International Space Station Skyrockets into 21st Century | A Safe Hand-Hold in Space

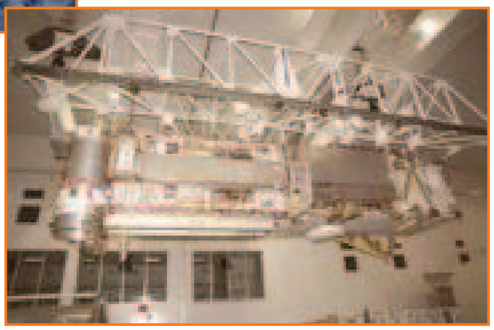
ALuminum Extrusion
S H O W C A S E
INNOVATIONS TAKING SHAPE

INTERNATIONAL SPACE STATION SKYROCKETS INTO 21ST CENTURY:

EXTRUDED ALUMINUM TRUSS STRUCTURES LINK STATION MODULES TOGETHER IN THE MOST COMPLEX SCIENTIFIC VENTURE IN HISTORY

With Earth on the horizon, the International Space Station, as seen from aboard the Space Shuttle Discovery.

Innovation launches into orbit, thanks to aluminum industry manufacturers who are supplying extruded aluminum tubing for the truss structures that link together the International Space Station (ISS). Boeing Company engineers are working with extruders on a massive scale during construction and assembly of the newest extruded truss sections: Starboard segments S3, S4, S6, and Portside segments P3, P4 and P5, scheduled to begin launching in Spring, 2005. Truss section P6, launched in November 2000, supports the current ISS configuration. A marvel of science and aerospace engineering, this vast ISS program is truly flourishing thanks to aluminum extruders across the globe.



The ISS is the most complex international scientific venture in history. Its crews are conducting research to support space exploration, and are providing a stable environment for scientific, technological and commercial research. Building the ISS involves more than 100,000 space agency and contractor personnel from 16 countries, including more than 10,000 first to fourth-tier suppliers—truly an example of international cooperation.

The Port Side P6 truss segment hangs suspended from a crane, moving through the Space Station Processing Facility, on its way to launch on the Space Shuttle Endeavour. The P6 comprises Solar Array Wing-3 and the Integrated Electronic Assembly, installed on the ISS in November 2000.

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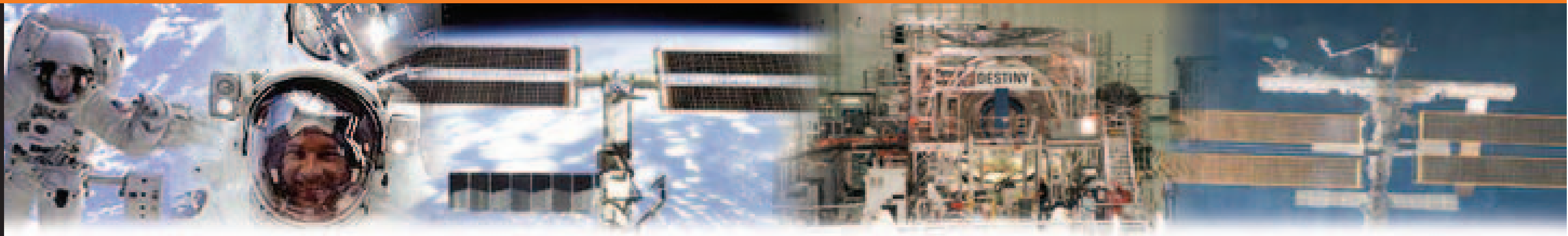
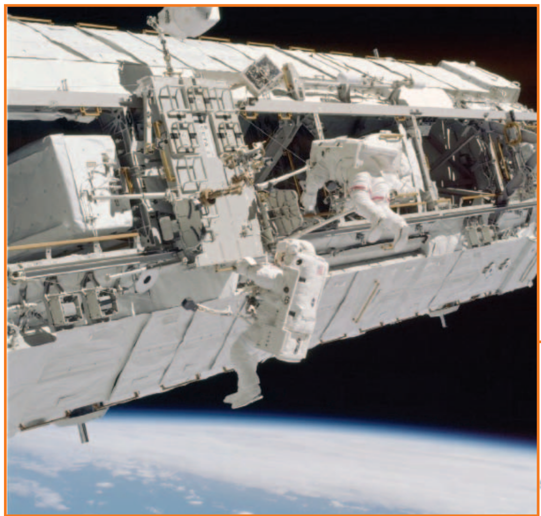


