National Aeronautics and Space Administration

Space Shuttle Transoceanic Abort Landing (TAL) Sites

NASAfacts

Space Shuttle Discovery blasts off from Launch Pad 39B at dawn March 8, 2001, on mission STS-102, the eighth flight to the International Space Station.

Planning for each space shuttle mission includes provisions for an unscheduled landing at contingency landing sites in the United States and overseas. Several unscheduled landing scenarios are possible, ranging from adverse weather conditions at the primary and secondary landing sites to mechanical problems during the ascent and mission phases that would require emergency return of the orbiter and its crew.

Types of Unscheduled Landings

The Transoceanic Abort Landing (TAL) is one mode of an unscheduled landing. The orbiter could have to make an unscheduled landing if one or more of its three main engines failed during ascent into orbit, or if a failure of a major orbiter system, such as the cooling or cabin pressurization systems, precluded satisfactory continuation of the mission.

Several unscheduled landing scenarios are possible, with available abort modes that include Return to Launch Site, Launch Abort Site landing, Transoceanic Abort Landing (TAL), Abort Once Around, and Abort to Orbit. The abort mode would depend on when in the ascent phase an abort became necessary.

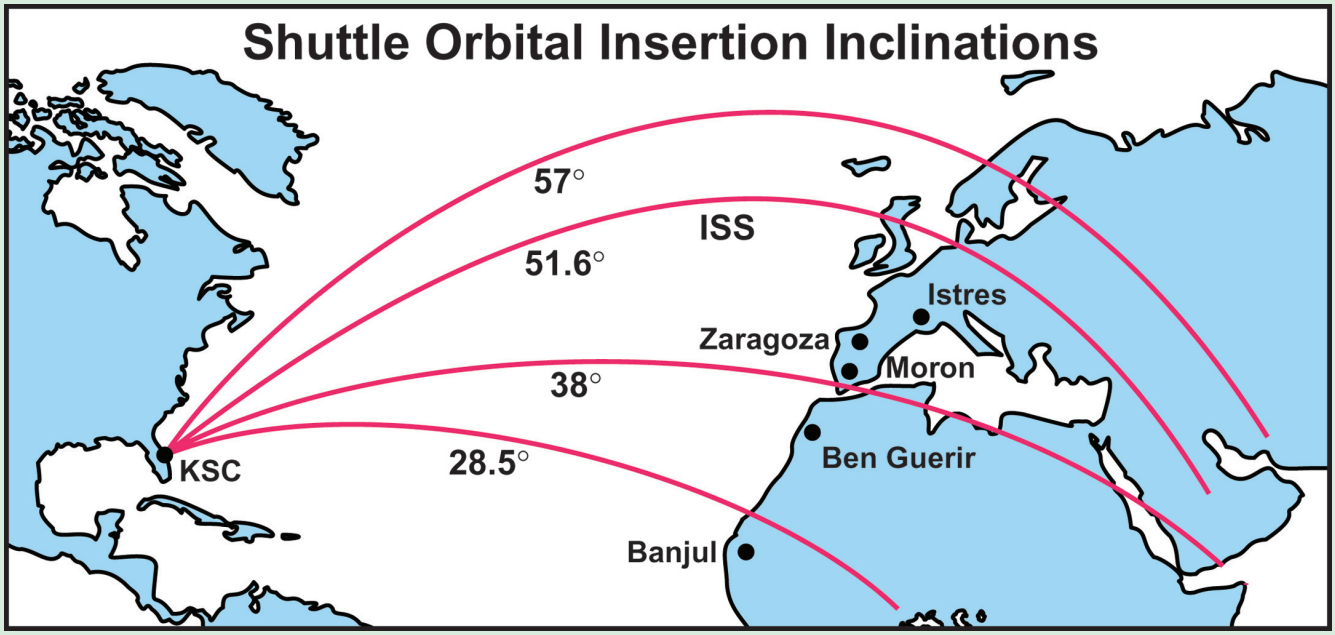
The TAL abort mode was developed to improve the options available if failure occurred after the last opportunity for a safe Return To Launch Site or Launch Abort Site landing, but before the Abort Once Around option became available. A TAL would be declared between roughly T+ 2:30 minutes (liftoff plus 2 minutes, 30 seconds) and T+ 7:30 minutes. Main engine cutoff occurs about T+ 8:30 minutes into flight, with the exact time depending on the payload and mission profile.

