TWO ROBOTS, ONE OF A KIND
Boeing's new dual robotic antenna measurement system (DRAMS) lab, located in Seattle, is the only known 14-axis antenna range. The robot shown here is one of two in the DRAMS anechoic chamber (free of echoes and reverberation).

Robot Room

Dual robots provide faster, more accurate antenna testing

BY MICK BOROUGHS, BOEING WRITER

Decades ago, it was quite common to see an antenna strapped to a chimney to get the best TV reception or attached to the hood of the family station wagon to pick up a favorite song on the radio. Antennas were a silent part of everyday life all over the world.

ALL PHOTOS: DAVE SIZER/BOEING (UNLESS INDICATED)

DRAMS DREAMERS

Technician Wayne Cooper (left) and engineer Dennis Lewis are part of the team that runs the DRAMS lab in Seattle.

“This is the Boeing precision antenna lab. … All other Boeing labs derive their accuracy from the antennas calibrated here. This gives Boeing the technological advantage, as it is one of the most state-of-the-art ranges in the world.”

WAYNE COOPER,
DRAMS LAB LEAD TECHNICIAN AND
BOEING ASSOCIATE TECHNICAL FELLOW

Though antennas may be less visually obvious in this digital age, they are still everywhere. Nearly everything designed, produced or serviced at Boeing has an antenna, from aircraft to spacecraft.

The antennas are used in the labs to test Boeing products and ensure they meet regulatory and performance requirements. Additionally, they transmit and receive information related to weather data and navigation, and they allow aircraft to communicate with other aircraft and the ground. Antennas also enable communications between satellites and GPS navigation and provide connectivity between portable electronic devices such as cellphones, laptops and tablets.

Each antenna must first be calibrated and traceable to the National Institute of Standards and Technology (NIST), the government agency that manages the antenna standards for the United States. To do that, Boeing uses antenna ranges — such as one in Kent, Washington — to measure the performance of an antenna.

More efficient technology and subsequent safety improvements, however, helped demonstrate the need for an updated calibration and developmental testing center — one that could also drive business results by allowing future consolidation of other existing labs into this new facility.

In May, Boeing opened its new dual robotic antenna measurement system (DRAMS) lab, following four years of planning and development. The lab fits into existing laboratory space in Seattle.

ROOM TO ROAM

The robot on the left moves on a 30-foot (9-meter) track. The robot on the right remains in a fixed position. The floor and the robots can be covered with radar-absorbing foam.

PHOTO: BOEING

MOBILE BOT

A rectangular antenna — 12- to 18-gigahertz standard gain horn — is positioned on the end of the movable robot. The robots provide a wide range of motion and allow the antenna to be placed nearly anywhere in the range.

“This is the Boeing precision antenna lab. This is where Boeing standards are directly compared to NIST standards,” said Wayne Cooper, DRAMS lab lead technician and a Boeing Associate Technical Fellow. “All other Boeing labs derive their accuracy from the antennas calibrated here. This gives Boeing the technological advantage, as it is one of the most state-of-the-art ranges in the world.”

WELCOME TO OUR PAD

This is one of two doors to the anechoic chamber.

The lab includes a 40-by-25-foot (12-by-8-meter) anechoic chamber and comes equipped with a stationary robot on a fixed pedestal. A second robot moves along a 30-foot (9-meter) track. The chamber is covered floor to ceiling by cone-shaped, radar-absorbing foam.

Each cone is filled with polyurethane and carbon to absorb electromagnetic energy. The anechoic chamber is used to keep out unwanted electromagnetic energy, such as cellphone transmissions. The chamber also effectively contains any energy created.

"When the door is closed, nothing gets into that room and nothing gets out," Cooper said. "It is completely shielded."

The lab supports multiple types of tests, including remote testing. It is also adaptable to test new technologies while providing more accurate and faster results.

"We can measure an antenna in a much smaller space — so instead of using a large outdoor testing range, we can measure it in a facility this size," Cooper said. "Anytime you want to know how much electromagnetic energy you have, whether it be antenna gain or volts per meter, you have to have a calibrated antenna."