International Space Station Skyrockets into 21st Century

A Safe Hand-Hold in Space

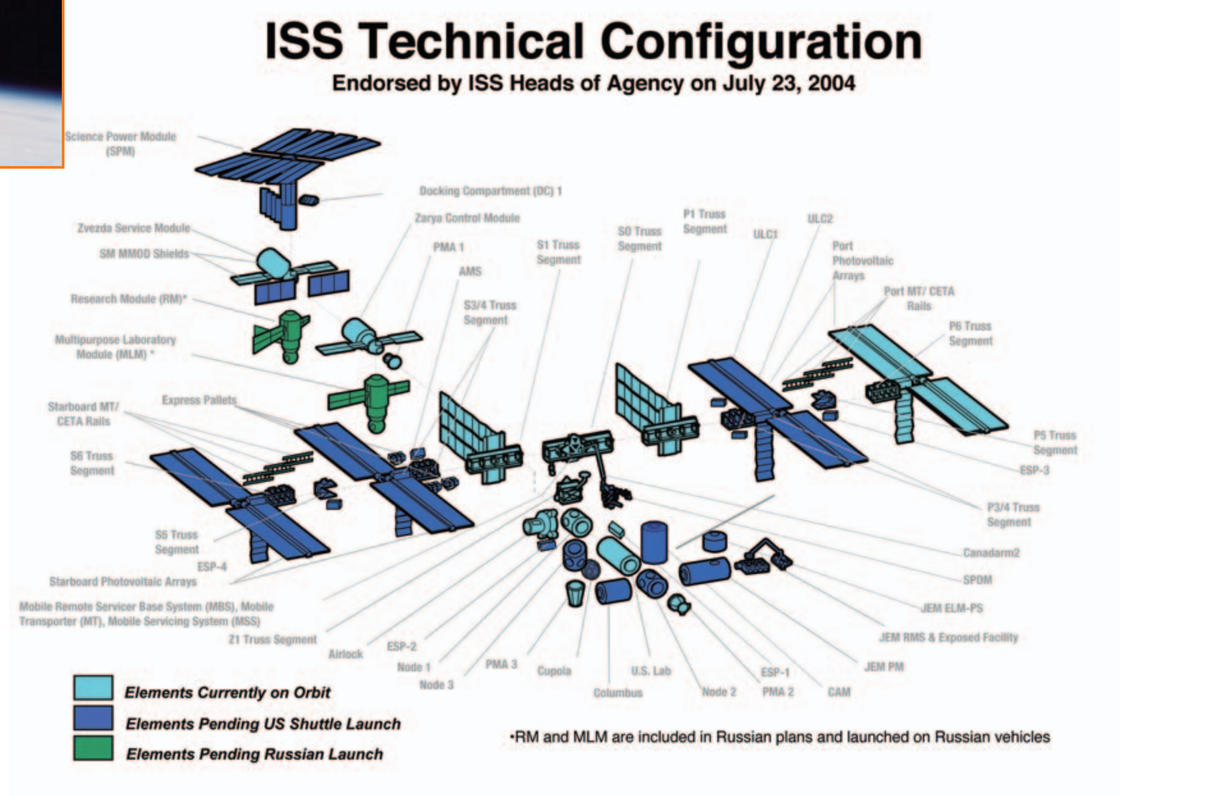
ASTRONAUTS WORK HAND-IN-HAND WITH ALUMINUM EXTRUDERS

Since the first module's launch in November 1998, 12 major ISS components have been assembled in space. Components are connected by inboard and outboard truss sections, designed to launch separately, or combine as cargo elements in the Space Shuttle. They are delivered to low Earth orbit, then assembled hands-on in space by the astronauts, using a robotic crane. The S0 (starboard segment zero) or central truss segment, S1 (starboard segment one), and P1 (port side segment one) truss sections were launched and assembled in 2002, uniting the Russian Progress cargo vehicle, the U.S. Quest airlock, and Destiny Lab modules.



