



The International Space Station moves away from the Space Shuttle Atlantis on 19 June above a blue and white Earth. Astronaut Lee Archambault was at the controls of the Shuttle for the departure and fly-around, which gave Atlantis' crew a look at the Station's new expanded configuration.

NASA

Solar array paves way for new modules

Atlantis completes spectacular mission

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The latest Space Shuttle mission to the International Space Station (ISS) has made another step on the way for Europe's Columbus module to be despatched later this year. The laboratory is Europe's key contribution to the £50 billion project.

Atlantis spent most of its almost 14 day STS-117 mission docked to the Space Station whilst its crew installed a 17 tonne metal truss that included solar panels to generate additional electricity for the half-finished complex - and delivered a new Space Station crew member (Clayton Anderson) who replaced Sunita Williams, whose more than six months in space set a record for the longest single spaceflight by a woman.

The other Shuttle crew members were Frederick Sturckow, commander, Lee Archambault, pilot, and mission specialists James Reilly, Patrick Forrester, Steven Swanson and John Olivas.

This mission was challenging enough without an insulation blanket problem on Atlantis and other major Space Station problems that manifested themselves during installation of the S3/S4 solar array truss.

At roughly the same time as the new arrays were attached, the Russian command module's three guidance, navigation and control computers (known collectively as the terminal computer, along with three high-level command-and-control machines known as the central computer) failed to reboot after the guidance system crashed.

After three days of around-the-clock troubleshooting, Russian engineers asked Station commander Fyodor Yurchikhin and flight engineer Oleg Kotov to install jumper cables to bypass suspect secondary power supply switches.

The repair worked and, after additional tests and checkout, two computers in each system were brought back online. The other two were kept off line in backup mode. But engineers still don't know what caused the so-called 'soft switches' in the secondary power supplies to act up. The circuitry is designed to cut off power to the computers if the incoming electricity isn't stable to within

fairly narrow parameters.

Some engineers suspected the new solar arrays caused a slight change in the Space Station's power grid that affected the power supply switches. But during a test the computers were isolated from the new arrays and they still failed to boot up.

Russian mission managers plan to launch replacement computer gear aboard an unmanned Progress supply ship scheduled for lift-off on 22 July 2007. First, however, they want to pin down the exact cause of the computer problems.

Because of concern about a peeled-back insulation blanket on the Shuttle's left-side Orbital Manoeuvring System rocket pod, NASA managers extended the Shuttle flight by two days and added a fourth spacewalk to give the crew time to make repairs and complete their other work.

The repair job was eventually added to the third spacewalk and Olivas, anchored to the end of the Shuttle's robot arm, pushed the blanket back down and used a surgical

Olivas moves toward Atlantis' port orbital manoeuvring system pod that was damaged during the Shuttle's climb to orbit.



A spectacular view of Steven Swanson during the mission's second spacewalk. NASA

stapler and stainless steel pins to hold it in place.

Engineers were waiting to examine the rocket pod after the orbiter's return to Florida from California - where it landed after a day's delay due to poor weather at the prime site - to make sure it didn't suffer heat damage during re-entry.

Long-range television views from the runway appeared to show the blanket had remained largely intact, though a corner may have pulled back up during entry.

NASA

Delayed launch

STS-117's launch preparations were certainly not among the smoothest. Originally targeted for 22 February, launch was first delayed to mid-March to leave more margin for getting the vehicle ready.

But after an unusually strong hailstorm hit the stack in late February while Atlantis was at the pad, it prompted a roll-back to the VAB in order to repair damage to the External Tank (ET).

In general this resembled preparations for STS-96 back in 1999, but Discovery's tank on that occasion had only about 650 hail-induced dents and this time Atlantis' tank had around four times more. On an earlier occasion Discovery was also damaged in a similar way as in 1995 a woodpecker hammered holes in its tank for mission STS-70!

While it took a week on the previous occasions to repair the tanks, it now lasted months before ET-124 was finally fixed and a new target launch date was set - 8 June 2007. Because of all this, Atlantis was upright in the VAB for a record 72 days.

