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DEPLOYING THE SPACE FENCE

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FPGAs rise to the challenge
By Denis Smetana, Curtiss-Wright Defense Solutions

Signal processing designs for radar and EW

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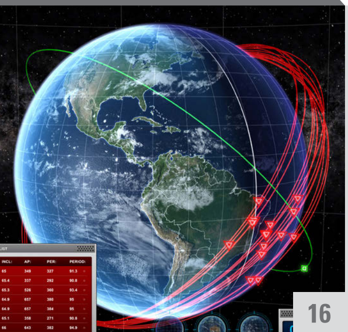
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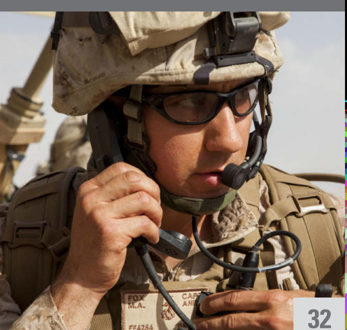
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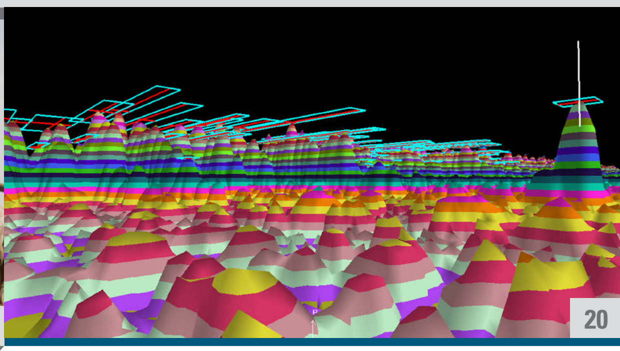
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ON THE COVER:

Top photo: Space Fence is a fully digital S-band radar system that can track debris as small as 10 centimeters.

Bottom photo: The Navy's Aegis-class ship uses a high-performance embedded computing solution from Mercury Systems for radar processing. Photo courtesy of Lockheed Martin.

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Expanding radar signal processing market and our expanding coverage

By John McHale, Editorial Director

Welcome to our 2015 Radar Issue. Once again we have started off the year with an issue focused on radar because embedded signal processing solutions are what drives the bandwidth in modern military radar systems and electronic warfare designs – two of the hottest areas in the defense electronics market.

The market for radar is especially strong and looks to stay that way. For example, for the radar/lidar there were 79 awards in 2013 totaling $4 billion with Raytheon leading the way, says Brad Curran, senior industry analyst at Frost & Sullivan. Through September 2014 there were 41 awards totaling $2 billion, he adds. "2014 is skewed with Lockheed Martin winning the $914 million Space Fence contract in June. The big money for radar is still in missile defense, which is proliferating. Secondly, funding for F-35 radar and upgrades to radars for other fighter jets – that cannot afford the F-35 radar – will be steady."

The Lockheed Martin Space Fence system, which graces this month's cover, tracks space junk in orbit around the Earth. For more details see Sally Cole's article on page 16.

Other big awards we covered on Mil-Embedded.com in 2014 included Northrop Grumman Corp's win of the Marine Corps AN/TPS-80 Ground/Air Task Oriented Radar (G/ATOR) systems low-rate initial production (LRIP) contract valued at $207,291,682. G/ATOR is a ground-based multi-mission active electronically scanned array (AESA) radar. For more on AESA radar see the Industry Spotlight section on page 36 and the Special Report on page 22.

Earlier in 2014 Raytheon won a $235.5 million contract to provide Radar Digital Processor (RDP) kits for upgrading the Patriot Air and Missile Defense System for the U.S. and two other partner nations. The contract looks to improve target detection and identification, enhance surveillance, and support the PAC-3 MSE missile, according to Raytheon.

"On the maritime side there's been a lot of radar contracts for applications such as surface ship self defense to deter incoming anti-ship missiles from potential adversaries in the Western Pacific," Curran says. Raytheon continues to be the leader in this after having won the U.S. Navy's Air and Missile Defense Radar (AMDR) contract – a next-generation defensive system for Arleigh Burke-class destroyers in 2013, he adds.

Since radar continues to be hot, we will be expanding our coverage and attention to the subject in 2015. First, this March we will be launching a new electronic newsletter called the Radar Tech Quarterly, coming to you four times a year of course. Content will include all the best latest radar-related articles, blogs, products, and news from the Mil-Embedded.com website.

On top of that we also will have a Radar E-Mag with the best print and online feature articles from *Military Embedded Systems* as well as content original to the e-mag.

Our third new product for 2015 is the monthly e-newsletter titled the McHale Report, where each month I gather the best coverage from Mil-Embedded.com such as blogs, top news, defense executive interviews, procurement roundtables, market updates, etc. Original to each issue of the McHale Report is the Executive Outlook interview, where I interview a top defense executive, and the COTS Confidential roundtable, which is an online roundtable with experts from the defense electronics industry – from major prime contractors to defense component suppliers.

Each COTS Confidential roundtable will explore topics important to the military embedded electronics market. This month we discussed the effect of the memo former U.S. Secretary of Defense William Perry issued in 1994 essentially directing all the Department of Defense to use commercial off-the-shelf (COTS) products wherever and whenever possible.

The first Executive Outlook was with Rob Smith, VP of C4ISR at Lockheed Martin Information Systems & Global Solutions, where he discussed the "insatiable need for ISR" in the defense community and how it should continue to grow.

To read these features and more check out the January McHale Report at bit.ly/1IJrTBV.

Online isn't the only area where we are adding new content sections. This month Assistant Editor Amanda Harvey debuts her University Update column on page 44. In that space Amanda will explore the latest military electronics research and development happening in the world of academia. Her first piece talks about lidar development at the Georgia Tech Research Institute.

