Radar activity

With size and weight issues defeated, AESA radars make their tactical aircraft debut

By Tom Kington

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U.S. Air Force F-22 Raptor fighters started operational duties this year equipped with the Northrop Grumman APG-77, an active electronically scanned array (AESA) radar reputed to give pilots the ability to track ground and air targets while simultaneously scanning as well as mapping terrain using synthetic aperture radar (SAR).

Now considered a "mature" technology, X-band AESA radar has been mounted on 18 Air Force F-15Cs since 2000 and is in the midst of operational trials on U.S. Navy F-18E/F Super Hornets.

But the limits on how to use the radar seem to be anything but fixed. From data transmission to radar and communications jamming, uses for the powerful new arrays seem to be limited only by the imagination of the engineers who built them.

"AESA radar is an electronic aperture, so depending on the band, you have an electronic warfare capability," said Mike Henchey, director for business development for Raytheon Air Combat Avionics. "And once you have mapped the terrain using SAR, you can send that image to another platform using the same aperture."

Plans are also afoot for huge active arrays to be used in space surveillance or suspended from giant airships. And with the help of new semiconductors, radar power may yet be multiplied fivefold, while arrays are set to be sewn along the fuselages of aircraft, giving them 360-degree vision.

This airborne radar revolution has been in the works for some time. Electronically scanned arrays are already a mainstay of naval radar, where thousands of radiating elements use phased shifters to electronically create and change the direction of an overall beam, or various beams, thus reducing the need for a rotating dish while accelerating scanning speed and allowing multiple scans simultaneously.

A subsequent evolution — active radar — saw the placing of transmit/receive (T/R) modules with each radiating element to generate signal power, rather than relying on a cumbersome transmitter positioned behind the array.

Most radar breakdowns on aircraft are attributed to the transmitter, while active radar can still operate despite the loss of around 5 percent of the individual modules, increasing reliability more than fivefold and pushing the case for its use on fighter aircraft. In addition, with signal power amplification occurring at the radiating element and not at the transmitter, signal losses are greatly reduced.

The results are now taking to the air. Northrop Grumman supplied its APG-80 AESA to the United Arab Emirates for its Block 60 F-16s, using modules built in Baltimore. The firm's APG-77 is also mounted on the F-22, and the APG-81, complete with electronic warfare function, is under development for the F-35 Lightning.

"Pilots tell us that the old degradation in quality when tracking while scanning has been replaced by satellite-quality pictures, while SAR image is also satellite quality," said Bob DeWeese, director of Aerospace Systems Division Marketing for Northrop Grumman Electronic Systems.

MODULES: SIZE MATTERS

Northrop Grumman is about midway through production of 180 radars for the F-22, with new processes speeding up manufacturing times, said Scott Porter, vice president for global field marketing at Northrop Grumman Electronic Systems. The APG-77 uses modules from several sources, including Raytheon, a partner on the program.

The Air Force meanwhile has been flying 18 F-15Cs in Alaska since 2000, with Raytheon's APG-63(V)2, the first operational deployment of AESA radar aboard a fighter aircraft. Plans are to equip its other 160 F-15Cs with the APG-63(V)3.

The (V)3 drops the (V)2's "brick" modules in favor of new smaller "tile" modules — 2.5 centimeter cubes that contain four T/R channels each, according to Raytheon's Henchey.

The Air Force took delivery of the first (V)3 radar to test for use on its remaining F-15Cs in September.

Raytheon's "tile" has also been developed for the Raytheon APG-79, now undergoing operational evaluation on the F-18E/F/G Super Hornet.

"While the brick modules were soldered onto the radar array, the new tiles snap into place and the resulting antenna is half the weight of the 400-to-500-pound version on the Alaska F-15Cs," Henchey said.

Northrop Grumman also has the ability to put multiple T/R channels on single modules, Porter said. He declined to give the size of Northrop's modules, but said the modules destined for the F-35s APG-81 radar are the firm's smallest yet.

Raytheon officials said they are in talks with Sweden's Saab to supply modules for an AESA radar earmarked for the Saab Gripen fighter.

Elsewhere in Europe, Thales is working to replace the Rafale's passive e-scan radar with an active update, while an EADS-Selex-led team is working to ready an active replacement for the Eurofighter's mechanically scanned Captor radar. This new system will have 1,400 modules and a range of around 65 nautical miles, even if cash-strapped Eurofighter partner nations appear unready to place an order.

