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LAURI N. HANSEN
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is August 13, 2015. This oral history session is being conducted with Lauri Hansen at the NASA Johnson Space Center in Houston, Texas, as part of the International Space Station Program [ISS] Oral History Project. Interviewer is Rebecca Wright, assisted by Sandra Johnson. Ms. Hansen currently serves as the Director of Engineering for the Johnson Space Center, and for the past 30-plus years has been involved with a number of aspects of the Agency's space exploration programs. Thank you, again, for taking time in that busy schedule that you have to meet with us.

We would like for you to begin, if you would, by sharing with us how you first became involved, and what led up to your involvement with the Space Station.

HANSEN: Actually I started my career in an organization called MPAD [Mission Planning and Analysis Division], which doesn't exist anymore, working on Space Station Freedom [ISS predecessor] doing design reference missions, integrated ops [operations] scenarios, and assembly sequence stuff. Migrated along until I was managing integrated performance for Level II [Space Station Program Office] on Freedom, then we had the big—Freedom dissolved, and we had the Crystal City [Virginia] activity [redesign].

I was on the Crystal City teams, and ended up, coming out of that, setting up the International Space Station Program, or Space Station Alpha at the time. I came back from

Crystal City and was originally on rotation in the program office, and then ended up applying for the Integrated Performance and Assembly Sequence Manager job, and was selected for that. I was in right at the start of the International Space Station. I started in that position, and went from there to Deputy Vehicle Manager.

WRIGHT: If we could walk through some of those. From an outside view, it sounds like it could all be the same, but I'm sure that there were things that you added to, and the value that you were able to contribute, and the knowledge you were able to gain. Walk us through those different aspects as you went through those years.

HANSEN: Space Station Freedom was structured very differently, from a contract perspective and an organization perspective. Freedom was more analogous to [Space] Shuttle in that it had work packages, so it had pieces responsible for building segments of the spacecraft. Then it had a Level II integration. It had a Level II and a Level III [NASA Center work packages]. I really supported what was Level II at that time, or the integration function.

Freedom went through a whole bunch of changes in its time. The original concept was that Level II was going to be done in-house, so by civil servants and the government. Quickly it became obvious that there wasn't enough manpower to do that, and so they hired Grumman [Corporation] as a program support contractor. Not an SE&I [systems engineering and integration] integrator, but a program support contractor.

Lot of lessons learned about contract structure and enabling success at that point, because Grumman really had no capability to influence the work packages. There was no carrot, there was no stick, and there wasn't really a significant separate budget. All of the budget was in the

pieces. They really had a very ineffectual integration function, and yet they separated the pieces out. It was pretty clear it wasn't working really well.

At that time integration was up in Reston [Virginia], and there were budget problems and schedule problems and so on. That was when they decided to do the Crystal City effort. It was an interesting time because Freedom had not been officially dissolved, and so actually we were going through—must have been PDR [Preliminary Design Review] at the time. I remember running a team for PDR on Freedom at the same time I was in Crystal City looking at how we could do it completely differently.

It was pretty clear that the Freedom people *per se* were becoming *persona non grata*. Interesting again how the Agency deals with that kind of thing, because there were a whole lot of people that were really very capable people that were left with sort of the stigma of, "Hey, you were part of this, that we've decided it failed, and so you're not welcome to participate in this new endeavor." I was lucky, I was probably low enough level that I wasn't branded with the Freedom versus Station Alpha at that point.

The Crystal City effort was interesting, because Crystal City was broken into three different teams. There was a Station concept A, B, and C. "C" was actually the one that I worked on initially, which was the one led out of JSC. "A" was the one led out of [NASA] Marshall [Space Flight Center, Huntsville, Alabama] that was selected. We all went to Crystal City, that one was selected, and we started working on refining that.

Honestly, there were a few really big holes technically. Part of the concept was it removed the alpha joints on the Space Station and relied on the beta joints to serve that function, and they really didn't have the right capability. We were coming out of there with a concept that was technically marginal, honestly, but was back in the cost box and back in the schedule box,

and so obviously lots of political considerations about how to keep the program sold. Space Station was always on a very shaky territory as far as remaining sold in those days.

At that point, it was essentially the end of the Cold War. I'm trying to think—that would have been '91, '92, somewhere in there. That's where some of the more geopolitical impacts came in. From a technical person's perspective, it's sometimes hard to understand exactly what drives it, but I think if you look at NASA, we're really an instrument of policy. We personally don't like to think that because we think we're about human spaceflight, and rockets, and putting people in space, but from a national level we're an instrument of policy.

