NASA STS RECORDATION ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

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These are written answers to questions provided by Donald L. McCormack for the NASA STS Recordation Oral History Project.

ROSS-NAZZAL: Please give us a brief overview of your career with NASA.

MCCORMACK: I started my career supporting the Space Shuttle Program (SSP) with Rockwell International in 1984. I was an Orbiter thermal control system (TCS) engineer, and our primary responsibility was to work with mission planning and operations personnel to develop Orbiter attitudes and durations that were thermally acceptable for the Orbiter structure and its systems. We would also provide real-time mission support. In 1991, I left Rockwell and joined NASA in what was then called the Orbiter and GFE (Government Furnished Equipment) Projects Office as a Mission Evaluation Room (MER) manager. The MER provides engineering support to the flight control team during Space Shuttle missions. I worked as a MER manager for about twelve years and supported fifty flights as a MER manager. Following the *Columbia* accident (STS-107), I moved to the SSP Flight Operations and Integration Office where I served as the Deputy Manager from 2004 through 2008. In 2008, I was moved to my current job in what is now called the Orbiter Project Office where I am the associate manager. Back in 2000, I was assigned the task of Ferry Operations manager and have maintained that task to this day. I have led the planning of thirty-five ferry missions and the execution of ten.

ROSS-NAZZAL: Describe for us how an Orbiter is prepared to be ferried from Edwards Air Force Base, California, to Kennedy Space Center (KSC), Florida. How many people are involved in the preparation? How long does it take to prepare the Orbiter before it is placed in the mate/demate device? When is the tail cone placed on the Orbiter? Why is it attached to the Orbiter? What is the most challenging aspect of preparation?

MCCORMACK: Following a landing at the Edwards Air Force Base, once the convoy operations are completed on the runway, the Orbiter is towed to what is referred to as Shuttle Area A at the Dryden Flight Research Center, which is located at Edwards. Upon arrival, the Orbiter is towed into and "spotted" in the mate/demate device (MDD). What then begins is a planned seven day period of preparations for the ferry mission, which we refer to as a turnaround operation. Note that in addition to being outfitted with the equipment needed to mate the Orbiter to the Shuttle Carrier Aircraft (SCA), the MDD provides platforms from which work to prepare the Orbiter for ferry can be performed.

The "big operations" that are performed during turnaround are Space Shuttle main engine (SSME) drying which consists of a dry nitrogen purge of the SSMEs to remover moisture; power reactant and stowage distribution system (PRSD) off-load to remove the cryogenic oxygen and hydrogen from the PRSD tanks as well as fuel cell purging; de-stowing the crew module to remove middeck payloads, the extravehicular mobility units (EMUs), and various other equipment; installing mechanical locks on the SSMEs and the elevon flight control surfaces to lock them into the position required for ferry; draining a small quantity of propellant from the orbital maneuvering engine (OME) ball valves to prevent seal deterioration; tail cone installation

for the reduction of aerodynamic drag; and finally, raising the Orbiter to then be lowered into position for mating to the SCA.

Since we no longer plan to land at Edwards, the team there for landing consists of only thirty or so people. Those folks perform the convoy operations and the initial turnaround operations, which include establishing purge and cooling to the vehicle, towing the vehicle to the MDD where it is jacked and leveled in addition to performing some initial operations to safe the Orbiter. In the meantime, a larger turnaround team is deployed from the Kennedy Space Center and typically arrives about twenty-four hours after landing. This deployment brings the total turnaround team size to about 150 people to support an around-the-clock operation. The turnaround plan shows that the effort will take seven days barring any delays due to weather or technical difficulties. Typically the Orbiter is mated to the SCA and ready to be ferried within seven to nine days of landing.

There are several operations that can be challenging but the most consistently challenging operation in preparing the Orbiter for ferry is the installation of the tail cone. It's a large structure that's attached to the Orbiter's base heat shield at eight attach points. Moving the tail cone into position and aligning it for attachment is very challenging. This operation typically takes two to three shifts to complete. Installation of the tail cone is one of the last operations performed prior to the actual mating of the Orbiter to the SCA. The operation typically begins about five days after landing. The purpose of the tail cone is to improve the aerodynamic performance of the mated vehicle.