Astronauts routinely work outside during space walks, using the Crew Equipment and Translation Aid (CETA) cart, as they build and maintain the ISS.

Extruded aluminum outboard truss sections house the U.S. power generation and distribution system. Four outboard truss sections house power generation modules, with two sections providing power from the superstructure's port side, and two from the starboard side. The final ISS integrated truss configuration will measure 361 feet end-to-end, with its solar arrays feeding the station's electrical power generation system. This comprises approximately one acre of solar collection, providing more than 80 kw of power. ISS construction is slated for completion in 2010.



ISS Technical Configuration Chart, July 2004.

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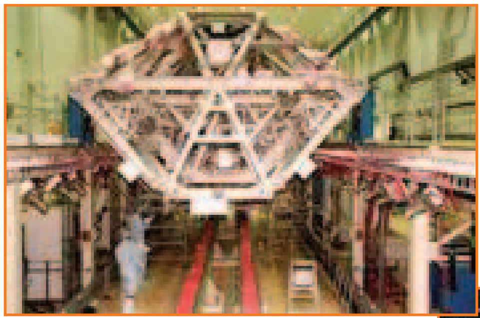
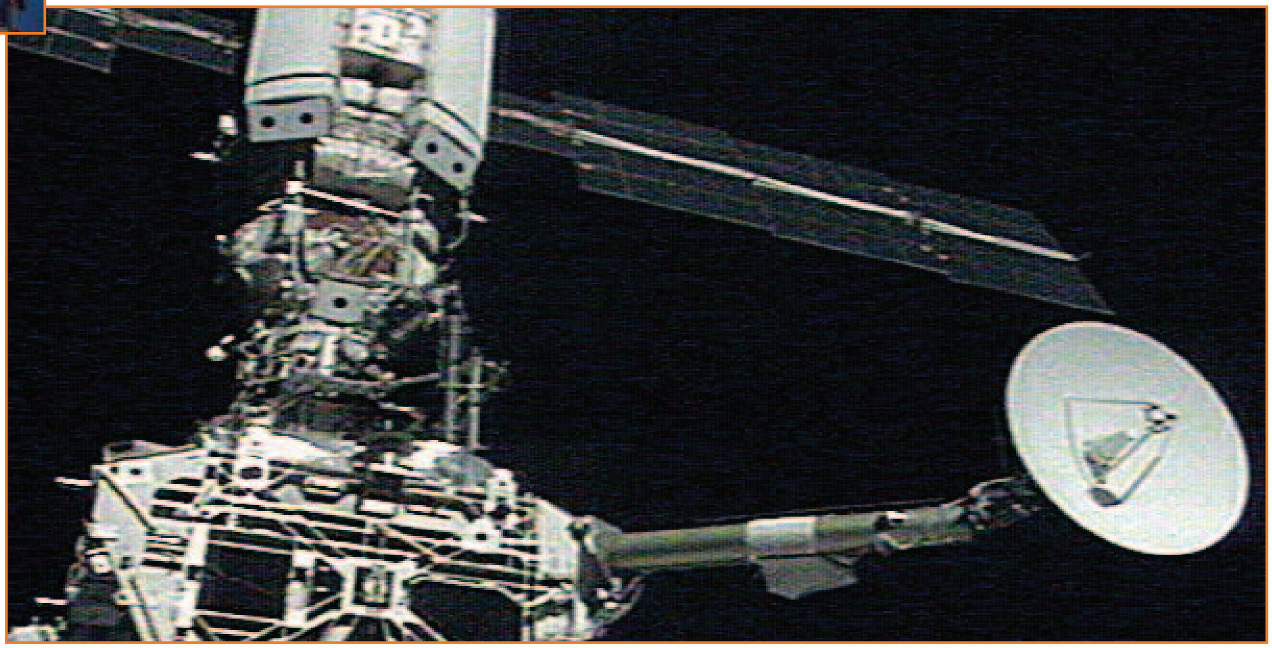
TRUSS DESIGN TEAM PUSHES THE ENVELOPE



Truss segment Starboard Zero (SO) takes center stage. Workers check the structure, as the Canadian Mobile Transporter, power distribution system modules, heat pipe radiator for cooling, and a pair of rate gyroscopes are installed. The structure will ultimately extend the length of a football field.