New fixing methods for the ET had to be developed and NASA was almost forced to send the ET back to its factory in New Orleans, using the next one, ET-117, instead.

What was removed early May though, were the Shuttle's main engines after contamination in the flow lines was found in two of Discovery's main engines after its last two missions; inspections showed Atlantis' engines were okay and they were re-installed a week later.

Meanwhile, the long delay also meant that astronaut Sunita Williams would have to stay on the ISS longer than planned as, after her launch on STS-116 (*Spaceflight*, February 2007, p50) she should have returned after six months, on STS-118.

With the various delays, it was decided to have her return on STS-117 instead, a mission which would now take her successor, astronaut Clayton Anderson, up as well.

This also prompted another re-designing of Shuttle mission patches as had happened with STS-117 already twice before. As it turned out, commander Sturckow and spacewalkers Reilly and Forrester were the only ones remaining from the original crew.

The seven STS-117 astronauts arrived 4 June at the Cape and after a very smooth countdown - though the weather seemed uncooperative in the days before the launch - Atlantis and its strangely looking patched-up tank, lifted-off four

days later in a clear sky.

Greeting them on orbit was capcom astronaut Terry Virts, who had replaced former astronaut Lisa Nowak in that position (*Spaceflight*, April 2007, p126) who was suspended after being arrested for assault and is facing court proceedings for allegedly attempting to murder a woman who she thought was her rival for the affections of Space Shuttle pilot Bill Oefelein (who in the meantime has also been suspended from the astronaut corps).

Launch videos revealed that little foam broke off the repaired tank, just bits and pieces. "It performed extremely well," commented lead mission manager John Shannon.

As to the damaged blanket on Atlantis, NASA managers now believe they underestimated how much heat the underlying layers had experienced during launch on 8 June.

"When they modelled it, they made a mistake," Shannon said of the original analysis. "Still, the engineering and safety teams believe there's absolutely no risk at all during re-entry."

Heat shield problems have been a major concern for NASA even before Columbia broke up while returning to Earth in 2003, killing all seven crew members.

ESA inquiry

The same computer systems that crashed aboard the Space Station are also incorporated into two new European contributions to the orbiting outpost due to be launched around the year's end.

The Columbus laboratory is scheduled to fly on Shuttle Atlantis' next flight in December and the Automated Transfer Vehicle (ATV) - a giant supply vessel - will make its maiden voyage atop an Ariane 5 rocket early next year.

As a result of the ISS's computer shutdown - which initially raised concerns that the outpost might have to be temporarily abandoned - ESA launched an investigation to see if similar problems could hit the systems incorporated into Columbus and the ATV.

The ISS's primary computers, which are located in the Russian command module Zvezda, were supplied by EADS Astrium Space Transportation in Bremen, Germany, under contract to the European Space Agency.

In exchange, ESA received equipment from Russia to dock the ATV at the Space Station.

ESA set up a team that joined the around-the-clock, multi-national effort to



Lift-off for the Space Shuttle Atlantis from Kennedy Space Center's launch pad 39A occurred at 7.38 pm local time on 8 June 2007.
NASA

recover the ISS computers and figure out the cause of the crash.

According to a statement issued by the agency, the team "looked at the relevance of this situation to the ATV (which has identical computers) and Columbus (which has similar machines), to ensure that corrective action, if any, is taken well before flight of the two European elements".

The Station's changing shape may be at the root of some problems, which shut down the rocket-steering system the Station needs to correct its alignment in space so that solar wing panels can track the Sun for power.

The thrusters are also used to keep the Station properly positioned for warming or cooling various elements, and to point antennas toward Earth for communications.

Most of the time the Station uses the US gyroscopes, which spin to maintain position, but the thrusters kick in to counteract stronger motions, such as those caused by the attachment and release of visiting spaceships, or when the Station has to be manoeuvred around a piece of orbital debris.

In addition, the computers also automatically control life-support equipment, though these can be manually operated as well.



Atlantis approaches the Space Station.
NASA



Atlantis touches down at Edwards Air Force Base.