ROSS-NAZZAL: Walk us through the process of attaching the Orbiter to the SCA. How is attached? How long does that process take? Does the process differ based on which Orbiter is placed on top of the SCA? If so, how?

MCCORMACK: As its name implies, an Orbiter can be mated to or demated from an SCA in the MDD. The MDD has a cantilevered structure that is equipped with a moveable frame, called a sling, that attaches the Orbiter at four locations. Those four locations, two forward and two aft on the sides of the Orbiter's mid fuselage, are the same four locations used to lift the Orbiter when it is mated to the ET (External Tank) in the VAB (Vehicle Assembly Building). The sling is attached to three hoists that act in unison to lift, or lower, the Orbiter. The sling is attached to the Orbiter early during the turnaround operation and remains attached until it is removed after the orbiter is mated to the SCA.

Once the Orbiter is ready to be mated it is raised about fifty feet and the SCA is towed into the MDD. The Orbiter is then slowly lowered onto the SCA and two large aft attach bolts are installed and the forward attach fitting is mated. Note that the three attach locations, two aft and one forward, are the same three locations used when the Orbiter is mated to the ET for launch. The mate process typically takes about twelve hours, and the process is the same for each Orbiter in the fleet.

ROSS-NAZZAL: Please describe the flight readiness review process, once the SCA and Orbiter have been mated. How long does an FRR take? Who is at an FRR?

MCCORMACK: One to two days prior to the initiation of a ferry mission a ferry flight readiness review (FRR) is held at Dryden and supported by teleconference from KSC and JSC (Johnson Space Center, Houston, Texas). The review is chaired, from Dryden or KSC, by the manager, Launch Integration who is ultimately responsible for ferry operations. The key players on the review board are representatives from KSC Shuttle Processing, United Space Alliance Ground Operations, JSC Aircraft Operations (SCA flight crew), JSC Orbiter Project Office, Human Space Flight Support Office (Department of Defense personnel), JSC Flight Operations and Integration (payload), JSC Safety and Mission Assurance, and the Ferry Operations manager. The review typically takes one to two hours.

The objective of the review is to determine the flight readiness of the SCA and the Orbiter, the flight readiness of the Pathfinder aircraft, the readiness of the ferry flight support equipment, the readiness of the ferry flight personnel (flight crews, aircraft maintenance personnel, Orbiter support personnel, Department of Defense support personnel), and the readiness of en-route support bases. During that review we also look at the planned route and take an initial look at the weather forecast.

ROSS-NAZZAL: What are the key considerations that are made before a flight is scheduled? Is the flight path the same every time or are adjustments made as weather or other issues are encountered?

MCCORMACK: I'd say the primary consideration is the determination that the aircraft and support equipment, the ferry flight personnel, and the en-route support bases are ready to support the mission. This, of course, is formally done during the ferry FRR. So, we review the issues

that may have arose during the turnaround period and ensure that the team is comfortable with the resolutions of those issues.

Another key consideration is the flight plan. There are about twenty military bases that are trained to support ferry operations. These bases are primarily located across the southern third of the U.S., so the flight path is always in that region of the country. In the planning phase of a mission, the selection of the bases we will use is primarily based on SCA performance. That is, what route makes the most sense from an efficiency standpoint given the capability of the SCA for the given Orbiter and the time of year. Occasionally we will select a route that will allow for a special event, such as a flyover or to perhaps utilize a base that we have not used in a long time.

With all that said, the ferry operation is extremely dependent on the weather. Therefore, the weather ALWAYS drives when we fly and the route that we take. The Orbiter absolutely cannot be flown through rain. Significant Thermal Protection System (tile) damage can occur with only brief flight through rain, even light rain. In addition, we work very hard to try to avoid rain when on the ground at a stopover. Our rules allow for light rain, but I prefer encountering no rain en route. The vehicle does leak, and water in the vehicle upon arrival at KSC drives additional work. Obviously, severe weather, for example lightning and hail in a thunderstorm, could damage the Orbiter on the ground and needs to be avoided.