So please check out our new online and print coverage and let us know what you think.

Thanks for reading!

John McHale
jmchale@opensystemsmedia.com

Prequalified system-level COTS takes the load

By Charlotte Adams

A GE Intelligent Platforms perspective on embedded military electronics trends

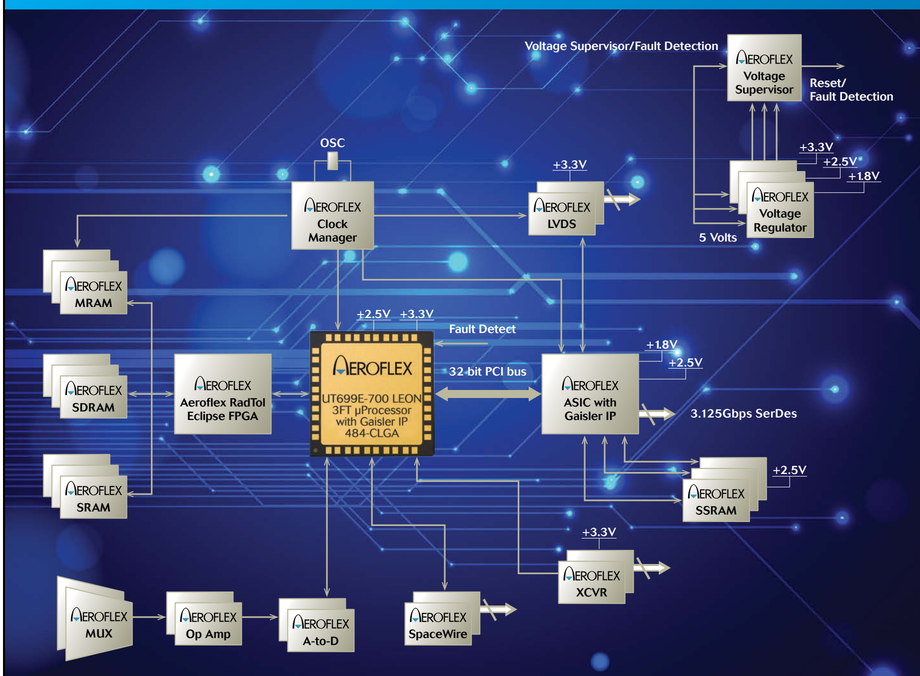
With military budgets under fire and program schedules increasingly pinched, design managers are focusing more than ever on cost. Gone are the days of gold-plated programs entailing high risk of cost overruns and schedule breaches. Suppliers are on the hot seat to deliver systems within tight cost and time constraints.

The situation is particularly challenging on the hardware side: The commercial off-the-shelf (COTS) revolution that kicked off in 1994 has increased performance and reduced costs despite the need to mitigate the obsolescence risks associated with dependence on the consumer electronics market. Yet the cost of developing software continues to rise. This reality means that, in order for customers to focus resources on adding value to their applications, the highly commoditized hardware side must bear the brunt of a new wave of retrenchment.

The COTS trend in military procurement began with chips and quickly expanded to encompass larger electronic modules. Integrated circuits, cards, and interconnects are now available from the commercial market, along with low-level software such as board-support packages, drivers, and operating systems. The challenge with military COTS lies in integrating the right pieces to meet solicitation requirements, test for performance and environmental rigor, and roll solutions out in a timely fashion.

The military high-performance embedded computing (HPEC) market has responded to these challenges with lines of rugged COTS subsystems, which reduce cost, schedule, and technical risk. These solutions are already integrated, analyzed, packaged, and tested before they are offered for sale. Once offered, they can be rapidly fielded.

Size, weight, and power (SWaP) optimization also has been baked in from the outset with these choices. Moreover, ruggedization is built into designs, including the arcana of thermal management, mechanical engineering, and hermetic control. Elements have already been screened, coated, stiffened, and cooled, according to expected requirements.



Even with all this advance work, these COTS subsystems still offer designers a wide range of choice. They avoid the risks of new hardware development – which could take as long as 24 months and millions of dollars to complete – yet don't box the customer into the suppliers' board, box, or system-level product lines. Depending on a program manager's specific needs, new combinations of components may be combined to create new products; happily, these products take much less time to field than would an all-new development. This procurement route promises flexibility and performance at the lowest possible cost.

The challenges of COTS

Repackaging cards, modules, connectors, and low-level software into new configurations is not a trivial or risk-free enterprise. It does, however, involve far less time and risk than developing a system from scratch. Connector design, for example, may have to be tweaked to provide the required level of signal integrity. In another example, low-level code will need to be optimized for the interoperation of components that had not previously been run together.

The whole system, moreover, from the cards to the enclosure, is often rigorously retested for compliance to environmental specifications – such as DO-160 for airborne applications or MIL-STD-810 for ground vehicles – even though it already uses battle-proven and prequalified components. This additional testing includes ensuring performance under stressors like temperature, shock, vibration, dust, humidity, and corrosion. Typically, manufacturers offer a range of ruggedization levels, depending on the platform type and intended operation.

The resulting unit can plug into a larger system such as a mission computer or display or can function alone as the brains of a smaller platform such as an unmanned vehicle.

One example of a rugged COTS subsystem is GE Intelligent Platforms' DO-160-qualified, conduction-cooled, rugged display computer. The DAQMAG2A offers a range of video input/output (I/O), from analog RGB (red/green/blue) sync-on-green and PAL/NTSC (phase-alternating line/ National TV System Committee) to high-definition SDI (serial digital interface) standards encompassing legacy analog and modern digital formats, ICS-8580 video compression, and on-board conversion from one signal format to another. The 18-36-VDC system also features the Intel Core-i7 processor and three Gigabit Ethernet, four USB, and two serial COM ports (see Figure 1).

