National Aeronautics and Space Administration

Supporting Shuttle

35+ Years of Excellence at Dryden

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SPACE SHUTTLE

Columbia
YOUNG · CRIPPEN

NASA

FERGUSON HURLEY MAGNUS WALHEIM
STS 135

30
YEARS

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Introduction

When the final space shuttle mission thundered into orbit on July 8, 2011, it closed one chapter in the story of human spaceflight, and ushered in another. Building on NASA's legacy, America stands poised to embark on a new era of space exploration within our solar system and development of commercial space vehicles for access to low Earth orbit.

The shuttle was a marvel of American engineering and the most capable and sophisticated spacecraft ever flown. As the first reusable spacecraft, it was designed to make space travel routine and allow humans to live and work in space, providing a platform for scientific and commercial opportunities. The three decades following its inaugural launch in April 1981 were characterized by both triumph and tragedy, but despite two catastrophic accidents the shuttle demonstrated a better safety record than any other existing launch vehicle.

Originally known as the Space Transportation System (re-designated the Space Shuttle Program in 1990), a fleet of five orbiters made 135 flights carrying 358 individual crewmembers from 16 countries. A sixth vehicle was flown in a series of five low-altitude approach and landing tests, but never went into space. At a cost of approximately $400 million per flight, the shuttle delivered some 3.5 million pounds of cargo mass to orbit. Among the 179 payloads deployed in space were three of the so-called "Great Observatories" – the Hubble Space Telescope, Compton Gamma Ray Observatory, and the Chandra X-Ray Observatory. The shuttle was also used to launch several robotic spacecraft to explore the solar system including Galileo to Jupiter, Magellan to Venus, and Ulysses to study the Sun.

The shuttle served as a platform for Earth sciences and environmental monitoring, human spaceflight physiology studies, material sciences, and numerous commercial and student science projects. It carried a variety of international science laboratories – such as Spacelab and Spacehab – into orbit, supported Hubble repair missions that allowed scientists to upgrade instruments, deployed Department of Defense payloads to improve national security, carried components of the International Space Station into orbit during construction, and resupplied the operational ISS with spare parts and consumables. Most important, the shuttle served as a learning tool to better understand how to live and work in space, a critical factor in the development of future space exploration missions.

This publication is not meant to be a comprehensive history of the Space Shuttle Program. It simply provides an overview of Dryden's contributions to the program, a statistical overview of the vehicle, and its missions, and accomplishments including both milestones and trivia. A tabular format is used in order to communicate most of the content in a clear and concise way. Several sources were used in creating this publication, including the author's personal notes and records, Dryden Shuttle and Flight Operations Office files and records, NASA Fact Sheets, NASA.gov, Wikipedia.com, the Boeing Reporter's Space Flight Note Pad, and the Space Shuttle Missions Summary by Robert Legler and Floyd Bennett, which was used as the primary source in dealing with data variances between sources.

Thousands of people contributed to the success of the shuttle, working in fields including design, construction, integration, testing, flight operations, processing, maintenance, and many others. This publication is respectfully dedicated to them.

Dryden's Contributions to the Space Shuttle Program

From development of key technologies to support of operational shuttle missions, personnel at NASA Dryden Flight Research Center contributed in numerous ways to the Space Shuttle Program. Dryden personnel perform research, development and verification of advanced aerospace technologies for production, prototype or experimental vehicles. In fact, Dryden pilots and engineers were testing and validating design concepts that helped in the development of the space shuttle configuration more than a decade before testing began with the prototype Enterprise. Subsequent flight-testing at Dryden also contributed significantly to development of the space shuttle thermal protection system, solid rocket booster recovery system, flight control system computer software, drag chutes that helped increase landing efficiency and safety, tests of the shuttle landing gear, tires and braking system with a specially-designed Landing Systems Research Aircraft (LSRA), and flight testing to better understand Shuttle external tank foam debris trajectories during launch.

Although Dryden is best known as NASA's lead installation for atmospheric flight research, the center has played a significant role in NASA's human spaceflight programs. Dryden's major past and present contributions to America's access to space date from the late 1950s and continue today as NASA looks toward resuming human exploration of the moon and the solar system.

X-15 Hypersonic Flight Research

The rocket powered X-15 was designed to explore the problems of atmospheric flight and suborbital space flight at supersonic and hypersonic speeds. It also served as a flying laboratory, carrying numerous scientific instruments up above the reaches of the atmosphere. Launched into a ballistic trajectory from beneath the wing of a modified B-52, the X-15 was capable of speeds in excess of Mach 6 and reaching altitudes above 350,000 feet – the fringes of space.

Using three X-15 vehicles, researchers collected a wealth of data during 199 flights accomplished between 1959 and 1968. The program made numerous contributions to aeronautical science and technology, many of which influenced modern aircraft and spacecraft design including those of the space shuttle and the Apollo lunar spacecraft.

Scientists and engineers found numerous applications for X-15 data related to hypersonic aerodynamics, advanced materials and structures, flight controls and energy management, aerothermal properties, and biomedical phenomena. The X-15 pilots – eight of whom earned astronaut wings during the program – experienced brief periods of weightlessness during their ballistic trajectories and gained experience in flying a low lift-over-drag approach to landing on the dry lakebed at Edwards Air Force Base, a technique used later for the space shuttle.

Among the most significant areas of research pioneered with the X-15 that contributed directly to development of the space shuttle:

- First use of reaction controls for attitude control in space
- First practical use of full-pressure suits for pilot protection
- Development of inertial flight data systems in high-dynamic-pressure and space environments
- Discovery of hot spots generated by surface irregularities
- Discovery that the hypersonic boundary layer is turbulent, and not laminar
- First demonstration of a pilot's ability to control a rocket-boosted aerospace vehicle through atmospheric exit
- Successful transition from aerodynamic controls to reaction controls, and back again
- Demonstration of a pilot's ability to function in a weightless environment
- First piloted, lifting atmospheric reentry
- First application of energy-management techniques for reentry guidance
- First application of hypersonic theory and wind-tunnel modeling to an actual flight vehicle
- Development of improved high-temperature seals and lubricants

The X-15 accelerates away from the B-52 mothership following ignition of its rocket engine. The white patches near the middle of the ship are frost from the cold liquid propellants. To withstand high temperatures from aerodynamic heating, the X-15 was built from Inconel-X and titanium alloys.

Wingless Lifting Body Vehicles

In the mid-1950s, engineering studies at NASA's Ames Research Center, Moffett Field, Calif., and Langley Research Center, Hampton, Va., resulted in the design of several aerodynamic shapes for vehicles that could survive the fast, fiery plunge from space into the atmosphere. Each of these wingless vehicles would generate sufficient lift through the shape of its fuselage for a controlled descent and a runway landing like that used for a conventional airplane. From 1963 to 1975, six full-scale vehicles were flight-tested at Dryden to determine the best configuration for a future reusable spacecraft. These tests validated the aerodynamics and low-speed handling qualities of each shape during approach and landing.

The first lifting body, designated M2-F1 was a lightweight vehicle built from plywood and fabric over a tubular-steel frame. It had no engine and was towed into the air — first behind a 1963 Pontiac convertible driving on Rogers Dry Lake and then behind a C-47 transport aircraft. It was flown hundreds of times in ground tows and over 70 times behind the C-47 from 1963 to 1966. The M2-F1 provided pilots with a basic feel for lifting body handling characteristics.

The wingless, lifting body aircraft included, from left to right, the X-24A, M2-F3 and the HL-10 in this 1969 photo. For a long time, the HL-10 shape was considered a leading contender for the space shuttle configuration.

Five heavyweight vehicles were flown at Dryden from 1966 to 1975. These included the M2-F2, M2-F3 (rebuilt from the M2-F2 – with the addition of a third vertical stabilizer – following a landing accident), HL-10, X-24A, and X-24B (a modification of the X-24A airframe with a different configuration).

A typical heavyweight lifting body flight profile began at about 45,000 feet with air launch from the same B-52 carrier aircraft used for the X-15. The pilot ignited the vehicle's rocket engine for a climb to altitudes of 50,000 to 80,000 feet, and then flew a gliding approach and landing similar to what would be used when returning from space. Most landings took place on the dry lakebed at Edwards.

The X-24B in flight over the lakebed at Edwards AFB, Cailf., in 1975.

In 1975, two touchdowns of the X-24B on the 15,000-foot concrete runway at Edwards validated the concept of making a precision low lift-over-drag landing on a conventional runway. These landings were representative of the type that would be flown with the space shuttles just a few years later. By this time, planners had already decided in favor of a winged configuration for the shuttle rather than a lifting body, but were considering including jet engines for use during final approach. The X-24B demonstrations verified that precise landings from space were feasible without the need for such engines, which would have added substantially to the weight of each vehicle and to overall program costs. Data from each lifting body configuration contributed to the database used to develop the shuttle and helped develop energy management and landing techniques.

All three X-15s, the HL-10, M2-F2 and M2-F1 lifting bodies and other aircraft in the main hangar at Dryden in 1966.

High-speed Flight Research

In 1969, Dryden began a high-speed flight research program with two YF-12 aircraft (one was actually an SR-71A, designated YF-12C for security reasons). These airplanes, capable of cruising at Mach 3 speeds and at altitudes above 80,000 feet, were flown over a 10-year span to collect data on materials, propulsion, aerothermal effects, and other phenomena associated with sustained high-speed flight.

During the program, Dryden engineers developed a central airborne performance analyzer that monitored a number of aircraft maintenance parameters, including the electrical, inlet control, and hydraulic systems. This device was capable of detecting problems arising during flight and presenting the information to the flight crew. The analyzer also provided data used for post-flight maintenance checks. Though initially developed solely as a research project, the central airborne performance analyzer became a forerunner of on-board diagnostic systems used on the space shuttles, as well as on a variety of other aircraft. The YF-12 program also produced some of the first measurements of thermally induced structural loads. These data were subsequently used to update analytical tools employed by designers of advanced high-speed aircraft including the shuttle.

The YF-12 was capable of cruise speeds up to Mach 3.2, and attaining altitudes above 80,000 feet.

Simulated Unpowered Shuttle Approaches and Landings with Winged Aircraft

In the early 1970's, Dryden used an Air Force B-52 and a NASA Ames Research Center CV-990 aircraft to fly a series of simulated Shuttle approaches and landings. The purpose of these tests was to investigate the flight characteristics of an orbiter without the use of an engine (unpowered) for landing purposes.

The unpowered approaches and landings were made with landing gear, spoilers, and landing flaps extended and all engines at idle power, providing a glide angle or sink rate comparable to that predicted for the proposed orbiter. These flights were not only flown by Dryden research pilots, but Apollo astronauts and even two airline pilots to demonstrate the feasibility of unpowered or "dead stick" approaches and landings for an orbiter returning to earth from space.

The success of these flight tests contributed significantly to NASA's decision not to incorporate jet engines into the orbiter design, thereby providing increased orbiter payload capacity and cost savings to the Shuttle Program.

Western Overland Route Used to Transport the Orbiters to Dryden

The Western Overland Route was conceived and developed at Dryden as the safest and most cost effective means of transporting the orbiters from Site 1 at Air Force Plant 42 in Palmdale, CA, where they were assembled, to Dryden. At Dryden the orbiters were lifted by the Mate Demate Device (MDD) and mounted atop the 747 Shuttle Carrier Aircraft (SCA) in preparation for ferry flights.

Requiring the cooperation of local agencies and some infrastructure changes in order to accommodate the orbiter's 78-foot wingspan, the overland route was used to transport the first five orbiters to Dryden. Weighing 150,000 lbs., the orbiters were mounted on a strong-back fixture known as the Over Land Transporter (OLT), which was towed by a semi-truck.

From Site 1, the orbiters were towed from Site 1 to Avenue M, to 10th Street East, to Avenue E, to a dirt road crossing Rosamond Dry Lake, to Rosamond Boulevard, to Lancaster Boulevard, to the Edwards AFB airfield and then to Dryden and the MDD via the aircraft taxi ways.

Enterprise was the first orbiter to be transported on the overland route to Dryden where it was flown for the approach and landing test and ferry test flights. Columbia, followed by Challenger, Discovery, and Atlantis were later transported on the overland route to Dryden in preparation for their initial ferry flights to Kennedy.

Enterprise mounted on the overland transporter being towed from Site 1 in Palmdale, CA. to Dryden at Edwards AFB, CA, on January 31, 1977.

By the time the sixth orbiter, Endeavour, was assembled, the Orbiter Lifting Frame (OLF), a lighter weight portable version of the MDD had been developed and was relocated from Vandenberg AFB, CA to Site 1. Like the MDD at Dryden, the OLF was used to lift orbiters so they could be mounted atop the SCA in preparation for ferry flights. Endeavour was the only orbiter to be ferried directly from Site 1 to Kennedy. Even though Endeavour was not transported to Dryden on the overland route, after retirement, she was towed over land on the OLT from LAX to her new home at the California Science Center.

Approach and Landing Test Program and Ferry Test Flights

The space shuttle Approach and Landing Test (ALT) program began in February 1977 following five years of planning, vehicle assembly, and systems testing. First, three taxi tests were conducted to validate structural loads and ground handling and control characteristics of the 747 Shuttle Carrier Aircraft (SCA) when mated with the prototype orbiter Enterprise.

Five captive-inactive flights followed, with Enterprise atop the SCA but without a crew on board, to collect aerodynamic data regarding the flight characteristics of the mated vehicles during takeoff, climb, cruise, and landing. These data were necessary not only for the initial glide flights of the orbiter, but also for later ferry flight operations.

During a series of three captive-active flights, astronauts were on board Enterprise with vehicle systems powered up to verify crew procedures that would be used during approach and landing.

Five free flights verified the orbiter's approach and landing capabilities and demonstrated its subsonic airworthiness. During each free flight, Enterprise was released from the SCA at altitudes between 19,000 and 24,700 feet, and the crew flew the vehicle to a glide landing. Tests of the shuttle's automatic flight control and navigation systems were prerequisites for orbital flights.

Enterprise flies free of the Shuttle Carrier Aircraft during the first of five free flights in the Approach and landing Test program.

Four of the flights ended on unpaved runways marked on the surface of Rogers Dry Lake. The fifth flight involved a precision landing on the 15,000-foot concrete runway at Edwards. This flight resulted in discovery of a potentially serious problem involving pilot-induced oscillation (PIO) that caused uncontrolled oscillations in pitch and roll, which was resolved using Dryden's F-8 Digital Fly-By-Wire aircraft.

Following the ALT program, Enterprise was reconfigured for ferry flight tests, conducted to ensure the SCA/orbiter mated configuration was viable for long duration flights between the landing and launch sites.

Pre-Flight Analysis of Aerothermally Induced Structural Loads and Orbiter Handling Qualities

Officials at Johnson Space Center asked Dryden engineers to conduct an independent analysis of two crucial areas of the orbiter design prior to its first orbital flight. These included aerothermally induced structural loads and orbiter handling qualities. Dryden had accumulated extensive expertise in both of these areas from the X-15, YF-12, and lifting body programs. Based on this experience, Dryden established levels of uncertainty that would exist in the predicted shuttle aerodynamic characteristics, and the shuttle control system was found to be capable of compensating for these uncertainties. Dryden's independent analysis of these areas identified some minor design deficiencies but verified the overall adequacy of the design to accomplish a successful entry from low earth orbit.

Shuttle management officials also asked Dryden to conduct a test of the orbiter elevon seals under simulated entry flight conditions. Dryden's Thermostructures Research Facility applied mechanical loads and heat to a test specimen that included a portion of the orbiter wing and elevon. This test was intended to verify proper functioning of the seals.

The seals were designed to prevent free-stream air from entering the gap between the aluminum wing structure and the elevons during movement of the control surfaces. The free-stream air temperature at atmospheric entry speeds greatly exceeds the melting point of the aluminum wing structure and it was essential to prevent superheated air from entering this gap and causing structural failure. The Dryden tests verified the design.

The NASA Dryden Flight Loads Laboratory is a unique national laboratory in which structural tests are conducted to support flight research and structures programs.

Shuttle Flight Control Software

In 1972, Dryden began research flights with the F-8 Digital Fly-By-Wire (DFBW) test bed – the first aircraft equipped with an electronic flight-control system coupled with a digital computer to replace conventional mechanical flight controls. Pilot control input was transmitted from the cockpit to a computer, and then to the aerodynamic control surfaces.

The F-8 DFBW was the forerunner of fly-by-wire flight control systems later used on the space shuttle, as well as on numerous military and civil aircraft to make them safer, more maneuverable and more efficient. Prior to the first shuttle orbital missions, this aircraft was used to test the IBM AP-101 computer hardware and software used in the orbiter's flight control system.

One of the most significant contributions to the shuttle was Dryden's use of the F-8 DFBW to solve the orbiter's pilot induced oscillation (PIO) problem. During the fifth ALT flight, the shuttle crew discovered that at the PIO condition, rate limiting decreased system gain and introduced phase lag into the system. In other words, when the pilot's initial input did not result in an immediate response, the pilot made a second input about the time that the first was being acted upon by the flight control system. This resulted in pitch and roll oscillations that ceased once the pilot let go of the controls and allowed the motions to damp out naturally.

The F-8 DFBW test bed was equipped with an electronic flight control system similar to that later developed for the space shuttle.

Researchers at Dryden sought to recreate the phenomenon using the F-8 DFBW, and develop a solution. Five research pilots flew PIO data flights in the F-8, making a total of 60 landings simulating the orbiter's control characteristics. They found that time lags as short as 200 milliseconds between pilot input and discernible control surface response profoundly affected the aircraft's handling qualities. To resolve the problem, Dryden engineers designed a PIO suppression filter that was incorporated into the orbiter's flight control system prior to the first orbital mission.

Microwave Scanning Beam Landing System Testing and Certification

From 1976 to 1982, Dryden's Jetstar aircraft was used to test and certify the Microwave Scanning Beam Landing System (MSBLS) for the space shuttle. This aircraft navigation system provided the precise position of the orbiter in relation to the runway during landing approach. The MSBLS consisted of equipment on board the aircraft and on the ground near the runway.

The JetStar was flown to Long Island, NY, where the AIL Division of Cutler Hammer installed the MSBLS equipment, and performed preliminary trials at Grumman's microwave test facility at Peconic, NY. In August 1976, NASA research pilots flew 21 MSBLS approaches to Runway 17 at Edwards. A laser tracking system provided the airplane's exact position in flight to validate the accuracy of the MSBLS.

NASA's JetStar was used to conduct MSBLS testing and certification for the space shuttle.

MSBLS commissioning tests certified Runway 17 for the use in the ALT program. A second set of MSBLS ground stations were installed for Runway 22 at Edwards in November 1976, and others were eventually installed at KSC, White Sands, and various shuttle contingency landing sites around the world. Dryden pilots logged 671 flight hours during 346 missions to check out MSBLS equipment at the three primary shuttle landing sites.

Solid Rocket Booster Recovery System

Dryden conducted Solid Rocket Booster (SRB) parachute recovery systems tests from June 1977 through 1978, and again from September 1983 to March 1985, to validate the system used to recover the space shuttle's rocket booster casings once their propellant was exhausted. For these tests, Dryden's modified B-52 carried a Drop Test Vehicle (DTV) that simulated the weight of the SRB.

The DTV was repeatedly dropped over the deserts of Southern California at the National Parachute Test Range near El Centro and China Lake Naval Weapons Center near Ridgecrest. These tests verified the performance and reliability of the parachute recovery system later used to recover the booster casings after they separated from the shuttle's external fuel tank during launch.

NASA Dryden's NB-52B mothership carries a Space Shuttle Solid Rocket Booster Drop Test Vehicle.

The boosters were one of the reusable components of the Space Transportation System. After being retrieved from the ocean, the SRBs were refurbished for use on later shuttle missions.

Orbiter Tile Tests

A NASA F-104 with an experimental fixture under the fuselage, and a rack under each wing. This airplane carried shuttle thermal protection tiles during flight loads tests and rain exposure studies.

In 1980, Dryden research pilots flew 60 flights to test the space shuttle's ceramic thermal protection system (TPS) tiles under various aerodynamic load conditions. Two research aircraft, an F-15 and an F-104, were used for the tests. TPS tiles were glued to special fairings on the F-15 and attached to a ventral flight-test fixture on the F-104.

The tiles were subjected to speeds of Mach 1.4 (nearly 1½ times the speed of sound) and dynamic pressures of 1,140 pounds per square foot to test them for deformation or structural changes as a result of the flight loads. They were also exposed to moisture in clouds, and artificial rain sprayed from a modified aerial tanker to study rain erosion effects.

The tiles assemblies tested represented six locations on the orbiters: the forward wing glove area, vertical tail leading edge, window post area, elevon trailing edge, elevon hinge area, and closeout tiles aft of the wing leading edge.

The Dryden TPS tile flight test program led to several changes to improve bonding and attachment techniques.

Shuttle Landing Support

The space shuttle Endeavour touches down at Edwards Air Force Base Nov. 30, 2008, concluding mission STS-126 to the International Space Station.

The Dryden/Edwards complex was selected as a shuttle landing site because of the safety margin presented by Rogers Dry Lake and its long runways. After Kennedy Space Center became the primary site for operational landings, Dryden continued to serve as an alternate site when unfavorable weather precluded a landing in Florida, or special circumstances necessitated a lakebed landing.

Scores of Dryden personnel supported each shuttle landing at Edwards, which included staffing and operating the Dryden Mission Control Room where orbiter reentry and descent parameters were monitored, post-landing orbiter servicing and processing operations; post-landing crew physicals, hosting agency and program visitors viewing the landings, and staffing and operating a media information center for domestic and international news personnel covering the landings.

During the program there were 54 shuttle landings at Dryden, starting with STS-1 on April 14, 1981, and ending with STS-128 on September 11, 2009.

Orbiter Drag Chute Tests

An experimental drag chute deploys amidst a cloud of dust behind NASA's B-52 research aircraft just after landing on Rogers Dry Lake.

In 1990, Dryden used its B-52 to test a drag parachute system for use on the space shuttle orbiter to provide better deceleration capabilities during landing, reduce tire and brake wear, and shorten runway rollout.

A series of eight drag chute deployment tests were carried out with the B-52 landing at speeds ranging from 160 to 230 miles per hour on a lakebed runway, and also on the 15,000-foot concrete runway at Edwards. Instrumentation on the B-52 obtained data during chute deployments to validate predicted loads that an operational orbiter would sustain with a drag chute.

A series of eight drag chute deployment tests were carried out with the B-52 landing at speeds ranging from 160 to 230 miles per hour on a lakebed runway, and also on the 15,000-foot concrete runway at Edwards. Instrumentation on the B-52 obtained data during chute deployments to validate predicted loads that an operational orbiter would sustain with a drag chute.

Endeavour (OV-105) was the first orbiter equipped with the drag chute. The device was deployed for the first time at the end of mission STS-49 on May 16, 1992.

Orbiter Landing Gear and Brake Tests

In the mid 1990's a CV-990 aircraft, modified and operated by Dryden personnel, performed landing gear and brake testing using an orbiter landing gear retraction system installed in the lower fuselage between the aircraft's main landing gear. During tests, the orbiter landing gear was lowered once the aircraft's main landing gear had contacted the runway. This allowed touchdowns at much higher speeds and loading on orbiter tires than existing ground facilities, and could duplicate conditions similar to actual shuttle landings.

Engineers assessed and documented tire wear as loads of up to 140,000 pounds were applied. The results of these tests led to a decision to resurface the runway at Kennedy Space Center to reduce tire wear and extend the crosswind landing limits up to 20 knots.

A space shuttle landing gear system is visible between the two main landing gear components on this NASA CV-990, modified as a Landing Systems Research Aircraft.

Shuttle External Tank Insulation Tests

F-15B flight tests in January 1999 demonstrated that a new type of insulation foam used on the Space Shuttle's giant external tank remains intact under some of the dynamic environments seen during the initial stage of the Shuttle's ascent.

Mimicking a Space Shuttle launch profile, the F-15B flew a series of missions to evaluate the dynamic response characteristics of the new insulation material. The Shuttle External Tank Experiment involved six research flights over a two-week period by Dryden's F-15B in partnership with NASA's Marshall Space Flight Center, Huntsville, Ala., and the Michoud Assembly Facility near New Orleans, La.

On each flight, the F-15B was put through a series of side-to-side yaw maneuvers beginning at 7,300 feet altitude. Speed and altitude were increased in a stair-step approach, finally zooming up to 61,000 feet at speeds of up to Mach 1.5 before descending for landing.

Test panels covered with advanced spray-on foam insulation were flown on NASA's F-15B testbed for Space Shuttle external tank tests

Lifting Insulation Foam Trajectory (LIFT) Tests

To help prepare the space shuttle for a safe return to flight after the Columbia reentry accident, Dryden conducted a series of flight tests to determine how pieces of insulating foam debris, or "divots," behave when small pieces are shed from the shuttle's external fuel tank during launch.

The Lifting Insulating Foam Trajectory (LIFT) flight test series used the center's F-15B Research Testbed aircraft to conduct the experiments in a real flight environment at speeds up to about Mach 2, or twice the speed of sound.

The LIFT flight tests required two new capabilities: an in-flight foam divot ejection system, and a high-speed video system to track and record the trajectories of the divots in flight. Dryden engineers and technicians developed these capabilities in just over two months. The LIFT team designed, fabricated, and ground-tested four different divot ejection systems, completing 70 ground tests to determine and refine the best approach.

Dryden engineers also designed and procured the high-speed digital video equipment and developed a system to synchronize the cameras with the divot ejection system. In addition, they developed video analysis techniques in order to quantify divot trajectories.

Divots of thermal insulation foam were ejected from the flight test fixture on NASA's F-15B testbed and captured on video for analysis.

Dryden's Shuttle Support Facilities, Systems and Equipment

In the 1960's America's human space flight program was geared toward pursuing President John F. Kennedy's goal of putting a man on the moon before the end of the decade. For the Mercury, Gemini, and Apollo programs, expendable space vehicles with ballistic crew capsules – that were recovered from the ocean following reentry – represented the most expedient approach to putting humans into space and returning them safely to Earth. At the same time high speed/high altitude aerospace research programs such as the X-15 and lifting bodies were flown at Dryden to prove the viability of a reusable space vehicle that could be launched into orbit and return to a conventional runway landing. Studies leading to what would become the space shuttle began even before the first lunar landing. On January 5, 1972, President Richard M. Nixon formally announced that the Space Transportation System would become NASA's follow-on program to Apollo, and would consist of a reusable orbiter lofted by solid-fuel rocket boosters and engines fueled from an expendable external tank. The space shuttle, as it came to be commonly known, would be used to build a permanent manned space station and deploy and service satellites in low earth orbit.

Since the orbiter would be reusable, it required special ground facilities, systems, and equipment to service it before and after each mission. Because it would not have jet engines for atmospheric flight, it also required special means of transportation to move it from alternate landing sites to Kennedy Space Center, Fl., in preparation for its next mission. Once the final design of the orbiter was selected, NASA began the arduous process of determining what kind of facilities would be needed and where they would be located. By 1974, NASA decided that the space shuttle Approach and Landing Test program and Secondary Landing Site (SLS) operations would be performed at Dryden.

Shuttle Processing Area (Areas A & B)

By late 1974, NASA had decided to construct shuttle facilities at Dryden to include a hangar with attached shop space, trailer complex, tow-way, parking area, fuel and oxidizer storage area, and mate/de-mate facility. KSC was the principal authority for design and construction, with Dryden providing a master plan for the site and associated infrastructure. Once completed and accepted by KSC, these facilities were turned over to Dryden for real property accountability, operations and maintenance, with KSC retaining responsibility for configuration control and sustaining engineering.

A view of the Dryden Shuttle Processing Area from the north as photographed in April 1981, with the Space Shuttle Columbia in the Mate/De-mate Device following its first orbital mission, STS-1.

An aerial view of the Dryden Shuttle Processing Area in 1993. The fuel and oxidizer storage area is in the lower right.


A view of the Dryden Shuttle Processing Area and the Post-flight Science Support Facility (lower left) from the south as they appeared on October 13, 2008. The concrete tow-way (60 feet wide and 15 inches thick) connects the MDD and the Space Shuttle hangar and the main Dryden complex, which in turn provides access to the Edwards Air Force Base flightline and runways. One of the 747 Shuttle Carrier Aircraft sits in front of the hangar.

The Mate/De-mate Device (MDD)

The Mate/De-mate Device (MDD) was a large gantry-type steel structure used to hoist the orbiters off the ground during post-landing servicing operations and during mating and de-mating operations with the 747 Shuttle Carrier Aircraft (SCA). It consisted of two 100-foot towers with stationary work platforms at the 20-, 40-, 60- and 80-foot levels and a 70-foot cantilevered horizontal structure mounted at the 80-foot level between the two towers to control and guide a large sling that attached to the orbiters to raise and lower them.

Three large hoists were used to raise and lower the sling. Two of the hoists were connected to the aft portion of the sling and one was attached to the sling's forward section. The three operated simultaneously during the hoisting process. Each of the hoists had a 100,000-pound lift capability. Operating together, the total lifting capacity of the three units was 240,000 pounds (120 tons). Two additional equipment hoists, each capable of lifting 10,000 pounds were also built into each tower. These hoists operated up to the 60-foot level of the MDD.

Left: an orbiter attached to the sling in the MDD with the side access panels lowered in place on the side of the orbiter. Right: Endeavour attached to the sling and hoisted inside the MDD following STS-49 in 1992.

During orbiter turnaround operations, two access platforms used for servicing the orbiter were positioned on each side of the vehicle after it was towed into the MDD. These platforms were normally stored at the 60-foot level when not in use. During servicing operations they were lowered on each side of the orbiter by a pair of telescoping tubes extending down from the cantilever section.

The MDD was designed by Connell Associates Inc. of Coral Gables, Fla., and constructed in 1976 by George A. Fuller Co., Chicago, Ill., at a cost of $1.7 million. It was first used during mate/de-mate operations with the prototype orbiter Enterprise during the ALT program in 1977 and then for all orbiter post-landing and SCA mating operations at Dryden.

The Space Shuttle mated with the 747 SCA in the MDD at Dryden.

Lightning strikes in the distance as Discovery receives post-flight processing in the MDD following post-Columbia return to flight mission STS-114 in August 2005.

Atlantis in the MDD being mated to 747 SCA 905 in preparation for her ferry flight to KSC in late June 2007, following STS-117.

The Space Shuttle Hangar

The Space Shuttle hangar, near the MDD, was a single-bay 25,000-square-foot structure 170 feet deep, 140 feet wide and 80 feet high originally used for maintenance and modification of the orbiter Enterprise. A 6,700-square-foot annex on the north side of the hangar building was used for administrative offices, a ground operations control room and a joint-use shop area. Inside the hangar, two overhead bridge cranes provided lift capability for orbiter or servicing equipment and maintenance operations. Each crane had a lift capability of 50,000 pounds. Voorheis, Trindle and Nelson, Irvine, Calif., designed the hangar. It was built by Santa Fe Engineers Inc., Lancaster, Calif., at a cost of $3.7 million. Construction was completed in 1976. Following the ALT program, it was primarily used as a maintenance facility for large equipment such as the purge and cool transporters and the orbiter tail cone.

The shuttle hangar and logistics warehouse (below the hangar) along with some of the newer facilities appear in this photo taken around 2000. The tail cone shipping containers are lined up below the warehouse. The large tan building in the forefront was the Payloads Processing Facility where experiments returning from space onboard the orbiter were processed.

Other Shuttle Area Facilities

A total of 29 facilities at Dryden were used specifically for shuttle support at Dryden. These included the Shuttle and Flight Operations Support Office, or simply “the Shuttle Office”, where NASA shuttle management personnel responsible for shuttle support oversight were located; the Payloads Processing Facility (PPF), a 4,000 square foot facility used for post-flight processing of animal and plant experiments returning from space onboard the orbiter; the Post-flight Sciences Support Facility (PSSF) was a 4,000 square foot facility used to conduct post-flight physicals and testing of the shuttle astronauts returning from space; a 10,000 square foot logistics warehouse provided storage for consumables, parts, tools, and equipment required for day-to-day shuttle facilities and ground support equipment maintenance and space shuttle orbiter post-flight servicing in preparation for ferry back to KSC; office space for on-site contractors, shop space for the personnel who worked on the various equipment, systems, and vehicles used to support shuttle as well as the shuttle carrier aircraft. Dedicated space was also available for NASA personnel from other NASA centers who traveled to Dryden to support shuttle landings, recoveries, turnarounds and ferry flights.

Shuttle Landing Systems

Special equipment to support shuttle landings was installed, operated and maintained by Dryden personnel and included the Microwave Scanning Beam Landing System (an instrument landing navigation system), and four visual landing systems. Another navigation system used by the orbiter flight crew was the Edwards AFB Tactical Air Navigation (TACAN) which provided bearing and distance (slant-range) information from a ground station to the orbiter. MSBLS and TACAN data was displayed on the Heads-up Display (HUD), where it could be monitored along with the visual landing systems as the commander and pilot looked out the front window of the orbiter. Systems specifically supported by Dryden personnel are described below.

Microwave Scanning Beam Landing Systems (MSBLS)

As the orbiter rolled out on final approach to the runway at approximately 12,000 feet altitude and 7 miles away from the runway, the Microwave Scanning Beam Landing System (MSBLS) provided highly accurate three-dimensional position information to the orbiter to compute steering commands in order for the shuttle commander to maintain the nominal flight trajectory during the landing phase of the mission. MSBLS systems were housed in shelters located and utilized on runways 22L, 22R, 04L, 04R and on lakebed runways 23, 17, and 15 earlier in the program.

MSBLS Shelters in place on the lakebed.

Precision Approach Path Indicator (PAPI) Lights

During final approach the commander used visual landing systems to verify the orbiter's position for landing. The first visual landing system used was the PAPI lighting system, which provided an outer glide slope lighting sequence indicating if the orbiter was on, above, below, left or right of the glide slope, prior to landing. Two sets of PAPI lights, one located at 7,500 feet and another located 6,500 feet, before the threshold, and on the centerline extending from the runway, were used to provide an indication of an 18- to 20-degree glide slope, which is six times steeper than the 3-degree slope of a typical commercial jet airliner.

One of the PAPIs located on the 6,500-foot aiming point.

Ball/Bar lights

As the orbiter got closer to the runway the commander used the ball/bar lighting system which provided an inner glide slope lighting sequence during landing. The ball/bar lights were installed along the runway on the left side (the commander's side of the orbiter). The pole-mounted lights forming the ball were located 1,700 feet down the runway and a bar with series of lights was located 2,200 feet down the runway. As the orbiter approached the runway, the commander would watch for the white ball light to be superimposed on the bar of red lights, indicating a 1.5 degree glide slope, allowing the commander to set the orbiter down approximately 2,500 feet down the runway.

Portable Approach Lights used to light the approach path to the runway.

Portable Approach Lights

In addition to the landing systems above, special lighting systems were required for night landings. Portable approach lights were special flashlights placed in a predetermined pattern on the underrun of the runway along a 3,000-foot extension of the runway centerline to give a lighted visual reference of the approach path to the runway to the orbiter commander and pilot.

Xenon Lights

Another lighting system used for night landings were xenon lights, high intensity one billion candle power flood lights that illuminated the touchdown and rollout areas of the runway. The xenon lights were mounted on trucks with scissor-lift beds that could be raised as high as 20 feet to ensure proper height alignment. They were located on each side of the threshold of each runway.

Two xenon lights illuminate the runway as a space shuttle rolls to a stop during a night landing at Edwards AFB, Calif.

A pilot's view of an approach to runways 22L and 22R taken in 2008 when 22R was being paved. The Shuttle approach PAPI aiming points for 22R are clearly visible on the lakebed and are also visible on the opposite ends (04L and 04R) of the runways.

A Heads-Up Display (HUD) view of Discovery's approach to runway 22L at Edwards AFB, Calif. ending STS-128 on September 11, 2009. This view indicates that Discovery is on the outer glide slope (7,500 foot PAPI) aiming point at an altitude of 10,100 ft and an airspeed of about 292 knots.

The Shuttle Support Team at Dryden and Edwards AFB

Throughout the program approximately 275 DFRC and Department of Defense (DoD) employees supported west coast shuttle landings. Approximately 50 NASA civil servant and contractor employees provided daily support to ensure that Dryden and Edwards were ready to support landing, recovery, post-fight servicing and ferry of an orbiter. During landing operations this number increased to 116 civil servant and contractor employees.

During post-flight processing another 150 personnel, primarily from KSC deployed to Dryden to prepare an orbiter for its ferry flight to KSC. The DoD provided approximately 159 military, civil service, and contractor personnel for contingency support during shuttle landings at Edwards. Many NASA and Air Force personnel also supported Shuttle Training Aircraft operations at Edwards.

Dryden shuttle support included on-orbit and entry radar, telemetry and communications; staffing the Dryden Mission Control Room for orbiter entry and landing; post-landing astronaut physicals and testing; staffing the Shuttle Area Ground Operations Control Room for post-landing orbiter servicing operations; post-landing orbiter servicing operations; hosting of agency and program visitors who viewed the landings; and staffing and operating a media information center for domestic and international news personnel. A project/operations manager, airfield scheduling coordinator, flow engineer and other employees assigned to the Dryden Shuttle and Flight Operations Support Office managed these complex activities at Edwards.

The Air Force Flight Test Center at Edwards provided DoD landing contingency support within 25 nautical miles of the base, in case an emergency situation arose before, during or after landing. Supporting DoD organizations included not only AFFTC personnel, but others from March Air Reserve Base, the Army's Fort Irwin, the Naval Air Weapons Station at China Lake, and the Civil Air Patrol's 35th Air Rescue Squadron in Pacoima, Calif. These personnel were trained and capable of responding to any space shuttle landing contingency including command and control, security, search and rescue, fire, bio/hazards, medical, weather, airspace and airfield management. The Edwards Space Shuttle Contingency Response Team Director, Edwards Shuttle Project Manager and the DoD Shuttle Support Coordinator were responsible for coordinating these activities.

The Dryden STS-1 landing, recovery, and turnaround team in front of the Shuttle hangar in April 1981.

The Dryden STS-135 landing, recovery, and turnaround team in front of the Shuttle hangar at day break on July 21, 2011.

The Western Aeronautical Test Range

The Western Aeronautical Test Range (WATR) at Dryden Flight Research Center, located on the Edwards AFB complex, supported all segments of the Space Shuttle Program, including the launch, on-orbit, and landing phases of each mission.

The WATR Aeronautical Tracking Facility

Aeronautical Tracking Facility (ATF)

The WATR Aeronautical Tracking Facility (ATF) provided telemetry, radar, voice communication, and video support of Shuttle and International Space Station (ISS) activities to Johnson Space Center (JSC).

The radar systems tracked every Shuttle orbit above five degrees in Edwards AFB airspace from launch to landing, relaying time-space positioning information. The radar systems also tracked the ISS from the day prior to the Shuttle launch and throughout the Shuttle mission to provide critical docking and un-docking information.

The telemetry systems provided downlinked orbiter health and status information to JSC and, when available, the pilot's point of view (PPOV) video sent to the NASA network via satellite. When required, the telemetry systems also had the capability to provide uplinked command data to the orbiter.

The WATR Communications Facility

Communications

The communications facility provided voice communication circuits between the various NASA centers and DOD facilities during each mission. While NASA's Tracking and Data Relay Satellite System (TDRSS) provided the orbiter's primary voice communication link, Dryden's communications facility provided backup support for TDRSS in the event of a failure during a Shuttle mission. In addition, the communications facility was the primary means of communication support when the Shuttle was diverted to Edwards for a landing.

The Long-Range Optic Tower south of runway 22.

Mission Control Center and other support

Additional support provided by the WATR for a shuttle landing at Edwards included long-range optics, vans equipped to provide video coverage and the Mission Control Center (MCC) which offered key support personnel a location in which to coordinate and monitor landing activities. All crucial WATR areas had uninterrupted power systems (UPS) as well as backup generators to ensure support during Shuttle activities. In addition, personnel were on sight to monitor the backup power systems and provide any emergency services required during critical shuttle operations.

One of the two Dryden Mission Control Rooms used to support shuttle landings.

Department of Defense Support

The Air Force Flight Test Center led Department of Defense (DoD) support for shuttle landings at Edwards, ensuring that the runways and airfield were secure and ready, and that emergency services were available in the event of a shuttle landing contingency. While NASA led nominal or normal, shuttle landing and recovery operations, had there been a contingency, such as a fire, or major toxic fuel leak, NASA would have declared an emergency and turned the operation over to the DoD shuttle contingency support team. Fortunately, an emergency never had to be declared.

Organizations at Edwards supporting shuttle landings and contingency exercises were each assigned specific areas of responsibility. The 95th Civil Engineer and Transportation Directorate ensured that runways and taxiways required for shuttle support were ready and available. The 95th Security Forces Squadron provided perimeter security and escorted the recovery convoy. The 95th Communications Squadron ensured base communications were operational. The 412th Operations Support Squadron managed the airfield, air traffic control and airspace clearance for shuttle landings, exercises and Shuttle Training Aircraft flight activities. The base fire department provided rescue and firefighting support. The 95th Aerospace Medical Squadron provided environmental engineering support in case chemicals or gases were released from the shuttle.

The flight surgeon's office and 95th Medical Operations Squadron, March Air Reserve Base, Calif., Naval Medical Center San Diego, Calif. and Fort Irwin, Calif. provided emergency medical care services. In the event of a contingency they were prepared to provide initial assessment of the astronaut crew and transportation via Army helicopters from Fort Irwin. to medical facilities at Loma Linda University and the University of California, Los Angeles (UCLA). Naval Air Weapons Station (NAWS) China Lake, near Inyokern, Calif., provided a helicopter for security and video support following shuttle landings. The Civil Air Patrol's 35th Air Rescue Squadron, Pacoima, Calif., provided in-air photography services as well. Other organizations included the Edwards AFB 95th Air Base Wing command post, Public Affairs office, and Flight Safety office.

DoD Contingency Exercises

Twice each year, DoD contingency exercises were held at Edwards to ensure the shuttle landing contingency support team was ready to support space shuttle landings in accordance with NASA's standards. Detachment 3 of the DoD Human Space Flight Support Office (formerly the DoD Manned Space Flight Support Office) at Patrick AFB, Florida directed these exercises as a safety requirement. During each exercise about 300 Edwards, March Air Reserve Base, Naval Medical Center San Diego, NAWS China Lake, Fort Irwin, Calif., Det. 3 and NASA personnel participated, practicing orbiter nominal and emergency space shuttle recovery operations because the shuttle had some very special handling requirements due to the toxic fuels used to power its various systems. Often these exercises followed a week of training provided by NASA and Det. 3 personnel in the latest shuttle landing contingency procedures.

A few months before each exercise, Edwards and NASA shuttle landing support leaders would begin planning and coordinating the scenarios that would be practiced. Typically, two of the four following landing contingency abort modes would be selected in developing the scenarios.

- **Mode V** - unaided egress and aided escape, where, after landing on the runway, the orbiter developed a problem such as smoke or fire and the astronauts could egress the orbiter, but need assistance from rescue personnel to get safely away from the orbiter.

- **Mode VI** - aided egress and aided escape, which was similar to a Mode V, however rescue personnel had to enter the orbiter, power it down and assist the astronauts in escaping from the orbiter.

- **Mode VII** - landing off the runway, aided egress and aided escape, which was similar to a Mode VI only extra precautions had to be taken because the orbiter landed somewhere other than the runway.

- **Mode VIII** - bailout, where the crew had to egress the orbiter in flight and had to be located/cared for by search and rescue personnel until more help could arrive.

During an exercise a shuttle approach and landing would be simulated to include the DoD organizations previously mentioned as well as local NASA shuttle support staff. NASA and DoD convoy and landing support elements were used and staged for a nominal landing, using Edwards AFB's shuttle crew rescue trainer, a life-size mockup of the orbiter's crew module designed and used for crew rescue purposes. At the appropriate time a "mode" would be declared by NASA at which time the DoD shuttle contingency team would move into action to assess and safe the orbiter, rescue and/or get the simulated astronaut crewmembers safely away from the orbiter. Medical personnel would assess the condition of the crew and prepare them for evacuation. The crew would then be loaded into the helicopters and flown to medical facilities at Loma Linda or UCLA. Usually, once the helicopters were close to the medical facilities the exercise would end. Following each exercise, de-briefings would be held to discuss lessons learned.

As fire-rescue personnel prepare evacuation litters, two stand-in "astronauts" use an exit slide from the Shuttle Crew Module Rescue Trainer during a rescue training exercise at Edwards AFB, Calif., in 2005.

