NASA Facts

National Aeronautics and
Space Administration

John F. Kennedy Space Center
Kennedy Space Center, Florida 32899
AC 321-867-2468

KSC Release No. FS-2001-05-012-KSC

Space Shuttle Transoceanic Abort Landing (TAL) Sites

Planning for each Space Shuttle mission includes provisions for an unscheduled landing at contingency landing sites in the U.S. 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. The Transoceanic Abort Landing (TAL) is one mode of an unscheduled landing. The orbiter would 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 abort modes available that include: Return to Launch Site (RTLS); East Coast Abort Landing (ECAL) Site; Transoceanic Abort Landing (TAL); Abort Once Around (AOA); and Abort to Orbit (ATO). 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 (RTLS) or East Coast Abort Landing (ECAL), but before the Abort Once Around (AOA) option became available. A TAL would be declared between roughly T+ 2:30 minutes (liftoff plus 2 minutes, 30 seconds) and Main Engine Cutoff, 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 four designated sites, two in Africa and two in Spain: Ben Guerir Air Base, Morocco; Banjul International Airport, The Gambia; Zaragoza Air Base, Spain, and Moron Air Base, 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 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 KSC for insertion into equatorial 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. The lower inclination launch allows for a higher maximum payload weight.

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

During a TAL abort, the orbiter continues on a trajectory across the Atlantic to a predetermined runway at one of the TAL sites. The four sites NASA has designated as TAL sites have been 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.

Ben Guerir, Morocco

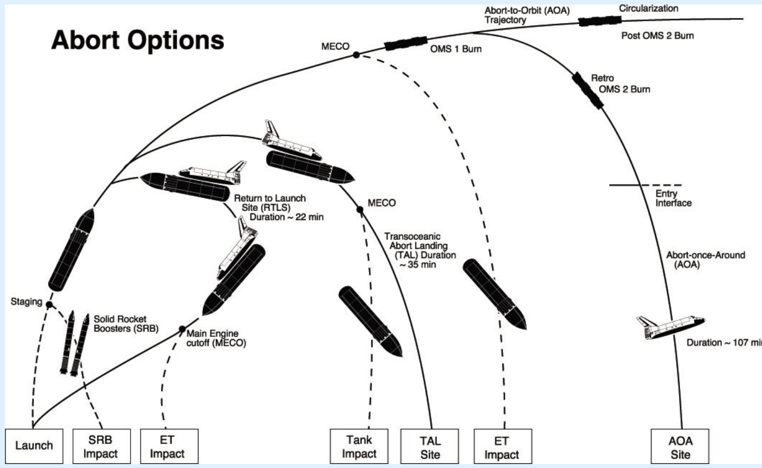
The Ben Guerir Air Base in Morocco is used for all inclination launches as a weather alternate TAL site because of its geographic location and its landing support facilities. Ben Guerir replaced Casablanca, Morocco, which was last used as a contingency landing site in January 1986. Ben Guerir was designated as a TAL site in September of the same year.

Morocco is located along the northwest coast of Africa, between 27 degrees and 37 degrees north. It is shielded from the Sahara desert of northern Africa by the Atlas Mountains on the eastern border of the country. A cool ocean current runs along the west coast, similar to the situation in southern California, which makes the coastal areas subject to low clouds and fog most of the year. The interior sections of the country are generally arid with most precipitation occurring from November to April and concentrated in the north.

Ben Guerir Air Base is located on a flat, rocky, desert plain about 36 miles north of Marrakech and is a former Strategic Air Command Base abandoned in 1962. It has one runway, oriented in a north-south direction, which is 200 feet wide with 25-foot shoulders, and is equipped with Shuttle-unique landing aids allowing for landings in both directions. Runway 18 is 12,720 feet long with a 1,000-foot underrun/overrun, while Runway 36, which is the primary runway, is 13,720 feet long with a 1,000-foot underrun and a 2,500-foot compacted dirt overrun for a total of 15,720 feet.

NASA completed a construction project in 1988 that rejuvenated the runway, added Shuttle-unique visual landing aids and a Microwave Landing System, a Tactical Air Control and Navigation system, two remote weather towers, and put in place utility and personnel transport vehicles, four fire trucks, and two ambulances. An operations and storage building was also constructed along with a tower to house the satellite communications systems and other antennas. A major project is in work to apply a sealer to the asphalt surface of the runway to help preserve and protect the surface.

