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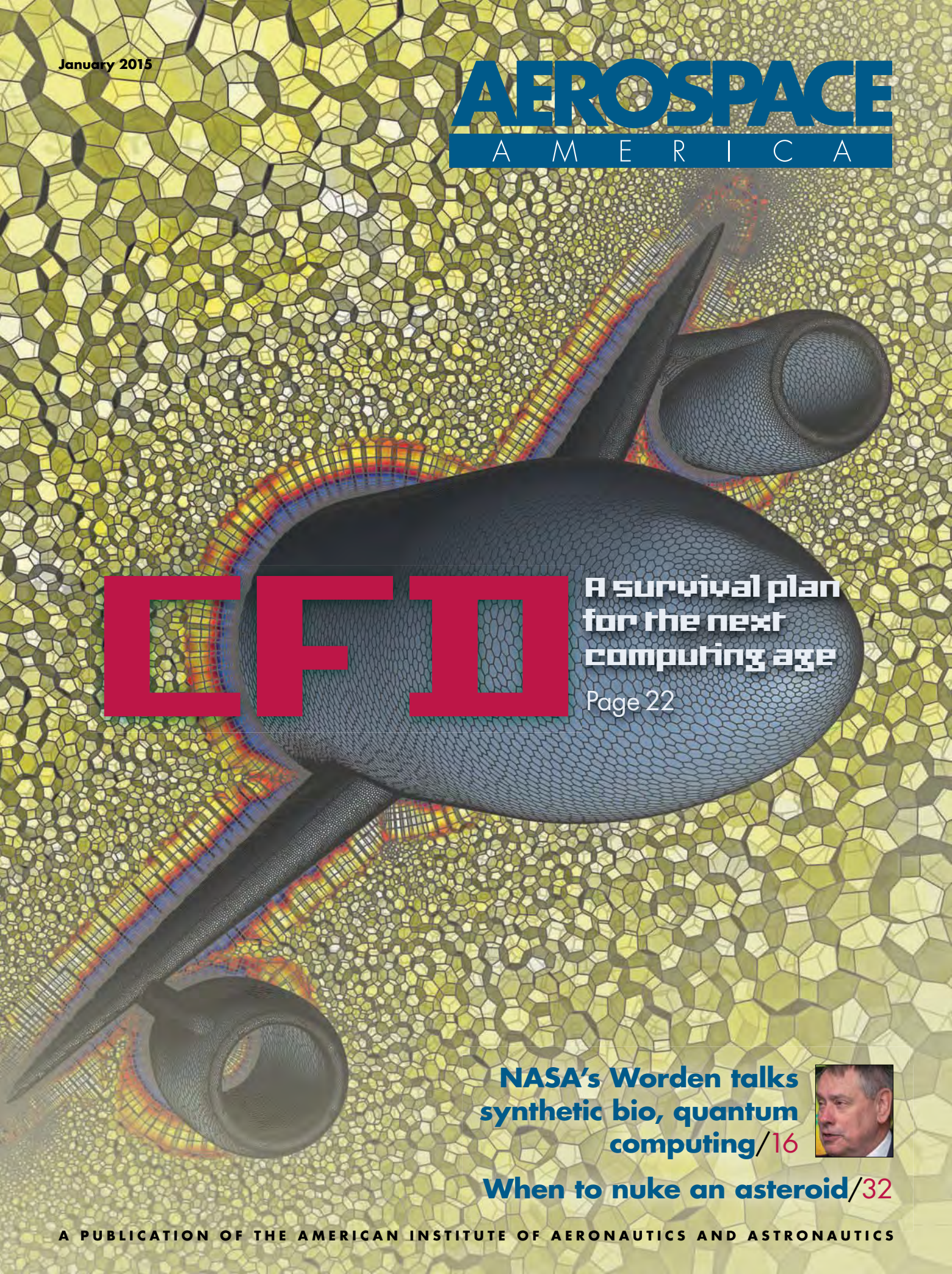

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Parsing Orion

With Orion now safely back on Earth, NASA and Lockheed Martin will be tearing down the capsule and analyzing data from sensors aboard the vehicle to answer some big questions, including how well the capsule's heat shield held up during the re-entry and what the ride would have felt like had astronauts been aboard during the Dec. 5 inaugural flight.

Engineers will use the findings to tweak the design of the second Orion now in development for Exploration Mission 1, an unmanned test run to the vicinity of the moon planned for 2018. Astronauts are expected to ride inside Orion for the first time on Exploration Mission 2 in 2022, a shakeout flight to the neighborhood of the moon or possibly an asteroid, if one can be pulled into range. If EM-2 goes off on time, the mission will occur 50 years after the final Apollo mission — Apollo 17.

Lockheed Martin is contractually obligated to analyze data from sensors distributed throughout the cabin and from avionic boxes in the crew vehicle and report findings to NASA within 90 days of the splashdown. The spacecraft was to be trucked back to Kennedy Space Center in Florida by Christmas for the start of teardown, Mike Hawes, Lockheed Martin's Orion program manager, told reporters. NASA plans to refurbish the spacecraft and use it in a 2018 test of Orion's launch-abort system.