Air Force rescue team members load a volunteer "injured astronaut" on a stretcher into a Blackhawk helicopter from Fort Irwin, Calif., for evacuation to a hospital during a shuttle landing contingency exercise at Edwards AFB, Calif.

The Orbiter Recovery Convoy

From launch to landing the orbiter recovery convoy at Dryden was ready and on call to support either an early end of mission (EEOM) or nominal end of mission (EOM) landing. The convoy consisted of 25 vehicle elements, many of which were specially designed to support the recovery, towing, and/or turnaround post landing operations required to prepare the orbiter for its ferry flight to KSC. Approximately 200 Dryden, Edwards AFB, and KSC personnel were a part of the convoy and performed a myriad of duties associated with assisting the astronauts in exiting the orbiter, safing the orbiter and then towing it to the Dryden MDD, where further servicing was performed in preparation for the ferry.

On landing day, convoy personnel arrived at Dryden about 3½ hours before landing to prepare for landing support. 2½ hours prior to landing a call-to-stations was held to ensure all personnel and equipment were ready to depart the Shuttle Area. 2 hours before landing the convoy departed the Shuttle Area for the Edwards AFB fire station to meet up with the Edwards AFB convoy elements including fire, rescue, and security vehicles and personnel. 1½ hours before landing the convoy commander held a final briefing to inform all convoy personnel of the latest landing plan. About 1 hour and 10 minutes before landing, the convoy departed the fire station to stage near the runway. Ten minutes before landing, the convoy commander conducted a readiness poll to ensure all personnel and elements were ready to support.

The Dryden Shuttle Recovery Convoy on its way to meet with Edwards AFB fire and rescue convoy elements for an exercise in 2005. With Edwards AFB Security providing an escort, the convoy vehicles from front to back are: the NASA 25 Convoy Command Vehicle, SCAPE 1, Crew Van, Fan Truck, White Room, Flight Crew Equipment Van, Payloads van, Astrovan, SCAPE Base, a manlift, Purge 1, Cool 1, Cool unit, Purge unit, and service trucks. Not shown are the Crew Transport Vehicle, tug and tow-bar, which were not typically deployed for an exercise.

Once the orbiter landed and rolled to stop the convoy elements rolled onto the runway and staged 1,350 feet away from the orbiter. A safety assessment team outfitted in SCAPE (Self Contained Atmospheric Protection Ensemble) suits and carrying vapor detection equipment would then approach the orbiter to determine if any toxic vapors were emanating from the orbiter. When it was determined to be safe, the remaining convoy elements rolled into their positions to begin recovering the orbiter so it could be towed to the Shuttle Area.

The Purge and Cool units moved into position behind the orbiter where their umbilical hoses were connected to the orbiter and the flow of air into the orbiter began. The Purge unit provided cool and humidified air to lines in the orbiter payload bay and other areas of the orbiter to remove any toxic fumes. The Cool unit provided a freon loop for cooling the orbiter environmental and avionics systems, so the orbiter's limited onboard cooling system could be powered down.

During this time, the astronaut crew was preparing to exit the orbiter. The White Room vehicle was moved up to the hatch followed by the Crew Transport Vehicle (CTV). About 45 minutes after landing, the hatch was opened, and the crew egressed the orbiter into the white room and then into the CTV. Within an hour, the safety assessment team typically gave total safety downgrade after which the astronauts and remaining convoy and ground crew personnel could approach the orbiter. At this time the astronauts would perform a post-flight walk around of the orbiter before boarding the CTV or astrovan for the trip to the Post Flight Sciences Support Facility (PSSF) at Dryden.

Convoy and other ground crew personnel continued to service and prepare the orbiter for the tow to the Shuttle Area. The runway measurements team measured the orbiter rollout distance from touchdown through wheel stop. The flight crew was replaced by a change-out crew who prepared the inside of the orbiter for the towing operation. Any critical or time-sensitive experiments or payloads were removed from the orbiter payload bay. Critical areas of the orbiter were inspected for damage such as the tires, landing gear, thermal protection system tiles and blankets, and any other areas of concern. The landing gear was locked and prepared for tow. The tow vehicle and tow bar were positioned in front of the orbiter and connected. The remaining convoy elements were then positioned for tow and then towing operations began. Towing typically began 6-8 hours after landing and lasted about 2 hours before the orbiter was in place or "spotted" inside the MDD. Major elements of the convoy included:

Convoy Command Vehicle

The mobile command post used as a command and control center during orbiter recovery and towing operations.

SCAPE 1 and SCAPE Base

Vehicles used to transport SCAPE personnel and equipment required to perform initial safety assessment of the orbiter including specialized air and chemical monitoring equipment as well as SCAPE suits used by technical personnel.

Fan Truck

A vehicle used to tow and position a large trailer-mounted fan which provided external airflow, over the crew module to dissipate any potential toxic gas vapors when prevailing winds are less than 5 knots.

White Room

A truck with a small room and stairway mounted on it used to access the orbiter hatch and for astronaut and ground crew access in to and out of the orbiter.

Columbia and the Shuttle Carrier Aircraft fly overhead as Endeavour is being prepared for tow on runway 22 at Edwards AFB, Calif., following landing and completion of STS-68 on October 11, 1994, Columbia was being ferried to Palmdale to undergo maintenance.

Flight Crew Equipment Vehicle

A vehicle used to transport critical and time sensitive experiments and payloads from the orbiter to the PPF in the Shuttle Area

Crew Transport Vehicle

A converted airport people-mover, used as a mobile medical facility to examine, care for and transport the astronauts to the DFRC PSSF for further medical examination and care.

Astrovan

A motorhome type vehicle used as a back-up mobile medical facility to examine, care for and transport the astronauts to the DFRC PSSF for further medical examination and care.

Cool and Purge Stair Trucks

Vehicles used to gain access to the aft of the orbiter in order to attach the ground cooling and purge unit hoses to the orbiter.

Cool unit

Provided a continuous freon loop, to various internal plumbing and cold plates inside the orbiter after landing.

Purge unit

Provided cool air to internal areas within the orbiter. Various vent doors were opened after landing to insure airflow throughout the mid body and payload bay.

Crew Module purge unit

Provided cooling air into the white room and crew module after landing.

Tug and Tow Bar

Used to tow the orbiter to the Dryden Shuttle Area.

Service Trucks

Provided tools, equipment and personnel to troubleshoot and repair any problems with the convoy elements.

TV 1 and 2

Mobile television vehicles used to televise orbiter landings, rollouts and recoveries.

The Shuttle Convoy returning to Dryden with Atlantis in tow following landing and completion of STS-117 on June 22, 2007.

Endeavour, accompanied by recovery convoy vehicles as she was towed up the taxiway at Dryden following landing and the completion of STS- 111 on June 19, 2002.

Runway Measurements Team

Following each landing at Edwards AFB, Dryden's runway measurements team was required to accurately determine the touchdown points of the orbiter's main and nose gear tires and then measure the complete landing rollout distance of the orbiter. From the touchdown points, a calibrated fifth-wheel attached to the rear of the team's vehicle was used to measure the distance to the point where the orbiter came to a complete stop. These measurements included the length of each tire skid/spin up, total rollout distance to the point where each wheel came to a complete stop, as well as position in relation to the centerline of the runway. The team also accurately documented and retrieved the final resting places of the various drag chute components that were jettisoned during deployment of the drag chute during the landing rollout. These components included the drag chute door, mortar cover, sabot, and main chute. All of these measurements were documented in an official report by the team and used by shuttle engineers to evaluate the orbiter's landing wheel, brake and nose wheel steering performance.

During the Shuttle Program rollout distances varied from a minimum of 6,015 feet, to a maximum of 13,732 feet, with an average rollout distance of 9,188 feet. Variances in the rollout distance were due to landing conditions such as weather, wind speed and direction, orbiter weight, sink rate, landing speed, braking time, chute deployment, runway surface, etc.

Early in the program there were problems with the orbiter's nose wheel steering system and excessive brake and tire wear during the landing rollout. Data gathered by the runway measurements team was used to document and research these problems. This data, along with brake and tire wear data gathered from the CV-990 Landing Systems Research Aircraft, led to nose wheel steering, tire and brake improvements as well as the smoothing of the Shuttle Landing Facility runway surface at Kennedy Space Center.

The calibrated fifth-wheel attached to the rear of a vehicle was used to measure the landing roll out distance of the orbiter Discovery following its landing at Dryden concluding the STS-128 mission.

Post-landing Orbiter Servicing

Once the orbiter was in the Shuttle Area and "spotted" (in position) in the MDD, the seven-day turn-around phase of post-flight processing began, which included more detailed inspections, servicing, and preparations for the ferry flight to KSC. Among the first things to be completed is the attachment of the sling to the orbiter so it can be raised off the ground and leveled. Once level, the side access panels (SAPs), one on each side of the orbiter were then lowered into place allowing engineers and technicians access along both sides of the orbiter. Some of the turnaround tasks performed included installation of OMS, RMS, windshield and other external covers; shuttle main engine drying operations; offloading of cryogenics; removal of the external tank separation camera; inerting the Power Reactant Storage and Distribution system battery tank; purging of the OMS fluid lines and valves and other tasks requiring access to the aft end of the orbiter; and inspection, annotation and photography of nicks and other damage to the thermal protection system tiles and blankets. Ferry flight preparations included: installing the tail cone; raising the orbiter's landing gear; positioning the body flap; lifting the SAPs and then the orbiter; towing the SCA into the MDD; lowering the orbiter onto the SCA and securing it in place; and backing the SCA, with the orbiter on top, out of the MDD. Weather permitting, ferry flight operations and the flight to KSC were ready to commence.

Endeavour level in the MDD with the yellow sling attached and the SAPs lowered. The stand behind the orbiter provides personnel access to both the main engines and OMS pods on each side of the tail. This photo was taken in early December 2008, following the landing and completion of STS-126 on November 30, 2008.

Endeavour undergoing post landing turnaround servicing in the MDD in December 2008 following STS-126.

The Orbiter Tail Cone

The tail cone was a large fairing mounted on the rear of the orbiter to improve its aerodynamic characteristics in flight while it was being ferried on top of the 747 shuttle carrier aircraft (SCA). Two reusable tail cones were designed and constructed, each consisting of six major structural component sections. Each section had its own shipping container and a structure known as a “hardback”, which was required for assembly to ensure the structural integrity once the tail cone was assembled. The tail cones were assembled in the shuttle hanger at DFRC using the forward overhead crane to lift each section. The sections were assembled on a specially designed tail cone stand and then stored on the stand in the Shuttle Hangar until needed for orbiter ferry operations. Prior to an orbiter being raised and mated to the SCA in the MDD, the tail cone stand was towed and rolled into place behind the orbiter where the tail cone was attached and bolted into place. The tail cone shipping containers were then trucked to KSC. Once the orbiter arrived at KSC and was lowered to the ground in the MDD there, the tail cone was removed and placed on the tail cone stand and towed to the Recovery Convoy Staging Area, disassembled, placed into its shipping containers and returned to DFRC for re-assembly prior to the next mission. After the Shuttle Program ended both tail cones, their shipping containers and the tail cone stand at Dryden were shipped to KSC to be used for ferrying the orbiters to museums.

The tail cone, on its stand, just prior to being installed on the orbiter in preparation for the ferry flight from Dryden to KSC.

The Space Shuttle Orbiters

Enterprise (OV-101)

Launched from the first 747 Shuttle Carrier Aircraft, Enterprise was flown in 1977 during the Approach and Landing Test (ALT) program at Dryden Flight Research Center on Edwards Air Force Base, Calif. Enterprise and her two flight crews demonstrated the space shuttle orbiter's capability to fly within the atmosphere and land as a conventional aircraft. Originally to be named Constitution in commemoration of the U.S. bicentennial in 1976, the name was changed in response to a write-in campaign by fans of the television series *Star Trek*. Plans to retrofit Enterprise for spaceflight after the ALT program were later cancelled, and OV-101 never flew in space.

The tribute poster for Enterprise features her pioneering role in the approach and landing, ferry flight and launch pad fit tests.

Overview	Assembly Rollout: Date	Date of Initial Transport from Plant 42 to DFRC	Date of Initial Ferry (DFRC to KSC)	First Flight	Last Flight
• The first airworthy orbiter • Named after the Starship Enterprise from the TV series *Star Trek* • Flown during the ALT program • Used for vertical ground vibration tests at Marshall Spaceflight Center, AL • Used for launch system fit checks at KSC • Used for fit checks at SLC-6, VAFB • Displayed at the National Air and Space Museum's Steven F. Udvar-Hazy Center in Chantilly, VA, from 1985 – 2012 • Currently on display at the Intrepid Sea, Air & Space Museum, New York City, New York	9/17/1976	1/31/1977	3/10/1978 (to MSFC for Mated Vehicle Ground Vibration Test) 4/10/1978 (ferried from MSFC to KSC	Captive 2/18/1977 ALT 8/12/1977	ALT 11/18/1977 Ferry 11/18/1985

Columbia (OV-102)

Columbia was the first reusable space vehicle, and the first manned spacecraft to make her maiden flight with a crew on board. Significant accomplishments include: the first deployment of commercial satellites and first four-member crew, on STS-5; first Spacelab mission and first six-member crew, on STS-9; first female mission commander (Eileen Collins), on STS-93; and multiple laboratory missions—many with international partnership. The Chandra X-Ray Observatory, deployed during STS-93, was the heaviest payload ever launched by the shuttle. Columbia was the only shuttle to land at White Sands Space Harbor, N.M. The orbiter and the STS-107 crew were lost in a fatal re-entry mishap in February 2003.

The tribute poster for Columbia features the insignia from her 28 missions , includingSTS-1, the first shuttle mision and her final crew and mission, STS-107.

Overview	Assembly Rollout: Date	Date of Initial Transport from Plant 42 to DFRC	Date of Initial Ferry (DFRC to KSC)	First Flight / Mission	Last Flight / Mission
• The first operational orbiter • Named after the Boston, MA, based sloop captained by American explorer Robert Gray • Flew 28 missions • Deployed 8 satellites • Traveled 125.2 million miles • Orbited Earth 4,808 times • Over 300 days in space • Landed at DFRC/EAFB12 times • Landed at KSC 14 times • Landed at WSSH 1 time (STS-3) • Crew and vehicle lost during re-entry on 2/1/2003	3/8/1979	3/12/1979	3/20/1979 to 3/24/1979	STS-1 4/12/1981 to 4/14/1981	STS-107 1/16/2003 to 2/1/2003

Challenger (OV-99)

Challenger blazed a trail for other orbiters with the first night landing (STS-8), as well as the first landing at Kennedy Space Center (STS-41B). Ironically, the vehicle's airframe was originally built as a structural test article (STA-099), and was never intended to fly in space. Because it was easier to convert STA-099 into OV-099, Challenger, instead of Enterprise, became the second operational orbiter. Astronauts aboard Challenger made the first spacewalk from a shuttle (STS-6) and the first ever un-tethered spacewalk (STS-41B). Other significant accomplishments include: first night launch (STS-8); the first in-flight capture, repair, and redeployment of an orbiting satellite (STS-41C); the first American woman in space (Sally Ride, on STS-7); the first African-American in space (Guion Bluford, on STS-8); and the first American woman to walk in space (Kathryn Sullivan, during STS-41G). Challenger was lost along with the STS-51L crew during launch on January 28, 1986.

The tribute poster for Challenger features the insignia from her 10 missions , as well as the first shuttle EVA, first night landing, first Florida landing and her final crew and mission, STS-51L.

Orbiter Name	Assembly Rollout: Date	Date of Initial Transport from Plant 42 to DFRC	Date of Initial Ferry (DFRC to KSC)	First Flight / Mission	Last Flight / Mission
• The second orbiter of the fleet • Named after the British Naval research vessel HMS Challenger that sailed the Atlantic and Pacific oceans during the 1870's • Flew 10 missions • Deployed 10 satellites • Traveled 25.8 million miles • Orbited Earth 995 times • Over 62 days in space • Landed at DFRC/EAFB 7 times • Landed at KSC 2 times • STS-51L crew and vehicle lost during ascent on 1/28/1986	6/30/1982	7/1/1982	7/4/1982 to 7/5/1982	STS-6 4/4/1983 to 4/9/1983	STS-51L 1/28/1986

Discovery (OV-103)

Discovery flew more missions than any orbiter in the fleet. The Hubble Space Telescope was launched aboard Discovery on STS-31 and serviced by Discovery crews on STS-82 and STS-103. Discovery's significant accomplishments include the first female Shuttle pilot (Eileen Collins on STS-63), former Mercury astronaut John Glenn's return to orbit on STS-95, and the celebration of the 100th space shuttle mission (STS-92). In addition, Discovery supported numerous Department of Defense programs, satellite deploy/repair missions, and 13 flights for construction and operation of the International Space Station. Discovery docked with both the Russian Mir space station and the ISS. This orbiter was also flown during the program's two "Return to Flight" missions, STS-26 and STS-114, following the Challenger and Columbia accidents.

The tribute poster for Discovery features the insignia from its 39 missions and.its role in return to flight and the building the ISS.

Overview	Assembly Rollout: Date	Date of Initial Transpor from Plant 42 to DFRC	Date of Initial Ferry (DFRC to KSC)	First Flight / Mission	Last Flight / Mission
• The third orbiter of the fleet • Named after the second ship used by the British explorer James Cook in the 1770s • Flew 39 missions • Deployed 31 satellites • Docked with Mir 1 times • Docked with ISS 13 times • On orbit a total of over 365 days • Orbited Earth 5,830 times • Traveled 148.2 million miles • Landed at DFRC/EAFB 15 times • Landed at KSC 24 times • Currently on display at the National Air and Space Museum's Steven F. Udvar-Hazy Center in Chantilly, VA	10/16/1983	11/5/1983	11/6/1983 to 11/9/1983	STS-41D 8/30/1984 To 9/5/1984	STS-133 2/24/2011 to 3/9/2011

Atlantis (OV-104)

Atlantis joined the shuttle fleet in 1985, and flew the largest number of dedicated Department of Defense missions. Astronaut crews flew seven missions to the Russian Mir space station in Atlantis, including the first (STS-71). In addition to 12 assembly, construction, and resupply missions to the International Space Station, Atlantis was also used for the final Hubble Space Telescope servicing mission (STS-125). The orbiter was also used to launch the Magellan probe to Venus (STS-30), the planet Galileo probe to Jupiter (STS-34), and the Compton Gamma Ray Observatory (STS-37). In July 2011, Atlantis was flown on STS-135, the final flight of the Space Shuttle Program.

The tribute poster for Atlantis features the insignia from its 33 missions, .the various phases of shuttle processing, and its role in building the ISS.

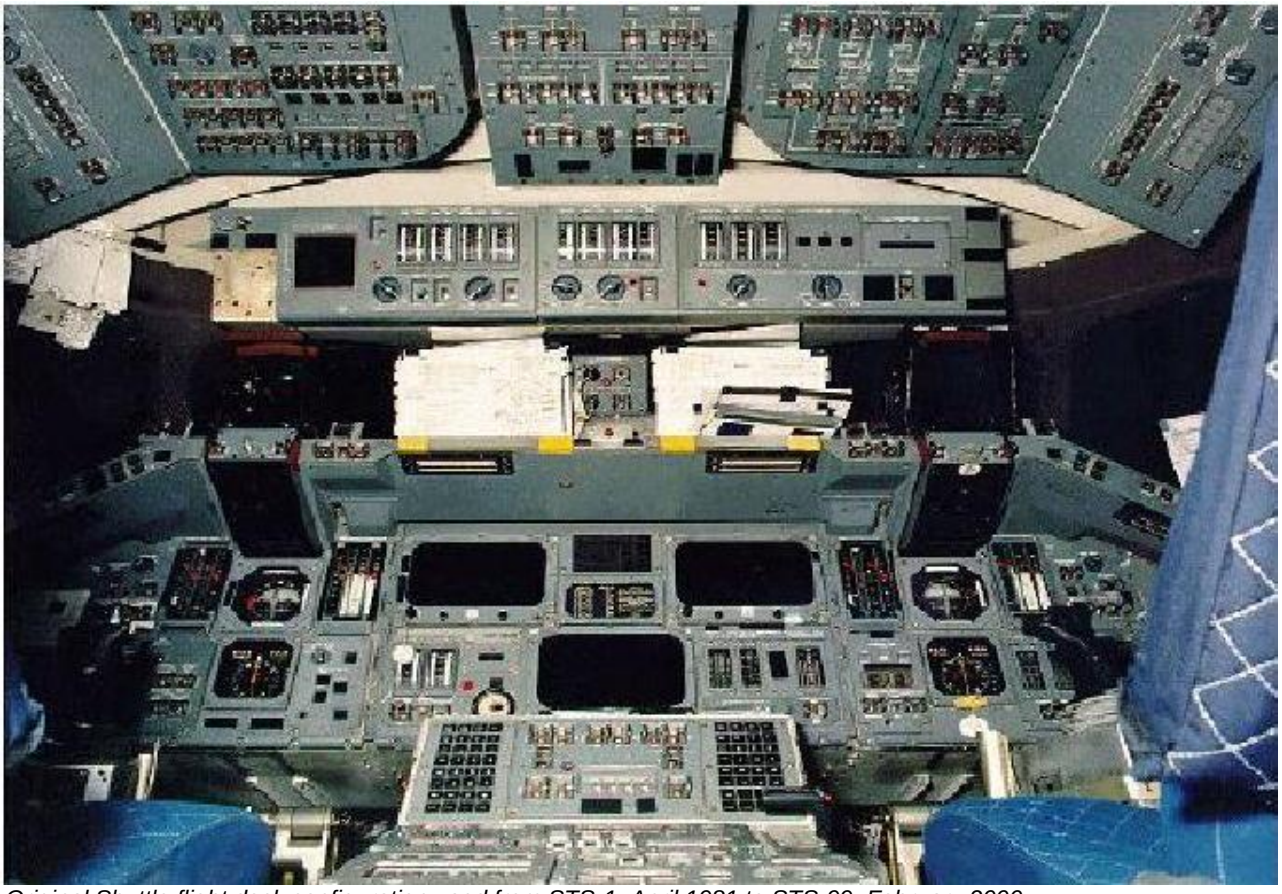
Overview	Assembly Rollout: Date	Date of Initial Transport from Plant 42 to DFRC	Date of Initial Ferry (DFRC to KSC)	First Flight / Mission	Last Flight / Mission
• The fourth orbiter of the fleet • Named after the primary research vessel for the Woods Hole Oceanographic Institute in Massachusetts, 1930 -1966 • Flew 33 missions • Deployed 14 satellites • Docked with Mir 7 times • Docked with ISS 12 times • On orbit a total of over 306 days • Orbited Earth 4,848 times • Traveled 125.9 million miles • Landed at DFRC/EAFB 13 times • Landed at KSC 20 times • Currently on display at Kennedy Space Center, FL	3/6/1985	4/3/1985	4/12/1985 to 4/13/1985	STS-51J 10/3/1985 to 10/7/1985	STS-135 7/8/2011 to 7/21/2011

Endeavour (OV-105)

Endeavour, the final addition to the shuttle fleet, was constructed as a replacement for Challenger. The orbiter was named through a national competition involving students in elementary and secondary schools. Accomplishments with Endeavour include the first ever use of a drag chute during a shuttle landing (STS-49); capture, repair and redeployment of the INTELSAT VI communications satellite (STS-49), the first Hubble Space Telescope servicing mission (STS-61), a mission to the Russian Mir space station (STS-89), and a dozen missions to the ISS. The STS-118 mission included astronaut Barbara Morgan, formerly assigned to the Educator Astronaut program but now a full member of the astronaut corps, as part of the crew. Morgan had been the backup for Christa McAuliffe on the STS-51L mission.

The tribute poster for Endeavour features it namesake, insignia from its 25 missions and delivery of the seven-window cupola to the ISS.

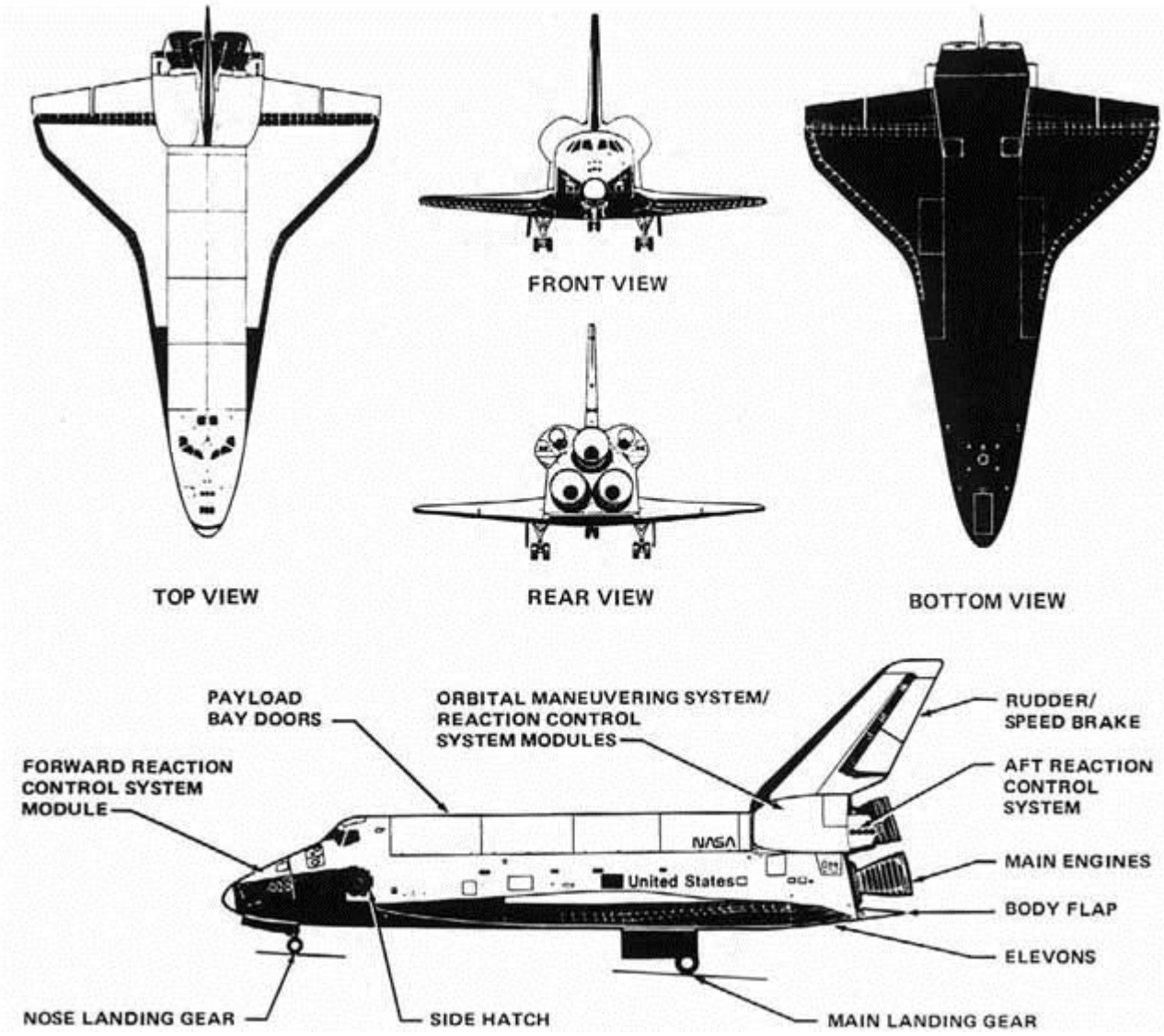
Overview	Assembly Rollout: Date	Date of Initial Transport from Plant 42 to DFRC	Date of Initial Ferry (DFRC to KSC)	First Flight / Mission	Last Flight / Mission
• The fifth orbiter of the fleet • Named after the first ship commanded by James Cook • Flew 25 missions • Deployed 3 satellites • Docked with Mir 1 time • Docked with ISS 12 times • On orbit a total of over 296 days • Orbited Earth 4,671 times • Traveled 122.9 million miles • Landed at DFRC/EAFB 7 times • Landed at KSC 18 times • Currently on display at the California Science Center, Los Angeles, CA	4/25/1991	N/A	5/2/1991 to 5/7/1991	STS-49 5/7/1992 to 5/16/1992	STS-134 5/16/2011 To 6/1/2011



Original Shuttle flight deck configuration used from STS-1, April 1981 to STS-99, February 2000.

Shuttle glass flight deck configuration used from STS-101, May 2000 to STS-135, July 2011.

Space Shuttle Orbiter General Information



DIMENSIONS AND WEIGHT

WING SPAN	(78.06 FT)
LENGTH	(122.17 FT)
HEIGHT	(56.58 FT)
TREAD WIDTH	(22.67 FT)
GROSS TAKEOFF WEIGHT	VARIABLE
GROSS LANDING WEIGHT	VARIABLE
INERT WEIGHT (APPROX)	(165 000 LB)

MINIMUM GROUND CLEARANCES

BODY FLAP (AFT END)	(12.07 FT)
MAIN GEAR (DOOR)	(2.85 FT)
NOSE GEAR (DOOR)	(2.95 FT)
WINGTIP	(11.92 FT)

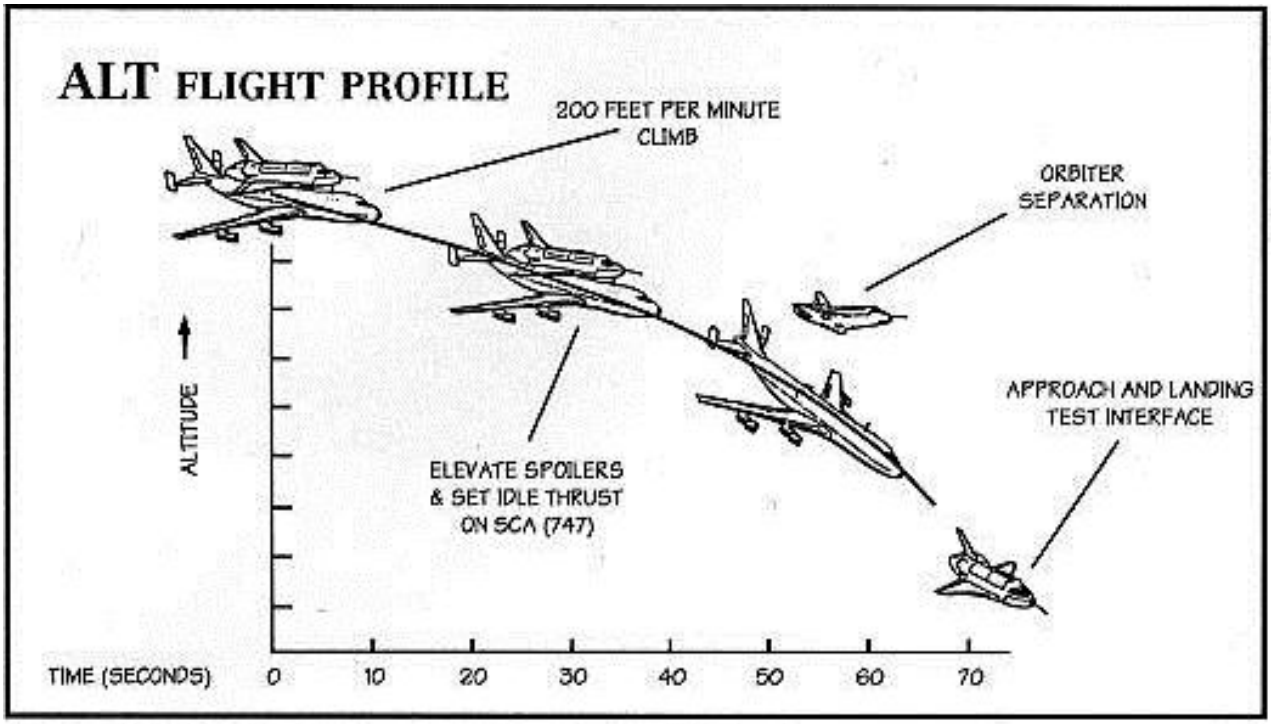
Enterprise (OV-101) Approach and Landing and Ferry Test Flights

One of Dryden's most notable contributions to the Space Shuttle Program was to test and validate the concept of a reusable orbiter that could re-enter the earth's atmosphere from space and glide safely to a landing. Second and just as important was to validate both the SCA and the orbiter's ability to fly mated together during extended flights from a landing site to the launch site. These were two of the important roles that Enterprise would fulfill during her short operational life. Leading up to and during these tests were a number of unique milestones, critical to the success of the program, including:

- Completion and rollout of the first airworthy orbiter.
- First overland transport of an orbiter from Site 1, the orbiter assembly facility at Air Force Plant 42, Palmdale Calif., to Dryden Flight Research Center at Edwards AFB.
- First time an orbiter was lifted in the Mate Demate Device at Dryden and mated to a Shuttle Carrier Aircraft (SCA) and demated from the SCA and lowered to the ground.
- First time an SCA was taxied with an orbiter on top.
- First time an SCA flew with an orbiter on top.
- First and only orbiter to fly with an astronaut flight crew on-board.
- First and only orbiter released from an SCA (to fly approaches and landings to a runway).
- First and only orbiter flown for ferry test flights.
- First orbiter to be ferried cross-country mated with the SCA.

These and other firsts such as being, mated with an external tank and solid rocket boosters and rolled out to the launch pad at KSC, were among the critical milestones required to be performed and tested before the first shuttle could be launched into orbit, repeatedly orbit the earth, re-enter the earth's atmosphere and land like an airplane.

The ALT astronaut test pilots from left to right: Gordon Fullerton, Fred Haise, Joseph Engle, Richard Truly



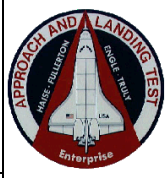
The above diagram depicts the ALT flight profile during which Enterprise separated from the SCA and flew its approach to the runway.

A view of the Enterprise flight deck with astronauts Fred Haise (left) and Gordon Fullerton (right) at the controls

Enterprise served as a backdrop for President and Mrs. Reagan's visit to Dryden when STS-4 landed on July 4, 1982.

Enterprise on display at the National Air & Space Museum's Udvar-Hazy Center in Chantilly, Va.

Enterprise (OV-101) ALT and Ferry Flight Log

Date Site	Event	Crew	Highlights
9/17/1976 Site 1 N/A	Rollout:	N/A	• The first Space Shuttle Orbiter • Built as an atmospheric test vehicle, not a space vehicle • Rolled out from the Rockwell assembly facility at Air Force Plant 42, Site 1, Palmdale CA
1/31/1977 N/A	Overland Transport	N/A	• Transported overland 36 miles from Plant 42 to DFRC.
02/15/1977 DFRC EDW 22	ALT 	N/A	• SCA/905 Taxi Tests • Tailcone installed • 1st Taxi Test max speed 89 mph • 2nd Taxi Test max speed 140 mph • 3rd Taxi Test max speed 157 mph
02/18/1977 DFRC EDW 22		N/A	• 1st Captive-Inactive Flight atop SCA/905 • Tailcone installed • Altitude: 16,000 feet • Air Speed: 287 mph. • Duration: 2H 5M
02/22/1977 DFRC EDW 22		N/A	• 2nd Captive-Inactive Flight atop SCA/905 • Tailcone installed • Altitude: 22,600 feet • Air Speed: 328 mph. • Duration: 3H 13M
02/25/1977 DFRC EDW 22		N/A	• 3rd Captive-Inactive Flight atop SCA/905 • Tailcone installed • Altitude: 26,600 feet • Air Speed: 425 mph. • Duration: 2H 28M
02/28/1977 DFRC EDW 22		N/A	• 4th Captive-Inactive Flight atop SCA/905 • Tailcone installed • Altitude: 28,565 feet • Air Speed: 425 mph. • Duration: 2H 11M
03/02/1977 DFRC EDW 22		N/A	• 5th Captive-Inactive Flight atop SCA/905 • Tailcone installed • Altitude: 30,000 feet • Air Speed: 474 mph. • Duration: 1H 39M
6/18/1977 DFRC EDW 22		CDR: Fred Haise PLT: Gordon Fullerton	• 1st Captive-Active Flight atop SCA/905 • Tailcone installed • Altitude: 14,970 feet • Air Speed: 208 mph. • Duration: 55M 46S
6/28/1977 DFRC EDW 22		CDR: Joseph Engle PLT: Richard Truly	• 2nd Captive-Active Flight atop SCA/905 • Tailcone installed • Altitude: 22,030 feet • Air Speed: 310 mph. • Duration: 1H 52M

Date Site	Event	Crew	Highlights
7/26/1977 DFRC EDW 22		CDR: Fred Haise PLT: Gordon Fullerton	• 3rd Captive-Active Flight atop SCA/905 • Tailcone installed • Altitude: 30,292 feet • Air Speed: 311 mph. • Duration: 59M 53S
8/12/1977 DFRC EDW 17		CDR: Fred Haise PLT: Gordon Fullerton	• 1st Free Flight after separating from SCA/905 • Tailcone installed • Altitude: 24,100 feet • Air Speed: 310 mph. • Duration: 5M 21S
9/13/1977 DFRC EDW 17		CDR: Joseph Engle PLT: Richard Truly	• 2nd Free Flight after separating from SCA/905 • Tailcone installed • Altitude: 26,000 feet • Air Speed: 310 mph. • Duration: 5M 28S
9/23/1977 DFRC EDW 15		CDR: Fred Haise PLT: Gordon Fullerton	• 3rd Free Flight after separating from SCA/905 • Tailcone installed • Altitude: 24,700 feet • Air Speed: 290 mph. • Duration: 5M 34S
10/12/1977 DFRC EDW 17		CDR: Joseph Engle PLT: Richard Truly	• 4th Free Flight after separating from SCA/905 • Tailcone not installed • Altitude: 22,400 feet • Air Speed: 278 mph. • Duration: 2M 34S
10/26/1977 DFRC EDW 04		CDR: Fred Haise PLT: Gordon Fullerton	• 5th Free Flight after separating from SCA/905 • Tailcone not installed • Altitude: 19,000 feet • Air Speed: 283 mph. • Duration: 2M 1S
11/15/1977		N/A	• 1st Ferry Test Flight • Tailcone installed • Fluid systems drained and purged • Elevon locks installed • Forward attachment strut replaced lowering the orbiter's cant from 6 to 3 degrees to reduce drag • Altitude: unk • Air Speed: unk • Duration: 3H 21M
11/16/1977		N/A	• 2nd Ferry Test Flight • Tailcone installed • Fluid systems drained and purged • Elevon locks installed • Forward attachment strut replaced lowering the orbiter's cant from 6 to 3 degrees to reduce drag • Altitude: unk • Air Speed: unk • Duration: 4H 17M

Date Site	Event	Crew	Highlights
11/17/1977		N/A	• 3rd Ferry Test Flight • Tailcone installed • Fluid systems drained and purged • Elevon locks installed • Forward attachment strut replaced lowering the orbiter's cant from 6 to 3 degrees to reduce drag • Altitude: unk • Air Speed: unk • Duration: 4H 13M
11/18/1977		N/A	• 4th Ferry Test Flight • Tailcone installed • Fluid systems drained and purged • Elevon locks installed • Forward attachment strut replaced lowering the orbiter's cant from 6 to 3 degrees to reduce drag • Altitude: unk • Air Speed: unk • Duration: 3H 37M
3/10/1978 to 3/11/1978	Ferry	N/A	• Ferry operational flights begin • Ferry flight from DFRC to MSFC to be mated with the ET and SRBs for Mated Vehicle Ground Vibration Test
4/10/1979	Ferry	N/A	• Ferry Flight from MSFC to KSC • Mated with the ET and SRBs • Transported on the mobile launch platform to LC 39-A for practice and fit check.
8/10/1979 to 8/16/1979	Ferry	N/A	• Ferry Flight from KSC to DFRC with seven stops across the country.
10/30/1979	Overland Transport	N/A	• Transported overland from DFRC to Rockwell's Palmdale final assembly facility.
9/16/1981	Overland Transport	N/A	• Transported overland from Rockwell's Palmdale final assembly facility to DFRC.
5/16/1983 to 5/24/1983	Ferry	N/A	• Ferry Flight from DFRC to the Paris Air Show
6/1/1983 to 6/13/1983	Ferry	N/A	• Ferry Flight from the Paris Air Show to DFRC
3/22/1984 to 3/29/1984	Ferry	N/A	• Ferry Flight from DFRC to Mobile, AL then transported by barge to New Orleans, LA, for the 1984 World's Fair.
11/10/1984 to 11/16/1984	Ferry	N/A	• Ferry Flight from Mobile AL to VAFB for practice and fit checks
5/24/1985	Ferry	N/A	• Ferry Flight from VAFB to DFRC
9/20/1985	Ferry	N/A	• Ferry Flight from DFRC to KSC
11/18/1985	Ferry	N/A	• Ferry Flight from KSC to Dulles Airport, Washington, D.C., and became the property of the Smithsonian Institution
4/27/2012	Ferry	N/A	• Ferry flight from Dulles Airport, to the Intrepid Sea, Air & Space Museum, New York City, New York

The Space Shuttle Mission Profile

The space shuttle consisted of an orbiter, an external tank (ET) that contained liquid oxygen and liquid hydrogen propellants, and two solid rocket boosters (SRB's) containing a solid propellant. The Orbiter and SRB's were reusable; the external tank was expended during each launch.

In preparation for a mission, the ET was mated to a mobile launch platform in the Vehicle Assembly Building (VAB) at KSC. The SRB's and orbiter, respectively, were then mated to the ET forming the space shuttle vehicle (SSV) or shuttle stack. The stack was then rolled out to one of two launch pads (LC-39A or LC-39B) at KSC to undergo further preparation for launch. While on the pad the primary mission payload was loaded into the orbiter payload bay during launch preparations.

Just prior to lift-off, the SRB's and the orbiter main engine fired simultaneously to begin the ascent to space and the desired orbit. Two minutes after lift-off, the two SRB's were jettisoned after burnout and then floated down by parachute into the Atlantic Ocean about 140 miles off the coast of Florida, where they were recovered and towed back to KSC for processing and reuse. Nine minutes after launch the ET was jettisoned and then burned up as it re-entered earth's atmosphere. 10 ½ minutes after launch the crew fired the orbital maneuvering system (OMS) engines on the orbiter to attain the desired orbit and to make any subsequent maneuvers that may be required during the mission. When the payload bay doors on the top of the orbiter fuselage opened to expose the payload, the crew began on-orbit operations.

Once orbital operations were complete and the orbiter was ready, the payload bay doors were closed in preparation for entry. When the orbiter is about halfway around the Earth from the selected landing site, the crew fired the reaction control system (RCS) thrusters to orient the orbiter tail first. The crew then fired the OMS engines to slow the orbiter down so it could re-enter Earth's atmosphere. During re-entry, the crew fired the RCS thrusters to orient the orbiter to a nose first attitude with bottom of the orbiter facing the atmosphere.

Upon re-entering the atmosphere the orbiter flew like an airplane. Flight computers flew the orbiter, making a series of S-shaped, banking turns to slow its descent speed in preparation for its final approach to the runway. Approximately 25 miles from the runway, the commander took control of the orbiter. As the orbiter approached the runway, the commander flew it around the Hidden Alignment Cone (HAC), an imaginary cylinder (20,000 feet in diameter) to line the orbiter up with the runway as it continued to descend. During the final approach, the commander adjusted the orbiter's angle of descent to minus 20 degrees (almost seven times steeper than the descent of a commercial airliner).

At 2,000 ft above the ground, the commander brought the orbiter's nose up to slow the rate of descent. The pilot then deployed the landing gear and the orbiter touched down on the runway and rolled to a stop as the commander applied the brakes, and the speed brake on the vertical tail opened up. A parachute deployed from the back to also help slow the orbiter. The orbiter typically stopped between 6,500 and 11,000 feet down the runway. After landing, the crew went through the shutdown procedures to power down the orbiter. 45 minutes to an hour later, the crew exited the vehicle. Ground crews were on-hand to begin servicing the orbiter and prepare it for its next mission.

The diagram above depicts the space shuttle mission profile from launch to landing.

Space Shuttle Mission Log

Format notes

The Space Shuttle Mission Log is a comprehensive list of all shuttle orbital space flights. The example below and accompanying notes illustrate how to interpret information presented in the mission log.

