Fighters feature electronic attack

There is new evidence of widespread research into alternate uses for the next generation of fighter radars—those with active electronically scanned array (AESA) antennas. The Air Force is finally talking about secret studies, conducted within the military and scientific communities, that propose using AESA antennas to focus energies in many of the same ways that the planned high-power microwave (HPM) devices will.

The peak power of fighter AESAs may not match that of dedicated directed energy weapons. However, Janet Fender, the USAF Air Combat Command's (ACC) top scientist at Langley AFB, Va., has discussed their ability to "operate in a surgical kill mode" by targeting specific frequencies of opposing electronic systems. The latter could include missile seekers and enemy radars or even computer systems. HPMs operate more by broadband electronic disruption or thermal destruction.

Earlier, a general "jamming" capability had been discussed for radars such as the F/A-18E/F Super Hornet's AN/APG-79, but it now seems there have been many studies of specific AESA uses. Fender refers to the potential destructive effects of "nonkinetic radar weapons" as "truly transformational," with hundreds or thousands of transmit/receive (T/R) modules in a single antenna focusing their power on a single target. Another plus of AESA weapons would be an increased ability to minimize the collateral damage caused by "kinetic" weapons.

The Air Force Research Laboratory (AFRL) and Aeronautical Systems Center (ASC), as well as the ACC, have reportedly been working on AESA airborne electronic attack possibilities. All these programs are classified; the discussion below focuses on the fighters and radars that could eventually gain these new capabilities by forecasting the 10-year future of the fighter radar market. We have also predicted the market shares of U.S. companies that would benefit from the massive funding likely to follow today's initial nonkinetic radar weapon concept studies.

Raytheon's AN/APG-63(V) is the fire control radar for the F-15A/B/C/D.

AESA radars and upgrades

Our funding forecast shows that more than $2.5 billion a year will be spent on fighter radars through the end of the decade. After this, production of several legacy radar programs will begin to trail off, and several AESA upgrades for other aircraft will be complete. Perhaps most important, USAF F/A-22 (recently renamed F-22A) production (APG-77) will end in about 10 years. By the middle of the next decade, the F-35 Joint Strike Fighter (APG-81) will begin to dominate the market for fighter radars, with its 46% share in FY14 likely to continue growing.

Raytheon's AN/APG-79 radar with its AESA antenna has been developed for the F/A-18E/F Super Hornet, for new builds, and as a retrofit replacement for the mechanically scanned AN/APG-73. With more power than the APG-73, the APG-79 will have two or three times the air-to-air detection range and will allow tracking of significantly more targets. It will also have a much better ability to identify targets and break out those that are closely spaced. It will integrate with Raytheon's AN/ASQ-228 ATFLIR (advanced targeting forward-looking infrared) via the Super Hornet's mission computer, allowing the radar to locate targets for FLIR targeting and reconnaissance.

For air-to-ground operations, the APG-79's synthetic aperture radar (SAR) mode can overlay GMTI (ground moving target indication) tracks on the SAR image, with a maximum SAR resolution three times that of the APG-73. With the APG-79's multimode capability, the F/A-18F's pilot can, for example, perform an air-to-air mission while the back-seater performs an air-to-ground mission. SAR imaging and air-to-air search and track can continue simultaneously, since there is no need for physically steering the antenna to either ground or air vectors. Raytheon engineers are referring to the APG-79 as a wideband device that can operate well outside the X-band, and planned upgrades include an electronic warfare jamming function.

In February 2001, Boeing and Raytheon won the $324-million engineering development contract to design, install, and test five full and two partial APG-79s. Low-rate initial production (LRIP) contracts were awarded in September 2003, February 2004, and June 2005. The first LRIP radar was delivered for flight testing in January 2005, and one delivery per month was planned through 2005. Devel-

opment flight testing was to be completed in 2005, with initial operational capability planned for September of this year.

Current Navy plans have the APG-79 equipping 415 Super Hornets, including 90 EA-18G Growler electronic attack aircraft, but this number could easily rise. Total APG-79 program costs could reach $6 billion.