Other constraints we manage are the ambient temperature and pressure that the Orbiter can be operated in during flight. The minimum temperature is 15 degrees Fahrenheit and the minimum pressure is 8 psia (pound-force per square inch absolute). These limits result in the flight altitude generally being in the range of 11,000 to 16,000 feet depending on the time of the year.

So, once we complete the ferry FRR and a go is given to ferry, we select a day that we can start the mission based on the weather forecast. Before every flight leg of the mission, a weather briefing is conducted to determine if the flight can proceed.

ROSS-NAZZAL: How many pilots and flight engineers typically fly onboard the SCA? Is there room for others or is the team limited by the weight of the Orbiter?

MCCORMACK: On end-of-mission ferry flights, there are two pilots and two flight engineers onboard the SCA. That is, essential personnel only. There's certainly room for others and weight is not the reason that we limit the number of people in the SCA. When an Orbiter is ferried following a spaceflight, there are still hazardous fluids on board during the ferry to KSC. Although unlikely, there's certainly the potential that a leak could develop creating a hazardous environment around the SCA. Exposing nonessential personnel to that hazard is not acceptable. Each member of the SCA crew is trained to use and equipped with a portable breathing apparatus so that they can safely depart the SCA following landing in the event of a leak.

ROSS-NAZZAL: Will the weight of the Orbiter vary by mission and what the crew has brought back from space? What complications, if any, does this pose for the return flight?

MCCORMACK: Yes, the weight of the Orbiter varies by mission primarily by what is returned in the Orbiter's payload bay. For example, if the mission delivered a large ISS (International Space Station) module or a large satellite, the Orbiter would return with essentially an empty payload bay and the ferry weight of the Orbiter would be on-the-order-of 195,000 to 205,000 pounds. If

the mission had a Spacelab module in the payload bay or an MPLM (Multi-Purpose Logistics Module), the ferry weight would be on-the-order-of 220,000 to 230,000 pounds. The heaviest Orbiter that we've ferried was *Discovery* after the STS-114 mission, which had an MPLM in the payload bay, and that vehicle weighed almost 228,000 pounds. So, all of the end-of-mission ferry flights can be bounded by a weight range of about 195,000 to 230,000 pounds.

It should also be noted that when the Orbiters were initially delivered to KSC or were ferried to Palmdale, California, for maintenance, their weights were in the 150,000 to 160,000 pound range.

I don't know if I'd call it complications, but the weight of the Orbiter clearly affects the ferry mission by the impact it has on SCA performance. The performance of the SCA is primarily impacted by the weight of the Orbiter, field elevation, ambient air temperature, and runway length. So, it can be more challenging ferrying a 228,000 pound Orbiter in August than it is a 195,000 pound Orbiter in January. The latter case would result in better SCA performance and that additional capability can provide more operational flexibility and make the mission easier to execute.

ROSS-NAZZAL: What role does the Pathfinder play in the ferry flights? What type of plane is the Pathfinder, typically?

MCCORMACK: The Pathfinder does two things for us. It provides weather reconnaissance and it transports the ferry flight team and the required ferry support equipment.

When we ferry in the winter, there are requirements to provide a heated purge to the Orbiter at overnight stopovers. The Orbiter requirement is to provide the purge if the overnight

temperature is expected to be below forty-five degrees Fahrenheit in excess of four hours in order to mitigate the risk of reaction control system (RCS) thruster leaks. In addition, payloads in the Orbiter payload bay may have purge requirements as well. So, when purge is likely to be required, we bring specialized purge equipment with us. Over the years, we've used either a USAF (United States Air Force) C-141 or C-17 to transport the purge equipment and therefore be used as the Pathfinder aircraft.

When purge equipment is not required, we typically use a NASA JSC aircraft. We've used the zero-G aircraft, which was a KC-135 up until a few years ago, and is currently a C-9. We've also used a USAF KC-135 on several occasions. These aircraft are somewhat less expensive to operate than the larger cargo aircraft and still work well in transporting the ferry team.

