The oral histories placed on this Website are from a few of the many people who worked together to meet the challenges of the Shuttle-Mir Program. The words that you will read are the transcripts from the audio-recorded, personal interviews conducted with each of these individuals.

In order to preserve the integrity of their audio record, these histories are presented with limited revisions and reflect the candid conversational style of the oral history format. Brackets or an ellipsis mark will indicate if the text has been annotated or edited to provide the reader a better understanding of the content.

Enjoy "hearing" these factual accountings from these people who were among those who were involved in the day-to-day activities of this historic partnership between the United States and Russia.

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RICHARD K. FULLERTON

May 21, 1998

Interviewers: Mark Davison, Rebecca Wright, Paul Rollins

Davison: Good afternoon. Today is May 21, 1998. This interview is with Richard Fullerton of the Phase 1 EVA [Extravehicular Activity] Working Group, Mark Davison, Rebecca Wright, and Paul Rollins from the Shuttle-Mir Oral History Project.

We wanted to talk to you today, Richard, about the Shuttle-Mir Program and how you got involved in it from the beginning and what the EVA Working Group is doing.

Fullerton: I came out of MOD [Missions Operations Directorate] end of '93, after the first Hubble maintenance mission. Moved over to a newly forming office for EVA, project office. In early '94, the station sort of revamped itself, brought in the Russians. A lot of Shuttle EVA guys had always been curious about what the Russians were doing. I went and sort of wandered over to Building 4 South, introduced myself, and started participating in some meetings, working Russian requirements, U.S.-Russia integration, and stumbled upon a requirements meeting for a docking module for Mir and flight hardware, training hardware. I've been working Shuttle-Mir and station U.S.-Russian ever since.

Davison: You said you worked requirements for the docking module. Was there EVAs involved in installing that?

Fullerton: No nominal EVAs, but we had several contained contingency EVAs for the installation primarily. Later on we nominally used the docking module as essentially a pin cushion for external science MEEP experiments. The docking module was used after it was on orbit as a site to retrieve docking solar arrays from that later on went on the Kvant module. The STS-76 crew went out and did a lot of the experiments, depositing the MEEP [Mir Environmental Effects Payload] experiments. They also retrieved a camera, (a Shuttle TV camera from the outside), so we could bring it home and recycle it. We had several Mir crews interface [too] (with astronauts included, from Jerry [M.] Linenger to—I've lost track).

Davison: You made sure that the handrails or EVA translation corridors were in place.

Fullerton: We checked the handrails. We checked basically the feasibility of the tasks and the safety of the tasks, whether it was handrails, the routing, the strength, the clearances. We checked labels outside, which we had a few of. We checked to make sure there were no sharp edges, made sure that from a requirements standpoint and a verification standpoint, thermal touch temperatures [were OK and that there were] no antennas that would radiate. We worked requirements for water tank mockups, delivery and acceptance of water tank mockups. We went to the Cape and did crew inspections of flight hardware, science experiment fit checks. It was quite a busy little module for us.

Davison: Can you explain to us what the task of the EVA Working Group was and how it got started working with the Russians?

Fullerton: The office that I came over to in '94 was basically set up under Clay McCullough's GFE [Government Furnished Equipment] office, flight crew equipment, and they had an EMU [Extravehicular Mobility Unit] function. Tommy Holloway, as part of a recommendation from some Shuttle missions (STS-49), brought over David Low to head up a new office for EVA as part of Clay's earlier office. David Low came in. Robert Trevino, Cal Seaman and I, we each picked a project. I worked with Dave on NASA-RSA [Russian Space Agency] contracts. Then we got involved via Tommy Holloway, who started up the Phase 1 Program back in that time.

We all went to Moscow in September of '94, and he gave everybody a charter, all the different working groups, and for EVA he gave us responsibilities for EVA requirements, integration, operations, hardware.

Davison: Who was your Russian counterpart?

Fullerton: My Russian counterpart on paper is Aleksandr [P.] Aleksandrov of Energia. His deputy is the guy that I interact with on a more frequent basis, Oleg [S.] Tsygankov. We also have counterparts we've developed since the original time with Zvezda, Dr. Abramov. We developed contacts with Star City at the water tank, at their TsUp training instructor area. Back then it was a combination of Nikolai Yuzov, [General] Vladmir [G.] Titov. It's now evolved into Nikolai Grekov, and Viktor Ren. Even at Krunichev we have other counterparts. Vladimir Kamenshikov is probably the prime guy.