Raytheon's AN/APG-63(V) is the fire control radar for the F-15A/B/C/D Eagle fighter. A modified version, the AN/APG-70, superseded the APG-63 on the F-15E Strike Eagle, but was then itself to be replaced with the APG-63(V)1 as part of a comprehensive APG-63 upgrade. The (V)1 includes many improvements, but the primary benefit is the increased reliability that will result from replacing the difficult-to-maintain 20-year-old circuitry in the original APG-63. The APG-63(V)1 LRIP contract was awarded in August 1997, with full-rate production beginning in 2002. Japan and South Korea also chose the APG-63(V)1.

However, in 2004 the Air Force changed its plans to upgrade 400 F-15s with the APG-63(V)1, deciding instead to install the APG-63(V)3 AESA antenna upgrade on the entire 224-aircraft F-15E fleet, beginning this year. The (V)3 is essentially an updated APG-79 front-end (antenna and power supply) and APG-63(V)1 hardware back-end. For the F-15E, the antenna size is increased to 0.9 m (36 in.) diam, and improved tile T/R modules with a greater mean time between overhaul are used, rather than the Super Hornet's brick T/R modules.

The APG-63(V)3 is 400 kg (900 lb) lighter than the (V)1, and will also improve reliability by 500% (AESA T/R modules seem to be living up to their billing as rarely needing maintenance or repair). This would leave only about 180 F-15Cs with the (V)1 (and 18 with the earlier (V)2 AESA), and (V)1 production line shutdown was begun in 2004, to be completed this month. The F-15E is slated to remain in service until 2035, with the F-15C continuing until 2025, to serve alongside the F-22A.

But by late 2005, the Air Force was reportedly seeking an even newer radar for the F-15E. Boeing claimed a competition was likely, with a version of Northrop Grumman's AN/APG-77 from the F-22A competing with an upgraded Raytheon APG-63(V)4. The (V)4 would have the (V)3 AESA antenna but more back-end components from the Super Hornet, including its processor and other upgrades.

After adding probable upgrades for Saudi Arabia and Israel, the September 2005 Singapore APG-63(V)3 buy, and Japan's decision in early 2005 to further upgrade its own F-15s, all the various APG-63 upgrades should be worth about $3.5 billion in our forecast period, running at almost a half billion dollars a year for several years at the end of this decade. This will make F-15 radars one of the world's largest radar programs over the next 10 years.

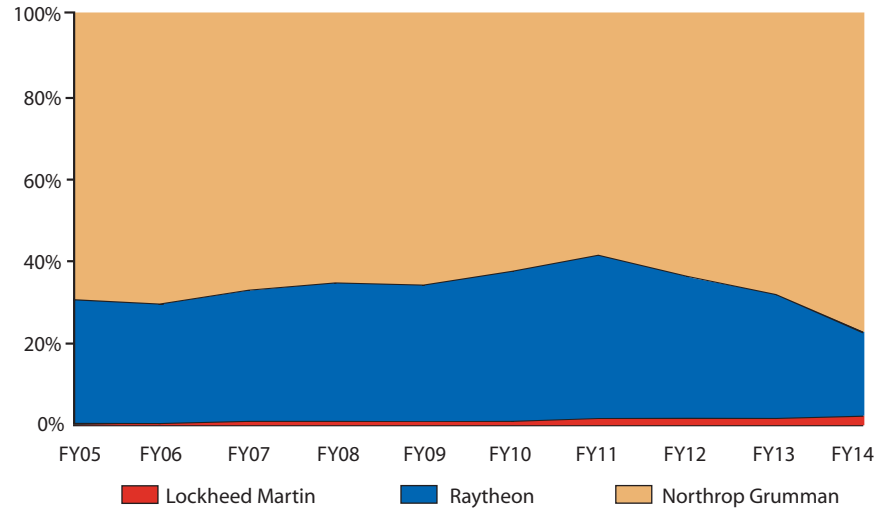
Northrop Grumman has developed the AESA AN/APG-80 Agile Beam Radar for the United Arab Emirates' 80 Block 60 F-16s. The APG-80 will have almost twice the air-to-air detection range offered by the mechanically scanned APG-68(V)7, although it will concentrate on air-to-ground modes, with SAR ground imaging resolution of 1 ft or better. The first 10 Block 60 F-16s had been delivered to the UAE by May 2005, although radar and avionics software development continues.

