

SPACE SHUTTLE CARRIER ORAL HISTORY PROJECT

EDITED ORAL HISTORY TRANSCRIPT

ARVID C. KNUTSON
INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is April 13, 2012. This interview with Arvid Knutson is being conducted for the Shuttle Carrier Aircraft [SCA] Oral History Project at the Kennedy Space Center. The interviewer is Jennifer Ross-Nazzal, assisted by Rebecca Wright. Thanks again for taking time out of your very busy day.

KNUTSON: Thank you for inviting me.

ROSS-NAZZAL: It's a pleasure. It's nice to finally meet you. Why don't you give us an overview of your career at NASA.

KNUTSON: I started May 4, 1987, after *Challenger* [STS 51-L accident], and everybody was starting to come back up on the new systems. STS-26 [return to flight] was my first mission. Basically my job was as a mechanic, and I helped maintain the single aircraft, Shuttle Carrier Aircraft 905. The normal day-to-day operation was various inspections, working day-to-day maintenance on the airplane, refueling, and in times when we flew, preparing the airplane for flight.

ROSS-NAZZAL: You said you're working day-to-day operations—

KNUTSON: Yes. At that time there were two mechanics and one avionics person and an inspector and their supervisor. We did normal inspections on the airplane as required. Times when the pilots were doing their proficiency flights, we would prepare their airplanes for flight and recover them and do post-flights and then return them back to our work area, which was in front of the Shuttle hangar in what they call Area A down at [NASA] Dryden Flight Research Facility [Edwards, California]. At the time it was Dryden Flight Research Facility, it's now a Center.

The airplane is not a lot different than a regular 747. The similarities kept us doing the same things as most mechanics did on other 747s, except for the added structure to the airplane which required inspections after every ferry flight, which entailed a lot of work in stripping the insulation out of the airplane to view all the structural significant items in the airplane. Eventually we talked NASA into letting us keep the insulation out of the airplane in the aft sections so that it would facilitate us doing our inspections faster.

From the first door aft, the airplane is basically all stripped out and down to the barest structure. We want the airplane as light as possible, but also we want it as light as possible aft. When we carry the Shuttle, the Shuttle rocket motors are very heavy and so the CG, center of gravity, of the Shuttle is very heavy aft. We wanted to compensate for that by making the airplane nose-heavy. To do that when we ferry, we actually carry 7,000 pounds of pea gravel in the cargo hold and at all times we carry a ton of pig iron on the main deck floor forward of the normal seating area. We can adjust our center of gravity of the airplane by compensating the horizontal stabilizer up and down to keep our CG in correct position.

We've removed all the seats, insulation, extraneous structures that support normally the stow bins and lavatories and galleys and cargo-handling equipment even in the back, aft cargo.

The airplane's modified so that we have more adjustability of the horizontal stabilizer than normal. We actually have an SP [special performance] version jack-screw which the horizontal stabilizer runs up and down on to adjust the angle of incidence to the oncoming air.

A lot of people wonder about the outriggers on the outside of the horizontal stabilizer. Those are fixed, and those are there to straighten airflow out because there's so much turbulence that comes off of the Shuttle as we were flying through the air. If we didn't have that structure back there to straighten the airflow out, it would give us handling problems. And because they're fixed, they actually give us a problem with rudder control, because we fly so slow we still have full authority of the rudder, and that gives us control of the airplane a lot better.

When we have the Shuttle on top, the tail cone is put on there for two reasons. It's to protect the rocket motors on the Shuttle, but the other thing is to straighten the airflow coming off of the Shuttle so that we have good flow that isn't turbulent that would destroy the back end of the airplane probably if we didn't have it on there. It also makes a giant vortex, and that vortex would cause the back end of the airplane to do what they call a Dutch roll. It would be picked up by the vortex and start moving it around, so the outrigger, the vertical fins on the horizontal stabilizer, actually straighten that airflow out so the airplane flies better.

ROSS-NAZZAL: Tell us about how you prepare the vehicle for the pilots to fly their training simulations versus preparing for an actual ferry flight.

KNUTSON: Actually, there isn't a whole lot of difference between what they do normally and what they do on a ferry flight. First off, the airplane flies very similar to a regular 747. The difference in flying it—you should probably talk to a pilot, but from what I understand, because

the weight carried on the roof of the airplane changes your vertical CG of the airplane so that now it acts like an arm up there, you don't want to do very severe turns when you're flying. Otherwise it might carry the airplane over more than normal, so they do very gentle aileron turns. But other than that, apparently it flies very normal to them.

All the pilots have to stay current, of course, and they have to come out and fly the Shuttle carrier, I think, once a month. Everybody has to stay current, so they fly about every two weeks. They used to. I don't know if that's true anymore, but we were pretty busy all the time. The normal maintenance that we did was more similar to what the station for an airline would do. It's not like a heavy maintenance area, although we did what they call a C-check over four years. We did intensive inspections of certain areas on a chronological basis, just one section at a time. Any heavy service bulletins or airworthiness directives that we weren't capable of doing, we would go to a heavy maintenance visit place.

Toward the end we went to Evergreen Air Center [Marana, Arizona]. Before that we'd gone to a place in San Antonio [Texas], Dee Howard [Maintenance Facility]. In the early days of the program, they actually went back to [the] Boeing [Company, Seattle, Washington], but Boeing's cost per hour got too prohibitive and so they farmed it out to bid. Evergreen did the most I think, toward the end. Right now we're pretty much caught up, and hopefully it will time out to the same time as all these Shuttle ferries.

ROSS-NAZZAL: These maintenance plans, were they given to you by Boeing or are these generated by FAA [Federal Aviation Administration]?

KNUTSON: Boeing provides a thing called a Maintenance Planning Data Document, MPDD, and that's the general requirements that they've discovered you should be looking at on the plane. You can set up your own maintenance program to however you want to do it, depending on the usage of your airplane as to what you're going to do and how often you're going to do it, as long as FAA and Boeing agree, and NASA engineering of course.

