

Also at the time of documentation, there were two primary features that distinguished one SCA from the other. The first is the number of upper-deck windows on the sides of the aircraft near the forward support strut for the orbiter; NASA 911 has five windows on each side and NASA 905 has only two. The second difference was the vinyl decals applied to NASA 905 in 2012. On each side of NASA 905, to the aft of the forward door and above the main deck windows, was a series of images depicting how many times the aircraft carried each of the orbiters (*Enterprise*, *Columbia*, *Challenger*, *Discovery*, *Atlantis*, and *Endeavour*) and the Phantom Ray; these were applied in March 2012. The second set of decals was located directly below the cockpit windows on each side of NASA 905; it depicted the names of the SCA pilots and flight engineers who participated in the final ferry flights of the orbiters.<sup>14</sup>

### History:

Originally, the Space Shuttle orbiter was designed with air-breathing engines that would be used to both carry the vehicle into orbit and return the vehicle from space; additionally, the engines could be used to ferry the orbiter from one location to another. However, studies revealed these engines caused weight problems in the design. As a result, engineers began to study alternative modes of transporting the orbiter from a potential remote landing site to KSC.<sup>15</sup>

In 1973, NASA was considering both the C-5A cargo aircraft, manufactured by Lockheed,<sup>16</sup> and the Boeing 747 “jumbo jet” as potential vehicles to ferry the orbiter. In August 1973, NASA’s DFRC awarded a \$56,000 contract to Boeing to study the feasibility of using the 747 to ferry the orbiter. The contract was the result of an unsolicited proposal submitted by Boeing. The objective of the sixty-day study was to define operational requirements, performance, cost, schedules and preliminary systems design for such a carrier aircraft.<sup>17</sup> In October 1973, Lockheed was awarded a contract that covered wind tunnel tests simulating the use of the C-5A as a ferry aircraft. The tests of a scale model of the orbiter

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<sup>14</sup> Alan Brown, “New Logos on NASA 905 Depict Ferry Flight History,” April 5, 2012, [http://www.nasa.gov/centers/dryden/Features/sca\\_905\\_logos.html](http://www.nasa.gov/centers/dryden/Features/sca_905_logos.html). NASA 911 had, by this time, been retired from service. Brewer, interview, 15.

<sup>15</sup> William G. Register, “747 Air Carriage of the Space Shuttle Orbiter,” in *Proceedings of the Twelfth Space Congress, Cocoa Beach, Florida, April 9-11, 1975* (Canaveral Council of Technical Societies, 1975), 1-1 through 1-3. KSC was chosen as the primary launch site for the Space Shuttle on April 14, 1972. Jenkins, *Space Shuttle*, 155. As early as October 1969, it was assumed that KSC also would be the primary landing site of the Space Shuttle. “12 Seek Space Shuttle Control Systems Study,” *Marshall Star*, October 22, 1969, 4.

<sup>16</sup> The original version of the C-5A was manufactured by Lockheed between 1968 and 1973. This large military transport aircraft, which featured a heavy airlift capacity, was used primarily by the United States Air Force.

<sup>17</sup> “Boeing Gets Contract for Shuttle Ferry,” *X-Press*, August 3, 1973, 2.

mounted atop a scale model of the C-5A were conducted in Lockheed's Low Speed Tunnel in Burbank, California. The objectives were to determine if the plan was technically feasible, and if so, to determine the optimum location for positioning the orbiter on the C-5A.<sup>18</sup>

Test results demonstrated that the 747 had several advantages over the C-5A. The 747 was shown to be safer, and to be capable of a nonstop transcontinental flight without the need for refueling. Additionally, it could use shorter runways, and had a longer structural life. As a result, by June 1974, NASA definitively replaced its earlier plans to install six air-breathing engines on the orbiter for ferry flights in favor of using a Boeing 747 to transport the orbiter. Following the June 1974 request of authorization made by Dr. Christopher Kraft, director of NASA's JSC, NASA's Space Shuttle Program Office approved the purchase of a Boeing 747 airplane for use as the SCA.<sup>19</sup>

On July 18, 1974, NASA purchased a used Boeing 747-123 jetliner from American Airlines for approximately \$15.6 million. At the time of purchase, the aircraft had logged about 9,000 flight hours. It was given the registration number N905NA.<sup>20</sup> Before being modified, the aircraft was initially used as part of a DFRC study of trailing wake vortices; this research was not directly connected to the SSP.<sup>21</sup> Subsequently, the Boeing 747 was used in a shuttle program-related simulated separation maneuver test.