A TAL would be made at one of three designated sites: Istres Air Base in France, Zaragoza Air Base in Spain and Moron Air Base in Spain.

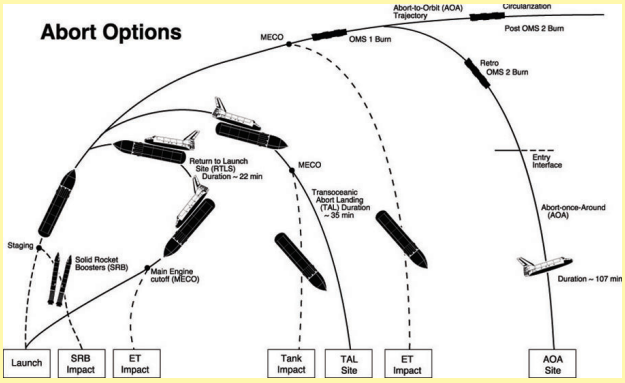
Each TAL site is covered by a separate international agreement. The TAL sites are referred to as augmented sites because they are equipped with space shuttle-unique landing aids and are staffed with NASA, contractor and Department of Defense personnel during a launch and contingency landing.

Space shuttles are launched eastward over the Atlantic Ocean from Kennedy Space Center in Florida for insertion into low- to high-inclination orbits. Depending on mission requirements, an orbiter follows an orbital insertion inclination between 28.5 degrees (low) and 57.0 degrees (high) to the equator. All space shuttle launches to the International Space Station use an inclination of 51.6 degrees. The lower inclination launches allowed for a higher maximum payload weight but are no longer used.

High- or low-inclination launches require different contingency landing sites, with two or three of the landing sites staffed to ensure there is acceptable weather for a safe landing at a TAL site.



A shuttle liftoff at 57 degrees inclination to the equator is considered high inclination, 38 to 45 degrees is mid-inclination, and 28.5 degrees is low-inclination. TAL sites are selected depending on launch inclination. All flights to the International Space Station are launched on a 51.6-degree inclination.



The abort scenario would depend on which point in the liftoff sequence the contingency occurs. Duration refers to the approximate time from liftoff to touchdown.

During a TAL abort, the orbiter continues on a trajectory across the Atlantic to a predetermined runway at one of the TAL sites. The three sites NASA designated as TAL sites were chosen in part because they are near the nominal ascent ground track of the orbiter, which would allow the most efficient use of main engine propellant and cross-range steering capability.

Moron Air Base, Spain

Moron Air Base is a joint-use U.S. and Spanish Air Force Base and was designated a TAL site in 1984. Moron Air Base serves as a weather alternate for low-, mid- and high-inclination launches.

Moron AB is located about 35 miles southeast of Seville and 75 miles northeast of Naval Station Rota. Although Moron is close to the foothills of the Sierra de Ronda mountain chain, most of the surrounding countryside is flat with a few hills and shallow valleys. Elevations vary from 200 to 400 feet above sea level. The weather is generally good with no associated unusual weather phenomena.

The Moron AB runway is 11,800 feet long by 200 feet wide with 50-foot asphalt-stabilized shoulders and 1,000-foot overruns. The runway is equipped with space shuttle-unique visual landing aids, a Microwave Landing System (MLS), a Tactical Air Control and Navigation (TACAN) system and a remote weather tower.

Communications at Moron include three INMARSAT satellite circuits, U.S. Defense Communication Net lines and Spanish commercial telephone lines. Internet capability is available through the base's Large Area Network.

Zaragoza Air Base, Spain

Zaragoza AB was designated a TAL site in 1983 and is the primary TAL site for high-inclination launches. Until the U.S. Air Force pulled out in 1992, it was a joint-use base with a NATO-instrumented bombing range nearby. Today the Zaragoza Spanish Air Force retains the base's status as a TAL site through cooperative agreements between the U.S. government (NASA) and the government of Spain, and between the U.S. Department of Defense (DOD) and the Spanish Ministry of Defense.