As far as weather reconnaissance goes, there's always an experienced SCA pilot in the Pathfinder, either in the middle seat of a USAF aircraft or in the middle seat or flying a NASA aircraft. The Pathfinder takes off prior to the SCA and proceeds out to 100 or so miles ahead of the SCA. If the weather is severe clear en route, the weather reconnaissance role of the Pathfinder is easy. If there's weather en-route, that was deemed acceptable to conduct the ferry flight yet we knew would require some maneuvering en route or had the potential to unexpectedly develop into something more difficult to deal with, the weather reconnaissance role of the Pathfinder would be more challenging.

The SCA pilot in the Pathfinder is in radio contact with the pilots in the SCA and provides the necessary guidance to safely navigate through more challenging weather conditions. Note that we always have a weather alternate for each leg that can be utilized in the event of a blown forecast. In my experience, we've never used the weather alternate.

ROSS-NAZZAL: How long does the trip between California and Florida typically take?

MCCORMACK: With good weather and a light Orbiter, that's of course a relatively light Orbiter, the trip can be made with two flight legs in one day. That has actually been accomplished on several occasions. However, with bad weather, a mission can stretch out to four days and more. I've had one that took seven days from the time we were ready-to-ferry to the time we arrived at KSC. Typically, a flight is accomplished in three to four legs flown over a period of two to three days.

ROSS-NAZZAL: How often do the pilots stop to refuel or rest? Where do they stop, at commercial airports? At military bases? Are there requirements for these facilities? If so, please explain.

MCCORMACK: This question has essentially been answered in the course of answering previous questions. The SCA takes on some amount of fuel whenever we stop. The amount will be determined by the SCA performance requirements of the next leg. Typically we'll rest overnight (RON) one or two times during a mission. We'll stop either due to weather or a lack of daylight. We have a requirement to fly only during daylight hours due to the requirement to see and then avoid flight through clouds.

As previously mentioned, there are twenty or so military bases that are trained to support our mission. In addition to that training, they have the ground support equipment to support our requirements and they have agreed to provide transportation and reserve lodging for the ferry

flight team at RON stopovers. The requirements are essentially those things typically required for aircraft, such as fuel and power. In addition, we require that they have man-lifts that allow our technicians to access the vehicle to establish purge and if necessary repair any damage that may have occurred to the Orbiter in flight.

There are two commercial airports that have also agreed to support ferry operations. Rick Husband International Airport in Amarillo, Texas, has been used twice in recent years as a refueling stop. The other, Orlando International, Florida, has never been used and would likely only be used as a weather alternate. In addition, we have used Ellington Field in Houston on several occasions during initial delivery or maintenance ferry missions.

ROSS-NAZZAL: Are there other safety precautions taken when the SCA lands at an airport, military base, or KSC? Please explain. What type of security, if any, is required for the Orbiter when the plane lands to refuel?

MCCORMACK: Upon landing, the SCA is typically taxied to a location where a safety assessment can be performed. Depending on the airfield, the location might be where it will be parked for refueling or RON, or it can be at a location where hazardous cargo is parked. The safety assessment is performed by KSC personnel on the ferry team and consists of toxic vapor tests and visual inspections performed at ground level. Once the environment is declared safe, the SCA is parked, if it wasn't at its park site already, and the SCA flight crew is given clearance to depart the aircraft.

If it's simply a refueling site, the base security personnel remain stationed at the aircraft until refueling is completed and the SCA is ready for departure. If it's a RON stopover, as they

are trained to do, base security personnel establish a restricted area around the SCA. This is done under the guidance of the KSC security personnel on the ferry flight team. The restricted area is established by setting up a perimeter that is at least 200 feet from the SCA—wing tips, nose, and tail. Ropes and stanchions are used, and there is a single controlled entry point. Military personnel control the entry point and monitor the restricted area. The ferry team has special badges that allow them access to the area. In addition, lighting is provided to keep the area illuminated overnight. Bottom line, there are young men with weapons at the SCA at all times. Unauthorized access to the SCA and Orbiter would be difficult and unwise to attempt.

Note that the primary reason that we have security personnel on the team is the unlikely event where we would land at an untrained military base or a commercial airfield. In those cases, the ferry team security personnel would work with the airfield security personnel to provide the security that is required.

ROSS-NAZZAL: How much fuel is used during a ferrying flight?