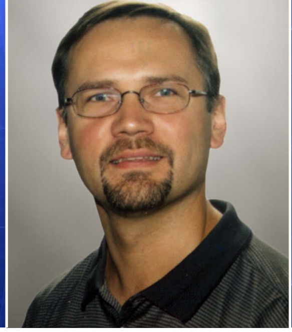
Figure 1 | The DAQMAG2A Rugged Display Computer from GE Intelligent Platforms is used in the development of sophisticated video applications.

The demand for high technology-readiness-level (TRL) embedded processing systems to meet the requirements of today's tight budgets has challenged the ingenuity and efficiency of HPEC vendors. Subsystem designers have responded by focusing their resources not just on developing new components, but on recombining existing modules into new configurations, where the emphasis is on integration, performance verification, and qualification testing.

This approach can cut development time on the hardware side to one-half or even a third of what it would take otherwise, and slash costs by millions of dollars, while providing considerable flexibility.

defense.ge-ip.com

Taming the tin-whiskers beast



By Ivan Straznicky

An industry perspective from Curtiss-Wright Defense Solutions

The introduction of the European Union (EU) WEEE/Restriction of Hazardous Substances (RoHS) legislation in 2006, which restricted the use of lead components in many electronic products, means that it has become increasingly important for defense and aerospace embedded-system designers to understand the challenges of lead-free design. Furthermore, since its introduction, the EU's RoHS regulations have continued to evolve. Recent changes to the laws were instituted in July 2011, when the rules were extended to include more electronic equipment categories and previous category exemptions were removed. Not surprisingly, interest in lead-free electronics is growing around the world, with countries beyond the EU enacting their own regulations. For this industry, one of the highest profile, yet least widely understood issues resulting from the global drive toward lead-free electronics is the product-integrity risk resulting from the so-called tin whisker phenomenon. The good news is that intensive research is leading to effective mitigation of tin whiskers.

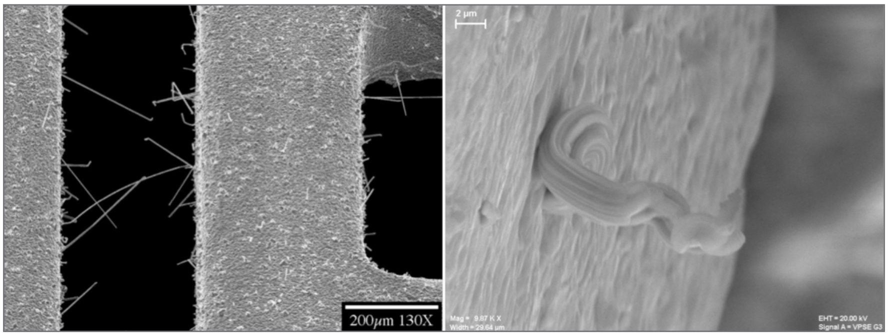


Figure 1 and 2 | Tin whiskers – thin metallic structures that grow out of tin-rich finishes on lead-free component terminations – can pose the risk of short-circuiting embedded electronics that need the highest level of reliability.

Tin whiskers – thin metallic structures that grow out of tin-rich finishes on lead-free component terminations – can pose a serious short-circuit risk (see Figures 1 and 2). As components that have lead-containing terminations and finishes are nearly eliminated, the tin-whisker issue will only continue to grow in significance. Just how big a threat is the tin-whisker phenomenon, and what impact will tin-whisker growth have on the integrity of fielded embedded systems using lead-free parts? While critical defense systems are eligible for an exemption to the RoHS, the value of that exemption is reduced as the availability of lead-based parts diminishes.

It's clear that the industry is only now beginning to understand the impact of industry's shift to lead-free components. The potential legal ramifications of lead-free construction and tin whiskers are already starting to emerge. At the end of October 2014, a class-action lawsuit was filed in Northern California District Court alleging that Apple's 2011 15-inch and 17-inch MacBook Pro laptops were defective and that the company failed to take appropriate measures to compensate customers whose hardware broke. In the suit, the plaintiffs claimed to have suffered from "random bouts of graphical distortion, system instability, and system failures." The complaint specifically blames the solder used to connect the dedicated GPU in the laptops to the main circuit board, stating that "lead-free solder…tends to develop microscopic 'tin whiskers,' which cause short circuiting and other problems within electronic devices." Further, the suit claims that lead-free solder was used by Apple to comply with EU regulations, with the lead-free approach making its way into U.S. products so that the company could save on manufacturing costs.

The introduction of lead-free components and assemblies into defense and aerospace systems poses a potential reliability risk if the proper measures are not taken, beginning with an understanding and mitigation of the various risks. In addition, the overall process of controlling if, when, and how lead-free manufacturing is introduced needs to be addressed through a comprehensive lead-free control plan (LFCP).

Curtiss-Wright has investigated the top risks identified by the PERM (Pb-free Electronics Risk Management) Consortium, an industry group that represents the defense/aerospace industry. The research includes testing of circuit-card assemblies to better understand tin-whisker risk and evaluate mitigations, together with extensive studies and testing of lead-free components, soldering, and assembly processes. (The resulting white paper, "Tin Whisker Risk Reduction and Mitigation Update" is available on request at www.cwcdefense.com.)

The embedded electronics industry must be committed to maintaining the high reliability of its products for the aerospace and defense sector. To that end, the embedded industry needs to educate itself on the risks associated with the use of lead-free parts. The good news is that effective means of reducing such risks as tin whiskers now exist; these mitigating techniques need to join the existing suite of mitigations already in place to ensure the ruggedness and reliability that deployed military systems demand.

