Phased Array Radar
At the Intersection of Military and Commercial Innovation

Glen Fields, MACOM, Lowell, MA

Accelerating innovation in phased array radar design and manufacturing is transforming our military radar infrastructure, enabling the achievement of unprecedented size weight and power (SWaP) profiles that in turn facilitate greater radar system accuracy, mobility and deployment flexibility for an ever widening range of ground-based, airborne and seaborne applications. This has enhanced the military's ability to equip existing ships, aircraft and vehicles with new high-performance, ultra compact radar systems while introducing new multi-function radar capabilities for a new generation of radar systems and a new era of deployment modes.

As phased array radar technology becomes ubiquitous for defense applications – driven by the military's significant and sustained investment in this field – the associated innovation has naturally flowed into the commercial domain, where today it's being adopted for applications spanning weather tracking to perimeter protection to air traffic control and beyond. This growing adoption of phased array radar for civilian applications has in turn yielded commercial-scale cost and component manufacturing efficiencies that are – in full circle – flowing into the military domain, where increasing reliance on COTS radar components and commercial manufacturing techniques is promoting leaner cost structures and eliminating cumbersome 'chip and wire' assembly approaches. This convergence of military and commercial innovation and best practices is driving greater SWaP optimization and cost efficiencies across both of these domains, unlocking the full potential of phased array radar technology.

WEATHER AND SAFETY APPLICATIONS AT THE FOREFRONT

The early adoption of phased array radar for non-military uses has been most prominent in weather and safety applications, particularly early warning detection of severe impending weather. New X-Band radar systems, networked across multiple nodes, are providing greater understanding of weather patterns like hurricanes and wildfires in real-time as they develop.

New weather radar initiatives such as the Collaborative Adaptive Sensing of the Atmosphere (CASA) Weather Radar Program – a multi-sector partnership among academia, industry and government – are emerging to better protect people and property, and mitigate damage through improved weather sensing. X-Band radar networks developed via the CASA program detect the region of the lower atmosphere currently below conventional radar range, providing the ability to map storms, wind, rain, temperature, humidity and the flow of airborne hazards.

The development of the Multi-function Phased Array Radar (MPAR) panel, a dual-polarized S-Band system, is an example of defense-caliber phased array radar technology applied to weather tracking and air traffic control applications simultaneously. MPAR panels were co-developed by MACOM and the Massachusetts Institute of Technology Lincoln Laboratory under sponsorship from the Federal Aviation Administration (FAA) as a next generation alternative to the existing civil radar network currently supplying air traffic and weather surveillance. MPAR panels consolidate eight separate radar systems that currently perform four unique missions – terminal air surveillance, en-route air surveillance, weather radar and terminal Doppler radar. This enables increased resolution and faster operation, providing improved data for weather forecasting together with advanced air traffic control capabilities. An MPAR system is constructed of multiple MPAR panels functioning in concert to radiate and receive pulses of radar energy used to detect, locate and track aircraft and weather features.

Other safety-driven applications of phased array radar for non-military purposes include radar-assisted search and rescue operations for disaster victims, including those trapped under rubble or underground by earthquake or landslide conditions. This capability requires high frequency radar to detect movement, which opens the door to additional non-weather-related safety applications like perimeter security and border protection.

FROM AIRBORNE TO UNDERGROUND

Another prominent example of phased array radar technology applied to commercial interests is the recent effort to begin transmitting high-speed Internet/voice data between airborne aircraft and ground stations via Ku-Band active phased array antenna or communication AESA, bringing broadband Internet access to in-flight passengers. Qualcomm has proposed an air-to-ground backhaul communication system of this nature, and has submitted a plan to the FCC that would leverage the 14 to 14.5 GHz band and a network of 150 ground stations to move this initiative forward.

At the infrastructure level, this would shift in-flight Internet traffic from satellite-based networks to terrestrial-based systems, which could potentially introduce significant cost efficiencies. This proposed system would boost current in-flight Internet capacity from 10 to 300 Gbps, enabling video streaming, gaming and other rich multimedia access for planes at altitudes of several miles.

The combination of ground penetration and range sensing capabilities enabled by phased array radar systems have shown considerable promise for the energy and mining sectors. Radar-assisted range sensing can be used to monitor and gauge fluid levels in underground pipelines and aboveground oil tanks. It can also be employed for mine exploration and mineral detection applications.

MILITARY AND COMMERCIAL CONVERGE

Just as the commercial domain is leveraging the military's heavy investment in phased array radar technology to drive innovation and cost-efficiencies for civilian applications, the military is increasingly adopting commercial design and manufacturing best practices to achieve cost and process efficiencies of its own. Consider, for example, the X-Band Core Chip designed by MACOM and FIRST RF Corp. for the common leg circuit in CASA-optimized radar systems. This integrated, surface mount solution enables high-yield automated assembly, smaller footprint design and improved reliability. The plastic packaged, 7 × 7 mm X-Band Core Chip for the 8 to 11 GHz range integrates a CMOS logic driver with a GaAs Transmit/Receive (T/R) MMIC within a single QFN package. The ability to offer a full SMT solution for demanding X-Band phased array radar applications combines the best of military radar innovation and high volume commercial manufacturing expertise in a bi-directional value proposition.

MACOM's work on the aforementioned MPAR program is another example of the use of commercial manufacturing practices for a technically demanding radar architecture originally developed for military purposes. In addition to meeting the exacting technical demands, the MPAR design team needed to achieve an order of magnitude or more reduction in cost compared to earlier military-class phased array radar systems. To meet these challenges, MACOM designed and manufactured highly integrated MMICs that would minimize total part count and simplify manufacturing and assembly, and packaged these MMICs in industry-standard surface mount plastic packages. This effort also included the design and manufacturing of PCB T/R modules to facilitate automated assembly and test, and a PCB-based line replaceable unit (LRU) which forms the fundamental RF building block for the system.

For phased array radar system OEMs, the convergence of military radar innovation and commercial cost efficiencies better enables them to serve both markets simultaneously with generic products assembled at high-volume via a common manufacturing platform, enabling significant cost savings. These OEMs must ruggedize their commercial products for use in high-reliability military applications if they are to effectively cross-purpose their product lines, and this ultimately relieves some of the high-reliability testing and screening burden that drives up costs for military systems – further promoting cost efficiencies for both domains.

The cross-domain flow of military investment and commercial best practices is lowering development and manufacturing costs for phased array radar systems while unlocking new application opportunities. Leveraging the volumes of both the commercial and defense applications will produce economies of scale further enhancing the cost equation. The continued erosion of cost barriers on both sides of the customer/supplier equation will ultimately accelerate the pace of innovation and adoption for phased array radar into the future. ■