You can see that really clearly when you go back to Apollo. From NASA's perspective, it was about putting somebody on the Moon. From the nation's perspective, it was about showing the world who the "big dog on the block" was without firing a nuke [nuclear missile]. At that time, you get to the last Apollo flight after a wildly successful program, and NASA was shocked that the program was cancelled. If you look at it from the political considerations, just exactly how many times do you need to be first to prove the point you're trying to make? To me, one of the lessons learned that I have is we forget about that from the engineers' and the program managers' perspective because to us, that's not what this business is about. As a nation, that is a really important part of what this business is about.

Fast forward to Space Station Alpha. The Cold War was ending. The USSR had dissolved at that point. You had nukes in a lot of areas with shaky governments. You had a pretty dicey atmosphere, really, worldwide, in terms of how everything was kind of coming apart. A brilliant move, I think—whether it was that strategic or whether it was happenstance—of using ISS as a mechanism to build international collaboration versus competition.

Apollo was all about competition. ISS, at that point—later, of course, became much more so—but at that point, it really became the start of using space seriously for collaboration. Actually before we left Crystal City, the Space Station Alpha concept—the original one—had no Russians involved at all. By the time we left Crystal City, the Russians were involved with the [Zarya] FGB [Functional Cargo Block] and the [Zvezda] Service Module. Probably bailed us out in some respects from the cost and schedule aspect, right?

Remember I said we were a little bit on shaky territory in terms of it being technically sound? That helped the technical aspects of it, because it gave us the time—and excuse, probably, if I'm being totally blunt—to restructure it. Then also geopolitically, all of the sudden it started to establish partnerships as opposed to competition. In that era, that was when the Russian—former Soviet—engineers weren't even getting paid for the most part. You can imagine that there's a lot of potential for distress, things going badly. Instead they were employed working on building the International Space Station. Stood up the office.

Let's see, also in that era there was contract consolidation. Space Station Freedom—you had McDonnell Douglas [Corporation], you had Rockwell [International]. I don't remember who all you had, but you had at least McDonnell Douglas and Rockwell. By the time ISS came along, [The] Boeing [Company] had bought everybody out. What that allowed was you no longer had to have this Level II and Level III, because the Level III were different contracts, so you had different contracts with that. Now you had essentially all one company, so you could do away with the Level II-Level III construct, and go to a much flatter organization, which should theoretically—and I think in actuality—save a bunch of money. It doesn't become as hierarchical.

A lot of challenges with that. Boeing, I would say, initially did not really put their A-team on it. It was not a group that was really experienced in human spacecraft development and integration. There were a lot of people that had done aircraft, which is not at all a slam on engineering skills, but it's a very different creature than building human spacecraft. The civil servants played a big role on that.

At the time, there was the IPT concept, Integrated Product Team, and AIT, which was Analysis Integration Teams. Really, those were nice, typical NASA acronyms for a combined contractor-civil servant team. It allowed the two to work together well, versus kind of a customer-provider relationship. Probably, in my opinion, enabled the success of ISS by doing all of that work, because really the skills were there from all of the Shuttle integration, and all of human spaceflight development. A lot of the skills were on the civil servant side.

Also that was following some review where we'd gotten in trouble for something, and all of the civil servants were supposed to be in the [Space Station] Program Office. The program office was pretty big for a program office. Probably some of the legacy of today—actually the program office is still pretty big compared to some of our other programs. System managers were in the program office, they weren't in Engineering [Directorate] at the time.

The contract relationship as we went forward—where the IPTs and the AITs enabled a lot of success, it also changes the dynamic. It's much less of a customer-provider relationship, and much more of a team relationship, the benefit of which you can bring skills from both sides. The disadvantage of that being you're much less likely to hold the contractors' feet to the fire and say, "Where are the deliverables and where are the schedules?"

There was a lot of, I would say, good teamwork. The program was struggling in terms of delivering stuff on schedule, delivering stuff on time. At that time it was Randy [Randolph H.]

Brinkley who was the Program Manger and Shep [William M. "Bill" Shepherd] was actually the Deputy Program Manager. A lot of sense of we weren't getting where we needed to at that point.