"It looks like it flew very close to what we expected, but we have 1,200 sensors, thousands of pieces of data that we're going to get back, and I'm sure we're going to find some very interesting things about how it behaved," said Mark Geyer, NASA's Orion program manager. "That's really important for us as we get ready for the next mission."

For NASA veterans, Exploration Flight Test 1 bore some resemblances to the unmanned Apollo 4 mission in 1967, which marked the first time a Saturn 5 rocket launched an Apollo service module to orbit. EFT-1, however, did not carry a fully operational service module. That will happen on the 2018 Orion mission, when a European Space Agency service module provides electricity and propulsion. The new module will be developed by Airbus from the design of the Automated Transfer Vehicles that make supply flights to the International Space Station.

Orion's first flight and splashdown looked picture perfect, but aerospace engineers know there are always lessons to be learned. In the coming weeks, NASA and its contractors will be taking Orion apart and studying reams of performance data with a goal of improving the design and opening deep space for exploration. Craig Covault and Marc Selinger explain.

by Craig Covault and Marc Selinger

New recovery method: Apollo-era capsules were hoisted aboard Navy ships after the crew exited the spacecraft in open water. Orion crews will get out once the capsule is safely in the well deck of an amphibious ship.

U.S. Navy

ANALYZING THE FLIGHT

HEAT SHIELD ANALYSIS: The recorded data and structural heat shield analysis could result in significant heat shield changes, officials said. Even before the December mission, managers were not entirely satisfied with the structural strength of the shield, especially for longer flights. In this case, the shield did its basic job of getting Orion through the atmosphere in one piece. "The Orion looks in great condition," said NASA spokeswoman Amber Philman, who witnessed the descent and retrieval of the Orion from on board the recovery ship USS Anchorage in the Pacific Ocean southwest of San Diego.

On Orion, 320,000 fiberglass-phenolic cells hold a foam-like material called Avcoat, which ablates, or wears away, during re-entry to shed heat. NASA describes the material as an improved version of the recipe flown on the Apollo missions.

One factor in considering changes will be the manufacturability of the heat shield, which is 16.5 feet across. Cost and workload impacts must be weighed, NASA's Bill Gerstenmaier, associate administrator for human exploration and operations, told reporters.

VERIFY AERODYNAMIC AND THERMAL MODELS: The comparison of preflight thermal and aerodynamic wind tunnel and computer models to actual Orion data will be critical in the post-flight analysis, said Darlene Pokora, who manages Orion work at Langley Research Center. Other members of the Orion "Aero Team" are the Johnson and Ames Research Centers, she said. They all have months of Orion data analysis ahead of them, Pokora said.

While temperatures on the blunt face of the heat shield were expected to peak at 4,000 degrees Fahrenheit, the side of the spacecraft was expected to be a bit cooler, about 3,150 degrees. There, 970 black silica tiles like those used on the belly of the space shuttle were to keep the inside of the spacecraft relatively cool. How cool it stayed inside must yet be pulled out of the data.

VAN ALLEN RADIATION BELT AVIONICS DISRUPTIONS: A key element in the analysis will be how well Orion's computers and other avionics coped with two passages through the Earth's Van Allen radiation belts. Hawes noted that while the last generation of avionics was heavily shielded from radiation, the newly designed space-qualified avionics have chips designed to take radiation hits, then "fix themselves" if damage is detected.

DEMONSTRATE CRITICAL SEPARATION EVENTS: During ascent this included the separation of three 13-by-14-foot service module side panels. These protected the simulated internal components of the dummy service module during launch and provided structural support. That occurred at 6 minutes, 15 seconds after liftoff and was done to reduce Orion's weight.

The launch abort system, inactive and minus propellant for this flight, also separated as planned just after the panels.

At 3 hours, 23 minutes into the flight, just after reaching apogee, the crew module separated from the service module, which remained attached to the Delta's second stage.

The remaining critical separation events occurred at the end of the re-entry and included separation of the forward bay cover, exposing two 23-foot-diameter drogue parachutes. They deployed as the vehicle fell through 25,000 feet at 300 miles per hour, slowed tremendously by the friction of re-entry. The drogues were followed by three smaller pilot chutes that pulled out the three 116-foot-diameter main parachutes, which slowed the vehicle to 20 miles per hour at about 7,000 feet above the ocean.

DEMONSTRATE MISSION CONTROL OVERSIGHT: Monitoring of the vehicle from the Johnson Space Center in Houston was a key element of the flight. This involved oversight of all major systems in the spacecraft, including flight control during the descent using one of two redundant thruster strings. The NASA flight director in Mission Control was Mike Sarafin, while the Lockheed Martin mission director was Bryan Austin at the Cape Canaveral launch site.