Davison: You are a team of one over here working with all these people, or do you have people--

Fullerton: No, we started out with just Dave and myself. Dave moved on. I worked with the help of a lot of institutional organizations. I had help from MOD--Jerry Miller, Mike Hess, more recently Alan Groskruetz. Help from safety. Carl Hammelman started out [early]. That evolved into some newer folks--Craig Perez, Paul Benfield, Dan DaSilva. Engineering--Roger Schwarz pitched in, worked interoperable common hardware like foot restraints and tethers. Worked with Jose Marmolejo for suits and airlocks. Space Station office, had some Boeing support early on—Carolyn Overmeyer. We've sort of had interfaces throughout the center, even at the water tank, had representatives working mockups, June Huhn in particular. So we sort of tapped in to all the people that normally interface with EVA. The crew office also had representatives. Started out with—there was Dave Low. Mike [C. Michael] Foale came in and actually worked as head of our office for a little while, then flew on Mir. We've had Leroy Chiao, Mark Lee, Jerry Ross.

Davison: You've been the one constant force there through the last four years, it sounds like.

Fullerton: I've been one of them. I've been there probably as long or longer than I should have. I've had others in my office also pitching in significantly. Kevin Engelbert's been there for a good part of it. Cal Seaman as well. A guy named Vince Witt is helping out on tools and hardware a lot recently. It's also a sort of growing and changing thing where people come and go.

Davison: You're still attached to the EVA project office, but you're just detailed to Phase 1, is that how it's working, a matrix, as they would say?

Fullerton: No, as an EVA guy you sort of work for everybody. So officially I work for XA in the EVA Project Office, but also support Phase 1 Office, support Phase Two-Three guys under [Randy] Brinkley.

Davison: Can you kind of describe the differences in EVA techniques between the Russian Orlan suit and the U.S. EMU?

Fullerton: There are many similarities and many differences. To boil it all down, the differences are there, but they're not really major. There's differences in mobility. There's differences in dexterity. There's differences in interfaces to the vehicle—umbilicals and other aspects. The Orlan has positive features over the EMU, and, vice versa, the EMU over the Orlan. They both sort of evolved around the vehicle and different requirements. Our suit evolved from Apollo; theirs evolved from a suit they were going to take to the moon. Their vehicle is designed so that you don't need a lot of tools. Most of their items that you do maintenance on are inside. They do a lot of work outside with science, with assembly of big things like solar arrays and propellant modules. They tend to not use foot restraints. That's one difference. I'm not sure whether that's because their design wasn't always as hot as it could have been, but they do a lot of what we call free-floating tasks where you hold on with one hand and working with the other.

Davison: How do they handle high torque, or do they avoid that?

Fullerton: With the design. Make sure the vehicle—that you don't need tools. They have a very small tool set compared to us. They use one or two wrenches. They do contingency tasks that require more tools, but they design their interfaces to be either tool-less or low torque. We've evolved around foot restraints from the Gemini days. But we are sort of converging, because we all know that foot restraints are a pain with high overhead to set up and tear down and move around. So we've developed alternatives that are sort of a body restraint, a tether rigidizes in between a handrail and your suit. We're implementing that on the Orlan as well. So we all use foot restraints to a different degree. We all use safety tethers. The techniques of restraints are pretty much the same. Physics is still physics: you push and it moves and it just keeps moving.

Davison: What about the differences in pressures and how that gets for prep for campout? I know their suit takes a little bit longer to set up but a shorter campout.

Fullerton: Well, they have a 5.8 psi [pounds per square inch] suit. We have a 4.3 suit. The pre-breathe for them is in the suit about thirty minutes, and they do a short stage decompression at 14.7, they stop at 10.2, then they press on. We have the protocol that uses a 4.3 suit and uses staged decompressions, either start out at 14.7, you're in the suit for four hours, or you're at 10.2 for twelve to twenty-four more hours, and end up pre -breathing in the suit forty-five to seventy-five minutes with an hour more on a mask before the 10.2 depress. So what you gain in pre -breathe you sacrifice in finger dexterity in the gloves and torques in the suits. But we have a lot of prep we do on the ground. They have prep on orbit they have to do, and that's what takes a lot of time. We do most of our preps for Shuttle missions and make sure that the suits are ready to jump in, but each take a while to get ready.