They're the people that came up with that, and it's basically what they call, like I say, a C-check over a four-year period. There's A-checks and then there's C-checks, and then they call them D-checks in some airplanes, but they're actually a Heavy Maintenance Visit now. An HMV requires you to almost take the whole airplane apart, so it's kind of intensive. I don't think we've actually ever done a full-blown HMV since we've had the airplane because we've flown so few hours on it.

In fact, we're kind of unique in the problems that we had with the airplane. Because of the low usage, we ran into a thing called low-cycle fatigue. That is a condition that happens when you don't utilize your airplane a lot, and you're subject to different kinds of problems that you wouldn't normally see. The desert atmosphere is very hot during the day and cold at night, and in the winter especially it's super cold sometimes.

We wouldn't run the engines for like two weeks. The normal operation of a 747, they hardly ever cool off because their engines are run probably on an average of 12 hours a day. Ours were maybe 50 hours a year sometimes. What would happen is the engines would get so cold that when they would be fired up that they were subject to cracking. We've had a couple combustion chambers cracks happen—I think it was one on each airplane actually. That required taking the engines off and sending them in for repair. We sent one set to Pratt &

Whitney [a United Technologies Corporation company] and the other to Air Canada the times that we've had problems.

Structure of the mod [modification] areas in the airplane that have had problems are relatively few. I think we've only had one actual crack that we can contribute to the weight of the Shuttle on top of the airplane. It was very minor and it was in an area called the stringer. It's on a thing called a hat section, and it was just a small crack, easily repaired. None of the skins, which are a very complicated skin structure—we've never had a problem with any of it.

ROSS-NAZZAL: Tell us about that.

KNUTSON: The structure that supports the Shuttle under the pedestal area in the back and then the diagonal brace that goes forward—the actual weight of the airplane is carried in the skin, and the skin is supported by the two bulkheads inside the airplane. The skins themselves are multiple layers of skin that distribute the weight over a large area, and each of those skins is actually chemically tapered.

It takes up to I think 18 months of dipping to get the right taper to the skin so that you don't have any quick steps between each layer as you build up under the pedestals so that you won't have an area that's susceptible to a crack. It's kind of like the soda-can theory. It's really strong as long as you don't put a dent in it. You can stand on a Coke can and as long as you don't dent it, you're going to be okay. It's that kind of idea.

ROSS-NAZZAL: Are you guys in charge of the struts that we've seen on the plane and putting those out there on the vehicle?

KNUTSON: The struts up to the pedestal that holds the ball are our responsibility, the diagonal braces, the main strut. USA [United Space Alliance] used to take care of the ball-and-pedestal structure. Even though they were on the airplane, we would have to take those off every two years to have them nondestructively tested for cracks and corrosion and things like that.

The only real interface we have with the Shuttle is that we changed AC [alternating current] power to DC [direct current] power. The Shuttle's basically battery-operated, and we would convert the AC power of the airplane to DC through transformer rectifiers located in the back of the airplane. We would provide that power for these ferry flights for circulating the cooling system, which is water basically, and also provide power for the tank heaters because there was still residual propellant in all the tanks. To keep the pressure up in those tanks, they would actually heat them a little bit, and that would keep the valves closed tight. If you look at the Shuttle when it's mated, there's all kinds of plugs in there, and those are added by the USA people to keep everything nice and tight from leaking any hypergolics out of the Shuttle.

ROSS-NAZZAL: Tell us about getting ready for a ferry flight. When would you start preparing, as soon as a launch occurred or were you planning well ahead of that?

KNUTSON: Yes, basically that's about the right scenario for that. After launch we would know the weight of the Shuttle as it was going to land and how much fuel we would have to put onboard, but there was many other things that we had to do personally for our use to keep the airplane in working order for the ferry flight. We would put the ballast on, and then we have what we call flight spares. That basically is our attrition parts needs, fuel pumps and hydraulic

pumps and things like that that we might need on the trip if something failed. All of those items were placed in LD [load device]-3 containers and they had to be weighed so that we knew exactly where our CG was at all times.

We'd carry spare oil and spare hydraulic fluid and tools of course, and items that you wouldn't normally think. A lot of times we'd carry little plastic stanchions and rope to cordon off some area in the airplane for tours if somebody wanted to come in the airplane or if a lot of kids were going to visit the Shuttle. If we were on the road we would cordon off the gear. We carried a lot of ancillary stuff that you wouldn't really think about. Of course you've got to have your vacuum cleaner to clean the carpet and things like that.

ROSS-NAZZAL: This would all go in the Pathfinder? Or it would go in the SCA?

KNUTSON: No, it would go on the airplane. Even though our empty weight was very low on the airplane, we liked to keep all our stuff that we really needed close-by because we didn't want to get separated from it. In the early days they used to carry toolboxes on the Pathfinder, and that didn't work out so well.

ROSS-NAZZAL: What kind of inspections did you have to do before that ferry flight?

KNUTSON: After the previous ferry flight we do most of the inspections related to hauling the Shuttle. That includes close visual inspection of all the structure in the back that has to do with the modification areas to carry the Shuttle, and of course the tires and wheels and brakes were

very important. Those are real stressful areas to us, because we never wanted to change tires on the road. We try to keep tires up really really well on both vehicles, and the brakes.

Back to preparation for the flight itself—we had to coordinate a lot of stuff with United Space Alliance, the people that were doing the actual mating of the Shuttle to the airplane. We had to do power checks of the inverters in the back that provided the power to the Shuttle. We'd do electrical loads checks on those before we hooked them to the Shuttle to make sure they were phased right and nothing had changed and that they were going to work right. We would do close inspections of all the attach points and things like that to make sure that everything was good there. That's normal stuff.

ROSS-NAZZAL: How long does it take you to get ready for a ferry flight, and what are your work hours like?