On August 2, 1976, modifications were started by Boeing at their production facilities near Everett, Washington. Work under this \$30 million contract was completed in December. Under a separate contract, the four original Pratt and Whitney JT9D-3A engines were converted to JT9D-7AHW engines to increase their power.<sup>22</sup> For the ALT Program, a flight crew escape system was installed. It consisted of an exit tunnel extending from the flight deck to a hatch in the bottom of the fuselage.<sup>23</sup>

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<sup>18</sup> "Shuttle Ferry Wind Tunnel Tests Slated," *X-Press*, October 26, 1973, 4.

<sup>19</sup> "747 to be Used for Orbiter Transport," *X-Press*, June 21, 1974, 2.

<sup>20</sup> T.A. Heppenheimer, *History of the Space Shuttle*, vol. 2, *Development of the Space Shuttle, 1972-1981* (Washington, DC: Smithsonian Institution Press, 2002), 94.

<sup>21</sup> Jenkins, *Space Shuttle*, 196.

<sup>22</sup> Jenkins, *Space Shuttle*, 197. The Pratt & Whitney JT9D engine was a large commercial turbo fan engine initially used on Boeing's 747-100. The JT9D-7AHW engines were replaced circa 1996, as noted in the description section.

<sup>23</sup> This system was removed from NASA 905 following the completion of the ALT Program. Curry, "Shuttle Carrier Aircraft."

In January 1977, the modified SCA was flown to Edwards AFB for use with the orbiter prototype *Enterprise* in the ALT Program, conducted at DFRC between February and October 1977. Prior to the actual test flights, wind tunnel tests in support of the ALT program were carried out at DFRC as well as NASA's Ames Research Center at Moffett Field, California.<sup>24</sup> The ALT Program consisted of a series of eight captive and five free-flight tests, with the orbiter mounted atop the SCA. The initial eight captive tests verified the aerodynamics and handling of the orbiter/SCA combination and the orbiter systems. The free-flight tests "allowed the pilots and engineers to learn how the shuttle handled during low-speed flight and simulated how it would land at the end of an orbital mission."<sup>25</sup>

NASA selected two, two-man orbiter crews for the ALT Program: Fred W. Haise, Jr. (Commander) and C. Gordon Fullerton (Pilot), and Joe H. Engle (Commander) and Richard H. Truly (Pilot). Crewmembers for the SCA included pilots Fitzhugh I. Fulton, Jr. and Thomas C. McMurtry, as well as flight engineers Victor W. Horton, Louis E. Guidry, Jr., William R. Young, and Vincent A. Alvarez.<sup>26</sup>

The first phase of the ALT program entailed three high speed taxi tests, conducted in February 1977 at the main concrete runway at Edwards AFB (Runway 04/22). These tests proved that the SCA, mated to *Enterprise*, could steer and brake with the orbiter mounted on top of the airframe.<sup>27</sup> Two unmanned "captive-inert" tests followed. The goal of the last two test flights was to conduct the maneuvers of an air launch. Next, three "captive-active" tests featuring two-person crews were performed on June 18, June 28, and July 26, 1977. During these tests, the orbiter was piloted and powered up while attached to the SCA to check how the *Enterprise* would perform in the air.<sup>28</sup> The final phase of testing marked the first free flight of the orbiter. Five test free-flights were conducted between August 12 and October 26, 1977. The first three free tests were flown with the tail cone (fairing) on the orbiter; the fourth and fifth free flights were made

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<sup>24</sup> "Shuttle Begins Wind Tunnel Tests," *X-Press*, June 20, 1975, 3.

<sup>25</sup> Lisa Tidwell, "Practice Makes Perfect. This Year Marks the 25<sup>th</sup> Anniversary of Shuttle's Free-Flight Tests," *Space Center Roundup*, October 2002, 6.

<sup>26</sup> Peter Merlin, "Proving Grounds. Enterprise Validated Shuttle Concepts," *The Dryden X-Press*, September 2011, 6-7.

<sup>27</sup> *Wings in Orbit: Scientific and Engineering Legacies of the Space Shuttle, 1971-2010*, ed. Wayne Hale (Washington, DC: US Printing Office, 2010), Appendix, 518.