Located northwest of the town of Zaragoza, the base has two parallel runways. The civilian airport runway, designated 30R, is 9,923 feet long by 197 feet wide. The Spanish Air Force runway, or space shuttle runway, designated Runway 30L, is 12,109 feet long by 197 feet wide and has 1,000-foot overruns. It is equipped with space shuttle-unique visual landing aids and an MLS, a TACAN system and a remote weather tower.

Through the agreement negotiated between the U.S. and Spanish militaries, NASA has retained the sole use of a hangar complex that is used as the operations and storage building. A building operations and maintenance contractor, with a contract administered out of Moron AB, is permanently stationed at Zaragoza to maintain the NASA/DOD complex and associated ground-support equipment.

Communications at Zaragoza include three INMARSAT satellite circuits and Spanish commercial telephone lines. Internet capability is available through a local Internet service provider.

Istres Air Base, France

Istres AB (known to the French as Base Aerienne 125 or BA-125) was activated during return-to-flight preparations to provide another high inclination site. It is located just outside of the town of Istres in the south of France, approximately 30 miles west of Marseille. The town of Istres, with about 40,000 inhabitants, is situated on the edge of Berre Lake. It is bordered on the south and east by major petrochemical and other heavy industry plants, and on the north and west by small and medium-sized towns, including Aix-en-Provence, Arles, Avignon, Martigues, Salon-de-Provence, Fos-sur-Mer and Marignane.

The Istres area is heavily influenced by its proximity to the major port city of Marseille, the second-largest city in France with a population of around 800,000 inhabitants. Istres AB is a major employer in the local area, with both active French Air Force (FAF) units and French civilian aviation companies

located there. The current base population consists of approximately 5,500 military and civilian personnel. The FAF presence includes an air-refueling squadron and a strategic bomber squadron. Istres AB is essentially the equivalent of Edwards AFB, Calif., as the FAF Flight Test Center. The base infrastructure includes those units and activities found on any major air force base.

Istres AB has a single runway oriented in a northwest to southeast direction. It is 197 feet wide with 25-foot shoulders, and is equipped with space shuttle-unique landing aids allowing for landings in the northwest direction only. Runway 33 is the primary runway and is 11,303 feet long with a 1,377-foot underrun and a 3,963-foot load-bearing overrun, for a total usable runway of 15,266 feet. The shuttle-unique landing aids consist of visual landing aids, an MLS, a TACAN system and a remote weather tower. Communications include three INMARSAT satellite circuits and French commercial telephone lines. Internet capability is available through a local Internet service provider.

Banjul, the Gambia

Banjul International Airport in the Republic of the Gambia, West Africa, was the primary TAL site for 28.5-degree, low-inclination launches because of its in-plane location. It was activated in July 1988, replacing a TAL site at Dakar, Senegal, that NASA concluded was unsatisfactory due to runway deficiencies and geographic hazards. Banjul was used for 28 of 36 low-inclination launches before being closed in November 2002.

Ben Guerir, Morocco

The Ben Guerir Air Base in Morocco was used for most of the launches as a weather alternate TAL site because of its geographic location and its landing support facilities. Ben Guerir replaced Casablanca, Morocco, which was used as a contingency landing site in January 1986. Ben Guerir was designated as a TAL site in July 1988 and was last used for STS-111 in June 2002. Ben Guerir is in the process of being closed after supporting 83 missions.

Shuttle Support Equipment at TAL Sites

NASA has enhanced each of the TAL sites with space shuttle-unique landing aids and equipment to support an orbiter landing and turnaround operation. Some of the specific equipment and systems that are installed include the following:

Navigation and Landing Aids

Three navigation aids are used during entry and landing. Beginning at approximately 8 miles from the TAL runway, the Microwave Scanning Beam Landing System or Microwave Landing System will provide highly accurate three-dimensional position information to the orbiter to compute steering commands to maintain the spacecraft on the nominal flight trajectory during the landing phase.