MCCORMACK: Obviously, the total ferry flight time will depend on the route and the number of legs flown. More fuel is burned during takeoff and climb to altitude so the amount of fuel used will increase with the number of flight legs. However, for a typical ferry flight from Edwards to KSC, the total flight duration is about seven hours. The average fuel burn for the SCA during a ferry flight is about 5750 gallons an hour. So, the amount of fuel used during a ferry flight is about 40,250 gallons (269,675 pounds). Incredibly, the total amount of fuel burned during a ferry mission weighs more than the Orbiter.

ROSS-NAZZAL: During these stops do the pilots meet with the media or chat with the public? Is the public given an opportunity to view the SCA when the Orbiter is on top of the 747? The SCA has flown several flybys at JSC, who decides what locations will be able to see the SCA in flight?

MCCORMACK: A representative from the KSC Public Affairs Office (PAO) is a member of the ferry flight team and they work directly with base PAO personnel to arrange for interviews with the local media upon arrival. If it's a refueling stop, the pilots typically don't have time to talk to the media, and questions at those stops are typically handling by the ferry team's PAO representative. However, either the manager, Launch Integration, if he's with the mission, the ferry manager, or one of the pilots will try to make time for a short interview. If we're at an overnight stopover, typically one of the pilots and one of the managers will do an interview with the media. Interest has grown during the most recent ferry flights and during the STS-128 ferry flight, we actually had a reporter and photographer from the ABC affiliate in Houston travel with the ferry team.

As for the public, the viewing opportunities are limited. Depending on the base, there are opportunities for some limited viewing from the perimeter fences. We typically do not make special arrangements to allow on base access to the public during post-mission ferry flights. There have been a few occasions, like during the initial deliveries of *Atlantis* and *Endeavour* and ferry flights of an Orbiter to Palmdale for maintenance, where we landed at Ellington Field and allowed the public access for viewing. In those cases the Orbiters were inert, did not have hazardous fluids on board, allowing for a safe environment for the public.

Flyovers are considered when a request is made by someone within the Agency or the government (federal or a state). One thing we make clear is that a flyover is only performed if it can be done so without adding a flight leg or adding an extra day to the mission. So, for example, if a flyover of JSC is being considered but the weather dictates a flight path to the north of Houston and the flyover could only be accomplished if the mission is delayed, the flyover would be cancelled.

ROSS-NAZZAL: How frequently is the Orbiter checked for damage on the return flight? Has the Orbiter ever suffered damage during a ferrying flight? If so, please explain.

MCCORMACK: Following each flight leg of a ferry mission, the Orbiter is visually inspected for damage. Occasionally, minor tears to blankets or other components of the Thermal Protection System are observed. On rare occasions, the observed TPS damage is repaired as a precaution to mitigate further damage to the Orbiter and to alleviate a debris concern for the SCA. The repairs that have been done in the past have been minor and usually consists of removing the damaged material.

The most significant damage that an Orbiter has ever experienced during ferry occurred back in 1985. The Orbiter was *Columbia*, and it was being ferried back to KSC following a maintenance period in Palmdale. The report indicated that on the final leg of the mission, from Offutt Air Force Base to KSC, the SCA was flown through light rain for an estimated ten to twelve seconds. The Orbiter sustained significant tile damage, especially to the tiles on the forward reaction control system module and on the tiles around the windows. As I indicated

earlier, flying through rain absolutely has to be avoided as significant damage can occur costing millions of dollars to repair and taking the Orbiter out-of-service for a significant period of time.

On another occasion, and I have no detailed information on this one, the Orbiter sustained a bird strike on takeoff from KSC and about a dozen tiles were damaged or lost.

The most common detrimental effect that occurs during ferry missions is something I alluded to earlier and that's caused by water intrusion that occurs either while the Orbiter is in the MDD at Dryden or while on the ground during the ferry mission. The Orbiter does leak, primarily around the payload bay door seals, and water leaking into the vehicle has the potential to damage components and thermal insulation blankets or lead to corrosion. So, during the ferry mission, we try hard to avoid rainfall on the ground.

ROSS-NAZZAL: When the plane finally lands at KSC, how is the Orbiter demated from the SCA? Where is it taken?

