OU's Advanced Radar Research Center is developing a new type of radar with unprecedented acuity and speed. Others are taking notice.

The HORUS PROJECT

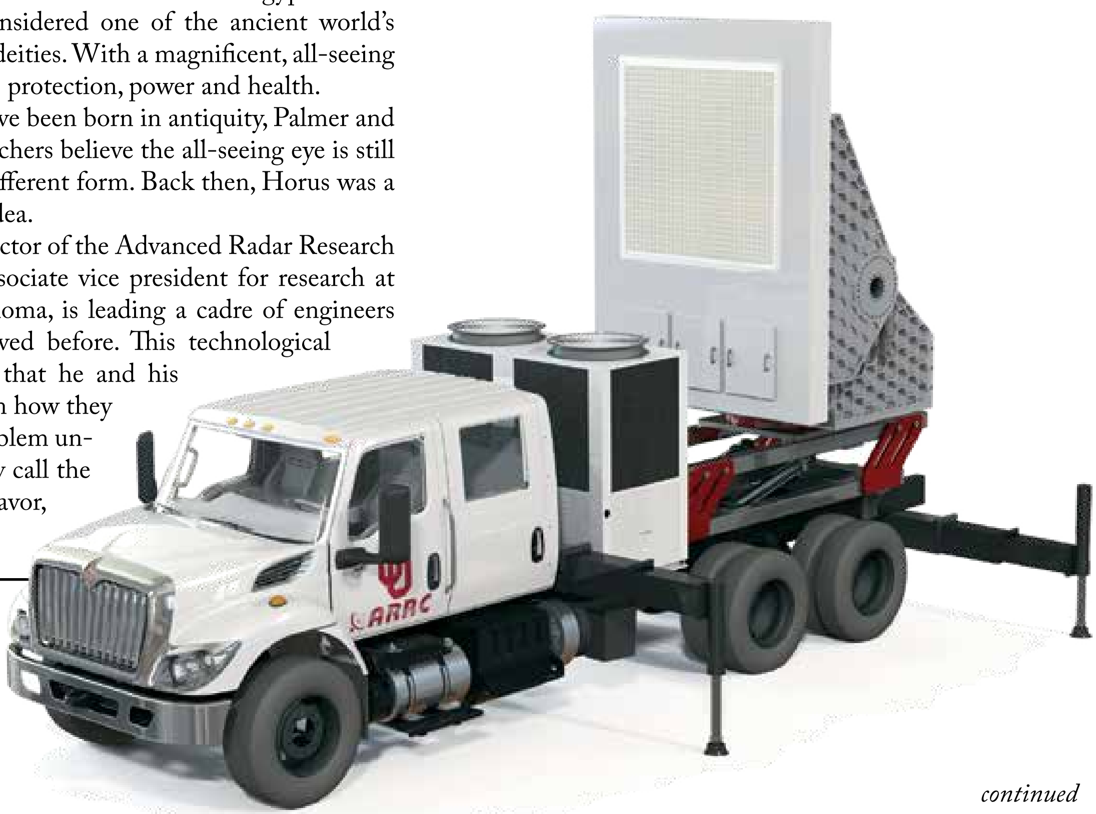
By Chip Minty

Photos by Hugh Scott

Standing over Robert Palmer's desk is an Egyptian icon called Horus, considered one of the ancient world's most significant deities. With a magnificent, all-seeing eye, it symbolizes protection, power and health.

While Horus may have been born in antiquity, Palmer and his team of young researchers believe the all-seeing eye is still around today, but in a different form. Back then, Horus was a god. Now, Horus is an idea.

Palmer, executive director of the Advanced Radar Research Center (ARRC) and associate vice president for research at the University of Oklahoma, is leading a cadre of engineers on a quest never achieved before. This technological holy grail is so elusive that he and his team weren't even certain how they should approach the problem until about a year ago. They call the daunting research endeavor, **"Project Horus."**



A rendering shows a prototype of the Horus Project, which combines phased array and dual polarization technologies.