<table>
<tr><th>Mission</th><th>Launch</th><th>Landing</th><th>Crew</th><th>Highlights</th></tr>
<tr>
<td rowspan="2">STS-1
1st Flight Test
1st mission
Columbia (1)
OV-102
 
</td>
<td>4/12/1981
Sunday
7:00 am EST
KSC (1)
LC-39A (1)</td>
<td>4/14/1981
Tuesday
10:20 am PST
Landing (1)
DFRC (1)
EDW 23 (1)
Lakebed (1)</td>
<td rowspan="2"> 
CDR: John Young (5)
PLT: Robert “Bob” “Crip” Crippen (1)

• Young previously flew on
– Gemini 3 in 1965 (1st manned Gemini)
– Gemini 10 in 1966
– Apollo 10 in 1969
– Apollo 16 in 1972</td>
<td rowspan="2">• Columbia’s maiden voyage
• 1st STS Orbital Flight Test mission
• 1st flight of a reusable manned orbital spacecraft
• 1st orbital Shuttle flight
• Orbital altitude: 170.31 statute miles
• Orbits: 37
• Duration: 02D 06H 20M 53S
• Traveled: .93 million statute miles
• Orbiter Turnaround: 13 Days
• Ferry departure, DFRC: 4/27/1981
• Ferry arrival, KSC: 4/28/1981
  </td>
</tr>
<tr>
<td>Flight Day 1 Contingency Landing Sites
TAL: None
AOA: DFRC
WSSH
PLS: DFRC
SLS: WSSH
CLS: Hickam
Kadena
Rota</td>
<td>Landing Rollout Data
8,993 feet
(1.70 miles)
60 seconds</td>
</tr>
</table>

Beginning at the left, the first column provides the following **Mission information** for each mission:

- The mission designation **(STS-1)** followed, in parentheses, by the total number of missions flown to date **(1).**

Notes:

1) Shuttle missions were not always flown in numerical sequence. Schedule delays due to vehicle or payload processing, unacceptable weather conditions, range scheduling conflicts, and other factors determined when missions could be flown. Missions were often rescheduled, retaining their originally assigned mission designation on the flight manifest.

2) Following STS-9 and preceding STS-26, alphanumeric mission designations were used to distinguish missions manifested for specific fiscal years and launch sites. At the time, mission planners expected shuttles to launch from both Kennedy Space Center (KSC), FL, and Vandenberg Air Force Base (VAFB), CA The first numeral in the designation denoted the last digit of the planned fiscal year for the mission (4 for FY1984, 5 for FY1985, and 6 for FY1986), followed by the launch site (1 for KSC and 2 for VAFB); followed by a sequential letter of the alphabet reflecting the planned mission sequence. For example, mission 41B was scheduled to be launched in 1984 (4); from KSC (1); and was the second mission scheduled for that fiscal year (B). The first mission from VAFB, scheduled for July 1986 was to have been STS-62A. Plans to use the Vandenberg launch site were abandoned following the Challenger disaster.

- The orbiter name (**Columbia**) followed by its number of flights to date appears in parentheses, **(1).**
- The orbiter vehicle (OV) designation, e.g. **OV-102**, the OV designation for the orbiter Columbia.
- The official insignia for each mission.

The second column provides the following **Launch information** for each mission:

- Numerical date according to month/day/year (**4/12/1981**).
- Day of the week (**Sunday**).
- Time – Eastern standard or daylight savings time as appropriate (**7:00 am EST**).
- The launch site – (**KSC**), followed by the total number of launches in parenthesis (**1**). All shuttle launches originated at KSC as plans to launch shuttles from VAFB were cancelled following STS-51L.
- The launch complex (**39A**) followed by the total number of launches from that pad to date in parentheses (**1**).

- **1st Day Contingency Landing Sites** (CLS) selected for each mission as follows:
  - **TAL**. The trans-oceanic abort landing (TAL) site is the location of the overseas airfield selected as a CLS during ascent. One or more TAL sites had to be operational and ready to support an orbiter landing in case of abort during ascent, after the orbiter could no longer return to KSC.
  - **AOA**. The abort once around (AOA) landing site for each mission is provided. Each AOA landing site had to be operational and ready to support an orbiter landing in case of abort after the orbiter reached orbit.
  - **PLS**. The early end of mission (EEOM) primary landing site (PLS) for flight day 1 is provided. The PLS site had to be operational and ready to support an orbiter landing in the event that after reaching orbit the orbiter could not support on-orbit operations.
  - **SLS**. Early in the program, a secondary landing site was selected as an alternate to the PLS.

The third column provides the following **Landing Information** for each mission:

- Numerical date according to month/day/year (**4/14/1981**).
- Day of the week (**Tuesday**).
- Time – Eastern standard, Pacific standard or daylight savings time as appropriate (**10:20 am PST**).
- Landing Site (**DFRC**). The number of landings for each site to date appears in parentheses next to the site name (**1**). Throughout the program, the orbiters usually landed at either DFRC, KSC. At the end of STS-3, Columbia became the only shuttle to land at White Sands Space Harbor, NM.
- Runway (**EDW 23**). The number of landings for each runway, to date, appears in parentheses next to the runway number (**1**).
- Approximate **Rollout** distance in both feet (**8,993 feet**) and statute miles (**1.70 miles**).

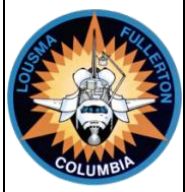
The fourth column provides the following information about the **Crew Members** for each mission:

- Crew Photograph.
- Crew assignment: Commander (**CDR**), Pilot (**PLT**), Mission Specialist (**MS**).
- First and last name followed by the total number of spaceflights to date in parentheses – **John Young** (**5**).

The fifth column provides other mission **Highlights**, including:

- Primary mission/payload.
- Approximate maximum orbital altitude (in statute miles*) attained during the mission,
- Number of orbits around the Earth,
- Duration, provided in days (D), hours (H), minutes (M), and seconds (S)
- Distance traveled, in statute miles.
- In case of a DFRC or WSSH landing, the duration of orbiter turnaround processing determined by subtracting the landing date from the ferry departure date.
- In case of a DFRC or WSSH landing, the ferry departure date.
- In case of a DFRC or WSSH landing, the ferry arrival date at KSC
- Some of the early shuttle astronauts previously flew in the X-15, Gemini, Apollo, and Skylab, programs as documented in this column.

* Altitude and distances are provided in statute miles for consistency

Mission	Launch	Landing	Crew	Highlights
STS-1 **1st Flight Test** 1st mission Columbia (1) OV-102 	**4/12/1981** Sunday 7:00 am EST KSC (1) LC-39A (1) **Flight Day 1 Contingency Landing Sites** TAL: None AOA: DFRC WSSH PLS: DFRC SLS: WSSH CLS: Hickam Kadena Rota	**4/14/1981** Tuesday 10:20 am PST Landing (1) DFRC (1) EDW 23 (1) Lakebed (1) **Landing Rollout Data** 8,993 feet (1.70 miles) 60 seconds	 CDR: John Young (5) PLT: Robert "Bob" "Crip" Crippen (1) • Young previously flew on – Gemini 3 in 1965 (1st manned Gemini) – Gemini 10 in 1966 – Apollo 10 in 1969 – Apollo 16 in 1972	• Columbia's maiden voyage • 1st STS Orbital Flight Test mission • 1st flight of a reusable manned orbital spacecraft • 1st orbital Shuttle flight • Orbital altitude: 170.31 statute miles • Orbits: 37 • Duration: 02D 06H 20M 53S • Traveled: .93 million statute miles • Orbiter Turnaround: 13 Days • Ferry departure, DFRC: 4/27/1981 • Ferry arrival, KSC: 4/28/1981
STS-2 **2nd Flight Test** 2nd mission Columbia (2) OV-102 	**11/12/1981** Thursday 10:10 am EST KSC (2) LC-39A (2) **Flight Day 1 Contingency Landing Sites** TAL: Rota AOA: DFRF PLS: DFRF SLS: WSSH	**11/14/1981** Saturday 1:23 pm PST Landing(2) DFRF (2) EDW 23 (2) Lakebed (2) **Landing Rollout Data** 7,711 feet (1.46 miles) 50 seconds	 CDR: Joseph "Joe" Engle (4) PLT: Richard "Dick" Truly (1) • Engle previously flew three X-15 sub-orbital flights in 1965.	• 2nd STS Orbital Flight Test mission • 1st reflight of a manned orbital spacecraft • 1st test of the Canadian-built RMS • Orbital Altitude: 161.11 statute miles • Orbits: 37 • Duration: 02D 06H 13M 12S • Traveled: .93 million statute miles • Mission shortened due to a fuel cell failure. • Orbiter Turnaround: 10 Days • Ferry departure, DFRF: 11/24/1981 • Ferry arrival, KSC: 11/25/1981
STS-3 **3rd Flight Test** 3rd mission Columbia (3) OV-102 	**3/22/1982** Monday 11:00 am EST KSC (3) LC-39A (3) **Flight Day 1 Contingency Landing Sites** TAL: Rota AOA: None PLS: DFRF SLS:WSSH	**3/30/1982** Tuesday 9:04 am MST Landing (3) WSSH (1) NOR 17 (1) Gypsum (1) **Landing Rollout Data** 13,737 feet (2.60 miles) 84 seconds	 CDR: Jack Lousma (2) PLT: Gordon "Gordo" Fullerton (1) • Lousma previously flew as the pilot on Skylab 3 from July 28 – September 25, 1973.	• 3rd STS Orbital Flight Test mission • 2nd test of the RMS • 1st launch with an unpainted ET • Orbital Altitude: 149.60 statute miles • Orbits: 130 • Duration: 08D 00H 04M 45S • Traveled: 3.9 million statute miles • Landing site changed from DFRF to WSSH due to wet lakebed runways • Only landing at WSSH • Longest landing rollout: of the SSP • Orbiter Turnaround: 7 Days • Ferry departure, DFRF: 4/6/1981 • Ferry arrival, KSC: 4/6/1981

Mission	Launch	Landing	Crew	Highlights
STS-4 **4th Flight Test** 4th mission Columbia (4) OV-102 	**6/27/1982** Sunday 11:00 am EDT KSC (4) LC-39A (4) **Flight Day 1 Contingency Landing Sites** TAL: Dakar AOA: DFRF PLS: DFRF SLS: KSC	**7/4/1982** Sunday 9:09 am PDT Landing (4) DFRF (3) EDW 22 (1) **Landing Rollout Data** 9,878 feet (1.87 miles) 64 seconds	 CDR: Kenneth "Ken" Mattingly (2) PLT: Henry "Hank" Hartsfield (1) • Mattingly previously flew as the command module pilot on Apollo 16 in 1972	• 4th & final STS Orbital Flight Test mission • 3rd test of the RMS • Orbital Altitude: 201.39 statute miles • Orbits: 113 • Duration: 07D 01H 09M 40S • Traveled: 2.9 million statute miles • 1st concrete runway landing • President Reagan at landing • Orbiter Turnaround: 10 Days • Ferry departure, DFRF: 7/14/1981 • Ferry arrival, KSC: 7/15/1981
STS-5 **COMSAT** 5th mission Columbia (5) OV-102 	**11/11/1982** Thursday 7:19 am EST KSC (5) LC-39A (5) **Flight Day 1 Contingency Landing Sites** TAL: Dakar AOA: WSSH PLS: DFRF	**11/16/1982** Tuesday 6:33 am PST Landing (5) DFRF (4) EDW 22 (2) **Landing Rollout Data** 9,553 feet (1.81 miles) 63 seconds	 CDR: Vance Brand (2) PLT: Robert "Bob" Overmeyer (1) MS2: Joseph "Joe" Allen (1) MS1: William "Bill" Lenoir (1) • Brand previously flew as the command module pilot on the Apollo- Soyuz Test Project mission in 1975	• 1st Fully Operational mission • 1st four-person Shuttle crew • 1st Shuttle mission with MS's • Deployed Anik C3 & SBS-C • Orbital Altitude: 186.51 statute miles • Orbits: 82 • Duration: 05D 02H 14M 26S • Traveled: 1.85 million statute miles • Orbiter Turnaround: 5 Days • Ferry departure, DFRF: 11/21/1982 • Ferry arrival, KSC: 11/22/1982
STS-6 **TDRS-1** 6th mission Challenger (1) OV-099 	**4/4/1983** Monday 1:30 pm EST KSC (6) LC-39A (6) **Flight Day 1 Contingency Landing Sites** TAL: Dakar AOA: DFRF PLS: N/A	**4/9/1983** Saturday 10:53 am PST Landing (6) DFRF (5) EDW 22 (3) **Landing Rollout Data** 7,180 feet (1.36 miles) 49 seconds	 CDR: Paul Weitz (2) PLT: Karol "Bo" Bobko (1) MS1/EV1: Story Musgrave (1) MS2/EV2: Donald "Don" Peterson (1) • Weitz previously flew as the pilot on the Skylab 2 mission from May 25 – June 22, 1973.	• Challenger's maiden voyage • 1st use of lightweight ET & SRBs • Deployed 1st TDRS (TDRS-1) • 1st mission to use EMUs • 1st SSP Spacewalk or EVA • Orbital Altitude: 178.89 statute miles • Orbits: 81 • Duration: 05D 00H 23M 42S • Traveled: 1.82 million statute miles • Orbiter Turnaround: 5 Days • Ferry departure, DFRF: 4/14/1983 • Ferry arrival, KSC: 4/16/1983

Mission	Launch	Landing	Crew	Highlights
STS-7 **COMSAT** 7th mission Challenger (2) OV-099 	**6/18/1983** Saturday 7:33 am EDT KSC (7) LC-39A (7) **Flight Day 1 Contingency Landing Sites** TAL: Dakar AOA: DFRF PLS: KSC	**6/24/1983** Friday 6:56 am PDT Landing (7) DFRF (6) EDW 15 (1) LAKEBED (3) **Landing Rollout Data** 10,450 feet (1.98 miles) 75 seconds	 CDR: Robert "Bob" "Crip" Crippen (2) PLT: Frederick "Rick" Hauck (1) MS1: John Fabian (1) MS2: Sally Ride (1) MS3: Norman "Norm" Thagard (1)	• 1st five-person Shuttle crew • 1st woman in space (Ride) • Deployed Anik C2 & PALAPA B-2 • Orbital Altitude: 186.67 statute miles • Orbits: 98 • Duration: 06D 02H 23M 59S • Traveled: 2.22 million statute miles • Landing site changed from KSC to DFRF due to poor visibility. • Orbiter Turnaround: 4 Days • Ferry departure, DFRF: 6/28/1983 • Ferry arrival, KSC: 6/29/1983
STS-8 **COMSAT** 8th mission Challenger (3) OV-099 	**8/30/1983** Tuesday 2:32 am EDT KSC (8) LC-39A (8) **Flight Day 1 Contingency Landing Sites** TAL: Dakar AOA: DFRF PLS: DFRF	**9/5/1983** Monday 12:40 am PDT Landing (8) DFRF (7) EDW 22 (4) **Landing Rollout Data** 9,371 feet (1.77 miles) 50 seconds	 CDR: Richard "Dick" Truly (2) PLT: Daniel "Dan Brandenstein (1) MS1: Guion "Guy" Bluford (1) MS2: Dale Gardner (1) MS3: William "Bill" Thornton (1)	• 1st night launch • 1st African-American in space (Bluford) • Deployed INSAT 1-B • Orbital Altitude: 185.35 statute miles • Orbits: 98 • 1st night landing • Duration: 06D 1H 08M 43S • Traveled: 2.22 million statute miles • Orbiter Turnaround: 4 Days • Ferry departure, DFRF: 9/9/1983 • Ferry arrival, KSC: 9/9/1983
STS-9 **Spacelab 1** 9th mission Columbia (6) OV-102 	**11/28/1983** Monday 11:00 am EDT KSC (9) LC-39A (9) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: WSSH PLS: DFRF	**12/8/1983** Thursday 3:47 PMPST Landing (9) DFRF (8) EDW 17 (1) Lakebed (4) **Landing Rollout Data** 8,556 feet (1.62 miles) 53 seconds	 CDR: John Young (6) PLT: Brewster Shaw (1) MS1: Owen Garriott (2) MS2: Robert "Bob" Parker (1) PS1: Byron Lichtenberg (1) PS2: Ulf Merbold, ESA (1) • Garriot previously flew on the Skylab 3 mission in 1973	• 1st Spacelab mission (Spacelab 1) • 1st six-person Shuttle crew • 1st shuttle mission with PSs • 1st ESA shuttle crew member • Orbital Altitude: 157.37 statute miles • Orbits: 167 • Duration: 10D 07H 47M 24S • Traveled: 3.33 million statute miles • Orbiter Turnaround: 6 Days • Ferry departure, DFRF: 12/14/1983 • Ferry arrival, KSC: 12/15/1983

Mission	Launch	Landing	Crew	Highlights
STS-41B **COMSAT** 10th mission Challenger (4) OV-099 	**2/3/1984** Friday 8:00 am EST KSC (10) LC-39A (10) **Flight Day 1 Contingency Landing Sites** TAL: Dakar AOA: DFRF PLS: KSC SLS: DFRF	**2/11/1984** Saturday 7:15 am EST Landing (10) KSC (1) SLF 15 (1) **Landing Rollout Data** 10,815 feet (2.05 miles) 64 seconds	 CDR: Vance Brand (3) PLT: Robert "Hoot" Gibson (1) MS1/EV1: Bruce McCandless II (1) MS2: Ronald "Ron" McNair (1) MS3/EV2: Robert "Bob" Stewart (1)	• Deployed PALAPA-B2 & WESTAR-VI • 2 EVA's • 1st untethered EVA • Orbital Altitude: 190.89 statute miles • Orbits: 128 • Duration: 07D 23H 15M 55S • Traveled: 2.87 million statute miles
STS-41C **LDEF** 11th mission Challenger (5) OV-099 	**4/6/1984** Friday 8:58 am EDT KSC (11) LC-39A (11) **Flight Day 1 Contingency Landing Sites** TAL: Dakar AOA: DFRF PLS: KSC SLS: DFRF	**4/13/1984** Friday 5:38 am PDT Landing (11) DFRF (9) EDW 17 (2) Lakebed (5) **Landing Rollout Data** 8,716 feet (1.65 miles) 48 seconds	 CDR: Robert "Bob" "Crip" Crippen (3) PLT: Francis "Dick" Scobee (1) MS1: Terry "T J" Hart (1) MS2/EV2: James "Ox" Van Hoften (1) MS3/EV1: George "Pinky" Nelson (1)	• 1st flight to use direct insertion to orbit • Deployed LDEF • 1st RNDZ & on-orbit spacecraft repair - Solar Max satellite • 1st grapple of satellite using RMS • IMAX camera used to film mission highlights • Extended 102 feet tall OAST-1 solar wing from the payload bay • 2 EVA's • Orbital Altitude: 308.41 statute miles • Orbits: 108 • Duration: 06D 23H 40M 07S • Traveled: 2.88 million statute miles • Orbiter Turnaround: 4 Days • Ferry departure, DFRF: 4/17/1984 • Ferry arrival, KSC: 4/18/1984
STS-41D **COMSAT** 12th mission Discovery (1) OV-103 	**8/30/1984** Thursday 8:41 am EDT KSC (12) LC-39A (12) **Flight Day 1 Contingency Landing Sites** TAL: Dakar AOA: DFRF PLS: EDW SLS: KSC	**9/5/1984** Wednesday 6:37 am PDT Landing (12) DFRF (10) EDW 17 (3) Lakebed (6) **Landing Rollout Data** 10,270 feet (1.95 miles) 60 seconds	 CDR: Henry "Hank" Hartsfield (2) PLT: Michael "Mike" Coats (1) MS1: Robert "Mike" Mullane (1) MS2: Steven "Steve" Hawley (1) MS3: Judith "Judy" Resnik (1) PS: Charles "Charlie" Walker (1)	• Discovery's maiden flight • 1st use of lightweight thermal blanket material • 1st flight to deploy 3 payloads • Deployed SBS-D Telstar 3C, Leasat-2, & OAST-1 • IMAX camera used to film mission highlights • Orbital Altitude: 201.32 statute miles • Orbits: 97 • Duration: 06D 00H 56M 4S • Traveled: 2.21 million statute miles • Orbiter Turnaround: 4 Days • Ferry departure, DFRF: 9/9/1984 • Ferry arrival, KSC: 9/10/1984

Mission	Launch	Landing	Crew	Highlights
STS-41G **ERBS** 13th mission Challenger (6) OV-099 	**10/5/1984** Friday 7:03 am EDT KSC (13) LC-39A (13) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: WSSH PLS: KSC SLS: N/A	**10/13/1984** Saturday 12:27 am EDT Landing (13) KSC (2) SLF 33 (1) **Landing Rollout Data** 10,527 feet (1.99 miles) 54 seconds	 CDR: Robert "Bob" Crippen (4) PLT: Jon McBride (1) PS2: Paul Scully-Power (1) MS1/PCDR/EV2: Kathryn Sullivan (1) MS2: Sally Ride (2) MS3/EV1: David "Dave" Leestma (1) PS1: Marc Garneau (1)	• 1st 7 person crew • 1st crew with two women • Deployed ERBS • 1 EVA • 1st EVA by a woman (Sullivan) • IMAX camera used to film mission highlights • Orbital Altitude: 220.65 statute miles • Orbits: 133 • Duration: 08D 05H 23M 38S • Traveled: 3.40 million statute miles
STS-51A **COMSAT** 14th mission Discovery (2) OV-103 	**11/8/1984** Thursday 7:15 am EST KSC (14) LC-39A (14) **Flight Day 1 Contingency Landing Sites** TAL: Dakar AOA: DFRF PLS: KSC SLS: N/A	**11/16/1984** Friday 7:00 am EST Landing (14) KSC (3) SLF 15 (2) **Landing Rollout Data** 9,461 feet (1.79 miles) 58 seconds	 CDR: Frederick "Rick" Hauck (2) PLT: David "Dave" Walker (1) MS1: Anna Fisher (1) MS2/EV2: Dale Gardner (2) MS3/EV1: Joseph "Joe" Allen (2)	• Deployed Anik D (TELESAT-H) & SYNCOM IV-I • 1st retrieval & return of satellites - Palapa & Westar 6 that were deployed during STS-41B • 2 EVA's • Orbital Altitude: 223.75 statute miles • Orbits: 127 • Duration: 07D 23H 44M 56S • Traveled: 2.87 million statute miles
STS-51C **DoD** 15th mission Discovery (3) OV-103 	**1/24/1985** Thursday 2:50 pm EST KSC (15) LC-39A (15) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: N/A PLS: KSC SLS: DFRF	**1/27/1985** Sunday 4:23 pm EST Landing (15) KSC (4) SLF 15 (3) **Landing Rollout Data** 7,370 feet (1.40 miles) 50 seconds	 CDR: Kenneth "Ken"Mattingly (3) PLT: Loren Shriver (1) MS1: Ellison "El" Onizuka (1) MS2: James "Jim" Buchli (1) PS1: Gary Payton (1)	• 1st Dedicated DoD mission (classified) • Deployed USAF IUS Booster • Orbital Altitude: 212.89 statute miles • Orbits: 49 • Duration: 03D 01H 33M 23S • Traveled: 1.23 million statute miles

Mission	Launch	Landing	Crew	Highlights
STS-51D **COMSAT** 16th mission Discovery (4) OV-103	**4/12/1985** Friday 8:59 am EST KSC (16) LC-39A (16)	**4/19/1985** Friday 8:54 am EST Landing (16) KSC (5) SLF 33 (2)		• 1st member of Congress and sitting Senator in space (Garn) • Deployed Anik C1, & SYNCOM IV-3 (Leasat-3) • 1 EVA • Orbital Altitude: 286.54 statute miles • Orbits: 110 • Duration: 06D 023H 55M 23S • Traveled: 2.50 million statute miles .
	Flight Day 1 Contingency Landing Sites	**Landing Rollout Data**		
	TAL: Moron AOA: DFRF PLS: KSC SLS: DFRF	10,430 feet (1.98 miles) 63 seconds	CDR: Karol "Bo" Bobko (2) PLT: Donald "Don" Williams (1) MS1: Rhea Seddon (1) MS2/EV1: Jeffrey "Jeff" Hoffman (1) MS3/EV2: David "Dave" Griggs (1) PS1: Charles "Charlie" Walker (2) PS2: Senator Jake Garn, Utah (only)	
STS-51B **Spacelab 3** 17th mission Challenger (7) OV-099	**4/29/1985** Monday 12:02 pm EDT KSC (17) LC-39A (17)	**5/6/1985** Monday 9:11 am PDT Landing (17) DFRF (11) EDW 17 (4) Lakebed (7)		• 2nd Spacelab mission (Spacelab 3) • Orbital Altitude: 220.94 statute miles • Orbits: 111 • Duration: 07D 00H 08M 46S • Traveled: 2.90 million statute miles • 1st crosswind landing • Orbiter Turnaround: 4 Days • Ferry departure, DFRF: 5/10/1985 • Ferry arrival, KSC: 5/11/1985
	Flight Day 1 Contingency Landing Sites	**Landing Rollout Data**		
	TAL: ZZA AOA: N/A PLS: DFRF SLS: KSC	8,317 feet (1.58 miles) 59 seconds	CDR: Robert "Bob" Overmyer (2) PLT: Frederick "Fred" Gregory (1) MS1: Don Lind (1) MS2: Norman "Norm" Thagard (2) MS3: William "Bill" Thornton (2) PS1: Lodewijk van den Berg (1) PS2: Taylor Wang (1)	
STS-51G **COMSAT** 18th mission Discovery (5) OV-103	**6/17/1985** Monday 7:33 am EDT KSC (18) LC-39A (18)	**6/24/1985** Monday 6:12 am PDT Landing (18) DFRF (12) EDW 23 (3) Lakebed (8)		• 1st member of royalty in space (Al Saud) • Deployed Arabsat-1B, Morelos 1, SPARTAN & Telstar-3D • Retrieved & returned SPARTAN Orbital Altitude: 242.01 statute miles • Orbits: 112 • Duration: 07D 01H 38M 52S • Traveled: 2.50 million statute miles • Rutted Lakebed 6" at end of Rollout: • Orbiter Turnaround: 4 Days • Ferry departure, DFRF: 6/28/1985 • Ferry arrival, KSC: 6/28/1985
	Flight Day 1 Contingency Landing Sites	**Landing Rollout Data**		
	TAL: Dakar AOA: DFRF PLS: N/A	7,433 feet (1.40 miles) 36 seconds	CDR: Daniel "Dan" Brandenstein (2) PLT: John Creighton (1) MS1: Shannon Lucid (1) MS2: John Fabian (2) MS3: Steven "Steve" Nagel (1) PS1: Patrick Baudry (CNES) (1) PS2: Sultan Salman Al Saud, Saudi Arabia (1)	

Mission	Launch	Landing	Crew	Highlights
STS-51F **Spacelab 2** 19th mission Challenger (8) OV-099	**7/29/1985** Monday 5:00 pm EDT KSC (19) LC-39A (19)	**8/6/1985** Tuesday 12:45 pm PDT Landing (19) DFRF (13) EDW 23 (4) Lakebed (9)		• ATO due to SSME 1 shutdown • 3rd Spacelab mission (Spacelab 2) • Orbital Altitude: 200.35 statute miles • Orbits: 127 • Duration: 07D 22h 45M 26S • Traveled: 2.85 million statute miles • Orbiter Turnaround: 4 Days • Ferry departure, DFRF: 8/10/1985 • Ferry arrival, KSC: 8/11/1985
	Flight Day 1 Contingency Landing Sites TAL: ZZA AOA: WSSH PLS: DFRF SLS: KSC	**Landing Rollout Data** 8,569 feet (1.62 miles) 55 seconds	CDR: Gordon "Gordo" Fullerton (2) PLT: Roy Bridges (1) MS1: Story Musgrave (2) MS2: Anthony "Tony" England (1) MS3: Karl Henize (1) PS1: Loren Acton (1) PS2: John Bartoe (1)	
STS-51I **COMSAT** 20th mission Discovery (6) OV-103	**8/27/1985** Tuesday 6:58 am EDT KSC (20) LC-39A (20)	**9/3/1985** Tuesday 6:16 am PDT Landing (20) DFRF (14) EDW 23 (5) Lakebed (10)		• Deployed AUSSAT-I, ASC-I, & SYNCOM IV-4 • Repaired SYNCOM IV-3 • 2 EVA's • Orbital Altitude: 278.49 statute miles • Orbits: 112 • Duration: 07D 02H 17M 42S • Traveled: 2.50 million statute miles • Orbiter Turnaround: 4 Days • Ferry departure, DFRF: 9/7/1985 • Ferry arrival, KSC: 9/8/1985
	Flight Day 1 Contingency Landing Sites TAL: Moron AOA: DFRF PLS: DFRF SLS: KSC	**Landing Rollout Data** 6,100 feet (1.15 miles) 47 seconds	CDR: Joseph "Joe" Engle (5) PLT: Richard "Dick" Covey (1) MS1/EV1: James "Ox" Van Hoften (2) MS2: John Lounge (1) MS3/EV2: William "Bill" Fisher (1)	
STS-51J **DoD** 21st mission Atlantis (1) OV-104	**10/3/1985** Thursday 11:16 am EDT KSC (21) LC-39A (21)	**10/7/1985** Monday 10:00 am PDT Landing (21) DFRF (15) EDW 23 (6) Lakebed (11)		• Atlantis' maiden voyage • 2nd dedicated DoD mission (classified) • Orbital Altitude: 292.30 statute miles • Orbits: 64 • Duration: 04D 01H 44M 38S • Traveled: 1.68 million statute miles • Orbiter Turnaround: 4 Days • Ferry departure, DFRF: 10/11/1985 • Ferry arrival, KSC: 10/11/1985
	Flight Day 1 Contingency Landing Sites TAL: Dakar AOA: N/A PLS: DFRF SLS: KSC	**Landing Rollout Data** 8,056 feet (1.53 miles) 65 seconds	CDR: Karol Bobko (3) PLT: Ronald "Ron" Grabe (1) MS1: David "Dave" Hilmers (1) MS2: Robert "Bob" Stewart (2) PS: William "Bill" Pailes (1)	

Mission	Launch	Landing	Crew	Highlights
STS-61A **Spacelab D1** 22nd mission Challenger (9) OV-099 	**10/30/1985** Wednesday 12:00 pm EST KSC (22) LC-39A (22) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: WSSH PLS: DFRF SLS: KSC	**11/6/1985** Wednesday 0945 am PST Landing (22) DFRF (16) EDW 17 (5) Lakebed (12) **Landing Rollout Data** 8,304 feet (1.57 miles) 49 seconds	 CDR: Henry "Hank" Hartsfield (3) PLT: Steven "Steve Nagel (2) MS1: Bonnie Dunbar (1) MS2: James "Jim" Buchli (2) MS3: Guion "Guy" Bluford (2) PS1: Reinhard Fehrer, DLR (1) PS2: Ernst Messerschmid, DLR (1) PS3: Wubbo Ockels, ESA (1)	• 1st & only 8 crew mission (ascent & descent) • Largest on-board Shuttle crew • 4th Spacelab mission (D1) • Deployed GLOMR • Orbital Altitude: 207.14 statute miles • Orbits: 112 • Duration: 07D 00H 44M 51S • Traveled: 2.50 million statute miles • 1st flight with full nose wheel steering • Last Challenger landing • Orbiter Turnaround: 4 Days • Ferry departure, DFRF: 11/10/1985 • Ferry arrival, KSC: 11/11/1985
STS-61B **COMSAT** 23rd mission Atlantis (2) OV-104 	**11/26/1985** Tuesday 7:29 pm EST KSC (23) LC-39A (23) **Flight Day 1 Contingency Landing Sites** TAL: Dakar AOA: DFRF PLS: DFRF SLS: KSC	**12/3/1985** Tuesday 1:34 pm PST Landing (23) DFRF (17) EDW 22 (5) **Landing Rollout Data** 10,759 feet (2.04 miles) 78 seconds	 CDR: Brewster Shaw (2) PLT: Bryan O'Conner, (1) MS1: Mary Cleave (1) MS2/EV1: Jerry Ross, (1) MS3/EV2: Sherwood Spring (1) PS1: Rodolfo Neri Vela, Mexico (1) PS2: Charles "Charlie" Walker (3)	• 2nd night launch • Deployed AUSSAT II, Morelos B, and SATCOM Ku-2. • 2 EVA's • Orbital Altitude: 298.06 statute miles • Orbits: 109 • Duration: 06D 21H 04M 49S • Traveled: 2.47 million statute miles • Orbiter Turnaround: 4 Days • Ferry departure, DFRF: 12/7/1985 • Ferry arrival, KSC: 12/7/1985
STS-61C **SATCOM** **COMSAT** 24th mission Columbia (7) OV-102 	**1/12/1986** Sunday 6:55 am EST KSC (24) LC-39A (24) **Flight Day 1 Contingency Landing Sites** TAL: Moron AOA: DFRF PLS: KSC SLS: DFRF	**1/18/1986** Saturday 5:59 am PST Landing (24) DFRF (18) EDW 22 (6) **Landing Rollout Data** 10,202 feet (1.93 miles) 59 seconds	 CDR: Robert 'Hoot" Gibson (2) PLT: Charles "Charlie" Bolden (1) MS1: Franklin "Chang" Chang-Diaz (1) MS2: Steven "Steve" Hawley (2) MS3: George "Pinky" Nelson (2) PS1: Robert Cenker (1) PS2: Rep. Bill Nelson, Florida (1)	• 1st African-American Shuttle pilot (Bolden) • 2nd member of U.S. Congress in space • 1st sitting Congressman in space • Deployed SATCOM Ku-1 • Conducted CHAMP Experiment • 5th Spacelab mission (MSL-2) • Orbital Altitude: 211.74 statute miles • Orbits: 98 • Duration: 06D 02H 03M 51S • 2nd night landing (2nd at DFRC) • Traveled: 2.20 million statute miles • Landing site changed from KSC to DFRC due to bad weather. • Orbiter Turnaround: 4 Days • Ferry departure, DFRF: 1/22/1986 • Ferry arrival, KSC: 1/23/1986

Mission	Launch	Landing	Crew	Highlights
STS-51L **TDRS-2** 25th mission Challenger (10) OV-099  	**1/28/1986** Tuesday 11:38 am EST KSC (25) LC-39B (1) **Flight Day 1 Contingency Landing Sites** TAL: Sunset (Casablanca) AOA: DFRF PLS: KSC SLS: DFRF	N/A	 CDR: Francis "Dick" Scobee (2) PLT: Michael "Mike" Smith (1) MS1: Ellison "El" Onizuka (2) MS2: Judith "Judy" Resnik (2) MS3: Ronald "Ron" McNair (2) PS1: Christa McAuliffe (1) PS2: Gregory "Greg" Jarvis (1)	• 1st "Teacher in Space" McAuliffe • Final launch of Challenger • First launch from LC-39B • Orbits: 0 • Duration: 01M 14S • Traveled: 18 miles • Explosion during ascent claiming the vehicle and crew due to an o-ring failure in the right SRB. Cold weather was a contributing factor. • Last flight of Challenger – 3 year career – Flew 10 missions – Deployed 10 satellites – Traveled 25.8 million miles – Orbited Earth 995 times – Over 62 days in space – Landed at DFRC/EAFB 7 times – Landed at KSC 2 times
STS-26 **Return to Flight** **TDRS-3** 26th mission Discovery (7) OV-103  	**9/29/1988** Thursday 11:37 am EST KSC (26) LC-39B (2) **Flight Day 1 Contingency Landing Sites** TAL: Moron AOA: DFRF PLS: DFRF SLS: WSSH	**10/3/1988** Monday 9:37 am PST Landing (25) DFRF (19) EDW 17 (6) Lakebed (13) **Landing Rollout Data** 7,451 feet (1.41 miles) 50 seconds	 CDR: Frederick "Rick" Hauck (3) PLT: Richard "Dick" Covey (2) MS1: John Lounge (2) MS2: George "Pinky" Nelson (3) MS3: David "Dave" Hilmers (2)	• Return to flight after STS-51L • Deployed TDRS-3 • Orbital Altitude: 203.69 statute miles • Orbits: 64 • Duration: 04D 01H 00M 11S • Traveled: 1.43 million statute miles • Vice President Bush at landing • Orbiter Turnaround: 5 Days • Ferry departure, DFRF: 10/8/1988 • Ferry arrival, KSC: 10/8/1985
STS-27 **DoD** 27th mission Atlantis (3) OV-104  	**12/2/1988** Friday 9:31 am EST KSC (27) LC-39B (3) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: WSSH PLS: DFRF	**12/6/1988** Tuesday 3:36 pm PST Landing (26) DFRF (20) EDW 17 (7) Lakebed (14) **Landing Rollout Data** 7,123 feet (1.35 miles) 41 seconds	 CDR: Robert "Hoot" Gibson (3) PLT: Guy Gardner (1) MS1: Richard "Mike" Mullane (2) MS2: Jerry Ross (2) MS3: William "Bill" Shepherd (1)	• 3rd Dedicated DoD mission (classified) • Orbital Altitude: 280.79 statute miles • Orbits: 68 • Duration: 04D 09H 05M 37S • Traveled: 1.81 million statute miles • Orbiter Turnaround: 5 Days • Ferry departure, DFRF: 12/11/1988 • Ferry arrival, KSC: 12/13/1985

Mission	Launch	Landing	Crew	Highlights
STS-29 **TDRS-4** 28th mission Discovery (8) OV-103  	**3/13/1989** Monday 9:57 am EST KSC (28) LC-39B (4) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: WSSH PLS: DFRF	**3/18/1989** Saturday 6:36 am PST Landing (27) DFRF (21) EDW 22 (7) **Landing Rollout Data** 9,339 feet (1.77 miles) 51 seconds	 CDR: Michael "Mike" Coats (2) PLT: John Blaha (1) MS1: James "Jim" Bagian (1) MS2: James "Jim" Buchli (3) MS3: Robert "Bob" Springer (1)	• Deployed 3rd TDRS (TDRS-4) • IMAX camera used to film the Earth • Orbital Altitude: 204.84 statute miles • Orbits:80 • Duration: 04D 23H 38M 50S • Traveled: 1.80 million statute miles • Orbiter Turnaround: 5 Days • Ferry departure, DFRF: 3/23/1989 • Ferry arrival, KSC: 3/24/1989
STS-30 **Magellan** 29th mission Atlantis (4) OV-104  	**5/4/1989** Thursday 2:46 pm PDT KSC (29) LC-39B (5) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: DFRF PLS: DFRF	**5/8/1989** Monday 12:43 pm PDT Landing (28) DFRF (22) EDW 22 (8) **Landing Rollout Data** 10,295 feet (1.95 miles) 51 seconds	 CDR: David "Dave" Walker (2) PLT: Ronald "Ron" Grabe (2) MS1: Mark Lee, M (1) MS2: Norman "Norm" Thagard (3) MS3: Mary Cleave (2)	• 1st Shuttle mission to deploy an interplanetary probe • Deployed Magellan spacecraft to map Venus • Orbital Altitude: 202.58 statute miles • Orbits: 65 • Duration: 04D 00H 56M 27S • Traveled: 1.48 million statute miles • 1st crosswind landing test • Orbiter Turnaround: 5 Days • Ferry departure, DFRF: 5/13/1989 • Ferry arrival, KSC: 5/15/1989
STS-28 **DoD** 30th mission Columbia (8) OV-102  	**8/8/1989** Tuesday 8:37 am PDT KSC (30) LC-39B (6) **Flight Day 1 Contingency Landing Sites** TAL: Moron AOA: WSSH PLS: DFRF	**8/13/1989** Sunday 6:37 am PDT Landing (29) DFRF (23) EDW 17 (8) Lakebed (15) **Landing Rollout Data** 6,015 ft (1.14 miles) 46 seconds	 CDR: Brewster Shaw (3) PLT: Richard "Dick" Richards (1) MS1: James "Jim" Adamson (1) MS2: David "Dave" Leestma (2) MS3: Mark Brown (1)	• 4th dedicated DoD mission (classified) • Orbital Altitude: 191.03 statute miles • Deployed 2 satellites • Orbits: 81 • Duration: 05D 01H 00M 09S • Traveled: 2.07 million statute miles • Shortest landing Rollout of the SSP • Orbiter Turnaround: 5 Days • Ferry departure, DFRF: 8/18/1989 • Ferry arrival, KSC: 8/21/1989

Mission	Launch	Landing	Crew	Highlights
STS-34 **Galileo** 31st mission Atlantis (5) OV-104 	**10/18/1989** Wednesday 12:54 PMEDT KSC (31) LC-39B (7) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: DFRF PLS: DFRF	**10/23/1989** Monday 9:33 am PDT Landing (30) DFRC (24) EDW 23 (7) Lakebed (16) **Landing Rollout Data** 9,677 feet (1.83 miles) 61 seconds	 CDR: Donald “Don” Williams (2) PLT: Michael “Mike” McCulley (1) MS1: Shannon Lucid (2) MS2: Franklin “Chang” Chang-Diaz (2) MS3: Ellen Baker (1)	• Deployed Galileo spacecraft to Jupiter • IMAX camera used to film mission highlights • Orbital Altitude: 213.69 statute miles • Orbits: 79 • Duration: 04D 23H 39M 20S • Traveled: 1.80 million statute miles • Orbiter Turnaround: 5 Days • Ferry departure, DFRC: 10/28/1989 • Ferry arrival, KSC: 10/29/1989
STS-33 **DoD** 32nd mission Discovery (9) OV-103 	**11/22/1989** Wednesday 7:24 pm EST KSC (32) LC-39B (8) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: DFRC PLS: DFRC	**11/27/1989** Monday 4:30 pm PST Landing (31) DFRC (25) EDW 04 (1) **Landing Rollout Data** 7,764 feet (1.47 miles) 46 seconds	 CDR: Frederick “Fred” Gregory (2) PLT: John Blaha (2) MS1: Manley “Sonny” Carter (1) MS2: Story Musgrave (3) MS3: Kathryn “Kathy” Thornton (1)	• 3rd night launch • 5th dedicated DoD mission (classified) • Orbital Altitude: 347.54 statute miles • Orbits: 79 • Duration: 05D 00H 06M 48S • Traveled: 2.05 million statute miles • Orbiter Turnaround: 5 Days • Ferry departure, DFRC: 12/2/1989 • Ferry arrival, KSC: 12/4/1989
STS-32 **COMSAT** 33rd mission Columbia (9) OV-102 	**1/9/1990** Tuesday 7:35 am EST KSC (33) LC-39A (25) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: DFRC PLS: DFRC	**1/20/1990** Saturday 1:36 am PST Landing (32) DFRC (26) EDW 22 (9) **Landing Rollout Data** 10,731 feet (2.03 miles) 64 seconds	 CDR: Daniel “Dan” Brandenstein (3) PLT: James “Jim” Wetherbee (1) MS2: Marsha Ivins (1) MS3: David “Dave” Low (1) MS1: Bonnie Dunbar (2)	• Deployed SYNCOM IV-F5 Satellite • Retreived LDEF • IMAX camera used to film mission highlights • Orbital Altitude: 222.65 statute miles • Orbits: 172 • 3rd night landing (3rd at DFRC) • Duration: 10D 21H 0M 36S • Traveled: 4.51 million statute miles • Orbiter Turnaround: 5 Days • Ferry departure, DFRC: 1/25/1990 • Ferry arrival, KSC: 1/26/1990

Mission	Launch	Landing	Crew	Highlights
STS-36 **DoD** 34th mission Atlantis (6) OV-104  	**2/28/1990** Wednesday 2:50 am EST KSC (34) LC-39A (26) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: WSSH PLS: DFRC	**3/4/1990** Sunday 10:09 am PST Landing (33) DFRC (27) EDW 23 (8) Lakebed (17) **Landing Rollout Data** 7,900 feet (1.50 miles) 53 seconds	 CDR: John Creighton (2) PLT: John Casper (1) MS1: David “Dave” Hilmers (3) MS2: Richard “Mike” Mullane (3) MS3: Pierre Thuot (1)	• 4th night launch • 6th Dedicated DoD mission (classified) • Orbital Altitude: 151.90 statute miles • Orbits: 72 • Duration: 04D 10H 18M 22S • Traveled: 1.84 million statute miles • Orbiter Turnaround: 6 Days • Ferry departure, DFRC: 3/10/1990 • Ferry arrival, KSC: 3/13/1990
STS-31 **HST** 35th mission Discovery (10) OV-103  	**4/24/1990** Tuesday 8:34 am EDT KSC (35) LC-39B (9) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: WSSH PLS: DFRC	**4/29/1990** Sunday 6:50 am PDT Landing (34) DFRC (28) EDW 22 (10) **Landing Rollout Data** 8,874 feet (1.68miles) 61 seconds	 CDR: Loren Shriver (2) PLT: Charles “Charlie” Bolden (2) MS1: Steven “Steve” Hawley (3) MS2: Kathryn ‘Kathy” Sullivan (2) MS3: Bruce McCandless (2)	• Deployed HST • IMAX camera used to film mission highlights • Orbital Altitude: 380.48 statute miles • Orbits: 80 • Duration: 05D 01H 16M 06S • Traveled: 2.07 million statute miles • Orbiter Turnaround: 6 Days • Ferry departure, DFRC: 5/5/1990 • Ferry arrival, KSC: 5/7/1990
STS-41 **Ulysses** 36th mission Discovery (11) OV-103  	**10/6/1990** Saturday 7:47 am EDT KSC (36) LC-39B (10) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: WSSH PLS: DFRC	**10/10/1990** Wednesday 6:57 am PDT Landing (35) DFRC (29) EDW 22 (11) **Landing Rollout Data** 8,478 feet (1.61 miles) 49 seconds	 CDR: Richard “Dick” Richards (2) PLT: Robert “Bob” Cabana (1) MS1: William ‘Bill” Shepherd (2) MS2: Bruce Melnick (1) MS3: Thomas “Tom” Akers (1)	• Deployed ESA Ulysses spacecraft • Orbital Altitude: 204.72 statute miles • Orbits: 66 • Duration: 04D 02H 10M 04S • Traveled: 1.71 million statute miles • Orbiter Turnaround: 5 Days • Ferry departure, DFRC: 10/15/1990 • Ferry arrival, KSC: 10/16/1990

