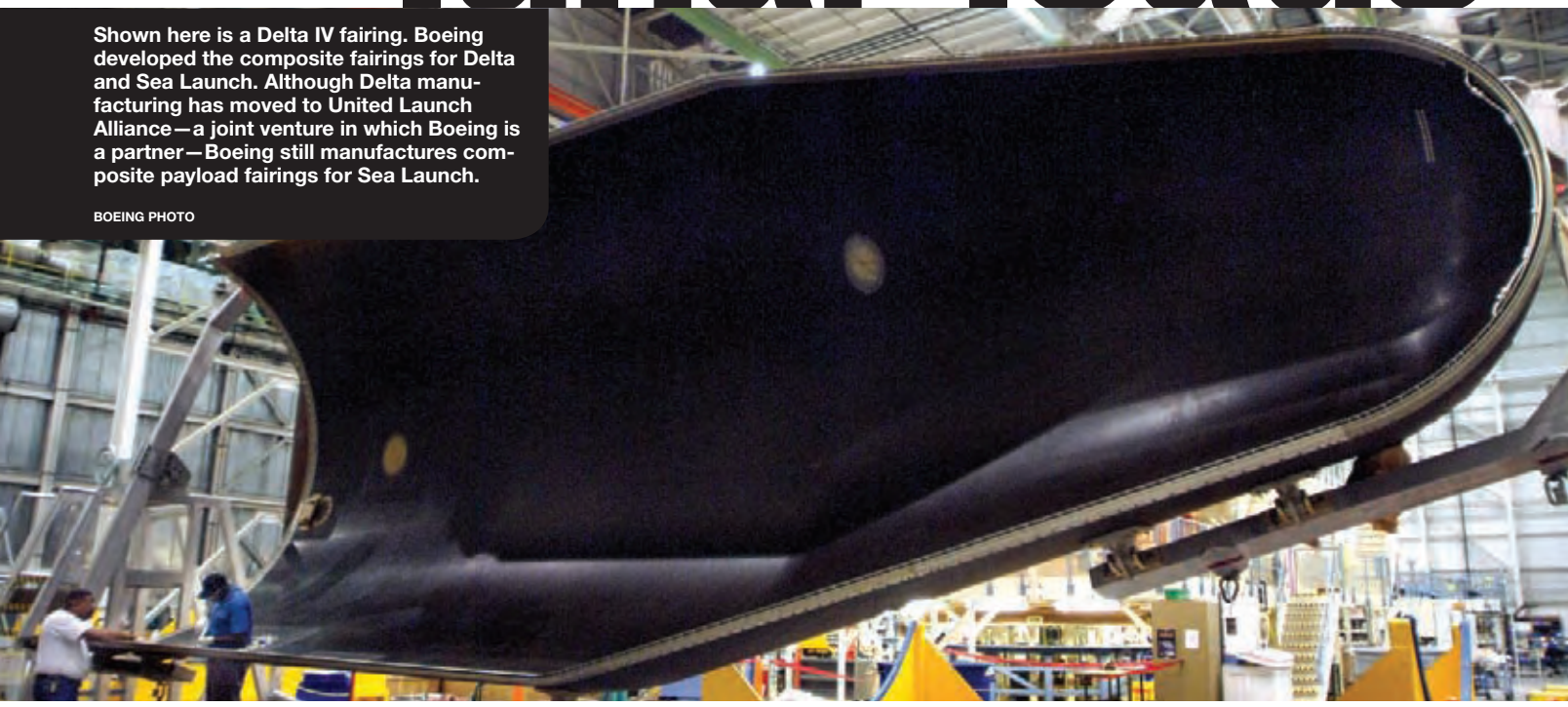
Lighter lunar loads

Boeing's knowledge in composites can cut cost for return to the moon



Shown here is a Delta IV fairing. Boeing developed the composite fairings for Delta and Sea Launch. Although Delta manufacturing has moved to United Launch Alliance—a joint venture in which Boeing is a partner—Boeing still manufactures composite payload fairings for Sea Launch.

BOEING PHOTO

By Ed Memi

Boeing is sharing with NASA composites expertise from its commercial airplanes, space and defense programs to help reduce the weight and development costs of new rockets and vehicles planned for a return to the moon by 2020.

Large composite structures, which can be 20 percent to 30 percent lighter than comparable aluminum structures, are being studied for use on elements of NASA's Constellation program, including the Ares I crew launch vehicle, Ares V cargo launch vehicle and the Altair lunar lander. The lower mass of composite structures will enable larger payloads to be transported to and from the moon, and eventually to Mars. Composite structures also can be less labor intensive to manufacture.