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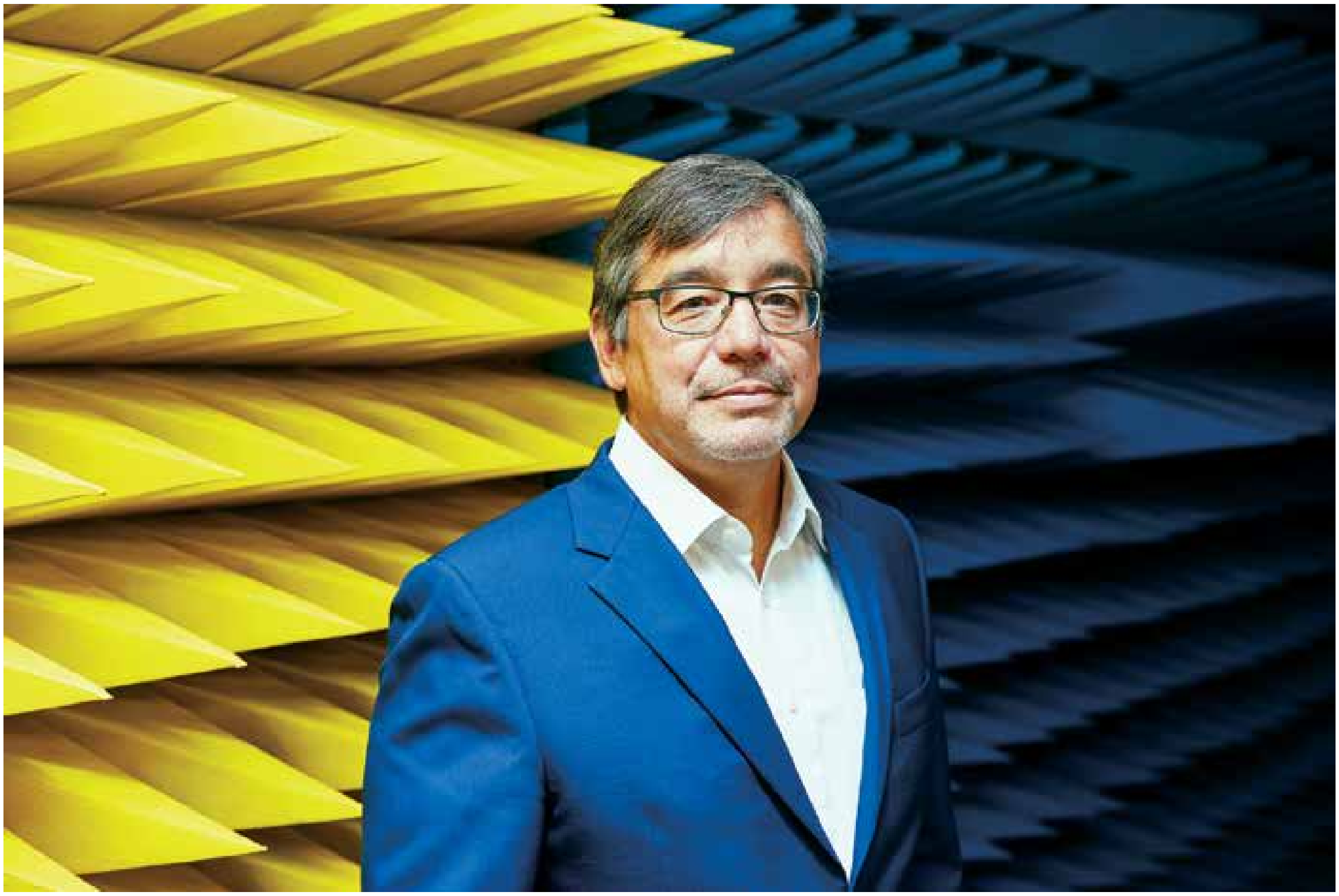

Robert Palmer, executive director of the Advanced Radar Research Center (ARRC) and associate vice president for research at OU, is leading a team of engineers to develop a new type of radar that combines the best of speed and accuracy.

After nearly a decade of work, ARRC is closing in on producing a weather radar system that will change the way we watch storms unfold in the atmosphere, Palmer says. Once a prototype is completed sometime next year, the radar will be able to accelerate radar updates from minutes to seconds.

Evolving radar images will become movies that will not only distinguish between snow, sleet, hail and rain, but will allow meteorologists to track it through towns and neighborhoods with the acuity of a motion picture. The radar will identify the size of raindrops as they fall through the atmosphere, allowing forecasters to instantly differentiate between a common rain shower and a flash flood event. One of its greatest values will be tornado detection, with the ability to spot a developing monster and track its every move with unprecedented effectiveness, Palmer says.

These weather radar innovations are so precise and advanced that the U.S. Department of Defense (DoD) has taken notice, but storms are not what the military is interested in tracking, Palmer says. They already have radar that can spot targets quickly. What they need is radar that provides more information about what the target might be.

"That's the Horus Project," Palmer says.

Researchers at ARRC and NOAA's National Severe Storms Laboratory in Norman are getting close to unlocking this technology. The U.S. military joined the effort last year, granting millions of dollars in research funding to ARRC, he says.

Most of the time, great inventions are built on the backs of existing technology, and Project Horus is no exception. Palmer and his team are working toward the digital marriage of two separate, long-established technologies that have been standards for decades.