Some really big misses in terms of the fact that we were flying Freedom at 28.5 degree inclination. We were flying ISS at 51.6. It wasn't until probably a year and a half or more into ISS really being established, that all of the sudden we get this big cost impact that said the change to 51.6 was never flowed down to all of these major component providers, and it's a dramatically different environment. All of a sudden, we had big problems in terms of could we generate enough power, could we fly at the right attitudes? All of that. A lot of problems in that direction.

About then, probably around '95, '96, Jay [H.] Greene came over to the program. Jay's management style was dramatically different. Some people loved it, some people hated it. He was very, very good technically. Not the easiest on working with people, but very, very good technically. He really started to shift the performance issues, and really hold the accountability of, "What's your schedule? When are you going to get stuff? How are you going to get it here?" Instituted things like noon boards, and so on.

What else? I've rambled for a while.

WRIGHT: No, you haven't. It's great background. Tell us about where you were and what you were doing during those time periods and up until that point.

HANSEN: When I first came over, I led the Integrated Performance and Assembly Sequence area. Our assembly sequence at the time was 25 Shuttle flights. It morphed over the years, but

something on that order. Very problematic in terms of when we had renegotiated the new contract for ISS, we had spelled out the flights pretty specifically, and of course as things evolved they didn't quite work out like that. Each time we wanted to make a change—because the contract actually specifically called for these flights and this goes on each flight—every time things changed it was an enormous impact to the contract.

One of the lessons learned that I have out of there is we need to be very careful how specific we get on requirements. We tend to think as a culture that the more specific you can get on requirements the better. In reality, requirements keep the provider in a box. If you understand that box really, really well that's okay, but if you think it might shift a little bit or grow a little bit, you're hurting yourselves by having defined it that well.

We thought we understood exactly what each of those flights would look like, and as things changed, we were wrong, which is hardly surprising. It was a phenomenal integration exercise, but every time we wanted to look at something different, it became a big cost impact, a big study impact because it had been defined as, "This is what you're delivering, these pieces on this flight." That's one of the lessons that I've kept with me is, yes, if you're absolutely 100 percent sure that you want it exactly this way, and colored blue, and all of that, then write the requirements that way. If you're wrong, you're going to pay for the changes as you go along.

I was doing that. I was doing integrated performance, which was basically running the design analysis cycles, and later the verification analysis cycles. Which really says, "Does my spacecraft operate the way I want it to? If I take the real loads, and the real flight environments, and the real external environments, and contamination, and the power utilization requirements, and the power generation capability, and the thermal capability—does it all fit together?"

That's always, again, challenging in terms of you write requirements to specify each of those, and then generally when you try and pull it together, you didn't get them 100 percent correct. Because in spaceflight, it's always the first time we've done it.

WRIGHT: It was a massive project, too. It wasn't just one unit.

HANSEN: Oh, it was huge. Yes. It was huge.

WRIGHT: When you used the word "integration," that's what I visualize, is not just a LM [Apollo Lunar Module] or it's not just [Orion] CEV [Crew Exploration Vehicle]. It's all these pieces.

HANSEN: Right, right. And a changing configuration. We actually would break it down into pieces and assemble it complete. I'd have to go back and check exactly what it went through, but it was like [Assembly] Flights 1 through 5 and Assembly Complete, because we couldn't cope with 1 through 20 or 25, or whatever it was. You couldn't really ignore the end-stage, because if you ignored the end-stage, you'd get totally disconnected. We would try and do it in segments, and then we'd try and do the end piece. Very, very clear at that time, I think, that Boeing had never done anything like that.

WRIGHT: How do you address that, at the point where you are with finding out that your major support contract doesn't have what you need to go forward?

HANSEN: Honestly, at that point, I think we just filled the void from the NASA side. The contract relationship allowed it, encouraged it. Really, we filled the void from the NASA side. Now since then—just so that my comments don't get misinterpreted—Boeing has grown tremendously. They have done a phenomenal job. It was very definitely a painful transition, and in fact, I remember the original Boeing contract had a look-back clause.

I think it was one of the very first contracts that we had that a look-back clause, which essentially meant, "I'm going to give you an award fee during each award period. Then at the very end of the contract, depending on how you did, you can either earn more, or actually earn less based on how did it end up at the end of the day." I'd actually long since left Space Station at that point, but I was on the Performance Evaluation Board, really from a historical perspective.

