Georgia Institute of Technology
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THE RIGHT SIGNALS: UNIQUE ANTENNA DEVELOPED AT GEORGIA TECH ENSURES CREW COMMUNICATIONS ON THE INTERNATIONAL SPACE STATION

A unique antenna designed and built at the Georgia Institute of Technology for NASA and The Boeing Company is now part of a vital crew communication system on the International Space Station.

Shaped like a bathroom towel bar, the 2-foot-long Orlan Antenna is located in the cramped cylindrical airlock that space-walking astronauts use to exit and enter the space station for construction, maintenance and other activities.

Its unique design allows the space station crew to communicate with users of the Russian-built Orlan spacesuits during critical times when they are preparing to enter space through the airlock.

Because of its placement in the airlock, the dual-band antenna was designed to serve as a hand- or foothold for astronauts clambering into space -- and to survive large temperature changes and bashing by equipment the astronauts carry.

But the most difficult design challenge came from the antenna's environment: It must work reliably inside the conductive airlock structure despite electromagnetic energy patterns that change constantly with the movement of astronauts. Most antennas are designed to work on the exterior of an aircraft or spacecraft.

"This was a very challenging design because we were essentially working with an

Georgia Tech researchers used this scale model astronaut inside a scale model crew air lock to design a special antenna needed to maintain communication with the International Space Station's crew.

antenna inside a metal can," explained Barry Mitchell, senior research engineer with the Sensors and Electromagnetic Applications Laboratory at the Georgia Tech Research Institute (GTRI). "The conductive walls of the airlock reflect signals back to the antenna, and bounce them around inside the cavity. The astronauts in the chamber also perturb the antenna patterns and make them difficult to predict."

Further complicating the challenge were the frequencies used by the Russian spacesuits -- 120 and 250 Megahertz. The 120-Megahertz frequency was barely short enough to resonate inside the airlock's 63-inch diameter,

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necessitating an antenna so large that it could serve double duty as a handhold.

Working with Boeing engineers based in Huntsville, Ala., GTRI researchers considered three types of antennas before settling on the half-loop design that resembles a towel bar. Boeing had hoped to use a patch-type device similar to the antenna used for the U.S.-designed spacesuits that also use the chamber.

But testing showed a patch antenna for the Russian frequencies would have been too large for the chamber to accommodate, says Victor K. Tripp, who led development of the antenna during the 1990s as a GTRI principal research engineer.

"There just weren't many parameters that we could adjust," he added.

To develop and test their designs, the Georgia Tech research team built a 1:6 scale model of the airlock, complete with 1-foot-tall scale model astronauts covered with a conductive metal coating to simulate their spacesuits. Electromagnetic energy measurements taken inside the scale model complemented two different computer techniques in determining and evaluating the options for antenna configuration, size and placement.

"How the astronaut or astronauts are oriented in the airlock affects how well the antenna works, and the antenna had to work no matter what the positions of the astronauts," Tripp explained. "The modeling suggested that signals were generally better when there were two astronauts in the chamber, rather than with just one."

After study at GTRI's Atlanta facilities, the prototype antenna -- 2 feet long and raised 4 inches off the metal wall -- was tested in a full-scale mockup of the airlock at the Johnson Space Center in Houston. Measurements made there closely approximated predictions from the GTRI modeling and scale-model tests.

Dependable operation of the airlock antennas is essential. While astronauts wait within the lock sealed in their spacesuits, the antennas must carry verbal communication between astronauts and crew, and also transmit vital signs and other data necessary to monitor the physical condition of each astronaut and spacesuit. For instance, cooling equipment in the spacesuits must be monitored at all times to make sure the astronauts do not become too hot.

The Orlan Antenna operates with the Russian-designed spacesuits used on the space station. In these suits, a conductive metal film that is part of the insulation system serves double duty as the antenna, with the upper and lower halves of the suit insulated from each other. The larger U.S.-designed spacesuits use a different communication system with higher frequencies and a discrete antenna.

As part of the STS-104 mission, the shuttle Atlantis delivered the Boeing-built airlock to the International Space Station in July 2001. Until the installation of the structure -- known as Quest -- U.S.-designed spacesuits could only be used when a shuttle was docked with the space station and astronauts could use its airlock.

Manufacture of the nickel-plated aluminum antennas provided GTRI with an education on high-reliability, space-qualified hardware. Each design and production step required extensive documentation and testing in compliance with ISO 9000 quality requirements.

"The level of work, the quality required and the level of documentation and testing were unprecedented, much more than is required for military specifications," Mitchell said. "We got a new appreciation for space-qualified hardware."

The 4-year project produced two flight units, two qualification units and a spare. GTRI also produced a single engineering model that was used for the preliminary design and testing.

Also contributing to the project were William Cooke, Greg Hampton, Cal Jameson, Jeff Kemp, Kerry Pullen and Al Vineyard, all of GTRI. # # #

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