Davison: You mentioned earlier the differences in tools. One thing comes to mind, that the development of the tool you did for cutting the cables on the solar array, I believe. Can you talk a little bit about that and how that transpired?

Fullerton: Spektr was launched, docked, and they attempted solar [array] redeploy, and one of the arrays didn't make it all the way. It was a pyro didn't fire or was miscommanded. Anyway, it didn't release. STS-71 was about to launch probably within a month or so. The Russians started working immediately from there and on how to fix it. They were building a cutter of their own, sort of a scissors-jack type of device, guillotine cutter. Tommy Holloway directed us to start on a version of ours, because we had the next vehicle going up, and we had cutters we'd used before. We didn't have any on the shelf ready to fly certified, but in about a week we took a tool that we had as a prototype, it was a commercial item that we were working on for some Shuttle payloads and for station, built some handles from scratch over at Tech Services over a weekend or so, did drawings, did cert. A guy named W. B. Wood led all that from engineering. Had cert [certain] folks from SR [Safety, Reliability] and QA [Quality Assurance] standing there side by side, the draftsmen and machinists, and we built a flight tool, training tool, which we shipped to Moscow. From my office, the hardware was led by a guy named Matt Leonard, who's since moved to station. But we flew that thing in less than two weeks, delivered in about one week, and they went on orbit, used it. Actually, before we flew it, we caught the Mir-18 crew right before they were about to launch, and trained them on it out at the quarantine on back. So we did all the ops things, the hardware things, and it worked.

Davison: So in a matter of two to three weeks, you had designed and built this thing and tested and trained the crew with it. Pretty amazing.

Fullerton: We threw good folks at it and a whole Tiger Team effort and pulled it off.

Davison: And as we all know, it worked like a charm on orbit.

Fullerton: It worked. We're going to try to bring it home and put it in a museum somewhere, probably beside the Sky Lab (tool).

Davison: Tell us a little bit about the NBL test that you did with the Orlan suit. I think you recently did a SAFER [Simplified Aid for EVA Rescue] test here at NBL or in hydro lab. I'm not sure which one.

Fullerton: We've done a lot of Orlan-suit tests. We've got three Orlans here, one a DMA we've modified into an M. We've got an Orlan M full-up for the water tank as well. One 1G Orlan M. We've done tests with foot restraints and tethers, safer (the self-rescue device, the jet backpack) has been developed using these suits. We trained Linenger (before he flew) in the WET-F. We've done Space Station tests for CETA [Crew and Equipment Translation Aid] carts. For ….. comes to mind Shannon Lucid flew on there [Mir], came back, and has helped us with development tests with the Orlan. Most recently there were tests to certify and rate the Orlan M water tank suit for the NBL. We just received that late last year. They followed that up with engineering tests for refining the weigh-out system of the suit and looking at Orlan SAFER in terms of donning and doffing and operations, clearances, basic engineering, clarification of the design.

Davison: I think I read in your EVA activity report that you were looking at—was it modifications to SAFER or the Orlan suit to make sure that they really did fit between the two? Can you talk a little bit about that?

Fullerton: Well, with anything that we've interfaced, we've tried to keep the suit as is. It's crucial to have a good solid understanding of both sides. On the Orlan, it sort of evolves, the design of SAFER, foot restraints, whatever, evolves. We develop ICDs [Interface Control Document/Drawings]. We do lots of fit checks, bring the Russians here for demonstrations and tests. We go to Moscow, do the same. We have another test coming up, take the mockup back over in June of this year.

Davison: The mockup NBL here or at the hydro lab?