KNUTSON: Once the Shuttle lands, it would take about a week before we actually were hard-mated and ready to go on the next flight. That wasn't so much because of us, but there's a lot of processing involved. Once the Shuttle lands it's towed under the mate-demate device, and from there the strong back that lifts the Shuttle itself is attached and brought up just so that the gear gets off the ground. They have to fold the gear up and put in all the plugs and take all the experiments off that they can. They can't open the payload bay doors on the ground, so whatever's back there stays there, and we carry the whole package.

The Shuttles vary in weight. A light one, an empty one, is about 175,000 [pounds] and the heaviest one we ever carried was 238,000 and that was LDEF [Long Duration Exposure Facility] that was in the back of the Shuttle. Of course the total weight of the airplane is

constant, so we have to adjust the fuel load to match the Shuttle weight. If we have a heavy Shuttle then we can't put as much fuel on because we can't exceed 700,000 pounds. That limits our length of flight, because you have to have a 45-minute reserve at all times of fuel. That cuts into your fuel capacity too.

Basically our fuel burn rate is 40,000 pounds an hour with the Shuttle on. It's 10,000 pounds with it off because there's so much drag. It's not so much the weight, it's the actual drag of the vehicle. The vehicle is on there at its most optimum least drag. The elevons and flapper arms are put on there to give the least drag possible, but it's still massive. You never see Shuttles doing a horizontal move. They're always coming in at almost 70-degree angles all the time, because if they didn't the weight of the rocket motors would make them lose their center of gravity, so you have to keep it pointed down. That affected us because of the weight of the Shuttles being so far aft we'd have to compensate, like I was telling you earlier.

ROSS-NAZZAL: Do you continue working on the SCA after it's been attached at the MDD [mate-demate device], or are you pretty much done once it goes to the attachment?

KNUTSON: Once it gets attached we have to get everybody's luggage aboard, and their food and stuff that we need along the way. And day-to-day kind of things that you wouldn't really think too much about. We have an interior checklist that we carry to make sure we have enough paper plates and paper dishes and cups and napkins and garbage bags, ice, coolers, things like that. Kind of like going camping.

ROSS-NAZZAL: It sounds like it. How many people from your crew go with the SCA?

KNUTSON: With an active Shuttle, it's just minimum crew allowed on the Shuttle carrier. That's the pilot, co-pilot, flight engineer, and an extra flight engineer who's able to roam the airplane to make sure that nothing's happening structure-wise or anything else that he can see. They all carry Scott Air-Paks [self-contained breathing apparatus], similar to firemen, that are placed in a convenient spot near the cockpit for contingencies.

If there are problems with the Shuttle leaking—we carry a Draeger sniffer, the sniffing device that senses hypergolic leaks that could penetrate the airplane. They're all trained in how to use the breathing equipment in case there's a problem. They don't want to expose but minimum crew to that, so all of us mechanic types went in the Pathfinder ahead of the Shuttle, and we'd be there to marshal the Shuttle carrier in and put it in a good spot that was downwind of anybody on-looking so that it was all safe.

ROSS-NAZZAL: Did the entire maintenance crew go with the SCA?

KNUTSON: Usually everybody. Sometimes we'd send someone ahead, clear out to the Cape [Canaveral, Florida] here to ensure that we had all our equipment lined up. That includes the tug and the tow bar. We have requirements to tie down the nose of the airplane. To do that there's a metal fixture that's attached to a point on the nose gear on each side with massive chains that go down to anchor a spot on the ground.

If something happens in removal of the Shuttle, it doesn't pull the airplane off the ground by accident if something sticks. I think that we've only had one occasion where somebody forgot to undo the nose attach point. We were starting to lift the airplane along with the Shuttle,

but they figured it out right away. It's there to ensure that there's no accidental tipping of the airplane. That's one thing we do as part of our prep when the Shuttle's finally lifted all the way up and we tow under, we tie that nose gear down.

ROSS-NAZZAL: When you land the Pathfinder and you're going to spend the night at an Air Force base, what are your duties associated with the plane?

KNUTSON: Depending on the temperature outside, we need to provide power to the Shuttle. To do that we have to monitor our airplane, so there was somebody always onboard overnight. The requirement is anytime it gets below 60, I believe, so that meant about all the time. We had to keep the airplane powered up overnight, so we would all take shifts of four hours apiece and be there onsite to monitor things, make sure everything was going okay with the Shuttle. Every hour we would log the consumption of power the Shuttle was taking, for reasons I never figured out, but somebody wanted it. Then when we get to a place for a leg of the trip, we'd have to know the fuel load and put the fuel load on. We'd always check oil, and normal stuff that you would do in a quick turn overnight, ensure the tires are still good.

ROSS-NAZZAL: Do you do the same thing when you're just making a pit stop for gas?

KNUTSON: Yes, pretty much. It's real critical as far as the fuel load, because we don't want to exceed what the pilots want. It always changed it seemed, because they'd never know exactly the day before where they were going the next day because we were so dependent upon weather conditions. When we ferried we weren't allowed to go through any moisture at all, so no clouds.

If the Shuttle is impacted by water when it's not coming back from space, when it's cold, there's enough space between the tiles that the water will actually get through the space between the tile and hydraulically push the tile off the airplane. Everybody knows that the tile's real fragile, kind of like eggshells, so we don't want to impact [them with] any hail or anything like that. We actually made circles and turned around and went home on ferry missions because of weather conditions.

ROSS-NAZZAL: Do you remember which flights those were?

KNUTSON: I can't remember right offhand, but it seemed like it was the ones around the early '90s. Probably 1990, something like that.

If it was an average load and it was a summer day, if we took off out of Edwards [Air Force Base, California] early in the morning, we could go to a halfway point and then into the Cape in one day. Because we're going backwards to the sun, our day is shorter. When it's dawn at Edwards it's already eight o'clock here, so our day is already impacted.

