
RADAR INNOVATIONS LABORATORY
2.0
4.0

Ahead of the Storm

Pioneering. World-class. State-of-the-art. Cutting-edge. All adjectives that almost have become cliché in these times of rapidly developing technological research and application.

Yet, there are few other words that aptly describe the new Radar Innovations Laboratory, located just east of the National Weather Center on the University of Oklahoma Research Campus in Norman.

Other descriptors—these decidedly not typically associated with a research facility—also define the RIL: Informative. Interactive. Fun. So much so that any visitor gets a true and personal sense of what happens there upon entering the front door.

The 35,000-square-foot building includes two precision anechoic chambers, the latest in testing equipment, a high-bay garage for mobile radar trucks, prototype fabrication facilities, a

AT LEFT: Robert Palmer, associate vice president for research and director for the Center for Applied Research and Development, left, and Tian Yu, interim director of the Advanced Radar Research Center, chat with OU student Kacie Shoemaker in the lobby of the newly opened Radar Innovations Laboratory. The terrazzo floor is designed to form the Smith Chart, used for electromagnetic analysis and known by all radar engineers.

The University's reputation for excellence in weather-related research has spawned a world-class research facility on the leading edge of radar technology.

By Debra Levy Martinelli
Photos by Robert Taylor

machine shop and an experimental observation deck where large, advanced radars will be mounted and tested.

The building also features a seminar room for presentations, a collaboration area known as the Bird's Nest with whiteboards, whiteboard-covered tables and beanbag chairs to encourage creative thinking, problem solving and team building; and on the lighter side, a combination kitchen/game room and a basketball court.

Eighteen faculty and research scientists, over 60 students, 15 post docs and eight staff members of the Advanced Radar Research Center (ARRC) occupy the building.

But let's start with the lobby.

"The lobby represents our story, and one of our goals was to inform the public," says Robert Palmer, associate vice president for research on OU's Norman campus and Tommy C. Craighead Chair in the School of Meteorology. "We are a state university. One of our most important jobs is to educate the people in Oklahoma. I really mean that. It's not a cliché. We're all professors, and we teach students who come to school here. But we also owe the citizens of Oklahoma something because they pay a lot of our salaries. We want them to experience what radar is and what it can do."

Through a clear glass wall etched with engineering calculations (the final selections were the winners of a student competition), visitors can see rows of work stations, all with computers and some covered in wires, electronic components, switches and other materials indicating radar fabrication, refining and testing are in process.

A Smith Chart—a classic graphical method of doing intricate electromagnetic calculations—is the centerpiece of the terrazzo tile floor design.

A small light radar called Lidar shoots out tiny beams that detect objects and their movement that then are converted into images displayed on a large wall-mounted monitor. Anyone in the lobby can see themselves walking, swinging their arms, and maybe even jumping or dancing a step or two.

The lobby's "wow factor" is a recently installed tornado simulator. When the Lidar interacts with the tornado, a true representation of the origins of OU's weather radar program is created.

Doctoral graduate students John Meier, left, and David Bodine work inside one of the mobile radar vehicles. This one contains the Cylindrical Polarimetric Phased Array Radar (CPPAR). Built in part by OU students and faculty, there is no other radar like it in the world. The CPPAR can scan a storm rapidly with very high quality polarimetric products, meaning it can distinguish clearly among different types of hydrometeors such as hail, rain, and snow.

The now-famous mobile radar trucks used for storm chasing are visible through a glass door in the lobby that leads to the high-bay garage, which contains a large crane used to build the trucks and pull the antennas off them. More radar trucks are stored in an adjacent secure parking area.

"The whole idea for this facility grew out of severe weather and weather radar," Palmer says. "Honestly, if it weren't for tornadoes, none of this meteorological machinery that we have here in Norman would be here."