Fullerton: We're taking an Orlan SAFER unit over to Moscow, a higher fidelity, more recent version of latches, interfaces. It doesn't have any real propulsion system or electronic system; it's only mechanical, but the Orlan has evolved. Dimensions changed. Probe on the front shifts a little bit, shifting down in later versions. You have to make sure you have clearances for the arm motions. Umbilicals have to stay clear so that they don't get trapped underneath the belt. There's a belt that comes around the front, wraps around to the side. It essentially attaches the same way as the MMU [Manned Maneuvering Unit] and locks, ball and socket on the sides. SAFER just built around the back, sides on the towers here. So it's a constant struggle between the design of the suit and design of SAFER and schedule and the costs and trying to get something that's safe and functional. ER [Engineering Directorate] is working with the Russians directly, helping to integrate it all between Energia, Zvezda, and Star City guys. Everybody pitches in and adds value. It's proceeding. Just like anything, it has growing pains.

Davison: We're going to have two versions of SAFER? We're going to have an EMU version and an Orlan version?

Fullerton: Well, from a technical schematic point of view, a lot of the guts are all the same. It has commonality to not have to start from scratch. Packaging is different. The EMU SAFER mounts to the bottom of the backpack. The Orlan SAFER mounts and towers off to each side of the backpack. So the attachment to the suit is different. The packaging of the components is different, but the guts—same hand controller, same propulsion tanks, same electronics boxes. A lot of the internal components, we've tried to be cost-effective and not start from scratch. It's been mainly a packaging job, but the test of the suit has been unique. So crew interfaces, in the end, should be the same.

Davison: What about the EVA operations on ISS [International Space Station] that you've learned with the Shuttle-Mir Program? Have you been able to pass on any of these ideas to the station program?

Fullerton: Oh, yes. We've been working it all along. The same MOD and crew folks and EVA Project

Office guys and engineering folks that worked Mir also worked the same station things. So we've taken experience as we learn it and apply it directly. For the folks that aren't directly involved in EVA, we've written lessons-learned papers, circulated those. Station is responding to those. We've incorporated ground rules, constraints, rules of engagement of how many EVAs per increment, into station programmatic documents. So we've taken the knowledge we've gotten and we've put it into books, we've put it into hardware, and, most importantly, we've put it into the people that are working the same long-term efforts. This goes on the Russian side and on our side.

Davison: What do you see as the complement of suits on station? Will you have two EMUs, two Orlans and they never go out with a mix? Or do we see some kind of mix evolving in the future?

Fullerton: You'll start out with essentially three Orlans on orbit, two arrive on service module and one arrives later with Progress. They're it until about 7A, except when the Shuttle visits and brings EMUs. After 7A, we leave behind three suits, the EMU suits. And each increment, we're going to look at each increment, and decide what makes sense suit-wise, based on the tasks and the complexity of work outside, where it's located.

With the Russian airlocks, they're primarily only compatible for normal ingress and egress with the Russian suits, so that's one cornerstone. The joint airlock station is just that: it's joint. We can take EMUs or Orlans out. The plan is to take either, not both, though you could. We would fix a few procedures and sync-up pre-breathe. You could take an Orlan and EMU out in parallel, but probably things like communication would be a problem because they're different radio systems. You might be able to do a relay. But essentially we will have three suits of each type after 7A, have plenty of redundance. The crew will be trained in EMUs on either side, either suit, one more as a primary than the other. So we'll have redundancy. We'll have capability to go anywhere if we need to outside. We'll basically be taking Orlans or EMUs a pair out at a time.

Davison: How did you find it working with the Russians, or negotiating with the Russians? Was that a challenge to you? Did you enjoy it? How did that evolve?

Fullerton: It's gotten to the point where I can almost argue with the Russians better than I can with the Americans. The Russians are very practical oriented. They want to know why and they want a real solid reason why you want to do something. If you change, they want to understand. They have personalities just like we do, and they have schedule problems, financial problems, some more or less than we do. A lot of the non-technical things are really what drive what our difficulties are at the moment. But they all know the fundamentals and they've been around for—Abramov has been around since their very first EVA, hasn't missed hardly a single one over the last thirty-plus years.

We had done, as of probably last year, about an equal amount of EVA in terms of hours, but we have a rotating cast of people. They have a constant cast. People are people, whether you speak English or Russian or live in Moscow or Houston.

Davison: Did you find the language differences to be a barrier, or were the translators able to work through it and just be patient?

