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Stages of a Space Flight -In Reference to the Space Shuttle Columbia

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Abstract

In its nearly 30-year history, the space shuttle program has seen exhilarating highs and devastating lows. The fleet has taken astronauts on dozens of successful missions-, resulting in immeasurable scientific gains. But this success has had a serious cost. In 1986, the Challenger exploded during launch. In 2003, the Columbia broke up during re-entry over Texas. Since the Columbia accident, the shuttles have been grounded pending redesigns to improve their safety. The 2005 shuttle Discovery was supposed to initiate the return to flight, but a large piece of insulating foam broke free from its external fuel tank, leaving scientists to solve the mystery and the program grounded once more until July 2006, when the Discovery and Atlantis both carried out successful missions.

1. Introduction

The Space Shuttle is the world's first reusable spacecraft, and the first spacecraft in history that can carry large satellites both to and from orbit. The Shuttle launches like a rocket, manoeuvres in Earth orbit like a spacecraft and lands like an airplane. Each of the three Space Shuttle orbiters now in operation - Discovery, Atlantis and Endeavour, is designed to fly at least 100 missions. So far, altogether they have flown a combined total of less than one-fourth of that.

Columbia was the first Space Shuttle orbiter to be delivered to NASA's Kennedy Space Centre, in March 1979. Columbia and the STS-107 crew were lost Feb. 1, 2003, during re-entry. The Orbiter Challenger was delivered to KSC in July 1982 and was destroyed in an explosion during ascent in January 1986. Discovery was delivered in November 1983. Atlantis was delivered in April 1985. Endeavour was built as a replacement following the Challenger accident and was delivered to Florida in May 1991. An early Space Shuttle Orbiter, the Enterprise, never flew in space but was used

for approach and landing tests at the Dryden Flight Research Centre and several launch pad studies in the late 1970s. The space shuttle consists of the following major components:

a) Two solid rocket boosters (SRB) - critical for the launch
b) External fuel tank (ET) - carries fuel for the launch
c) Orbiter - carries astronauts and payload

2. Typical Shuttle Mission

2.1 Launching the Space Shuttle

To lift the 4.5 million pound (2.05 million kg) shuttle from the pad to orbit (115 to 400 miles/185 to 643 km) above the Earth. The SRBs are solid rockets that provide most of the main force or thrust (71 percent) needed to lift the space shuttle off the launch pad. In addition, the SRBs support the entire weight of the space shuttle orbiter and fuel tank on the launch pad.

2.2 Solid Rocket Booster Separation

The Solid Rocket Boosters (SRBs) operate in parallel with the main engines for the first two minutes of flight to provide the additional thrust needed for the Orbiter to escape the gravitational pull of the Earth. At an altitude of approximately 45 km (24 nautical miles), the boosters separate from the orbiter/external tank, descend on parachutes, and land in the Atlantic Ocean. They are recovered by ships, returned to land, and refurbished for reuse. The boosters also assist in guiding the entire vehicle during initial ascent. Thrust of both boosters is equal to 5,300,000 lbs.

2.3 Fuel Tank Separation

The tank is also the "backbone" of the Shuttle during the launch, providing structural support for attachment with the solid rocket boosters and orbiter. The tank is the only component of the Space Shuttle that is not reused. Approximately 8.5 minutes into the flight, with its propellant used, the tank is jettisoned.

When the Solid Rocket Boosters separate at an altitude of approximately 45 kilometres (28 miles), the orbiter, with the main engines still burning, carries the external tank piggyback to near orbital velocity, approximately 113 kilometres (70 miles) above the Earth. The now nearly empty tank separates and falls in a pre-planned trajectory with the majority of it disintegrating in the atmosphere and the rest falling into the ocean.

The three main components of the External Tank are an oxygen tank, located in the forward position, an aft-positioned hydrogen tank, and a collar-like inter-tank, which connects the two propellant tanks, houses instrumentation and processing equipment, and provides the attachment structure for the forward end of the solid rocket boosters.