Precision Approach Path Indicator (**PAPI**) lights are used by the orbiter crew to verify outer glide slope during a landing. Two sets of PAPI lights are used to accommodate high-wind and low-wind scenarios. High-wind PAPI lights are located 6,500 feet prior to the threshold on an extended centerline of the runway, and the low-wind PAPI lights are located 7,500 feet prior to the threshold on the centerline.

Ball/bar lights are used by the space shuttle astronauts to verify the proper inner glide slope during landing. The ball/bar lights are installed along the runway on the left, which is the commander's side of the orbiter. The ball light is located 1,700 feet down the runway from the threshold with the bar light at 2,200 feet. Superimposing the ball light on the bar lights places the orbiter on a 1.5-degree glide slope and enables the orbiter crew to touch down approximately 2,500 feet down the runway.

Distance-to-go markers display to the crew the distance remaining to the end of the runway during landing and rollout. These markers are installed on the left side of the runway, 1,000 feet apart, starting from the threshold and counting down to the overrun.

Xenon lights are high-intensity flood lights that provide runway lighting for night landings at the TAL sites. Each light provides 1 billion candle power each. A set of three lights is installed on raised platform trucks on each side of the runway

at the beginning of the underrun, shining down the runway to provide illumination of the entire touchdown area.

Portable approach lights (flashlights) are required for night landings at Istres and Zaragoza because no approach light systems are installed on the space shuttle runway approach paths. The flashlights are placed in a predetermined pattern on the underrun and along a 3,000-foot extension of the runway centerline to give a lighted visual reference of the approach path to the runway.

The PAPI lights, Xenon lights and portable approach lights are installed prior to each space shuttle launch, dismantled after the TAL site is released from support, and stored until required for the next mission.

Weather Equipment

Each TAL site has an automated weather station or tower that collects and transmits weather data every four hours, 365 days a year, via satellite to the Spaceflight Meteorology Group (SMG) at Johnson Space Center in Houston. Responsibility for weather forecasting for the space shuttle program rests with the SMG.

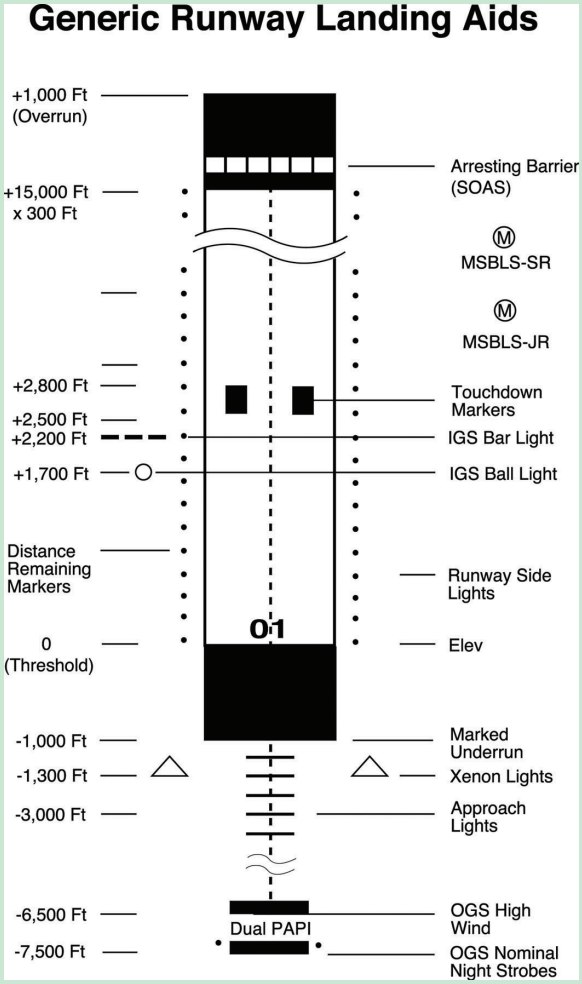
The DOD deploys U.S. Air Force or Navy weather personnel to the TAL sites to provide real-time weather observations from launch minus 48 hours to launch plus 30 minutes. These personnel act as the SMG weather point of contact on site and provide hourly weather observations to the SMG to assist in accurately forecasting weather conditions at the TAL sites. They also operate the TAL Atmospheric Sounding System (TASS), ceilometers and visibility detectors installed at the sites. Ceilometers measure the cloud ceiling while a visibility detector provides information on the amount of dust in the air.