Mission	Launch	Landing	Crew	Highlights
STS-38 **DoD** 37th mission Atlantis (7) OV-104	**11/15/1990** Thursday 6:48 pm EST KSC (37) LC-39A (27)	**11/20/1990** Tuesday 4:43 pm EST Landing (36) KSC (6) SLF 33 (3)	 CDR: Richard "Dick" Covey (3) PLT: Frank Culbertson (1) MS1: Robert "Bob" Springer (2) MS2: Carl Meade (1) MS3: Charles "Sam" Gemar (1)	• 5th night launch • 7th dedicated DoD mission (classified) • Orbital Altitude: 163.41 statute miles • Orbits: 79 • Duration: 04D 21H 54M 27S • Traveled: 2.05 million statute miles • Landing site changed from DFRF to KSC due to high wind forecast.
	Flight Day 1 Contingency Landing Sites TAL: Banjul AOA: DFRF PLS: DFRF	**Landing Rollout Data** 9,003 feet (1.71 miles) 57 seconds		
STS-35 **ASTRO-1** 38th mission Columbia (10) OV-102	**12/2/1990** Sunday 1:49 am EST KSC (36) LC-39B (11)	**12/10/1990** Monday 9:54 pm PST Landing (37) DFRC (30) EDW 22 (12)	 CDR: Vance Brand (4) PLT: Guy Gardner (2) MS1: Jeffrey "Jeff" Hoffman (2) MS2: John Lounge (3) MS3: Robert "Bob" Parker (2) PS1: Samuel "Sam" Durrance (1) PS2: Ronald "Ron" Parise (1)	• 6th night launch • 6th Spacelab mission (ASTRO-1) • Orbital Altitude: 224.63 statute miles • Orbits: 144 • 4th night landing (4th at DFRC) • Duration: 08D 23H 05M 08S • Traveled: 3.73 million statute miles • Orbiter Turnaround: 6 Days • Ferry departure, DFRC: 12/161990 • Ferry arrival, KSC: 12/21/1990
	Flight Day 1 Contingency Landing Sites TAL: Banjul AOA: DFRC PLS: DFRC	**Landing Rollout Data** 10,450 feet (1.98 miles) 58 seconds		
STS-37 **GRO** 39th mission Atlantis (8) OV-104	**4/5/1991** Friday 9:23 am EST KSC (39) LC-39B (12)	**4/11/1991** Thursday 5:55 am PDT Landing (38) DFRC (31) EDW 33 (1) Lakebed (18)	 CDR: Steven "Steve" Nagel (3) PLT: Kenneth "Ken" Cameron (1) MS1: Linda Godwin (1) MS2/EV1: Jerry Ross (3) MS3/EV2: Jerome "Jay" Apt (1)	• Deployed Compton Gamma Ray Observatory (GRO) • 2 EVA's • Orbital Altitude: 285.39 statute miles • Orbits: 93 • Duration: 05D 23H 32M 44S • Traveled: 2.49 million statute miles • Orbiter Turnaround: 5 Days • Ferry departure, DFRC: 4/16/1991 • Ferry arrival, KSC: 4/18/1991
	Flight Day 1 Contingency Landing Sites TAL: BEN AOA: DFRC PLS: DFRC	**Landing Rollout Data** 6,364 feet (1.21 miles) 56 seconds		

Mission	Launch	Landing	Crew	Highlights
STS-39 **DoD** 40th mission Discovery (12) OV-103	**4/28/1991** Sunday 7:33 am EDT KSC (40) LC-39A (28)	**5/6/1991** Monday 2:56 pm EDT Landing (39) KSC (7) SLF 15 (4)	 CDR: Michael "Mike" Coats (3) PLT: Blaine Hammond (1) MS1: Gregory "Greg" Harbaugh (1) MS2: Donald "Don" McMonagle (1) MS3: Guion "Guy" Bluford (3) MS4: Charles "Lacy" Veach (1) MS5: Richard "Rick" Hieb (1)	• 8th Dedicated DoD mission (unclassified) • Orbital Altitude: 162.89 statute miles • Orbits: 134 • Duration: 8D 7H 22M 21S • Traveled: 3.48 million statute miles
	Flight Day 1 Contingency Landing Sites	**Landing Rollout Data**		
	TAL: BEN AOA: DFRC PLS: DFRC	9,234 feet (1.75 miles) 56 seconds		
STS-40 **SLS-1** 41st mission Columbia (11) OV-102	**6/5/1991** Wednesday 9:25 am EDT KSC (41) LC-39B (13)	**6/14/1991** Friday 8:39 am PDT Landing (40) DFRC (32) EDW 22 (13)	 CDR: Bryan O'Conner (2) PLT: Sidney Gutierrez (1) MS1: James "Jim" Bagian (2) MS2: Tamara "Tammy" Jernigan (1) MS3: Rhea Seddon (2) PS1: Drew Gaffney (1) PS2: Millie Hughes-Fulford (1)	• 7thSpacelab mission (SLS- 1) • Orbital Altitude: 185.46 statute miles • Orbits: 146 • Duration: 09D 02H 14M 20S • Traveled: 3.29 million statute miles • Orbiter Turnaround: 5 Days • Ferry departure, DFRC: 6/19/1991 • Ferry arrival, KSC: 6/21/1991
	Flight Day 1 Contingency Landing Sites	**Landing Rollout Data**		
	TAL: BEN AOA: DFRC PLS: DFRC	9,438 feet (1.79 miles) 55 seconds		
STS-43 **TDRS-E** 42nd mission Atlantis (9) OV-104	**8/2/1991** Friday 11:02 am EDT KSC (42) LC-39A (29)	**8/11/1991** Sunday 6:23 am EDT Landing (41) KSC (8) SLF 15 (5)	 CDR: John Blaha (3) PLT: Michael "Mike" Baker (1) MS1: Shannon Lucid (3) MS2: David "Dave" Low (2) MS3: James "Jim" Adamson (2)	• Deployed TDRSS-E • Orbital Altitude: 204.72 statute miles • Orbits: 142 • Duration: 08D 21H 21M 25S • Traveled: 3.70 million statute miles
	Flight Day 1 Contingency Landing Sites	**Landing Rollout Data**		
	TAL: BEN AOA: DFRC PLS: DFRC	9,890 feet (1.87 miles) 59 seconds		

Mission	Launch	Landing	Crew	Highlights
STS-48 **UARS** 43rd mission Discovery (13) OV-103 	**9/12/1991** Thursday 7:11 am EDT KSC (43) LC-39A (30) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: WSSH PLS: DFRC	**9/18/1991** Wednesday 12:38 am PDT Landing (42) DFRC (33) EDW 22 (14) **Landing Rollout Data** 9,384 feet (1.77 miles) 49 seconds	 CDR: John Creighton (3) PLT: Kenneth "Ken" Reightler (1) MS1: James "Jim" Buchli (4) MS2: Mark Brown (2) MS3: Charles "Sam" Gemar (2)	• Deployed UARS • Orbital Altitude: 360.19 statute miles • Orbits: 81 • 5th night landing (5th at DFRC) • Duration: 05D 08H 27M 38S • Traveled: 2.19 million statute miles • Orbiter Turnaround: 6 Days • Ferry departure, DFRC: 9/24/1991 • Ferry arrival, KSC: 9/26/1991
STS-44 **DoD** 44th mission Atlantis (10) OV-104 	**11/24/1991** Sunday 6:44 am EST KSC (44) LC-39A (31) **Flight Day 1 Contingency Landing Sites** TAL: Banjul AOA: DFRC PLS: DFRC	**12/1/1991** Sunday 2:35 pm PST Landing (43) DFRC (34) EDW 05 (1) Lakebed (19) **Landing Rollout Data** 11,191 feet (2.12 miles) 106 seconds	 CDR: Frederick "Fred" Gregory (3) PLT: Terence "Tom" Henricks (1) MS1: James "Jim" Voss (1) MS2: Story Musgrave (4) MS3: Mario Runco (1) PS: Thomas "Tom" Hennen (1)	• 7th night launch • 9th dedicated DoD mission (unclassified) • Deployed the DSP Satellite • Orbital Altitude: 244.43 statute miles • Orbits: 110 • Duration: 06D 22H 50M 43S • Traveled: 2.89 million statute miles • Mission shortened 3 days due to an orbiter IMU problem. • Longer Rollout: due to minimal braking for a test • Final Lakebed landing • Orbiter Turnaround: 6 Days • Ferry departure, DFRC: 12/7/1991 • Ferry arrival, KSC: 12/8/1991
STS-42 **IML-1** 45th mission Discovery (14) OV-103 	**1/22/1992** Wednesday 09:53 am EST KSC (45) LC-39A (32) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: N/A PLS: DFRC	**1/30/1992** Thursday 8:17 am PST Landing (44) DFRC (35) EDW 22 (15) **Landing Rollout Data** 9,841 feet (1.86 miles) 59 seconds	 CDR: Ronald "Ron" Grabe (3) PLT: Stephen "Steve" Oswald (1) MS1/PCDR: Norman "Norm" Thagard (4) MS2: William "Bill" Readdy (1) MS3: David "Dave" Hilmers (4) PS1: Roberta Bondar, CSA (1) PS2: Ulf Merbold, ESA (2)	• 8th Spacelab mission (IML-1) • Orbital Altitude: 186.43 statute miles • Orbits: 129 • Duration: 08D 01H 14M 44S • Traveled: 3.35 million statute miles • Orbiter Turnaround: 11 Days • Ferry departure, DFRC: 2/11/1992 • Ferry arrival, KSC: 2/16/1992

Mission	Launch	Landing	Crew	Highlights
STS-45 **ATLAS-1** 46th mission Atlantis (11) OV-104	**3/24/1992** Tuesday 8:24 am EST KSC (46) LC-39A (33)	**4/2/1992** Thursday 6:23 am EST Landing (45) KSC (9) SLF 33 (4)	 CDR: Charles "Charlie" Bolden (3) PLT: Brian Duffy (1) MS1: Kathryn "Kathy" Sullivan (3) MS2: David "Dave" Leestma (3) MS3: Michael Foale (1) PS1: Dirk Frimout, ESA (1) PS2: Byron Lichtnburg (2)	• 9th Spacelab mission (ATLAS-1) • Orbital Altitude: 183.89 statute miles • Orbits: 143 • Duration: 08D 22H 09M 28S • Traveled: 3.27 million statute miles
	Flight Day 1 Contingency Landing Sites TAL: ZZA AOA: WSSH PLS: DFRC	**Landing Rollout Data** 9,227 feet (1.75 miles) 56 seconds		
STS-49 **INTELSAT VI** 49th mission Endeavour (1) OV-105	**5/7/1992** Thursday 7:40 am EDT KSC (47) LC-39B (14)	**5/16/1992** Saturday 1:58 pm PDT Landing (46) DFRC (36) EDW 22 (16)	 CDR: Daniel "Dan" Brandenstein (4) PLT: Kevin Chilton (1) MS1/EV2: Richard "Rick" Hieb (2) MS2: Bruce Melnick (2) MS3/EV1: Pierre Thuot (2) MS4/EV3: Kathryn "Kathy" Thornton (2) MS5/EV4: Thomas "Tom" Akers (2)	• Endeavour's Maiden voyage • Repair INTELSAT VI • ASEM • Final commercial satellite retrieval and repair mission • 4 EVA's • Orbital Altitude: 227.85 statute miles • Orbits: 141 • Duration: 08D 21H 17M 39S • Traveled: 3.97 million statute miles • First shuttle landing to use a drag chute and improved NWS • Orbiter Turnaround: 5 Days • Ferry departure, DFRC: 5/21/1992 • Ferry arrival, KSC: 5/30/1992
	Flight Day 1 Contingency Landing Sites TAL: BEN AOA: DFRC PLS: DFRC	**Landing Rollout Data** 9,490 feet (1.80 miles) 55 seconds		
STS-50 **USML-1** 48th mission Columbia (12) OV-102	**6/25/1992** Thursday 1212 EDT KSC (48) LC-39A (34)	**7/9/1992** Thursday 0742 EDT Landing (47) KSC (10) SLF 33 (5)	 CDR: Richard "Dick" Richards (3) PLT: Kenneth "Ken" Bowersox (1) MS1/PCDR: Bonnie Dunbar (3) MS2: Ellen Baker (2) MS3: Carl Meade (2) PS1: Lawrence "Larry" DeLucas (1) PS2: Eugene "Gene" Trinh (1)	• 10th Spacelab mission (USML-1) • Orbital Altitude: 188.15 statute miles • Orbits: 221 • Duration: 13D 19H 30M 04S • Traveled: 5.79 million statute miles • Longest shuttle mission to date • 1st Extended Duration Orbiter mission
	Flight Day 1 Contingency Landing Sites TAL: BEN AOA: DFRC PLS: DFRC	**Landing Rollout Data** 10,765 feet (2.04 miles) 58 seconds		

Mission	Launch	Landing	Crew	Highlights
STS-46 **EURECA** 49th mission Atlantis (12) OV-104  	**7/31/1992** Friday 9:57 am EDT KSC (49) LC-39B (15) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: DFRC PLS: DFRF	**8/8/1992** Saturday 9:12 am EDT Landing (48) KSC (11) SLF 33 (6) **Landing Rollout Data** 10,860 feet (2.06 miles) 55 seconds	 CDR: Loren Shriver (3) PLT: Andrew "Andy" Allen (1) MS1: Claude Nicollier, ESA (1) MS2: Marsha Ivins (2) MS3/PCDR: Jeffrey "Jeff' Hoffman (3) MS4: Franklin "Chang" Chang-Diaz (3) PS: Franco Malerba, ASI (1)	• Deployed EURECA • 1st tethered satellite mission • Deployed and retrieved TSS-1 • Orbital Altitude: 266.18 statute miles • Orbits: 127 • Last shuttle flight without drag chute and improved NWS • Duration: 07D 23H 15M 02S • Traveled: 3.32 million statute miles
STS-47 **Spacelab J** 50th mission Endeavour (2) OV-105  	**9/12/1992** Saturday 10:23 am EDT KSC (50) LC-39B (16) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: WSSH PLS: DFRC	**9/20/1992** Sunday 8:53 am EDT Landing (49) KSC (12) SLF 33 (6) **Landing Rollout Data** 8,567 feet (1.62 miles) 49 seconds	 CDR: Robert "Hoot" Gibson (4) PLT: Curtis "Curt" Brown (1) MS1/PCDR: Mark Lee (2) MS2: Jerome "Jay" Apt (2) MS3: Jan Davis (1) MS4: Mae Jemison (1) PS1: Mamoru Mohri, NASDA (1)	• 11th Spacelab mission (Spacelab J) • Orbital Altitude: 191.03 statute miles • Orbits: 126 • Duration: 07D 22H 30M 22S • Traveled: 3.31 million statute miles • 1st African-American woman in space (Jemison) • 1st Japanese shuttle crew member (Mohri) • 1st married couple in space (Lee & Davis)
STS-52 **USMP-1** 51st mission Columbia (13) OV-102  	**10/22/1992** Thursday 1:09 am EDT KSC (51) LC-39B (19) **Flight Day 1 Contingency Landing Sites** TAL: Banjul AOA: DFRC PLS: DFRC	**11/1/1992** Sunday 9:06 am EST Landing (50) KSC (13) SLF 33 (7) **Landing Rollout Data** 10,708 feet (2.03 miles) 63 seconds	 CDR: James "Jim" Wetherbee (2) PLT: Michael "Mike" Baker (2) MS1: Charles "Lacy" Veach (2) MS2: William "Bill" Shepherd (3) MS3: Tamara "Tammy" Jernigan (2) PS: Steven "Steve" McLean (1)	• USMP-1 • Deployed LAGEOS-II • Orbital Altitude: 195.06 statute miles • Orbits: 159 • Duration: 09D 20H 56M 13S • Traveled: 4.13 million statute miles

Mission	Launch	Landing	Crew	Highlights
STS-53 **DoD** 52nd mission Discovery (15) OV-103 	**12/2/1992** Wednesday 8:24 am EST KSC (52) LC-39A (35) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: WSSH PLS: WSSH	**12/9/1992** Wednesday 12:44 pm PST Landing (51) DFRC (37) EDW 22 (17) **Landing Rollout Data** 10,165, feet (1.93 miles) 82 seconds	 CDR: David “Dave” Walker (4) PLT: Robert “Bob” Cabana (2) MS1: Guion “Guy” Bluford (4) MS2: James “Jim” Voss (2) MS3: Michael “Mike”Clifford (1)	• 10th and final dedicated DoD mission (classified and unclassified payloads) • Orbital Altitude: 234.76 statute miles • Orbits: 116 • Duration: 07D 07H 19M 47S • Traveled: 3.03 million statute miles • Landing site changed from KSC to DFRF due to low ceiling. • Orbiter Turnaround: 7 Days • Ferry departure, DFRC: 12/16/1992 • Ferry arrival, KSC: 12/20/1992
STS-54 **TDRS-F/I** 53rd mission Endeavour (3) OV-105 	**1/13/1993** Wednesday 9:00 am EST KSC (53) LC-39B (19) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: WSSH PLS: WSSH	**1/19/1993** Tuesday 8:38 am EST Landing (52) KSC (14) SLF 33 (8) **Landing Rollout Data** 8,723 feet (1.65 miles) 49 seconds	 CDR: John Casper (2) PLT: Donald “Don” McMonagle (2) MS1/EV1: Gregory “Greg” Harbaugh (2) MS2/EV2: Mario Runco (2) MS3: Susan Helms (1)	• Deployed TDRS-F/I • Orbital Altitude: 199.08 statute miles • Orbits: 96 • Duration: 05D 23H 38M 19S • Traveled: 2.50 million statute miles
STS-56 **ATLAS-2** 54th mission Discovery (16) OV-103 	**4/8/1993** Thursday 1:29 am EDT KSC (54) LC-39B (19) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: WSSH PLS: DFRC	**4/17/1993** Saturday 7:37 am EDT Landing (53) KSC (15) SLF 33 (9) **Landing Rollout Data** 9,530 feet (1.80 miles) 63 seconds	 CDR: Kenneth “Ken” Cameron (2) PLT: Stephen “Steve” Oswald (2) MS1: Michael “Mike” Foale (2) MS2: Kenneth “Ken” Cockrell (1) MS3: Ellen Ochoa (1)	• 8th night launch • 12th Spacelab mission (ATLAS-2) • Deployed SPARTAN 201-01 • Orbital Altitude: 185.39 statute miles • Orbits: 148 • Duration: 09D 06H 08M 19S • Traveled: 3.85 million statute miles

Mission	Launch	Landing	Crew	Highlights
STS-55 **Spacelab D-2** 55th mission Columbia (14) OV-102  	**4/26/1993** Monday 10:50 am EDT KSC (55) LC-39A (36) **Flight Day 1 Contingency Landing Sites** TAL: Banjul AOA: DFRC PLS: DFRC	**5/6/1993** Thursday 7:30 am PDT Landing (54) DFRC (38) EDW 22 (18) **Landing Rollout Data** 10,125 feet (1.92 miles) 61 seconds	 CDR: Steven "Steve" Nagel (4) PLT: Terence "Tom" Henricks (2) MS1/PCDR: Jerry Ross (4) MS2: Charles "Charlie" Precourt (1) MS3: Bernard Harris (1) PS1: Ulrich Walter, DFVLR (1) PS2: Hans Schlegel, DFVLR (1)	• 13th Spacelab mission (D-2) • Orbital Altitude: 187.58 statute miles • Orbits: 160 • Duration: 09D 23H 39M 59S • Traveled: 4.16 million statute miles • Planned landing site changed from KSC to DFRC • Orbiter Turnaround: 12 Days • Ferry departure, DFRC: 5/18/1993 • Ferry arrival, KSC: 5/21/1993
STS-57 **SPACEHAB-1** 56th mission Endeavour (4) OV-105  	**6/21/1993** Monday 9:07 am EDT KSC (56) LC-39B (20) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: DFRC PLS: DFRC	**7/1/1993** Thursday 8:52 am EDT Landing (55) KSC (16) SLF 33 (10) **Landing Rollout Data** 9,955 feet (1.89 miles) 65 seconds	 CDR: Ronald "Ron" Grabe (4) PLT: Brian Duffy (2) MS1/PCDR/EV1: David "Dave" Low (3) MS2: Nancy Sherlock (1) MS3/EV2: Peter 'Jeff" Wisoff (1) MS4: Janice Voss (1)	• SPACEHAB-1 • Retrieved EURECA • 1 EVA • Orbital Altitude: 296.90 statute miles • Orbits: 155 • Duration: 09D 23H 44M 54S • Traveled: 4.12 million statute miles
STS-51 **ORFEUS-SPAS** 57th mission Discovery (17) OV-103  	**9/12/1993** Sunday 7:45 am EDT KSC (57) LC-39B (21) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: DFRC PLS: DFRC	**9/22/1993** Wednesday 3:56 am EDT Landing (56) KSC (17) SLF 15 (6) **Landing Rollout Data** 8,271 ft (1.56 miles) 50 seconds	 CDR: Frank Culbertson (2) PLT: William "Bill' Readdy (2) MS1/EV2: James "Jim" Newman (1) MS2: Daniel "Dan" Burcsh (1) MS3/EV1: Carl Walz (1)	• Deployed ACTS • Deployed & retrieved ORFEUS-SPAS • 1 EVA • Orbital Altitude: 199.66 statute miles • Orbits: 157 • 6th night landing (1st at KSC) • Duration: 09D 20H 11M 06S • Traveled: 4.11 million statute miles

Mission	Launch	Landing	Crew	Highlights
STS-58 **SLS-2** 58th mission Columbia (15) OV-103  	**10/18/1993** Monday 10:53 am EDT KSC (58) LC-39B (22) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: DFRC PLS: DFRC	**11/1/1993** Monday 7:06 am PST Landing (57) DFRC (39) EDW 22 (19) **Landing Rollout Data** 9,640 ft (1.83 miles) 62 seconds	 CDR: John Blaha (4) PLT: Richard "Rick" Searfoss (1) MS1/PCDR: Rhea Seddon (3) MS2: William "Bill" MacArthur (1) MS3: David "Dave" Wolf (1) MS4: Shannon Lucid (4) PS1: Martin Fettman (1)	• 14th Spacelab mission (SLS-2) • Orbital Altitude: 178.37 statute miles • Orbits: 225 • Duration: 14D 00H 12M 32S • Traveled: 5.84 million statute miles • Last Columbia landing at DFRC • Longest Shuttle mission to date • Orbiter Turnaround: 6 Days • Ferry departure, DFRC: 11/7/1993 • Ferry arrival, KSC: 11/8/1993
STS-61 **HST-SM1** 59th mission Endeavour (5) OV-105  	**12/2/1993** Thursday 4:27 am EST KSC (59) LC-39B (24) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: DFRC PLS: DFRC	**12/13/1993** Monday 12:26 am EST Landing (58) KSC (18) SLF 33 (11) **Landing Rollout Data** 7,922 feet (1.50 miles) 53 seconds	 CDR: Richard "Dick" Covey (4) PLT: Kenneth "Ken" Bowersox (2) MS1/EV3: Kathryn 'Kathy" Thornton (3) MS2: Claude Nicollier, ESA (2) MS3/EV1: Jeffrey "Jeff" Hoffman (4) MS4/PCDR/EV2: Story Musgrave (5) MS5/EV4: Thomas "Tom" Akers (3)	• 9th night launch • 1st HST Servicing mission (SM-1) • 1st mission with four EVA crewmembers • 1st Shuttle mission with 5 EVA's • Orbital Altitude: 370.21 statute miles • Orbits: 163 • 7th night landing (2nd at KSC) Duration: 10D 19H 58M 33S • Traveled: 4.43 million statute miles
STS-60 **Shuttle-Mir** (1) 60th mission Discovery (18) OV-103  	**2/3/1994** Thursday 7:10 am EST KSC (60) LC-39A(37) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: WSSH PLS: DFRC	**2/11/1994** Friday 2:19 pm EST Landing (59) KSC (19) SLF 15 (7) **Landing Rollout Data** 7,820 feet (1.48 miles) 51 seconds	 CDR: Charles "Charlie' Bolden (4) PLT: Kenneth "Ken" Reightler (2) MS1: Jan Davis (2) MS2: Ronald "Ron" Sega (1) MS3: Franklin "Chang" Chang-Diaz (4) MS4: Sergei Krikalev, RKA (3)	• 1st Russian Cosmonaut on U.S. spacecraft (Krikalev) • 1st Shuttle-Mir mission via Good Morning America audio/video link • SPACEHAB-2 • Deployed/retrieved WSF-1 • Orbital Altitude: 223.71 statute miles • Orbits: 130 • Duration: 08D 07H 09M 22S • Traveled: 3.44 million statute miles

Mission	Launch	Landing	Crew	Highlights
STS-62 **USMP-2** 61st mission Columbia (16) OV-102  	**3/4/1994** Friday 8:53 am EST KSC (61) LC-39B (24) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: KSC PLS: DFRC	**3/18/1994** Friday 8:10 am EST Landing (60) KSC (20) SLF 33 (12) **Landing Rollout Data** 10,156 feet (1.92 miles) 54 seconds	 CDR: John Casper (3) PLT: Andrew “Andy” Allen (2) MS1/PCDR: Pierre Thuot (3) MS2: Charles “Sam” Gemar (3) MS3: Marsha Ivins (3)	• USMP-2 • OAST-2 • Orbital Altitude: 187.58 statute miles • Orbits: 224 • Duration: 13D 23H 16M 41S • Traveled: 5.82 million statute miles
STS-59 **SRL-1** Endeavour (6) OV-105  	**4/9/1994** Friday 7:05 am EDT KSC (62) LC-39A (38) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: WSSH PLS: WSSH	**4/20/1994** Wednesday 9:55 am PDT Landing (61) DFRC (40) EDW 22 (20) **Landing Rollout Data** 10,638 feet (2.01 miles) 53 seconds	 CDR: Sidney Guiterrez (2) PLT: Kevin Chilton (2) MS1: Jerome “Jay” Apt (3) MS2: Michael “Mike” Clifford (2) MS3 PCDR: Linda Godwin (2) MS4: Thomas “Tom” Jones (1)	• 15th Spacelab mission (SRL-1) • Orbital Altitude: 139.24 statute miles • Orbits: 183 • Duration: 11D 05H 49M 30S • Traveled: 4.70 million statute miles • Orbiter Turnaround: 6 Days • Ferry departure, DFRC: 4/26/1994 • Ferry arrival, KSC: 5/3/1994
STS-65 **IML-2** 63rd mission Columbia (17) OV-102  	**7/8/1994** Friday 12:43 pm EDT KSC (63) LC-39A (39) **Flight Day 1 Contingency Landing Sites** TAL: Banjul AOA: DFRC PLS: DFRC	**7/23/1994** Saturday 6:38 am EDT Landing (62) KSC (21) SLF 33 (13) **Landing Rollout Data** 10,211 feet (1.93 miles) 68 seconds	 CDR: Robert “Bob” Cabana (3) PLT: James “Jim” Halsell (1) MS1/PCDR: Richard “Rick” Hieb (3) MS2: Carl Walz (2) MS3: Leroy Chiao (1) MS4: Donald “Don” Thomas (1) PS: Chiaki Naito-Mukai (1)	• 16th Spacelab mission (IML-2) • 1st Japanese woman to fly in space (Naito-Mukai) • Orbital Altitude: 187.58 statute miles • Orbits: 235 • Duration: 14D 17H 55M 00S • Traveled: 6.14 million statute miles • Longest mission to date

Mission	Launch	Landing	Crew	Highlights
STS-64 **LITE** 64th mission Discovery (19) OV-103	**9/9/1994** Friday 6:22 pm EDT KSC (64) LC-39B (25)	**9/20/1994** Tuesday 2:13 pm PDT Landing (63) DFRC (41) EDW 04 (2)	 CDR: Richard "Dick" Richards (4) PLT: Blaine Hammond (2) MS1: Jerry Linenger (1) MS2: Susan Helms (2) MS3/EV2: Carl Meade (3) MS4/EV1: Mark Lee (3)	• LITE • Deployed & retrieved SPARTAN-201 • Orbital Altitude: 162.26 statute miles • 1 EVA • Orbits: 176 • Duration: 10D 22H 49M 57S • Traveled: 4.58 million statute miles • Landing site changed from KSC to DFRC due to weather • Orbiter Turnaround: 6 Days • Ferry departure, DFRC: 9/26/1994 • Ferry arrival, KSC: 9/27/1994
	Flight Day 1 Contingency Landing Sites	**Landing Rollout Data**		
	TAL: ZZA AOA: WSSH PLS: DFRC	12,045 feet (2.28 miles) 61 seconds		
STS-68 **SRL-2** 65th mission Endeavour (7) OV-105	**9/30/1994** Friday 7:16 am EDT KSC (65) LC-39A (40)	**10/11/1994** Tuesday 10:02 am PDT Landing (64) DFRC (42) EDW 22 (21)	 CDR: Michael "Mike" Baker (3) PLT: Terrence "Terry" Wilcutt (1) MS1: Steven "Steve" Smith (1) MS2: Daniel "Dan" Bursh (2) MS3: Peter "Jeff" Wisoff (2) MS4/PCDR: Thomas "Tom" Jones (2)	• 17th Spacelab mission (SRL-2) • Orbital Altitude: 138.09 statute miles • Orbits: 182 • Duration: 11D 05H 46M 08S • Traveled: 4.70 million statute miles • Landing site changed from KSC to DFRF due to weather • Orbiter Turnaround: 8 Days • Ferry departure, DFRC: 10/19/1994 • Ferry arrival, KSC: 10/20/1994
	Flight Day 1 Contingency Landing Sites	**Landing Rollout Data**		
	TAL: Moron AOA: WSSH PLS: DFRC	8,495 feet (1.61 miles) 62 seconds		
STS-66 **ATLAS-3** 66th mission Atlantis (13) OV-104	**11/3/1994** Thursday 12:00 pm EST KSC (66) LC-39B (26)	**11/14/1994** Monday 7:34 am PST Landing (65) DFRC (43) EDW 22 (22)	 CDR: Donald "Don" McMonagle (3) PLT: Curtis "Curt" Brown (2) MS1/PCDR: Ellen Ochoa (2) MS2: Joseph "Joe" Tanner (1) MS3: Jean-Francois Clervoy, CNES (1) MS4: Scott Parazynski (1)	• 18th Spacelab mission (ATLAS-3) • Deployed & retrieved CRISTA-SPAS • Orbital Altitude: 189.65 statute miles • Orbits: 174 • Duration: 10D 22H 34M 02S • Traveled: 4.55 million statute miles • Landing site changed from KSC to DFRC due to Tropical Storm Gordon • Orbiter Turnaround: 7 Days • Ferry departure, DFRC: 11/21/1994 • Ferry arrival, KSC: 11/22/1994
	Flight Day 1 Contingency Landing Sites	**Landing Rollout Data**		
	TAL: BEN AOA: N/A PLS: DFRC	7,647 feet (1.45 miles) 50 seconds		

Mission	Launch	Landing	Crew	Highlights
STS-63 **Shuttle-Mir** (2) 67th mission Discovery (20) OV-103	**2/3/1995** Friday 12:22 am EST KSC (67) LC-39B (27)	**2/11/1995** Saturday 6:50 am EST Landing (66) KSC (22) SLF 15 (8)		• 1st female Shuttle pilot (Collins) • 2nd shuttle flight with Russian Cosmonaut • 10th night launch • 1st part of Phase 1 of ISS Program • 2nd Shuttle-Mir mission • 1st Shuttle approach & fly around of Mir • SPACEHAB-3 • 1 EVA • IMAX camera used to film mission highlights • Orbital Altitude: 243.97 statute miles • Orbits: 129 • Duration: 08D 06H 28M 15S • Traveled: 2.92 million statute miles
	Flight Day 1 Contingency Landing Sites TAL: ZZA AOA: KSC PLS: DFRC	**Landing Rollout Data** 11,008 feet (2.08 miles) 70 seconds	CDR: James "Jim" Wetherbee (3) PLT: Eileen Collins (1) MS1/PCDR/EV2: Bernard Harris (2) MS2/EV1: Michael "Mike" Foale (3) MS3: Janice Voss (2) MS4: Vladimir Titov, RKA (4)	
STS-67 **ASTRO-2** 68th mission Endeavour (8) OV-105	**3/2/1995** Thursday 1:38 am EST KSC (68) LC-39A (41)	**3/18/1995** Saturday 1:47 pm PST Landing (67) DFRC (44) EDW 22 (23)		• 11th night launch • 19th Spacelab mission (ASTRO-2) • 1st advertised shuttle mission connected to the Internet • Most people in orbit (11) at one time to date (including Mir crew) • Orbital Altitude: 222.10 statute miles • Orbits: 262 • Duration: 16D 15H 08M 48S • Traveled: 6.9 million statute miles • Changed landing site from KSc to DFRF due to weather • Longest shuttle flight to date • Orbiter Turnaround: 8 Days • Ferry departure, DFRC: 3/26/1995 • Ferry arrival, KSC: 3/27/1995
	Flight Day 1 Contingency Landing Sites TAL: BEN AOA: DFRC PLS: DFRC	**Landing Rollout Data** 9,935 feet (1.88 miles) 47 seconds	CDR: Stephen "Steve" Oswald (3) PLT: William "Bill" Gregory (1) MS1: John Grunsfeld (1) MS2: Wendy Lawrence (1) MS3/PCDR: Tamara Jernigan (3) PS1: Samuel "Sam" Durrance (2) PS2: Ronald "Ron" Parise (2)	
STS-71 **Shuttle-Mir** (3) 69th mission Atlantis (14) OV-104	**6/27/1995** Tuesday 3:32 pm EDT KSC (69) LC-39A (42)	**7/7/1995** Friday 10:55 am EDT Landing (68) KSC (23) SLF 15 (9)		• 100th U.S. Human Spaceflight • 3rd Shuttle-Mir mission • 20th Spacelab mission (Spacelab-Mir) • 2nd Shuttle RNDZ with Mir • 1st Shuttle-Mir Docking • Largest spacecraft in orbit to date • 1st Mir crew transfer using Shuttle • Shuttle Crew of 8 returned from Mir • Orbital Altitude: 247.42 statute miles • Orbits: 153 • Duration: 09D 19H 22M 17S • Traveled: 4.10 million statute miles
	Flight Day 1 Contingency Landing Sites TAL: Moron AOA: WSSH PLS: DFRC	**Landing Rollout Data** 8,364 feet (1.58 miles) 53 seconds	CDR: Robert "Hoot" Gibson (5) PLT: Charles "Charlie" Precourt (2) MS1 PCDR: Ellen Baker (3) MS2: Gregory "Greg" Harbaugh (3) MS3: Bonnie Dunbar (4) <u>Ascent: Mir 19 Crew</u> MCDR: Anatoly Solovyev, RKA (4) FE: Nikolai Budarin, RKA (1) <u>Descent: Mir 18 Crew</u> MCDR: Vladimir Dezherov, RKA (1) FE: Gennady Strekalov, RKA (6) CR: Norman "Norm" Thagard (5)	

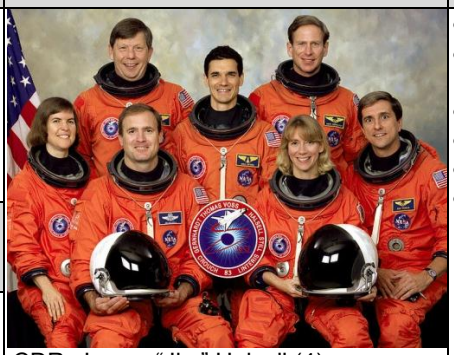
Mission	Launch	Landing	Crew	Highlights
STS-70 **TDRS-G** 70th mission Discovery (21) OV-103 	**7/13/1995** Thursday 9:42 am EDT KSC (70) LC-39B (28) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: DFRC PLS: DFRC	**7/22/1995** Saturday 8:02 am EDT Landing (69) KSC (24) SLF 33 (14) **Landing Rollout Data** 8,465 feet (1.60 miles) 58 seconds	 CDR: Terence “Tom” Henricks (3) PLT: Kevin Kregel (1) MS1: Nancy Currie (2) MS2: Donald “Don” Thomas (2) MS3: Mary Ellen Weber (1)	• Deployed TDRS-G • Orbital Altitude: 191.03 statute miles • Orbits: 143 • Duration: 08D 22H 20M 05S • Traveled: 3.70 million statute miles
STS-69 **SPARTAN** **WSF-2** 71st mission Endeavour (9) OV-105 	**9/7/1995** Thursday 11:09 am EDT KSC (71) LC-39A (43) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: DFRC PLS: DFRC	**9/18/1995** Monday 7:38 am EDT Landing (70) KSC (25) SLF 33 (15) **Landing Rollout Data** 10,230 feet (1.94 miles) 60 seconds	 CDR: David “Dave” Walker (4) PLT: Kenneth “Ken” Cockrell (2) MS1/PCDR: James “Jim” Voss (3) MS2/Ev1: James “Jim” Newman (2) MS3/EV2: Michael “Mike” Gernhardt (1)	• Deployed & retrieved SPARTAN 201-03 • Deployed & retrieved WSF-2 • 1st time two different payloads were retrieved and deployed during the same mission • 1 EVA • Orbital Altitude: 231.31 statute miles • Orbits: 171 • Duration: 10D 20H 28M 55S • Traveled: 4.50 million statute miles
STS-73 **USML-2** 72nd mission Columbia (18) OV-102 	**10/20/1995** Friday 9:53 am EDT KSC (72) LC-39B (29) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: DFRC PLS: DFRC	**11/5/1995** Sunday 7:45 am EST Landing (71) KSC (26) SLF 33 (16) **Landing Rollout Data** 9,032 feet (1.71 miles) 71 seconds	 CDR: Kenneth “Ken” Bowersox (3) PLT: Kent Rominger (1) MS1: Catherine “Cady” Coleman (1) MS2: Michael “LA” Lopez-Alegria (1) MS3/PCDR: Kathryn Thornton (4) PS1: Fred Leslie (1) PS2: Albert “Al” Sacco (1)	• 21st Spacelab mission (USML-2) • Orbital Altitude: 173.77 statute miles • Orbits: 256 • Duration: 15D 21H 52M 28S • Traveled: 6.60 million statute miles

Mission	Launch	Landing	Crew	Highlights
STS-74 **Shuttle-Mir** (4) 73rd mission Atlantis (15) OV-104  	**11/12/1995** Sunday 7:31 am EST KSC (73) LC-39A (44) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: KSC PLS: DFRC	**11/20/1995** Monday 12:01 pm EST Landing (72) KSC (27) SLF 33 (17) **Landing Rollout Data** 8,607 feet (1.63 miles) 58 seconds	 CDR: Kenneth "Ken" Cameron (3) PLT: James "Jim" Halsell (2) MS1: Chris Hadfield (CSA) (1) MS2: Jerry Ross (5) MS3: William "Bill" MacArthur (2)	• 4th Shuttle-Mir mission • 2nd Shuttle-Mir Docking • Delivered Russian Docking Module • Transferred cargo • Orbital Altitude: 212.89 statute miles • Orbits: 129 • Duration: 08D 04H 30M 44S • Traveled: 3.40 million statute miles
STS-72 **OAST** **JAXA SFU** 74th mission Endeavour (10) OV-105  	**1/11/1996** Thursday 4:41 am EST KSC (74) LC-39B (30) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: DFRC PLS: DFRC	**1/20/1996** Saturday 2:42 am EST Landing (73) KSC (28) SLF 15 (10) **Landing Rollout Data** 8,767 feet (1.66 miles) 66 seconds	 CDR: Brian Duffy (3) PLT: Brent Jett (1) MS1/EV1: Leroy Chiao (2) MS2/EV3: Winston Scott (1) MS3: Koichi Wakata, JAXA (1) MS4/EV2: Daniel "Dan" Barry (1)	• 12th night launch • Deployed & retrieved OAST-Flyer • Retrieved & returned JAXA SFU • 2 EVA's • Orbital Altitude: 295.52 statute miles • Orbits: 142 • 8th night landing (3rd at KSC) • Duration: 08D 22H 00M 40S • Traveled: 3.70 million statute miles
STS-75 **TSS-1R** **USMP-3** 75th mission Columbia (19) OV-102  	**2/22/1996** Thursday 3:18 pm EST KSC (75) LC-39B (31) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: KSC PLS: KSC	**3/9/1996** Saturday 8:58 am EST Landing (74) KSC (29) SLF 33 (18) **Landing Rollout Data** 8,460 feet (1.60 miles) 65 seconds	 CDR: Andrew "Andy" Allen (3) PLT: Scott Horowitz (1) MS1: Jeffrey "Jeff" Hoffman (5) MS2: Maurizio Cheli, ESA (1) MS3: Claude Nicollier (3) MS4/PCDR: Franklin Chang-Diaz (5) PS: Umberto Guidoni, ASI (1)	• Reflight of TSS-1R –Tether Broke, loss of TSS-1R • USMP-3 • Orbital Altitude: 199.08 statute miles • Orbits: 252 • Duration: 15D 17H 40M 21S • Traveled: 6.5 million statute miles

Mission	Launch	Landing	Crew	Highlights
STS-76 **Shuttle-Mir** (5) 76th mission Atlantis (16) OV-104 	**3/22/1996** Friday 3:13 am EST KSC (76) LC-39B (32) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: KSC PLS: DFRC	**3/31/1996** Sunday 5:28 am PST Landing (75) DFRC (45) EDW 22 (24) **Landing Rollout Data** 8,367 feet (1.59 miles) 55 seconds	 CDR: Kevin Chilton (3) PLT: Richard "Rick" Searfoss (2) MS1/PCDR: Ronald 'Ron' Sega (2) MS2/EV2: Michael "Mike' Clifford (3) MS3/EV1: Linda Godwin (3) <u>Ascent: Mir 21</u> MS4: Shannon Lucid (5)	• 13th night launch • 5th Shuttle-Mir mission • 3rd Shuttle-Mir docking • 1st SPACEHAB pressurized module in support of Shuttle-Mir • Crew/cargo transfers. • 1 EVA (1st with orbiter docked to Mir) • Orbital Altitude: 248.57 statute miles • Orbits: 145 • Duration: 09D 05H 15M 53S • Traveled: 3.80 million statute miles • Landing site changed from KSC to DFRC due to ground fog. • Last mission from old JSC MCC (used since Gemini IV) • Orbiter Turnaround: 6 Days • Ferry departure, DFRC: 4/6/1996 • Ferry arrival, KSC: 4/12/1996 • 1st U.S. female crewmember to visit Mir (Lucid) • Lucid's six months aboard Mir set a space endurance record for women and a U.S. space endurance record
STS-77 **SPACEHAB-4** 77th mission Endeavour (11) OV-105 	**5/19/1996** Sunday 6:30 am EDT KSC (77) LC-39B (33) **Flight Day 1 Contingency Landing Sites** TAL: Moron AOA: KSC PLS: DFRC	**5/29/1996** Wednesday 7:09 am EDT Landing (76) KSC (30) SLF 33 (19) **Landing Rollout Data** 9,291 feet (1.76 miles) 51 seconds	 CDR: John Casper (4) PLT: Curtis "Curt" Brown (3) MS1: Andrew "Andy" Thomas (1) MS2: Daniel Bursch (3) MS3: Mario Runco (3) MS4: Marc Garneau, CSA (2)	• SPACEHAB-4 • SPARTAN Free Flyer (IAE) • Orbital Altitude: 177.22 statute miles • Orbits: 161 • Duration: 10D 00H 39M 20S • Traveled: 4.10 million statute miles • 1st flight completely controlled from new JSC MCC
STS-78 **LMS** 78th mission Columbia (20) OV-102 	**6/20/1996** Thursday 10:49 EDT KSC (78) LC-39B (34) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: DFRC PLS: DFRC	**7/7/1996** Sunday 8:40 am EDT Landing (77) KSC (31) SLF 33 (20) **Landing Rollout Data** 9,339 feet (1.77 miles) 55 seconds	 CDR: Terence "Tom" Henricks (4) PLT: Kevin Kregel (2) MS1: Richard Linnehen (1) MS2/PCDR: Susan Helms (3) MS3: Charles Brady (1) PS1: Jean Favier, CNES (1) PS2: Robert "Bob" Thirsk, CSA (1)	• Life and Microgravity Sciences (LMS) • 22nd Spacelab mission • Orbital Altitude: 176.76 statute miles • Orbits: 272 • Duration: 16D 21H 47M 35S • Traveled: 7.05 million statute miles • Longest shuttle mission to date