Raytheon's AN/APG-79 radar was developed for the Super Hornet, for new builds, and as a retrofit replacement for the mechanically scanned AN/APG-73.

We had been forecasting healthy additional production of the Block 60 beyond the UAE order, but the F-16's fortunes have been greatly complicated by the increasingly real F-35 Joint Strike Fighter, as well as disappointments in Block 60 development (it is still too expensive). As a result, there is a good chance the Block 60 and APG-80 could be produced only for the UAE.

FIGHTER RADAR MARKET SHARE

RDT&E + Procurement Available to U.S.



Legacy radars: Last of the mechanical arrays

Despite their now-dated mechanically steered antennas, two legacy fighter radar programs will continue to be worth several hundred millions of dollars a year past the end of the decade—that is, if we consider the AH-64D Apache attack helicopter's Longbow fire control radar (FCR) to be a fighter radar.

Northrop Grumman's AN/APG-68(V) is an improved version of the AN/APG-66 radar, developed as the fire control radar for the F-16C/D Fighting Falcon. It is a pulse-Doppler, multimode air-to-air and air-to-ground radar, with a VHSIC advanced programmable signal processor.

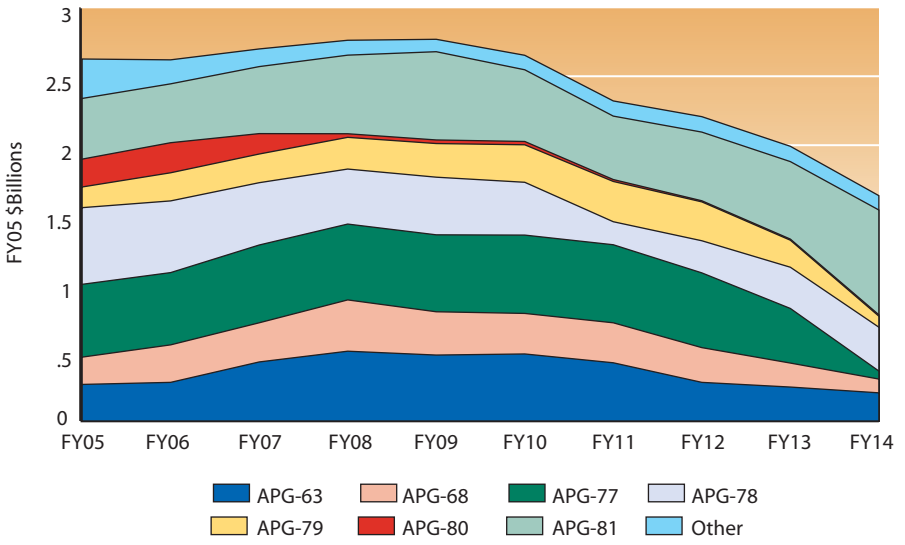
Production for the Air Force has concluded, and any future U.S. F-16s might be Block 60s with the APG-80 radar. But substantial production for FMS F-16C/Ds will continue through the decade, especially for the new APG-68(V)9 version with SAR modes.

With more than 2,000 radars in service, upgrades and support will continue for decades. In 2004, the USAF contracted for a major (V)5 to (V)9 upgrade kit, to be procured for 280 F-16s. In 2005, Turkey also contracted for (V)9 upgrades, and we believe many of the remaining earlier version APG-68s out there will also be converted.

Northrop Grumman's AN/APG-78 Longbow FCR is one component of the Army's Longbow system, which comprises the AH-64D Apache helicopter, the millimeter-wave FCR, and Hellfire antitank missiles equipped with millimeter-wave seekers. With continuing U.S. and international orders, and cancellation of the Army's Comanche, we forecast at least another 400 APG-78 radars produced over the next 10 years.

In June 2005, the Army and Boeing contracted to develop the Block III Apache Longbow, which will include an extended-range Longbow FCR and a new Longbow Fire Control Radar Electronics Unit. Block III upgrade production will begin in 2010, following the completion of current new-build Apache production.

FIGHTER RADAR FUNDING FORECAST
RDT&E + Procurement Available to U.S.



F-22A and JSF

The two biggest fighter radar programs in our 10-year forecast are, understandably, the radars for the F-22A Raptor and F-35.