Fullerton: In the final analysis, no, but it does slow things down. You can't go as fast as you want to go sometimes. It takes sometimes two or three times as long to get something across, you have to backtrack and clarify. But it depends on the individuals you're working with, the quality of your interpreter, and the knowledge of the person across the table. A lot of times we communicate without any words; we draw pictures and we look at hardware, and it goes lickety-split. So it depends on the people and the topics. The language hasn't been a real barrier; it's more of a barrier when you want a fast exchange of ideas and solutions when there's not a lot of time available, whether it's management meetings or sitting on console in the Control Center. It would be nice if everybody spoke one language, but it won't happen.

Davison: What about your trips over to Russia? Did you start off enjoying them or you grew to like them?

Fullerton: I don't know. The first plane ride seemed like it never ended. They get easier. The travel's kind of nice. It's quiet. Don't have to listen to the phone ringing. Once you're there, after about three weeks living out of a hotel, you start going nuts. But you can get around in Moscow. It's easy to travel--subways. I feel safer over there sometimes than I do over here in big cities, except in traffic. It's not somewhere you'd want to live forever, maybe, but it's hard to move anywhere.

Davison: Where did you do most of your meetings and negotiations? At Kaliningrad [TsUP] or at the factories?

Fullerton: We just go where the action is. Like I said, we meet a lot at Energia. But over the last year or two, we've been all over. There are times when we go for two weeks or three weeks, and almost every day we're going to a different place—the Control Center, the TsUP, the Energia offices, the water tank out at Star City, Krunichev, Zvezda. We're just all over the map. That's just because we've got to go where all the hardware is, where the people are.

Davison: Were you able to visit any Russian homes, or did you ever bring Russians into your house, that type of interchange?

Fullerton: We do the social thing, the team-building thing. We've been to the dacha of one of the folks out there. We've not done a lot of personal home things out in Moscow, but at the end of business meetings you have your celebration that it's all over with in the office. We've had them over here. Every trip we try to take them to somebody's house and have a get-together. We've taken them to Galveston. We've taken them to movies. We've taken them shopping downtown, ice hockey games. We try to relieve the tension and build up the team every once in a while. They do that in Moscow. They've taken us out to Kaluga where they have their space museum from their original days of the program. They've taken us out to historical areas. So we get a good flavor. Not a lot of time for it, but every once in a while on a trip we get a day, half a day.

Davison: Did you want to talk about the suit at all or point out anything, any differences in the suit?

Fullerton: The suits are pretty much, in terms of physics, all one and the same. You've got a pressure garment that holds in the life support breathing gas, which is, in both cases, the EMU and Orlan, oxygen. You've got pressure restraint bladder. You've got restraints lines around it—bearings for mobility. You've got sizing systems that you adjust to long arms, short arms, put the elbow in the right spot so you can bend. The Orlan is nice because it's got fairly rapid resize; you sort of dial in a setting for what you want. The cord's down the length of the arms and legs. You either shorten or lengthen to get what you want. EMU has an extra bearing in the waist—compared to the Orlan DMA, but they've since added more bearings in the Orlan ankles. This suit has the same as we do—the wrist, the lower arm, the upper arm. The difference with EMU is, we have a pivot function for this, and Orlan is a bit more of challenge to come across the body with the arms. You can do this function. The new bearings have gotten it easier to come across. The arms are, except for the pivot, about the same functionally.

The fit of the gloves is a little different. There's a nonconformal fit in the Orlan groves. You don't have as tight or snug a fit. You don't have as much tactility. There are fewer sizes, but you can get custom if you have to. They're adjusted to fit. You have the same palm bar, the same type of idea, to keep the palm from ballooning, so you have a good grip.

Davison: You said earlier that the dexterity on this suit wasn't as good? Was that the glove or the pressure?

Fullerton: The dexterity is sort of built around what it needs to be. Like I mentioned earlier, you don't have to have a lot of tools. You don't have to use foot restraints, because they design their vehicle and their suits to go together. We sort of came in with the philosophy on the EMU as we wanted the suit to not be the limiting function; we wanted the guys themselves to be the limiting function. So the suit has tried to anthropometrically reproduce normal functions. The Russians have just recognized that you build your task and your suit to go together and they're compatible. So they don't have some of the features we have, but it does all the things it needs to do. And they've done some tasks that we would maybe even still with our suit have trouble with. So in the end, it's all doable; it's just a matter of time. It may not be as efficient in one way or the other, but it all gets done.