Ivan Straznicky, Technical Fellow
Curtiss-Wright Defense Solutions • www.cwcdefense.com

DEFENSE TECH WIRE

NEWS | TRENDS | DOD SPENDS | CONTRACTS | TECHNOLOGY UPDATES

By Amanda Harvey, Assistant Editor

NEWS

MQ-8C Fire Scout, first unmanned helicopter to take off from a destroyer

U.S. Navy and Northrop Grumman officials flew the MQ-8C Fire Scout system for the first time off the guided-missile destroyer, USS Jason Dunham (DDG 109) off the Virginia coast last month. The MQ-8C Fire Scout made 22 takeoffs and 22 landings while operators controlled it from the ship's control station. This flight followed more than a year of land-based testing at Point Mugu, Calif.

"This is the first time an unmanned helicopter has operated from a destroyer," says Capt. Jeff Dodge, Naval Air Systems Command Fire Scout program manager. The unmanned helicopter's increased endurance will enable ship commanders and pilots to have a longer on-station presence, he adds. To watch a video of the flight, visit http://bit.ly/1xbLuZi.

Figure 1 | The MQ8-C Fire Scout unmanned helicopter prepares for landing on the USS Jason Dunham. Photo courtesy of Northrop Grumman.

U.S. Air Force awards General Dynamics, Raytheon contract for RGNext joint venture

General Dynamics and Raytheon won the U.S. Air Force's $1.5 billion, single-award contract to operate, maintain, and sustain launch ranges in a joint venture called Range Generation Next (RGNext). RGNext is responsible for operations as well as depot-level and organizational maintenance and sustainment for effective launch, testing, and tracking of civil, commercial, DoD, and international spacelift vehicles at Space Coast in Florida and Vandenberg Air Force Base in California. RGNext will also support ballistic missile, guided weapon, and aeronautical evaluations and tests. Raytheon and General Dynamics formed RGNext to fulfill the U.S. Air Force Space and Missile Systems Center's Launch and Test Range (LTRS) Integrated Support (LISC) contract, supporting the U.S. Air Force Space Command.

Philippine army orders $18 million worth of Falcon III radios and intercoms from Harris

Officials with the Armed Forces of the Philippines (AFP) ordered Falcon III tactical vehicular radios and intercom systems from Harris Corp. under an $18 million initial contract. The Philippine army will use the radios for its tactical communications modernization program. Harris will upgrade the communications capability of the Philippine army's Light Armored Division with the latest Falcon RF-7800V Combat Net Radio integrated into the company's RF-7800I Intercom Systems to provide secure tactical network connectivity. The embedded encryption in the radios will enable secure interoperability with more than 13,000 Harris Falcon radios currently used by the AFP.

NASA tasks Rockwell Collins single-pilot operations study

NASA officials chose Rockwell Collins as the lead research firm for its Single Pilot Operation program, which focuses on developing concepts and technology for commercial airline crew capacity, ground support, and automation.

The aviation industry is exploring single-pilot operations to address concerns about potential pilot shortages, but first there are technical, certification, social acceptability, and policy considerations that must be looked at as well, says John Borghese, Rockwell Collins vice president for the company's Advanced Technology Center. The Rockwell Collins and NASA teams are researching crew resource management and physiological monitoring technologies for the program.

Figure 2 | Rockwell Collins' Advanced Technology Center is teaming up with NASA to conduct research for the Single Pilot Operation program. Photo courtesy of Rockwell Collins.

Boeing Crew Space Transportation (CST)-100 spacecraft completes critical design review

NASA and Boeing completed the Ground Segment Critical Design Review for the Crew Space Transportation (CST)-100 spacecraft. The baseline design for the Commercial Crew Transportation System has also been set, moving the project one step closer to the planned early 2017 voyage to the International Space Station. Now that the Certification Baseline Review is complete, construction on system hardware, including the spacecraft and United Launch Alliance (ULA) launch vehicle adaptor can begin

Boeing's CST-100 spacecraft will provide a U.S. system for transporting astronauts and cargo to low-Earth orbit destinations, such as the ISS. The CST-100 will be able to accommodate up to seven people, or a mix of crew and cargo, and features Boeing LED "Sky Lighting" technology, a weldless architecture, and Wi-Fi.

Figure 3 | Shown is a Boeing illustration of the Crew Space Transportation (CST)-100 spacecraft, set for launch in 2017. Photo courtesy of Boeing.

F-35 JSF Air Combat Training contract won by Cubic

Cubic Corp. won a series of contracts from Lockheed Martin Aeronautics to develop and add enhancements to the F-35 fighter jet's Air Combat Training System (ACTS). The F-35 Joint Strike Fighter's (JSF'S) version of the P5 Combat Training System (P5CTS) uses an internally mounted subsystem that enables the F-35 to maintain its stealth characteristics during training, a capability not available with the wing-mounted pods used on 4th gen fighters. Cubic and DRS Technologies, the principal subcontractor, will provide additional JSF P5 systems to support production aircraft. Two enhancements will then be made to the system, such as upgrading ground subsystems to be compliant with Microsoft Windows 7 OS and upgrading the encryption capability for the JSF P5 systems.

Qatar spends billions for Patriot Air and Missile Defense System

Officials at the State of Qatar are now Patriot Air and Missile Defense System users, having signed a $2.4 billion Foreign Military Sales contract to procure new-production fire units of the system from Raytheon. This acquisition comes under an Armed Services modernization and recapitalization effort Qatar officials announced this past spring. The contract includes the newest Patriot fire units with their increased computing power and radar processing efficiency and enhanced man-machine interface as well as reduced life cycle costs.