Mission	Launch	Landing	Crew	Highlights
STS-79 **Shuttle-Mir** (6) 79th mission Atlantis (17) OV-104	**9/16/1996** Monday 4:55 am EDT KSC (79) LC-39A (45)	**9/26/1996** Thursday 8:13 am EDT Landing (78) KSC (32) SLF 15 (11)	 CDR: William "Bill" Readdy (3) PLT: Terrence "Terry" Wilcutt (2) MS1: Jerome "Jay" Apt (4) MS2: Thomas "Tom" Akers (4) MS3: Carl Walz (3) <u>Ascent: Mir 22</u> MS4: John Blaha (5) <u>Descent: Mir 22</u> MS4: Shannon Lucid (5)	• 14th night launch • 6th Shuttle-Mir mission • 4th Shuttle-Mir Docking • SPACEHAB Double Module (DM) • Crew Transfer • Orbital Altitude: 240.63 statute miles • Orbits: 160 • Duration: 10D 03H 18M 24S • Traveled: 3.90 million statute miles
	Flight Day 1 Contingency Landing Sites TAL: ZZA AOA: KSC PLS: DFRC	**Landing Rollout Data** 10,981 feet (2.08 miles) 81 seconds		
STS-80 **ORFEUS-SPAS II** 80th mission Columbia (21) OV-102	**11/19/1996** Tuesday 2:56 pm EST KSC (80) LC-39B (35)	**12/7/1996** Saturday 6:49 am EST Landing (79) KSC (33) SLF 33 (21)	 CDR: Kenneth "Ken" Cockrell (3) PLT: Kent Rominger (2) MS1/EV1: Tamara "Tammy" Jernigan (4) MS2/EV2: Thomas "Tom" Jones (3) MS3: Story Musgrave (6)	• ORFEUS-SPAS II • Wake Shield Facility-3 • EVAs cancelled – hatch problem • Orbital Altitude: 233.61 statute miles • Orbits: 279 • Duration: 17D 15H 53M 18S • Traveled: 7.04 million statute miles • Longest Shuttle mission
	Flight Day 1 Contingency Landing Sites TAL: BEN AOA: DFRC PLS: DFRC	**Landing Rollout Data** 8721 feet (1.65 miles) 69 seconds		
STS-81 **Shuttle-Mir** (7) 81st mission Atlantis (18) OV-104	**1/12/1997** Sunday 4:27AM EST KSC (81) LC-39B (36)	**1/22/1997** Wednesday 9:23 am EST Landing (80) KSC (34) SLF 33 (22)	 CDR: Michael "Mike" Baker (4) PLT: Brent Jett (2) MS1: Peter "Jeff" Wisoff (3) MS2: John Grunsfeld (2) MS3: Marsha Ivins (4) <u>Ascent: Mir 22</u> MS4: Jerry Linenger (2) <u>Descent: Mir 22</u> MS4: John Blaha (5)	• 15th night launch • 7th Shuttle-Mir mission • 5th Shuttle-Mir Docking • SPACEHAB Double Module (DM) • Tested TVIS designed for ISS • Orbital Altitude: 244.77 statute miles • Orbits: 160 • Duration: 10D 04H 55M 21S • Traveled: 3.90 million statute miles
	Flight Day 1 Contingency Landing Sites TAL: BEN AOA: DFRC PLS: DFRC	**Landing Rollout Data** 9350 feet (1.77 miles) 67 seconds		

Mission	Launch	Landing	Crew	Highlights
STS-82 **HST-SM2** 82nd mission Discovery (22) OV-103  	**2/11/1997** Tuesday 3:55 am EST KSC (82) LC-39A (46) **Flight Day 1 Contingency Landing Sites** TAL: N/A AOA: KSC PLS: KSC	**2/21/1997** Friday 3:32 am EST Landing (81) KSC (35) SLF 15 (12) **Landing Rollout Data** 7,066 feet (1.34 miles) 52 seconds	 CDR: Kenneth “Ken” Bowersox (4) PLT: Scott “Doc” Horowitz (2) MS1/EV4: Joseph “Joe” Tanner (2) MS2: Steven “Steve” Hawley (4) MS3/EV3: Gregory “Greg” Harbaugh (4) MS4/EV1: Mark Lee (4) MS5/EV2: Steven “Steve” Smith (2)	• 16th night launch • 2nd HST servicing mission (SM-02) • 5 EVA’s • Orbital Altitude: 385.63 statute miles • Shuttle altitude record • Orbits: 150 • 9th night landing (4th at KSC) • Duration: 09D 23H 37M 07S • Traveled: 3.8 million statute miles
STS-83 **MSL-1** 83rd mission Columbia (22) OV-102  	**4/4/1997** Friday 2:21 pm EST KSC (83) LC-39A (47) **Flight Day 1 Contingency Landing Sites** TAL: Banjul AOA: KSC PLS: N/A	**4/8/1997** Tuesday 2:33 pm EDT Landing (82) KSC (36) SLF 33 (23) **Landing Rollout Data** 8,602 feet (1.63 miles) 60 seconds	 CDR: James “Jim” Halsell (3) PLT: Susan Still (1) MS1/PCDR: Janice Voss (3) MS2: Michael “Mike” Gernhardt (2) MS3: Donald “Don” Thomas (3) PS1: Roger Crouch (1) PS2: Greg Linteris (1)	• 23rd Spacelab mission (MSL-1) • Shortened due to fuel cell problem • Orbital Altitude: 188.15 statute miles • Orbits: 63 • Duration: 03D 23H 12M 39S • Traveled: 1.50 million statute miles • Mission re-flown as STS-94
STS-84 **Shuttle-Mir** (8) 84th mission Atlantis (19) OV-104  	**5/15/1997** Thursday 4:08 am EDT KSC (84) LC-39A (48) **Flight Day 1 Contingency Landing Sites** AOA: KSC PLS: DFRC	**5/24/1997** Saturday 9:28 am EDT Landing (83) KSC (37) SLF 33 (24) **Landing Rollout Data** 8,384 feet (1.59 miles) 53 seconds	 CDR: Charles “Charlie” Precourt (3) PLT: Eileen Collins (2) MS1/PCDR: Jean Clervoy, ESA (2) MS2: Carlos Noriega (1) MS3: Edward “Ed” Lu (1) MS4: Yelena Kondakova, RKA (2) <u>Ascent: Mir 23</u> MS5: Michael “Mike” Foale (4) <u>Descent: Mir 23</u> MS5: Jerry Linenger (2)	• 17th night launch • 8th Shuttle-Mir mission • 6th Shuttle-Mir Docking • SPACEHAB Double Module (DM) • Crew change-out • Orbital altitude: 248.11 statute miles • Orbits: 144 • Duration: 09D 05H 19M 55S • Traveled: 3.60 million statute miles

Mission	Launch	Landing	Crew	Highlights
STS-94 **MSL-1R** 85th mission Columbia (23) OV-102	**7/1/1997** Tuesday 2:02 pm EDT KSC (85) LC-39A (49)	**7/17/1997** Thursday 6:47 pm EDT Landing (84) KSC (38) SLF 33 (25)		• 24th Spacelab mission (MSL-1R) • 1st re-flight of the same payload (MSL-1) • Orbital altitude: 188.04 statute miles • Orbits: 251 • Duration: 15D 16H 44M 33S • Traveled: 6.20 million statute miles
	Flight Day 1 Contingency Landing Sites	**Landing Rollout Data**		
	TAL: Banjul AOA: DFRC PLS: DFRC	8,892 feet (1.68 miles) 58 seconds	CDR: James "Jim" Halsell (4) PLT: Susan Still (2) MS1/PCDR: Janice Voss (4) MS2: Michael "Mike" Gernhardt (3) MS3: Donald "Don" Thomas (4) PS1: Roger Crouch (2) PS2: Greg Linteris (2)	
STS-85 **CRISTA-SPAS** 86th mission Discovery (23) OV-103	**8/7/1997** Thursday 10:41 am EDT KSC (86) LC39A (50)	**8/19/1997** Tuesday 7:08 am EDT Landing (85) KSC (39) SLF 33 (26)		• CRISTA-SPAS-02 • Orbital Altitude: 184.12 statute miles • Orbits: 185 • Duration: 11D 20H 26M 58S • Traveled: 4.73 million statute miles
	Flight Day 1 Contingency Landing Sites	**Landing Rollout Data**		
	TAL: Moron AOA: WSSH PLS: DFRC	8,792 feet (1.67 miles) 68 seconds	CDR: Curtis "Curt" Brown (4) PLT: Kent Rominger (3) MS1/PCDR: Jan Davis (3) MS2: Robert "Beamer" Curbeam (1) MS3: Stephen "Steve" Robinson (1) PS1: Bjarni Tryggvason, CSA (1)	
STS-86 **Shuttle-Mir** (9) 87th mission Atlantis (20) OV-104	**9/25/1997** Thursday 10:34 pm EDT KSC (87) LC-39A (51)	**10/6/1997** Monday 5:55 pm EDT Landing (86) KSC (40) SLF 15 (13)		• 18th night launch • 9th Shuttle-Mir mission • 7th Shuttle-Mir Docking • SPACEHAB DM • Crew/cargo transfer • 1 EVA (1st joint U.S.- Russian EVA) • Orbital Altitude: 243.97 statute miles • Orbits: 170 • Duration: 10D 19H 20M 51 • Traveled: 4.23 million statute miles
	Flight Day 1 Contingency Landing Sites	**Landing Rollout Data**		
	TAL: Moron AOA: KSC PLS: DFRC	11,947 feet (2.26 miles) 81 seconds	CDR: James "Jim" Wetherbee (4) PLT: Michael "Mike" Bloomfield (1) MS1/EV2: Vladimir Titov, RKA (5) MS2/EV1: Scott Parazynski (2) MS3: Jean-Loup Chretien, CNES (3) MS4: Wendy Lawrence (2) <u>Ascent: Mir 24</u> MS5: David "Dave" Wolf (2) <u>Descent: Mir 24</u> MS5: Michael "Mike" Foale (5)	

Mission	Launch	Landing	Crew	Highlights
STS-87 **USMP-4** 88th mission Columbia (24) OV-102 	**11/19/1997** Wednesday 2:46 pm EST KSC (88) LC-39B (37) **Flight Day 1 Contingency Landing Sites** TAL: Banjul AOA: DFRC PLS: WSSH	**12/5/1997** Friday 7:20 am EST Landing (87) KSC (41) SLF 33 (27) **Landing Rollout Data** 8,047 feet (1.52 miles) 58 seconds	 CDR: Kevin Kregel (3) PLT: Steven "Steve" Lindsey (1) MS1: Kalpana Chawla (1) MS2/EV1: Winston Scott (2) MS3/EV2: Takao Doi, JAXA (1) PS: Leonid Kadeniuk, NSAU (1)	• USMP-4 • SPARTAN 201-04 (unsuccessful) • 2 EVA's • Orbital Altitude: 178.37 statute miles • Orbits: 252 • Duration: 15D 16H 34M 04S • Traveled: 6.54 million statute miles
STS-89 **Shuttle-Mir** (10) 89th mission Endeavour (12) OV-105 	**1/22/1998** Thursday 9:48 pm EST KSC (89) LC-39A (52) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: WSSH PLS: DFRC	**1/31/1998** Saturday 5:35 pm EST Landing (88) KSC (42) SLF 15 (13) **Landing Rollout Data** 9,790 feet (1.85 miles) 72 seconds	 CDR: Terrence "Terry" Wilcutt (3) PLT: Joseph "Joe " Edwards (1) MS1: James "Jim" Reilly (1) MS2: Michael "Mike" Anderson (1) MS3: /PCDR Bonnie Dunbar (5) MS4; Salizhan Sharipov, RKA (1) <u>Ascent: Mir 24</u> MS5: Andrew "Andy" Thomas (2) <u>Descent: Mir 24</u> MS5: David "Dave" Wolf (2)	• 19th night launch • 10th Shuttle-Mir mission • 8th Shuttle-Mir Docking • Crew exchange • Orbital Altitude: 248.11 statute miles • Orbits: 139 • Duration: 08D 19H 46M 54S • Traveled: 3.61 million statute miles
STS-90 **Neurolab** 90th mission Columbia (25) OV-102 	**4/171998** Friday 2:19 pm EDT KSC (90) LC-39B (38) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: DFRC PLS: DFRC	**5/3/1998** Sunday 12:09 pm EDT Landing (89) KSC (43) SLF 33 (29) **Landing Rollout Data** 9,998 feet (1.89 miles) 58 seconds	 CDR: Richard "Rick" Searfoss (3) PLT: Scott Altman (1) MS1/PCDR: Richard "Rick" Linnehan (2) MS2: Kathryn "Kay" Hire (1) MS3: Dafydd "Dave" Williams, CSA (1) PS1: Jay Buckey (1) PS2: James "Jim" Pawelczyk (1)	• 25th & final Spacelab mission (Neurolab) • Most animals (2,000) on board • Orbital Altitude: 177.22 statute miles • Orbits: 255 • Duration: 15D 21H 49M 59S • Traveled: 6.38 million statute miles

Mission	Launch	Landing	Crew	Highlights
STS-91 **Shuttle-Mir** (11) **AMS** 91st mission Discovery (24) OV-103	**6/2/1998** Tuesday 6:06 pm EDT KSC (91) LC-39A (53)	**6/12/1998** Friday 2:00 pm EDT Landing (90) KSC (44) SLF 15 (14)		• 11th & final Shuttle-Mir mission • 9th & final Shuttle-Mir Docking • 1st mission to use the super light weight ET. • 1st AMS mission • Orbital Altitude: 234.76 statute miles • Orbits: 155 • Duration: 09D 19H 53M 53S • Traveled: 3.80 million statute miles
	Flight Day 1 Contingency Landing Sites	**Landing Rollout Data**		
	TAL: ZZA AOA: KSC PLS: DFRC	10,717 feet (2.03 miles) 71 seconds	CDR: Charles "Charlie" Precourt (4) PLT: Dominic "Dom" Gorie (1) MS1/PCDR: Franklin Chang-Diaz (6) MS2: Wendy Lawrence (3) MS3: Janet Kvandi (1) MS4: Valery Ryumin, RKA (4) <u>Descent: Mir 25</u> MS5: Andrew "Andy" Thomas (2)	
STS-95 **SPACEHAB** **SPARTAN** 92nd mission Discovery (25) OV-103	**10/29/1998** Thursday 1419 EST KSC (92) LC-39B (39)	**11/7/1998** Saturday 1204 EST Landing (91) KSC (45) SLF 33 (30)		• SPACEHAB • Deployed and retrieved SPARTAN-201 • HOST in preparation for 3rd HST Servicing mission • Orbital Altitude: 348.69 statute miles • Orbits: 134 • Duration: 08D 21H 43M 56S • Traveled: 3.64 million statute miles • John Glenn's 1st Shuttle flight – Oldest person to fly in space at 77 years old. – 2nd (last) sitting senator to fly in space • Glenn previously flew on Mercury Friendship 7 spacecraft and was the first American to orbit the Earth.
	Flight Day 1 Contingency Landing Sites	**Landing Rollout Data**		
	TAL: Banjul AOA: DFRC PLS: DFRC	9,508 feet (1.80 miles) 60 seconds	CDR: Curtis "Curt" Brown (5) PLT: Steven "Steve" Lindsey (2) MS1: Pedro Duque, ESA (1) MS2: Scott Parazinski (3) MS3: Stephen "Steve" Robinson (2) PS1: Chiaki Mukai, NASDA (2) PS2: Senator John Glenn, Ohio (2)	
STS-88 **ISS 2A** 93rd mission Endeavour (13) OV-105	**12/4/1998** Friday 3:36 am EST KSC (93) LC-39A (54)	**12/15/1998** Tuesday 10:54 pm EST Landing (92) KSC (46) SLF 15 (15)		• 20th night launch • 1st mission to the ISS (ISS 2A) • Delivered and installed the Unity Node including 2 PMA's. • ICBC used to document the mission • Orbital Altitude: 245.81 statute miles • Orbits: 185 • 10th night landing (5th at KSC) • Duration: 11D 19H 17M 51S • Traveled: 4.65 million statute miles
	Flight Day 1 Contingency Landing Sites	**Landing Rollout Data**		
	TAL: Moron AOA: KSC PLS: KSC	8,343 feet (1.58 miles) 44 seconds	CDR: Robert "Bob" Cabana (4) PLT: Frederick "Rick" Sturckow (1) MS1/EV1: Jerry Ross (6) MS2: Nancy Currie (3) MS3/EV2: James "Jim" Newman (3) MS4: Sergei Krikalev, RKA (4)	

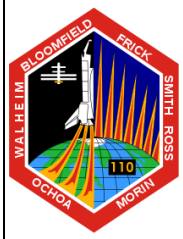
Mission	Launch	Landing	Crew	Highlights
STS-96 **ISS 2A.1** 94th mission Discovery (26) OV-103  	**5/27/1999** Thursday 6:50 am EDT KSC (94) LC-39B (40) **Flight Day 1 Contingency Landing Sites** TAL: Moron AOA: KSC PLS: DFRC	**6/6/1999** Sunday 2:03 am EDT Landing (93) KSC (47) SLF 15 (15) **Landing Rollout Data** 8,866 feet (1.68 miles) 52 seconds	 CDR: Kent Rominger (4) PLT: Rick Husband (1) MS1/EV1: Tamara "Tammy" Jernigan (5) MS2: Ellen Ochoa (3) MS3/EV2: Daniel "Dan" Barry (2) MS4: Julie Payette, CSA (1) MS5: Valery Tokarev (1)	• 2nd mission to the ISS (ISS 2A.1) • SPACEHAB DM • 1st Docking with ISS (Unity) • Transferred cargo • 1 EVA • Orbital Altitude: 236.15 statute miles • Orbits: 154 • 11th night landing (6th at KSC) • Duration: 09D 19H 13M 01S • Traveled: 4.05 million statute miles
STS-93 **Chandra** 95th mission Columbia (26) OV-102  	**7/23/1999** Friday 12:31 am EDT KSC (95) LC-39B (41) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: DFRC PLS: DFRC	**7/28/1999** Wednesday 11:20 pm EDT Landing (94) KSC (48) SLF 33 (32) **Landing Rollout Data** 6,851 feet (1.30 miles) 44 seconds	 CDR: Eileen Collins (3) PLT: Jeffrey "Jeff" Ashby (1) MS1: Catherine "Cady" Coleman (2) MS2: Steven "Steve" Hawley (5) MS3: Michel Tognini, CNES (2)	• 21st night launch • Deployed the Chandra X-ray Observatory • Orbital Altitude: 177.22 statute miles • Orbits: 80 • 12th night landing (7th at KSC) • Duration: 04D 22H 49M 35S • Traveled: 1.80 million statute miles • 1st woman CDR (Collins)
STS-103 **HST-SM3A** 96th mission Discovery (27) OV-103  	**12/19/1999** Sunday 7:50 pm EST KSC (96) LC-39B (42) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: DFRC PLS: DFRC	**12/27/1999** Monday 7:01 pm EST Landing (95) KSC (49) SLF 33 (33) **Landing Rollout Data** 7,005 feet (1.33 miles) 48 seconds	 CDR: Curtis "Curt" Brown (6) PLT: Scott Kelly (1) MS1/EV1: Steven "Steve" Smith (3) MS2: Jean Clervoy, ESA (3) MS3/EV2: John Grunsfeld (3) MS4/EV3: Michael "Mike" Foale (5) MS5/EV4: Claude Nicollier, ESA (4)	• 22nd night launch • 3rd HST Servicing mission (SM-3A) • 3 EVA's • Orbital Altitude: 379.76 statute miles • Orbits: 120 • 13th night landing (8th at KSC) • Duration: 07D 23H 10M 47S • Traveled: 3.27 million statute miles

Mission	Launch	Landing	Crew	Highlights
STS-99 **SRTM** 97th mission Endeavour (14) OV-105 	**2/11/2000** Friday 12:44 pm EST KSC (97) LC-39A (55) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: WSSH PLS: DFRC	**2/22/2000** Tuesday 6:22 pm EST Landing (96) KSC (50) SLF 33 (34) **Landing Rollout Data** 9,943 feet (1.88 miles) 59 seconds	 CDR: Kevin Kregel (4) PLT: Dominic “Dom” Gorie (2) MS1: Gerhard Thiele (1) MS2: Janet Kavandi (2) MS3: Janice Voss (5) MS4: Mamoru Mohri, JAXA (2)	• Last mission with standard cockpit • 1st Shuttle Radar Topography Mission (SRTM) • Last flight with lightweight ET • Orbital Altitude: 149.03 statute miles • Orbits: 182 • Duration: 11D 05H 38M 44S • Traveled: 4.71 million statute miles
STS-101 **ISS 2A.2a** 98th mission Atlantis (21) OV-104  	**5/19/2000** Friday 6:11 am EDT KSC (98) LC-39A (56) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: KSC PLS: DFRC	**5/29/2000** Monday 2:20 am EDT Landing (97) KSC (51) SLF 15 (16) **Landing Rollout Data** 8,813 feet (1.69 miles) 48 seconds	 CDR: James “Jim” Halsell (5) PLT: Scott Horowitz (3) MS1: Mary Weber (2) MS2/EV1: Jeffrey “Jeff” Williams (1) MS3/EV2: James “Jim” Voss (4) MS4: Susan Helms (4) MS5: Yuri Usachev, RKA (3)	• 23rd night launch • First mission with glass cockpit • 3rd mission to ISS (ISS 2A.2a) • SPACEHAB DM • Delivered supplies • Performed U.S/Russian crane work • 1 EVA (49) • Orbital Altitude: 199 statute miles • Orbits: 155 • 14th night landing (9th at KSC) • Duration: 09D 20H 09M 09S • Traveled: 5.08 million statute miles
STS-106 **ISS 2A.2b** 99th mission Atlantis (22) OV-104  	**9/8/2000** Friday 8:46 am EDT KSC (99) LC-39B (43) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: WSSH PLS: DFRC	**9/20/2000** Wednesday 3:57 am EDT Landing (98) KSC (52) SLF 15 (17) **Landing Rollout Data** 9,127 feet (1.73 miles) 78 seconds	 CDR: Terrence “Terry” Wilcutt (4) PLT: Scott Altman (2) MS1/EV1: Edward “Ed” Lu (2) MS2: Richard “Rick” Mastracchio (1) MS3: Daniel “Dan” Burbank (1) MS4/EV2: Yuri Malenchenko, RKA (2) MS5: Boris Morukev, RKA, (1)	• 4th mission to ISS (ISS 2A.2b) • SPACEHAB DM • ICC • Delivered supplies & installed power, data & comm. cables. • 1 EVA (50) • Orbital Altitude: 237.06 statute miles • Orbits: 185 • 15th night landing (10th at KSC) • Duration: 11D 19H 10M 57S • Traveled: 4.92 million statute miles

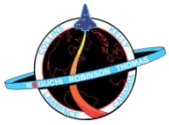
Mission	Launch	Landing	Crew	Highlights
STS-92 **ISS 3.3A** 100th mission Discovery (28) OV-103   	**10/11/2000** Wednesday 6:17 am EDT KSC (100) LC-39A (57) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: KSC PLS: DFRC	**10/24/2000** Tuesday 1:00 am PDT Landing (99) DFRC (46) EDW 22 (25) **Landing Rollout Data** 9,090 feet (1.72 miles) 67 seconds	 CDR: Brian Duffy (4) PLT: Pamela "Pam" Melroy (1) MS1/EV1: Leroy Chiao (3) MS2/EV2: William "Bill" McArthur (3) MS3/EV3: Peter "Jeff" Wisoff (4) MS4/EV4: Michael Lopez-Alegria (2) MS5: Koichi Wakata, JAXA, (2)	• 24th night launch • 5th mission to ISS (ISS 3.3A) • Installed Z1 Truss & PMA-3 and associated assemblies • 4 EVA's • Orbital Altitude: 245.12 statute miles • Orbits: 203 • Landing site changed from KSC to DFRC due to rainy weather • Duration: 12D 21H 42M 42S • Traveled: 5.33 million statute miles • Orbiter Turnaround: 9 Days • Ferry departure, DFRC: 11/2/2000 • Ferry arrival, KSC: 11/3/2000
STS-97 **ISS 4A** 101st mission Endeavour (15) OV-105   	**11/30/2000** Thursday 10:06 am EST KSC (101) LC-39B (44) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: KSC PLS: DFRC	**12/11/2000** Saturday 6:03 pm EST Landing (100) KSC (53) SLF 15 (18) **Landing Rollout Data** 7,980 feet (1.51 miles) 57 seconds	 CDR: Brent Jett (3) PLT: Michael "Mike" Bloomfield (2) MS1/EV1: Joseph "Joe" Tanner (3) MS2: Marc Garneau, CSA (3) MS3/EV2: Carlos Noriega (2)	• 25th night launch • 6th mission to ISS (ISS 4A) • Delivered P6 truss (1st photovoltaic solar array assembly) • Installed and configured the P6 solar arrays. • 3 EVA's • Orbital Altitude: 236.45 statute miles • Orbits: 170 • 16th night landing (11th at KSC) • Duration: 10D 19H 57M 22S • Traveled: 4.48 million statute miles
STS-98 **ISS 5A** 102nd mission Atlantis (23) OV-104   	**2/7/2001** Wednesday 6:13 pm EST KSC (102) LC-39A (58) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: KSC PLS: DFRC	**2/20/2001** Tuesday 12:33 pm PST Landing (101) DFRC (47) EDW 22 (26) **Landing Rollout Data** 7,970 feet (1.51 miles) 56 seconds	 CDR: Kenneth "Ken" Cockrell (4) PLT: Mark "Roman" Polansky (1) MS1/EV2: Robert "Beamer" Curbeam (2) MS2: Marsha Ivins (5) MS3/EV1: Thomas "Tom" Jones (4)	• 7th mission to ISS (ISS 5A) • Delivered and installed the U.S. "Destiny" Laboratory. • 3 EVA's • Orbital Altitude: 242.58 statute miles • Orbits: 203 • Duration: 12D 20H 20M 04S • Landing site changed from KSC to DFRC • Traveled: 5.37 million statute miles • Orbiter Turnaround: 8 Days • Ferry departure, DFRC: 2/28/2001 • Ferry arrival, KSC: 3/4/2001

Mission	Launch	Landing	Crew	Highlights
STS-102 **ISS 5A.1** 103rd mission Discovery (29) OV-103  	**3/8/2001** Thursday 6:42 am EST KSC (103) LC-39B (45) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: KSC PLS: DFRC	**3/21/01** Wednesday 2:31 am EST Landing (102) KSC (54) SLF 15 (19) **Landing Rollout Data** 11,244 feet (2.13 miles) 85 seconds	 CDR: James "Jim" Wetherbee (5) PLT: James "Jim" Kelly (1) MS1/EV3: Andrew "Andy" Thomas (3) MS2/EV4: Paul Richards (1) <u>Ascent: Expedition 2 crew</u> MS3/EV 1/FE1: James "Jim" Voss (5) MS4/EV 2/FE2: Susan Helms (5) MS5/ICDR: Yury Usakev, RKA (4) <u>Descent: Expedition 1 crew</u> MS3/FE: Sergei Krikalev, RKA (5) MS4/ICDR: William "Bill" Shepherd (4) MS5/SPLT: Yuri Gidzenko, RKA (2)	• 8th mission to ISS (ISS 5A.1) • Resupplied ISS using "Leonardo" MPLM • 2 EVA's • 1st Shuttle-ISS crew exchange • Orbital Altitude: 199 statute miles • Orbits: 202 • 17th night landing (12th at KSC) • Duration: 12D 19H 49M 32S • Traveled: 5.36 million statute miles
STS-100 **ISS 6A** 104th mission Endeavour (16) OV-105  	**4/19/2001** Thursday 2:41 pm EDT KSC (104) LC-39A (59) **Flight Day 1 Contingency Landing Sites** TAL: Moron AOA: KSC PLS: KSC	**5/1/2001** Tuesday 9:11 am PDT Landing (103) DFRC (48) EDW 22 (27) **Landing Rollout Data** 7,964 feet (1.51 miles) 51 seconds	 CDR: Kent Rominger (5) PLT: Jeffrey "Jeff" Ashby (2) MS1/EV1: Chris Hadfield CSA (2) MS2: John Phillips (1) MS3/EV2: Scott Parazynski (4) MS4: Umberto Guidoni, ESA (2) MS5: Yuri Lonchakov, RKA (1)	• 9th mission to ISS (ISS 6A) • Delivered racks for "Destiny" Lab using "Raffaelo" MPLM • Installed Canadarm2 • 2 EVA's • Orbital Altitude: 252.03 statute miles • Orbits: 187 • Landing site changed from KSC to DFRC due to rainy weather forecast • Duration: 11D 21H 30M 01S • Traveled: 4.9 million statute miles • Orbiter Turnaround: 7 Days • Ferry departure, DFRC: 5/8/2001 • Ferry arrival, KSC: 5/9/2001
STS-104 **ISS 7A** 105th mission Atlantis (24) OV-104  	**7/12/2001** Thursday 5:04 am EDT KSC (105) LC-39B (46) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: KSC PLS: DFRC	**7/24/2001** Tuesday 11:39 pm EDT Landing (104) KSC (55) SLF 15 (20) **Landing Rollout Data** 10,858 feet (2.06 miles) 68 seconds	 CDR: Steven "Steve" Lindsey (3) PLT: Charles "Charlie" Hobaugh (1) MS1/EV1: Michael "Mike" Gernhardt (4) MS2: Janet Kavandi (3) MS3/EV2: James "Jim" Reilly (2)	• 26th night launch • 10th mission to ISS (ISS 7A) • Spacehab Double Pallet • Installed joint U.S./Russian "Quest" airlock for EVA's • 3 EVA's • Orbital Altitude: 242.81 statute miles • Orbits: 201 • 18th night landing (13th at KSC) • Duration: 12D 18H 34M 56S • Traveled: 5.30 million statute miles

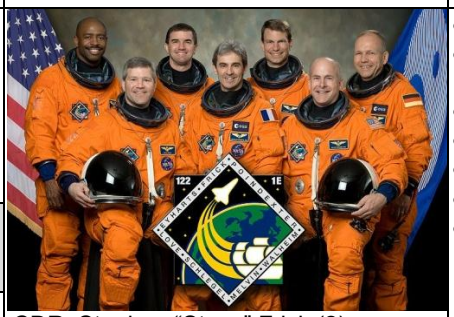
Mission	Launch	Landing	Crew	Highlights
STS-105 **ISS 7A.1** 106th mission Discovery (30) OV-103  	**8/10/2001** Friday 5:10 pm EDT KSC (106) LC-39A (60) **Flight Day 1 Contingency Landing Sites** TAL: Moron AOA: KSC PLS: DFRC	**8/22/2001** Wednesday 2:23 pm EDT Landing (105) KSC (56) SLF 15 (21) **Landing Rollout Data** 10,036 feet (1.90 miles) 66 seconds	 CDR: Scott Horowitz (4) PLT: Frederick "Rick" Sturckow (2) MS1/EV1: Patrick"Pat" Forrester (1) MS1/EV2: Daniel "Dan" Barry (3) <u>Ascent: Expedition 3 crew</u> MS3/CDR: Frank Culbertsen (3) MS4/SPLT: Mikhail Turin, RKA (1) MS5/FE: Vladimir Dezhurov, RKA (2) <u>Descent: Expedition 2 crew</u> MS3/FE1: James "Jim" Voss (5) MS4/FE2: Susan Helms (5) MS5/ICDR: Yury Usakev, RKA (4)	• 11th mission to ISS (ISS 7A.1) • 2nd ISS crew exchange • Delivered racks and supplies using the "Leonardo" MPLM • Prepared ISS for delivery of the S0 truss • 2 EVA's • Orbital Altitude: 251.79 statute miles • Orbits: 186 (landed on orbit 187) • Duration: 11D 21H 12M 45S • Traveled: 4.91 million statute miles
STS-108 **ISS UF-1** 107th mission Endeavour (17) OV-105  	**12/5/2001** Wednesday 5:19 am EST KSC (107) LC-39B (47) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: WSSH PLS: DFRC	**12/17/2001** Monday 12:55 pm EST Landing (107) KSC (57) SLF 15 (22) **Landing Rollout Data** 8,941 feet (1.69 miles) 66 seconds	 CDR: Dominic "Dom" Gorie (3) PLT: Mark Kelly (1) MS1/EV1: Linda Godwin (4) MS2/EV2: Daniel "Dan" Tani (1) <u>Ascent: Expedition 4 crew</u> MS3/FE1: Carl Walz, (4) MS4/FE2: Daniel Bursch (4) MS5/ICDR: Yuri Onufrienko, RKA (4) <u>Descent: Expedition 3 crew</u> MS3/ICDR: Frank Culbertsen (3) MS4/SPLT: Vladimir Dezhurov, RKA (2) MS4/FE: Mikhail Turin, RKA (1)	• 27th night launch • 12th mission to ISS (ISS-UF1) • 3rd ISS crew exchange • Delivered supplies using the "Raffaello" MPLM • 1 EVA • Orbital Altitude: 234.76 statute miles • Orbits: 185 (landed on orbit 186) • Duration: 11D 19H 35M 44S • Traveled: 4.82 million statute miles

Mission	Launch	Landing	Crew	Highlights
STS-109 **HST-SM3B** 108th mission Columbia (27) OV-102  	**3/1/2002** Friday 6:22 am EST KSC (108) LC-39A (61) **Flight Day 1 Contingency Landing Sites** TAL: BEN AOA: DFRC PLS: DFRC	**3/12/2002** Tuesday 4:32 am EST Landing (107) KSC (58) SLF 33 (35) **Landing Rollout Data** 10,119 feet (1.92 miles) 72 seconds	 CDR: Scott Altman (3) PLT: Duane Carey (1) MS1/EV1: John Grunsfeld (4) MS2: Nancy Currie (4) MS3/EV2: Richard "Rick" Linnehan (3) MS4/EV3: James "Jim" Newman (4) MS5/EV5: Michael Massimino (1)	• 28th night launch • 4th HST Servicing mission (SM-3B) • 5 EVA's • Orbital Altitude: 312.60 statute miles • Orbits: 165 (landed on orbit 166) • 19th night landing (14th at KSC) • Duration: 10D 22H 09M 51S • Traveled: 3.94 million statute miles • Columbia's last landing
STS-110 **ISS 8A** 109th mission Atlantis (25) OV-104   	**4/8/2002** Monday 4:44 pm EDT KSC (109) LC-39B (48) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: KSC PLS: DFRC	**4/19/2002** Friday 2:27 pm EDT Landing (108) KSC (59) SLF 33 (36) **Landing Rollout Data** 9,619 feet (1.82 miles) 70 seconds	 CDR: Michael "Mike" Bloomfield (3) PLT: Stephen "Steve" Frick (1) MS1/EV2: Rex Walheim (1) MS2: Ellen Ochoa (4) MS3/EV4: Lee Morin (1) MS4/EV3: Jerry Ross (7) MS5/EV5: Steven "Steve" Smith (4)	• 13th mission to ISS (ISS 8A) • Installed S0 ITS to "Destiny" • Delivered the Mobile Transporter • 4 EVA's • Orbital Altitude: 251.68 statute miles • Orbits: 170 (landed on orbit 171) • Duration: 10D 19H 42M 39S • Traveled: 4.53 million statute miles
STS-111 **ISS UF-2** 110th mission Endeavour (18) OV-105   	6/5/2002 Wednesday 5:23 pm EDT KSC (110) LC-39A (62) **Flight Day 1 Contingency Landing Sites** TAL: Moron AOA: KSC PLS: DFRC	6/19/2002 Wednesday 10:58 am PDT Landing (109) DFRC (49) EDW 22 (28) **Landing Rollout Data** 9619 feet (1.82 miles) 64 seconds	 CDR: Kenneth "Ken" Cockrell (5) PLT: Paul Lockhart (1) MS1/EV2: Philippe Perrin, CNES (1) MS2/EV1: Franklin Chang-Diaz (7) <u>Ascent: Expedition 5</u> MS3/FE: Peggy Whitson, (1) MS4/ICDR: Valery Korzun, RKA (2) MS5/FE: Sergei Treshchev (1) <u>Descent: Expedition 4</u> MS3/FE: Carl Walz, (4) MS4/FE: Daniel Bursch (4) MS5/ICDR: Yuri Onufrienko, RKA (4)	• 14th mission to ISS (ISS UF-2) • ISS crew exchange • Delivered racks and supplies using the "Leonardo" MPLM • Delivered and installed the MBS to the MT completing the MSS • 3 EVA's • Orbital Altitude: 242.24 statute miles • Orbits: 217 (landed on orbit 218) • Landing site changed from KSC to DFRC due to thunderstorms • Duration:13D 20H 34M 53S • Traveled: 5.78 million statute miles • Orbiter Turnaround: 7 Days • Ferry departure, DFRC: 6/26/2001 • Ferry arrival, KSC: 6/29/2001

Mission	Launch	Landing	Crew	Highlights
STS-112 **ISS 9A** 111th mission Atlantis (26) OV-104   	**10/7/2002** Monday 3:46 pm EDT KSC (111) LC-39B (49) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: KSC PLS: DFRC	**10/18/2002** Friday 11:44 am EDT Landing (110) KSC (60) SLF 33 (37) **Landing Rollout Data** 8305 feet (1.57 miles) 52 seconds	 CDR: Jeffrey "Jeff" Ashby (3) PLT: Pamela "Pam" Melroy (2) MS1/EV1:David "Dave" Wolf (3) MS2: Sandra Magnus (1) MS3/EV2: Piers Sellers (1) MS4: Fyodor Yurchikhin, RKA (1)	• 15th mission to ISS (ISS-9A) • 1st ascent with ET Shuttle observation camera • Delivered and installed the S1 Truss and the CETA • 3 EVA's • Orbital Altitude: 253.17 statute miles • Orbits: 170 (landed on orbit 171) • Duration: 10D 19H 57M 50S • Traveled: 4.51 million statute miles
STS-113 **ISS-11A** 112th mission Endeavour (19) OV-105   	**11/23/2002** Saturday 7:50 pm EDT KSC (112) LC-39A (63) **Flight Day 1 Contingency Landing Sites** TAL:ZZA AOA: KSC PLS: EDW	**12/7/2002** Saturday 2:37 pm EDT Landing (111) KSC (61) SLF 33 (38) **Landing Rollout Data** 10,574 feet (2.00 miles) 75 seconds	 CDR: James "Jim" Wetherbee (6) PLT: Paul Lockhart (2) MS1/EV1: Michael Lopez-Alegria (3) MS2/EV2: John Herrington (1) <u>Ascent:(Expedition 6)</u> MS3/ICDR: Kenneth Bowersox (5) MS4/FE1: Nikolai Budarin, RKA (3) MS5/FE2: Donald Pettit (1) <u>Descent: (Expedition 5)</u> MS4/ICDR: Valery Korzun, RKA (2) MS5/FE1: Peggy Whitson, (1) MS3/FE2: Sergei Treshchev (1)	• 29th night launch • 16th mission to ISS (ISS-11A) • Crew exchange • Delivered and installed the P1 ITS Truss & the second CETA. • 3 EVA's • Orbital Altitude: 246.27 statute miles • Orbits: 215 (landed on orbit 216) • Duration: 13D 18H 47M 26S • Traveled: 5.74 million statute miles • 1st time a mission ended on EOM 3, the 4th day of landing attempts
STS-107 **SPACEHAB** 113th mission Columbia (28) OV-102  	**1/16/2003** Thursday 10:39 am EST KSC (113) LC-39A (64) **Flight Day 1 Contingency Landing Sites** TAL: Moron AOA: DFRC PLS: DFRC	**2/1/2003** Saturday Loss of crew and vehicle during re-entry	 CDR: Rick Husband (2) PLT: William "Willie" McCool (1) MS1: David "Dave" Brown (1) MS2: Kalpana Chawla (2) MS3/PCDR: Michael Anderson (2) MS4: Laurel Clark (1) MS5: Ilan Ramon, Israel (1)	• SPACEHAB Double Module • Freestar experiment • 1st flight with an Israeli astronaut • Extended Duration Orbiter Pallet • Orbital Altitude: 179.52 statute miles • Orbits: 255 • Duration: 15D 22H 20M 32S • Traveled: 6.65 million miles • Loss of Columbia and crew during re-entry to KSC at 0859 EST • Last flight of Columbia – Flew 28 missions – Deployed 8 satellites – Traveled 125.2 million miles – Orbited Earth 4,808 times – Over 300 days in space – Landed at DFRC/EAFB12 times – Landed at KSC 14 times – Landed at WSSH 1 time (STS-3)

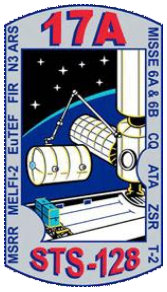
Mission	Launch	Landing	Crew	Highlights
STS-114 **Return to Flight** **ISS LF-1** 114th mission Discovery (31) OV-103  	**7/26/2005** Tuesday 10:39 am EDT KSC (114) LC-39B (50) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: KSC PLS: DFRC	**8/9/2005** Tuesday 05:11 am PDT Landing (112) DFRC (50) EDW 22 (29) **Landing Rollout Data** 11,346 feet (2.15 miles) 68 seconds	 CDR: Eileen Collins (4) PLT: James "Jim" Kelly (2) MS1/EV1: Soichi Noguchi, JAXA (1) MS2/EV2: Stephen Robinson (3) MS3: Andrew "Andy" Thomas (4) MS4: Wendy Lawrence (4) MS5: Charlie Camarda (1)	• Return to flight mission • 17th mission to the ISS (ISS LF-1) • Delivered equipment/supplies using the "Raffaelo" MPLM • Flight safety evaluation • 3 EVA's • Orbital Altitude: 219.80 statute miles • Orbits: 219 (landed on orbit 220) • 20th night landing (6th at DFRC) • Duration: 13D 21H 32M 23S • Traveled: 5.75 million statute miles • Orbiter Turnaround: 10 Days • Ferry departure, DFRC: 8/19/2005 • Ferry arrival, KSC: 8/21/2005
STS-121 **Return to Flight** **ISS ULF-1.1** 115th mission Discovery (32) OV-103  	**7/4/2006** Tuesday 2:38 pm EDT KSC (115) LC-39B (51) **Flight Day 1 Contingency Landing Sites** TAL:Moron AOA: KSC PLS: DFRC	**7/17/2006** Monday 9:15 am EDT Landing (113) KSC (62) SLF 15 (23) **Landing Rollout Data** 8,965 feet (1.70 miles) 74 seconds	 CDR: Steven Lindsey (4) PLT: Mark Kelly (2) MS1/EV2: Michael "Mike" Fossum (1) MS2: Lisa Nowak (1) MS3: Stephanie Wilson (1) MS4/EV1: Piers Sellers <u>Ascent: Expedition 13 crewmember</u> MS5: Thomas Reiter, ESA (2)	• 2nd Return to flight mission • 18th mission to the ISS (ULF1.1) • Delivered equipment and supplies using the "Leonardo" MPLM • 3 EVA's • Orbital Altitude: 219.45 statute miles • Orbits: 202 (landed on orbit 203) • Duration: 12D 18H 36M 47S • Traveled: 5.30 million statute miles • Most photographed Shuttle mission to assess any damage to the TPS.
STS-115 **ISS 12A** 116th mission Atlantis (27) OV-104  	**9/9/2006** Saturday 11:15 am EDT KSC (116) LC-39B (52) **Flight Day 1 Contingency Landing Sites** TAL: Moron AOA: KSC PLS: DFRC	**9/21/2006** Thursday 6:21 am EDT Landing (114) KSC (63) SLF 33 (39) **Landing Rollout Data** 7,539 feet (1.43 miles) 52 seconds	 CDR: Brent Jett (4) PLT: Chris Fergusen (1) MS1/EV1: Joe Tanner (4) MS2/EV2: Dan Burbank (2) MS3/EV3: Heidemarie "Heide" Stefanyshyn-Piper (1) MS4/EV4: Steve MacLean, CSA (2)	• 19th mission to the ISS (ISS-12A) • Delivered P3/P4 trusses and 2A/4a solar arrays • 1st use of airlock campout prebreathe protocol (Quest AL) • 3 EVA's • Orbital Altitude: 218.65 statute miles • Orbits: 185 (landed on orbit 186) • 21st night landing (15th at KSC) • Duration: 11D 19H 06M 28S • Traveled: 4.87 million statute miles