The Department of Defense has been using "phased array" radar technology for more than 50 years, Palmer says. The ad-

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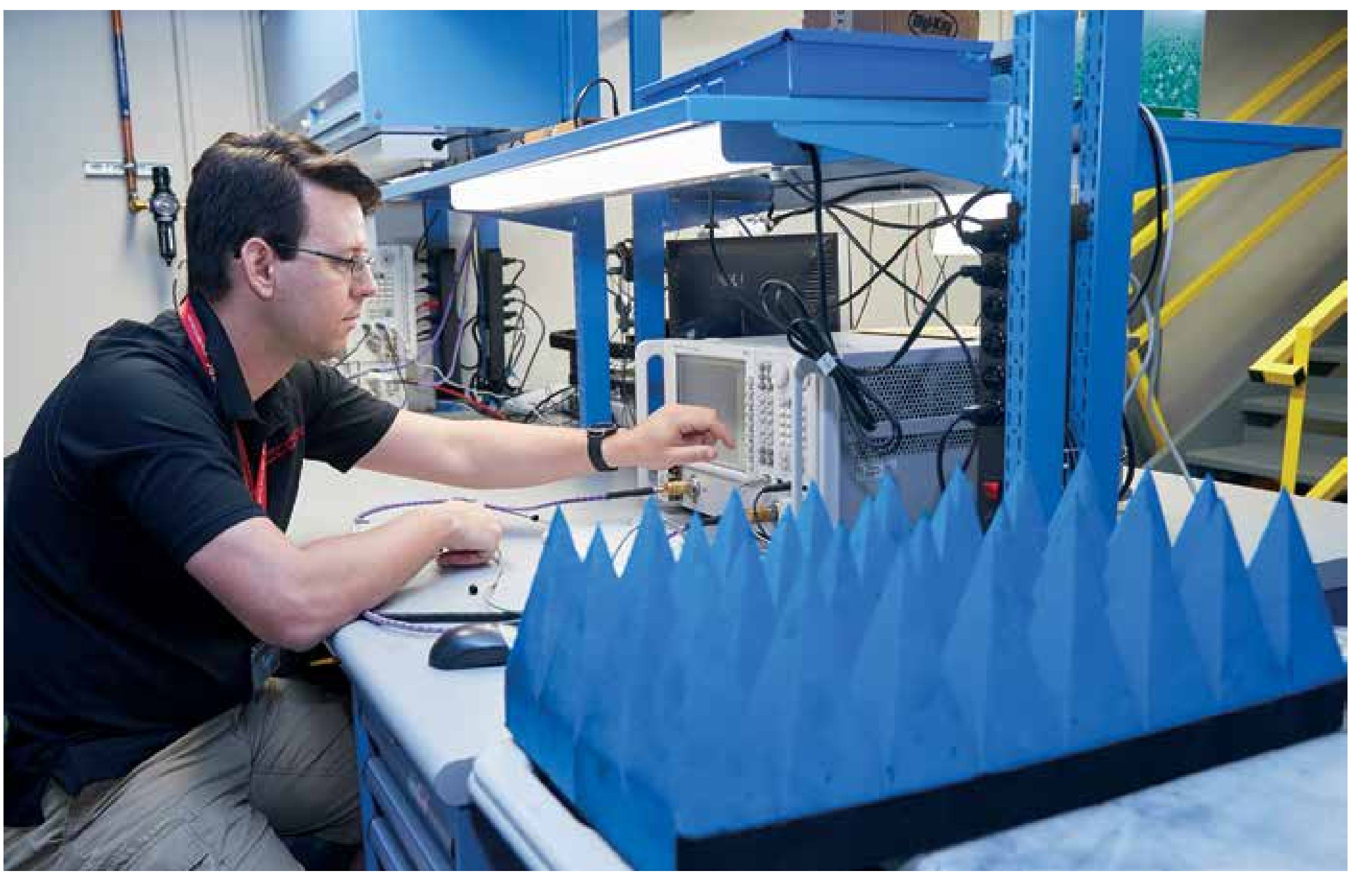
Left - ARRC engineer John Meier uses a robotic arm to test some of the prototype Horus phased-array antennas inside a chamber which controls the temperature and humidity. The blue foam absorbs electromagnetic energy, preventing reflections from interfering in the testing.

Below - ARRC engineer Matt McCord calibrates a network analyzer before using it to take measurements of RF components, such as filters, amplifiers and antennas.



ARRC engineer Matt McCord inspects the connections from the CPPAR electronics to the CPPAR antennas in preparation for transmission from the antenna.

vancement was developed with an electronic configuration on a flat panel, which allows the military to scan the skies much quicker than conventional radar. Speed was the objective in their effort to quickly spot and respond to fast-moving targets as they approached. However, the technology is limited in its ability to identify shapes and sizes.