Raytheon officials announced the company signed a U.S. Air Force contract to give Qatar an Air and Missile Defense Operations Center (ADOC) that will integrate U.S. air defense systems – including Patriot, the Early Warning Radar, and THAAD – with European air defense systems and radars and Qatar's Air Operation Center.

MilSource announces Techaya's rugged 8-port Power over Ethernet gigabit switch for power and data connectivity

U.S. military-grade Ethernet distributor MilSource has announced the availability of Techaya's rugged, 8-port MILTECH 910 PoE (Power over Ethernet) MIL-STD gigabit switch. The MILTECH 910 provides power and data connectivity to PoE-enabled cameras, mesh nodes, WiFi access points, and other devices that are in compliance with IEEE 802.3af/at standards for PoE.

The MILTECH 910 PoE is designed for mobile Ethernet-equipped applications, like avionics and vetronics platforms. Offering 330 W allocated over eight ports (up to 60 W per port), the MILTECH 910 can power both IEEE 802.3at- and 802.3af-compliant devices through an Ethernet cable.

Figure 4 | The Techaya MILTECH 910 is a rugged, 8-port Power over Ethernet (PoE) gigabit switch. Photo courtesy of MilSource.

Army ATACMS upgrade contract won by Lockheed Martin

Lockheed Martin won a $78 million contract to upgrade the U.S. Army's Tactical Missile System (ATACMS). The program will use hardware from early-production ATACMS Block 1 missiles to develop an enhanced and affordable weapon system that can eliminate targets without risking unexploded ordnance, which meets the Army's long-range precision strike requirement.

The program's first phase will have flight tests, followed by production starting in 2016. Work will be done at Lockheed Martin facilities in Camden, Arkansas and Dallas. Each ATACMS missile is packaged in a Guided Missile Launch Assembly pod and is fired from the Multiple Launch Rocket System (MLRS) family of launchers.

Figure 5 | An Army Tactical Missile System (ATACMS) missile blasts from its launcher during a recent test flight. Photo courtesy of Lockheed Martin.

First missile launched from V-22 during tests by Raytheon, Bell Helicopter

Raytheon and Bell Helicopter personnel completed the first two launches of the Griffin B missile from a Bell Boeing V-22 Osprey aircraft at Yuma Proving Ground in Arizona. Bell flight test crew personnel launched two Griffin B missiles with each scoring direct hits from hover mode and during conversion mode at 110 knots. The missile's off-axis launch capability enables precise striking of targets to the left or right of the aircraft flight path.

The Griffin A (AGM-176A) is an aft-eject missile produced for employment from platforms such as the C-130 aircraft. The Griffin B (BGM-176B) is a forward-firing missile that can launch from rotary- and fixed-wing aircraft, ground-launch applications, and maritime platforms. The missile is 43 inches long, weighs 33 pounds, has a 13-pound warhead, and is in production.

NASA Orion completes first spaceflight with TTTech's TTEthernet technology onboard

NASA, Lockheed Martin, and Honeywell have successfully completed the NASA Orion test flight, which lifted off aboard a Delta IV Heavy rocket to perform its first spaceflight. NASA, TTTech, and other industry participants contributed to an open Ethernet-based standard suitable for the deployment in upcoming NASA programs and space systems, such as the Orion project. TTTech's Deterministic Ethernet network technology – TTEthernet – combines commercially available Ethernet infrastructure with deterministic QoS Layer 2 enhancements and services. These services are designed to enable synchronous, embedded computing and networking capable of tolerating multiple faults.

TTEthernet used onboard the Orion spacecraft enables graphics data streams, partitioned critical control data, and standard LAN messages to operate in one network without interference. TTEthernet also enables the handling of mixed-level criticality functions in Ethernet-based networks.

DARPA selects BAE Systems for phase 2 of radar countermeasure effort

BAE Systems officials announced that the Defense Advanced Research Projects Agency (DARPA) chose the company for Phase 2 of its Adaptive Radar Countermeasures (ARC) program, which has a goal to develop technology to counter threats from air defense systems. Currently, electronic warfare (EW) systems must be used only on known emitter databases to characterize emerging threats. As part of ARC Phase 2, BAE Systems will look to deliver a prototype system that will have software algorithms capable of detecting and countering emerging radar threats, enabling a major capability enhancement without costly hardware upgrades.

This award follows on the company's work in Phases 1A and 1B to create technology that leverages advancements in EW systems to rapidly characterize emerging radar threats, synthesize electronic countermeasures, and then assess the effectiveness of the response.

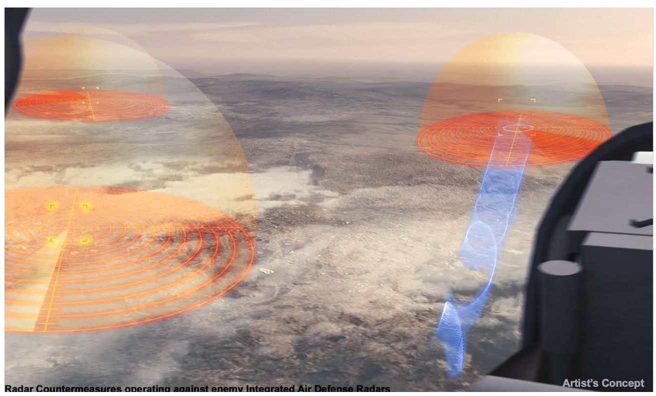


Figure 6 | Pictured is an artist rendering of Adaptive Radar Countermeasures (ARC). Photo courtesy of BAE Systems.

Space Fence radar system to identify, track space junk

By Sally Cole, Senior Editor

Space Fence, a fully digital S-band radar system, is being built for the U.S. Air Force by Lockheed Martin to better identify and track space junk to help protect military satellites and other space assets by preventing conjunctions and the creation of more debris – hurtling along at speeds of 17,500 mph – within low-Earth orbit.

