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Space Exploration

The End is Just the Beginning: The Final Boeing-Built Hardware Helps International Space Station Reach Full Potential



In the Space Station Processing Facility at NASA's Kennedy Space Center in Florida, the integrated truss structure, S6, and solar arrays are lifted across the floor to install in the payload canister for transfer to Launch Pad 39A. The truss and arrays are space shuttle Discovery's payload for the STS-119 mission to the International Space Station. (NASA Photo by Kevin Gill)

When Boeing International Space Station engineer Bob Levy was in fourth grade, he was so excited about the Apollo launch that he dragged in a new color television to his classroom. Levy still maintains that enthusiasm for the space program, but now he's more than an observer. Levy is working to make sure the final piece of Boeing-built

hardware for the International Space Station is installed without a hitch.

Space Shuttle Discovery's STS-119 mission delivers the Boeing-built Starboard 6 (S6) truss segment, solar arrays and fresh batteries to the ISS. The truss will support a pair of solar arrays, whose power-generating capability will enable the station to reach

its potential capacity – housing a full crew of six astronauts. The mission marks the station's designation U.S. core complete, signifying the last major U.S.-built element to be delivered.

By the numbers:

- The Starboard 6 element is 16.3 feet wide by 45.4 feet long with a height of 14.7 feet and weighs 31,060 pounds
- The S6 costs \$297,918,471, which includes the costs of maintaining it while it sat on ground as a result of delays from the *Columbia* accident
- The ISS solar array surface will be large enough to cover the U.S. Senate Chamber more than three times over. About 84 to 120 kilowatts of power for the ISS will be supplied by an acre of solar panels.
- The ISS eventually will be larger than a five-bedroom house.
- ISS will have an internal pressurized volume of 33,023 cubic feet, or equal to that of a Boeing 747.
- The solar array wingspan (240 ft) is longer than that of a Boeing 777 200/300 model, which is 212 ft.
- The ISS will weigh almost one million pounds (925,627 lbs). That's the equivalent of more than 320 automobiles and will measure 361 feet end-to-end. That's equivalent to the length of a football field including the end zones.

Designing, building and installing a 31,000-pound, 45-foot long truss segment for the extreme environment of space is no easy feat, according to Boeing employees. The latest addition to the station took years of hard work at sites in Oklahoma, California, Colorado, Texas and finally Florida.

Levy, who works on the electrical system, has worked on all four of the solar array modules, including helping to figure out how to start them initially when the first set was flown up in 2000. "We knew how to design the power module, but we did not understand how to get it powered up initially in space. My idea was to use the shuttle's power system to start the arrays by converting the power."

Levy started out in 1989 at Boeing's Rocketdyne division (now elements owned by United Technologies Hamilton Sundstrand and Pratt and Whitney) in Canoga Park, Calif. He was one of more than a thousand people working on the design details of the station's power modules. Much more recently, Levy helped design a modification to S6 that allows it to accommodate a couple of spare battery chargers. "S6 is the only module to get that modification." Otherwise, S6 is a near-copy of the Port 6 module, which was the first power module delivered to orbit.

The actual S6 truss hardware that will be flown to space initially was just a test unit. When NASA decided to convert the test truss into flight hardware, it was shipped to Houston for refurbishment. The truss segment was then mated with the solar arrays and batteries and assembled with all of its electronics at NASA's Kennedy Space Center, Fla., where it has been since Dec. 17, 2002 – earning the distinction of the single element that has been on the ground the longest.

Rick Bentley, a manufacturing engineer at the Houston Product Support

Center, worked on the element while it was built in Oklahoma and later at Houston. Like Levy, he started out working for Rocketdyne in 1984. Bentley

manufacturing and engineering to re-outfit it.”

A retired U.S. Air Force colonel and now Boeing’s flow manager for the



Under Boeing’s Checkout, Assembly and Payload Processing Services (CAPPS) contract, Boeing technicians are installing new batteries on the Starboard 6 truss. The batteries had to be replaced because they had exceeded their life limits as a result of the delays caused by the Space Shuttle Columbia accident. The batteries were replaced in the summer of 2009. (Indyne photo by Dave Brinko)

spent a lot of time in Oklahoma working on the truss, sacrificing time with his family because of the high operations tempo.

“We had to completely re-outfit it from all the testing. All the non-flight hardware had to be removed. We basically had to strip it down and do a complete inspection, perform some repairs, re-build and revalidate it for flight conditions,” said Bentley. “As stressful as it can be at times, it gives you an adrenaline rush when you see that piece of hardware go up, even with all the challenges that you have to go through. It was a great team effort between

STS-119 mission, Dave Cormack says his team has been working hard on the Starboard 6 truss element since it arrived at Kennedy Space Center. One of his jobs over the past eight years has been to make sure everything goes smoothly with scheduling of assembly and testing of operations. “Because of the delay from the Columbia accident, we put the freshest batteries on it that we could. We did a confidence test in December 2007 because the element had not been fully assembled and tested with all of the systems, to include the ammonia cooling system.” Because the flight hardware was on the ground for an extended duration, his team maintained and

cleaned the element, checked for corrosion, and charged the nickel hydrogen batteries every two weeks until new batteries were installed this past summer.

Cormack says his team has gotten smaller as it completed many of the earlier truss segments, but says about 35 folks, less than half of what his team was at its peak, continue to work in support of the elements on orbit and prepare the processing facility in Florida for closeout of station assembly, which he describes as a bittersweet day. “I still get a thrill out of watching the space station fly over and once we get this other set of wings on it, it will be reflecting brighter than ever before,” he said.