If we could get a quick turn in a halfway point—the place that we always had our best turns was at a place called Kelly Air Force Base in San Antonio [Texas]. We could turn around in an hour to get all the fuel on, because we worked really well with those guys. They knew what we wanted and were capable of putting four trucks at once on the airplane if need be, and we'd utilize that capability. We could put a lot of fuel on the airplane in a real hurry. Each truck's probably right around 30 to 35,000 pounds capacity, and we could put all four trucks on at once, so we could put a lot of fuel on if we had to.

However, if we had missions that were like that LDEF one—that was horrible. It wasn't real bad, but it just took a long time because of all the stops we had. We went from Edwards to Davis-Monthan [Air Force Base] in Tucson [Arizona], then we went from Tucson to Biggs [Army Airfield] in El Paso [Texas], then we went from El Paso to Kelly, Kelly to Columbus [Air Force Base] in Mississippi, and then Columbus to Fort Walton Beach [Florida, Eglin Air Force Base], and then into the Cape. Those were all fuel stops because we couldn't put enough fuel on.

ROSS-NAZZAL: How many days did it end up taking you?

KNUTSON: It wasn't so bad day-wise, I think it was only two days. That was LDEF, I think that was like STS-[32].

ROSS-NAZZAL: What were some of your other memorable ferry flights, and how many have you done since you've been here?

KNUTSON: I'm trying to recollect. I think I've done probably 40 of them, somewhere in that neighborhood, between [SCA] 911 and [SCA] 905. 911 came along in '89 I think it was. We picked up the second airplane for a couple reasons. They realized that if we had a failure of the 905 for some reason, it would impact the Shuttle program by 18 months because of those skin issues, making those skins. So they went ahead and got the second airplane. I think they started that in probably '86, and then it finally came to fruition in '89. I think the first flight was '90, I think we moved *Endeavour* on its first flight from Palmdale [California] to here when it was brand new.

ROSS-NAZZAL: Were you on that flight?

KNUTSON: Yes. Actually, I was on the airplane too.

ROSS-NAZZAL: That's right, because it was inert, right?

KNUTSON: Yes, it was inert then.

ROSS-NAZZAL: Tell us about some of those stops.

KNUTSON: Those were pretty exciting times. There was a big crowd there I remember when we rolled it out of the Palmdale Site 1 at Rockwell [International].

The device that we used to attach *Endeavour* is actually the device that used to be at the Vandenberg Air Force Base [California]. They were going to have Shuttle launches and Shuttle ferries running out of there at one time, but because of the SALT [Strategic Arms Limitation Talks] treaty we agreed not to do launches from Vandenberg, so all that stuff went away. Except the device was still there, and it turned out to be somewhat portable. They took it apart from Vandenberg and hauled it up the mountain to our place in Palmdale, which is about 100, 120 miles, and reassembled it up there. That was there up until last year, and they unfortunately destroyed it all, cut it up. They could probably use it right now on this mission [ferrying *Discovery* to the Smithsonian National Air and Space Museum in Chantilly, Virginia].

Anyway, there was a lot of dignitaries there, a lot of astronauts. It was a pretty good time. Unfortunately I came after the [1983] Paris Air Show. My fellow guys that I worked with told me all about the Paris Air Show, and that was quite something I guess. They went to St. Louis [Missouri] and Montreal [Canada], and then it went to Reykjavik in Iceland. Then it must have been in England and then into Frankfurt [Germany] and then into Paris on that trip. That was quite a trip.

One of the pilots onboard at that time was [Francis R.] “Dick” Scobee that flew the Shuttle carrier. He had done his homework and figured out that it was possible to fly the 747 through the St. Louis Arch with 20 feet of clearance on each side. He was going to attempt it. He was asking permission to do that feat, but of course they said no. He really wanted to do it. He was that kind of guy, you know. He was a good pilot, I understand.

When they got to Montreal they were enthralled, big crowds and a lot of dignitaries wanted tours. They were supposed to leave just after dawn, and they never left till eleven o’clock or something in the morning. They had to make the long haul from Montreal to Reykjavik, so they had a full load of gas. Everybody and their neighbor came out at the end of the runway to say bon voyage. They’re rolling down the runway, and they’re going, “Oh my god, the temperature is high,” and they just broke ground at the end of the runway and went right over that crowd by just a couple hundred feet at the most. That was very thrilling, I guess, for the people on the ground. Those are kind of cool memories.

ROSS-NAZZAL: And you got to fly the Pathfinder with *Discovery* when she came back from STS-26. Was there a lot of interest in that ferry flight?

KNUTSON: Oh yes. Return to flight was a big deal. The early ferry flights, there seemed to be a lot more public interest. And that one was a pretty spectacular memory. The politics were different back then too, as far as letting crowds near the airplane. They weren't so security-conscious. Even though they were at a base, they did let people get close enough to get a pretty good view. After 9/11 [September 11, 2001 terrorist attacks], things changed, and we were way off in the distance a lot of times, but there's always been big crowds.

ROSS-NAZZAL: When you got 911, now you suddenly had two SCAs. Did you have a lot more work as a result?

KNUTSON: Oh, yes. 911 basically was a JAL [Japan Airlines] commuter airplane, and myself and my cohort John Goleno and a guy named Jerry McQuarter [phonetic] were tasked with stripping that airplane, strip it as identical to 905 as we could. But they didn't really have a plan, they just said, "Well, you guys figure it out."

So we took Polaroids—at the time that was the big deal—of every section of the airplane in increments on both sides of 905. Then we went over to 911 and started taking parts off the airplane. Take the stow bins out, take the seats out, take the sidewalls off, take the wiring that wasn't needed for the actual airplane, entertainment stuff in your seats and stuff that gives you your tunes and speakers. We took all of that out and, "Yes, that looks about right." We just kept going down the whole airplane.