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



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

Banjul, The Gambia

Banjul International Airport (formerly Yundum Airport) is normally the primary TAL site for 28.5-degree (low) inclination launches because of its in-plane location. It was selected in September 1987, replacing a TAL site at Dakar, Senegal, that NASA concluded was unsatisfactory due to runway deficiencies and geographic hazards.

The Republic of The Gambia is a former British Colony that gained independence in February 1965. The Gambia, the oldest English-speaking country in West Africa, is surrounded on all sides except its seaboard by Senegal. It reaches 300 miles inland, but is never wider than 15 miles on either side of the Gambia River. Ocean-going vessels can navigate as far up as Kuntaur, 150 miles inland. The international airport, located adjacent to the countryís capital, Banjul, is located on a flat plain 7 miles inland from the Atlantic and 6 miles south of the Gambia River. The Gambia has a dry season that extends from November to May, during which weather conditions are generally good, with the only difficulty being lowered runway visibility due to airborne dust.

NASA has completed four phases of construction projects at Banjul International Airport. These include improvements to the runway, adding of Shuttle-unique visual landing aids and a Microwave Landing System, a Tactical Air Control and Navigation system and a Shuttle Orbiter Arresting System or barrier net located in the overrun of the runway.

Also included are a remote weather tower, operations and storage buildings, an orbiter de-service and turnaround pad, and utility and personnel transport vehicles. The airport lies almost directly below the 28.5-degree flight path, hence its designation as an in-plane contingency landing site.

After extending the existing overruns to 1,000 feet, the site was declared a full-up TAL site in April 1990. The runway is 11,811 feet long by 150 feet wide with 25-foot paved shoulders.

Communications include three INMARSAT satellite circuits and Gambian commercial telephone lines. Internet capability is available through GAMTEL, the local telephone company. Other communications options are available through the American Embassy located nearby.