Boeing engineer Matt Fields has been working on the station program with Rocketdyne since 1992 and joined the Florida team in 1999. Fields remembers testing the electrical power system at Rocketdyne to prove the various stages of space station assembly. “We found and solved lots of problems during our testing in the early design. When you get into the heat of things, you are working on tasks that are very mentally challenging.”

He worked on the element to join the Integrated Equipment Assembly (IEA), which contains most of the electronics and solar arrays, with the long spacer truss segment. The Boeing Florida team populated the truss structure with the Orbital Replacement Units (ORUs) and associated components. “Our first series of testing that we performed was a command-and-response test to verify all the data buses were good and all the ORUs had full functionality,” he recalled.

Boeing engineer Danom Buck worked closely with Fields and had

responsibility for much of the forward manufacturing and assembly work that was planned when S6 was transferred from Houston to Kennedy Space Center. “I enjoy working with people across the country that come from multiple engineering disciplines. It is fun, exciting, challenging and rewarding.



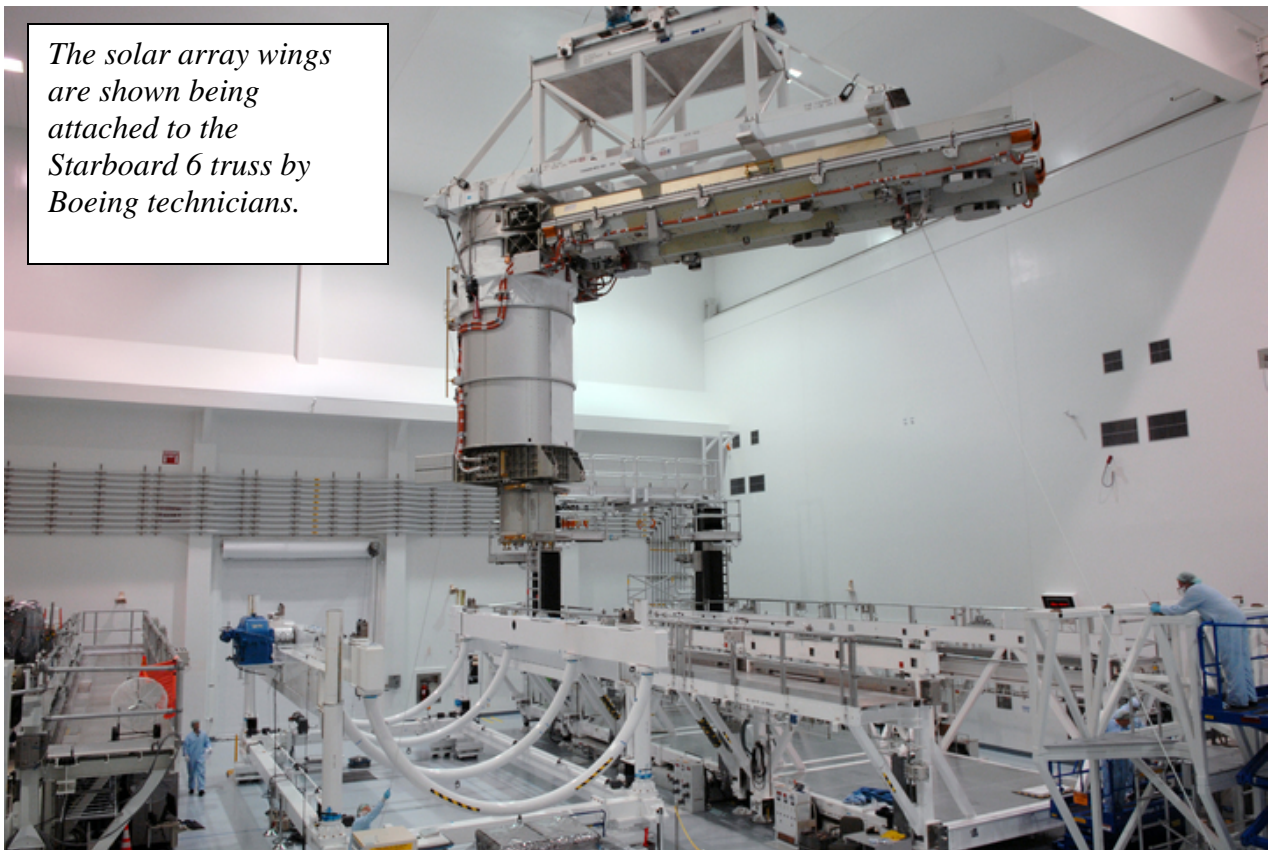
After new batteries were installed on the Starboard 6 lower deck Integrated Equipment Assembly, the Solar Array Wing was reinstalled. Boeing engineer Sam Amundsen is shown on the left of mast canister while Elijah Walker technician is on the right. (Indyne photo by Melanie Gurnavage)

Seeing the hardware on orbit is also a very rewarding aspect of the job.”

Buck and several of his coworkers support on-orbit installation and operation of the truss segment. “On all of the truss elements, we travel to Houston to sit in the NASA Mission Evaluation Room to help verify vehicle operation. The MER always has the right mix of personnel involved to handle any challenges that get thrown our way,” Buck said.

“We are finally transitioning from assembling the station to operating ISS to its envisioned potential. The electrical power generation system on station has been incredibly reliable to date, but there are so many places you can have problems, and that is where our team will be focused on keeping it operational in the future,” concluded Levy.

The solar array wings are shown being attached to the Starboard 6 truss by Boeing technicians.



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