That story began in the 1960s when the National Weather Service established the National Severe Storms Program,

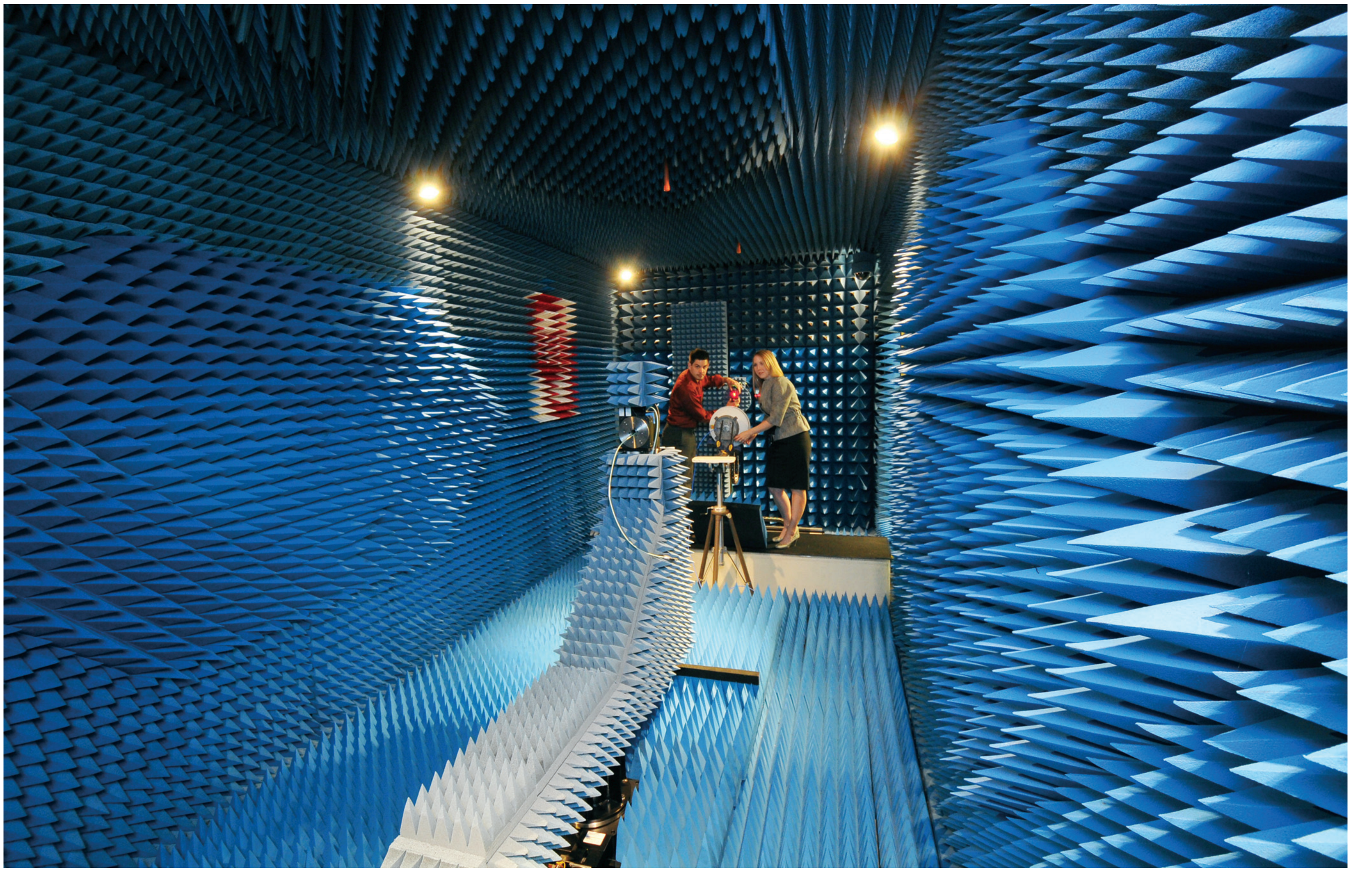
Doctoral graduate students Feng Nai, left, and Jim Kujdzo are among young researchers who have the opportunity to work with the CPPAR, giving them experience in the latest radar technology.

which later became the National Oceanic and Atmospheric Administration's National Severe Storms Laboratory. About the same time, OU created its School of Meteorology.