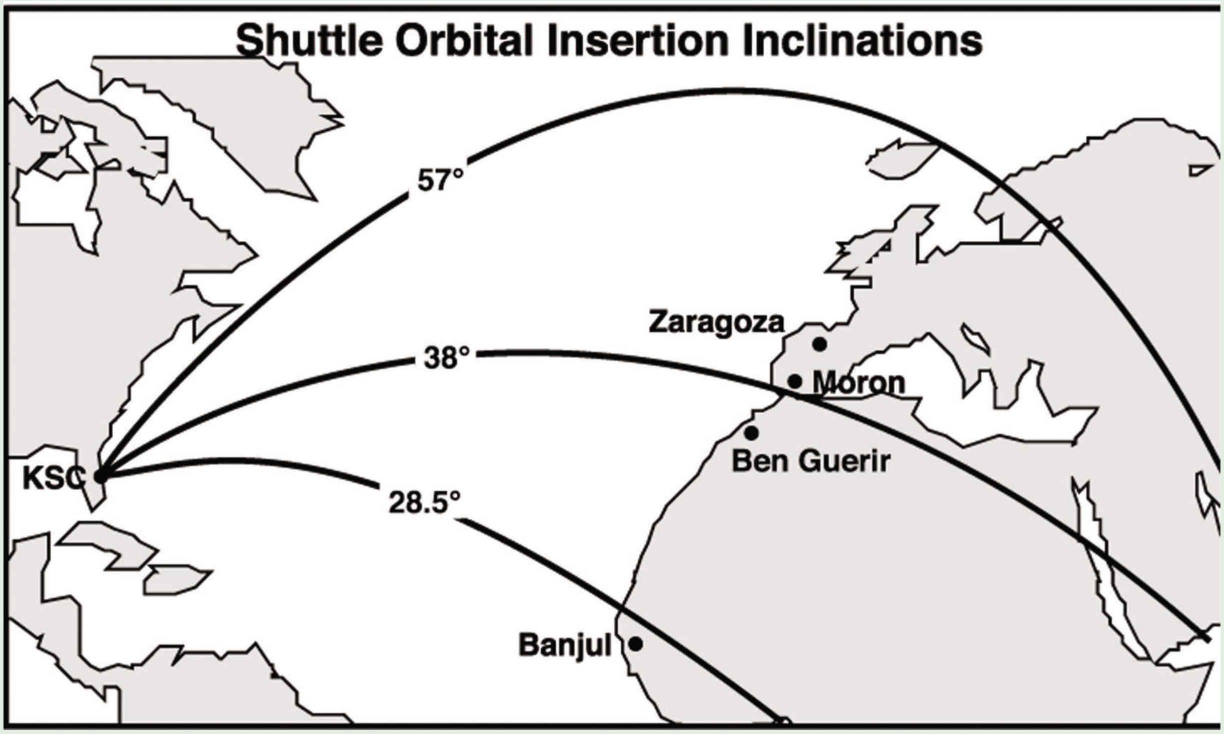
Moron Air Base, Spain

Moron Air Base is a joint-use U.S. Air Force and Spanish Air Force Base and was designated a TAL site in 1984. Moron Air Base serves as a weather alternate for both low- 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 has an 11,800-by-200-foot runway with 1,000-foot overruns and 50-foot asphalt-stabilized shoulders. The runway is equipped with Shuttle-unique visual landing aids and a Microwave Landing System, a Tactical Air Control and Navigation system, a remote weather tower and a Shuttle Orbiter Arresting System.

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



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.

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, the base was a joint-use base with a NATO-instrumented bombing range nearby. Today the Zaragoza Spanish Air Force retains its 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 Shuttle runway, designated Runway 30L, is 12,109 feet by 197 feet and has 1,000-foot overruns. It is equipped with Shuttle-unique visual landing aids and a Microwave Landing System, a Tactical Air Control and Navigation system, a remote weather tower and a Shuttle Orbiter Arresting System or barrier net, located in the overrun of the runway.

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.

Shuttle Support Equipment at TAL Sites

NASA has enhanced each of the four TAL sites with 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 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 commanderís 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.

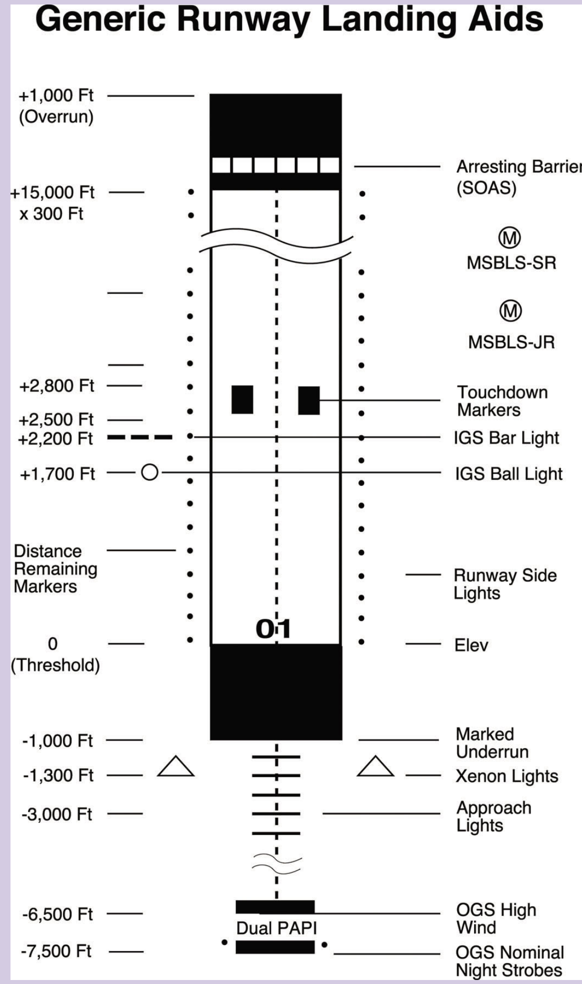
Xenon lights are high-intensity flood lights that provide runway lighting for night landings at the TAL sites. Each light provides 1 billion candle power each. A set of three lights are installed on raised platform trucks on each side of the runway at the beginning of the underrun, shining down the runway to provide illumination of the entire touchdown area.

Portable approach lights (flashlights) are required for night landings at Ben Guerir and Zaragoza because no approach light systems are installed on the runway approach paths. The flashlights are placed in a pre-determined 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 Shuttle launch and 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 Shuttle program rests with the SMG.