Thanks in part to Boeing's Truss Design Team, the international crews are successfully building, operating and powering up the amazing International Space Station, currently weighing in at over 400,000 pounds, measuring 146 feet long, 240 feet wide, and 90 feet high. Aluminum extruded tubing is used in much of the truss structures, including a dozen outboard and inboard truss sections designed by Boeing engineering teams in Canoga Park and Huntington Beach, California. Forty-three space flights will be conducted over the course of the station's construction.



The ISS, in October 2000, following deployment of the Z1 truss structure.

Bob Josker, Director of Outboard Truss & Manufacturing at Boeing, Karl Wefers, Boeing's Manager of Materials & Process on the ISS Space Program, and John Badalich, Boeing's Manager of the Outboard Truss Elements at Boeing Canoga Park, agree that aluminum extrusions provide the excellent mechanical properties needed for this mission-critical application. Josker sites the outstanding ease of machinability that makes the extruded aluminum so easy to work with. "We get a consistent extruded part with a good anodized finish," Josker notes, "Direct extrusion through the die shape allows excellent quality and surface finish."

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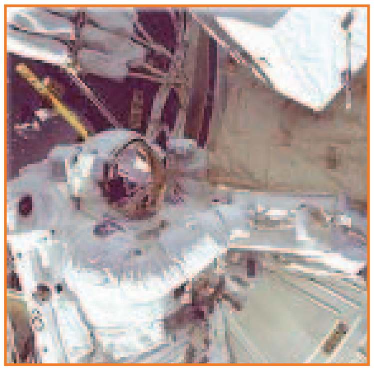

An astronaut performs external tasks on the ISS's U.S.-built Unity Node.

Against the backdrop of Earth and space, the ISS separates from Space Shuttle Endeavour during undocking over western Kazakhstan in June 2002.

Engineers and crew are pleased with the trusses' stable performance in orbit. The truss teams' Wefers affirms, "The electrical power system the trusses house has provided 100 percent power availability since solar array deployment in December 2000." He sums up, "Aluminum extrusions will always be considered for future structures in space, because the extruded aluminum's mechanical and optical properties are so ideally suited to space applications."

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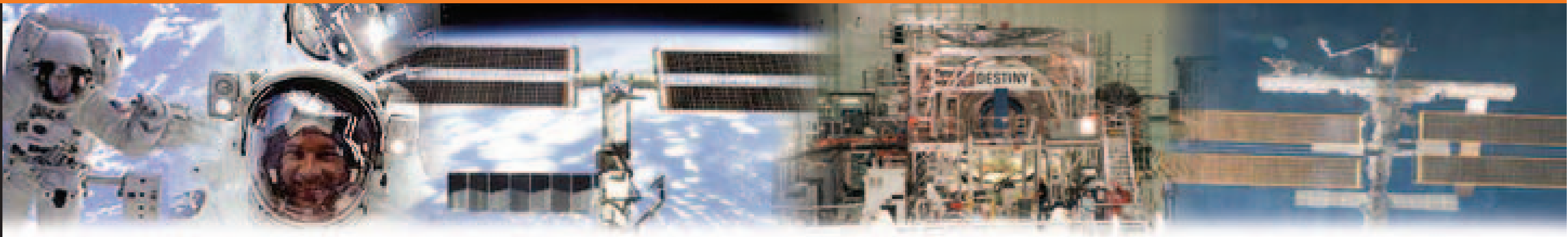

ENGINEERS DIVE DEEP TO ENSURE SAFETY

An astronaut wears a training version of the extravehicular mobility unit (EMU) space suit during an underwater simulation of a space walk, conducted in the Neutral Buoyancy Laboratory in Houston, Texas.

Boeing engineers in Canoga Park and Huntington Beach work closely with Boeing personnel in Houston, Texas—the systems integrator is the prime interface with NASA. An ISS "Neutral Buoyancy" mock-up was constructed and assembled under water to simulate on-orbit conditions. Astronauts provided feedback early in the truss design cycle, influencing the current design. Thorough testing and review provided the truss design team with lots of practical feedback on assembly, maintenance and safety issues.

