diplomatic challenges, because those challenges are actually what solidified the political motive to go and execute.

WRIGHT: Thank you, that was a great answer. I know that your contributions to the Station Program are not complete. You still have more to do, but looking back, what do you feel that you have been able to contribute to this program that's reaching across the globe?

WILLIAMS: Well, I don't think there's anything unique that I contributed. I would say maybe I'm representative of many people, thousands of people across the partnership, that have dedicated either their entire lives or much of their careers to making this thing work. It still amazes me that, in spite of all its complexity that I've already talked about, and the software integration I didn't mention, just the technical complexity, the political complexity, the languages, and not only just the language, but understanding the unspoken part of communication across cultures. The privilege that I've had to participate along the way and enjoying the successes that we've had, I think is representative of the many people across the partnership and in the communities of each partner. Here, at Johnson Space Center, of course the ops [operations] team, the program team, the engineering team, the medical folks, the research folks, all doing their part, contributing as a team member to the team to execute this program.

WRIGHT: I wish you the best of luck in your training and your upcoming missions. Thank you so much for this morning.

WILLIAMS: Thank you.

[End of interview]