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

The DOD deploys U.S. Air Force and U.S. 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 also operate the Radio Automatic Theodolite System (RATS), 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 RATS 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.

The weather personnel also provide hourly weather observations to the SMG to assist in accurately forecasting weather conditions at the TAL sites.

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 Shuttle launch will be made from Kennedy Space Center in Florida.

Shuttle Orbiter Arresting System

Three of the TAL sites, Banjul, Moron and Zaragoza, are equipped with the Shuttle Orbiter Arresting System (SOAS), which is a barrier net system installed across the runway in the overrun. The system is designed to stop the orbiter within a distance of 800 feet with minimal, if any, damage to the orbiter.

The SOAS is a self-contained system that can be installed in approximately eight hours by a crew of eight and dismantled and stored at the end of launch support.

The system consists of the net elements, two hydraulic stanchions to raise and support the net, and two energy absorbers that provide resistance to bring the orbiter to a safe stop. Once installed, the net lies flat on the runway until raised into position when a landing has been declared.

Dedicated Ground Support Equipment

Dedicated orbiter ground support equipment has also been pre-positioned at the TAL sites.

This equipment includes a hatch opening tool, landing gear lock pins, grounding cable, tire chocks, tow bar, tow bar adapter, staircase for the crew to disembark from the orbiter, 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 pre-staged at Moron AB. This equipment would be moved to the TAL landing site by a C-130 aircraft coming from Zaragoza AB or Ben Guerir, Morocco.

Emergency Equipment

Fire, crash and rescue (F/C/R) resources include fire-fighting equipment and personnel. A team of seven Air Force F/C/R personnel from Europe deploys to the Spanish and Banjul TAL sites for contingency landing support and are augmented by 18 trained firefighters from the host country.

Seven contractor F/C/R personnel from KSC deploy to Ben Guerir for contingency landing support and are augmented by 18 Moroccan firefighters.

Dedicated NASA fire trucks and equipment are permanently stored and maintained at Ben Guerir, while at Banjul, Moron AB and Zaragoza AB, the local airport fire-fighting equipment is available.

Aircraft Support

Aircraft support at the TAL sites, and all other Department of Defense (DOD) support to the Shuttle Program, is managed through the Department of Defense Manned Space Flight support Office, located at Patrick Air Force Base, Fla. A C-130 aircraft is deployed to the Zaragoza and Ben Guerir TAL sites 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 and recommendations back to the Spaceflight Meteorology Group (SMG) at Johnson Space Center.

The astronaut is referred to as the TALCOM, the TAL site equivalent of the CAPCOM, or capsule communicator, the Mission Control-based astronaut in Houston who serves as the liaison with on-orbit 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 to provide airborne, real-time weather observations to the SMG at Johnson Space Center. The aircraftís UHF radio is linked to the Weather CAPCOM and SMG 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 Shuttle launch date, depending on the TAL site, a team of NASA and contractor personnel will depart KSC and begin activating the TAL sites assigned to support the mission. Four to five days are required onsite to prepare the TAL site for launch support.

The mission support team is managed by the NASA Ground Operations Manager (GOM) and includes about 20 contractor personnel. Department of Defense support for NASA and the GOM include two aircraft with an additional 35 personnel, the majority of which arrive onsite 48 hours prior to scheduled liftoff.

If a TAL were declared, the GOM at the TAL site would be notified by the Landing Support Officer (LSO) in the Mission Control Center (MCC) at Johnson Space Center that the Shuttle was aborting to the emergency landing site. The LSO 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 about 25-30 minutes. Once the Shuttle crew commander selects the TAL option, the pre-programmed 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 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 reentry into the Earthís atmosphere.