They didn't want to ever have 911 and 905 together because there was always a risk of a terrorist threat or something. The original idea was 911 was going to be stationed in El Paso, Texas [Biggs Army Airfield] and run by the group there, but it didn't work out so well because

they didn't have any 747 experience and it's kind of a complicated airplane. Not to say that you have to be super special to work on a 747, but it is probably one of the most complicated airplanes around. Even now, airplanes are built to be more conducive to maintenance. Back then it was just make sure that we can fly this thing safely, but now that they've got more experience under their belt—the [Boeing] 787 will tell you what's wrong with it. You don't even have to try to figure something out.

We'd spend two weeks at a time in El Paso, and we took all the seats out. We had a method down for taking the seats out. We'd pop them out and then we'd turn them over, shake them this way and shake them the other way, and all these little yen would fall out. We must have got about 10 million soy sauce packets. Then finally we got to the upper deck seats, and when we shook those we finally got some cash out of it. My friend John found a pair of diamond earrings, and I found a gold lighter. Finally we got a tip out of the deal. And we got a really nice letter. We'd saved them about \$950,000 from what Boeing wanted.

ROSS-NAZZAL: Did you go out to Wichita [Kansas], where they were doing the changes to the vehicle?

KNUTSON: I didn't get to go on that trip, but I was there when we took delivery of it. John Goleno and Pete Siedl were mainly the ones involved in going to Wichita. There wasn't really a whole lot that we could do other than advise or tell them our experiences from 905. They're pretty much identical, except that 911 actually can carry more weight than 905. We can carry up to 250,000 pounds on 911, and 905 we're limited to 225,000.

ROSS-NAZZAL: Why is that?

KNUTSON: Structural differences and gear differences. The gear on 911, because it was used as a commuter airplane, it's actually a 747-SR-46. It's called short range, SR-46. What that gives you is a beefed-up gear system compared to a normal 100 Model like we have on 905. And it has taller tires, one-inch different-size wheels than 905, which has 16s. The 911 has 17s. That gives you more weight-carrying capability, landing capability.

The total gross weight of either airplane is about the same, 700,000. We don't want to exceed that. The empty weight of 911 is 323,000, and the empty weight of 905 I think is 318. That's always a good number to know, because you have to add the Shuttle weight and then you add the fuel weight, and that's the weight that you don't want to exceed at the end. You want to be under 700,000.

ROSS-NAZZAL: Do you guys have names for the planes? They're referred to by their tail numbers.

KNUTSON: No no, we never got into that kind of idea. There was a guard on the airplane. 905 had an armed guard on the airplane 24 hours a day because it was a single-source asset. That's another reason we got 911, to take some of the pressure off the security issue of the airplane. She thought that airplane was hers, she used to call it "the lady." "How's my lady, today?" she used to say. That was kind of funny.

ROSS-NAZZAL: So she had that guard from '77 until you had 911 delivered?

KNUTSON: Yes. Well not the same guard, but there was a guard group. She was active there for four or five years I think.

ROSS-NAZZAL: Interesting. Tell us about how many people go on the Pathfinder that you were on. Obviously your crew, and I understand people who were Shuttle folks and DoD [Department of Defense].

KNUTSON: Right. The Pathfinder road crew started out reasonably small, was basically our little group of guys that maintained the airplane. We had USA people onboard that would be there to set up purge equipment if needed or heaters. Sometimes they needed to fix tile or something as we were flying because we inadvertently hit a bird or whatever. We used to carry a safety guy that would make sure that it was safe to be around the vehicle, and then one weather person and a move crew director.

Over the years that changed into two weather guys, because they needed a guy to be able to be relieved for rest. It was too much duty he was getting, because he'd have to stay up half the night checking weather to make sure where we were going the next day. So it became two guys, and then it became three weathermen, and then it was four weathermen there for a while.

Then the move director wasn't enough, they had to have an orbiter executive. He was always an astronaut it seemed like. He wanted to go on the trip. It seemed like there was more and more and more people going. It started out at maybe 15, and then it got up to about 40 toward at the end. There are safety issues, and it did make things easier sometimes, but at the

same time it made it hard for us logistically. They were always kind of in our way. The idea is to quick turn the airplane, and then you want to start doing other kinds of maintenance.

You have to feed all these people, and that made it rough for whoever was doing that part of the mission. You get somewhere and you're tired, you've been on the airplane, you want something to eat. We would immediately jump off the airplane, get to the point where we were going to marshal the airplane in, and then we were the last ones back on because we wanted to make sure that the airplane got started and everything was going to go good with that part. Then we'd come back, "Where's our lunch?"

"Oh, we forgot you guys." That happened a couple times. We were the first ones there and the last ones to leave most of the time on any given day, so there was a lot of hours involved.

ROSS-NAZZAL: Sounds like it. Once you got back to KSC [Kennedy Space Center], would you take the SCA back immediately to California or would you hang out here for a while?

KNUTSON: No, we would bring the Shuttle in and park here until they were ready for us to tow under, then we would tow under and we'd finally get some rest. Usually we'd been up 20-hour, 30-hour day sometimes. We'd go to Cocoa Beach [Florida] and get some rest, and they would invariably call us too soon because they thought it was ready to come off.

It was in their book for the process. It would say call SCA crew after this particular point, and it was way too early because by the time we'd get here we'd have to spend another four hours just standing there waiting to watch this thing. Is it moving, is it moving, is it moving? Then finally it would get off. We'd have to tow it back, and then we'd get some sleep.

We'd have to come back the next possible time, because we had to arrange for fuel at a time that was convenient to the fuelers here. If we got home at midnight and they wanted to fuel at dawn, then we'd be back at dawn to fuel. That is quite an operation. On our flight back we usually take four 7,000-gallon tankers, but they only have two available, so once they offloaded the two 7,000-gallon-apiece tankers they'd have to go clear to the other side of the Cape to get another 7,000 gallons each. It was pretty much an all-day operation to get fuel onboard the airplane, as compared to going to a military base and they had four trucks ready.