Let's see. The legs, from the boots up, we have a waist bearing. They don't have a waist bearing. Our waist bearing is for foot restraint use. Since they don't use as many foot restraints, they didn't incorporate it, though have since added an ankle bearing, which gives you almost the same kind of functionality for foot restraint use.

You have chest-mounted controls, thermal regular, warm or hot. We have a similar function. Oxygen controls, primary and reserve. Helmet lights, communication, hard line and radio frequency, control display for certain parameters, switches for fans and pumps. They have redundancy. You have two pumps, two fans. We try to have full-up redundancy so no one system will stop them. We have sort of a primary system, a backup system, that functionally has reserve capability but it's not identical reserve.

Their helmets, same kind of polycarbonate, lexan polycarbonate visors as we do, gold-plated visors. Helmet lights, a little less strength than the lights than we do, but they're designed for localized work. With a big vehicle like Mir, they don't have a lot of external lights. During the dark passes, they tend to stop, rest, wait for the daylight to come back. They're in no rush. They're doing orbits year-round, and they can afford to take a time-out.

The backpack is probably one of the things that is the big advantage with Orlan. This is a rear door opening system. The life support components are all in the backpack here. There's additional on the lower unit. This thing takes two or three minutes to ingress, so it takes significantly longer with the EMU. You get in all by yourself, close it up. This is what we've been trying to migrate to in our advance suits, the higher pressure suits for lunar Mars efforts. So they started out with this, and it's just continued to evolve in the same suit over the last twenty years. We're sort of going back to this in our future efforts.

Let's see. What else?

Davison: How do they open that door back up or make sure that they don't open it while they're on orbit? Double locking feature?

Fullerton: Yes, there's double locks. I probably won't be able to work it properly, but you can see there's a sliding—not only do you engage the roller here with the cam, but there's a sliding pin that engages this slot over here. So it locks. The handle lock's in place. It has the same independent life support rough capability that we have in terms of six, seven hours. We probably have a little more margin in ours, but it does what it needs to do. They've got umbilicals for connecting to the airlock before and after EVA. They even have a 25-meter umbilical they can come out and work from.

Davison: That they run through the hatch or through a pressure bulkhead?

Fullerton: The umbilical would probably run out through the hatch. It's got another interesting new feature, something our guys have talked about a little bit recently, is the moon roof on top. You can look up to a certain degree, if you tilt your head back, and you see different translation modes. So that's a function that we may consider adding some day.

The suit's very maintainable. You can basically strip the guts out of it and start over, replace individual components in the backpack. So in terms of easy to resize, maintainable, easy to don quickly, get out, it's got a lot of the features that everybody wants. You take the best of the Orlan, the best of the EMU, and you've got a winner.

We had actually started—one of the first efforts we did with the Russians was a common suit effort. We were going to merge the best of the two suits. For various reasons that stopped. We've proceeded down a path of selective commonality with foot restraints and tethers. The Russians have safety hooks. We've made it so that our NASA tether can also go on the suit.

Davison: Are you releasing something before you pinch it there?

Fullerton: You hit the release in the front and the rest goes. They use a dual safety tether protocol, the theory always you're two tethers hooked on, so if one fails, you're still hooked.

Davison: So they do a hand-over-hand type translation?

Fullerton: Yes, hand over hand. Fortunately, while you're moving one, you've only got one attached, so that's kind of why we're all evolving toward the SAFER, adds extra redundancy and margin of safety.

Davison: When we talked to Mr. Aleksandrov, he talked about one of the U.S. tethers that's been used. I guess it's the one that has the recoil on it.

Fullerton: Yes. It's a 55-foot cable on a spring reel, feed out and retract. It works well for Shuttle, but even then it gets tangled every once in a while and you've got to be careful not to pull it out too far and attend to it. It's nice because you hook once and you never have to mess with it again. It stays clean. On station vehicles it's a little more challenging to do. But what we've done is we've tried to build in the option to do what makes sense for each task in each location tether-wise.

We've done things as simple as patches. We put a Russian patch on the EMU for STS-86 when Titov went out with Scott Parazynski. Haven't got an EMU patch on the Orlan.