Really interesting discussions, because I think what we all struggled with was—at the end of the day, Space Station is a phenomenal achievement. I look at where we were at the beginning, and we had all these assembly flights, and we had all these EVAs [Extravehicular Activities], and we all honestly thought there's no way this is really going to work the way we planned it. We know that partway through, we're going to throw all the cards up in the air. It really did pretty much work the way it was planned, which is mindboggling when you look at the fact that those were really all separate spacecraft. They were assembled on orbit. They had all the complications of a spacecraft. Pulled off—there were certainly some hiccups along the way—but really very smoothly.

The look-back meeting was interesting, because no one could argue that boy, at the end of the day, it was a phenomenal achievement. I don't think anybody could argue—probably not even Boeing at the time—that a lot of that was enabled by NASA in the early days, so then what

do you do on an award fee given that? How do you balance that out? It was an interesting discussion.

Let's see, in terms of where I was. I stayed in the Integrated Performance and Assembly area through the time that we realized we couldn't fly in the attitude that we wanted to fly. We were at 51.6 and so we had to come up with a completely new attitude to fly to Space Station. We had to rework a bunch of things in that area.

WRIGHT: Just for my clarification, that's after we—with the Russians—became part of Alpha, when the degrees changed?

HANSEN: Yes. Yes, yes. When the Russians became part of Alpha is when we went to a 51.6 inclination because they could not launch to a 28.5 degree. Essentially, where their launch facilities are located, if they launch 51.6—they're in a middle of a landmass, whereas we're on the coast. If we change inclination, it affects where you drop things in the ocean. If they changed inclination, it affects where they drop things on land, and so they really couldn't decrease their inclination any. We had to increase ours, which had dramatic performance impacts.

The Shuttle lift capability went down—it's been too long for me to remember the exact numbers. Somewhere around 15,000 pounds a flight we lost, going to 51.6. There was a lot of lift capability lost, and then there were a lot of performance implications about being at a different inclination in orbit. We actually went back to Shuttle at the time, and really Station assembly was not doable with the capability that Shuttle had at the time. So, that was when we went into the serious upgrades on the Shuttle side, with the lightweight aluminum lithium tank

[Super Lightweight External Tank]. That was the biggest upgrade. There were a whole slew of them that ended up getting about an additional 12,000 pounds of performance out of the Shuttle fleet a flight. That was what really made it doable from our side, that we got more performance.

WRIGHT: Not only did you have to work with the new international partner that you just had, you have to work within your own Agency to work those issues out with those programs.

HANSEN: Right, and of course Shuttle was not necessarily thrilled with the concept. They had been sort of merrily going along, flying Spacelab [habitat module] and various things at 28.5 degree inclination, and now here's this other program coming in and saying we need more performance, and can you make significant mods [modifications]? There was a lot of tension at first between the programs. Is this even possible, and where's the money coming from, and how do we get this done? There was a pretty clear mandate that we would indeed get the Shuttle to 51.6 degrees, and so there were modifications made on that.

WRIGHT: Pretty interesting time period. Then Shuttle-Mir [Program, ISS Phase One], the in-between.

HANSEN: Right, right. Shuttle-Mir was in that era. I don't remember when Shuttle-Mir started flying.

WRIGHT: Around '94, somewhere in there.

HANSEN: It was probably right about when Alpha was formalized, and flew through much of it. Somewhere around ’95 or ’96 I went from Integrated Performance and Assembly, which was in the Vehicle Office, to the Deputy Vehicle Manager. At that time, the Vehicle Office had really all of the development for Space Station. We hadn’t separated out OM [Systems Engineering and Integration Office]. In today’s org [organizational] structure, what I initially did is really OM’s function now.

Then we hadn’t separated out Software and Avionics, so OD [Avionics and Software Office] was part of that as well. Really, at that point, OB, the Vehicle Office included what today is OB, OD, and OM. Station was the first human spaceflight program that I’m aware of that set up an ops function within the program office. There was a little bit of stress around that.

WRIGHT: That’s a big culture change here at the Center to do that.

HANSEN: That was a big culture change. I was only aware of that peripherally, since I was really on the development side, not the ops side, but certainly there was some stress. Where it crossed my path was really in the assembly sequence stuff. “Okay, so what am I doing on the development side, and what’s OC [Mission Integration and Operations Office] doing versus what was MOD [Mission Operations Directorate] doing?” That was a big change.