<sup>28</sup> Heppenheimer, *Development of the Space Shuttle*, 121.

with dummy engines in an effort to replicate actual flight conditions.<sup>29</sup> Overall, the ALT program was successful in providing both operational experience as well as “benchmarking data for the flight simulators that were the working tools of day-to-day astronaut training.”<sup>30</sup>

Following completion of the ALT Program, NASA 905 ferried *Enterprise* to the George C. Marshall Space Flight Center (MSFC) in Huntsville, Alabama, for a series of vertical ground vibration tests, which began in March 1978. On March 20, 1979, the SCA began a four-leg ferry flight to deliver the newly assembled *Columbia* to KSC. Subsequently, the SCA moved *Enterprise* from MSFC to KSC where, from May through July 1979, NASA used the orbiter prototype to verify the correct locations of maintenance platforms, and to check crew escape procedures.<sup>31</sup> Later that year, the SCA flew *Enterprise* to California, where selected parts, including most of the cockpit instrumentation and consoles, the control sticks, and most of the avionics, were removed and refurbished in October 1979, for use on later orbiters.

The next use of the SCA came in April 1981 when NASA 905 returned *Columbia* to KSC following the STS-1 landing at Edwards AFB. Early in the SSP, Edwards AFB was the preferred landing site due to more stable weather conditions, as well as the choice of concrete and dry lakebed runways. Thus, the first nine flights of the SSP ended with a landing at Edwards AFB, with the exception of STS-3, which landed in New Mexico; the orbiter was subsequently carried to KSC with the SCA.

Upon the roll-out of *Challenger*, NASA 905 ferried her to KSC on a two-leg journey, flown on July 4-5, 1982. In 1983, the American Airlines markings in red, blue and silver were replaced when NASA repainted the SCA to its current white and blue. Subsequently, NASA 905 ferried *Enterprise* around the world for air shows, including the Paris Air Show in May and June 1983. Later that year, between November 6 and 9, NASA 905 carried the new orbiter *Discovery* to KSC.

In early 1984, DFRC conducted a series of inflight refueling tests to evaluate the process for application to the SCA. Two tankers, a KC-135 and a KC-10, handled the refueling of the SCA. Center personnel mounted the *Enterprise* atop NASA 905 in the mate-demate device (MDD) for six

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<sup>29</sup> Merlin, “Proving Grounds,” 7.

<sup>30</sup> Heppenheimer, *Development of the Space Shuttle*, 121.

<sup>31</sup> Jenkins, *Space Shuttle*, 216.

of the nine test flights. Both the *Enterprise* and SCA were instrumented with pressure sensors and accelerometers to evaluate structural effects of the refueling.<sup>32</sup> Later that year, the SCA also transported *Enterprise* to the 1984 World's Fair in New Orleans, Louisiana.<sup>33</sup>

By 1984, the Shuttle Landing Facility (SLF) at KSC became the primary orbiter landing site; the first landing at KSC was at the end of mission STS-41B, on February 11, 1984. Although this reduced the need for post-mission ferry flights, ten additional landings were made at Edwards AFB prior to the *Challenger* accident in January 1986, particularly after *Discovery* blew a tire upon landing at KSC following STS-23 (April 19, 1985) prompting NASA to return to using Edwards AFB as the primary landing site. NASA 905 also completed two ferry flights (January 1984 and July 1985) in support of *Columbia's* first modification period, which took place in California.

The year 1985 marked several milestones in the career of NASA 905. In April, she delivered the new orbiter *Atlantis* to KSC, and in July, she returned *Columbia* from California following more than one year of modifications at Palmdale.<sup>34</sup> Later, in September 1985, the SCA moved *Enterprise* to KSC for display. On November 18, 1985, *Enterprise* became the property of the Smithsonian's National Air and Space Museum; the SCA ferried *Enterprise* to her new home in Washington, DC.

In the wake of the 1986 *Challenger* accident, the Rogers Commission recommended that increasing the ferry capacity would enhance reliability of ferry operations and would eliminate a "single point failure from the program."<sup>35</sup> In accordance, in February 1988, NASA announced plans to acquire a second 747 to serve as backup to NASA 905.<sup>36</sup> A surplus Japan Air Lines domestic passenger aircraft with about 32,000 hours of flight time was acquired for NASA by Boeing in April 1988. Boeing began modifications to the aircraft in 1988, at the Boeing Military Airplanes manufacturing facility in Wichita, Kansas, under a \$55 million contract,

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<sup>32</sup> "Inflight Refueling Tests for Shuttle Ferry Flights," *X-Press*, February 3, 1984, 3-4.