Wright: Would you show us again how it attaches?

Davison: The tether again?

Wright: You mentioned earlier that it somewhat attaches umbilical.

Davison: The umbilical? Is that what you're asking about?

Wright: Yes.

Fullerton: These? There's electrical umbilical, an oxygen umbilical, and also a fluid line. There's a panel on the wall that's got its own life support system, cooling system. The crew connects to it before getting into the suits, checks out the suits, gets in, do the airlock operations, pre-breathe, depress. Before they go out, they switch to independent life support, disconnect the umbilical, and they're on their way. That's basic scenario with the EMU as well. We have a multi-connector. It's all in one block. We've got a little different system, but it's functional. These, one of them is the reserve line. This is actually the primary umbilical line here, with all the multiple fittings. Water in, water out. Oxygen. The electrical's separate over here. So it's a bit of a trick to get on when it's pressurized, but like with EMU, there's things that if we had the opportunity we'd tweak a little here and there. It's serviceable, for sure, for station.

Davison: What are the restrictions in wearing the suit, as far as height or weight?

Fullerton: Let me put it this way. I'm 6'2". When I get in it, its all let out, it's riding on my head. So it's like 180, 186 millimeters in height down to—I forget--5', 5'4", something in that area. It's kind of reminiscent of the original Apollo-Gemini suits where everybody had to fit the vehicle, so the Soyuz is the launch vehicle for everybody and you've got to fit in basically—I won't call a basket, but your knees are scrunched up and you're pretty snug. So there tend to be not a lot of tall people, not a lot of small people.

If you fit the Soyuz, then you fit this. That's one of the challenges we have with the EMU-Orlan, is making sure that when guys get to orbit, that they all fit.

Wright: Could you describe some of the tests and/or demonstrations that you go through with the crew and the suit? I'm sure there's a lot. Just want to pick one or two that explain what they have to do when they're testing the suit?

Fullerton: Well, you start with evaluating the suit fit itself. That's the first thing you do is you get in the suit and make sure everything matches up. You know the adjustments are proper. You make sure you can reach all the controls, preferably with both hands. You'd like to be ambidextrous. Make sure you can read everything, operate the visors, turn lights on and off. Oxygen emergency systems. You can close the backpack. This is the backpack cord.

Davison: I was wondering how you closed that. I thought maybe you pushed it against the wall or something.

Fullerton: That's how you close it, and then once you actually lock it, it goes over the pin and stays there. So you want to be able to do that yourself. You want to be able to operate your tethers, your umbilicals. You get in the water and you evaluate airlock operations—ingress, egress. You get outside, you do the task, work with tools and restraints, moving things around, transport, turning bolts, cutting things. You do engineering tests of new hardware. The evaluations are pretty much the same for the Russians and for us. It's hardware, it's the evaluative procedures hardware. The suit itself, the vehicle, tools.

Wright: I've never seen it tested, so I'm watching a crew member at the pool. How do they get into the water and how long do they stay in?

Fullerton: Well, in the pool there's an umbilical that's connected. Let's see. The umbilical comes into the backpack of the Orlan, so it's out of the way. They lift them into the water using the strap. They get essentially lowered in via crane. They get taken off the crane. They adjust weights that are on the suit for neutral buoyancy, as close as you can get. Divers take them over to the airlock, and from there it's all up to them.

The EMU, pretty much the same. You've got a water tank umbilical. With our new NBL, really long cord, somebody tends it for you, simulates that it's not there on orbit. You're translating around on handrails. You're on the end of the robotic manipulator, interacting with it. You're doing the same work you do on orbit, and if you do it right, you don't notice the difference.

Wright: How long are they in the pool?

Fullerton: You can go up to, say, six hours, with a depth. You have to be careful with nitrogen washout, decompression sickness things, so we have a gas mixture at the NBL of enriched oxygen instead of lower nitrogen. The Russians tend to run three- to four-hour runs, but can run longer. We run some runs three, four. We've been doing more runs more recently up to six, to full-duration EVA.

Wright: What is the average EVA?

Fullerton: Average for the Russians, probably in recent history have been five and a half hours, but they've gone six, six and a half, a couple at seven. Ours are typically six, six and a half. It varies. We've gone beyond that if necessary—seven plus.