The TASS automatically tracks weather instruments called "rawindsondes" that are carried aloft by weather balloons to monitor upper winds and other data. This data is transmitted to the SMG via the TAL INMARSAT satellite circuits and/or commercial telephone lines. Flight rules call for at least one TAL site to be in the "go" status for weather, meaning it would be suitable for an orbiter landing, before a space shuttle launch will be made from Kennedy Space Center.

Dedicated Ground-Support Equipment

Dedicated orbiter ground-support equipment has been prepositioned at the TAL sites. This equipment includes a hatch opening tool, tow bar, tow bar adapter, staircase for the crew to disembark from the orbiter, grounding cable, landing gear lock pins, tire chocks, light banks for night operations and many more pieces of equipment for ground support.

Extra tires, brake-removal equipment and a Rhino jack – used for jacking up the orbiter – are prestaged at Moron AB. Since a C-130 is not staged at Moron, this equipment would be moved to the actual TAL landing site by a C-130 aircraft coming from Zaragoza AB, Spain, or Istres, France.



A complement of navigational aids are available to assist the orbiter commander during landing.

Emergency Equipment

Fire, crash and rescue (F/C/R) resources include firefighting equipment and personnel. A team of seven Air Force F/C/R personnel from Europe deploys to the Spanish TAL sites for contingency landing support and is augmented by 18 trained firefighters from the host country. The French Air Force provides both internal rescue and 18 external firefighters for support at Istres.

Aircraft Support

Aircraft support at the TAL sites, and all other DOD support to the space shuttle program, is managed through the DOD's Manned Space Flight support office, located at Patrick Air Force Base, Fla. A C-130 aircraft is deployed to the Zaragoza and/or Istres TAL site two days prior to launch.

The C-130 serves a variety of roles, including search and rescue, medical evacuation and logistics. The TAL site C-130s are equipped with eight crew members, three air-deployable Zodiac rafts, nine pararescue jumpers, two DOD flight surgeons, a nurse and medical technician, and approximately 2,500 pounds of medical equipment.

The TAL sites are also supported by a DOD weather aircraft, either a C-21 (similar to a Learjet) or a C-12 (Beachcraft turboprop). An astronaut flies on this aircraft to provide real-time weather observations for the Spaceflight Meteorology Group and recommend go/no go status to the flight director at Johnson Space Center.

The astronaut is referred to as the TALCOM, the TAL site equivalent of the CAPCOM, or capsule communicator. The CAPCOM is the Mission Control-based astronaut in Houston who serves as the communication liaison with on-orbit space shuttle crews.

TALCOMs are deployed to each of the three TAL sites supporting a launch as the Johnson Flight Crew Operations Directorate representative; at the TAL site, he or she is also designated as the deputy ground operations manager.

The TALCOM is normally airborne from T- 1:30 hours (one hour, 30 minutes before launch) through main engine cutoff. The aircraft's UHF radio is linked to the weather CAPCOM and the Spaceflight Meteorology Group at Mission Control.

The TALCOM also becomes familiar with the surrounding terrain along the approach path to the runway at the TAL site, and his or her observations are duly noted to assist an orbiter commander during a landing. The TALCOM checks out slant-range visibility and intensity settings on the visual landing aids, PAPI and ball/bar lights.

Preparing for a TAL

Seven or eight days prior to a space shuttle launch date, depending on the TAL site, a team of NASA and contractor personnel will depart Kennedy Space Center and begin activating the TAL sites assigned to support the mission. Four to five days are required on site to prepare the TAL site for launch support.