MCCORMACK: Upon landing at KSC, once the safety assessment is completed and the SCA is shut down on the ramp at the SLF (Shuttle Landing Facility), the mated vehicle is towed in to the MDD. The MDD at KSC is similar to the one at Dryden. Typically, within about sixteen hours, the Orbiter is demated from the SCA and towed into its Orbiter Processing Facility (OPF) bay.

ROSS-NAZZAL: How much does it cost to ferry the Orbiter from California to Florida?

MCCORMACK: This is one of the media's favorite questions and probably my least favorite to answer mainly because it can't be answered with a single number and without some explanation.

If you look at just the marginal cost of a single ferry flight, it's about $400,000. That includes primarily the flight hour costs of the SCA, the flight hour costs of the Pathfinder, and the travel and per diem costs for the ferry flight team. That cost is a good estimate but it will vary depending on the duration of the mission, the aircraft used as the Pathfinder, and other factors. However, that does not include the cost to actually maintain and operate the SCA, which is significant and will vary from year-to-year depending on the maintenance required.

In addition, whenever a landing at Edwards occurs, a large team from KSC is required to travel to Dryden for a week or more to perform the turnaround operation. This expense, the largest part of which is a contracted amount that the SSP pays to the United Space Alliance, is also significant and not included in the ferry flight cost number provided above. So, if you look at the total cost of landing at Edwards incurred by the SSP, it's on the order of $2 million.

ROSS-NAZZAL: How many times has the Shuttle landed at Edwards and had to be ferried to KSC?

MCCORMACK: So here we are, STS-133 just landed at KSC and we have two flights remaining, STS-134 and STS-135. As of this time, fifty-four missions have ended with landings at the Edwards Air Force Base and one ended with a landing at White Sands Space Harbor in New Mexico. So an Orbiter has been ferried fifty-five times following a landing at a site other than KSC. *Columbia* landed at Edwards twelve times and the one time at White Sands, *Challenger* landed at Edwards seven times, *Discovery* fifteen times, *Atlantis* thirteen times, and *Endeavour* seven times.

ROSS-NAZZAL: How many times has the SCA flown the Orbiters to Palmdale? If the Shuttle needed to go to Palmdale, do you land there or at Edwards? If the pilots land at Edwards, how is the Orbiter taken to Palmdale?

MCCORMACK: The Orbiters were taken back to Palmdale eight times for maintenance periods. *Columbia* made four trips back to Palmdale; *Atlantis* made two, and *Discovery* and *Endeavour* each made one. On its first trip back to Palmdale in 1984, *Columbia* was flown to and from Edwards. It was demated and mated at the Dryden MDD and towed to and from Palmdale. In the late 1980s, after the *Challenger* accident, a device called the Orbiter Lifting Fixture (OLF) was assembled at Palmdale and was used to mate and demate an Orbiter to the SCA during the remainder of the program. Note that the OLF was going to be used at Vandenberg Air Force Base, California, until the decision was made to cancel West Coast launches after *Challenger* (STS 51-L). The OLF was first used at Palmdale for a mating operation for the initial delivery of *Endeavour*. For the initial delivery of each of the other Orbiters, they were towed to Edwards and mated using the MDD at Dryden.

ROSS-NAZZAL: I understand that *Enterprise* was ferried to England and also Paris for the air show. What challenges, if any, did flying over the Atlantic pose?

MCCORMACK: The ferry flight of *Enterprise* to Europe for the Paris Air Show took place in May and June of 1983. Obviously that was well before my time and quite frankly, I know very little detailed information about that flight. From what I do know, it must have been a fascinating trip. The SCA and *Enterprise* departed Edwards on May 16 and flew approximately twenty flight legs

including several short flights at the air show in Paris over the next thirty days. On the way to Europe they made stops in Colorado, Kansas, and Ohio in the U.S. They followed what I refer to as the northern route where they made a stop at Keflavik, Iceland, before arriving in England. They arrived in Paris on May 24 and were at the Paris Air Show until June 5. While in Europe, they also made appearances in Germany and Italy. On the way home, they followed a similar route and made additional stops in the U.S. in Illinois, Washington D.C., and Texas before arriving back at Edwards on June 13.