Mission	Launch	Landing	Crew	Highlights
STS-116 **ISS 12A.1** 117th mission Discovery (33) OV-103  	**12/9/2006** Saturday 8:48 pm EST KSC (117) LC-39B (53) **Flight Day 1 Contingency Landing Sites** TAL:Moron AOA: WSSH PLS: DFRC	**12/22/2006** Friday 5:32 pm EST Landing (115) KSC (64) SLF 15 (24) **Landing Rollout Data** 8,155 feet (1.54 miles) 53 seconds	 CDR: Mark "Roman" Polansky (2) PLT: William "Bill" Oefelein (only) MS1: Nicholas Patrick (1) MS2/EV1: Robert "Beamer" Curbeam (3) MS3/EV2: Christer Fuglesang (1) MS4: Joan Higginbotham (only) <u>Ascent: Expedition 14 crewmember</u> MS5/EV3/FE: Sunita Williams (1) <u>Descent: Expedition 14 crewmember</u> MS5/FE: Thomas Reiter (2)	• 30th night launch • 20th mission to the ISS (ISS 12A.1) • SPACEHAB-SM Logistics Module • Delivered the ITS segment P5 and equipment and supplies • 4 EVA's • Orbital Altitude: 212.32 statute miles • Orbits: 203 (landed on orbit 204) • Duration: 12D 20H 44M 33S • Traveled: 5.33 million statute miles
STS-117 **ISS 13A** 118th mission Atlantis (28) OV-104  	**6/8/2007** Friday 7:38 pm EDT KSC (118) LC-39A (65) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: KSC PLS: DFRC	**6/22/2007** Friday 12:50 pm PDT Landing (116) DFRC (51) EDW 22 (30) **Landing Rollout Data** 9,979 feet (1.89 miles) 64 seconds	 CDR: Frederick "Rick" Sturckow (3) PLT: Lee Archambault (1) MS1/EV3: Patrick "Pat" Forrester (2) MS2/EV4: Steven "Steve" Swanson (1) MS3/EV2: John Olivas (1) MS4/EV1: James "Jim" Reilly (3) <u>Ascent:(Expedition 15)</u> MS5/FE: Clayton "Clay" Anderson (1) <u>Descent: (Expedition 14)</u> MS5/FE: Sunita "Sunny" Williams (1)	• 21st mission to the ISS (ISS 13A) • Delivered the S3/S4 truss • 4 EVA's • Orbital Altitude: 221.87 statute miles • Orbits: 218 (landed on orbit 219) • Duration: 13D 20H 11M 33S • Traveled: 5.81 million statute miles • Orbiter Turnaround: 9 Days • Ferry departure, DFRC: 7/1/2007 • Ferry arrival, KSC: 7/3/2007
STS-118 **ISS 13A.1** 119th mission Endeavour (20) OV-105  	**8/8/2007** Wednesday 6:37 pm EDT KSC (119) LC-39A (66) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: KSC PLS: DFRC	**8/21/2007** Tuesday 12:32 pm EDT Landing (117) KSC (65) SLF 15 (25) **Landing Rollout Data** 10,234 feet (1.94 miles) 46 seconds	 CDR: Scott Kelly (2) PLT: Charles "Charlie" Hobaugh (2) MS1: Tracy Caldwell (1) MS2/EV1: Richard Mastracchio (2) MS3/EV2: Dafydd Williams, CSA (2) MS4: Barbara Morgan (1) MS5: Alvin Drew (5)	• 22nd mission to the ISS (ISS 13A.1) • Final SPACEHAB mission -SM Logistics module • Delivered & installed S5 truss & ESP-3 • 1st mission SSPTS was available • 4 EVA's • Orbital Altitude: 215.43 statute miles • Orbits: 200 (landed on orbit 201) • Duration: 12D 17H 55M 35S • Traveled: 5.27 million statute miles

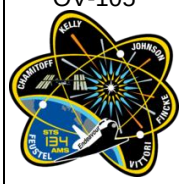
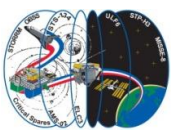
Mission	Launch	Landing	Crew	Highlights
STS-120 **ISS 10A** 120th mission Discovery (34) OV-103   	**10/23/2007** Tuesday 11:38 pm EDT KSC (120) LC-39A (67) **Flight Day 1 Contingency Landing Sites** TAL: Moron AOA: WSSH PLS: DFRC	**11/7/2007** Wednesday 1:01 pm EST Landing (118) KSC (66) SLF 33 (40) **Landing Rollout Data** 8,346 feet (1.58 miles) 54 seconds	 CDR: Pamela "Pam" Melroy (3) PLT: George Zamka (1) MS1/EV1: Scott Parazynski (5) MS2: Stephanie Wilson (2) MS3/EV2: Douglas Wheelock (1) MS4: Paolo Nespoli, ESA (1) <u>Ascent: Expedition 16</u> MS5/FE: Daniel "Dan" Tani (2) <u>Descent: Expedition 15/16</u> MS5/FE: Clayton "Clay" Anderson (1)	• 23rd mission to the ISS (ISS 10A) • 1st dock of two spacecraft commanded by women – Peggy Whitson was ISS CDR. • Delivered and attached the U.S. "Harmony" module (Node 2) • 4 EVA's • Orbital Altitude: 216.35 statute miles • Orbits: 237 (landed on orbit 238) • Duration: 15D 2H 22M 58S • Traveled: 6.25 million statute miles
STS-122 **ISS 1E** 121st mission Atlantis (29) OV-104   	**2/7/2008** Thursday 2:46 pm EST KSC (121) LC-39A (68) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: WSSH PLS: DFRC	**2/20/2008** Wednesday 9:07 am EST Landing (119) KSC (67) SLF 15 (26) **Landing Rollout Data** 8,567 feet (1.62 miles) 58 seconds	 CDR: Stephen "Steve" Frick (2) PLT: Alan "Dex" Poindexter (1) MS1: Leland Melvin (1) MS2/EV1: Rex Walheim (2) MS3/EV2: Hans Schelgel, ESA (2) MS4/EV3: Stanley "Stan" Love (1) <u>Ascent: Expedition 16</u> MS5/FE: Leopold Eyharts, ESA (2) <u>Descent: Expedition 16</u> MS5/FE: Daniel "Dan" Tani (2)	• 24th mission to the ISS (ISS-1E) • Delivered and attached the ESA "Columbus" Lab • 3 EVA's • Orbital Altitude: 215.89 statute miles • Orbits: 202 (landed on orbit 203) • Duration: 12D 18H 21M 39S • Traveled: 5.30 million statute miles

Mission	Launch	Landing	Crew	Highlights
STS-123 **ISS 1J/A** 122nd mission Endeavour (21) OV-105  	**3/11/2008** Tuesday 2:28 am EDT KSC (122) LC-39A (69) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: WSSH PLS: DFRC	**3/26/2008** Wednesday 8:39 pm EDT Landing (120) KSC (68) SLF 15 (27) **Landing Rollout Data** 11,455 feet (2.17 miles) 90 seconds	 CDR: Dominic "Dom" Gorie (4) PLT: Gregory "Greg" Johnson (1) MS1/EV2: Robert "Bob" Behnken (1) MS2/EV3: Michael "Mike" Foreman (1) MS3: Takao Doi (2) MS4/EV1: Richard "Rick" Linnehan (4) <u>Ascent: Expedition 16/17</u> MS5/FE: Garrett Reisman (1) <u>Descent: Expedition 16</u> MS5/FE: Leopold Eyharts, ESA (2)	• 31st night launch • 25th mission to the ISS (ISS 1J/A) • 26th Spacelab mission (SLP-D1) • Delivered and attached the JEM ELM-PS & SPDM • 5 EVA's • Orbital Altitude: 218.65 statute miles • Orbits: 249 (landed on orbit 250) • 22nd night landing (16th at KSC) • Duration: 15D18H 10M 52S • Traveled: 6.58 million statute miles
STS-124 **ISS 1J** 123rd mission Discovery (35) OV-103  	**5/31/2008** Saturday 5:02 pm EDT KSC (123) LC-39A (70) **Flight Day 1 Contingency Landing Sites** TAL: Moron AOA: KSC PLS: DFRC	**6/14/2008** Saturday 11:16 am EDT Landing (121) KSC (69) SLF 15 (28) **Landing Rollout Data** 9,321 feet (1.77 Miles) 62 seconds	 CDR: Mark Kelly (3) PLT: Kenneth "Ken" Ham (1) MS1: Karen Nyberg (1) MS2/EV2: Ronald "Ron" Garan (1) MS3/EV1: Michael Fossum (2) MS4: Akihiko Hoshide, JAXA (1) <u>Ascent: Expedition 17/18</u> MS5/FE: Gregory "Greg" Chamitoff (1) <u>Descent: Expedition 16/17</u> MS5/FE: Garrett Reisman (1)	• 26th mission to the ISS (ISS-1J) • Delivered JEM "Kibo" & JEM RMS • Delivered Buzz Lightyear to ISS • EVA's • Orbital Altitude: 219.34 statute miles • Orbits: 217 (landed on orbit 218) • Duration: 13D 18H 13M 06S • Traveled: 5.74 million statute miles

Mission	Launch	Landing	Crew	Highlights
STS-126 **ISS ULF-2** 124th mission Endeavour (22) OV-105   	**11/14/2008** Friday 7:56 pm EST KSC (124) LC-39A (71) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: KSC PLS: DFRC	**11/30/2008** Sunday 1:25 pm PST Landing (122) DFRC (52) EDW 04L (1) **Landing Rollout Data** 9,140 feet (1.73 miles) 53 seconds	 CDR: Christopher Ferguson (2) PLT: Eric Boe (1) MS1: Donald "Don" Petitt (2) MS2: Stephen "Steve" Bowen (1) MS3: Heidemarie Stefanyshyn-Piper (1) MS4: Shane Kimbrough (2) <u>Ascent: Expedition 18</u> MS5/FE: Sandra Magnus (2) <u>Descent: Expedition 17</u> MS5/FE: Gregory "Greg" Chamitoff (1)	• 32nd night launch • 27th mission to the ISS (ISS ULF-2) • Delivered equipment and supplies using the "Leonardo" MPLM • 4 EVA's • Orbital Altitude: 222.22 statute miles • Orbits: 250 (landed on orbit 251) • Duration: 15D 20H 29M 30S • Traveled: 6.62 million statute miles • Only Shuttle landing on EDW inside runway / asphalt / 12,000 feet runway • Orbiter Turnaround: 10 Days • Ferry departure, DFRC: 12/10/2007 • Ferry arrival, KSC: 12/12/2007
STS-119 **ISS 15A** 125th mission Discovery (36) OV-103   	**3/15/09** Sunday 7:44 pm EDT KSC (125) LC-39A (72) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: KSC PLS: DFRC	**3/28/09** Saturday 3:13 pm EDT Landing (123) KSC (70) SLF 15 (29) **Landing Rollout Data** 10,345 feet (1.96 miles) 77 seconds	 CDR: Lee Archambault (2) PLT: Dominic "Tony" Antonelli (2) MS1/EV3:Joseph "Joe" Acaba (1) MS2/EV1:Steven "Steve" Swanson (2) MS3/EV2: Richard "Rick" Arnold (1) MS4: John Philips (3) <u>Ascent: Expedition 18</u> MS5/FE: Koichi Wakata (3) <u>Descent: Expedition 18</u> MS5/FE: Sandra Magnus (2)	• 33rd night launch • 28th mission to the ISS (ISS 15A) • Delivered and installed the S6 Truss and Solar Arrays completing the ITS. • 3 EVA's • Orbital Altitude: 212.66 statute miles • Orbits: 201 (landed on orbit 202) • Duration: 12D 19H 29M 42S • Traveled: 5.30 million statute miles
STS-125 **HST-SM4** 126th mission Atlantis (30) OV-104  	**5/11/09** Monday 2:02 pm EDT KSC (126) LC-39A (73) **Flight Day 1 Contingency Landing Sites** TAL: Moron AOA: DFRC PLS: DFRC	**5/24/09** Sunday 8:39 am PDT Landing (124) DFRC (53) EDW 22L (31) **Landing Rollout Data** 8,504 feet (1.61 miles) 69 seconds	 CDR: Scott Altman (4) PLT: Gregory "Greg" Johnson (1) MS1/EV4: Michael "Mike" Good (1) MS2: Megan MacArthur (1) MS3/EV1: John Grunsfeld (5) MS4/EV3: Michael Massamino (2) MS5/EV2: Andrew "Drew" Feustel (1)	• 5th and final HST servicing mission (SM-4) • IMAX camera used to document mission highlights • 5 EVA's • Orbital Altitude: 338.67 statute miles • Orbits: 197 (landed on orbit 198) • Duration: 12D 21H 37M 18S • Traveled: 5.28 million statute miles • Change landing site from KSC to DFRC due to weather • 1st Shuttle landing on the refurbished EDW concrete runway • Orbiter Turnaround: 7 Days • Ferry departure, DFRC: 6/1/2009 • Ferry arrival, KSC: 6/2/2009

Mission	Launch	Landing	Crew	Highlights
STS-127 **ISS 2J/A** 127th mission Endeavour (23) OV-105   	**7/15/09** Wednesday 6:03 pm EDT KSC (127) LC-39A (74) **Flight Day 1 Contingency Landing Sites** TAL: Moron AOA: WSSH PLS: DFRC	**7/31/09** Friday 10:48 pm EDT Landing (125) KSC (71) SLF 15 (30) **Landing Rollout Data** 10,059 feet (1.91 miles) 66 seconds	 CDR: Mark “Roman” Polansky (3) PLT: Douglas “Doug” Hurley (1) MS1/EV4: Christopher Cassidy (1) MS2: Julie Payette, CSA (2) MS3/EV3: Thomas “Tom” Marshburn (1) MS4/EV1:David “Dave” Wolf (4) <u>Ascent: Expedition 20</u> MS5/EV2/FE: Timothy Kopra (1) <u>Descent: Expedition 20</u> MS5/FE: Koichi Wakata, JAXA (3)	• 29th mission to the ISS (ISS 2J/A) • Delivered and installed JEM-EF, JEM ELM ES • 13 people on ISS (most people in space at any one time) • 5 EVA’s • Orbital Altitude: 212.32 statute miles • Orbits: 248 (landed on 249) • Duration: 15D 16H 44M 58S • Traveled: 6.55 million statute miles
STS-128 **ISS 17A** 128th mission Discovery (37) OV-103   	**8/28/09** Friday 12:00 am EDT KSC (128) LC-39A (75) **Flight Day 1 Contingency Landing Sites** TAL: Moron AOA: WSSH PLS: DFRC	**9/11/09** Friday 5:53 pm PDT Landing (126) DFRC (54) EDW 22L (32) **Landing Rollout Data** 11,594 feet (2.20 miles) 73 seconds	 CDR: Frederick “Rick” Sturckow (4) PLT: Kevin Ford (1) MS1: Patrick ”Pat” Forrester (3) MS2: Jose Hernandez (1) MS3/EV3: Christer Fuglesang (2) MS4/EV1: John Olivas (2) <u>Ascent: Expedition 20</u> MS5/EV2: Nicole Stott (1) <u>Descent: Expedition 20</u> MS5: Timothy “Tim” Kopra (1)	• 34th night launch • 30th mission to the ISS (ISS 17A) • Delivered equipment and supplies using the “Leonardo” MPLM • 3 EVA’s • Orbital Altitude: 221.06 statute miles • Orbits: 218 (landed on 219) • 23rd night landing (7th at DFRC) • Returned Buzz Lightyear to Earth • Duration: 13D 20H 53M 43S • Traveled: 5.70 million statute miles • Orbiter Turnaround: 8 Days • Ferry departure, DFRC: 9/19/2009 • Ferry arrival, KSC: 9/21/2009

Mission	Launch	Landing	Crew	Highlights
STS-129 **ISS ULF-3** 129th mission Atlantis (31) OV-104   	**11/16/09** Monday 2:28 pm EST KSC (129) LC-39A (76) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: KSC PLS: DFRC	**11/27/09** Friday 9:44 am EST Landing (127) KSC (72) SLF 33 (41) **Landing Rollout Data** 6.586 feet (1.25 miles) 44 seconds	 CDR: Charlie Hobaugh (3) PLT: Barry "Butch" Wilmore (1) MS1: Leland Melvin (2) MS2/EV3: Randolph Bresnik (1) MS3/EV1:Michael "Mike" Foreman (2) MS4/EV2: Robert "Bob" Satcher (1) <u>Descent: Expedition 21</u> MS5/FE: Nicole Stott (1)	• 31st mission to ISS (ISS ULF-3) • 2 ELCs with parts for the ISS exterior • 3 EVA's • Orbital Altitude: 220.83 statute miles • Orbits: 171 (landed orbit 172) • Duration: 10D 19H 16M 14S • Traveled: 4.49 million statute miles • Last ISS crew member rotation flight
STS-130 **ISS 20A** 130th mission Endeavour (24) OV-105   	**2/8/10** Monday 4:14 am EST KSC (130) LC-39A (77) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: KSC PLS: DFRC	**2/21/10** Sunday 10:20 pm EST Landing (128) KSC (73) SLF 15 (31) **Landing Rollout Data** 10,206 feet (1.93 miles) 91 seconds	 CDR: George Zamka (2) PLT: Terry Virts (1) MS1: Kathryn "Kay" Hire (2) MS2: Stephen "Steve" Robinson (4) MS3/EV2: Nicholas Patrick (2) MS4/EV1: Robert "Bob" Behnken (2)	• 35th night launch • 32nd mission to ISS (ISS 20A) • Delivered and installed the Node 3 "Tranquility" module and the Cupola robotic control station • 3 EVA's • Orbital Altitude: 219.0 statute miles • Orbits: 219 • 24th night landing (17th at KSC) • Duration: 13D 18H 06M 22S • Traveled: 5.13 million statute miles
STS-131 **ISS 19A** 131st mission Discovery (38) OV-103   	**4/5/10** Monday 6:21 am EDT KSC (131) LC-39A (78) **Flight Day 1 Contingency Landing Sites** TAL: Moron AOA: KSC PLS: KSC	**4/20/10** Tuesday 9:08 am EDT Landing (129) KSC (74) SLF 33 (32) **Landing Rollout Data** 8,327 feet (1.58 miles) 58 seconds	 CDR: Alan "Dex" Poindexter (2) PLT: James "Jim" Dutton (1) MS1/EV1: Richard Mastracchio (3) MS2: Dottie Metcalf-Lindenberger (1) MS3: Stephanie Wilson (3) MS4: Naoko Yamazaki, JAXA (1) MS5/EV2: Clayton Anderson (2)	• 33rd mission to ISS (ISS 19A) • Delivered equipment and supplies using the "Leonardo" MPLM • 3 EVA's • Last 7 crewmember flight • Orbital Altitude: 219.34 statute miles • Orbits: 238 (landed on orbit 239) • Duration: 15D 02H 47M 09S • Traveled: 6.23 million statute miles • Longest flight of Discovery

Mission	Launch	Landing	Crew	Highlights
STS-132 **ISS ULF-4** 132nd mission Atlantis (32) OV-104  	**5/14/10** Friday 2:20 pm EDT KSC (132) LC-39A (79) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: KSC PLS: DFRC	**5/26/10** Wednesday 8:49 am EDT Landing (130) KSC (75) SLF 33 (42) **Landing Rollout Data** 9,100 feet 1.72 miles 79 seconds	 CDR: Kenneth "Ken" Ham (2) PLT: Dominic "Tony" Antonelli (2) MS1: Garrett Reisman (2) MS2: Michael "Mike" Good (2) MS3:Stephen "Steve" Bowen (2) MS4: Piers Sellers (3)	• 34th mission to ISS (ISS ULF4) • Delivered and installed MRM-1 • 3 EVA's • Orbital Altitude: 224.9 statute miles • Orbits: 186 • Duration: 11D 18H 29M 09S • Traveled: 4.9 million statute miles • 75th landing at KSC
STS-133 **ISS ULF-5** 133rd mission Discovery (39) OV-103  	**2/24/11** Thursday 4:53 pm EST KSC (133) LC-39A (80) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: KSC PLS: DFRC	**3/9/11** Wednesday 11:57 am EST KSC (76) SLF 15 (32) **Landing Rollout Data** 7,195 feet 1.36 miles 56 seconds	 CDR: Steven "Steve" Lindsey (5) PLT: Eric Boe (2) MS1:Benjamin "Alvin" Drew (2) MS2: Stephen "Steve" Bowen (3) MS3: Michael "Mike" Barratt (2) MS4: Nicole Stott (2)	• 35th mission to ISS (ISS ULF5) –PMM, ELC • 2 EVA's • Orbital Altitude: 224.9 statute miles • Orbits: 202 • Duration: 12D 19H 04M 50S • Traveled: 5.3 million statute miles • 76th landing at KSC • Last flight of Discovery –Flew 39 missions. –Deployed 31 satellites –Docked with Mir 1 times –Docked with ISS 13 times –On orbit a total of over 365 days. –Orbited Earth 5,830 times. –Traveled 148.2 million miles. –Landed at DFRC/EAFB 15 times –Landed at KSC 24 times
STS-134 **ISS ULF-6** 134th mission Endeavour (25) OV-105  	**5/16/11** Monday 8:56 am EDT KSC (134) LC-39A (81) **Flight Day 1 Contingency Landing Sites** TAL: ZZA AOA: NOR PLS: DFRC	**6/1/11** Wednesday 2:32 am EDT KSC (77) SLF 15 (33) **Landing Rollout Data** 6,574 feet 1.25 miles 42 seconds	 CDR: Mark Kelly (4) PLT: Gregory "Greg" Johnson (2) MS1: Michael "Mike" Fincke (3) MS2: Roberto Vittori, ESA (3) MS3: Andrew "Drew" Feustel (2) MS4:Gregory "Greg" Chamitoff (2)	• 36th mission to ISS (ISS-ULF6) –AMS, ELC • 4 EVA's including 162nd and final Shuttle crew EVA • Over 1,000 hours of Shuttle EVA's? • Last 6 crewmember flight • Orbital Altitude: 224.9 statute miles • Orbits: 248 • Duration: 15D 17H 38M 51S • Traveled: 6.5 million statute miles • Last flight of Endeavour –Flew 33 missions. –Deployed 14 satellites –Docked with Mir 7 times –Docked with ISS 12 times –On orbit a total of over 306 days. –Orbited Earth 4,848 times. –Traveled 125.9 million miles. –Landed at DFRC/EAFB 13 times –Landed at KSC 20 times

Mission	Launch	Landing	Crew	Highlights
STS-135 **ISS ULF-7** 135th mission Atlantis (33) OV-104	**7/8/2011** KSC LC-39A (82)	7/21/2011 5:57 am EDT KSC (78) SLF 15(34)	 CDR: Christopher Ferguson (3) PLT: Douglas "Doug" Hurley (2) MS1: Sandra Magnus (3) MS2: Rex Walheim (3)	• 37th mission to ISS (ISS-ULF7) • Last 4 crewmember flight • Orbital Altitude: • Orbits: • Duration: • Traveled: million statute miles • Last flight of Atlantis – Flew 33 missions. – Deployed 14 satellites – Docked with Mir 7 times – Docked with ISS 12 times – On orbit a total of over 306 days. – Orbited Earth 4,848 times. – Traveled 125.9 million miles. – Landed at DFRC/EAFB 13 times – Landed at KSC 20 times
	Flight Day 1 Contingency Landing Sites	**Landing Rollout Data**		
	TAL: ZZA AOA: NOR PLS: DFRC	9,712 feet 1.84 miles 51 seconds		

Atlantis reenters Earth's atmosphere for the final time as seen from the International Space Station

Space Shuttle End of Mission Landing Sites

During the shuttle program there were three landing sites used for normal end of mission orbiter landings: Edwards AFB, California, where Dryden Flight Research Center is located; the Shuttle Landing Facility at Kennedy Space Center (KSC), Florida; and White Sands Space Harbor (WSSH), located at the U.S. Army White Sands Missile Range New Mexico.

Space Shuttle Endeavour touches down at Edwards Air Force Base November 30, 2008 to conclude mission STS-126 to the International Space Station.

Dryden was the primary landing site for the first six missions due to the safety margins provided by using Rogers Dry Lake. These landings provided the shuttle commander, pilot and support teams experience with landing and recovering the orbiter prior to using the SLF in Florida as the primary landing site. STS-3 landed at Northup Strip (later named WSSH) on March 30, 1982, due to inclement weather conditions at Edwards. In 1984 KSC became the primary landing site where five of the next six missions landed. However, problems with orbiter brake and tire damage and safety concerns in the wake of the Challenger accident resulted in Dryden becoming the primary landing site until 1991, when KSC became the primary landing site for the remainder of the program.

Dryden continued to serve as an alternate site when unfavorable weather in Florida or special circumstances prevented a landing there. White Sands was the tertiary landing site and was available in case weather or circumstances prevented a landing at KSC or DFRC. During the program 54 orbiters landed at Dryden, including STS-1, which landed on runway 23 on April 14, 1981. The last mission to land at Dryden was STS-128 on September 11, 2009. 78 orbiters landed at KSC, including Mission 41-B on February 11, 1984 and the final mission of the program, STS-135, which landed on July 21, 2011. STS-3 was the only mission to land at WSSH.

The Space Shuttle Colombia touches down on runway 17 at the White Sands Space Harbor on March 30, 1982 completing STS-3.

Space Shuttle Landing Log

Shuttle Landings at DFRC/Edwards AFB, CA

Orbiter		Mission	Date	Day/Night	Runway	Surface
Enterprise	OV-101	ALT-1	8/12/77	Day	17	Lakebed
Enterprise	OV-101	ALT-2	9/13/77	Day	17	Lakebed
Enterprise	OV-101	ALT-3	9/23/77	Day	15	Lakebed
Enterprise	OV-101	ALT-4	10/12/77	Day	17	Lakebed
Enterprise	OV-101	ALT-5	10/26/77	Day	04	Concrete
Columbia	OV-102	STS-1	4/14/81	Day	23	Lakebed
Columbia	OV-102	STS-2	11/14/81	Day	23	Lakebed
Columbia	OV-102	STS-4	7/4/82	Day	22	Concrete
Columbia	OV-102	STS-5	11/16/82	Day	22	Concrete
Challenger	OV-099	STS-6	4/9/83	Day	22	Concrete
Challenger	OV-099	STS-7	6/24/83	Day	15	Lakebed
Challenger	OV-099	STS-8	9/5/83	Night	22	Concrete
Columbia	OV-102	STS-9	12/8/83	Day	17	Lakebed
Challenger	OV-099	STS-41C	4/13/84	Day	22	Concrete
Discovery	OV-103	STS-41D	9/5/84	Day	17	Lakebed
Challenger	OV-099	STS-51B	5/6/85	Day	17	Lakebed
Discovery	OV-103	STS-51G	6/24/85	Day	23	Lakebed
Challenger	OV-099	STS-51F	8/5/85	Day	23	Lakebed
Discovery	OV-103	STS-51I	9/3/85	Day	23	Lakebed
Atlantis	OV-104	STS-51J	10/7/85	Day	23	Lakebed
Challenger	OV-099	STS-61A	11/6/85	Day	17	Lakebed
Atlantis	OV-104	STS-61B	12/3/85	Day	22	Concrete
Columbia	OV-102	STS-61C	12/18/85	Night	22	Concrete
Discovery	OV-103	STS-26	10/3/88	Day	17	Lakebed
Atlantis	OV-104	STS-27	12/6/88	Day	17	Lakebed
Discovery	OV-103	STS-29	3/18/89	Day	22	Concrete
Atlantis	OV-104	STS-30	5/8/89	Day	22	Concrete
Columbia	OV-102	STS-28	8/13/89	Day	17	Lakebed
Atlantis	OV-104	STS-34	10/23/89	Day	23	Lakebed
Discovery	OV-103	STS-33	11/27/89	Day	04	Concrete
Columbia	OV-102	STS-32	1/20/90	Night	22	Concrete
Atlantis	OV-104	STS-36	3/4/90	Day	23	Lakebed
Discovery	OV-103	STS-31	4/29/90	Day	22	Concrete
Discovery	OV-103	STS-41	10/10/90	Day	22	Concrete
Columbia	OV-102	STS-35	12/10/90	Night	22	Concrete
Atlantis	OV-104	STS-37	4/11/91	Day	22	Concrete
Columbia	OV-102	STS-40	6/14/91	Day	22	Concrete
Discovery	OV-103	STS-48	9/18/91	Night	22	Concrete
Atlantis	OV-104	STS-44	12/1/91	Day	05	Lakebed
Discovery	OV-103	STS-42	1/30/92	Day	22	Concrete
Endeavour	OV-105	STS-49	5/16/92	Day	22	Concrete
Discovery	OV-103	STS-53	12/9/92	Day	22	Concrete
Columbia	OV-102	STS-55	5/6/93	Day	22	Concrete
Columbia	OV-102	STS-58	11/1/93	Day	22	Concrete
Endeavour	OV-105	STS-59	4/20/94	Day	22	Concrete
Discovery	OV-103	STS-64	9/20/94	Day	04	Concrete
Endeavour	OV-105	STS-68	10/11/94	Day	22	Concrete
Atlantis	OV-104	STS-66	11/14/94	Day	22	Concrete
Endeavour	OV-105	STS-67	3/18/95	Day	22	Concrete
Atlantis	OV-104	STS-76	3/31/96	Day	22	Concrete
Discovery	OV-103	STS-92	10/24/00	Day	22	Concrete
Atlantis	OV-104	STS-98	2/20/01	Day	22	Concrete
Endeavour	OV-105	STS-100	5/1/01	Day	22	Concrete
Endeavour	OV-105	STS-111	6/19/01	Day	22	Concrete
Discovery	OV-103	STS-114	8/9/05	Night	22	Concrete
Atlantis	OV-104	STS-117	6/22/07	Day	22	Concrete
Endeavour	OV-105	STS-126	11/30/08	Day	04L	Asphalt
Atlantis	OV-104	STS-125	5/24/09	Day	22L	Concrete
Discovery	OV-103	STS-128	9/11/09	Day	22L	Concrete

Shuttle Landings at Kennedy Space Center, FL

Orbiter		Mission	Date	Day/Night	Runway	Surface
Orbiter		**Mission**	**Date**	**Day/Night**	**Runway**	**Surface**
Challenger	OV-099	STS-41B	2/11/84	Day	15	Concrete
Challenger	OV-099	STS-41G	10/13/84	Day	33	Concrete
Discovery	OV-103	STS-51A	11/16/84	Day	15	Concrete
Discovery	OV-103	STS-51C	1/27/85	Day	15	Concrete
Discovery	OV-103	STS-51D	4/19/85	Day	33	Concrete
Atlantis	OV-104	STS-38	11/20/90	Day	33	Concrete
Discovery	OV-103	STS-39	5/6/91	Day	15	Concrete
Atlantis	OV-104	STS-43	8/11/91	Day	15	Concrete
Atlantis	OV-104	STS-45	4/2/92	Day	33	Concrete
Columbia	OV-102	STS-50	7/9/92	Day	33	Concrete
Atlantis	OV-104	STS-46	8/8/92	Day	33	Concrete
Endeavour	OV-105	STS-47	9/20/92	Day	33	Concrete
Columbia	OV-102	STS-52	11/1/92	Day	33	Concrete
Endeavour	OV-105	STS-54	1/19/93	Day	33	Concrete
Discovery	OV-103	STS-56	4/17/93	Day	33	Concrete
Endeavour	OV-105	STS-57	7/1/93	Day	33	Concrete
Discovery	OV-103	STS-51	9/22/93	Night	15	Concrete
Endeavour	OV-105	STS-61	12/13/93	Night	33	Concrete
Discovery	OV-103	STS-60	2/11/94	Day	15	Concrete
Columbia	OV-102	STS-62	3/18/94	Day	33	Concrete
Columbia	OV-102	STS-65	7/23/94	Day	33	Concrete
Discovery	OV-103	STS-63	2/11/95	Day	15	Concrete
Atlantis	OV-104	STS-71	7/7/95	Day	15	Concrete
Discovery	OV-103	STS-70	7/22/95	Day	33	Concrete
Endeavour	OV-105	STS-69	9/18/95	Day	33	Concrete
Columbia	OV-102	STS-73	11/5/95	Day	33	Concrete
Atlantis	OV-104	STS-74	11/20/95	Day	33	Concrete
Endeavour	OV-105	STS-72	1/20/96	Night	15	Concrete
Columbia	OV-102	STS-75	3/9/96	Day	33	Concrete
Endeavour	OV-105	STS-77	5/29/96	Day	33	Concrete
Columbia	OV-102	STS-78	7/7/96	Day	33	Concrete
Atlantis	OV-104	STS-79	9/26/96	Day	15	Concrete
Columbia	OV-102	STS-80	12/7/96	Day	33	Concrete
Atlantis	OV-104	STS-81	1/22/97	Day	33	Concrete
Discovery	OV-103	STS-82	2/21/97	Night	15	Concrete
Columbia	OV-102	STS-83	4/8/97	Day	33	Concrete
Atlantis	OV-104	STS-84	5/24/97	Day	33	Concrete
Columbia	OV-102	STS-94	7/17/97	Day	33	Concrete
Discovery	OV-103	STS-85	8/19/97	Day	33	Concrete
Atlantis	OV-104	STS-86	10/6/97	Day	15	Concrete
Columbia	OV-102	STS-87	12/5/97	Day	33	Concrete
Endeavour	OV-105	STS-89	1/31/98	Day	15	Concrete
Columbia	OV-102	STS-90	5/3/98	Day	33	Concrete
Discovery	OV-103	STS-91	6/12/98	Day	15	Concrete
Discovery	OV-103	STS-95	11/7/98	Day	33	Concrete
Endeavour	OV-105	STS-88	12/15/98	Night	15	Concrete
Discovery	OV-103	STS-96	6/6/99	Night	15	Concrete
Columbia	OV-102	STS-93	7/28/99	Night	33	Concrete
Discovery	OV-103	STS-103	12/27/99	Night	33	Concrete
Endeavour	OV-105	STS-99	2/22/00	Day	33	Concrete
Atlantis	OV-104	STS-101	5/29/00	Night	15	Concrete
Atlantis	OV-104	STS-106	9/20/00	Night	15	Concrete
Endeavour	OV-105	STS-97	12/11/00	Night	15	Concrete
Discovery	OV-103	STS-102	3/21/01	Night	15	Concrete
Atlantis	OV-104	STS-104	7/24/01	Night	15	Concrete
Discovery	OV-103	STS-105	8/22/01	Day	15	Concrete
Endeavour	OV-105	STS-108	12/17/01	Day	15	Concrete
Columbia	OV-102	STS-109	3/12/02	Night	33	Concrete
Atlantis	OV-104	STS-110	4/19/02	Day	33	Concrete
Atlantis	OV-104	STS-112	10/18/02	Day	33	Concrete

Shuttle Landings at Kennedy Space Center, FL (Contd.)

Orbiter		Mission	Date	Day/Night	Runway	Surface
Endeavour	OV-105	STS-113	12/7/02	Day	33	Concrete
Discovery	OV-103	STS-121	7/17/06	Day	15	Concrete
Atlantis	OV-104	STS-115	9/21/06	Day	33	Concrete
Discovery	OV-103	STS-116	12/22/06	Day	15	Concrete
Endeavour	OV-105	STS-118	8/21/07	Day	15	Concrete
Discovery	OV-103	STS-120	11/7/07	Day	33	Concrete
Atlantis	OV-104	STS-122	2/20/08	Day	15	Concrete
Endeavour	OV-105	STS-123	3/26/08	Night	15	Concrete
Discovery	OV-103	STS-124	6/14/08	Day	15	Concrete
Discovery	OV-103	STS-119	3/28/09	Day	15	Concrete
Endeavour	OV-105	STS-127	7/31/09	Day	15	Concrete
Atlantis	OV-104	STS-129	11/27/09	Day	33	Concrete
Endeavour	OV-105	STS-130	2/21/10	Night	15	Concrete
Discovery	OV-103	STS-131	4/20/10	Day	33	Concrete
Atlantis	OV-104	STS-132	5/26/10	Day	33	Concrete
Discovery	OV-103	STS-133	3/9/11	Day	15	Concrete
Endeavour	OV-105	STS-134	6/1/11	Night	15	Concrete
Atlantis	OV-104	STS-135	7/21/11	Night	15	Concrete

Shuttle Landings at White Sands Space Harbor, NM

Orbiter		Mission	Date	Day/Night	Runway	Surface
Columbia	OV-102	STS-3	3/30/82	Day	17	Lakebed

Shuttle Landing Statistics

Orbiter	Day	Night	DFRC	WSSH	KSC	Total
Enterprise	5	0	5	0	0	5
Columbia	22	5	12	1	14	27
Challenger	8	1	7	0	2	9
Discovery	32	7	15	0	24	39
Atlantis	28	5	13	0	20	33
Endeavour	18	7	7	0	18	25
Total	113	25	59	1	78	138

The space shuttle Columbia following the STS-1 landing on Rogers Dry Lake at Edwards Air Force Base, Calif.

The Shuttle Carrier Aircraft

Two modified Boeing 747 airliners served as Shuttle Carrier Aircraft (SCA). The first initially served as a launch aircraft for the prototype orbiter Enterprise during the Approach and Landing Test (ALT)program in 1977. Although the primary function of the SCA was to transport the orbiters to Kennedy Space Center from Dryden, or other contingency landing sites, the aircraft also carried shuttles to and from Palmdale for modifications and maintenance, and for special events such as the Paris Air Show and the 1984 World's Fair in New Orleans, LA. Both SCAs belonged to the Johnson Space Center and were based at Dryden.

B-747-123 (N905NA): This airplane was a 747-100 obtained from American Airlines in 1974. Shortly after acceptance by NASA it was used for a series of wake vortex research flights at Dryden to seek ways of reducing turbulence produced by large aircraft. Boeing modified NASA 905 to the SCA configuration in 1976. It was then returned to Dryden for its role in the 1977 Space Shuttle ALT program. Modifications to the 747 included a flight-crew escape system, consisting of an exit tunnel extending from the flight deck to a hatch in the bottom of the fuselage, was installed during the modifications. The system also included a pyrotechnic system to activate the hatch release and cabin window release mechanisms. The flight crew escape system was removed following the successful completion of the ALT program. On September 24, 2012, 905 was flown from Los Angeles International Airport to Dryden completing her service to the Space Shuttle Program. One month later she was flown to Johnson Space Center's Ellington Field aircraft operations facility where she has since been retired.

B-747-SR-46 (N911NA): This airplane was a 747-200 SR (short range) obtained from Japan Airlines in 1989. Boeing modified the aircraft to the SCA configuration and it was delivered to NASA on November 20,1990. On February 8, 2012, 911 was flown from Dryden Flight Research Center at Edwards AFB, to the Dryden Aircraft Operations Facility at Palmdale, CA. completing her service to the Space Shuttle Program and retired from service.

NASA photographer Carla Thomas captured the two modified Boeing 747 Shuttle Carrier Aircraft, N905A (front) and N911A (rear), as they flew in formation near Edwards Air Force Base on 8/2/2011. This was the only time the two aircraft flew together.

Ferry Flight Totals

Vehicle		Delivery	OMM/OMDP	Post Mission	Other	Vehicle Total
Atlantis	OV-104	1	4	13	0	18
Challenger	OV-099	1	0	7	0	8
Columbia	OV-102	1	8	13	2	24
Discovery	OV-103	1	2	15	1	19
Endeavour	OV-105	1	2	7	1	11
Enterprise	OV-101	0	0	0	*27	*27
	Totals	5	16	55	28	90

*Includes ALT and Ferry Test Flights

Shuttle Carrier Aircraft Technical Specifications

Dimensions
- Wingspan: 195 ft. 8 in.
- Length: 231 ft. 10 in.
- Height: Top of vertical stabilizer, 63 ft. 5 in. To top of cockpit area, 32 ft. 1 in.
- Weight: Basic weight, NASA 905, 318,053 lbs. NASA 911, 323,034 lbs.
- Maximum gross taxi weight, 713,000 lbs
- Maximum gross brake release weight, 710,000 lbs
- Maximum gross landing weight, 600,000 lbs

Engines
- Four Pratt and Whitney JT9D-7J gas turbine engines, each producing 50,000 lbs of thrust.

Performance
- Airspeed limits with, and without an orbiter: 250 knots or Mach 0.6
- Altitude: Typical cruise with orbiter, 13,000-15,000 ft; typical cruise unmated, 24,000-26,000 ft. Minimum temperature at altitude 15 degrees (F) (-9 degrees C)
- Range: Typical mated, 1000 nautical miles (with reserves); maximum unmated, 5500 nautical miles

Fuel Capacity
- 47,210 gallons (316,307 lbs) jet fuel

Crew Size
Minimum for flight is two pilots and one flight engineer. Minimum for mated flight is two pilots and two flight engineers.

NASA photographer, Jim Ross, captured this image of the Space Shuttle Endeavour atop the 747 Shuttle Carrier Aircraft taxing on the ramp at Dryden on May 1, 2001.

The flight deck of a Shuttle Carrier Aircraft.

The interior of one of the SCA's looking aft.