The mission support team is managed by the NASA ground operations manager and includes about 20 contractor personnel. DOD support for NASA and the manager include a deployed forces coordinator and two aircraft with an additional 35 personnel. The majority of the DOD personnel arrive on site 48 hours prior to scheduled liftoff.

If a TAL were declared, the ground operations manager at the TAL site would be notified by the landing support officer in the Mission Control Center at Johnson Space Center that the space shuttle was aborting to the emergency landing site. The landing support officer would begin coordination to clear the upper air space with the Federal Aviation Administration and the International Civil Aviation Organization. The U.S. State Department would notify the American embassy in the country involved.

The time from declaration of a TAL abort to a landing is estimated at approximately 25-30 minutes. Once the space shuttle crew commander selects the TAL option, the preprogrammed onboard orbiter computers would automatically steer the craft toward the designated landing site. The orbiter would roll heads up before main engine cutoff and all extra fuel would be dumped to increase vehicle performance by decreasing weight and reducing the toxic environment in and around the orbiter after a landing.

The space shuttle would be flown to an altitude of about 350,000 feet and the main engines would cut off at the correct velocity. The external tank would be jettisoned after main engine cutoff, as in a normal launch, and tumbled to ensure that it burns up on re-entry into the Earth's atmosphere.

A preloaded re-entry program would then go into effect, with the orbiter encountering the atmosphere and a normal re-entry planned. Ten minutes before landing, communications would resume through the Tracking and Data Relay Satellite network, used for orbiter/Mission Control contact.

The landing support officer and flight director in the Mission Control center would keep the ground operations manager and the TAL site informed of the status of the orbiter systems during the approach to the TAL site. Data received from the TAL site TACAN would be used to update the orbiter's inertial guidance system 200 miles from touchdown as the spacecraft slowed to Mach 7 (seven times the speed of sound).

At landing minus six minutes, the orbiter would enter what is referred to as the terminal area. At this point, its altitude is still quite high (82,000 feet) and its speed still supersonic at Mach 2.5. Its flight would be akin to a conventional aircraft's except

that the orbiter's speed brakes would be left open to provide greater stability during supersonic flight.

Approximately five minutes before touchdown, the orbiter's speed would be approximately Mach 1. About four minutes before touchdown, the commander would take over manual control of the spacecraft. This would be just prior to a maneuver known as intercepting the Heading Alignment Circle.

The Heading Alignment Circle is a large turn to align the orbiter with the centerline of the runway and to allow the commander to bleed off or reduce any excess speed the vehicle may have. At landing minus two minutes, the orbiter would enter its final approach at an altitude of 13,000 feet. The speed brakes would be closed at an altitude of 3,000 feet.

At an altitude of 1,800 feet and a distance of 7,500 feet from the threshold of the runway, the commander would begin a preflare maneuver to pull up from a glide slope of 19 degrees to a gentler one of 1.5 degrees. Touchdown normally would occur at a speed of about 200 miles per hour.

A typical power-down would be completed before the crew members exited the orbiter, much the same as in a normal end-of-mission landing. At a TAL site, this would take approximately 30 minutes to accomplish.

At about T+ 3 hours (touchdown plus three hours), the crew members would depart the TAL site onboard the C-130 aircraft en route to the hospital at Naval Station Rota, Spain (if uninjured or with minor injuries), where they would be met by the crew-return aircraft from Johnson Space Center for their return to the United States.

If there were severely injured crew members, they would be medevaced on the C-130 aircraft or taken by ambulance to identified critical care medical facilities in Europe. The crew would remain together, escorted by security forces, unless medical circumstances or aircraft availability dictated otherwise.