In the lab's chamber, Cooper steps up 6 inches (15 centimeters) to easily attach the antenna to the robot's arms while the robot is positioned at the chamber's door. At the soon-to-be decommissioned

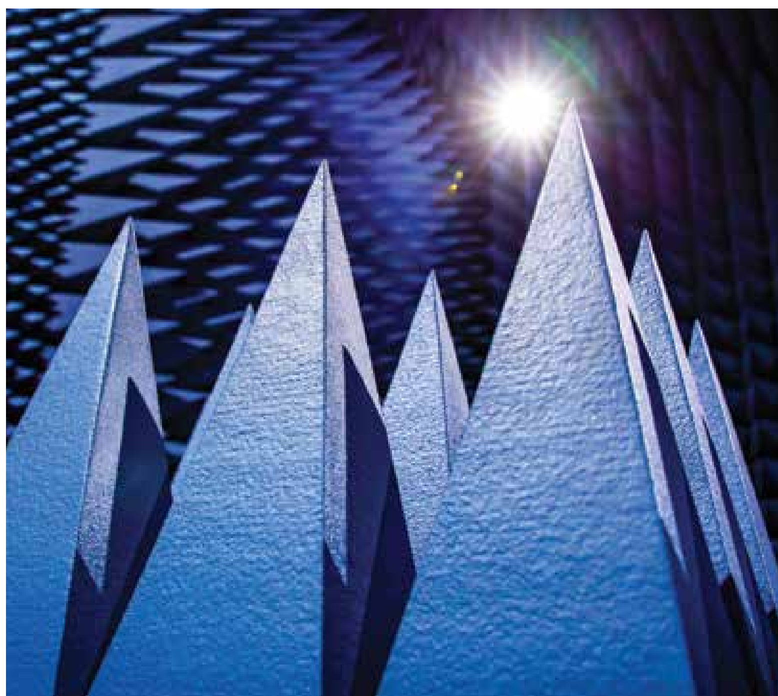
> "When the door is closed, nothing gets into that room and nothing gets out. It is completely shielded."
>
> **WAYNE COOPER, DRAMS LAB LEAD TECHNICIAN AND BOEING ASSOCIATE TECHNICAL FELLOW**

DOOR NO. 2

The larger door into the chamber is 8 feet tall by 10 feet wide (2.4 meters tall by 3.1 meters wide), accommodating large equipment.

MUFFLING MOUNTAINS

The entire chamber is lined with cone-shaped foam to absorb electromagnetic energy.



FLEXIBLE ON THE FLY

In the DRAMS lab, unlike at many ranges, technicians can easily access the robots to make adjustments.

“There is a lot of interest in the antenna community about robots because they are so flexible. We used to have to align the antennas to the room geometry, but that can all be done through the robots now. Before, the axis of motion was fixed. But now with the robots, we can have the axis wherever we want. Previously, we could move one antenna across one straight line. Now we can move that straight line anywhere in the chamber.”

**DENNIS LEWIS,
PROJECT TECHNICAL LEAD AND
BOEING TECHNICAL FELLOW**

Kent range, Cooper and others would need to be safely harnessed before climbing a 15-foot (4.6-meter) platform to set up the calibration. “This is now so much safer and also less expensive to maintain,” he said.

Robots also offer a wider range of capabilities, said Dennis Lewis, project technical lead and a Boeing Technical Fellow.

“There is a lot of interest in the antenna community about robots because they are so flexible,” Lewis said. “We used to have to align the antennas to the room geometry, but that can all be done through the robots now. Before, the axis of motion was fixed. But now with the robots, we can have the axis wherever we want. Previously, we could move one antenna across one straight line. Now we can move that straight line anywhere in the chamber.”

