

Discovery leaves Space Station in fine shape

Shuttle mission re-wires ISS

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

The Space Shuttle Discovery's astronauts arrived safely back on Earth just in time for Christmas after a spectacular STS-116 mission which involved an unprecedented fourth spacewalk to fix a recalcitrant solar panel.

The unscheduled repair work to retract the solar panel kept the crew at the International Space Station (ISS) an extra day as mission specialists Robert Curbeam and Christer Fuglesang laboured through an extraordinary effort to reel in the accordion-like panel.

Full retraction of the array was critical to completion of ISS construction because the array has to be moved to the left end of the Station's central truss next autumn - and this couldn't happen if part of the array was still jutting out.

Early in the mission, repeated wiggle tests didn't work and ground controllers beamed up commands to tilt the array back and forth in an effort to free its bunched-up

blankets - all to no avail.

European astronaut Thomas Reiter was even ordered to work out vigorously on a resistive exercise device inside the Station in the hope that vibrations might create enough rippling wave action to straighten the blankets on either side of the mast.

During his third spacewalk, Curbeam also tried manhandling the array, shaking it over and over, but still no joy.

Again, during the fourth spacewalk Fuglesang - ESA's Swedish astronaut on his first trip into space - repeatedly shook the stubborn panel.

At the same time Curbeam used tools to tighten slack guidewires on the high-voltage array, which consists of two golden solar cell blankets on either side of a telescopic mast.

Loud applause erupted in NASA's mission control when the panel - which is nearly 30 m long when fully unfurled - finally folded up into blanket boxes that are less than 50 cm deep.



Flight controllers finally breathed a sigh of relief after Curbeam, armed with needle-nose pliers, also fixed a loose guidewire still jutting out from the rectangular boxes.

Another objective of this extra spacewalk was to collect information that could prove useful when the opposite side of the array is retracted during the STS-117 mission in March 2007.

The unscheduled excursion meant Curbeam set a new Space Shuttle programme record for the most spacewalks performed during a single mission.

Some two dozen astronauts have chalked up three spacewalks during 18 different missions, but no one before has gone into

Three days after launch both STS-116 solid rocket boosters arrived back at KSC. The first, right-hand, booster was brought into the Cape Canaveral port on time and looked to be in good shape. The left one, however, came in much later the same day after problems with the parachutes, cable lines and wind. Also, one of the divers from the Freedom Star retrieval ship was injured and had to be transferred to hospital. A first inspection revealed butts and dents in the casing and nozzle; this booster was made of many old segments, even from pre-Challenger flights including ones used already on STS-2 and -3 back in 1981-2! Rudolf van Beest





Night-time launch of Discovery as seen through the camera lens of Rudolf van Beest stationed at a viewing area about 2.5 miles from the launch pad.

*On the morning of the first launch attempt Shuttle Discovery is revealed as the launch pad rotating service structure is rolled back. The flag was at half mast to commemorate Pearl Harbour Day.
Clive Simpson*

the void four times during a Shuttle flight.

Curbeam has now tallied 45 hours and 34 minutes working outside the spacecraft - a total that ranks him in the top five of spacewalking records.

Launch of Discovery

All appeared to go well on the first launch attempt for STS-116 on 7 December - the tower rolled back at midnight and tanking

was complete by the time the astronauts left their crew quarters for the pad, with Fuglesang waving enthusiastically to the people seeing them off.

Weather was the only concern during the countdown and everybody at and around KSC was deeply disappointed when upper level winds and low clouds over the runway scrubbed the launch at T-5 mins.

Among the crowd was the Swedish deputy prime minister Maud Olofsson and the lieutenant governor of Alaska, the latter to see the first Alaskan astronaut - William Oefelein - lift off into space.

Two days later not only was the weather bad at first, but also tower roll-back and tanking were much delayed. But as darkness came down and the launch window approached all preparations were completed on time, the astronaut crew was onboard again and even the weather in the

Group portrait of the STS-116 and Expedition 14 crew members in the Destiny laboratory. Pictured are (front from left): Thomas Reiter, Nicholas Patrick, Joan Higginbotham and William Oefelein. Centre (from left): Robert Curbeam, Christer Fuglesang and Mark Polansky. Back (from left): Michael Lopez-Alegria, Mikhail Tyurin and Sunita Williams.