The most anxiously awaited new fighter radar of recent years was certainly Northrop Grumman's and Raytheon's AN/APG-77 for the Raptor (Northrop Grumman has the larger workshare). Originally designed as a pure air-to-air system, its AESA antenna and high power provide by far the longest detection range of any fighter radar, greater than 120 n.mi. Combined with the extended-range AIM-120 AMRAAM missile, this allows the F-22 to obtain multiple kills well beyond the reach of any current or foreseen enemy.

AN/APG-81 JSF radar was shown on Northrop Grumman's BAC 1-11 test bed aircraft with its radome removed prior to its successful first flight test.

However, the Air Force has changed the primary mission of the Raptor from air superiority to strike. This might seem odd, considering how the Air Force's argument for not cutting the F-22 rested on its very different mission compared to the Joint Strike Fighter. Even more unexpected is the plan to add many air-to-ground capabilities to the APG-77. Unfortunately, these new capabilities have recently become classified, and very little information is available.

What we do know is all these changes will not be cheap, and RDT&E and modification funding will remain high, alongside already high production dollars. We forecast more than a half-billion dollars a year in total F-22A radar funding for most of our forecast period, though this will drop precipitously when production finally ends, now forecast to occur by the middle of the next decade.

MIRFS (multifunction integrated RF system) is the integrated avionics system being developed for the JSF. The most important and expensive sensor in MIRFS is Northrop Grumman's AN/APG-81 MFA (multifunction nose array), which includes an AESA that will function as the antenna for the JSF radar, as well as for communications and electronic support measures (ESM) systems.

Designed from the start for air-to-ground missions, and given its lesser power, the JSF's integrated radar and sensor system will have a shorter range but

greater capabilities than the F-22A. The APG-81 will provide near-simultaneous air-to-ground and air-to-air radar modes, and high-gain ESM and EW (electronic warfare) jamming functions. The X-band MFA will also interact with other frequency band antennas in apertures around the stealthy JSF.

Teal Group sees the possibility that several thousand JSFs could be built through at least the 2030s, and even though many of these will be for international customers, it will be practically impossible to swap out the highly integrated APG-81 for another radar (unlike engines and FLIRs, for example). Thus, the APG-81 has an excellent chance of being built for the vast majority of the JSFs produced.

In November 2004, MIRFS/MFA antenna tests were being conducted by the AFRL's Newport facility in upstate New York. In August 2005, the APG-81 radar flew for the first time aboard Northrop Grumman's BAC-1-11 jet. About 120 additional test flights are planned through 2009. Northrop Grumman delivered the first APG-81 to Lockheed Martin in November 2005, for flights on a test bed aircraft and then on the F-35.

Drawing conclusions

Our fighter radar market share forecast seemingly shows a fairly constant split between Northrop Grumman and Raytheon, albeit heavily favoring Northrop Grumman. But this is somewhat deceptive, as Raytheon's decreasing share from FY11 to FY14 will probably continue to fall. By FY14, the F-15 (APG-63), F-16 (APG-68), F/A-18 (APG-79), F-22A (APG-77), and AH-64 (APG-78) programs will all be ending or seeing minimal new production. Only the JSF will be growing. And while upgrades for legacy radars will continue, Northrop Grumman's APG-81 will lead the fighter radar market. In fact, one of the biggest future programs may be AESA upgrades for F-16s; but Northrop Grumman built the F-16's APG-68 and APG-66 radars, and could offer either APG-80- or APG-81-based antennas. Raytheon would not have a chance here.

Raytheon's best hope to maintain a relative parity with Northrop Grumman is to continue AESA upgrade development, and possibly to expand into the UCAV market, if fighter-like fire control radars become a requirement. We have not included J-UCAS (joint unmanned combat systems) or other UCAVs in our forecasts, but Raytheon's dominance of today's UAV electrooptics market (see "U.S. players in the world electrooptics market," September 2005, page 22) may well save them in the fighter radar market of the next decade. If not, Raytheon may be relegated to being a mere technology supplier to a totally dominant Northrop Grumman in the fighter radar market.

David L. Rockwell
Teal Group
drockwell@tealgroup.com