<sup>33</sup> Tidwell, "Practice makes perfect," 6.

<sup>34</sup> NASA 905 delivered *Columbia* to California on January 27, 1984, following a two-day, two-leg ferry flight.

<sup>35</sup> Barbara Schwartz, "NASA Announces Delivery of Second Shuttle Carrier Aircraft," NASA News Release, November 16, 1990, accessed at [http://www.nasa.gov/centers/johnson/pdf/83142main\\_1990.pdf](http://www.nasa.gov/centers/johnson/pdf/83142main_1990.pdf); Jeff Carr, "Ferry Fleet Doubles in Size," *Space News Roundup*, November 16, 1990, 1 and 4.

<sup>36</sup> Jenkins, *Space Shuttle*, 198.

which included the cost of purchase.<sup>37</sup> After the structural work was completed, the aircraft was delivered to Chrysler Technologies in Waco, Texas, for painting.<sup>38</sup> NASA 911 was added to the NASA fleet on November 20, 1990, and for her maiden flight in May 1991, she delivered the new orbiter *Endeavour* (OV-105) to KSC.<sup>39</sup>

Between August 1991 and March 2001, the two SCAs ferried *Columbia*, *Discovery*, *Atlantis*, and *Endeavour* between KSC and Palmdale, California for major modifications and maintenance, referred to as Orbiter Maintenance Down Periods (OMDPs) and Orbiter Major Modifications (OMMs). *Columbia* made six transcontinental trips aboard both NASA 905 (February 7-9, 1992; October 8-11, 1994; April 11-14, 1995; September 24-25, 1999; and March 1-5, 2001) and NASA 911 (August 9-13, 1991). Both SCAs transported *Discovery* for her OMDP; NASA 905 left KSC on September 27, 1995 and delivered the orbiter to Palmdale the following day, while NASA 911 returned *Discovery* to KSC on a four-leg<sup>40</sup> ferry flight made June 25-29, 1996. NASA 911 ferried *Atlantis* to Palmdale for two OMDPs in October 1992, and November 1997, and returned her to KSC in May 1994; the other return of *Atlantis* to KSC was made by NASA 905 in September 1998. *Endeavour* underwent one OMDP at the Palmdale plant. She was carried to California atop NASA 911 on July 30, 1996, and returned to KSC by NASA 905 in March 25-27, 1997.

Notably, in 2001, a unique event in the history of the SSP took place in the form of simultaneous ferry missions. As related by Donald McCormack, NASA Ferry Operations manager, *Columbia* was at Palmdale for maintenance, and scheduled to be ferried back to KSC in late February using NASA 905, when *Atlantis* concluded her STS-98 mission with a landing at Edwards AFB on February 20. Since *Atlantis* would be flown again sooner than *Columbia*, NASA decided that the *Columbia* ferry mission could not interfere with the *Atlantis* ferry, and neither ferry flight could interfere with the launch of the STS-102 (*Discovery*) mission, scheduled for March 8. Subsequently, two independent ferry missions were accomplished, with *Columbia* using NASA 905 and *Atlantis* atop

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<sup>37</sup> Jeffrey E. Carr, "NASA Buys Second Shuttle Carrier Aircraft," NASA News Release, August 10, 1988, [http://www.nasa.gov/centers/johnson/pdf/83140main\\_1988.pdf](http://www.nasa.gov/centers/johnson/pdf/83140main_1988.pdf).

<sup>38</sup> Schwartz, "Second Shuttle Carrier Aircraft."

<sup>39</sup> The maiden ferry flight crew for NASA 911 included Arthur "Ace" Beall, Dave Mumme, Larry LaRose, Henry Taylor, A.J. Roy, Skip Guidry, and Bud Meins. "Endeavour takes bow in Houston," *Space News Roundup*, May 10, 1991, 1 and 4.

<sup>40</sup> A leg is the distance traveled between stops for fueling or other purposes.