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An image of a kink that occurred in the port-side P6 solar array during the first attempt to retract it on 13 December. The crew later extended the array and managed to clear it.

NASA

end cooperated, with lift-off occurring on time at 8.47 pm local time.

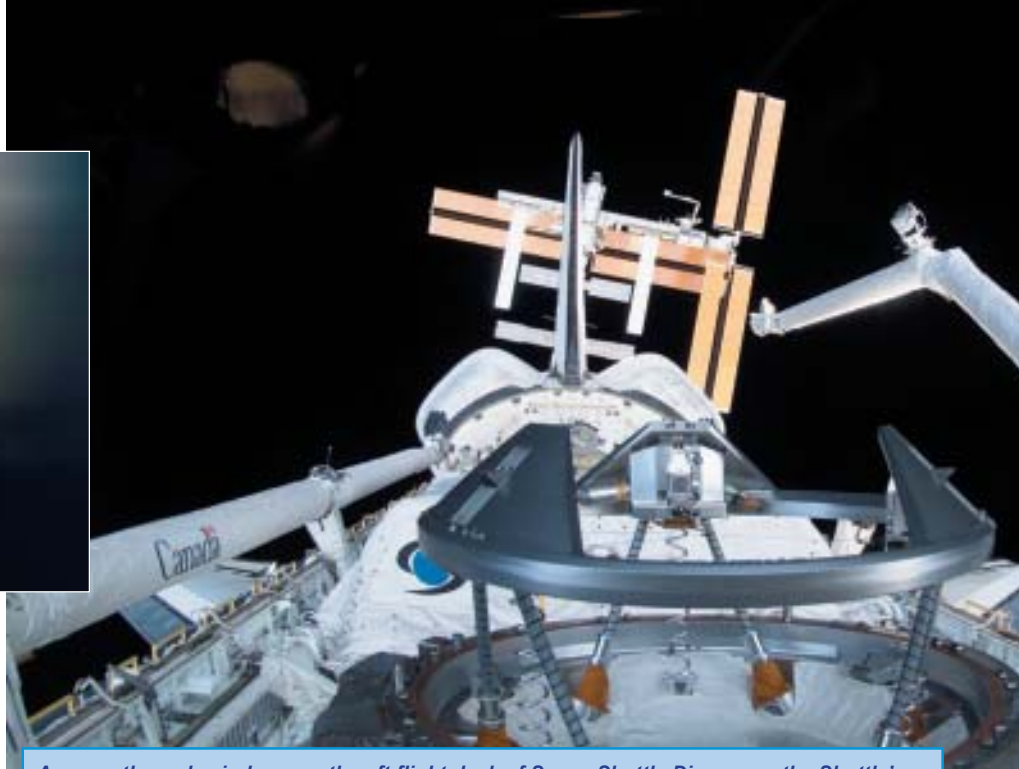
It was a spectacular night launch, the first since STS-113 in 2002 and the 29th Shuttle night launch overall, lighting the whole mid-Florida coast-line.

Other firsts for this launch were the use of an advanced monitoring system for the Shuttle main engines and the first re-use of a Spacehab module since the return-to-flight after the ill-fated STS-107 mission.

On the other side of the coin it was likely to be the last Space Shuttle leaving from pad 39B which is soon to be reconfigured for the new Ares-1 rocket.

Commander Mark Polansky cheered after reaching orbit. "You've got a lot of smiling faces up here," he said, whilst Fuglesang

Fuglesang during the first six hour, 36 minute spacewalk.



As seen through windows on the aft flight deck of Space Shuttle Discovery, the Shuttle's payload bay and the approaching Space Station. In the payload bay are the Shuttle's docking mechanism (foreground), Spacehab module (partially obscured), the Canadian-built Remote Manipulator System (RMS) robotic arm (right), and the Remote Manipulator System/Orbiter Boom Sensor System (left, in stowed position).

