

NASA reassesses foam problem after STS-118

# Endeavour finally returns to space

by Clive Simpson, Gerard van de Haar & Rudolf van Beest

The Space Shuttle Endeavour and its STS-118 crew completed a 13 day journey of more than 5.3 million miles in August, adding another truss segment, a new gyroscope and an external spare parts platform to the International Space Station (ISS).

Endeavour's commander Scott Kelly, pilot Charlie Hobaugh and mission specialists Tracy Caldwell, Rick Mastracchio, Barbara Morgan, Alvin Drew and Canadian Space Agency astronaut Dave Williams landed at NASA's Kennedy Space Center in Florida on 21 August.

Williams, Mastracchio and Space Station flight engineer Clayton Anderson made four spacewalks between them to accomplish various construction tasks, and they also completed work in preparation for future assembly missions, such as relocating an equipment cart and installing support equipment and communication upgrades.

During the mission, a new system that enables docked Shuttles to draw electrical power from the ISS to extend visits to the outpost was activated successfully, enabling two days to be added to Endeavour's flight.

Although managers addressed several issues with Endeavour's heat shield, including a worrisome gouge in the protective tile on the orbiter's belly, inspections in orbit revealed no critical damage and the orbiter's thermal protection system was declared safe for re-entry.

Soon after landing and inspection of the

gouge NASA said it still wanted to try and launch the next mission (Discovery on 23 October 2007) without external tank changes despite the Endeavour damage during blastoff.

The agency also aims to launch Atlantis and the long-awaited European science laboratory, Columbus, on 6 December 2007. But NASA acknowledged it will be hard to launch the 13 remaining Space Station assembly flights and a Hubble Space Telescope servicing mission before the presidential deadline to retire the Shuttle fleet in September 2010.

"I think we get into trouble if we start holding up some kind of standard that we have to complete all remaining 14 flights and it's a failure if we don't," said NASA space operations chief Bill Gerstenmaier.

"We need to look beyond the flight number and look at what we're accomplishing on each flight and see how it fits into the future."

Despite the gouge in the thermal tiles near the orbiter's right main landing gear door the orbiter came through the return to Earth in excellent shape.

The damage (see picture on p381) was done by foam that broke free from a fuel line bracket on Endeavour's external tank on 8

*A rare close-up view of Endeavour's forward Reaction Control System from inside the launch tower.*



August at 58 seconds after launch.

The foam ricocheted off a strut and slammed into heat shield tiles on the orbiter's underside.

Mission managers considered sending astronauts on a spacewalk to repair the damage. But engineering analyses showed Endeavour's crew was not in danger and no significant damage would be done during re-entry.

Preliminary inspections on the runway indicated the analyses were correct. The damaged tiles - which were exposed to temperatures around 2,300 degrees Fahrenheit - eroded slightly but otherwise came through unscathed.

## A long lay off

It took over four years for Endeavour to return to flight after its previous STS-113 mission concluded on 7 December 2002. This was caused by a series of major modifications leading to some 200 improvements to the orbiter and including a new glass cockpit.

So, a little over 48 months after its previous mission Endeavour was finally ready for its next flight as it left the Orbiter Processing Facility on 2 July 2007 for attachment to its SRB/ET-stack in the



*Aerial view of Kennedy Space Center before Endeavour's launch and (inset) roll-back of the launch pad gantry.*



*Lift-off of Endeavour captured in this remote camera photograph by Don Hladiuk.*

Vehicle Assembly Building, followed by roll-out to pad 39A on 11 July.

As the crew for STS-118 was selected in late 2002, the main attention before launch was focused on teacher-astronaut Barbara Morgan, who was backup for Christa McAuliffe, the teacher that tragically died during the launch of Challenger in 1986; pilot Hobaugh has a link to the other fatal Shuttle flight as he was capcom during Columbia's catastrophic re-entry in early 2003.

Lisa Nowak, the NASA astronaut currently facing attempted kidnap charges, was also originally in the STS-118 crew but later moved to STS-121 before being suspended. Later crew changes included Drew replacing Anderson, as the latter was launched earlier on the STS-117 to become an ISS increment crew member.

Endeavour's launch was first set for 9 August but brought forward by two days as processing was going smoother than expected. Then, because of predicted bad weather at the early evening launch time lift-off was finally set for 8 August.

Meanwhile, the STS-118 crew had arrived five days earlier at the Kennedy Space Center (KSC) Shuttle landing strip in Gulfstream jets. In their customary short

speeches some of the astronauts made reference to the strong educational element of their upcoming flight, whilst mission commander Kelly issued a written statement where he rejected the accusations involving astronauts drinking alcohol before launches.

During the countdown itself the only major issue was a cabin leak, but after the faulty valve was located and replaced, launch processing continued smoothly, and even tower roll-back was on time the evening before.

As they walked out of the O&C Building on their way to the pad four hours before lift-off, the crew smiled and waved. Walking with them was Kelly's twin-brother astronaut Mark Kelly.