Shuttle Carrier Aircraft Ferry Flight Log

Approach and Landing Test Flights

FLT NO.	PURPOSE	SCA	ORBITER	DATE(S)	ROUTE	
					From	To
1	1st Captive-Inactive Flight with Orbiter	905	Enterprise OV-101	2/18/1977	DFRC/EAFB, CA	DFRC/EAFB, CA
2	2nd Captive-Inactive Flight with Orbiter	905	Enterprise OV-101	2/22/1977	DFRC/EAFB, CA	DFRC/EAFB, CA
3	3rd Captive-Inactive Flight with Orbiter	905	Enterprise OV-101	2/25/1977	DFRC/EAFB, CA	DFRC/EAFB, CA
4	4th Captive-Inactive Flight with Orbiter	905	Enterprise OV-101	2/28/1977	DFRC/EAFB, CA	DFRC/EAFB, CA
5	5th Captive-Inactive Flight with Orbiter	905	Enterprise OV-101	3/2/1977	DFRC/EAFB, CA	DFRC/EAFB, CA
6	1st Captive-Active Flight with Orbiter	905	Enterprise OV-101	6/18/1977	DFRC/EAFB, CA	DFRC/EAFB, CA
7	2nd Captive-Active Flight with Orbiter	905	Enterprise OV-101	6/28/1977	DFRC/EAFB, CA	DFRC/EAFB, CA
8	3rd Captive-Active Flight with Orbiter	905	Enterprise OV-101	7/26/1977	DFRC/EAFB, CA	DFRC/EAFB, CA
9	1st Separation and Free Flight of Orbiter	905	Enterprise OV-101	8/12/1977	DFRC/EAFB, CA	DFRC/EAFB, CA
10	2nd Separation and Free Flight of Orbiter	905	Enterprise OV-101	9/13/1977	DFRC/EAFB, CA	DFRC/EAFB, CA
11	3rd Separation and Free Flight of Orbiter	905	Enterprise OV-101	9/23/1977	DFRC/EAFB, CA	DFRC/EAFB, CA
12	4th Separation and Free Flight of Orbiter	905	Enterprise OV-101	10/12/1977	DFRC/EAFB, CA	DFRC/EAFB, CA
13	5th Separation and Free Flight of Orbiter	905	Enterprise OV-101	10/26/1977	DFRC/EAFB, CA	DFRC/EAFB, CA

Shuttle Ferry Test Flights

FLT NO.	PURPOSE	SCA	ORBITER	DATE(S)	ROUTE	
					From	To
1	1st Ferry Test Flight	905	Enterprise OV-101	11/15/1977	DFRC/EAFB, CA	DFRC/EAFB, CA
2	2nd Ferry Test Flight	905	Enterprise OV-101	11/16/1977	DFRC/EAFB, CA	DFRC/EAFB, CA
3	3rd Ferry Test Flight	905	Enterprise OV-101	11/17/1977	DFRC/EAFB, CA	DFRC/EAFB, CA
4	4th Ferry Test Flight	905	Enterprise OV-101	11/18/1977	DFRC/EAFB, CA	DFRC/EAFB, CA

Operational Shuttle Ferry Flights

FLT NO.	PURPOSE	SCA	ORBITER	DATE(S)	ROUTE	
					From	To
1	Ferry from DFRC to MSFC for Mated Vehicle Ground Vibration Test (MVGVT)	905	Enterprise OV-101	3/10/1978 3/11/1978	DFRC/EAFB, CA JSC, TX	JSC, TX MSFC, AL
2	Local flight	905	Columbia OV-102	3/9/1979	DFRC/EAFB, CA	DFRC/EAFB, CA
3	Local flight	905	Columbia OV-102	3/20/1979	DFRC/EAFB, CA	DFRC/EAFB, CA
4	Initial delivery from DFRC to KSC	905	Columbia OV-102	3/20/1979 3/22/1979 3/23/1979 3/24/1979	DFRC/EAFB, CA Biggs AAF, TX Kelly AFB, TX Eglin AFB, FL	Biggs AAF, TX Kelly AFB, TX Eglin AFB, FL KSC, FL
5	Ferry from MSFC to KSC for launch system fit checks	905	Enterprise OV-101	4/10/1979	MSFC, AL	KSC, FL
6	Ferry from KSC to VAFB for fit checks and then back to VAFB and DFRC	905	Enterprise OV-101	8/10/1979 8/11/1979 8/12/1979 8/13/1979 8/14/1979 8/15/1979 8/16/1979	KSC, FL Atlanta, GA St. Louis, MI Tulsa, OK Denver, CO Hill AFB, UT Vandenberg AFB, CA	Atlanta, GA St. Louis, MI Tulsa, OK Denver, CO Hill AFB, UT Vandenberg AFB, CA DFRC/EAFB, CA
7	STS-1 post mission ferry from DFRC to KSC	905	Columbia OV-102	4/27/1981 4/28/1981	DFRC/EAFB, CA Tinker AFB, OK	Tinker AFB, OK KSC, FL
8	STS-2 post mission ferry from DFRC to KSC	905	Columbia OV-102	11/24/1981 11/25/1981	DFRC/EAFB, CA Bergstrom AFB, TX	Bergstrom AFB, TX KSC, FL
9	STS-3 post mission ferry from WSSH to KSC	905	Columbia OV-102	4/6/1982 4/6/1982	WSSH, NM Barksdale AFB, LA	Barksdale AFB, LA KSC, FL
10	Initial delivery from DFRC to KSC (takeoff from lakebed due to Columbia on main concrete runway)	905	Challenger OV-099	7/4/1982	DFRC/EAFB, CA JSC, TX	JSC, TX KSC, FL
11	STS-4 post mission ferry from DFRC to KSC	905	Columbia OV-102	7/14/1982 7/15/1982	DFRC/EAFB, CA Dyess AFB, TX	Dyess AFB, TX KSC, FL
12	STS-5 post mission ferry from DFRC to KSC	905	Columbia OV-102	11/21/1982 11/22/1982	DFRC/EAFB, CA Dyess AFB, TX Kelly AFB, TX	Dyess AFB, TX Kelly AFB, TX KSC, FL
13	STS-6 post mission ferry from DFRC to KSC	905	Challenger OV-099	4/14/1983 4/16/1983	DFRC/EAFB, CA Kelly AFB, TX	Kelly AFB, TX KSC, FL
14	Ferry to Paris Air Show and back to DFRC	905	Enterprise OV-101	5/16/1983 5/18/1983 5/18/1983 5/19/1983 5/19/1983 5/20/1983 5/20/1983 5/24/1983 5/27/1983 5/28/1983 5/29/1983 6/1/1983 6/2/1983 6/4/1983 6/5/1983 6/7/1983	DFRC/EAFB, CA Peterson AFB, CO McConnell AFB, KS Wright-Patt. AFB, OH Goose Bay, Canada Keflavik NAS, Iceland RAF Fairford,England Cologne, Germany Paris, France Paris, France Paris, France Paris, France Paris, France Rome, Italy Paris, France Paris, France	Peterson AFB, CO McConnell AFB, KS Wright-Patt. AFB, OH Goose Bay, Canada Keflavik NAS, Iceland RAF Fairford, England Cologne, Germany Paris, France Paris, France Paris, France Paris, France Rome, Italy Paris, France Paris, France London, England Keflavik NAS, Iceland

Operational Shuttle Ferry Flights (continued)

FLT NO.	PURPOSE	SCA	ORBITER	DATE(S)	ROUTE	
					From	To
14	Ferry to Paris Air Show and back to DFRC	905	Enterprise OV-101	6/8/1983 6/8/1983 6/10/1983 6/12/1983 6/13/1983 6/13/1983	Keflavik NAS, Iceland Goose Bay, Canada Ottawa, Canada Scott AFB, IL Dulles, VA Sheppard AFB, TX	Goose Bay, Canada Ottawa, Canada Scott AFB, IL Dulles, VA Sheppard AFB, TX DFRC/EAFB, CA
15	STS-7 post mission ferry from DFRC to KSC	905	Challenger OV-099	6/28/1983 2/29/1983	DFRC/EAFB, CA Kelly AFB, TX	Kelly AFB, TX KSC, FL
16	STS-8 post mission ferry from DFRC to KSC	905	Challenger OV-099	9/9/1983 9/10/1983	DFRC/EAFB, CA Sheppard AFB, TX	Sheppard AFB, TX KSC, FL
17	Initial delivery from DFRC to KSC	905	Discovery OV-103	11/6/1983 11/8/1983 11/9/1983	DFRC/EAFB, CA Vandenberg AFB, CA Carswell AFF, TX	Vandenberg AFB, CA Carswell AFF, TX KSC, FL
18	STS-9 post mission ferry from DFRC to KSC	905	Columbia OV-102	12/14/83 12/14/83 12/15/83 12/15/83	DFRC/EAFB, CA Biggs AAF, TX Kelly AFB, TX Eglin AFB, FL	Biggs AAF, TX Kelly AFB, TX Eglin AFB, FL KSC, FL
19	Ferry from KSC to DFRC for modification work	905	Columbia OV-102	1/26/84 1/27/84	KSC, FL Kelly AFB, TX	Kelly AFB, TX DFRC/EAFB, CA
20	Ferry from DFRC to World's Fair in New Orleans, LA.	905	Enterprise OV-101	1/26/84 1/27/84	DFRC/EAFB, CA Vandenberg AFB, CA Kelly AFB, TX Little Rock AFB, AR	Vandenberg AFB, CA Kelly AFB, TX Little Rock AFB, AR Mobile, AL
21	STS-41C post mission ferry from DFRC to KSC	905	Challenger OV-099	44/18/84	DFRC/EAFB, CA Kelly AFB, TX	Kelly AFB, TX KSC, FL
22	STS-41D post mission ferry from DFRC to KSC	905	Discovery OV-103	9/9/84 9/10/84	DFRC/EAFB, CA Altus AFB, OK	Altus AFB, OK KSC, FL
23	Ferry from World's Fair in New Orleans, LA to Vandenberg AFB, CA	905	Enterprise OV-101	11/10/84 11/11//84 11/13/84 11/16/84	Mobile, AL Kansas City, Vandenberg AFB, CA DFRC/EAFB, CA	Kansas City, MO Vandenberg AFB, CA DFRC/EAFB, CA Vandenberg AFB, CA
24	Initial delivery from DFRC to KSC	905	Atlantis OV-104	4/12/85 4/13/85	DFRC/EAFB, CA Ellington /JSC, TX	Ellington /JSC, TX KSC, FL
25	STS-51B post mission ferry from DFRC to KSC	905	Challenger OV-099	5/10/85 5/10/85	DFRC/EAFB, CA Kelly AFB, TX	Kelly AFB, TX KSC, FL
26	Ferry orbiter from Vandenberg AFB, CA to DFRC/EAFB, CA	905	Enterprise OV-101	5/24/85	Vandenberg AFB, CA	DFRC/EAFB, CA
27	STS-51G post mission ferry from DFRC to KSC	905	Discovery OV-103	6/28/85 6/28/85	DFRC/EAFB, CA Bergstrom AFB, TX	Bergstrom AFB, TX KSC, FL
28	Ferry from DFRC to KSC after modification work performed	905	Columbia OV-102	7/14/85 7/14/85	DFRC/EAFB, CA Offut AFB, NE	Offut AFB, NE KSC, FL
29	STS-51F post mission ferry from DFRC to KSC	905	Challenger OV-099	8/10/85 8/10/85 8/11/85 8/11/85	DFRC/EAFB, CA Davis-Mon. AFB, AZ Kelly AFB, TX Eglin AFB, FL	Davis-Mon. AFB, AZ Kelly AFB, TX Eglin AFB, FL KSC, FL
30	STS-51I post mission ferry from DFRC to KSC	905	Discovery OV-103	9/7/85 9/8/85	DFRC/EAFB, CA Kelly AFB, TX	Kelly AFB, TX KSC, FL

Operational Shuttle Ferry Flights (continued)

FLT NO.	PURPOSE	SCA	ORBITER	DATE(S)	ROUTE	
					From	To
31	Ferry from DFRC to KSC	905	Enterprise OV-101	9/20/85 9/20/85	DFRC/EAFB, CA Kelly AFB, TX	Kelly AFB, TX KSC, FL
32	STS-51J post mission ferry from DFRC to KSC	905	Atlantis OV-104	10/11/85 10/11/85	DFRC/EAFB, CA Kelly AFB, TX	Kelly AFB, TX KSC, FL
33	STS-61A post mission ferry from DFRC to KSC	905	Challenger OV-099	11/10/85 11/10/85 11/11/85 11/11/85	DFRC/EAFB, CA Davis-Mon. AFB, AZ Kelly AFB, TX Eglin AFB, FL	Davis-Mon. AFB, AZ Kelly AFB, TX Eglin AFB, FL KSC, FL
34	Ferry from KSC to the Smithsonian, National Air and Space Museum, Stephen F. Udvar-Hazy Center, Chantilly, VA.	905	Enterprise OV-101	11/18/85	KSC, FL	Chantilly, VA.
35	STS-61B post mission ferry from DFRC to KSC	905	Atlantis OV-104	12/7/85 12/7/85	DFRC/EAFB, CA Kelly AFB, TX	Kelly AFB, TX KSC, FL
36	STS-61C post mission ferry from DFRC to KSC	905	Columbia OV-102	1/22/86 1/22/86 1/23/86 1/23/86	DFRC/EAFB, CA Davis-Mon. AFB, AZ Kelly AFB, TX Eglin AFB, FL	Davis-Mon. AFB, AZ Kelly AFB, TX Eglin AFB, FL KSC, FL
37	STS-26 post mission ferry from DFRC to KSC	905	Discovery OV-103	10/8/88 10/8/88	DFRC/EAFB, CA Kelly AFB, TX	Kelly AFB, TX KSC, FL
38	STS-27 post mission ferry from DFRC to KSC	905	Atlantis OV-104	12/11/88 12/12/88 12/13/88	DFRC/EAFB, CA Davis-Mon. AFB, AZ Kelly AFB, TX	Davis-Mon. AFB, AZ Kelly AFB, TX KSC, FL
39	STS-29 post mission ferry from DFRC to KSC	905	Discovery OV-103	3/23/89 3/24/89	DFRC/EAFB, CA Kelly AFB, TX	Kelly AFB, TX KSC, FL
40	STS-30 post mission ferry from DFRC to KSC	905	Atlantis OV-104	5/13/89 5/15/89 5/15/89 5/15/89	DFRC/EAFB, CA Biggs AAF, TX Dallas/Ft. Worth, TX WRAFB, GA	Biggs AAF, TX Dallas/Ft. Worth, TX WRAFB, GA KSC, FL
41	STS-28 post mission ferry from DFRC to KSC	905	Columbia OV-102	8/18/89 8/20/89 8/20/89 8/21/89	DFRC/EAFB, CA DFRC/EAFB, CA Sheppard AFB, TX WRAFB, GA	DFRC/EAFB, CA Sheppard AFB, TX WRAFB, GA KSC, FL
42	STS-34 post mission ferry from DFRC to KSC	905	Atlantis OV-104	10/28/89 10/28/89 10/29/89	DFRC/EAFB, CA Biggs AAF, TX Columbus AFB, MS	Biggs AAF, TX Columbus AFB, MS KSC, FL
43	STS-33 post mission ferry from DFRC to KSC	905	Discovery OV-103	12/2/89 12/3/89 12/3/89 12/4/89	DFRC/EAFB, CA Davis-Mon. AFB, AZ Kelly AFB, TX Eglin AFB, FL	Davis-Mon. AFB, AZ Kelly AFB, TX Eglin AFB, FL KSC, FL
44	STS-32 post mission ferry from DFRC to KSC	905	Columbia OV-102	1/25/90 1/25/90 1/26/90	DFRC/EAFB, CA Davis-Mon. AFB, AZ Kelly AFB, TX	Davis-Mon. AFB, AZ Kelly AFB, TX KSC, FL
45	STS-36 post mission ferry from DFRC to KSC	905	Atlantis OV-104	3/10/90 3/11/90 3/13/90 3/13/90	DFRC/EAFB, CA DFRC/EAFB, CA Biggs AAF, TX Columbus AFB, MS	DFRC/EAFB, CA Biggs AAF, TX Columbus AFB, MS KSC, FL
46	STS-31 post mission ferry from DFRC to KSC	905	Discovery OV-103	5/5/90 5/6/90 5/7/90	DFRC/EAFB, CA Sheppard AFB, TX WRAFB, GA	Sheppard AFB, TX WRAFB, GA KSC, FL

Operational Shuttle Ferry Flights (continued)

FLT NO.	PURPOSE	SCA	ORBITER	DATE(S)	ROUTE	
					From	To
47	STS-41 post mission ferry from DFRC to KSC	905	Discovery OV-103	10/15/90 10/15/90 10/16/90	DFRC/EAFB, CA Kelly AFB, TX Eglin AFB, FL	Kelly AFB, TX Eglin AFB, FL KSC, FL
48	STS-35 post mission ferry from DFRC to KSC	905	Columbia OV-102	12/16/90 12/18/90 12/18/90 12/19/90 12/21/90	DFRC/EAFB, CA DFRC/EAFB, CA Biggs AAF, TX Kelly AFB, TX Barksdale AFB, LA	DFRC/EAFB, CA Biggs AAF, TX Kelly AFB, TX Barksdale AFB, LA KSC, FL
49	STS-37 post mission ferry from DFRC to KSC	905	Atlantis OV-104	4/16/91 4/16/91 4/17/91 4/18/91	DFRC/EAFB, CA Kelly AFB, TX Columbus AFB, MS Mac Dill AFB, FL	Kelly AFB, TX Columbus AFB, MS Mac Dill AFB, FL KSC, FL
50	Initial delivery from Palmdale to KSC (unlike previous orbiters, OV-105 was not first trucked to DFRC)	911	Endeavour OV-105	5/2/91 5/3/91 5/5/91 5/6/91 5/6/91 5/7/91	Palmdale, CA Palmdale, CA Biggs AAF, TX Kelly AFB, TX Ellington, JSC, TX Columbus AFB, MS	Palmdale, CA Biggs AAF, TX Kelly AFB, TX Ellington, JSC, TX Columbus AFB, MS KSC, FL
51	STS-40 post mission ferry from DFRC to KSC	905	Columbia OV-102	6/19/91 6/20/91 6/20/91 6/21/91	DFRC/EAFB, CA Biggs AAF, TX Kelly AFB, TX Columbus AFB, MS	Biggs AAF, TX Kelly AFB, TX Columbus AFB, MS KSC, FL
52	Ferry to Palmdale for Orbiter Maintenance Down Period (OMDP)	905	Columbia OV-102	8/9/91 8/10/91 8/12/91 8/13/91	KSC, FL KSC, FL Kelly AFB, TX Kelly AFB, TX	KSC, FL Mac Dill AFB, FL Kelly AFB, TX Palmdale, CA
53	STS-48 post mission ferry from DFRC to KSC	911	Discovery OV-103	9/24/91 9/24/91 9/25/91 9/26/91	DFRC/EAFB, CA Biggs AAF, TX Tinker AFB, OK Columbus AFB, MS	Biggs AAF, TX Tinker AFB, OK Columbus AFB, MS KSC, FL
54	STS-44 post mission ferry from DFRC to KSC	911	Atlantis OV-104	12/7/91 12/8/91	DFRC/EAFB, CA Sheppard AFB, TX	Sheppard AFB, TX KSC, FL
55	Ferry from Palmdale to KSC from Orbiter Maintenance Down Period (OMDP)	905	Columbia OV-102	2/7/92 2/9/92 2/9/92	Palmdale, CA Palmdale, CA Kelly AFB, TX	Palmdale, CA Kelly AFB, TX KSC, FL
56	STS-42 post mission ferry from DFRC to KSC	905	Discovery OV-103	2/11/92 2/14/92 2/15/92 2/16/92 2/16/92	DFRC/EAFB, CA DFRC/EAFB, CA Biggs AAF, TX Kelly AFB, TX Columbus AFB, MS	DFRC/EAFB, CA Biggs AAF, TX Kelly AFB, TX Columbus AFB, MS KSC, FL
57	STS-49 post mission ferry from DFRC to KSC	905	Endeavour OV-105	5/21/92 5/27/92 5/29/92	DFRC/EAFB, CA DFRC/EAFB, CA Biggs AAF, TX Kelly AFB, TX	DFRC/EAFB, CA Biggs AAF, TX Kelly AFB, TX KSC, FL
58	Ferry to Palmdale for Orbiter Maintenance Down Period (OMDP)	905	Atlantis OV-104	10/18/92 10/18/92 10/18/92	KSC, FL Longview, TX Biggs AAF, TX	Longview, TX Biggs AAF, TX Palmdale, CA
59	STS-53 post mission ferry from DFRC to KSC	911	Discovery OV-103	12/16/92 12/18/92 12/20/92	DFRC/EAFB, CA Kelly AFB, TX Eglin AFB, FL	Kelly AFB, TX Eglin AFB, FL KSC, FL

Operational Shuttle Ferry Flights (continued)

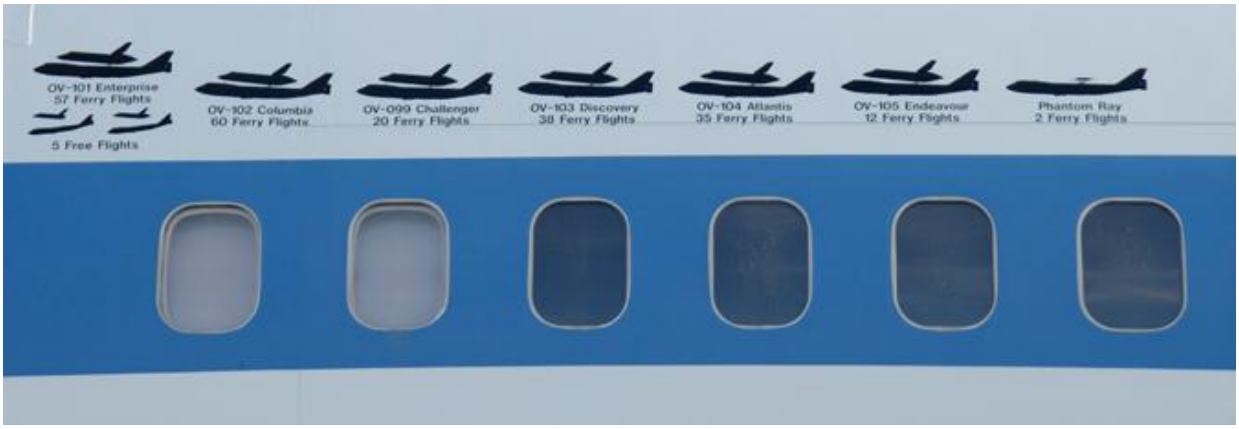
FLT NO.	PURPOSE	SCA	ORBITER	DATE(S)	ROUTE	
					From	To
60	STS-55 post mission ferry from DFRC to KSC	905	Columbia OV-102	5/18/93 5/19/93 5/21/93 5/21/93	DFRC/EAFB, CA Biggs AAF, TX Kelly AFB, TX Columbus AFB, MS	Biggs AAF, TX Kelly AFB, TX Columbus AFB, MS KSC, FL
61	STS-58 post mission ferry from DFRC to KSC	911	Columbia OV-102	11/7/93 11/7/93 11/7/93 11/8/93	DFRC/EAFB, CA Biggs AAF, TX Kelly AFB, TX Columbus AFB, MS	Biggs AAF, TX Kelly AFB, TX Columbus AFB, MS KSC, FL
62	STS-59 post mission ferry from DFRC to KSC	911	Columbia OV-102	4/26/94 4/30/94 5/1/94 5/3/94	DFRC/EAFB, CA DFRC/EAFB, CA El Paso, TX Columbus AFB, MS	DFRC/EAFB, CA El Paso, TX Little Rock AFB, AR KSC, FL
63	Ferry from Palmdale to KSC from Orbiter Maintenance Down Period (OMDP)	911	Atlantis OV-104	5/27/94 5/28/94 5/28/94 5/29/94	Palmdale, CA Biggs AAF, TX Columbus AFB, MS WRAFB, GA	Biggs AAF, TX Columbus AFB, MS WRAFB, GA KSC, FL
64	STS-64 post mission ferry from DFRC to KSC	905	Discovery OV-103	9/26/94 9/26/94	DFRC/EAFB, CA Kelly AFB, TX	Kelly AFB, TX KSC, FL
65	Ferry to Palmdale for Orbiter Maintenance Down Period (OMDP)	905	Columbia OV-102	10/8/94 10/10/94 10/11/94 10/11/94	KSC, FL Huntsville, AL Ellington, JSC, TX Biggs AAF, TX	Huntsville, AL Ellington, JSC, TX Biggs AAF, TX Palmdale, CA
66	STS-69 post mission ferry from DFRC to KSC	911	Endeavour OV-105	10/19/94 10/19/94 10/20/94 10/20/94	DFRC/EAFB, CA Biggs AAF, TX Dyess AFB, TX Eglin AFB, FL	Biggs AAF, TX Dyess AFB, TX Eglin AFB, FL KSC, FL
67	STS-66 post mission ferry from DFRC to KSC	911	Atlantis OV-104	11/21/94 11/21/94 11/22/94	DFRC/EAFB, CA Kelly AFB, TX Eglin AFB, FL	Kelly AFB, TX Eglin AFB, FL KSC, FL
68	STS-67 post mission ferry from DFRC to KSC	905	Endeavour OV-105	3/26/95 3/27/95 3/27/95	DFRC/EAFB, CA Dyess AFB, TX Columbus AFB, MS	Dyess AFB, TX Columbus AFB, MS KSC, FL
69	Ferry from Palmdale to KSC from Orbiter Maintenance Down Period (OMDP)	905	Columbia OV-102	4/11/95 4/14/95	Palmdale, CA Ellington, JSC, TX	Ellington, JSC, TX KSC, FL
70	Ferry to Palmdale for Orbiter Maintenance Down Period (OMDP)	905	Discovery OV-103	9/27/95 9/27/95 9/28/95	KSC, FL NAS Fort Worth, TX Salt Lake City, UT	NAS Fort Worth, TX Salt Lake City, UT Palmdale, CA
71	STS-76 post mission ferry from DFRC to KSC (First attempt resulted in emergency return to EAFB due to engine fire warning)	905	Atlantis OV-104	4/6/96 4/11/96 4/11/96 4/12/96 4/12/96	DFRC/EAFB, CA DFRC/EAFB, CA Davis-Mon. AFB, AZ Dyess AFB, TX Eglin AFB, FL	DFRC/EAFB, CA Davis-Mon. AFB, AZ Dyess AFB, TX Eglin AFB, FL KSC, FL
72	Ferry from Palmdale to KSC from Orbiter Maintenance Down Period (OMDP)	911	Discovery OV-103	6/25/96 6/28/96 6/28/96 6/29/96	Palmdale, CA Palmdale, CA Altus AFB, OK WRAFB, GA	Palmdale, CA Altus AFB, OK WRAFB, GA KSC, FL
73	Ferry to Palmdale for Orbiter Maintenance Down Period (OMDP)	911	Endeavour OV-105	7/30/96 7/30/96	KSC, FL Kelly AFB, TX	Kelly AFB, TX Palmdale, CA

Operational Shuttle Ferry Flights (continued)

FLT NO.	PURPOSE	SCA	ORBITER	DATE(S)	ROUTE	
					From	To
74	Ferry from Palmdale to KSC from Orbiter Maintenance Down Period (OMDP)	905	Endeavour OV-105	3/25/97 3/26/97 3/26/97 3/37/97	Palmdale, CA Palmdale, CA NAS Fort Worth, TX WRAFB, GA	Palmdale, CA NAS Fort Worth, TX WRAFB, GA KSC, FL
75	Ferry to Palmdale for Orbiter Maintenance Down Period (OMDP)	911	Atlantis OV-104	11/11/97 11/14/97	KSC, FL Tinker AFB, OK	Tinker AFB, OK Palmdale, CA
76	Ferry from Palmdale to KSC from Orbiter Maintenance Down Period (OMDP)	905	Atlantis OV-104	9/22/98 9/23/98 9/23/98 9/27/98	Palmdale, CA Palmdale, CA Robert Gray AAF,TX Ft. Campbell, KY	Palmdale, CA Robert Gray AAF,TX Ft. Campbell, KY KSC, FL
77	Ferry to Palmdale for Orbiter Maintenance Down Period (OMDP)	905	Columbia OV-102	9/24/99 9/25/99	KSC, FL Whiteman AFB, MO	Whiteman AFB, MO Palmdale, CA
78	STS-92 post mission ferry from DFRC to KSC	905	Discovery OV-103	11/2/00 11/2/00 11/3/00	DFRC/EAFB, CA Altus AFB, OK Whiteman AFB, MO	Altus AFB, OK Whiteman AFB, MO KSC, FL
79	Ferry from Palmdale to KSC from Orbiter Maintenance Down Period (OMDP)	905	Columbia OV-102	3/1/01 3/4/01 3/5/01	Palmdale, CA Dyess AFB, TX Cape Canaveral, FL	Dyess AFB, TX Cape Canaveral, FL KSC, FL
80	STS-98 post mission ferry from DFRC to KSC	911	Atlantis OV-104	3/1/01 3/3/01 3/3/01 3/4/01	DFRC/EAFB, CA Altus AFB, OK Barksdale AFB, LA Eglin AFB, FL	Altus AFB, OK Barksdale AFB, LA Eglin AFB, FL KSC, FL
81	STS-100 post mission ferry from DFRC to KSC	905	Endeavour OV-105	5/8/01 5/8/01 5/9/01	DFRC/EAFB, CA Altus AFB, OK Little Rock AFB, AR	Altus AFB, OK Little Rock AFB, AR KSC, FL
82	STS-111 post mission ferry from DFRC to KSC	911	Endeavour OV-105	6/28/02 6/28/02 6/29/02	DFRC/EAFB, CA Altus AFB, OK Whiteman AFB, MO	Altus AFB, OK Whiteman AFB, MO KSC, FL
83	STS-114 post mission ferry from DFRC to KSC	905	Discovery OV-103	8/19/05 8/19/05 8/21/05	DFRC/EAFB, CA Altus AFB, OK Barksdale AFB, LA	Altus AFB, OK Barksdale AFB, LA KSC, FL
84	STS-117 post mission ferry from DFRC to KSC	905	Atlantis OV-104	7/1/07 7/1/07 7/2/07 7/2/07	DFRC/EAFB, CA Amarillo, TX Offutt AFB, LA Ft. Campbell, KY	Amarillo, TX Offutt AFB, LA Ft. Campbell, KY KSC, FL
85	STS-126 post mission ferry from DFRC to KSC	911	Endeavour OV-105	12/10/08 12/10/08 12/11/08 12/12/08	DFRC/EAFB, CA Biggs AAF, TX NAS Ft. Worth, TX Barksdale AFB, LA	Biggs AAF, TX NAS Ft. Worth, TX Barksdale AFB, LA KSC, FL
86	STS-125 post mission ferry from DFRC to KSC	911	Atlantis OV-104	6/1/09 6/1/09 6/2/09 6/2/09	DFRC/EAFB, CA Biggs AAF, TX Kelly AFB, TX Columbus AFB, MS	Biggs AAF, TX Kelly AFB, TX Columbus AFB, MS KSC, FL
87	STS-128 post mission ferry from DFRC to KSC	911	Discovery OV-103	9/20/09 9/20/09 9/20/09 9/21/09	DFRC/EAFB, CA Amarillo, TX NAS Ft. Worth, TX Barksdale AFB, LA	Amarillo, TX NAS Ft. Worth, TX Barksdale AFB, LA KSC, FL

Post Operational Shuttle Ferry Flights

FLT NO.	PURPOSE	SCA	ORBITER	DATE(S)	ROUTE	
					From	To
1	Ferry from KSC to Dulles International Airport , Chantilley, VA.	905	Discovery OV-103	4/17/12	KSC	Chantilly , VA
2	Ferry Dulles International Airport , Chantilley, VA. to John F. Kennedy International Airport, New York, NY	905	Enterprise OV-100	4/27/12	Dulles, VA	New York, NY
3	Ferry from KSC to Los Angeles International Airport, Los Angeles, CA	905	Endeavour OV-105	9/19/12 9/20/12 9/20/12 9/21/12	KSC, FL Ellington, JSC, TX Biggs AAF, TX DFRC/EAFB, CA	Ellington, JSC, TX Biggs AAF, TX DFRC/EAFB, CA Los Angeles, CA



A graphic history of 35 years of space shuttle ferry flights now adorns the upper forward fuselage of NASA Shuttle Carrier Aircraft 905. (NASA/Tony Landis)

Space Shuttle Discovery in flight over her new home, at the National Air and Space Museum's Udvar-Hazy Center Friday, April 17, 2012, in Chantilly, VA.. (NASA/Jim Ross)

Space shuttle Enterprise, in flight over her new home, the Intrepid Sea, Air and Space Museum, Friday, April 27, 2012, in New York. Photo Credit: (NASA/Robert Markowitz)

Space shuttle Endeavour in flight over her new home, the California Science Center, Friday, September 21, 2012, in Los Angeles. Photo Credit: (NASA/Jim Ross)

Airfields used for Ferry Flights

Airfield Location	City	State or Country	Airport Code	Times Used
Altus Air Force Base	Altus	Oklahoma	LTS	7
Atlanta International Airport	Atlanta	Georgia	ATL	1
Barksdale Air Force Base	Bossier City	Louisiana	BAD	6
Bergstrom Air Force Base	Austin	Texas	BSM	2
Biggs Army Airfield / Ft. Bliss	El Paso	Texas	BIF	19
Cape Canaveral Air Force Station	Cape Canaveral	Florida	CCAS	1
Carswell Air Force Base, (now Naval Air Station Ft. Worth)	Fort Worth	Texas	FWH	1
Cologne/Bonn Airport,	Cologne	Germany	DDK	1
Columbus Air Force Base	Columbus	Mississippi	CBM	12
Dallas/Fort Worth International Airport		Texas	DFW	1
Davis-Monthan Air Force Base, Arizona	Tucson	Arizona	DMA	6
Denver International Airport,	Denver	Colorado	DEN	1
*Dryden Flight Research Center/ Edwards Air Force Base	N/A	California	EDW	78
Dulles International Airport,	Chantilly	Virginia	IAD	2
Dyess Air Force Base, Texas	Abilene	Texas	DYS	5
Eglin Air Force Base	Valparaiso	Florida	VPS	12
Ellington Field/Johnson Space Center	Houston	Texas	EFD	6
Fort Campbell Army Airfield	Hopkinsville	Kentucky	HOP	2
Goose Bay Airport	Goose Bay	Canada	YYR	2
Gregg County Airport	Longview	Texas	GGG	1
Hill Air Force Base	Ogden	Utah	HIF	1
Huntsville International Airport,	Huntsville	Alabama	HSV	1
John F. Kennedy International Airprot	New York	New York	JFK	1
Kansas City International Airport	Kansas City	Missouri	MCI	1
Kelly Air Force Base,	San Anotnio	Texas	SKF	36
**Kennedy Space Center, Shuttle Landing Facility	Merritt Island	Florida	TTS	79
Le Bourget Airport,	Paris	France	FPB	2
Leonardo da Vinci-Fiumicino Airport,	Rome	Italy	IRA	1
Little Rock Air Force Base	Jacksonville	Arkansas	LRF	3
Los Angeles International Airport	Los Angeles	California	LAX	1
MacDill Air Force Base,	Tampa	Florida	MCF	2
McConnell Air Force Base	Wichita	Kansas	IAB	1
Mobile Downtown Airport	Mobile	Alabama	BFM	1
Naval Air Station Fort Worth (formerly Carswell AFB)	Fort Worth	Texas	NFW	4
Naval Air Station Keflavik	N/A	Iceland	IKF	2
**Northrop Strip, White Sands Space Harbor	N/A	New Mexico	SNG	1
Offutt Air Force Base	Omaha	Nebraska	OFF	2
Ottawa International Airport	Ottawa	Canada	YOW	1
Peterson Air Force Base	Colorado Springs	Colorado	COS	1
RAF Fairford,	Gloucester- shire	England	GVA	1
Redstone Army Airfield, Alabama	Huntsville	Alabama	HUA	1
Rick Husband Amarillo International Airport,	Amarillo	Texas	AMA	2
Robert Gray Army Airfield / Ft. Hood	Killeen	Texas	GRK	1
Salt Lake City International Airport	Salt Lake City	Utah	SLC	1
Scott Air Force Base	Belleville	Illinois	BLV	1
Sheppard Air Force Base,	Wichita Falls	Texas	SPS	6
Site 1, USAF Plant 42	Palmdale	California	PMD	14
St. Louis International Airport,	St. Louis	Missouri	STL	1
Stansted Airport,	London	England	GSS	1
Tinker Air Force Base	Oklahoma City	Oklahoma	TIK	2
Tulsa International Airport,	Tulsa	Oklahoma	TUL	1
Vandenberg Air Force Base		California	VBG	5
Warner Robbins Air Force Base	Warner Robbins	Georgia	WRB	6
Whiteman Air Force Base	Knob Noster	Missouri	SZL	3
Wright-Patterson AFB	Dayton	Ohio	FFO	1

*Home Location of SCA's and ferry flight origin/destination location

**Ferry flight origin/destination location

The Shuttle Training Aircraft

The Shuttle Training Aircraft (STA) were Gulfstream G-II aircraft modified to simulate the space shuttle orbiter's in-flight handling qualities and approach and landing profile, so space shuttle pilots could practice flying approaches and landings under controlled conditions before flying the orbiter. The STA was necessary for training shuttle pilots because the orbiter did not have aircraft engines and had to land on its first attempt after re-entering Earth's atmosphere.

The exterior of each STA was modified to withstand the high aerodynamic forces encountered during simulated orbiter approaches and landings. The cockpits were redesigned to accurately simulate the orbiter's controls and the pilots' vantage point; even the seats were positioned like those in the orbiter. A sophisticated computer system was installed on each STA to accurately simulate the flight dynamics of the orbiter. The STA's highly realistic simulation of the orbiter was not only limited to handling characteristics, but also included the shuttle control interfaces for the pilot. Covers were placed on the left hand cockpit windows to provide the same view as from an orbiter cockpit, and the left-hand pilot's position was fitted with the same controls as a Shuttle. The STA's normal flight controls remained on the right side of the cockpit where the instructor pilot sat. Both seat positions had a Heads Up Display (HUD).

In order to match the descent rate and drag profile of an orbiter at 37,000 feet, the STA main landing gear was lowered (the nose gear stayed retracted due to wind load constraints) and engine thrust was reversed. Its flaps could also be deflected upwards to decrease lift as well as downwards to increase lift.

STA NASA 947 flying a simulated 20-degree orbiter approach to a runway at White Sands Space Harbor, NM.

To simulate a shuttle landing, the pilot descended to 20,000 feet at an airspeed of 280 knots, 15 miles from the targeted runway. The pilot then flew the STA around a heading alignment cone (HAC), a maneuver used to align the flight path with the landing runway at an altitude of 12,000 feet and 7 miles from landing. This was verified by an indication from the microwave scanning beam landing system (MSBLS), which was displayed on the pilot's HUD. The nose of the aircraft was then dropped to increase air speed to 300 knots, and begin a descent at an 18-20-degree angle based on the Outer Glide Slope (OGS) aiming points. The OGS aiming points were located at 7,500 feet and 6,500 feet short of the runway threshold, and were illuminated by a precision approach path indicator (PAPI) lighting system, providing the pilot with visual cues to let him/her know if they were on, above, below, left or right of the desired glide slope.

At 2,000 feet altitude the guidance system changed to the pre-flare configuration and shortly after, at 1,700 feet, the pilot started the flare maneuver to gradually reduce the descent angle and transition to the Inner Glide Slope (IGS) angle of 1.5 degrees at 300 feet, using a "Ball-bar" lighting system for visual cues. The lowering of the orbiter landing gear was also simulated at this time. It had to be simulated because the STA main gear had been lowered for the whole simulated approach. The nose gear of the STA was lowered at 150 feet in case of an inadvertent touchdown on the surface of the runway. If the airspeed was correct, a green light on the instrument panel illuminated indicating a simulated shuttle landing when the pilot's eyes were 32 feet above the runway, simulating the view the pilot would have during an actual orbiter landing. At this time the STA was still flying 20 feet above the ground. The instructor pilot would then deselect the simulation mode, stow the thrust reversers, and fly around the runway, never actually landing the aircraft. Every shuttle commander and pilot had to practice at least 1,000 landings in the STA before being allowed to fly and land an orbiter.

STA 946 flying 20 feet above the runway simulating an orbiter landing on runway 04R at Edwards AFB, CA.

All four STAs were based at NASA ‘s facility in El Paso, Texas and rotated through Ellington Field (Houston, Texas) for maintenance. They were flown to Dryden Flight Research Center/Edwards AFB, CA, Kennedy Space Center, FL and White Sands Space Harbor, NM, for astronauts to practice landings as well as to assess weather conditions prior to Space Shuttle launches and landings.

All four Shuttle Training Aircraft on the ramp at NASA’s Ellington Field aircraft facility.

The cockpit of an STA showing the Shuttle commander's side of (left), with a HUD, rotational hand controller (RHC) for flying the vehicle, and multi-function displays, as they appeared in the Shuttle. The STA instructor pilot sits on the right-hand side and has conventional G-II aircraft controls and instruments.

With NASA's second modified Boeing 747 Shuttle Carrier Aircraft NASA 911 in the background, retired Shuttle Training Aircraft NASA 944 is parked on the ramp at NASA's Dryden Flight Research Center following its arrival on August 19, 2011

Space Shuttle Facts

	Shuttle Stack	Orbiter
Length	184.2 feet	122.17 feet
Height	76.6 feet	56.67 feet
Wingspan	78.06 feet	78.06 feet
Approximate weight	4.5 million lbs. gross liftoff weight	230,000 lbs. nominal end-of-mission weight
Engine thrust	SRB's – 3.3 million lbs. each in vacuum	SSME's - 393,800 lbs each at sea level at 104%
Cargo Bay dimensions		60 feet length x 15 feet diameter

Speed: 17,322 mph (orbital velocity); 1 orbit around earth: ~90 minutes.

Launches: 135
- LC-39A: 81
- LC-39B: 54

Landings: 133*
- DFRC: 54, clay lakebed: 19 (runways 23, 05, 15, 17, 33), concrete: 34 (runway 22/04), asphalt: 1 (runway 04L),
- KSC: 78, concrete (runway 15/33)
- WSSH: 1, gypsum lakebed (runway 17)

* Two vehicles lost prior to end of mission

Landing Rollout: Distance:
- Shortest: 6,015 feet (1.14 statute miles) STS-28 EDW, runway 17
- Longest: 13,737 feet (2.60 statute miles) STS-3 WSSH, runway 17

Largest Crew: 8
- STS-61A (up and down)
- STS-80 (down from ISS)

Smallest Crew: 2
- STS-1, STS-2, STS-3, STS-4

Orbital Altitude
- Maximum: 385.63 statute miles (STS-82)
- Minimum: 139 statute miles (STS-59)

Mission Duration (completed missions)
- Longest: 17 Days, 15 Hours, 53 Minutes, 18 Seconds (STS-80)
- Shortest: 2 Days, 6 Hours, 13 Minutes, 13 Seconds (STS-2)

Orbits:
- Most: 279 (STS-80)
- Least: 36 (STS-2)

Miles Traveled:
- Most: 7.0 million statute miles (STS-80)
- Least: .93 million statute miles (STS-2)

Orbiter Space Flights: 135		**Total Ferry Flights**
• Enterprise:	N/A	19 (including ALT)
• Columbia:	28	24
• Challenger:	10	8
• Discovery:	39	18
• Atlantis:	33	18
• Endeavour:	25	10

Operational Ferry Flights: 87 (284 total flight legs; 173 flight legs for the 55 Post Mission Ferry Flights (average of 3.15 legs per flight))
- SCA/905: 70
- SCA/911: 17

Acronyms, Abbreviations and Terms

A	**Assembly** Designation for most of the assembly missions to the ISS • Preceded by a number or letter, e.g. 1A.
AAF	**Army Airfield**
ACBM	**Active Common Berthing Mechanism** The ACBM enables on-orbit mating and airtight seals between ISS pressurized elements • Consists of powered computer-controlled components that align capture and are secured to passive CBMs
ACTS	**Advanced Communications Technology Satellite** Deployed during STS-51, ACTS served as a test bed for advanced communications satellite technology.
AFB	**Air Force Base**
AL	**Airlock** A pressurized flight element consisting of two cylindrical chambers attached end-to-end by a connecting bulkhead and hatch that allows EVAs to be performed without major loss of air. • Used for EVA entry and departure and as a stowage area for EMU hardware as well as a staging area for crewmembers preparing to conduct an EVA
ALT	**Approach and Landing Test** The flight test program of the space shuttle Enterprise that validated the concept of a reusable orbiter that could re-enter the earth's atmosphere from space and glide safely to a landing on a runway like a conventional aircraft.
am	An abbreviation of the Latin phrase ***ante meridian*** meaning "before noon" used in reference to the 12-hour clock chronology to differentiate between morning and afternoon time indications
AMS	**Alpha Magnetic Spectrometer** An experiment module consisting of a series of detectors designed to look for dark and missing matter in the universe . • AMS-01 successfully flew on STS-91. • AMS-02 was delivered to the ISS on STS-134/ULF-6
Anik	**Name for a series of Canadian communications satellites** A series of geostationary commercial communications satellites launched by Telesat Canada for television in Canada • Anik is a Canadian Eskimo word that means "little brother" • Anik C2 (Telesat 7) was deployed during STS-7 • Anik D (Teleset H) was deployed during STS-51A • Anik C1 (Telesat I) was deployed during STS-51D
AOA	**Abort Once Around** An STS ascent abort mode designed to allow the orbiter to fly once around the Earth and make a nominal (normal) entry and landing. • This mode generally involved two orbital maneuvering system (OMS) thrusting sequences, with the second sequence being a deorbit maneuver.