Now, with all that said, I suspect the flight was somewhat easier than what we do today. First of all, *Enterprise* did not have most of the internal components required for spaceflight and obviously did not have a payload. As a result, she only weighed 126,600 pounds, well less than a post-mission Orbiter. So, the SCA could carry a lot more fuel and therefore had much better range. In addition, since the vehicle was inert and was never intended for spaceflight, I'm sure they didn't have the temperature and pressure driven altitude restrictions we have today for a post-mission ferry flight. Flying higher, I suspect up to 20,000 to 25,000 feet, would have improved the SCA's range even more and would have resulted in a greater capability to avoid weather. In addition, since it didn't have the Thermal Protection System used on the spaceflight Orbiters, I believe it was less sensitive to flight through rain, although I suspect they still tried to avoid it. All in all, as I stated above, I suspect it was a somewhat easier mission to execute even though it was a very lengthy mission, in miles and duration. And besides, they got to spend about ten days in Europe with an Orbiter mated to a 747. I suspect they were like rock stars.

ROSS-NAZZAL: Are there any particularly challenging or memorable ferry flights that jump out in your memory? If so, would you share those details with us?

MCCORMACK: They are all challenging and memorable. I'd say the most challenging and memorable was what turned out to be a simultaneous duel ferry mission back in 2001. I'll try to give a brief summary of that somewhat complex event.

Columbia was at Palmdale for what turned out to be its last maintenance period. It was scheduled to be ferried back to KSC in late February using SCA 905. As luck would have it, the STS-98 mission ended with *Atlantis* landing at Edwards on February 20, 2001. So, turnaround processing began immediately on *Atlantis* while discussions ensued as to how these two ferry missions should be accomplished. Guidelines were established to assist the decision making process. These guidelines were basically that the *Columbia* ferry could not interfere with the *Atlantis* ferry, since *Atlantis* would be flown again sooner, and that neither ferry mission could interfere with the launch of the STS-102 (*Discovery*) mission, scheduled for March 8. However, after careful evaluation, it was determined that two independent ferry missions could be accomplished with the equipment and personnel assets that were available. *Atlantis* would be ferried using SCA 911. With independent missions, both Orbiters could be returned to KSC as soon as possible.

Early during the turnaround processing of *Atlantis*, it appeared that the *Columbia* ferry would be completed several days prior to the time the *Atlantis* ferry would be ready to start. However, if you're ever going to see an extended period of rain in the high desert region of California it's going to be in the late winter months, and that's exactly what happened. Overcast conditions with periods of light to moderate rain delayed the start of the *Columbia* ferry flight and by the time the mission was able to start, *Atlantis* was ready to go as well.

So once again, as luck would have it, by the time the weather allowed the *Columbia* ferry flight to start, *Atlantis* was ready to be ferried as well. On March 1, 2001, the first simultaneous ferry flights in the history of the SSP began. I was with *Columbia* and my good friend Denny Gagen, the NASA KSC Ground Operations Manager (GOM) at Dryden was leading the *Atlantis* ferry mission. Jim [James D.] Halsell, the Manager, Launch Integration and the SSP person ultimately responsible for ferry operations was traveling back and forth between both missions. The three of us had worked together closely in the planning of these missions and would continue to do so during their execution.

On the first day of the mission, *Columbia* was flown to Dyess Air Force Base in Abilene, Texas, and *Atlantis* was flown to Altus Air Force Base in Atlus, Oklahoma. Both missions were held up there while we waited for the same slow moving low pressure system that had caused the delay in California to clear the area across the southeastern region of the country. *Atlantis* and *Columbia* finally arrived in Florida on March 4, twelve days after *Atlantis*'s landing at Edwards and seven days after *Columbia* was ready-to-ferry. *Atlantis* went to the KSC SLF and *Columbia* went to the skid strip at the Cape Canaveral Air Force Station. *Columbia* went to the skid strip because with the STS-102 launch preparations that were on-going at KSC, the ramp at the SLF could not accommodate both SCAs at the same time. Following the demate of *Atlantis* and the departure of SCA 905, *Columbia* made the short hop to the SLF on March 5.