Composite material typically consists of high-strength fibers embedded in a resin matrix, such as epoxy, that is heated under pressure to form finished parts and structures. Composites are pervasive today, used in products from automobiles to sporting goods to aircraft. Boeing uses composites in jetliners such as the 777 and the 787 Dreamliner, and in military aircraft such as the F/A-18 fighter attack aircraft and Bell-Boeing V-22 tilt rotor. The company also uses composites in launch vehicles, satellites, missiles, ground vehicles and unmanned air vehicles.

The 787 employs more composites than any other commercial jetliner in production today. "Besides the strength and weight advantages, Boeing also is projecting a reduced lifecycle cost, because you do not have the corrosion issues that aluminum airplanes have," said Brice Johnson, a Phantom Works engineer and a Technical Fellow.

Boeing Ares I upper stage composites lead Don Barnes, who works alongside NASA at Marshall Space Flight Center in Huntsville, Ala., has a mission to show NASA how composites can be applied to future spacecraft. Similarly, NASA has expressed interest in Boeing efforts, and its representatives have toured Boeing commercial-aircraft and defense-program facilities to learn more about Lean composite manufacturing.

Composites currently are in use in other space applications. The Delta IV launch vehicle uses composites in all major structures except its cryogenic tanks. Boeing Commercial Space Company currently builds composite fairings and payload-accommodation structures for Sea Launch rockets in its Seattle facility.

Boeing will manufacture a composite interstage, systems tunnel and various small shrouds, fairings, covers and doors for the

Ares I rocket, under current plans, when it begins production in late 2009 at NASA's Michoud Assembly Facility in New Orleans.

Barnes said he sees numerous applications of composites for lunar landers and habitats. "Their lighter weight is a key advantage, since getting things to the moon is quite expensive," he said. "Another benefit is better radiation protection inherent in composite materials."

Boeing intends to use composites on launch-vehicle propellant tanks as well. "No other company surpasses Boeing in the utilization and knowledge of composites, including the development of cryogenic tanks. We've built four large tanks and we've done significant development work at the structural element and coupon level," said Michael Robinson, an Associate Technical Fellow who works in Phantom Works structures research and development at Huntington Beach, Calif.

Boeing—through predecessor company McDonnell Douglas—learned about composite cryogenic tanks when it built and flew the world's first composite liquid-hydrogen tank as part of the DC-XA test program during the 1990s. The program built a vertical-takeoff-and-landing launch vehicle much like a prototype lunar lander. Both Barnes and Robinson worked on the DC-XA program.

Johnson is working with Boeing's Space Exploration team on payload fairings and 10-meter/33-foot-diameter cryogenic tanks for the Ares V. With more than 18 years' experience with composites, his primary focus has been in automating the manufacturing of composites for Boeing.

"The 10-meter tanks for Ares V are well beyond anybody's current capability. However, all the manufacturing process and tooling that we developed on the 787 are scalable to larger structures," he said.

Dianne Wiley, a Technical Fellow for Boeing Space Exploration, is working with colleagues from Phantom Works and Integrated Defense Systems on utilizing technologies developed in other programs to leverage and tailor them to new programs.

"We are evaluating the potential development of a large cryogenic tank demonstrator in the Ares I class to demonstrate manufacturing technologies that could be scaled up in anticipation of an Ares V application," she said. "Composites are a way for us to tailor the structure to the load environment and to make the most efficient types of structures that we possibly can. This is very exciting because they are infinitely variable and 'tailorable' to the application."

Mark Cleveland is a principal engineer in advanced design for structures and materials for Boeing Phantom Works. His first job with composites structures was leading the design and build of the 3-meter/10-foot-diameter composite Delta II fairing in the late '80s. He then moved on to lead development of the Delta III 4-meter/13-foot- and Delta IV 5-meter/16-foot-diameter composite fairings. "It is much cheaper today to use composites because the aluminum fairings are so labor intensive. By unitizing the structure with composites, we eliminated 90 percent of the piece parts," Cleveland said.

Cleveland is helping NASA develop its vision for a 10-meter-diameter Ares V fairing by combining the best Boeing and Sea Launch capabilities. "We are currently exploring design and construction options in trying to figure out the best way to fabricate and transport this massive fairing." ■

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David Frost (from left), Boeing Commercial Space Company, Sea Launch Systems Engineering and Integration manager; Todd Mather, BCSC program manager; and Kevin Davis, senior principal engineer for 787 Fuselage Structures, examine the 787 Section 46/47 Fuselage Structural Test Article. Boeing showed a team of NASA officials some of the innovative uses of composites on the 787.

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