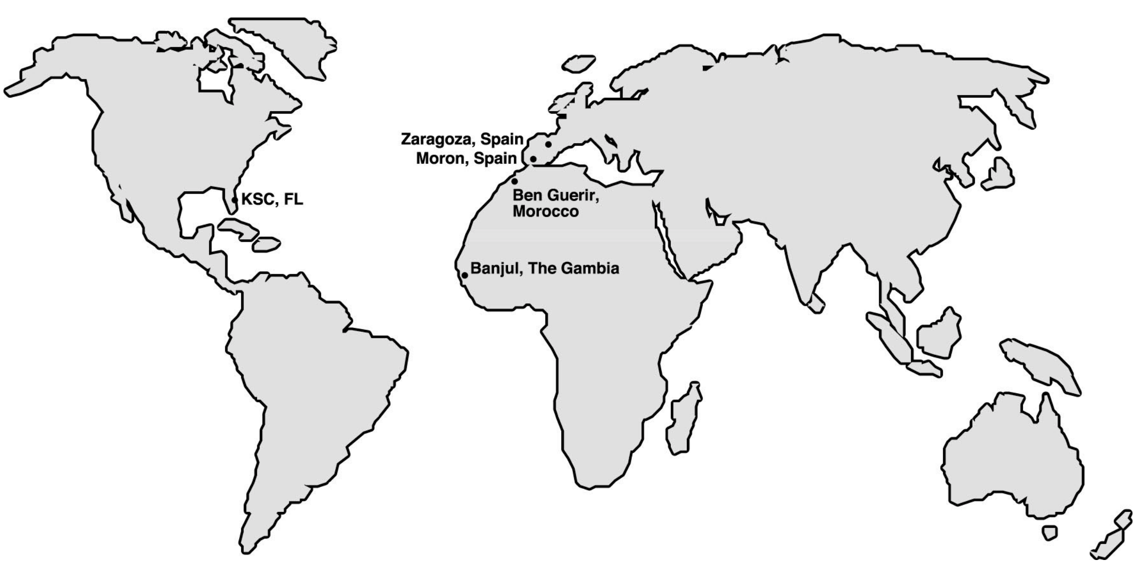
A pre-loaded reentry program would then go into effect, with the orbiter encountering the atmosphere and a normal reentry planned. Ten minutes before landing, communications would resume through the Tracking and Data Relay Satellite network, used for orbiter/Mission Control contact.

The LSO and Flight Director in the MCC would keep the GOM 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 orbiterís 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, at 82,000 feet, and its speed still supersonic at Mach 2.5. Its flight would be akin to a conventional aircraftís except that the orbiterís speed brakes would be left open to provide greater stability during supersonic flight.

Approximately five minutes before touchdown,

KSC and TAL sites



the orbiterís speed would be about Mach 1. About four minutes before touchdown, the crew commander would take over manual control of the spacecraft. This would be just prior to a maneuver known as intercepting the Heading Alignment Circle (HAC).

The HAC is a large turn to align the orbiter with the centerline of the runway and to allow the commander to 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 speedbrakes 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 pre-flare 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 300 knots (230 miles) per hour.

A typical powerdown would be completed before the crew exited the orbiter, much the same as at 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 would depart the TAL site onboard the C-130 aircraft enroute to the hospital at Naval Station Rota, Spain (if uninjured or only minor injuries), where they would be met by the crew-return aircraft from JSC 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 members would remain together unless medical circumstances or aircraft availability dictated otherwise.

Post-Landing Operations

Once the crew has exited the orbiter, and the Recovery Management Team at KSC has granted permission, the crew hatch will be closed and the orbiter prepared for towing to a remote de-servicing area or park site.

Safing and de-servicing of the orbiter would be initiated by the deployed TAL team and augmented by a team known as the Rapid Response Team (RRT). A Mishap Investigation Team (MIT) may also travel to the TAL site to collect data and conduct a mishap investigation on the unscheduled landing.

The RRT/MIT would arrive at the TAL site aboard C-141 or C-17 aircraft within 24 hours carrying personnel and equipment. Most of the equipment would be coming from Kennedy Space Center, Fla., and Dryden Flight Research Center, Calif.

Following the advance RRT/MIT 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 six C-17 and 13 C-5 aircraft sorties 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 on site to put in place a ìBare Baseî operation consisting of general purpose shelters, latrines, kitchen, aircraft hangars and other support equipment if the TAL site does not have adequate facilities to support such a large team. The Bare Base operation would definitely be deployed to the African sites and to a lesser extent to the Spanish sites.

Some of the equipment also would go by sea-lift to the TAL site. The TAL site Ground Operations Manager would initially be in charge until relieved by a more senior management official who would arrive on the RRT/MIT aircraft.

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.

Find more NASA Facts on the Web at:

http://www-pao.ksc.nasa.gov/kscpao/nasafact/docs.htm

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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FS-2000-05-012-KSC