There are so many details I could add, and probably a few I've forgotten, but needless to say, it was a "challenging and memorable" operation.

ROSS-NAZZAL: Describe the SCA and what modifications were made to the plane so that it could ferry the Orbiter. Where is the SCA typically housed, at Dryden, JSC, or KSC? How

often is the SCA is flown without the Orbiter? Would the number of crew and/or passengers change as a result?

MCCORMACK: I know that you're also talking to one of the SCA flight engineers and he'd be much better at answering this question than I. However, I'll provide a very high level summary of the SCA and the major modifications that were required to support ferry operations. An SCA is a modified Boeing 747-100. The most obvious modification from the outside of the aircraft are the struts that were added for the attachment of the Orbiter. Another obvious modification are the two vertical stabilizers that were added to the ends of the standard horizontal stabilizer. These were added to provide additional directional stability. Inside the aircraft there's a dramatic modification from a 747s commercial configuration. Aft of the forward doors, all of the standard internal furnishings, seats, overhead bins, etc. were moved to reduce the weight of the aircraft. What you see is the green painted structure of the aircraft fuselage. It's a very interesting look into aircraft construction. Finally, a less obvious modification was the addition of redundant power supplies and cabling to provide electrical power to the Orbiter as well as the SCA instrumentation required to monitor these devices. The power supplies are primarily used to power Orbiter fluid system heaters and water coolant loop pumps during ferry operations. There are two SCAs, and they are housed at Dryden.

On average, I believe the SCAs are flown about once a quarter. (Again, a better question for a flight engineer). Those flights are for maintenance or systems checkouts or for flight crew proficiency. Where there are strict rules regarding the number of persons in the SCA during an Orbiter ferry flight, those rules do not apply for SCA flights for maintenance or systems checkouts or for flight crew proficiency. For those flights, those particular missions define the

crew size. With the seating still available in the aircraft, it can accommodate about fifteen passengers.

ROSS-NAZZAL: How many SCAs has NASA had over the years? How many are in service today?

MCCORMACK: The first SCA was SCA 905, and it was the aircraft used during the Orbiter Approach and Landing Test (ALT) Program performed at the Edwards Air Force Base in 1977. There were eight captive test flights using the Orbiter *Enterprise* and five free flights where the *Enterprise* was released from the SCA. After the ALT Program was completed, the SCA was modified to its ferry flight configuration, which was primarily a modification to the forward attach hardware. SCA 905 was modified from a 747 owned by American Airlines. The modification was done for NASA by the Boeing Corporation.

After the *Challenger* accident, the SSP decided to add a second aircraft, and SCA 911 was added to the fleet. SCA 911 was modified from a 747 owned by Japan Airlines. It was also modified by Boeing. Interestingly, the first ferry flight using SCA 911 was for the initial delivery of *Endeavour* to the KSC.

Both aircraft are in service today.

ROSS-NAZZAL: How many SCA pilots work for NASA? Do they also fly other NASA planes?

MCCORMACK: Currently, there are only three SCA pilots that are qualified to support ferry operations. During my tenure we've had up to six pilots available for ferry operations and I've

worked with nine different pilots over the years. But as the SSP winds down, that number has dwindled. I've seen many very qualified SCA pilots retire over that past six to seven years. However, the guys left should be all we need to support the remainder of the SSP and deliver the Orbiters to museums.

Yes, the SCA pilots fly other aircraft, typically several.

ROSS-NAZZAL: Is there anything else about ferrying operations or the SCA we might have overlooked that we should know about?

MCCORMACK: I've got to compliment you on your questions. They're actually very good and I believe they've allowed me to cover ferry operations pretty thoroughly.

I would like to add that it's been my great pleasure to be involved in Orbiter Ferry Operations. I actually consider it the best job I've had in my NASA career. It's a fascinating operation, and I've always considered it a privilege to play a small part in transporting these incredible vehicles across the country. The Orbiters are the most capable spacecraft ever built and are likely to retain that title for many, many, years to come. The people I've worked with are true professionals that are very good at their jobs and take pride in what they do. It's been fun.

[End of interview]