I would say also, one of the things that happened in ISS that I was probably fairly oblivious to at the time, but now recognize the implications, was ISS actually pulled the spacecraft software development into the program office. It really left the institution, left the line organizations. In Shuttle, the JSC institution actually built the backup flight software for Shuttle.

There was a fair amount of inherent software capability in Space Station that was pulled into the program office, which was convenient for the program. It puts that resource under your control.

Looking at it in hindsight, and looking at it from a different perspective as the Director of Engineering, that really means that you're not preserving the capability, because a program has a short-term horizon. Even a program like ISS, which is up there for decades, still has a short-term horizon. Their job is not to preserve a capability for the long term. It's to either get a product out the door or maintain the product, whereas the institution is responsible for preserving that capability.

It's interesting today, until we started building a lot of software—really after Constellation [Program] dissolved, doing it through some of the AES [Advanced Exploration Systems] projects—we were really losing that capability, which is probably not a good move. It's not a good move for human spaceflight to pull something in such that you're not caring for it and nurturing it for the long term.

WRIGHT: How long did you stay with the Vehicle Office as its Deputy?

HANSEN: I was there until [ISS Assembly Mission] 2A [STS-88] flew. That was December '98. Stayed through them, and at that point decided I was ready for a change, and went over to Engineering. I actually spent about the first 15 years of my career on Space Station in some form, in various different forms, and then after that went over to Engineering.

WRIGHT: At least you were able to stay until you got to see the first couple of modules go up.

HANSEN: Yes. Yes, that was a special moment, seeing the 2A launch.

WRIGHT: Can you share with us where you were?

HANSEN: For 2A I went down [to Cape Canaveral, Florida] for launch. I would say probably most of the leadership team did at that point.

WRIGHT: What a celebration.

HANSEN: It's such a huge milestone, such a huge celebration. We all went down for the launch. Some folks went to the control room [NASA Kennedy Space Center (KSC) Launch Control Center], some folks went to the Banana Creek viewing stand. I went to Banana Creek, so I watched it from there. Just an incredible experience to see the fruition of so much work.

Of course, it kept dragging out. Originally it was supposed to be considerably earlier than '98. We had welding problems—it's amazing to me. We always seem to be surprised when we have welding problems. We had welding problems on Orion too, and yet every major spacecraft we—

WRIGHT: Probably Apollo, too.

HANSEN: Right, right. All kinds of schedule problems. It seemed like it was a very long time coming. It was wonderful to finally see it launch.

WRIGHT: Looking back on those 15 years, what do you think was the biggest challenge that you and/or the program had to face as it was moving toward actually being put into space?

HANSEN: I would say many, at different levels. One was just whether the program itself would survive. The program was, really all through that era, on shaky ground politically. There was the infamous vote in Congress where we made it by one vote. It was a lot of money for something that people questioned the value of. When I first started on Space Station, we had a dual keel, and we had a servicing platform, and we had life sciences, and microgravity, and it was this huge thing.

I think, as an engineer—particularly at that time I was a young engineer without a whole lot of visibility into the politics, the redesign after redesign after redesign—which was always because of money, and schedule, and so on—was extremely frustrating. Part of that's probably age. By the time you're a few decades older, you look back at it, and say, "Okay. Yes, you know, we'll eventually get through it." When you're in your mid-20s, you're like, "Oh my gosh, I've worked on this the last three years and now they want to go redesign the whole thing! What are they doing? Why are they doing this? Those idiots!" That, I think, was very, very frustrating.

In reality, the international collaboration was a stroke of genius, because I don't think ISS would have survived without it. I really don't. I think it became—as soon as you start to get into [U.S.] State Department agreements and so on, it became too hard for the nation to back out of it. I think probably we would have backed out of it again when they first wanted to establish Constellation if it weren't for the international agreements. That was the thing that really kept

Station there, and I guess emphasized in my mind—because further on in my career I did go to Constellation, and it's interesting how people take different lessons away, right?

One of the lessons that people took away from ISS is the Russians kind of had us over a barrel, which they did. They were our propulsion capability. They were our only propulsion capability. We absolutely, positively were dependent on them, and they were in our critical path. As the Soviet Union dissolved and Russia stood up, they learned to negotiate really, really well, and probably much better as a culture than we did.

Some people took the lesson of, "That's bad." It's bad to have an international partner on your critical path. In fact, when Constellation was stood up, one of the main premises was, "We love international collaboration, it's great, but I will never again have an international partner on my critical path." You fast-forward a few years, and you go, "Okay, I get the downside of having somebody out of your control on your critical path." But on the upside, in my opinion, that's what kept Station alive, and look what happened to Constellation.