Meanwhile, researchers in the weather community went a different direction, Palmer says. Still using a parabolic dish, rotating on an axis, they developed "dual polarization" technology, which gave forecasters dimensional information through measurements taken with both horizontal and vertical polarization. Rather than speed, this technology can detail the contents of clouds, distinguishing between types of precipitation, such as snow, hail and rain. The radar also can detect debris fields and the telltale signs of tornadic rotation within storms.

The downside to conventional dual polarization is that image updates come slowly and that can be a handicap when evaluating a developing tornado.

"Today, the data we look at could be up to three minutes old. Based on that, we may think we're clear, but a lot can happen in three minutes," Palmer says.

That's why researchers at ARRC and NOAA have been working to combine the capabilities of phased array with dual polarization.

"The work going on in the ARRC is truly groundbreaking and has been built on a 50-plus year collaboration with NOAA in Norman," says Berrien Moore, dean of the College of Atmospheric and Geographical Sciences and the director of the National Weather Center.

"Without this strong relationship, I doubt these advances could have happened. It is beautiful to see this synergy between our significant weather radar R and D successes and the needs and interests of NOAA and now the Department of Defense."

The key to solving the problem is in the digital world, Palmer says. His team is working to create a digital bridge between the two technologies to convert information from the two radars into a single, cohesive product with the speed of phased array and the acuity of dual polarization. Palmer believes the military had been working on this problem for some time when they became aware of the progress ARRC and NOAA were making in Norman.

Palmer says ARRC is an international leader in developing radar technology, and that leadership has been attracting millions of dollars to OU for years, starting with NOAA and now from the Defense of Department.

"The thing I love about it is, we have this long history in weather radar, so our work with NOAA in the field of advanced weather radar has led to this work with the Department of Defense," Palmer says. "The money from the DoD has come because of the expertise that we have gained through our work with NOAA."

The research has attracted tens of millions of dollars in grant money during the past decade, much of it from NOAA. In 2018, NOAA provided ARRC with a $6.4 million grant, and now that the military is involved, federal funding has nearly doubled.

The Office of Naval Research provided ARRC with a

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Redmond Kelley, an ARRC staff engineer, checks the radio frequency connections on the phased array antenna for the Atmospheric Imaging Radar (AIR).

$3.4 million grant in 2017, and in 2018, the Office of Naval Research and the Army Research Lab provided a total of $5.4 million in research funding. ARRC research funding has steadily grown since OU established the center in 2005, and since 2008, ARRC’s research expenditures have totaled nearly $50 million.

“Honestly, we have too much work to do,” Palmer says with a smile. “It’s like a dream come true to have this increasing DoD activity.”

Palmer says ARRC’s relationship with the DoD could last for decades, with demand for more research and development of radar systems with more advanced capabilities. He envisions an active exchange of ideas between the ARRC and DoD labs.

“It can get much bigger. We are currently developing a careful plan of how to grow the ARRC to take advantage of these opportunities.”

Eventually, there could be demand for larger radar systems compared with the smaller, mobile system under development today, Palmer says.

“They’ll likely want something bigger, eventually,” he says. “I see a larger system, not only for DoD, but also for NOAA. It’s possible, 10 years from now, that we’ll be building a very large-scale, all-digital polarimetric, phased array radar. It’s possible, if that happens, it will be very expensive, and it will be at a permanent location somewhere, hopefully here in Norman.”

The ARRC is world renowned in the meteorological community, but outside of the university and Norman, it remains somewhat obscure. Few are aware of the center’s growing impact as an economic driver and source of high-paying jobs.

Palmer says the center has attracted a commercial weather radar manufacturing operation to Norman. The center is also a significant employer, accounting for many highly skilled, well-paying technical positions on OU’s Research Campus. The center employs a full-time staff of 12 software and electrical engineers and has 20 faculty members with academic appointments in departments throughout the university. Eighty graduate students also work at the center.

“I have a team of engineers that are the best in the world. I have people from Raytheon and MIT come here to visit, and when they see what these guys are doing, I know they’d desperately like to recruit them.” Palmer says.

“They stay because we have built a really cool culture here. They have fun at the university and do great things and are funded well, and we keep their salaries competitive with all the major defense contractors.”

Palmer says team members are in their 20s and 30s. The top engineers have a decade of experience, but above all, they’re talented and energetic.

“It’s an amazing team,” he says. “These guys are scary smart.”

That’s important, Palmer says, because they are pushing technological boundaries to a point where there will be little difference between weather radar and defense radar. Both will have the speed to track targets as they race across the sky and both will have the acuity to spot a raindrop from far away.

Whether the object is a thunderstorm or something else, the technology will serve forecasters and soldiers alike, and when the engineers at ARRC finally find it, the all-seeing eye of Horus will be more powerful than ever.

Chip Minty is a Norman-based writer and the principal of Minty Communications, LLC.