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described it as the "experience of a lifetime!"

As the most complex ISS flight yet speeded towards its destination, Expedition 14 commander Lopez-Alegria announced they would "leave the porch light on" for the arriving Shuttle crew.

In orbit, inspection of Discovery's reinforced carbon carbon (RCC) wing leading edge and nose cap material by the Orbiter Boom Sensor System (OBSS) showed no sign of any external tank foam or ice impact

During launch, wing leading edge accelerometers detected six events of 1.2-

1.3 g's each on the orbiter wing leading edges. Four of these were on the left and two were on the right, occurring some 110-120 seconds after lift-off.

The characteristic has been seen on other flights and is believed to be caused by a shock wave moving along the wings combined with the settling of the T-seals that bridge the RCC with the upper wing surface.

The data were only one-tenth of what would be required to even scuff an RCC panel and one-twentieth of what would be required to actually cause damage, but it illustrates the level of detail being looked at on current Shuttle missions.

The main trust of the STS-116 mission, the third Shuttle flight of 2006, was for the seven Shuttle astronauts and three Space Station astronauts to work closely with flight controllers at NASA's Johnson Space Center, Houston, to reconfigure the ISS's electrical power and cooling systems.

The Station had been running on a temporary electrical system since 1998 and in the new, permanent, configuration it will incorporate power from the Port 4 (P4) solar arrays that were installed during STS-115 in September 2006.

Discovery also delivered a new ISS crew member and an important new element for the Station's girder-like truss, the Port 5 (P5) element, nicknamed 'Puny', to extend the left side of the overall truss, allowing the P4 solar panels to rotate. It also sets the stage for the future relocation of the P6 solar arrays.

STS-116 astronaut Sunita Williams replaced Expedition 14 flight engineer



Curbeam and Fuglesang (left, partially out of frame) work to fix the solar array.

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Thomas Reiter - the ESA astronaut who became the third ISS crew member and the first long-term participant for Europe - who returned to Earth aboard Discovery.

The long-term nature of Reiter's 'Astrolab' mission has significantly enhanced ESA's familiarity with continuous ISS operations, as well as providing the opportunity to acquire experience for future operations of the Columbus science laboratory which is due to be added in late 2007.

View from orbit

Writing from space before preparing for his second spacewalk of the mission, Christer Fuglesang, said: "It is incredibly good fun and unbelievably busy – and yesterday's spacewalk [the first] was amazingly cool!

"To float along the outside of the Station, to watch the Earth down below glide past, to see the curved horizon with a thin, blue layer of atmosphere bordering on black space... I need much more time to describe all that is great and all the wonderful emotions that I felt."

Fuglesang said that after the first spacewalk the crew had a party with international food from the US, Germany, England (Nicholas Patrick, NASA's yorkshire-born astronaut) and Sweden.

"It was the first time I showed the Swedish food I had brought with me. I treated the others to elk sausage and Swedish toffee which was much appreciated," he said.

Fuglesang described his second spacewalk of the mission as "yet another spectacular, extraordinary experience".

"Today everything went as planned, largely without problems, and the Station's new

Robert Curbeam (left) and Christer Fuglesang during the mission's first of three planned EVAs.

NASA

electrical system (the half we did today) got up perfectly and much quicker than expected.

"Ground control has done a fantastic job. The only difficulty for my part was that the connections in the "rats' nest" were tougher and required more strength than when we practiced in the pool. It is complicated to reach them and I wanted to be as careful as possible so none of the other cables or anything else was damaged.

"When I stood on the end of the robotic arm during the relocation of the CETA carts it was incredibly beautiful. We came in over

Europe during a night pass. I could see lights from several cities and, up north towards Sweden, the whole horizon was covered by the Aurora! Soon afterwards I was met by a fantastically splendid sunrise."

Before the fourth spacewalk, the astronauts spent most of their 'Sunday' hauling supplies into the Space Station. Discovery carried about 3,000 pounds in a Spacehab cargo bay carrier and a similar amount of rubbish, plus a faulty Elektron oxygen unit and surplus equipment, was stowed in the module for return to Earth.