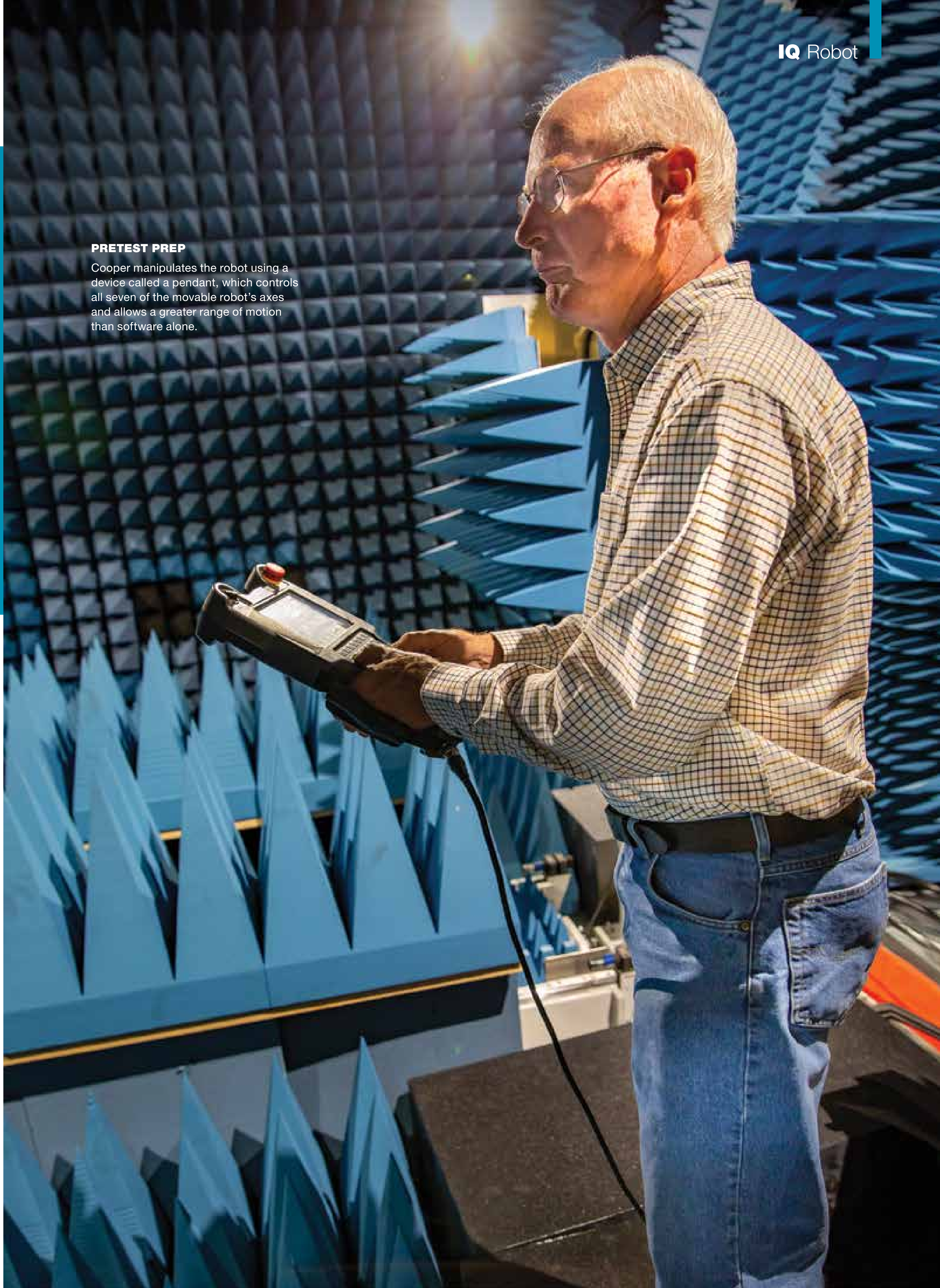
When the lab chamber is in use, the door is shut, and the technician monitors the results on a fully automated control panel. Closed-circuit cameras rotate views from inside the chamber. Array patterns shown on the screen mark the calibration’s progress.

“You can monitor everything from this panel,” Cooper said. “You set up your frequencies, the polarization, and the distances and technique. Those are all important to think about before you run your calibration.”

Over time, a calibrated antenna will need recalibration — sometimes within three years. Parts become worn or damaged, and repairs can change the quality and characteristics of an antenna.

While the calibration is underway, the operator can perform other tasks and return to it when the test is done. “I can process data from a previous run while this is occurring,” Cooper said. “Calibrations that took three days at the Kent range take a few hours at the Seattle lab.”

The test team can also use model-based engineering (MBE), allowing them to run a variety of simulations on the lab’s computer. Using computer-aided design (CAD) models of the chamber, robots and antenna together with electromagnetic simulation software, the antenna can be “tested” digitally before ever entering the test chamber.



PRETEST PREP

Cooper manipulates the robot using a device called a pendant, which controls all seven of the movable robot’s axes and allows a greater range of motion than software alone.

This simulated test, a digital twin, allows the team to analyze the data and the potential electromagnetic impacts of the chamber and robots before the actual antenna ever reaches the lab, potentially saving time and cost.

Another example of how the team uses MBE is analyzing the logistics of bringing a large antenna into the lab. Perhaps a large antenna is scheduled for delivery to the lab from another site. The antenna's dimensions are 5 feet by 5 feet (1.5 meters by 1.5 meters). "We know that results in a 7-foot-wide [2-meter-wide] diagonal array. We didn't want to bring it down here, only to find out it wouldn't fit," Cooper said.

Antennas are shipped to the lab from around the world. While most antennas are from Boeing sites, some of those to be calibrated are from other companies and suppliers.