The modules that EADS is readying for Eurofighter are the same size — 64.5 by 13.5 by 4.5 millimeters — as those it is supplying for the fire control radar for the U.S.-German-Italian Medium Extended Air Defense System, which will use around 10,000 modules in total.

Selex Sensors & Airborne Systems meanwhile boasts a production AESA module measuring around 80 by 14 by 5 millimeters, although it expects the size to get smaller as research progresses. The firm said it "scored a world first" by supplying the U.S. Coast Guard this year with the first AESA maritime surveillance radar.

According to Forecast International analyst Bill Ostrove, AESA radars could account for up to 25 percent of the radar market over the next decade, rising to 50 percent of the airborne radar market and 60 percent of the fighter radar market.

Forecast International's 2006 analysis of more than 100 of the world's major radar programs envisions a $40 billion market for radar over the next decade, with airborne systems accounting for $14 billion and fighter radars totaling $8 billion.

Research needed to put AESA radar aboard fighters has in turn triggered the development of new applications for such active arrays, as well as lighter and more potent radars, which could yet increase the AESA market share.

Beyond using powerful AESA radar signals to jam enemy radar, Northrop Grumman, Lockheed Martin and L-3 Communications are each investigating how to use antennas for high-bandwidth communications, driven by the idea that if a radar can capture satellite-quality SAR images, it should probably be able to e-mail them as well.

Tests at Northrop Grumman's Baltimore facility with an APG-77 radar showed data could be sent and received using a radar signal, at up to four times the 274 megabits per second speed offered by the modem used in trials. With lighter, smaller modules and without bulky transmitters wedged behind them, AESA radars are ready for space, according to Porter.

"The military requires 24/7 battle- space awareness, meaning longer loitering time and greater efficiencies," he said. "That means very large, space-based arrays that are extremely light and use less power. We need to take the same functionality we are developing for fighter radar and emulate it in space."

BLIMPS & UAVS

The U.S. Defense Advanced Research Projects Agency has similar ideas, but is mulling airships instead of satellites. In August, it gave Raytheon an $8 million contract to figure out how to fix a football-field-size antenna — the largest ever built — to the underside of a blimp designed to hover at 70,000 feet.

Measuring just a single centimeter in depth, the lined-up modules would use the blimp's structure for rigidity, giving engineers the job of finding glue to bond the modules at minus 80 degrees centigrade.

At lower altitudes, the challenge centers on how to liberate modules from the nose of aircraft and insert them along the fuselage, turning the platform into flying, 360-degree radar. So-called conformal arrays could be placed on leading or trailing edge of a wing or on the vertical stabilizer, said Barry Alexia, business development executive at Raytheon Space and Airborne Systems' Advanced Concept Technology group.

"Size and weight become an issue as does the development of algorithms that can compensate for the shape of the arrays on the aircraft," he said. "The challenge is also to join the information received by different arrays seamlessly."

The next step, known as structurally integrated arrays, involves placing arrays as part of the fuselage itself.

"At that point, the stresses handled by the fuselage need to be handled by the arrays as well," Alexia said. "UAVs, which do not need to accommodate pilots, can be built more robustly and do more to resist stresses, thus making them more accommodating to structurally integrated arrays, and to electronics in general."

An EADS official said the European group is also looking into such arrays, adding that the work is prompting a look at other materials than gallium arsenide, currently the standard semiconductor material for AESA radar.

"Gallium nitride, which needs less cooling, could be used for one centimeter cubed modules integrated into the body of the platform," he said.

Gallium nitride is jousting with other potential candidates such as silicon carbide and silicon germanium to become the next big thing in AESA. The substance was first developed in the late 1980s for use in LED displays, given its ability to emit blue light, and today it features in Sony's Playstation.

But radar builders have hitherto stuck with the easier to grow gallium arsenide for semiconductor use in modules, despite nitride's potential to offer five times more power density, said an official at the U.K.'s Qinetiq, which is researching the material.

“That does not mean five times more range, but it does mean we can shrink the size and the weight of the module by that magnitude, which allows you to put the radar on a smaller platform,” he said.

Colin Humphrey, director of the Cambridge University Centre for Gallium Nitride, had few doubts.

“Compared to gallium arsenide, gallium nitride generates more power, can operate at higher frequencies, survive temperatures 100 centigrade higher and is less susceptible to cosmic rays and other radiation,” he said. •