Space Fence is a fully digital S-band radar system that can track debris as small as 10 centimeters. Photo courtesy of Lockheed Martin.

Since 1961, the U.S. Air Force has maintained a highly accurate catalog of objects within low-Earth orbit that are larger than the size of a softball, sharing responsibility with NASA for providing situational awareness of this environment to avoid potential conjunctions – a.k.a. "collisions" – with satellites and spacecraft.

Now the Air Force's Space Surveillance System, which tracks more than 200,000 pieces of debris, will soon be enhanced by "Space Fence," a fully digital S-band radar system being built by Lockheed Martin, capable of tracking debris as small as 10 centimeters.

Clearly, as space junk continues to proliferate at a rapid pace, it's critical to be able to know not only where all of this debris is – so that it can be avoided during critical space launches and missions, or to maneuver satellites that cost hundreds of millions of dollars out of harm's way – but also to be able to identify what exactly it is.

At the heart of the problem is that space junk begets more space junk. In 2007, for example, China's anti-satellite test, which used a missile to destroy an old weather satellite, contributed 3,000 more pieces of space junk to be tracked. And in 2010, when a defunct Russian satellite collided with and destroyed a functioning U.S. Iridium commercial satellite, it added more than 2,000 pieces of trackable debris (see Figure 1).

With every space launch, there is always a risk of creating more space junk via rocket engines and other material jettisoned off, if it is not planned and carried out with foresight. "An astronaut's glove from a spacewalk, dead satellites, and other equipment that used to be operational are currently among the items in orbit," explains Steve Bruce, vice president for advanced systems at Lockheed Martin Mission Systems and Training.

Military satellites are not the only space assets that need to be protected from space junk. We rely on a variety of satellites for nearly every aspect – including GPS, banking, and telecommunications – of our interconnected lives now.

Space Fence design

Lockheed Martin's Space Fence design combines a scalable solid-state S-band radar with a higher wavelength frequency capable of detecting much smaller objects than the Air Force's Space Surveillance Network.

"Space Fence will become part of the Space Surveillance Network, which is a whole series of radars and optical sensors on the ground and in space charged with discovering where objects are and then tracking them in low-Earth orbit," Bruce explains. "It will have more capability than any of the systems currently in inventory, provide

more sensitivity, and have the ability to track more objects."

Part of Space Fence's new capability, for example, involves optical sensors that can be used to identify debris.

What else differentiates Space Fence from earlier radar systems? One key aspect is that its radar is classified as fully digital. "With older radar systems, the antenna was made out of a dish to act as a big deflector, or involved a phased array using electronics at the element level to create an array of transmitters and receivers," Bruce says. "In the past, those were typically analog radars, in which case an analog circuit formed the combined data from these transmit/receive modules to form beams in space that the antennas could steer."

Space Fence is also an active electronically scanned array (AESA), but a digital one. Two key pieces make it digital. "First, it uses distributed waveform generators.

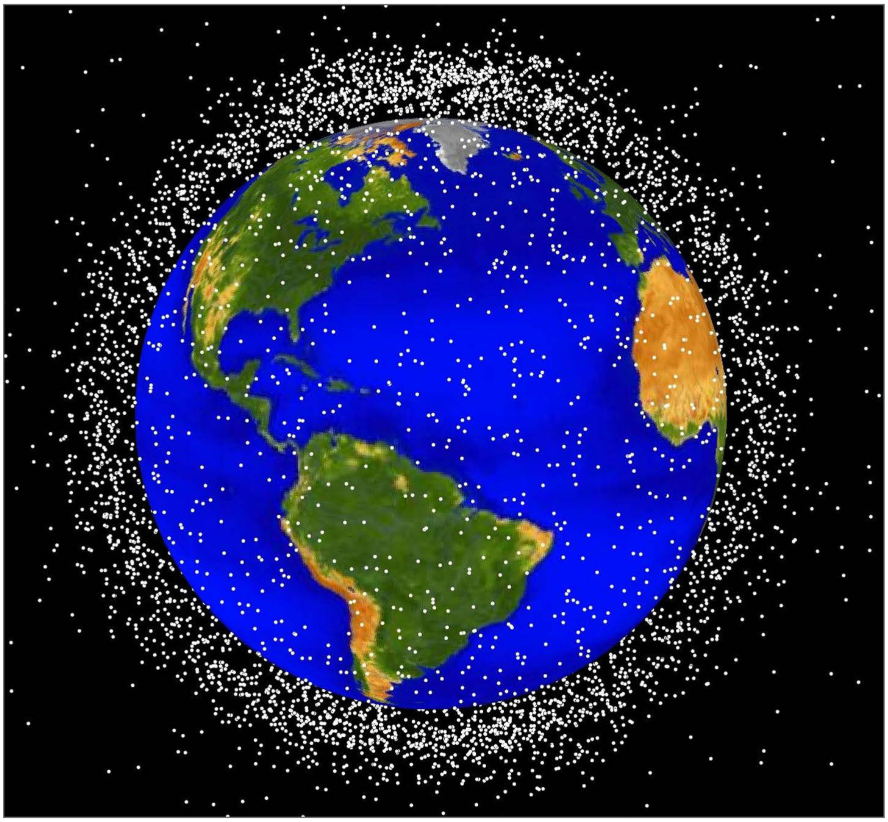


Figure 1 | Pictured is a radar-generated graphical image of space junk in low-Earth orbit. Image courtesy of Lockheed Martin.

Figure 2 | The Space Fence screen shows how operators can track space junk and other debris in orbit.