"Excellence in one area of research sometimes leads to excellence and expertise in broader areas. This is certainly true in the case of radar capabilities at OU," says OU President David L. Boren. "The University's first intensive study of the use of radar started with the use of radar equipment in the prediction of weather. Our radar research then expanded broadly into other areas. The new Radar Innovations Lab will keep OU on the leading edge of the development of radar technology and its interdisciplinary applications."

"The reason I'm here and the reason a lot of the faculty in this building are here is because President Boren started the University's strategic radar initiative in 2004," Palmer relates. "We still do tons of research on tornadoes, but this building is about all aspects of radar."

The word radar originally was an acronym for "radio, detec-



In the smaller of two anechoic (echoless) chambers at the new Radar Innovations Laboratory, Jessica Ruyle and Caleb Fulton can set up electromagnetic experiments to determine what direction an antenna is sending high-frequency electromagnetic waves, how the waves bounce off an object and what direction they are bouncing. The small chamber also has a near-field measurement system that can measure every antenna within a phased array of antennas to determine how the array of antennas is working together.

tion and ranging," so it's fitting that a wave theme runs throughout the two-story building. The imagery is represented in roof tiles and awnings on the exterior and ceilings, walls, art and furniture on the interior. There are wave-shaped backless benches and wave-patterned upholstery.

The end goal in this functional facility with futuristic decor is ambitious but simple: to develop next-generation radar, microwave electronics and related technologies and educate OU students in the expanding field of radar.

Much of that is expected to happen in the RIL's two anechoic—or echoless—chambers where scientists conduct controlled weather radar experiments. Measuring 27' x 38' x 27' and 13' x 26' x 13', respectively, the chambers' thick metal walls block radio waves from getting inside. A spiky, colorful absorbent lining prevents waves emitted during the experiments from bouncing. Each chamber contains apparatus for hanging and rotating objects for radar cross-section measurements of up to 50 GHz. (1 GHz represents 1 billion cycles per second; the average speed for a laptop computer microprocessor is less than 3 GHz.)

"This lab is designed to promote collaboration, enhance communication and inspire new ideas."

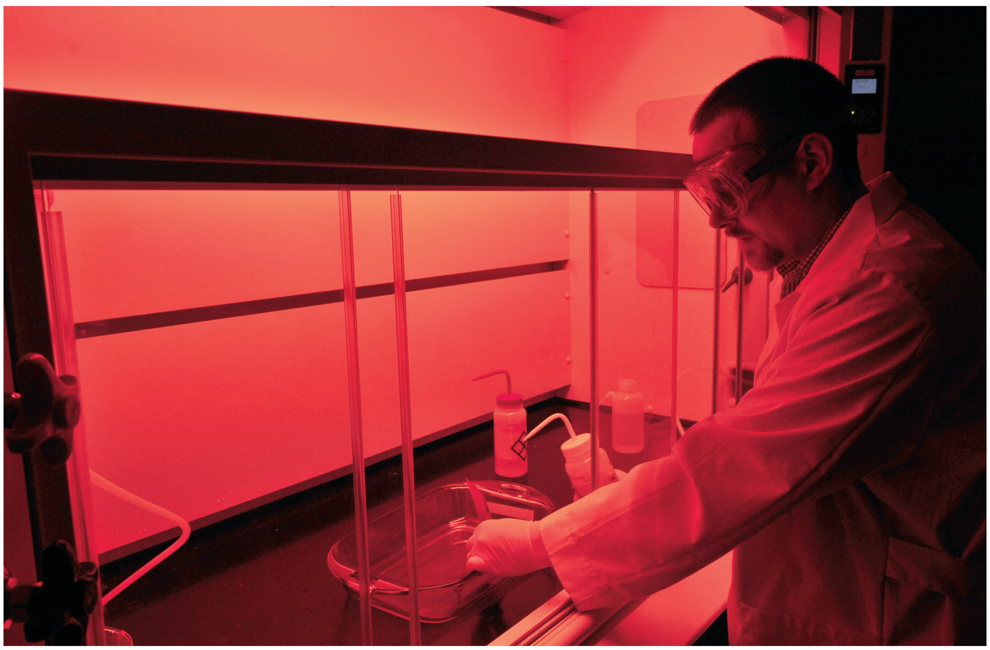
Palmer uses the chambers for a new research project that examines radar signatures from tornadic debris ranging from two-by-four wood pieces and tree limbs to sections of roofs and walls.