There were no real political impacts—that's maybe not 100 percent accurate—there weren't political impacts at that magnitude. There weren't international political impacts of cancelling Constellation. I guess the lesson that I took away from it was a little bit different, and it really circles back to what I was saying before. We are an instrument of policy, and if we don't recognize what that policy is, and make sure we stay aligned with it, we're putting our programs at risk.

We care passionately about the next spacecraft. It's not on the top of most people's agenda in [Washington] D.C., so we need to be aligned with what that policy is. Even then it doesn't always work, but I think that's important.

WRIGHT: Looking at those early days as an engineer, and then of course looking at where you are now—being on the design, and on the redesign, and the change of design teams—do you feel that if you could have some elements now in the Station, that you were first talking about, if there was a way that you could put them in now, or wish they would have been able to stay, are there some [elements] that you felt could really benefit the Station's future?

HANSEN: They were a lot in terms of design, development, and process that we cut out, and ended up realizing later that it was dumb to cut out. In general, those found their way back in, just at considerably more expense. I can't remember the name of the acronym for the testing that we did at the Cape. Originally, we had lots of testing in the program. Then, like most programs, you realize you can't afford all of this.

We did an "ugly baby review," was the phrase that I remember. It was anything that only a mother could love, you had to come and defend. They cut things right and left. At that point—this was shortly after the program got established, and of course we were already out of the box, moneywise—we threw a whole bunch of things out, including testing that we could mate the hardware at the Cape.

Remember, we were building this spacecraft in pieces on orbit, and because we couldn't afford it, because there's schedule implications and everything, we said, "We're just going to count on this stuff going together. We're going to count on the drawings," and so on. We didn't get too far down the road before it became clear that that was really an unacceptable risk. You had to have some assembly and checkout at the Cape to make sure the pieces could go together.

That was probably the biggest example, but there a lot of examples where we pulled something out because we felt like we couldn't afford it, and then we'd get farther in and we'd

realize, "Oh, we have to afford it." Of course it costs more then, because it always costs more then.

In terms of basic capabilities, the Station's a pretty darn capable spacecraft. There's not a lot that I think we really gave up in terms of capabilities. Certainly the way it was envisioned originally, there was more time for the crew to do payload ops. That's something we struggle with today, right? We seem to spend a lot of time maintaining the Station itself, and never seem to be able to carve out as much time as we want for payload operations.

If I went back, would we try and do that better? Of course. I don't think, though, that that was so much consciously eliminating things as just not understanding when we got a system up there, quite how demanding it was. Our ecosystem seems to take a phenomenal amount of manpower and resources and so on just to keep it running. That was never a decision we made. That was the way it turned out in the end, was it took a lot to keep it running.

The only things that I can think of in terms of major capabilities that we gave up along the way was way back in the beginning, it was a dual-keel truss. It had a big rectangle, kind of around the middle. You were to have lots of room for external payloads. Yes, that might be nice to have. I'm sure you could do more if you had it, but I haven't seen a huge penalty for that. We were going to have a servicing capability, so you could bring a payload in, and service it without Shuttle flying. That's sort of irrelevant in this stage.

Station, again, you look at it, and it's just been, in my opinion, phenomenally successful. The big achievement—so you're asking what the big challenges and achievements are—to me, that's the biggest achievement. No single thing on Space Station was that technically challenging. We weren't really pushing the envelope in terms of building a solar array, or

building a lab module. The part that was technically challenging was the integration, making sure it could actually all come together on orbit.

WRIGHT: Even though you're not in that program, you're certainly involved with Station, and Station operations with EVAs, and Commercial Crew [Program]. We have a little bit more time. Can you share a little bit about what currently you and Engineering—how you impact all those other pieces of Station that are still very important to its life and its future.

HANSEN: Yes, right. Actually, at my current job, I spend a lot of time working Space Station stuff. All of the system managers reside in Engineering, so essentially we're responsible for the technical part of sustaining the Space Station, and oversight of the prime contractor in terms of the system management.

Oversight's kind of a funny word in that context, because it implies that they're doing all the work, and you're looking over them and grading their paper. That's not what the system manager role is. The system manager role is really, "What do we have to do to fix this system? What do we have to do to improve this system? Some anomaly happened—how do we be sure that we've got the right response?" A considerable portion of my workforce supports Station every day.