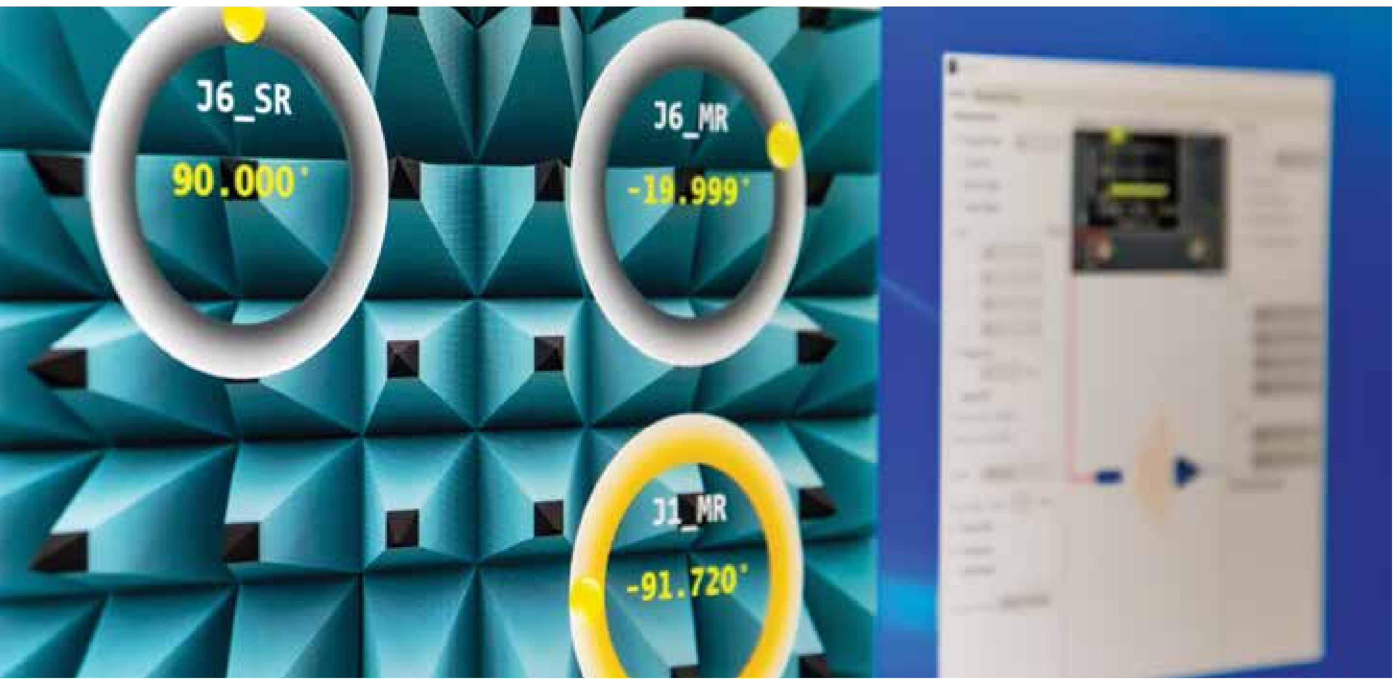
SCREEN TEST

Cooper monitors a current test while processing another at the control panel.

This simulated test, a digital twin, allows the team to analyze the data and the potential electromagnetic impacts of the chamber and robots before the actual antenna ever reaches the lab, potentially saving time and cost.

FULL CIRCLES

This control screen tracks robots' positions, and the operator can click on the gray circles to move robots within the range. The numbers show the rotational position of the SR (stationary robot) and MR (movable robot). The yellow circle (lower right) represents the antenna attached to the MR.



"It's not a big part of our business, as most companies have their own ranges or use a commercial range," Cooper said. "There has to be a compelling reason to send it here. A lot of times it's part of a joint program with Boeing. They know we can do it more quickly."

The lab's future capabilities will include material measurements and electro-optics. It can also test antennas in motion to simulate tracking radar, which was difficult to do in previous testing facilities.

In 2023, the lab will expand to commercial and military radome qualification testing and servicing. Radomes are protective structures on an aircraft that are transparent to radio waves, such as those on a nose cone of an airplane where weather radar is located.

What gives Cooper, now in his 37th year at Boeing, the most job satisfaction?

"That's easy," he responded. "It's innovation like what we're able to do now in this new lab, and that's followed closely by customer satisfaction." **IQ**

BOOST YOUR IQ!
Video: Meet the team.
See the robot in action.

IQR