NASA/Tony Landis

Official welcome

During their first day in orbit, pilot Lee Archambault and mission specialists Patrick Forrester and Steven Swanson used the Shuttle's robotic arm to unberth the Orbiter Boom Sensor System (OBSS) for a detailed examination of Atlantis' thermal protection system.

The previous evening they had taken a close look at an area of insulation blanket on the port orbital manoeuvring system pod that was seen to be pulled away from adjacent thermal tiles during the robot arm checkout.

The crew of Space Shuttle Atlantis was officially welcomed by the Space Station crew on 10 June some two hours after the two craft had docked while travelling 220 miles above the northeast coast of Australia.

Prior to docking, Sturckow flew Atlantis through an orbital backflip while stationed about 600 feet below the Space Station. The manoeuvre was documented with long-range, high resolution cameras by ISS Expedition

crew members Kotov and Yurchikhin.

Earlier, mission specialist John Olivas used a 400 mm camera from the crew cabin aft window to get up-close shots of the port orbital manoeuvring system. The photos were downlinked for review by imagery analysts and mission managers.

Soon after docking, Archambault and Forrester used the Shuttle's robotic arm to grapple the S3/S4 truss, lift it from its berth in the payload bay, and manoeuvre it for handover to the Station's Canadarm2. The S3/S4 truss is the heaviest Station payload the Shuttle has carried to date.

First spacewalk

The Space Station grew in size and capability the following day (11 June) when the S3/S4 truss became a permanent addition as crew members worked inside and outside the complex to complete the final hook-ups.

A key part of the task was a six hour, 15 minute spacewalk by Jim Reilly and John

Olivas, who focused on final attachment of bolts, cables, and connectors to begin the activation of the truss and ready it for deployment of its solar arrays.

Start of the spacewalk was delayed for about an hour after the Station temporarily lost attitude control when control moment gyroscopes went offline due to the mass of the new truss segment in the final stage of its attachment. The loss was not unexpected because of the Station's skewed asymmetry as the bus-sized truss was being moved toward the S1 truss.

The installation paved the way for the start of the spacewalk – the fourth for Reilly and first for Olivas. The truss stretches 356 feet from end to end.

On 12 June the Space Station was able to spread its wings again with the activation of a new pair of solar arrays that will generate the equivalent of enough power to supply about eight homes. The extra power sets the stage for addition of European and Japanese laboratories later this year and early next respectively.

Prior to the crew wake up call on this day, mission controllers began unfurling the solar array attached to the newly installed S3/S4 truss segment.

Atlantis' astronauts then took over, unfolding one wing at a time in stages, pausing to let the solar array panels soak up some sun, which helps to prevent the thin individual panels from sticking together.

This paved the way for a spacewalk the next day (13 June) when Patrick Forrester and Steve Swanson went outside - on their first of two spacewalks - to remove launch locks from the 10 foot wide solar alpha rotary joint to free the arrays to rotate and track the Sun.

During the six hour spacewalk, they also helped flight controllers fold up an older solar array to make room for the rotation. They were able to poke and prod another five and a half bays' worth of panels into folding correctly before moving on to other tasks. That retracted pair of arrays and corresponding truss segment eventually will be relocated and redeployed to add even more power capability.

The spacewalkers ran into a problem when Forrester tried to install a drive-lock assembly and found that commands being sent to it were actually being received by a drive-lock assembly installed during the mission's first spacewalk.

Once fully activated, the drive-lock assemblies engage gears permitting the massive joint to rotate allowing the arrays to track the Sun as the Station circles the Earth.



STS-117 crew members in the Destiny laboratory shortly after docking. Front (from left): Lee Archambault and Rick Sturckow. Back (from left): Patrick Forrester, Jim Reilly, Steven Swanson and John 'Danny' Olivas. NASA

Navigation problem

Late that day, the Space Station experienced a problem with a Russian navigation computer that challenged flight controllers in Houston and Moscow to manage the Station's attitude in space. Several methods of attitude control are available - Russian thrusters, Atlantis thrusters, or Station electrically-driven gyroscopes.