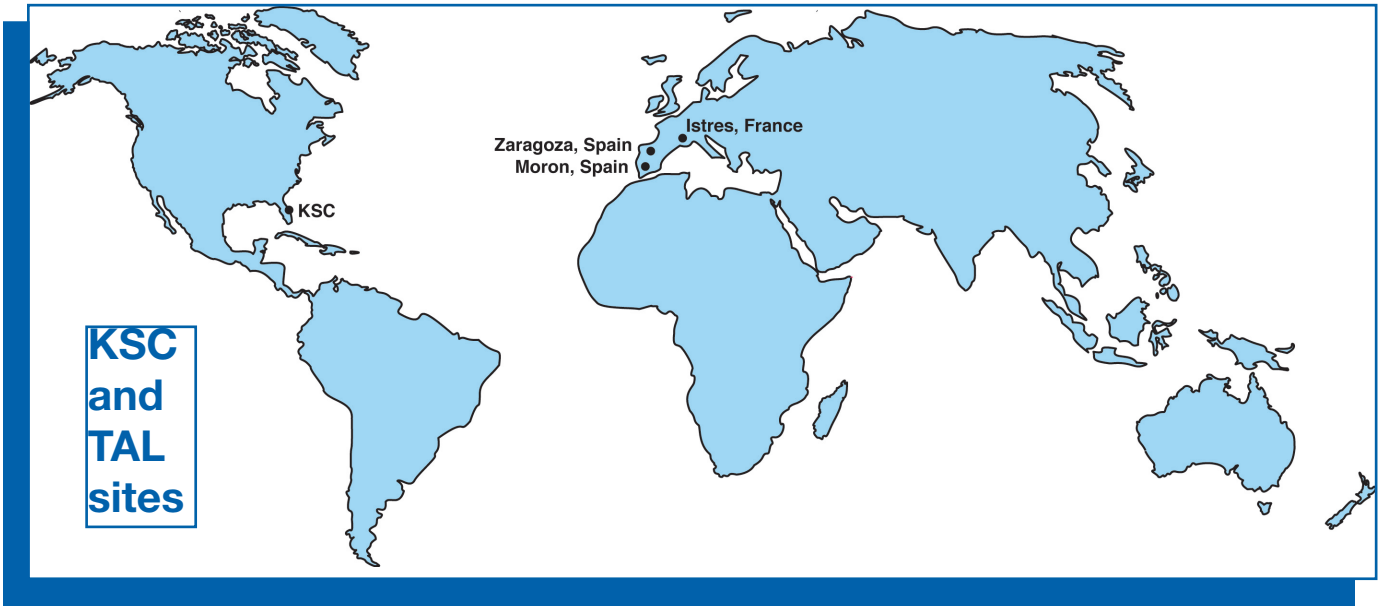
Post-Landing Operations

Once the crew exited the orbiter, and the recovery management team at Kennedy Space Center granted permission, the crew hatch would be closed and the orbiter prepared for towing to a remote deservicing area or park site. Safing and deservicing of the orbiter would be initiated by the deployed TAL team and augmented by a team known as the Rapid Response Team.

A Mishap Investigation Team may also travel to the TAL site to collect data and conduct a mishap investigation on the unscheduled landing. The TAL site ground operations manager would initially be in charge until relieved by a higher-ranking management official who would arrive on the response/investigation team aircraft.

Within 24 hours, the response/investigation teams would arrive at the TAL site aboard C-17 aircraft carrying personnel and equipment. Most of the equipment would come from Kennedy Space Center and Dryden Flight Research Center in California.

Following the advance response/investigation teams contingent, the Deployed Operations Team, consisting of additional personnel and equipment, would begin arriving at the TAL site for the orbiter turnaround operation. NASA estimates it would take about 19 C-17/C-5 aircraft sorties, a significant Navy sealift operation, and 450 NASA and contractor personnel to complete the turnaround.



Not all of these personnel would be on site at any one time.

In addition to these personnel, another 150 to 200 DOD personnel may be required to put in place a "bare-base" operation consisting of portable general-purpose shelters, latrines, a kitchen, aircraft hangars and other support equipment if the TAL site does not have adequate facilities to support such a large team.

Payloads and/or airborne support equipment will remain onboard the orbiter for the flight back to Kennedy Space Center unless the capability of the shuttle carrier aircraft, landing site location or other requirements dictate otherwise.

Kennedy Space Center, home of the space shuttle, is making the Vision for Space Exploration a reality.

More information about the space shuttle program can be found online at the Web site:
http://www-pao.ksc.nasa.gov/kscpao/nasafact/docs.

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