Wright: What prepared you for your role to be able to work with the Russians to do this?

Fullerton: I've worked EVA operations since 1982 through 1993, so, ten-plus years. I started out as an EMU person and learned all there was to know—not all, but I learned a good piece of it. Worked on console in the Control Center, front and back room. I did crew training, built procedures, sort of worked suit when we were flying it. I worked task operations, tried to hit all the highlights in it. I moved over to a different office in the project program office, so I had the technical background to take with me. It's made it a lot easier, because I don't have to worry so much about knowing the fundamentals. I can concentrate on the new stuff.

Wright: You said when you're in the suit, you hit the top. Do you get in it often to try things?

Fullerton: Me personally, my big hurrah with getting in the suits and doing tests was back in MOD. I've been in this thing once or twice. I don't have a lot of time anymore to get in the water tank; that's for other people to do nowadays. It does help to get in and get the experience, because you have more sympathy for the guys who've got to do work in it. So we help set up other people to do the tests, essentially.

Wright: What's on the right arm?

Fullerton: That's a little cue card of pressures and settings, time remaining versus oxygen bottle pressures, for example. It's basically a little cheat sheet for the crew, emergency checklist.

Rollins: How much is it worth?

Fullerton: This?

Rollins: Yes.

Davison: In rubles or dollars? It's worth a lot.

Rollins: It's almost priceless isn't it? I'm sure there's a fixed price for it, because somebody has to buy it. There are only a few in the world, so it's really not priceable.

Fullerton: They're not easy to come by, and we keep this one over here in a controlled environment. The same guys that process the EMUs handle this thing so we know it's in good hands.

Davison: Is there a company over there like ILC that makes the ones here?

Fullerton: ILC and Ham Standard up in Connecticut and Delaware do the EMUs for us. Zvezda in Moscow do these suits for EVA, they also do the space suits for launch and entry, Soyuz. They do quite a bit for their space program in general. We've got, like I said, a total of three of these in the States, and this is our one high-fidelity external unit that we don't put in the water. It's not a vacuum chamber unit. It's not flight, but in terms of what the crew interacts with, we can do a lot of training to supplement the water and testing more important. So for us it's pretty much invaluable because it saves a lot of travel. A lot of people can stay here and do work. We're about to deposit EMUs in Moscow in the water tank, so we each have resources at the other end to test and train on. We can't very well transport the vehicle back and forth between countries easily, so we bring the suits.

Davison: What about a tool caddie? I don't see a tool caddie on this one like you do on the EMU. Where do they carry their tools?

Fullerton: Well, they have a wrist-mounted cuff with some clips on it, and their tools have rings that hook onto those. They also wrap bungees around the arms, stuff it under their bungee for restraint. Again, they don't use a lot of tools. They don't have a lot to carry around. They have a tool kit or a basket that they can carry. They tether to handrails and slide it down the rails. They bungee tools to it. We've got a unit that just arrived, it's their station equivalent, with a whole bunch of tools that is down the hall that we're going to use. Basically they strap tools to their arm, to this portable carrier, or to the device that they're going out to install, just merge the two together and take it on down the road.

Wright: Has there been a high point in the Phase 1 mission?

Fullerton: About this suit here? Well, this particular suit only arrived late last year. The previous suit we got, the Orlan DMA, we used. We could not have done what we did with Linenger and Foale training here. We couldn't have learned as much as we did when we did. That really came in handy in developing hardware and comfort levels. This is an investment in the future, essentially.

Davison: Anything you want to add about what was the biggest accomplishment during Phase 1 or anything like that?

Fullerton: Biggest accomplishment, I would probably say, was not so much the hardware, not so much the individual flights, the cargo transfers and actual EVAs themselves; it was getting to know the people and the processes. The Russians learned a little bit about us, we learned a little bit about them. We've got a ways to go, but everyone's got a pretty good comfort level and experience now, an understanding. That, I think, was really the point of Phase 1, was to develop experience for later. So we pulled off everything we wanted to do. We did EVAs safely, successfully. It wasn't always pretty, but it got done. So from a technical standpoint, it worked. From a people level, it worked, I think, a little better.

Rollins: Thanks for all the information. It's valuable.

[End of interview]