NASA 911. Both *Atlantis* and *Columbia* arrived at their destination on March 4; *Atlantis* went to the KSC SLF and *Columbia* went to the skid strip at Cape Canaveral Air Force Station. Following the demating of *Atlantis*, *Columbia* was moved to the SLF on March 5.<sup>41</sup>

For cost-saving reasons, beginning in September 2002, NASA relocated the orbiter overhaul and upgrade operations from Palmdale to KSC; therefore, the SCAs were no longer required to carry the vehicles between Florida and California for maintenance. However, five missions between August 2005 and September 2009 required a landing at Edwards AFB. NASA 905 returned the orbiters from two of these flights to KSC; its ferry flight of *Atlantis* from July 1-3, 2007, was NASA 905's final flight in support of the operational phase of the SSP. NASA 911 returned the other three. Its final ferry flight in support of the SSP's operational phase was carrying *Discovery* from Edwards AFB to KSC from September 19-21, 2009.

On December 13, 2010, NASA 905 carried the Phantom Ray, a 36'-long unmanned airborne system manufactured by Boeing Integrated Defense Systems, during a 50-minute test flight at Lambert International Airport in St. Louis, Missouri. This marked the first time in the SCA's thirty-three-year history that an aircraft other than the space shuttle had flown on the SCA. The following day, NASA 905 transported the Phantom Ray from St. Louis to Edwards AFB.<sup>42</sup> On August 2, 2011, the two SCAs flew in formation for the first time, a historic event that occurred over the Edwards AFB test range. NASA 911 was on a pilot proficiency flight while NASA 905 was on a functional check flight following maintenance operations.<sup>43</sup>

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<sup>41</sup> McCormack, interview, 19-20.

<sup>42</sup> This test flight was in preparation for its transport to DFRC, on top of NASA 905, where the Phantom Ray made its first flight, which lasted seventeen minutes, on April 27, 2011. The SCA flights with Phantom Ray were conducted under a Boeing-funded, commercial Space Act Agreement with NASA. The Phantom Ray and special adapter weight approximately 30,000 pounds together. Boeing, "Boeing Phantom Ray Takes a Ride on NASA's Shuttle Carrier Aircraft," December 13, 2010, accessed at <http://boeing.mediaroom.com/index.php?s=43&item=1559>; Brian Heater, "Boeing's Phantom Ray soars like a terrifying, unmanned eagle," posted May 3, 2011, accessed at <http://www.engadget.com/2011/05/03/boeings-phantom-ray-soars-like-a-terrifying-unmanned-eagle/>; Chris Haddox (Boeing), "Shuttle Carrier Aircraft and Phantom Ray make tandem flight," No date, accessed at [http://www.boeing.com/Features/2010/12/bds\\_phantom\\_ray\\_12\\_10\\_10.html](http://www.boeing.com/Features/2010/12/bds_phantom_ray_12_10_10.html).

<sup>43</sup> Robert Z. Pearlman, "New Boarding: Inside NASA's Boeing 747 Shuttle Carrier Aircraft," April 13, 2012, accessed at <http://www.space.com/15266-nasa-shuttle-carrier-aircraft-explained.html>.

NASA 911 made its final flight on February 8, 2012. The twenty-minute flight began at DFRC and ended at the Dryden Aircraft Operations Facility located adjacent to Air Force Plant 42 in Palmdale, California.<sup>44</sup> At this time, “it had amassed 33,004 flight hours over its 38-year career, including 386 flights as a NASA shuttle carrier aircraft, 66 of which were ferry flights with a space shuttle mounted atop the fuselage.”<sup>45</sup>

Between April and September 2012, NASA 905’s final service to the Space Shuttle Program was the transport of *Enterprise*, *Discovery*, and *Endeavour* for delivery to airports near their recipient museums. On April 17, 2012, the SCA carried *Discovery* from KSC to Dulles International Airport in Chantilly, Virginia, for display at the Smithsonian Institution National Air and Space Museum’s Udvar-Hazy Center. After the delivery of *Discovery*, the SCA ferried *Enterprise* to JFK International Airport in New York City, on April 27, 2012, for its display at the Intrepid Sea, Air and Space Museum.<sup>46</sup>

The last ferry flight of NASA 905 was the transport of *Endeavour* from KSC to Los Angeles, California. The SCA left KSC on September 17, 2012, and made an overnight stop at Ellington Field in Houston near JSC. The second leg ended at Biggs Army Airfield at El Paso, Texas for refueling and flight crew change; the third leg ended at Edwards AFB, where the orbiter/SCA combo overnighted. The following day, September 21, the SCA, flown by pilots Jeff Moultrie and Bill Rieke, along with flight engineers Henry Taylor, Larry LaRose, and Gary Ash, touched down at Los Angeles International Airport at 12:51 PM. This last leg took 4 hours and 34 minutes, during which time the aircraft made low-level flybys over numerous California cities and landmarks.<sup>47</sup>