Then we'd get to have some time off for maybe a day, but normally we just turned around and went back home. We made the most we could out of it; we enjoyed it here. There's a lot of stuff after we take the orbiter off that we have to do to prepare for the trip home. There's some support structure for the bipod on the front that has to be reattached to hold that structure up, some kind of diagonal brace things that come off it, and then we have to lower the pressure in the tires. We run at max [maximum] tire pressure with the Shuttle on because it's the heaviest weight, but it's not very conducive to tire life. If you don't let the air back out of the tires, it wears all the tire out in the middle real quick, so we have to let half the air out. That takes a long time. And it's not air, it's nitrogen actually.

Then there's some devices in the airplane that we have to change. When we ferry we use a different set of electrical limits on the horizontal stabilizer capability, so we have two sets of switches that have to be activated when we ferry and when we're not ferrying. You've got to flip the switch back and forth. That's not such a big deal, but there's an indicator, which we call an eyebrow, that gives you the readout of where your stabilizer is on the airplane, and you have to change that out. We service the bathroom and everything else like you normally do, and we

have to go buy food for the long drive home. The pilots and everybody else are off having a good time most of the time, and, “Hey, could you get us some food too?”

“Yes, sure.”

“Here’s a few bucks, go ahead.” That’s how that operates.

ROSS-NAZZAL: Can you make it home in one leg?

KNUTSON: Oh yes. We’re limited, with or without the Shuttle on, to 250 knots, which is like .6 Mach. A regular 747, they do like 550 and .92 Mach. We’re also limited in altitude. We can never go above 26.5 because of the structure. We don’t want to build a big pressure differential between the inside and the outside of the airplane because the added skin structure makes the airplane less expandable. It’s stiffer, it’s not as balloon-like. A regular airplane actually grows and breathes a little bit.

That dome in the back, it’s dome-shaped for a reason. That’s there to flex so that it absorbs the pressure changes in the airplane and relieves the assault on your eardrums. It takes the beating instead of your ears. Otherwise, if it was flat, your ears would be going like this [demonstrates], oscillating back and forth because of the pressure changes. It would be worse anyway. I don’t know if you’ve ridden any Lockheed [Corporation] airplanes. Old Lockheed airplanes had flat bulkheads in them, and they’re hard on your ears.

Normally it would take six hours, seven hours back. I think that’s what it was the other day coming here. It wasn’t bad. It’s slow, but it gets there.

ROSS-NAZZAL: For a while in the '90s they were bringing the orbiters back to Palmdale. Was it unique doing the ferry from this side?

KNUTSON: Yes, that was a lot better actually. Then we could ride onboard, for one thing, because they were all inert. The OMS [orbital maneuvering system] pods were left here and the engines were here, so the Shuttles were very light then. With the material missing off the Shuttles, other than the Shuttle itself, it gave us the opportunity to go different places than normal.

One of the places that we went to out of the ordinary by request was we did a flyby in Corpus Christi [Texas]. A lot of senators and congressmen like to have us, if possible, pass by their constituency to see where the money's going, so we did a stop in Corpus Christi. That was one of the most beautiful flybys I've ever seen. The Pathfinder had landed, and we had gotten out of the airplane. You could see the Shuttle carrier with the Shuttle on top coming, and he was actually pretty low. He was like 300 feet, but he was going at full speed. He went down the runway at full speed with the orbiter on, and it was just unbelievable. Everybody thought that was pretty cool.

Another time we went into El Paso in the middle of their air show when the Blue Angels were there. The crowd was supposed to be in awe of the Blue Angels and then we show up in the middle of their air show, and they were absolutely mad at us because we'd stolen their show. We'd landed because we needed some gas and we had to stop, so I think that kind of ruined that.

Senator [Edwin J. "Jake"] Garn in Salt Lake [City, Utah] wanted us to come by. We were eight hours late because we were using a C-5 for a Pathfinder, and we had to change airplanes because it had broken in Dallas-Fort Worth [Naval Air Station Joint Reserve Base Fort

Worth, Texas]. So we showed up eight hours late, and I happened to be on the Shuttle carrier at the time. I'm looking out and it's about dusk, all these sparkles, and I'm thinking, "Boy, I don't remember all this water in Salt Lake." It was flashbulbs and flashes from cameras, thousands of them, and people had actually stopped the freeway. They were out of their cars on the freeway looking at this thing coming in. That was crazy. Those are interesting times for sure.

ROSS-NAZZAL: You've had some interesting pilots and flight engineers on that plane. Would you tell us about your relationship with them?

KNUTSON: Competency-wise, an unbelievable group of good pilots. They're kind of competitive—Air Force-Navy thing going on—and it all makes for really good piloting. But there's some stories that after work they're a different breed, some of them.

Unbelievable some of the landings that I've had. My buddy John and I were riding 905 and we were going into Palmdale, I think. We were both kind of asleep in the seat and, "Did you hear that? What's that noise?" It hit so light that we didn't even hardly wake up. Bump bump, bump bump, bump bump, bump bump. It was the pavement that was making noise as we were rolling down the pavement. We hadn't even heard, it was so smooth, such a landing. That was A.J. [Arda J.] Roy. He was good. Unfortunately, he passed.

Oh man, and Dave [David H.] Finney. Dave Finney was a great pilot, and he was Navy too. Not that I'm partial to Navy or anything, because I was never in the armed services. I came from Boeing. I used to work at the factory at Everett [Washington], and then I wanted to work for the Shuttle carriers. I had given them a résumé a long time ago, and it just never worked out

that they needed anybody. Then one time they called, and I didn't want to leave Boeing. It all finally worked out about 1987, I finally went down to the desert.

ROSS-NAZZAL: That's quite a change from western Washington.