In the transmit aperture, line replaceable units (LRUs) take digital commands – it creates the transmit waveform right on the digital LRU and sends it through power amplifiers to create a transmit signal," Bruce continues. "Next, on the receive side, a series of low-noise amplifiers receive the radio frequency energy, which is then digitized to allow us to form numerous simultaneous receive beams. This makes our radar extremely flexible from an energy management perspective."

The reason Lockheed Martin decided to separate its transmit and receive antennas was primarily to improve the overall efficiency of the antennae. "This allowed us to build a very efficient transmit antenna by using gallium nitride (GaN) technology. It also allowed us to build a larger receive antenna, which needs to be a bit larger to make more accurate measurements about where the objects are in space," he notes.

In the array, they use a combination of custom technology and specific miniaturized microwave IC. "There are specific electronics in the aperture, but also custom electronics in the aperture. In the back end, our signal processing uses standard server technology," Bruce says.

"Once we digitize and form digital beams, all the processing uses commercial off-the-shelf (COTS) server technology," he adds. "So we have a very large server farm that does most of the signal, data, and mission processing. If you look at our compute engines that do orbital mechanics … it really isn't much different from a typical server farm." (See Figure 2 on previous page.)

Another big advantage of Space Fence's digital radar is that it can be software defined. "This allows us to change the way energy is managed in space, the way waveforms are transmitted or received – it's all fully programmable. The fact that it can be fully programmed to do many different things in the future adds tremendous flexibility to the system," Bruce explains. "This is a great asset not only for the U.S., but the entire world."

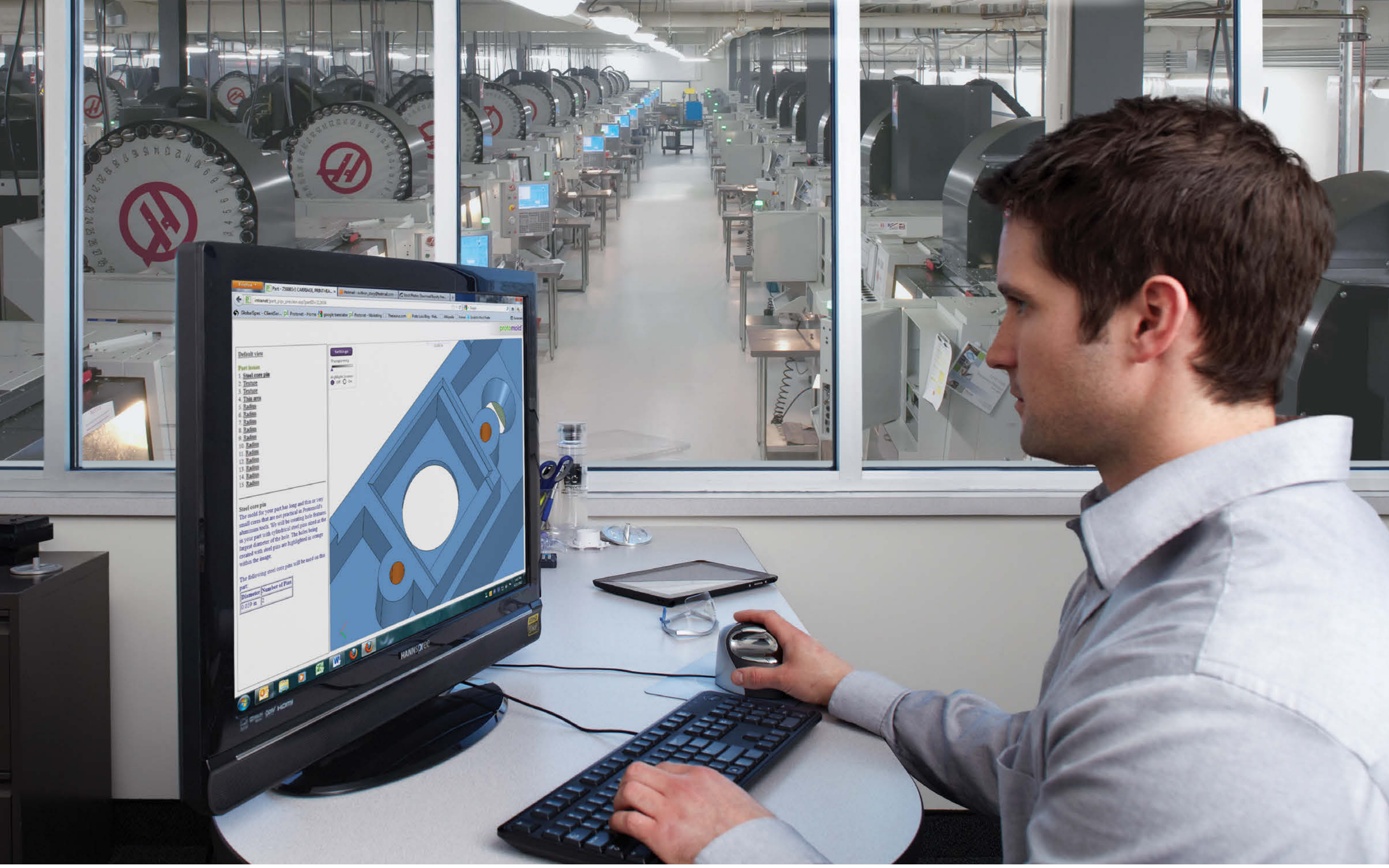
Project timeline

As far as a timeline for the Space Fence, the project began in June of 2014, will undergo a critical review in March 2015, and "in less than five years, Lockheed Martin will build the radar, get all of the electronics into it, test it, and then turn it over to the U.S. Air Force for operation by the end of 2018," Bruce says.