Surrounded by Kennedy Space Center workers in the Space Station Processing facility at KSC, Florida, in February 2004, Boeing senior truss manager Chuck Hardison (left), presents the "key" for Starboard truss segments S3 and S4 to Scott Gahring (center), ISS vehicle office manager, Johnson Space Center.

Truss design and test teams support the Kennedy Space Center in Florida with launch integration activities, test coordination, and multi-element integrated pre-launch systems testing.

This view of the Space Station Processing Facility shows elements lined up in various stages of preparation for future flights to the ISS.

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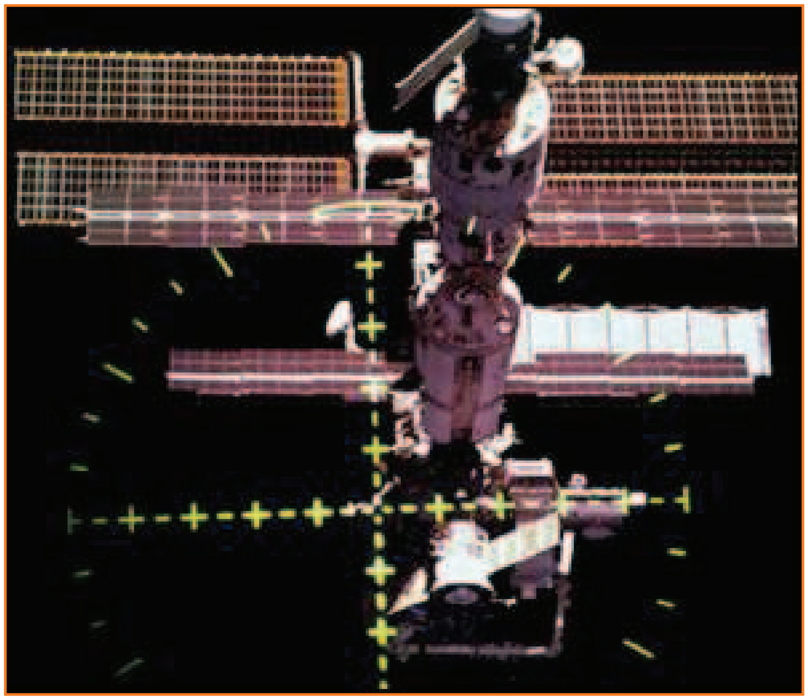

The ISS in sunlight and shadows, viewed by the Space Shuttle Discovery's crew optical alignment system (COAS) during separation operations, in August 2001.

During truss component assembly in space, the on-orbit thermal environment's effects are challenging. Boeing's Badalich explains, "In space, direct sunlight and shadowing cause wide swings in temperature when joining truss elements, so the truss-to-truss attachment interface is critical. The trusses' large extruded tubes provide stability to the attachment interface, along with additional thermal expansion/contraction compliance being incorporated into the attachment design." Josker adds, "The primary structural truss members feature large elements of extruded aluminum tubing that are fastened together with stainless steel bolts. In these structural joints, extruded aluminum tubing provides the lightest possible weight, yet retains the greatest strength. The anodized surface finish on the extrusions provides superior optical properties, because anodized aluminum doesn't get as hot, giving better overall thermal control."

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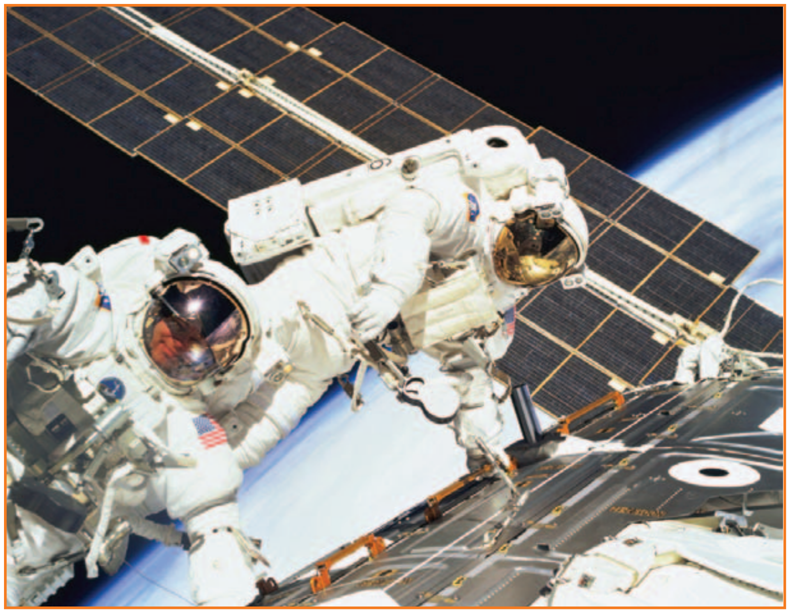
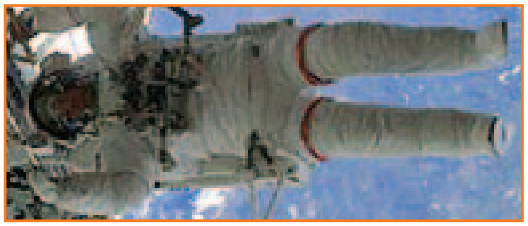
A SAFE HAND-HOLD IN SPACE