Then another significant portion supports Commercial Crew. Commercial Crew is a little bit hard to get our heads around sometimes in terms of what the model is. From the official responsibility for Engineering, we're on the hook to make sure that the on-orbit spacecraft can't hurt Space Station. We don't have oversight responsibility for—I guess really I'm talking the CRS [Commercial Resupply Services cargo] contracts, not so much Commercial Crew. We

don't have responsibility for making sure CRS companies can deliver. That's a commercial thing. We don't have responsibility for making sure it can't hurt Station. Really once they get inside what we call "rendezvous box," that's when we have to make sure there are no hazards to Station, there's nothing that could put it at risk.

The other thing, which is a little bit more nebulous—whereas we don't have oversight responsibility for the launch vehicle and system, from the Station perspective, we do have a technical responsibility in terms of risk to the program. For example, if you see a launch vehicle that we're not responsible for, but making questionable technical decisions that you think is putting the program at significantly more risk, we do get engaged.

That's been a bit of a learning experience. Where do you draw that line? Certainly we got more engaged after the Orbital [ATK, Inc., CRS-3] accident. More engaged again after the [Russian] Progress [cargo vehicle 59] accident, and more engaged again after the SpaceX [Space Exploration Technologies Corp., CRS-7] accident. It's honestly a little bit uncomfortable, from my engineers' perspective, because you only kind of, sort of have some responsibility. And kind of, sort of responsibility's a little difficult.

Really we look at it from the perspective of making sure, to the degree we can, that the program understands the risk it's assuming. Obviously it's a very different risk when you're down to one launch provider, and all of the sudden you're worried about, "Have they done the right testing? Are they in the right position to launch?" Ultimately, that does put your crew at risk on orbit.

We're also in the middle of the Commercial Crew Program itself. Not CRS, but Commercial Crew, in terms of oversight of building the next set of vehicles. We do all the system management for that, working with KSC. Probably on Station those are our biggest

things. Then the other way that we really interact, is we do a lot of small system development for Exploration [Systems Development]. That comes in through the payload side of Space Station. For example, we built Robonaut [humanoid robot], which is up there as a payload.

We built the Amine Swingbed [experiment], which went up there as a payload, to demonstrate that it could be used to reduce CO_2 [carbon dioxide] levels, and has kind of morphed along the way to sort of a system. Not quite, but it's actually an interesting model. If you put something up that's just built as a payload, it might work, might not. Then you end up it does work, and you want to use it. How do you make that transition? That's part of what we're working through now.

WRIGHT: Never a dull day.

HANSEN: Nope. Never a dull day.

WRIGHT: I know you have touched on pieces of this through our conversation today, but if you don't mind, if you could give us some thoughts on what you believe that the legacy of the ISS will be?

HANSEN: I think, honestly, its biggest legacy is international collaboration. I would really like to see us go to Mars one day. I don't think we'll ever go to Mars as a nation. I don't honestly think any single nation is going to have the resources to go to Mars. Not to wax too melodramatic, but if humankind is really going to go beyond the Earth-Moon system, I think it has to be as

humankind, not as the U.S. I don't think we have the resources to pull it off, or the will to pull it off at that expense.

I think the biggest legacy ISS has left for us is setting the framework of how do you really pull a complicated, complex, difficult international collaboration together and make it work? If you think about it, no partners have walked out. ISS has lasted longer than many marriages. I mean, it really has. You look at the complexity of the relationships, and it's amazing that it's lasted, and really serves as an example. On ISS, with the exception of the Russians, it was kind of, "We're going to do this, and we'd love to have you join us." For the next step, the "we are going to do this" has to be everybody. It's a different dynamic in the partnership. That, I think, is honestly its biggest legacy.

Beyond that, there's a plethora of them. It's shown that we can actually live and operate in space, 365 days a year, for years on end, which is phenomenal. It shows we can pull of a big, integrated, complex assembly of 20-odd spacecraft, over and over and over again. I think ultimately, it will provide us some really groundbreaking science. I don't know what it will be, but I don't have much doubt that we'll find things up there that we wouldn't have found if we didn't have Space Station.

WRIGHT: Well thank you. I appreciate your thoughts. Hopefully we'll get back soon and talk about more.

HANSEN: Okay, sounds good.

WRIGHT: Thank you.

[End of interview]