KNUTSON: Yes. I grew up in Spokane [Washington], but I'd lived in western Washington. When they called me I was actually living back in Spokane. I'd gotten laid off from Boeing, and I was working for a little airline called Cascade [Airways], which was being put out of business by Horizon Air [Industries, Inc.] at the time because we were too stubborn to get onto some computer link that everybody else was using. We would come up on the last page of anybody buying a ticket, so they finally ate their lunch and put us out of business.

I had got laid off at Boeing, went to work for the airline, and then the airline was starting to fold. One of the perks that I got for getting laid off as a union guy was that I could still ride the airline for a year. I got my job back at Boeing about that time, and I was flying on the airline that had laid me off back to Boeing, using it as a commuter 300 miles clear across the state.

I had a really nice house in Spokane, and I thought I'd end up trying to find another job someplace in Spokane, but it was really hard. Then my wife was really getting tired of me doing the commute to Seattle [Washington]. I had a really good job at Boeing at the time, I was working in maintenance and ground operations systems. I was a mechanic on the flight line for a number of years in preflight and delivery of 747s, then when they recalled me I went back in the same job.

I ran into a guy wearing a suit one day, that happened to be a mechanic that I had worked with, and I asked him, "Where are you working these days?"

He said, "Oh, I'm working maintenance and ground operations systems."

"What are you doing?"

"I write task cards and stuff. We need somebody else too."

I said, "Well okay, I'll give them a résumé."

One of the things was the stipulation that you had to have a degree besides your A&P [airframe and powerplant mechanics] license. I said, "I have half a degree, and if you're willing, I'll get the rest of it if you hire me."

They said, "Okay, maybe we can do that." So they did. I ended up working out okay, and they were still kind of pressing me for the degree.

I'm going, "Okay okay, I'll get to it."

At the same time, my wife's telling me, "I'm getting tired of you living over in Seattle, and we're here."

So I finally made the decision, I'll just have to quit because my family comes first, and we had such a nice house there set up.

I went in to tell my boss that I was going to quit, and he said, "I'm glad you're here, I wanted to talk to you about your job. We've been asking you to get your engineering degree of some kind, and we decided that we'd just let you go to school on the clock."

I'm going, "I wish you hadn't said that, because I'm here to tell you that I'm giving you my two weeks' notice."

He said, "Are you sure?"

I said, "Yes, it's too much for the family." They didn't want to move back to Seattle because it rains there all the time. Spokane's pretty nice.

So I end up back in Spokane, and then I don't have a job. I end up at Fairchild Air Force Base working on KC-135s, [Boeing] 707, and that was working out really well.

Then Pete Siedl called me finally and says, "Hey Arv, you want to come down?" So I talked to the wife, and she said, "Okay, I guess we'll pick up sticks and move down there." We did, and she's hated it ever since. No, she's gotten used to it. We've bought this other place down in Fallbrook [California], which is just north of San Diego [California]. It's avocados and orange trees, it's really nice. She'll be happy there. Now if we can get my kids out of it, it'll be okay.

ROSS-NAZZAL: Do you have any questions [Rebecca]?

WRIGHT: I do want to ask you a couple things, about any kind of interference with debris along the way. Did you pick up birds or other things?

KNUTSON: Oh yes, we have. We've actually had stuff fall off the orbiter. One of those plugs wasn't attached properly. It's a six-inch dish-looking thing, and it went through the horizontal stabilizer leading edge. If you look at the plane right along the front, it went in just like a Frisbee through peanut butter. It tore right into the airplane. That was the first stop too, and we were going, "Oh my god, what are we going to do?" We pulled it out as best we could, and then we just put this what they call speed tape on there. It's heavy aluminum tape, and it held up all the way to Florida. We had put it on there in such a way that it actually stuck the whole way.

Birds—we hit a bird coming out of Houston one time. That must have been an inert Shuttle because I was riding on it. It was another one of those occasions where, "Thank god

we're off the ground. I'm so tired. I need to rest," so I plopped down in the seat. We were about 2,000 feet in the air, and somebody had forgot to open the outflow valves, which are the devices that control the pressurization in the airplane. All of a sudden, they opened them. It went from manual to automatic on a switch. They turned it on, and the pressure differential was so quick that it dropped the masks on the airplane.

At the same time, just a couple seconds later, ka-bang! We hit a buzzard, a big one of these birds out here, and it hit right next to where I was sitting in the airplane, right below the window. I about had a heart attack. I thought we were getting shot at or something. I didn't know what was going on. It just scared the daylights out of me.

There was a mission before I got there. They were using a [Lockheed] C-130 [Hercules] for a Pathfinder, and that was probably in the first 20 missions. Joe [Joseph S.] Algranti was flying. He was the Aircraft Operations Division director at Houston. He also was a pilot, and he was flying the Shuttle carrier. Because the C-130 was so slow, he actually passed the Pathfinder and got into some hail just before we landed here.

When the Shuttle carrier lands, they're looking up at the Shuttle and it looks like there's snow on the Shuttle around the front of the nose. The impact of the hail on the tile had eroded all the black stuff off and made this big ring. They had to change all the tile on the front of the nose there, must have been 30 of them. He had to go talk to whoever was in charge up in Washington after that, almost lost his job.

WRIGHT: You mentioned Pathfinder, and most of the planes that you mentioned, they're not comfort planes.

KNUTSON: No, let's see. What do we use for Pathfinders? Most of the time they're military planes. We've used a lot of [Lockheed C]-141 [Starlifter] transports. We've used KC-135s. We've used NASA airplanes, which aren't real bad. The zero-G airplane, airplanes that we used to have, and now we're getting to use the [McDonnell Douglas] DC-9 this next time.

One time we actually got to ride on a G-II [Grumman Gulfstream II], just a small group of us because they left the purge and USA people back with the broken airplane while we went ahead on another airplane, a Shuttle trainer G-II. We actually rode in a G-I one time, the old NASA one. That's really nice, I like that airplane. Old propeller-driven, but it's plush. I don't know if you ever get a chance to go in it, but it's a nice airplane, quiet too.