The problem with the navigation computer began when flight controllers attempted to turn attitude control over to the Station computers after letting Shuttle computers handle it while the arrays were unfolded. The computer would not allow them to do so, and forced a reboot of the main Russian command and control computer, which triggered an alarm alerting the problem to the crew and ground controllers.

Meanwhile, as the second spacewalk continued, mission managers decided that at least part of the third spacewalk, scheduled for Friday (15 June), would be dedicated to repairing the raised corner of a thermal insulation blanket that came loose from the Shuttle during launch.

During their working day on 14 June the two crews partially retracted a solar array and prepared for the third spacewalk that would include assisting "on the scene" with additional retraction of the array. They were able to retract 16 of the 31½ bays into a 20 inch deep protective box.

The crew also reviewed procedures for the blanket repair task which Olivas was to perform while in a foot restraint on the end of the Shuttle's robotic arm.

The repair procedure involved pressing down on the blanket and stapling one side of

the four by six inch raised corner to an adjacent blanket. Olivas then pinned the other side of the blanket to a thermal tile. Due to the extra work the EVA lasted nearly eight hours (the second longest ever for ISS).

After the successful third spacewalk the final one on 17 June - lasting 6.5 hours - was made by Forrester and Swanson to activate a new solar array joint mechanism.

Following undocking on 19 June Atlantis circled the ISS, the latter's appearance now resembling a 'Star Wars fighter', according to lead flight director Cathy Koerner.

Californian landing

Running a day late because of thundery Florida weather, Atlantis dropped out of a sunny Mojave Desert sky to a smooth touchdown on runway 22 at Edwards Air Force Base, California on 22 June.

NASA had wanted to return to Florida but cloudy weather and rain showers prevented a landing the previous day and, with a forecast of more of the same on the second landing day, entry flight director Norman Knight diverted the crew to Edwards one orbit after waving off the first of two opportunities to land at the Kennedy Space Center.

Mission duration for STS-117 was 13 days 20 hours 11 minutes and 34 seconds covering 219 complete orbits and 5.8 million miles since blast off on 8 June 2007.

Flight surgeons were standing by to assist Sunita Williams - who made the trip back to Earth resting on her back in a recumbent seat bolted to the floor of the Shuttle's lower deck. She had logged 195 days in orbit, a single-flight record for a female astronaut.

"I can't wait to get back and feel the air on my face and the sea breeze," she had said from orbit shortly before returning. "I'm looking forward to going to the beach and taking a walk with my husband and my dog. And I can't wait for a good piece of pizza and a hair cut."

Typically it takes returning Space Station astronauts a month or so to get their land legs back and up to a full year to completely recover from the bone and muscle loss associated with long stays in weightlessness.

The next planned Shuttle launch is Endeavour around 7 August 2007 to deliver a short spacer segment that will be attached to the S4 solar array permitting the eventual attachment of a new set of arrays - S6 - next year. The crew will also deliver a Spacehab external equipment storage platform (ESP-3).

The Endeavour mission also features educator-astronaut Barbara Morgan, who was the backup to Challenger's 'teacher-in-space' Christa McAuliffe. Morgan is now a fully-fledged astronaut and will be making her first flight.

Atlantis extension

Meanwhile, NASA has revealed that the Space Shuttle Atlantis is likely to continue flying now until 2010 rather than being retired next year as originally planned.

Information gained from processing documentation for STS-122 - the next flight of Atlantis which is currently scheduled for this December and will carry the European Columbus module - along with the most recent Flight Assignment Working Group (FAWG) manifests, confirm the addition of two further missions for the orbiter.

Atlantis was originally set to retire in late 2008 after the Hubble Space Telescope servicing mission because of the subsequent Orbiter Maintenance Down Period (OMDP) - which would have taken at least a year - and the ending of the Shuttle programme in 2010.

The orbiter would have remained inside an OPF (Orbiter Processing Facility) and maintained to near flight ready condition, to be used as a parts donor for her two sisters, Discovery and Endeavour.

However, Atlantis will now be assigned two missions which were previously allocated to either Discovery or Endeavour.

NASA says that, even with this extension to Atlantis' operational lifetime, certain elements of the OMDP can still be safely carried out during pre/post-launch processing intervals.