2.4 Into Orbit

Once in space, the shuttle orbiter is your home for seven to 14 days. The orbiter can be oriented so that the cargo bay doors face toward the Earth or away from the Earth

depending upon the mission objectives; in fact, the orientation can be changed throughout the mission. One of the first things that the commander will do is to open the cargo bay doors to cool the orbiter.

2.5 Re-entry into Earth's orbit

In most cases, they have been flying nose-first and upside down, so they then fire the RCS thrusters to turn the orbiter tail first. Once the orbiter is tail first, the crew fires the OMS engines to slow the orbiter down and fall back to Earth; it will take about 25 minutes before the shuttle reaches the upper atmosphere. During that time, the crew fires the RCS thrusters to pitch the orbiter over so that the bottom of the orbiter faces the atmosphere (about 40 degrees) and they are moving nose first again. Finally, they burn leftover fuel from the forward RCS as a safety precaution because this area encounters the highest heat of re-entry.

Because it is moving at about 17,000 mph (28,000 km/h), the orbiter hits air molecules and builds up heat from friction (approximately 3000 degrees F, or 1650 degrees C). The orbiter is covered with ceramic insulating materials designed to protect it from this heat.

2.6 Shuttle flight path for landing

When the orbiter is 2,000 feet (610 metres) above the ground, the commander pulls up the nose to slow the rate of descent. A parachute is deployed from the back to help stop the orbiter. The orbiter stops about midway to three-quarters of the way down the runway. After landing, the crew goes through the shutdown procedures to power down the spacecraft. During this time, the orbiter is cooling and noxious gases, which were made during the heat of re-entry, blow away. Once the orbiter is powered down, the crew exits the vehicle. Ground crews are on-hand to begin servicing the orbiter.

3. Columbia's Accident

On the morning of February 1st, 2003, the space shuttle Columbia broke up during re-entry, more than 200,000 feet above Texas. The subsequent investigation revealed the cause of the accident. During lift-off, pieces of foam insulation fell off the ET and struck the left wing. The insulation damaged the heat protection tiles on the wing. When Columbia re-entered the atmosphere, hot gases entered the wing through the damaged area and melted the airframe. The shuttle lost control and broke up.

Killed in the Columbia shuttle disaster were STS-107 mission commander Rick Husband and included pilot Willie McCool, mission specialists Kalpana Chawla, Laurel Clark and David Brown, payload commander Michael Anderson and payload specialist Ilan Ramon, Israel's first astronaut.

Computer generated picture of Columbia space shuttle entering into the orbit (in reference with channel.nationalgeographic.com)

4. Space Shuttle Improvements

4.1 Redesign the ET to prevent insulation from damaging the shuttle orbiter.
4.2 Improve inspection of the shuttle to detect damage.
4.3 Find ways to repair possible damage to the orbiter while in orbit.
4.4 Formulate contingency plans for the crew of a damaged shuttle to stay at the ISS until rescue.

5. Is human Space Flight Worth That Risk?

When the Columbia Accident Investigation Board (CAIB) subsequently enquired about Columbia disaster, it accused NASA's internal culture as much as the foam strike as causes of the shuttle disaster. The Columbia accident ultimately led then-President George W. Bush to announce plans to abandon NASA's space shuttle fleet (which was more than 20 years old at the time) once construction of the International Space Station was complete. It was planned that a capsule-based spacecraft will replace the shuttles.

NASA's space shuttle fleet resumed launches in July 2005, after spending more than two years developing safety improvements and repair tools and techniques to avoid a repeat of the Columbia disaster and not pose a threat to human lives who are devoting their lives for the humanity. In 2011, NASA launched the final space shuttle mission, STS-135, to complete the shuttle fleet's role in space station construction.

In 2012, NASA's three remaining shuttles - Discovery, Atlantis and Endeavour - were delivered to museums in Washington, D.C., Florida and California, while the test shuttle Enterprise was delivered to New York City. Under President Barack Obama, NASA was directed to rely on private spacecraft to launch Americans to the International Space Station and return them to Earth. NASA, meanwhile, is on the mission of developing a new giant rocket - the Space Launch System - and the Orion space capsule for future deep-space missions to an asteroid, the moon and Mars.

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