WRIGHT: I've just got a couple more. Other than the number of flights that got changed because KSC became the primary landing site, were there a lot of other changes that were made during that time period with what you were having to do because you were having less flights?

KNUTSON: Yes, we'd always prepare. No matter where it landed, we would still prepare like we were going to fly—short of putting all the ballast on and the weights, but normally we've got it down so that we knew what we could carry with any load. We'd always carry our tow bar onboard and we'd always carry a spare brake and things like that. We always kind of hoped that we would get a ferry mission, of course.

The early days we ferried almost all of them, before they had enough confidence in the inertial nav [navigation] systems on the Shuttle and GPS [global positioning system]. Actually the reason they chose Edwards for a landing site was the fact that if all else failed, you could still

see Edwards for a place to land from space. It's kind of interesting, the progression. Now, heaven forbid, they could all be dead on there and it'd still land by itself probably.

WRIGHT: The last one has to do with that ballast. When you got somewhere and you were flying back, did you leave that pea gravel somewhere or did you bring it back?

KNUTSON: No, we could actually adjust for it. It just made the airplane more nose-heavy than normal. You can adjust the horizontal stabilizer to pick the nose up more, but it makes more drag on the airplane. A normal 747 at high altitude, in a nice trimmed normal airplane, only burns like 5,000 pounds of fuel in an hour, but when it gets up to where we are—I work on SOFIA [Stratospheric Observatory for Infrared Astronomy] now, and once we get to altitude we hardly burn any fuel, really. It just kind of floats along, plus you don't have as much drag on the airplane.

Anything above 35,000 feet, you're 1/100th of the atmosphere you have down here. So there's hardly any drag on the plane. As long as you can keep the engines running, compress enough available air into the motor to keep it running, you can get phenomenal mileage. In fact, we go as high as 47,000 feet with the SOFIA, because we want to get as much water vapor out of the picture of what we're taking when we're flying the telescope.

WRIGHT: Yes, it's pretty neat.

ROSS-NAZZAL: It's fascinating. Thank you very much for your time, unless there's anything else you'd like to add.

KNUTSON: We had a really good group of guys at one time, and over the years toward the end here, it's not as good as it used to be it seems. It seems like there's not as much pride in what you were doing as there used to be. That's just me and my personal thing, but attitudes change. I was just thrilled to be part of this, and these guys it's like, "It's a job. Make sure I get my overtime in here on my sheet," kind of thing.

WRIGHT: That was a great experience, and sounds like you're going to have more with SOFIA.

KNUTSON: Yes, I like SOFIA too. I like the position I have there. Now I'm an engineering tech [technician], and what I do is troubleshoot the problems that they're having on the plane, plus help all the younger guys understand the airplane. It's kind of complicated, and I write the maintenance manual and a lot of different things. I have a good boss too. I couldn't believe he let me go on this trip.

ROSS-NAZZAL: Are you going to get to move the *Endeavour* when she leaves to go to California [California Science Center, Los Angeles]?

KNUTSON: I don't know about that. We'll see how this one goes. I'm supposed to be doing my maintenance manual and doing this at the same time.

ROSS-NAZZAL: Are you also helping with *Enterprise* [ferry trip from Washington, D.C. to the Intrepid Sea, Air & Space Museum in New York City]?

KNUTSON: Yes, I'm going to do all this leg here. It was supposed to be only 21 days originally they said, and I hear it's like 41 days. I don't know what the boss is going to say about that, but oh well. Thankfully we're down right now with the SOFIA because they're changing the cockpit out to a modern glass cockpit like the Shuttle, so they get all their new toys to play with and all the problems we're going to have figuring it out. That will be cool.

That program, they're talking at least 20 years with that, and if we get some new engines along the way it could last a long time. We're doing really good science. The beauty of SOFIA is that if you have an occurrence going on in space like an eclipse between some planets, you can be at the spot where it's going to happen with the telescope. That affords you views that nobody else can ever get, because an eclipse happening over the top of a telescope is about impossible, but if you're right there you can plot where it's going to be. All these whiz-kid computer guys can figure out we can be in the shadow of this thing for two or three minutes if we get to New Guinea, so that's what they're going to do. We did one this summer, and all of the astronomy magazines are going crazy over this idea.

We actually had a planet blot out an area during this eclipse that you could see way deep where they couldn't see before because of the normal light that was interfering with what we were going to look at, so they got some really deep space pictures. It's a lot like Hubble [Space Telescope] only in a lot of ways better because it comes back and you can service it. The other thing is it doesn't cost as much, and then you have that added thing of being able to get around someplace.

WRIGHT: Do you think the 911's going to be able to handle that?

KNUTSON: Well, 911 is just going to be our parts bird, stuff we can glean off of it. We actually bought another airplane that's an SP, just for parts. We got a really good deal on it at Evergreen when they were going to demolish it, so we have a lot of spares off of that, and then we'll get a lot of spares off 911. We're always kind of shopping around.

We're looking at airborne laser. Airborne laser was the experiment they were doing shooting missiles down with another 747-400. Brand-new airplane, 90 hours on it, got brand-new engines on it, and they're going to mothball that airplane. The reason they're not going to utilize it is because they've contaminated this airplane because it had all these chemicals in it, and they just don't want to take the blame. It's household chemicals like chlorine bleach and something else that fires the laser. But they've proved the concept, and that was all it was, just a proof concept vehicle. \$400 million or whatever it was to prove that they could shoot a missile down with an airplane with a laser.

WRIGHT: At least it provides you good stuff.

KNUTSON: I guess, I hope we get the engines off of it. They're different kinds of engines, and it'll cost a lot of money for us to mod the airplane to get them to work, but it might work.

[End of interview]