*The Freedom Star with STS-118/Endeavour's left booster after retrieval from the ocean.*



*Rudolf van Beest*



*The STS-118 crew in orbit. Pictured (front from left) are: Alvin Drew, Barbara Morgan and Scott Kelly. Back row (from left): Charlie Hobaugh, Tracy Caldwell, Rick Mastracchio and Dave Williams.*

NASA

On the day before launch Barbara Morgan had received a telephone call from First Lady Laura Bush, a former teacher herself, offering congratulations and best wishes for a good flight.

After the astronauts had entered

Endeavour, the cabin hatch was stubborn in latching but, after solving this, all went very well and Endeavour eagerly jumped straight-up towards space exactly on time at 6.36 pm local time into an almost cloudless sky. The NASA commentator called the launch “flying

on the wings of a legacy” and as the orbiter reached orbit added that the “astronaut class is now in session”.

### Approach and docking

The now-standard post-Columbia rendezvous pitch manoeuvre (RPM) began with Endeavour about 600 feet below the Space Station as the two craft passed just off the northeast coast of Brazil. The slow-motion back flip ended about 10 minutes later above northwest Africa. Flying from the Shuttle’s aft flight deck, Kelly then guided Endeavour through a slow pitch up to a point about 300 feet directly in front of the station before driving in for a precision docking.

Endeavour docked with the Space Station on 10 August and the next day, spacewalking astronauts installed a short spacer segment on the right end of the Station’s main solar power truss.

Two days later, Mastracchio and Williams replaced a faulty stabilising gyroscope whilst inside work continued to transfer 5,000 pounds of equipment and supplies to and



*Teacher-astronaut Barbara Morgan in orbit.*

***Endeavour docked to the Destiny laboratory of the Space Station. The Canadian-built Remote Manipulator System (RMS) robotic arm and Station's Canadarm2 can also be seen, and the Spacehab pressurised logistics module is visible in the payload bay.***

from the lab complex.

The astronauts used robot arms on the Shuttle and Space Station to attach an equipment storage platform to the solar array truss and staged a third spacewalk on 15 August to complete a variety of assembly 'get-ahead' tasks.

With the mission extended due to the new Station-to-Shuttle power transfer system that enabled the orbiter to plug into the Space Station's solar power grid, NASA added a fourth spacewalk which was then delayed a day while managers debated whether to turn the excursion into a tile repair task.

In the end, a repair was deemed unnecessary and Williams and Space Station flight engineer Clay Anderson were cleared to carry out the originally planned EVA on 18 August. But the threat of Hurricane Dean raised the possibility flight controllers at the Johnson Space Center might have to evacuate so the spacewalk was shortened and undocking moved forward a day to 19 August so that Endeavour could return 24 hours early.

Landing was successfully carried out at

the first opportunity on 21 August.

Endeavour touched down at KSC at 12.32 local time after a mission lasting 12 days, 17 hours and 56 minutes.

### Foam debris

The foam debris that smacked into Endeavour during launch has bigger implications than the decision about whether to send astronauts outside to repair the spaceship's heat shield. If the post-landing detailed investigation leads NASA to believe the foam on the brackets poses a bigger threat, it will be fixed before flying again.

The possibility of another redesign of the external tank's foam jeopardises NASA's ability to launch two more Space Shuttle missions this year and, ultimately, its goal of completing the Space Station before the Shuttle programme's 2010 retirement.

During early post-flight processing engineers found no heat damage to Endeavour's structure after removal of the damaged tiles, a justification of NASA's decision not to carry out an on orbit repair.

But as NASA's quest to minimise the foam debris coming off its Shuttle tanks continues to suffer setbacks, the longer-term ramifications of the debris strike could prove far more worrisome.

To date NASA has spent \$235 million trying to fix the tank foam debris problem. A re-designed tank with titanium brackets is being manufactured for the Discovery mission in April. Titanium is less prone to the ice build-up that causes foam chunks to come off but the three planned flights before then will use the same fixings that have shown persistent foam loss.

Until now, NASA kept flying the foam-covered aluminium brackets because its analyses showed it was highly unlikely that foam from the brackets would hit the orbiter hard enough to do the kind of damage that led to the Columbia tragedy and killed seven astronauts in 2003. It did not take into account the possibility of the foam bouncing off something else and ricocheting into the orbiter.

By delaying the introduction of a new design, NASA was able to resume



*Photo of the troublesome gouge taken after Endeavour had returned to Earth. NASA*

construction of the Space Station and stay on track to meet the looming deadline to retire the Shuttle fleet in 2010.

A recent independent safety review of the Space Station programme called all the flights critical to Station's viability.

"If the entire planned manifest is not flown, the basic ISS objectives would be compromised, thus raising the question of whether ISS operations should be continued," said the 2007 report from the ISS Independent Safety Task Force.

### Early return

As it turned out, Hurricane Dean never threatened the Texas coast but by that point NASA was committed to an early return if weather permitted.

STS-118 was the 119th Space Shuttle flight, the 22nd flight to the Station, the 20th flight for Endeavour and the second of four missions planned for 2007. Endeavour's next flight is targeted for February 2008.

There will be a full report on the mission's spacewalks as part of 'Orbital operations' in the next edition (November 2007) of *Spaceflight*.

*A perfect landing on the Kennedy Space Center runway, a day earlier than scheduled. NASA*