"If you're in a tornado, the wind might cause damage, but it's the debris flying around in the wind that cause most of the casualties and damage. A piece of wood flying at 100 miles an hour can kill you," he says. "When we put an actual piece of debris in the anechoic chamber and hit it with a small radar, the radio waves hit only the debris. They don't bounce off the walls, and there's no interference from the outside. Therefore, we know what we get back is solely from that piece of debris. Then we can change its orientation and hit it again. This is the experimental path to actually understanding radar echoes from tornadic debris."

In addition to those ordinary objects that become lethal weapons during a tornado, Palmer's group also studies the effect of even smaller, relatively benign structures like pieces of grass that pop skyward when a tornado comes through a field. While they don't cause a lot of damage, Palmer says, they do affect the radar signatures.

"If we understand that data well, it makes sense that we could go out in the field and try to extrapolate that knowledge to real measurements."

Researchers also use the anechoic chambers to measure the characteristics of new antennas being developed for a variety of applications from weather radar to defense-related sensors.



Hjalti Sigmarsson works in the lithography room for processing photosensitive materials. The primary process is photolithography, a process in which a photosensitive polymer or photoresist is exposed through a mask that is then developed to realize patterns on a substrate, such as a circuit board.

In the facility's micro fabrication lab, faculty and students build and fabricate circuit boards and antennas and build the housing for them in the machine shop. "When you build a radar like this, there are a lot of mechanical pieces," Palmer states. "Even though many of us are electrical engineers, there are a lot of support structures that have to be fabricated. For example, the big pedestal of one of our radars was built as a mechanical engineering capstone project. I've gained an appreciation for all of this other work that must be done to complete our projects.

"We like to say that what we do here is end-to-end," he continues. "At one end, we have theoretical engineers who design the hardware; at the other, we have meteorologists who interpret and make sense of the data collected with that hardware in the field."

While developing life-saving weather technologies remains a core objective, the scope of the research conducted at the laboratory is growing rapidly.

"We're starting to move into the defense part of radar, which offers interesting applications and opportunities for economic growth," Palmer says. "We're working with both NOAA and the FAA—which is responsible for all airport radars—on a multi-mission phased array radar that will be able to see both weather and aircraft," Palmer says, adding that four new ARRC faculty focus solely on Department of Defense radar work.

"This lab is designed to promote collaboration, enhance communication and inspire new ideas," says ARRC interim director Tian-You Yu, who also holds the Tuma Presidential Professorship in the School of Electrical and Computer Engineering. "Since March 2014, more than 30 private companies and research institutes have visited the RIL for ongoing research projects or potential collaboration."

Kelvin Droegemeier, vice president for research on the Norman campus, says the RIL turns a lot of heads when people visit campus. "They see our passion for progress, our ability to think out of the box, and the high quality that infuses everything we do," he notes.

Recent visitors to the laboratory include Toshiba, Korean radar subsystem manufacturer RFHIC, Ball Aerospace, IT and business process services provider CGI, and the Air Force Research Laboratory. Seeking out additional collaborative opportunities, Palmer traveled to Japan in August to visit Weathernews Inc. (one of the first and largest private industry tenant on the University Research Campus), Toshiba, Osaka University and Kyoto University.

"We have some fantastic technology here, and I want companies to spring up here or move here," Palmer asserts. "Our reputation is getting really strong. I would love to see OU recognized as *the* comprehensive radar center of the country."

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