ARABSAT	**Arab Satellite** The ARABSAT system was a Saudi Arabian communications satellite is operated by the Arab Satellite Communications Organization • Arabsat-1B was deployed during STS-51G
ASC	**American Satellite Company** A U.S. based communications satellite company • ASC-1 was deployed during STS-51I
ASEM	**Assembly of Station by EVA Methods** An experiment during STS-49 that demonstrated and verified maintenance and assembly capabilities for SSF and the ISS
ASI	**Agenzia Spaziale Italiana** Italy's space agency
ATF	**Aeronautical Tracking Facility** The WATR facility that provided telemetry, radar, voice communication, and video support of Shuttle and International Space Station.
ATLAS	**Atmospheric Laboratory for Applications and Science** ATLAS was flown on Spacelab pallets mounted in the orbiter's cargo bay and equipped with 12 instruments from the U.S., France, Germany, Belgium, Switzerland the Netherlands and Japan, to study the energy of the sun and how it affects the Earth's climate and environment • ATLAS-1 was flown on STS-45 • ATLAS-2 was flown on STS-56 • ATLAS-3 was flown on STS-66
Astro	**Astro Observatory** Astro consisted of three ultraviolet telescopes mounted on the Instrument Pointing System on the Spacelab pallet in the Shuttle cargo bay • Astro-1 flew on STS-35 • Astro-2 flew on STS-67
ATO	**Abort to Orbit** An STS ascent abort mode designed to allow the orbiter to achieve a lower than nominal orbit requiring less performance and allowing time to evaluate problems, then choose an early deorbit maneuver to land or an OMS thrusting maneuver to raise the orbit and continue the mission • Only occurred during STS-51F
AUSSAT	**Australian Satellite** A series of satellites built by Hughes Aircraft Corporation to provide communications services for Australia • AUSSAT-I was deployed during STS-51I • AUSSAT-II was deployed during STS-61B

Chandra	**Chandra X-ray Observatory** Formerly the Advanced X-ray Astrophysics Facility, Chandra was one of NASA's "Great Observatories" and the most sophisticated X-ray observatory ever built. • Designed to observe X-rays from high energy regions of the universe, such as hot gas in the remnants of exploded stars. • Deployed during STS-93.
CBM	**Common Berthing Mechanism** Passive berthing mechanisms with the reciprocal mating fittings and alignment components of ACBMs.
CDR	**Commander** The highest ranking crewmember
CETA	**Crew Equipment Translation Aid** Two carts, the equivalent of a flatbed truck, that are integrated parts of S1 and P1 allowing crew members to propel themselves and hardware manually along the MT rails, which run the length of the truss structure • The first CETA was delivered and installed during STS-112/ISS-9A • The second CETA was delivered and installed during STS-113/11A
CHAMP	**Comet Haley Active Monitoring Program** An experiment consisting of a 35mm camera to photograph Comet Halley • CHAMP was flown on STS-61C • Did not function properly due to battery problems
CLS	**Contingency Landing Site** A designated landing site in the event of an EEOM during Shuttle missions. • Included the RSTLS, TAL's, PLS's, Hickam AFB, HI and Kadena AFB, Korea
CNES	**Centre National d'Études Spatiales** France's space agency
Comm.	**Communications**
Columbus	**The ESA ISS laboratory** • Delivered and installed during STS-122/ISS-1E
COMSAT	**Communications Satellite(s)**
CR	**Cosmonaut Researcher**
CRISTA-SPAS	**Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere-Shuttle Pallet Satellite** CRISTA instruments gathered the first global information about medium and small scale disturbances in trace gases in middle atmosphere, which could lead to better models of the atmosphere and Earth's energy balance • Flew at a distance of 25-44 miles (40-70 kilometers) behind the shuttle, collecting data for more than eight days before being retrieved and returned to cargo bay. • For retrieval of CRISTA-SPAS, the R-Bar approach, a different method of approaching spacecraft was successfully tested as prelude to upcoming U.S. Shuttle/Russian Space Station Mir docking flights. The R-Bar approach saved propellant while reducing risk of contamination to Mir systems from orbiter thruster jet firings. • CHRISTA-SPAS-01 was deployed and retrieved during STS-66. • CHRISTA-SPAS-02 was deployed and retrieved during STS-85.

CSA	**Canadian Space Agency**
CTV	**Crew Transport Vehicle** A converted airport people-mover, used as a mobile medical facility to examine, care for and transport astronauts, from the runway after landing, to the DFRC PSSF for further medical examination and care.
D	**Day or days.**
D1	**Deployable 1** A Spacelab pallet configured with the Canadian Special Purpose Dextrous Manipulator (SPDM) aka “Dextre”. • Flew on STS-123
D2	**Deployable 2** A Spacelab pallet configured with the Canadian Special Purpose Dextrous Manipulator (SPDM) aka “Dextre”. • Flew on STS-127
Dakar	**Dakar, Senegal, West Africa** One of the TAL sites.
DARPA	**Defense Advanced Research Projects Agency** An agency of the U.S. DoD responsible for the development of new technology for use by the military
Destiny	**The U.S. ISS laboratory** Delivered and installed during STS-98/ISS-5A.
DFBW	**Digital Fly-By-Wire** An electronic flight-control system coupled with a digital computer to replace conventional mechanical flight controls. • Pilot control input was transmitted from the cockpit to a computer, and then to the aerodynamic control surfaces. • • First flown in an F-8 aircraft at DFRC.
DFRC	**Dryden Flight Research Center** The NASA flight research center located on EAFB, CA Provided landing, recovery and turnaround services in support of Space Shuttle missions • Home to both 747 Shuttle Carrier Aircraft
DFRF	**Dryden Flight Research Facility** The DFRC was part of the NASA Ames Research Center and redesignated the DFRF from 10/1/1981 to 2/28/94
DFVLR	**Deutsche Forschungs- und Versuchsanstalt für Luftund Raumfahrt** • The “German Test and Research Institute for Aviation and Space Flight”

DoD	**U.S. Department of Defense**
DSP	**Defense Support Program**
DTV	**Drop Test Vehicle** A flight test vehicle used to validate the parachute system used in recovering the space shuttle's SRB casings once their propellant was exhausted.
E	**Alpha designation for the ESA ISS assembly missions** Preceded by a number e.g. 1E.
EAFB	**Edwards Air Force Base** The west coast shuttle landing site. • Used as both primary and secondary EOM site.
EDO	**Extended Duration Orbiter** Modifications to allow the shuttle to remain in orbit longer than 10 days
EDT	**Eastern Daylight Time**
EDW	**The designation for the airfield at EAFB.**
EEOM	**Early End of Mission**
ELC	**ExPRESS Logistics Carrier** Large logistics carriers used to carry parts and assemblies to the ISS • ELC1 was flown on STS-129/ULF3 • ELC2 was flown on STS-129/ULF3 • ELC3 was flown on STS-134/ULF6 • ELC4 was flown on STS-133/ULF5
EMU	**Extravehicular Mobility Unit** A self-contained (no umbilicals) spacesuit used by crewmembers during EVAs. Provides thermal and micrometeoroid protection.
EO	Russian abbreviation for Principal Expedition (**expeditsiya osnovnaya**) Part of the alphanumeric designation for MIR expedition primary crews. • Followed by a number, e.g. EO-1
EOM	**End of Mission** Time the orbiter comes to a full stop on the runway after landing
ERBS	**Earth Radiation Budget Satellite** A satellite designed to measure the amount of energy received from the sun and reradiated into space. It also studied the seasonal movement of energy from the tropics to the polar regions • ERBS was deployed during STS-41G
ESA	**European Space Agency** • Europe's equivalent of NASA consisting of partners from several European countries

ESP	**External Stowage Platform** Unpressurized storage pallets installed on the outside of the ISS to hold spare parts and assemblies • ESP 1 was delivered and installed on the aft portion of “Destiny” during STS-102/ISS-5.1 • ESP 2 was delivered and installed to the “Quest” airlock during STS-114/ISS-LF1 • ESP 3 was delivered and installed to the P3 truss during STS-118/ISS-13A.1
EST	**Eastern Standard Time**
ET	**External Tank** The Shuttle’s large external fuel tank that provides liquid propellant for the SSMEs. • The ET was jettisoned from the orbiter prior to orbit insertion and burned up as it re-entered the Earth’s atmosphere.
EURECA	**European Retrievable Carrier** An ESA carrier deployed during STS-46 and retrieved during STS-57.
EUVE	**Extreme Ultraviolet Explorer** A space telescope for ultraviolet astronomy
EV	**Extra-vehicular** Designation for an astronaut performing an EVA
EVA	**Extra-vehicular Activity** An activity performed by an astronaut outside of a spacecraft
FE	**Flight Engineer**
Ft.	The standard abbreviation for **foot** or **feet**
GLOMR	**Global Low Orbiting Message Relay Satellite** A DARPA project designed to demonstrate the ability to read out, store, and forward data from remote ground-based sensors • Deployed during STS-61A
GRO	**Compton Gamma Ray Observatory** The second of the NASA "Great Observatories" to be launched to space, following the HST. • Deployed during STS-37.
H	Abbreviation for **hour** or **hours.**
HAC	**Heading Alignment Cone** An imaginary cylinder (18,000 feet in diameter) flown during approach by the pilot to align the orbiter’s flight path with the runway
Harmony	**Harmony Module** An ISS utility hub, aka “Node 2”, that provides air, electrical power, water, and other LSS essential to the ISS. Distributes resources from the truss to “Destiny,” “Columbus” and “Kibo.” Acts as an internal connecting port and passageway to other ISS labs and cargo spacecraft • Delivered during STS-120/ISS-10A and installed during Expedition 16

HOST	**Hubble Space Telescope Orbital Systems Test** HOST flew on STS-95 and provided an on-orbit test bed for hardware that was used during the third Hubble servicing mission
HST	**Hubble Space Telescope** The first of NASA's "Great Observatory's" the HST is one of the largest and most versatile telescopes. It is well-known as both a vital research tool and a public relations boon for astronomy • HST was deployed during STS-31 • Servicing Mission (SM) 1 was carried out during STS-61 • SM2 was carried out during STS-82 • SM3A was carried out during STS-103 • SM3B was carried out during STS-109 • SM4 was carried out during STS-125
HUD	**Head-Up Display** A transparent display that indicates data such as an aircraft's attitude, altitude, airspeed, course, heading, etc. for pilots as they look out the front window at their usual viewpoints.
IAE	**Inflatable Antenna Experiment** The SPARTAN 207/IAE was flown on STS-77
ICBC	**IMAX Cargo Bay Camera** Flew on STS-88/ISS-2A, the first Shuttle mission to the ISS
ICC	**Integrated Cargo Carrier (ICC)** Shuttle payload used to transport large external spare parts called ORUs (i.e. space to ground antenna, linear drive unit, pump module, batteries ,etc.) to and from the ISS
ICDR	**ISS Commander** ISS Commanders often flew to and from the ISS on Shuttle-ISS missions
IGS	**Inner Glide Slope** A runway approach descent angle of 1.5 degrees using a "ball-bar" lighting system which provided visual guidance to the commander and pilot when landing a space shuttle orbiter.
IMAX	**IMAX Corporation** A motion picture film format and projection standard created by the Canadian IMAX Corporation. IMAX cameras were flown onboard several Shuttle missions to document mission highlights
IML	**International Microgravity Laboratory** A pressurized Spacelab module used to explore the complex effects of weightlessness on living organisms and materials processing • IML-1 flew on STS-42 using the pressurized Spacelab module • IML-2 flew on STS-65
INSAT	**Indian National Satellite** The Indian National Satellite system is a series of multipurpose Geo-stationary satellites that provide telecommunications, broadcasting, meteorology, and search and rescue needs for India. • INSAT-1B was deployed during STS-8

INTELSAT

International Telecommunications Satellite

The INTELSAT organization is an inter-governmental consortium owning and managing communications satellites that provide international broadcast services

- INTELSAT IV was retrieved and redeployed during STS-49

IMU

Inertial Measurement Unit

An electro-mechanical navigation unit used to determine position and velocity with respect to the earth.

ISS

International Space Station

The Space Shuttle was used to deliver assemblies, equipment, modules and supplies during the construction of the ISS

Shuttle – ISS Assembly Missions

Number	ISS Assembly Mission	Shuttle Mission	Number	ISS Assembly Mission	Shuttle Mission
1	ISS-2A	STS-88	19	ISS-12A	STS-115
2	ISS-2A.1	STS-96	20	ISS-12A.1	STS-116
3	ISS-2A.2a	STS-101	21	ISS-13A	STS-117
4	ISS-2A.2b	STS-106	22	ISS-13A.1	STS-118
5	ISS-3.3A	STS-92	23	ISS-10A	STS-120
6	ISS-4A	STS-97	24	ISS-1E	STS-122
7	ISS-5A	STS-98	25	ISS-1J/A	STS-123
8	ISS-5A.1	STS-102	26	ISS-1J	STS-124
9	ISS-6A	STS-100	27	ISS-ULF2	STS-126
10	ISS-7A	STS-104	28	ISS-15A	STS-119
11	ISS-7A.1	STS-105	29	ISS-2J/A	STS-127
12	ISS-UF1	STS-108	30	ISS-17A	STS-128
13	ISS-8A	STS-110	31	ISS-ULF3	STS-129
14	ISS-UF2	STS-111	32	ISS-20A	STS-130
15	ISS-9A	STS-112	33	ISS-19A	STS-131
16	ISS-11A	STS-113	34	ISS-ULF4	STS-132
17	ISS-LF1	STS-114	35	ISS-ULF5	STS-133
18	ISS-ULF1.1	STS-121	36	ISS-ULF6	STS-134
			37	ISS-ULF-7	STS-135

ITS

Integrated Truss Structure

Consists of 11-segments forming the ISS backbone with mounts for unpressurized logistics carriers, radiators, solar arrays, and various other elements (P1, P3, P4, P5, P6, S0, S1, S3, S4, S5, and S6)

IUS

Inertial Upper Stage

The USAF IUS booster was deployed STS-51C, the first DoD dedicated mission.

J

Part of alphanumeric designation for the JAXA ISS assembly missions. Preceded by a number e.g. 1J

- Preceded by the number 1, e.g. 1J.

J/A

Part of alphanumeric designation for the JAXA ISS assembly missions. Preceded by a number e.g. 1J/A.

- Preceded by the number 1, e.g. 1J/A.

JAXA	**Japan Aerospace Exploration Agency** On October 1, 2003, JAXA was formed from a merger of Japan's Institute of Space and Astronautical Science (or ISAS), the National Aerospace Laboratory of Japan (NAL), and National Space Development Agency of Japan (NASDA).
JEF	**JEM Exposed Facility** A component like a front porch attached to the JEM or "Kibo.". Delivered and installed during STS-127/ISS-2J/A
JEM	**Japanese Experiment Module (JEM)** AKA "Kibo", Japan's first human-rated space facility. Delivered during STS-123, and installed during STS-124/1J & 127/ISS-2J/A
JEM ELM-PS	**Experiment Logistics Module - Pressurized Section** The pressurized section of the JEM or "Kibo." Installed during STS-123.
JEM RMS	**JEM Remote Manipulator System** The robotic arm component of the JEM or "Kibo." Delivered and installed during STS-124/1J.
JLE	**Japanese Experiment Logistics Module - Exposed Section** The part of the JEM that is exposed to the space environment and used for conducting experiments. Delivered and installed during STS-127/ISS-2J/A.
JLP	**Japanese Experiment Logistics Module - Pressurized Section** JEM Pressurized Section on ISS
JPM	**Japanese Pressurized Module** A component of "Kibo." Delivered and installed during STS-124/1J.
JRMS	**JEM Remote Manipulator System** NASA's human space flight launch and landing field center located on Florida's central east coast.
KSC	**Kennedy Space Center** The NASA space center located on the east coast of central Florida and where the Space Shuttles launched and landed.
Landsat	**Land Satellite** A series of Earth-observing satellite missions jointly managed by NASA and the U.S. Geological Survey.
LAGEOS	**Laser Geodynamic Satellite** Joint effort between NASA and ASI, deployed during STS-52.
LC	**Launch Complex** The area where the Space Shuttle launch pads are located at KSC. Launch Complex 39 includes launch pads 39A and 39B

Leasat	**Leased Satellite** A Hughes-built defense communications satellite also known as SYNCOM. Leasat-2 was the first large communications satellite designed specifically to be deployed from the Space Shuttle. • Leasat -2 was deployed during STS-41D
LDEF	**Long Duration Exposure Facility** A payload carrying 57 experiments which were deployed left on orbit and later retrieved • Deployed during STS-41C • Retrieved during STS-32
LIDAR	**Light Detection and Ranging** A type of optical radar using laser pulses instead of radio waves to study Earth's atmosphere • Part of the Tri-DAR system used for gathering long-range data • Flew on STS-64 (see LITE)
LIFT	**Lifting Insulating Foam Trajectory** A series of flight tests conducted using DFRC's F-15B Research Testbed aircraft to determine how pieces of insulating foam debris behave when small pieces are shed from the shuttle's external fuel tank during launch.
LITE	**Lidar In-space Technology Experiment** The LITE science program is part of NASA's mission to Planet Earth • The LITE payload employs LIDAR. • During STS-64, the LITE instrument operated for 53 hours yielding more than 43 hours of high-rate data. Unprecedented views were obtained of cloud structures, storm systems, dust clouds, pollutants, forest burning and surface reflectance. • Sites studied included atmosphere above northern Europe, Indonesia and the south Pacific, Russia and Africa
LM1	**Laboratory Module 1** • The first Spacelab science laboratory module built by the ESA for use on the Space Shuttle
LM2	**Laboratory Module 2** • The second Spacelab science laboratory module built by the ESA for use on the Space Shuttle
LMS	**Life and Microgravity Spacelab** LMS was the 21st Spacelab mission and was flown on STS-78
LSRA	**Landing Systems Research Aircraft** A General Dynamics CV-990 airliner modified with shuttle landing gear to perform Shuttle tire wear and braking systems tests, resulting in surface improvements to the SLF runway at KSC and increased wind limits for Shuttle landings.
M	Abbreviation for **minute** or **minutes**
MAPS	**Measurement of Air Pollution from Satellites** An atmospheric instrument that was part of SRL-1 and 2.

MBS

Mobile Base System (MBS)

A moveable work platform installed during STS-111/UF-2 putting much of the ISS within grasp of Canadarm2 when it was attached.

- Part of the MSS.
- The MBS has the ability to travel to work sites all along the truss structure.
- Astronauts also use the MBS as a platform from which to perform EVAs as well as a storage facility for tools.

MCDR

Mir Commander

MDD

Mate Demate Device

A large gantry-like steel structure used to hoist the space shuttle orbiters off the ground during post-landing servicing operations and during mating and demating operations with the 747 SCA.

Mir

The name of the Russian Space Station (Mir is Russian for “peace”)

Mir was on orbit from 1986 to 2001.

- There were 11 Shuttle missions to Mir which included 9 Shuttle-Mir dockings beginning on the third mission.

Shuttle – Mir Missions

Number	Shuttle Mission	Number	Shuttle Mission
1	STS-60	7	STS-81
2	STS-63	8	STS-84
3	STS-71	9	STS-86
4	STS-74	10	STS-89
5	STS-76	11	STS-91
6	STS-79		

Morelos

Mexican communications satellite

A series of two Mexican communications satellites, built by the Hughes Aircraft Corporation, that provided telephony, data, and television services for Mexico between 1985 and 1998

- Morelos-I was deployed during STS-51G
- Morelos-B was deployed during STS-61B

MPLM

Multi-Purpose Logistics Module

Italy's contribution to the ISS.

- The three modules were named Leonardo, Raffaello, and Donatello for some of the great engineers in Italian history.
- Pressurized and reusable as cargo carriers and ISS modules, they were the “moving vans” that carried new laboratory racks filled with equipment,experiments and supplies to the ISS and returned old racks and experiments back to Earth.
- Transported to/from the ISS by the Shuttle

MRM

Mini Research Module

Two components of the ISS used for science research, cargo storage and docking ports for Russian Soyuz and Progress vehicles.

- Formerly known as the Docking Cargo Module
- MRM-2, aka “Poisk” was delivered by Russia just prior to STS-129/ULF-3.
- MRM-1 aka “Rassvet” was delivered by STS-132/ISS-ULF4

MS	**Mission Specialist** A Shuttle crew member first selected as an astronaut and then assigned to a mission.
MSBLS	**Microwave Scanning Beam Landing System** An aircraft instrument landing system that operated in the microwave frequency band that provides precise elevation, directional and distance data used by the commander to guide the orbiter during the last two minutes of flight as it approached the runway for landing. • The MSBLS signal was typically usable from a horizontal distance of approximately 15 miles and an altitude of approximately 18,000 feet and provided the commander with a superimposed signal that lined up on the runway when viewed through the HUD.
MSL	**Materials Science Laboratory** ESA payload • Launched on STS-128 • Installed in the “Destiny” module on the ISS
MSL	**Microgravity Science Laboratory** ESA Spacelab module • MSL-1 flew on STS-83, which ended early due to s fuel cell problem. • MSL-1R, a reflight of MSL-1, flew on STS-94.
MSS	**Mobile Servicing System** Consists of the SSRMS, the MBS, and the SPDM. • Delivered and installed during STS-100/UF-2.
MST	**Mountain Standard Time**
MT	**Mobile Transporter** Part of the MSS delivered and installed during STS-110/ISS-8A.
NAS	**Naval Air Station**
NASA	**National Aeronautics and Space Administration**
NASDA	**National Space Development Agency of Japan** Became a part of JAXA on October 1, 2003
NAWS	**Naval Air Weapons Station**
nm	**nautical mile(s)** 1 nm= 6,080.2 feet
NOR	**Northrup Strip** The original airfield designation for the airfield at White Sands Space Harbor, NM • The landing site for STS-3.

NSAU	**National Space Agency of Ukraine**
NWS	**Nose Wheel Steering**
Node	A passageway to which an ISS module(s) are attached. **Node 1 -** 1st US component of ISS. AKA "Unity". Connecting module installed on Zarya. See "Unity." Delivered and installed during STS-88/ISS-2A. **Node 2 -** a utility hub, AKA "Harmony", that provides air, electrical power, water, and other systems essential to support life on the ISS. It distributes resources from the ISS truss to the Destiny and Columbus labs and the JEM (Kibo). The module acts as an internal connecting port and passageway to additional international science labs and cargo spacecraft Delivered and installed during STS-120/ISS-10A and Expedition 16. **Node 3 -** AKA "Tranquility", delivered and installed to "Unity: during STS-130/ISS-20A. Includes the Cupola, a large window module and robotics work station.
OAST	**Office of Application and Space Technology** **OAST-1**, flown on STS-41D was a solar wing extended from the payload bay. It carried different types of solar cells and was extended to its full height several times. It demonstrated large lightweight solar arrays for future use in construction of large facilities in space such as a space station. **OAST-2** flew on STS-62 and featured six experiments located in the payload bay focusing on space technology and spaceflight **OAST-Flyer** was deployed and retrieved during STS-72 and was the seventh in a series of missions aboard reusable free-flying Spartan carriers. It consisted of four experiments
OGS	**Outer Glide Slope** A runway approach descent angle of 18 to 20 degrees using a PAPI lighting system with aiming points and a series of lights, located 6500 feet and 7500 feet short of the runway, which provided visual guidance to the commander and pilot when flying an approach to a runway in a space shuttle orbiter.
OMDP	**Orbiter Maintenance Down Period**
OMM	**Orbiter Major Modification**
OMS	**Orbiter Maneuvering System** Small engines used to place the orbiter into the desired orbit and to maneuver the orbiter during on-orbit operations.
ORFEUS-SPAS	**Orbiting and Retrievable Far and Extreme Ultraviolet Spectrograph-Shuttle Pallet Satellite** First in series of ASTRO-SPAS astronomical missions.

<table>
<tr><td>OV</td><td>Orbiter Vehicle

Part of alphanumeric designation for the Space Shuttle orbiters

The Space Shuttle Orbiters
<table>
<tr><th>Designation</th><th>Name</th><th>Comments</th></tr>
<tr><td>OV-099</td><td>Challenger</td><td>• Second orbiter of the fleet
• Namesake: British Naval research vessel HMS Challenger that sailed the Atlantic and Pacific oceans during the 1870's</td></tr>
<tr><td>OV-101</td><td>Enterprise</td><td>• Prototype orbiter flown only during the Approach and landing Test (ALT) program
• Namesake: The Starship Enterprise from the 1960’s TV series Star Trek</td></tr>
<tr><td>OV-102</td><td>Colombia</td><td>• First orbiter of the fleet
• Namesake: The Boston, MA, based sloop captained by American explorer Robert Gray</td></tr>
<tr><td>OV-103</td><td>Discovery</td><td>• Third orbiter of the fleet
• Namesake: The second ship used by the British explorer James Cook in the1770s during his voyages</td></tr>
<tr><td>OV-104</td><td>Atlantis</td><td>• Fourth orbiter of the fleet
• Namesake: The primary research vessel for the Woods Hole Oceanographic Institute in Massachusetts from 1930 to 1966</td></tr>
<tr><td>OV-105</td><td>Endeavour</td><td>• Fifth orbiter of the fleet
• Namesake: The first ship commanded by James Cook, the 18th century British explorer, navigator and astronomer</td></tr>
</table></td></tr>
<tr><td>P</td><td>Port

A nautical term used for “left”</td></tr>
<tr><td>P1 Truss</td><td>Port 1 Truss Segment

The P1 truss was attached to S0.

• Delivered and installed during STS-113/ISS-11A.</td></tr>
<tr><td>P3 Truss</td><td>Port 3 Truss Segment

The P3 truss is attached to the P1 truss and provides an attachment point for P5 as well as a second set of SAWs and the first alpha joint. Supports utility routing, power distribution and a translation path for the MBS.

• Delivered and installed during STS-115/ISS-12A.</td></tr>
<tr><td>P4 Truss</td><td>Port 4 Truss Segment

The P4 truss is attached to the P1 truss and provides an attachment point for P5 as well as a second set of SAWs and the first alpha joint.

• Supports utility routing, power distribution and a translation path for the MBS. Delivered and installed during STS-115/ISS-12A.</td></tr>
<tr><td>P5 Truss</td><td>Port 5 Truss Segment

Attached to the P4 truss element via the MRTAS interface. Used primarily to connect power and cooling lines and serve as a spac-er between the P4 and P6 PVM.

• Delivered and installed during STS-116/ISS-12A.1.</td></tr>
</table>

P6 Truss	**Port 6 Truss Segment** Has solar arrays attached. • P6 was installed during (STS-97/ISS-4A). • The P6 solar arrays were deployed during STS-113.
PALAPA	**An Indonesian communications satellite** A series of communication satellites owned by Indosat, an Indonesian telecommunications company. Palapa is Indonesian for "fruits of labor" • PALAPA-B2 was deployed during STS-7 • PALAPA-B2 was deployed during STS-41B and retrieved during STS-51A
PAPI	**Precision Approach Path Indicator** A lighting system that provided an outer glide slope lighting sequence indicating if the space shuttle orbiter was on, above, below, left or right of the glide slope, prior to landing. • Two sets of PAPI lights, one located at 7,500 feet and another located 6,500 feet, prior to the threshold and on the centerline extending from the runway were used to provide an indication of an 18 to 20 degree glide slope, which was six times steeper than the 3-degree slope of a typical commercial jet airliner.
PDGF	**Power Data Grapple Fixture** Fixtures used to lock the free end of the MSS and to provide the MSS with power, data, and video to the arm through its LEEs.
PDT	**Pacific Daylight Time**
PIO	**Pilot Induced Oscillation** An in-flight condition where a pilot's initial input to an aircrafts flight controls does not result in an immediate response from the aircraft causing the pilot to make a second input about the time that the first input was being acted upon by the aircraft's flight control system and resulting in aircraft pitch and roll oscillations.
PL CDR	**Payload Commander** The MS or PS lead assigned to a Shuttle mission payload.
PLS	**Primary (or Prime) Landing Site** The scheduled landing site in the event of an EEOM during Shuttle missions • PLS's included: – Dryden Flight Research Center/ Edwards AFB, CA – Kennedy Space Center, FL – Northrup Strip/White Sands Space Harbor, NM
PLT	**Pilot**
pm	An abbreviation of the Latin phrase ***post meridian*** meaning "after noon" used in reference to the 12-hour clock chronology to differentiate between morning and afternoon time indications
PM	**Pressurized Module** A pressurized SPACEHAB module flown on STS-76.

PMA	**Pressurized Mating Adapter (PMA)** PMA's are the docking ports for the ISS. *They allow the docking systems used by the space shuttle and Russian modules to attach to the ISS. Delivered and installed during STS-88/ISS-2A.* **PMA-1** *connects U.S. and Russian elements. Delivered and installed during STS-88/ISS-2A.* **PMA-2** *shuttle docking location. Delivered and installed during STS-88/ISS-2A.* **PMA-3** *provided shuttle docking port for solar array installation. Delivered and installed during STS-92//3A.*
PMM	**Permanent Multi-purpose Logistics Module** An MPLM with external MMOD shield modifications allowing it to be permanently attached to the ISS. Delivered and installed on STS-134
PPF	**Payloads Processing Facility** A DFRC facility used for post-flight processing of animal and plant experiments returning from space onboard the space shuttle orbiter.
PS	**Payload Specialist** A Shuttle crew member responsible for the operation and management of the payloads elements assigned to him/her. • A person selected and trained by commercial or research organizations for flights of a specific payload on a Space Shuttle mission. A PS was generally selected for a single specific mission and chosen outside the astronaut training process.
PSSF	**Post-flight Sciences Support Facility** A DFRC facility used to conduct post-flight physicals and testing of the shuttle astronauts upon returning from space.
PST	**Pacific Standard Time**
Quest	A joint airlock on the ISS Consists of two sections, a crew lock that is used to exit the station for an EVA, and an equipment lock for storing gear. • Delivered and installed during STS-107/ISS-7A.
R&D	**Research & Development**
RADAR	**Radio Detecting and Ranging**
RAF	**Royal Air Force**
RCA	**Radio Corporation of America**
RCS	**Reactionary Control System** The thrusters used to maneuver the orbiter during on-orbit operations.
RMS	**Remote Manipulator System** Also known as the Shuttle robotic arm and Canadarm • Built in Canada

RNDZ	**Rendezvous** Proximity operations (approach/ flyaround) between two spacecraft
Rota	**Rota Naval Air Station, Spain** • One of the TAL sites.
RWY	**Runway**
S	**Second or seconds**.
S	**Starboard** Nautical term for “right”
S0 Truss	**Starboard 0 Truss Segment** The central integrated truss forming the center backbone of the ISS. • It is attached to “Destiny” and is used to route power to the pressurized station modules and conduct heat away from the modules to the S1 and P1 trusses. • From S0, the truss segments are P1, P3, P4, P5, & P6; and S1, S3, S4, S5, & S6. • Delivered and installed during STS-110/ISS-8A.
S1 Truss	**Starboard 1 Truss Segment** Attached to S0. • Delivered and installed during STS-112/ISS-9A
S3 Truss	**Starboard 3 Truss Segment** Attached to S0. • Provides electrical power and data interfaces for mission payloads and convert sunlight to electricity. • Has another set of SAWs and a second SARJ, which keeps the arrays permanently pointed toward the sun. • Delivered and installed during STS-117/ISS-13A.
S4 Truss	**Starboard 4 Truss Segment** Attached to S0. • Provides electrical power and data interfaces for mission payloads and convert sunlight to electricity. • Has another set of SAWs and a second SARJ, which keeps the arrays permanently pointed toward the sun. • Delivered and installed during STS-117/ISS-13A.
S5 Truss	**Starboard 5 Truss Segment** Attached to S4. Used primarily to connect power, cooling lines, and as a spacer between the S4 & S6 PVMs. • Delivered and installed during STS-118/13A.1

S6 Truss	**Starboard 6 Truss Segment** The final truss element completing the station's 11-segment ITS). • Major subsystems include a PVM, PVR, the LST, and the MRTAS. • It also carries the BCDUs. • Delivered and installed during STS-119/ISS-15A.
SAFER	**Simplified Aid for EVA Rescue** A new backpack tested during STS-64 for use in event crew member becomes un-tethered while conducting an EVA.
SAPS	**Side Access Panels** Movable structures, one on each side of the MDD that were lowered into place next to the space shuttle orbiter fuselage, allowing engineers and technicians access along both sides of the orbiter.
SARJ	**Solar Array Rotating Joint (SARJ)** A P3 and S3 subsystem
SATCOM	**Satellite Communications** A series of Ku-band communications satellites operated by RCA • SATCOM Ku-2 was deployed on STS-61B • SATCOM Ku-1 was deployed on STS-61C
SAW	**Solar Array Wing** • **Solar energy collection panel on ISS**
SBS	**Satellite Business Systems** A U.S. company that provided a digital satellite communications network for business and other professional clients • SBS-C was deployed during STS-5 • SBS-D was deployed during STS-41D
SCA	**Shuttle Carrier Aircraft** Two modified Boeing 747s used to ferry space shuttle orbiters from one site to another.
SCAPE	**Self Contained Atmospheric Protection Ensemble** A protective suit worn by the safety assessment team when testing the space shuttle orbiter for toxic vapor leaks once it landed.
SFU	**Space Flyer Unit** SFU was launched aboard a Japanese H-2 rocket March 18, 1995 from the Tanegashima Space Center. It was retrieved during STS-72 and returned to earth completing a 10-month scientific mission involving almost a dozen experiments including materials science to biological studies.
SitS-C	The SBS communications satellite aka SBS-C deployed during STS-5.

SIR-C/X-SAR	**Spaceborne Imaging Radar-C and the X-band Synthetic Aperture Radar** Part of SRL -1 and 2.
SLC	**Space Launch Complex** Abbreviation used for launch sites at Vandenberg AFB, CA (e.g., SLC-6)
SLF	**Shuttle Landing Facility** The airfield located at KSC.
SLS	**Secondary Landing Site** The scheduled landing site in the event of an EEOM during Shuttle missions and the PLS was unavailable. • SLS's included Dryden Flight Research Center/ Edwards AFB, CA; Kennedy Space Center, FL, and White Sands Space Harbor, NM
SLS	**Spacelab Life Sciences** Spacelab modules dedicated to life sciences experiments.
SM	**Single Module** A configuration of SPACEHAB and Spacelab employing only one module.
SM	**Statute Miles** 1 SM = 5280 feet
Solar Max	**Solar Maximum satellite** A satellite that investigated solar phenomenon, including solar flares from 1980 to 1989. • The first satellite serviced in space by a Shuttle crew during STS-41C.
SPACEHAB	**Space Habitat** A reusable laboratory flown on the Space Shuttle consisting of mixed-cargo carriers used for experiment equipment and a habitat for the crew. It is installed in the payload bay and augmented the mid-deck.

Shuttle – SPACEHAB Missions

SPACEHAB	Shuttle Mission	SPACEHAB	Shuttle Mission
1	STS-57	5	STS-95
2	STS-60	DM	STS-96/ISS-2A.1
3	STS-63	DM	STS-101/ ISS-2A.2a
PM	STS-76	DM	STS-106/ ISS-2A.2b
4	STS-77	DM	STS-107
DM	STS-79	SM	STS-116
DM	STS-86	SM	STS-118

Spacelab

Space Laboratory

A reusable laboratory pallet flown in the shuttle's cargo bay

Spacelab	Shuttle Mission	Spacelab	Shuttle Mission
1 (LM1 and pallet)	STS-9	SRL-1 (pallet)	STS-59
3 (LM1)	STS-51B	IML-2 (LM1)	STS-65
2 (triple pallet)	STS-51F	SRL-2 (pallet)	STS-68
D1 (LM2)	STS-61A	ATLAS-3 (pallet)	STS-66
MSL-2	STS-61C	ASTRO-2 (pallet)	STS-67
ASTRO-1 (pallet)	STS-35	USML-2 (LM1)	STS-73
SLS-1 (LM1)	STS-40	LMS (LM2)	STS-78
IML-1 (LM2)	STS-42	MSL-1 (LM1)	STS-83
ATLAS-1 (double pallet)	STS-45	MSL-1R (LM1)	STS-94
USML-1 (LM1)	STS-50	Neurolab (LM2)	STS-90
Spacelab J (LM2)	STS-47	SRTM (pallet)	STS-99
ATLAS-2 (pallet)	STS-56	SLP-D1 (pallet)	STS-123
Spacelab D2 (LM1)	STS-55	SLP-D2 (pallet)	STS-127
SLS-2 (LM2)	STS-58		

SPARTAN

Shuttle Pointed Autonomous Research Tool for Astronomy

SPARTAN was designed to collect data about acceleration and velocity of solar wind and to measure aspects of sun's corona. The free flyer was released using the Shuttle RMS. Data was recorded for playback after return to Earth

- SPARTAN was deployed and retrieved during STS-51G
- SPARTAN 201-01 was deployed and retrieved during STS-56
- SPARTAN 201-02 was deployed and retrieved during STS-64
- SPARTAN 201-03 was deployed and retrieved during STS-69
- SPARTAN 207/IAE Free Flyer was flown on STS-77
- SPARTAN 201-04 was deployed and retrieved during STS-87

SPDM

Special Purpose Dexterous Manipulator

A two armed robot that is part of the MSS on the ISS. Aka "Dextre."

- Installed during STS-123.

SPLT

Soyuz Pilot

Soyuz pilots often flew to or from the ISS as an MS on the Shuttle, then flew back to earth as a pilot on the Russian Soyuz Crew Module.

SRB

Solid Rocket Booster(s)

The Shuttle's externally mounted solid rocket motor that augmented ascent thrust at launch and soon afterwards separated from the orbiter and was recovered for reuse.

SRL

Space Radar Laboratory

Part of NASA's mission to Planet Earth

- SRL-1, included SIR-C/X-SAR and MAPS, was flown on STS-59
- SRL-2, included SIR-C/X-SAR and MAPS, was flown STS-68 to compare changes with SRL-1 which occurred during a different season.

SRTM	**Shuttle Radar Topography mission** SRTM flew on STS-99 and mapped the land area between 60^{o} north latitude and 56^{o} south latitude.
SSF	**Space Station Freedom** Pre-ISS space station concept
SSME	**Space Shuttle Main Engine(s)**
SSP	**Space Shuttle Program**
SSRMS	**Space Station Remote Manipulator System**
SSV	**Space Shuttle Vehicle** Consists of the orbiter, external tank, and solid rocket boosters when mated together. • Also called the Shuttle stack.
STA	**Shuttle Training Aircraft** Gulfstream G-II aircraft modified to simulate the space shuttle orbiter's in-flight handling qualities and approach and landing profile, so space shuttle pilots could practice flying approaches and landings under controlled conditions before flying the orbiter. • STAs were needed to train Shuttle pilots because the orbiter did not have aircraft engines and had to land on its first attempt after re-entering the earth's atmosphere.
STBD	**Starboard** Nautical term meaning "to the right" (alternate abbreviation S used for ISS components)
STS	**Space Transportation System** Consists of the Space Shuttle (Orbiter, ET, SRB) and associated flight hardware and software.
SYNCOM	**Synchronous Communications Satellite** A defense communications satellite also known as Leasat. • SYNCOM IV-1 (Leasat-1) was deployed during STS-51A • SYNCOM IV-3 (Leasat-3) was deployed during STS-51D and repaired during STS-51I • SYNCOM IV-4 was deployed during STS-51I • SYNCOM IV-F5 was deployed during STS-32
TACAN	**Tactical Air Navigation** A military aircraft navigation system that provides bearing and distance (slant-range) information from a ground station to an aircraft.

TAL	**Transoceanic Abort Landing (a.k.a. Trans-atlantic Abort Landing)** Overseas contingency landing sites available to land an orbiter in the event of an abort during ascent after the orbiter can no longer return to KSC to land • TAL sites selected during the SSP: – Banjul, The Gambia, West Africa – Ben Guerir Air Base, Morocco (BEN) – Dakar, Senegal, West Africa – Moron Air Base (MRN), Spain – Rota Naval Air Station, Spain – Sunset, Casablanca – Zaragoza, Spain (ZZA)
TDRS	**Tracking and Data Relay Satellite** The satellites that make up the TDRSS • TDRS-1 (A) was deployed during STS-6 • TDRS-2 (B) was destroyed during STS-51L • TDRS-3 (C) was deployed during STS-26 • TDRS-4 (D) was deployed during STS-29 • TDRS-5 (E) was deployed during STS-43 • TDRS-6 (F/I) was deployed during STS-54 • TDRS-7 (G) was deployed during STS-70
TDRSS	**Tracking and Data Relay Satellite System** A space-based network that provides communications, tracking, telemetry, data acquisition and command services essential to the Space Shuttle and other low-Earth orbital spacecraft such as the HST, ISS, GRO, UARS, COBE, EUVE, Landsat, TOPEX-Poseidon, and many more
TELESAT	**Telecommunications Satellite** A Canadian communications satellite company. • Manufacturer of the Anik and TELESAT series satellites, many of which were deployed during Space Shuttle missions.
Telstar	**AT&T communications satellite.** A series of communications satellites developed by AT&T. • Telstar-3C was deployed during STS-41D. • Telstar-3D was deployed on STS-51G.
TOPEX-Poseidon	**Ocean Topography Expriment** Spacecraft to monitor global ocean circulation, improve global climate predictions, and track El Niño conditions and ocean eddies
TPS	**Thermal Protection System** The light weight insulating tiles and blankets used to protect the orbiter from the extreme heat encountered during reentry into the earth's atmosphere.

TSS	**Tethered Satellite System** A joint NASA/ASI operation, the satellite was provided by Italy and the tether deployment assembly by the U.S. • The TSS was deployed during STS-46. During deployment, it reached a maximum distance of only 840 feet from the orbiter instead of planned 12.5 miles because of a jammed tether line. After numerous attempts over several days to free the tether, TSS operations were curtailed and satellite was stowed for return to Earth. • TSS-1R was deployed during STS-75. On flight day three the tether broke just short of full deployment (12.8 miles) resulting in loss of the satellite. Fortunately, valuable scientific data was still gathered
Tranquility	**Tranquility module** Node 3 “Tranquility” module was delivered and installed during STS-130/ISS-20A.
TVIS	**Treadmill Vibration Isolation and Stabilization System** Also known as “Treadmill 1”, TVIS flew on STS-81 and was designed for use in the Russian Service Module of the ISS.
UARS	**Upper Atmosphere Research Satellite** Deployed during the STS-48 mission. During its planned 18-month mission, UARS made the most extensive study ever conducted of the Earth's troposphere, the upper level of the planet's envelope of life sustaining gases which also include the protective ozone layer. UARS had ten sensing and measuring devices.
UF	**Utility flight** ISS assembly flight that delivered equipment and supplies to the ISS • MPLM used to deliver cargo to the ISS
ULF	**Utilization and Logistics flight (ULF)** ISS assembly flight that delivered equipment and supplies to the ISS • MPLM used to deliver cargo to the ISS
Unity	**A connecting module installed on the Zarya module.** ISS: 1st U.S. component of ISS. AKA “Node 1”. • It has six passageways to which modules were attached as the ISS expanded. Links “Destiny” with “ Zarya.” • Connecting point for airlock, cupola, Node 3, MPLM, and control module delivered and installed during STS-88/ISS-2A.
USAF	**United States Air Force**
USML	**United States Microgravity Laboratory** USML was a Spacelab module with a connecting tunnel to the orbiter crew compartment • USML-1 flown on STS-50 was a national effort to advance microgravity research in a broad number of disciplines • USML-2 flew on STS-73 concentrated within same overall areas of USML-1, with many experiments flying for second time

USMP	**U.S. Microgravity Payload** USMP consisted of U.S. and international experiments located in the payload bay, that investigated materials processing and crystal growth in microgravity. • USMP-1 flew on STS-52. • USMP-2 flew on STS-62. • USMP-3 flew on STS-75. • USMP-4 flew on STS-87.
VAFB	**Vandenberg Air Force Base** Located near Lompoc, CA • The Western Space and Missile Center • Plans for using a West Coast shuttle launch site (SLC-6) were cancelled following the STS-51L accident due to safety concerns
WATR	**Western Aeronautical Test Range** The DFRC RADAR, telemetry and communications tracking and data transmission assets located on Edwards Air Force Base that supported all segments of the Space Shuttle program, including the launch, on-orbit, and landing phases of each mission.
Westar	**A Western Union communications satellite** A fleet of Western Union geosynchronous comm. satellites • Westar-VI was deployed during STS-41B and retrieved during STS-51A
WSF	**Wake Shield Facility** The WSF was a deployable/retrievable experiment platform consisting of a 12-foot diameter stainless steel disk used to grow thin films for advanced electronics in a near perfect vacuum created by the wake of the satellite as it moves through space in low earth orbit which is 10,000 times greater than what is achievable on Earth. In this ultra-vacuum environment defect-free thin-film layers of gallium arsenide and other semiconductor materials can be grown • WSF-1 was deployed and retrieved during on STS-60. • WSF-2 was deployed and retrieved during STS-69 and was first spacecraft to maneuver itself away from orbiter rather than other way around by firing small cold gas nitrogen thruster to maneuver away from Endeavour. • WSF-3 was deployed and retrieved during STS-80.
WSSH	**White Sands Space Harbor** NASA Shuttle landing site at White Sands, NM.
Z1 Truss	**Zenith 1 Truss** ISS: 1st truss piece and early framework for first U.S. solar arrays. • Temporarily installed during STS-92/ISS-3A. • Permanently delivered and installed during STS-92/ISS-3.3A.

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