After all the orbiters were delivered, NASA’s plans called for both SCAs to be transferred to DFRC’s Stratospheric Observatory for Infrared

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<sup>44</sup> Yvette Smith, ed., “World’s Greatest Piggyback Ride,” April 19, 2012, accessed at [http://www.nasa.gov/topics/nasalife/features/shuttle\\_museum.html](http://www.nasa.gov/topics/nasalife/features/shuttle_museum.html).

<sup>45</sup> Curry, “Shuttle Carrier Aircraft.”

<sup>46</sup> *Enterprise* was barged by way of the Hudson River from JFK International Airport to the Intrepid Sea, Air and Space Museum. To secure *Enterprise* to the barge, the pedestals from NASA 911’s aft mounting struts, removed by NASA technicians, were used. Robert Z. Pearlman, “NASA Space Shuttle Carrying Jumbo Jet Retires After One Last Flight,” February 13, 2012, accessed at <http://www.space.com/14555-space-shuttle-piggyback-jumbo-jet-retired.html>.

<sup>47</sup> NASA DFRC, “Endeavour Ferry Flight Status,” September 21, 2012, accessed at [http://www.nasa.gov/centers/dryden/status\\_reports/SCA\\_Endavour\\_status\\_09\\_12.html](http://www.nasa.gov/centers/dryden/status_reports/SCA_Endavour_status_09_12.html).

Astronomy (SOFIA) Program; the SOFIA Program wanted the engines as spares, so the SCAs “probably won’t fly anymore.”<sup>48</sup>

**Function:**

The SCAs primary function was to ferry the Space Shuttle orbiters from one location to another. The SCAs delivered the newly assembled orbiters to KSC to begin their operational service. NASA 905 delivered four of the five orbiters, *Columbia* (March 1979), *Challenger* (July 1982), *Discovery* (November 1983), and *Atlantis* (April 1985); NASA 911 delivered *Endeavour* (May 1991). Between April 1981 (STS-1) and July 2011 (STS-135), the SCAs completed fifty-five post-mission ferry flights following an orbiter’s landing at Edwards AFB or White Sands Space Harbor. In addition to the post-mission flights and initial deliveries, between 1985 and 2001, the SCAs transported the orbiters between KSC and Palmdale, for eight modification periods (sixteen one-way ferry flights).

Flight Procedures

In order to carry the orbiter from one place to another, the vehicle had to be attached to the SCA. This task was completed using one of two MDD structures (one at DFRC and one at KSC), an Orbiter Lifting Frame (at Palmdale), or, if necessary, stiff-legged derricks. First, a tail cone to reduce aerodynamic drag was attached to the orbiter’s base heat shield at eight attach points; this took two to three shifts to accomplish. After the orbiter was raised about fifty feet, the SCA was towed underneath, and the orbiter was lowered into position and attached at the two aft and one forward points. These three attach locations were the same as those used when the orbiter was mated to the ET. The mate process typically took about twelve hours.<sup>49</sup>

The SCA was required to fly only during daylight hours. Chief Flight Engineer, Henry Taylor, noted that the SCA was allowed to take off up to twenty minutes before sunrise, and had to land no later than twenty minutes after sunset. The flight path was determined mostly by the weather, and generally was not the same for each ferry operation. The

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<sup>48</sup> Taylor, interview, 16-17. SOFIA uses a highly modified Boeing 747SP aircraft as a platform for the 100”-diameter, 19-ton reflecting telescope, which is mounted in the rear fuselage. SOFIA is the world’s largest airborne astronomical observatory. Pearlman, “NASA Space Shuttle.”

<sup>49</sup> McCormack, interview, 2-4. For post-mission ferry flights, the orbiter typically was ready to be ferried within seven to nine days of landing. For additional information on the KSC MDD, see Patricia Slovinac, “Cape Canaveral Air Force Station, Launch Complex 39, Shuttle Landing Facility (John F. Kennedy Space Center),” HAER No. FL-8-11-J. Historic American Engineering Record (HAER), National Park Service, US Department of the Interior, April 2011.