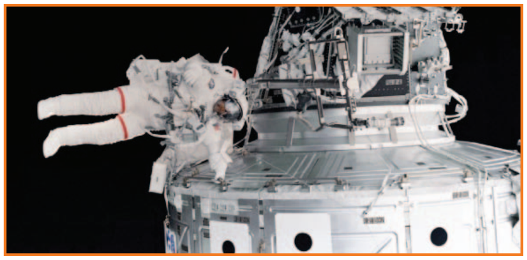
EXTRUDED ALUMINUM TRUSS STRUCTURES LINK STATION MODULES TOGETHER IN THE MOST COMPLEX SCIENTIFIC VENTURE IN HISTORY

Extruded aluminum handrails are both anchors and lifelines for every ISS astronaut—keeping them from floating off into outer space when they venture outside on a space walk, or EVA as they are called (extra-vehicular activities). Handrails are anodized in a bright gold finish to stand out visually against the clear silver truss structures—an essential point of safety for every crewmember on an EVA. Critical to all EVAs are the hundreds of extruded aluminum handrails covering the exterior of the International Space Station, which allow the astronauts to negotiate the vast truss structures during construction assemblies. Handrails are also used to tether lines that attach to crew and equipment for tests and repairs that occur round the clock, 365 days a year. Each handrail is distanced apart from the next one by the length of an astronaut's reach.



Get a grip! Mission specialists work together on the last of three space walks on mission STS-88. They both have a firm grasp on the gold-anodized extruded handrails.





Hanging tough: During space walks, astronauts rely on every extruded aluminum handrail to do its job without fail. Handrails are always within reach, serving as tether anchors for equipment, and lifelines for the ISS crew.

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The Russian Mission Commander (top), U.S. science officer and flight engineer (center), and European Space Agency astronaut (bottom) of the Expedition 9 Crew prepare to board the Soyuz TMA-4 vehicle for their launch to the ISS on April 19, 2004.

Between April and October 2004, Expedition 9's commander and ISS astronauts monitor the arrival of two Russian Progress re-supply ships, upgrade the station's computer software, work with the station's robotic arm (Canadarm2), and conduct scientific experiments. During EVAs, astronauts will install retro reflectors and communications equipment needed for the docking of the European Automated Transfer Vehicle, the cargo ship taking flight next year.

Boeing's truss structures and handrails are, and will continue to be key components in the International Space Station's success, and critical to the ISS crews' safety, thanks in part to the long-term attributes of reliable, strong, lightweight, and cost-effective aluminum extrusions.

For additional information on crew activities aboard the ISS, and sighting opportunities from Earth, log on at: http://spaceflight.nasa.gov/

The European astronaut returned to Earth with the Expedition 8 crew on April 30, 2004, while the Expedition 9 crew continue to work and live aboard the ISS, returning in October, 2004.

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Aluminum extruders providing truss and handrail extrusions for the ISS include: Alcoa, Inc., Kaiser Aluminum, Hoogovens/Reynolds, and LeFiell Manufacturing. Watch for more extruded aluminum application stories in future issues!

If you have an application story to share, email the Showcase staff at: mail@aec.org

ALuminum Extrusion SHOWCASE
INNOVATIONS TAKING SHAPE