The radar facilities for Space Fence are currently being constructed on Kwajalein Atoll, an island in the Pacific Ocean. In terms of scale, once built, if you looked down on it from above it would look much like a couple of football stadiums.

Once Space Fence is up and running, it will allow the military to determine what types of objects are in low-Earth orbit and to track them. "They'll use it to manage our U.S. space assets as well as to inform the world about potential conjunctions," he adds. "It's in every country's best interest to know what's going on so they can maneuver their satellites out of the way to avoid creating more space debris."

The catalogue of space junk, which currently stands at about 20,000 objects being tracked by the U.S., is expected to grow quite substantially. "No one really knows what's up there; it could be upward of 200,000 objects that we'll be able to find and track," Bruce notes. "But what's most important is being able to figure out where these objects will be in the future so we can predict and avoid conjunctions." **MES**



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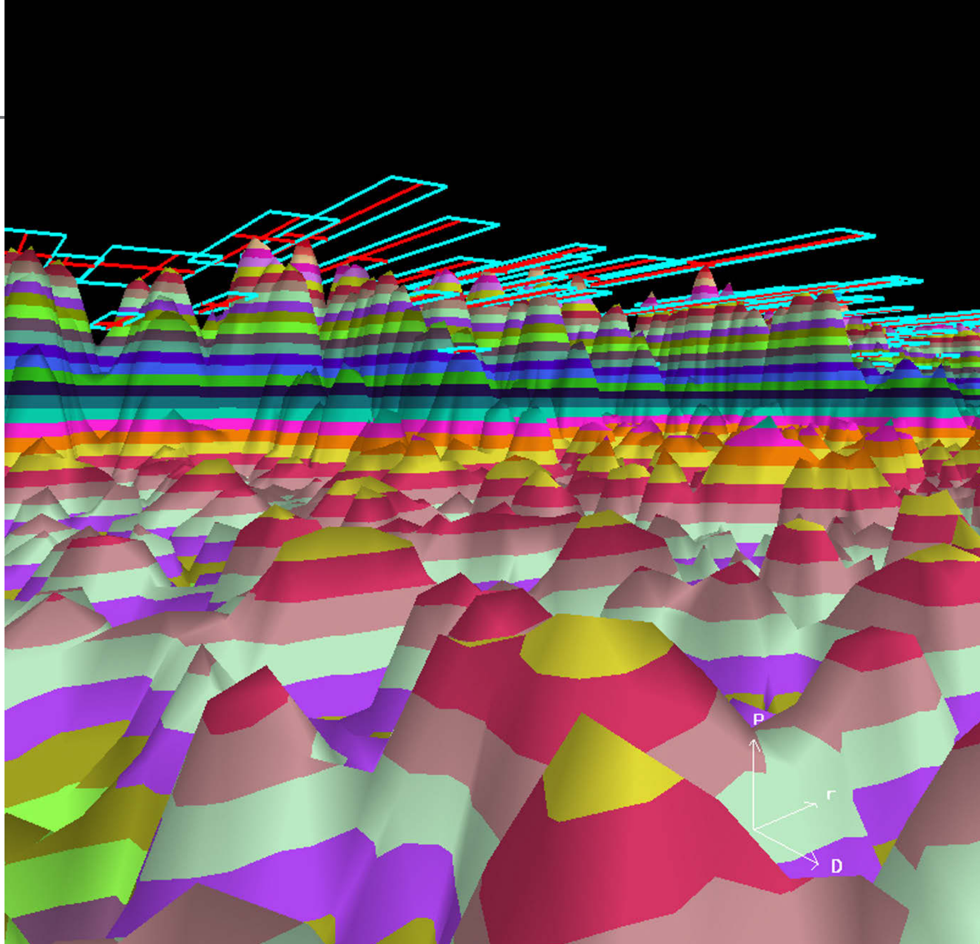
RADAR DESIGN TRENDS

Small radars enable detection in coastal zones

By Sally Cole, Senior Editor

For force protection in tight areas such as coastlines and coastal zones, military leaders are leveraging small, compact surveillance radar systems. Mark Radford, CEO of Blighter Surveillance Systems, discusses this trend and talks about the technology behind small radars with Senior Editor Sally Cole. Edited excerpts follow.



The image above depicts a 3-D Doppler view of sea clutter detection with separate target RGB.

MIL-EMBEDDED: ***How are small radars being leveraged for military applications?***

RADFORD: In recent years, a number of smaller 'compact surveillance radars' (CSR) were launched for military force protection and gap filling applications. Such CSR have reduced the antenna size below 0.5 meters, but due to the inevitable inaccuracy in the angular measurement, can only offer useful performance out to limited ranges of around 1 kilometer. An angular error of ±2 degrees at 500 meters is just ±17 meters, but at 5 kilometers is a whopping ±175 meters.

MIL-EMBEDDED: ***How much smaller will these radar systems go in the future?***

RADFORD: The limiting factor for radar system size is primarily the size of the antenna required to achieve useful accuracy in the angular measurement of detected targets. Laws of physics dictate that a radar antenna that is, say, 0.5 meters across, will detect targets to an accuracy of approximately 1 to 2 degrees – perhaps 0.5 to 1 degree through the use of additional tracking software.

MIL-EMBEDDED: ***What are the biggest technical challenges involved in designing small radar systems?***

RADFORD: The key challenge is being able to amass all of the design disciplines necessary to design a compact radar system. Such systems require a synergy of radar system design, RF and microwave, waveform generation, digital signal processing, radar data processing, power supply, and mechanical design skills such as thermal analysis. Unless every part of the radar system is designed with a deep understanding of the other system components, compromises will inevitably occur. The smaller the radar system, the greater the concentration of compromises.

MIL-EMBEDDED: ***What types of form factors and processing are involved? Custom design or not?***

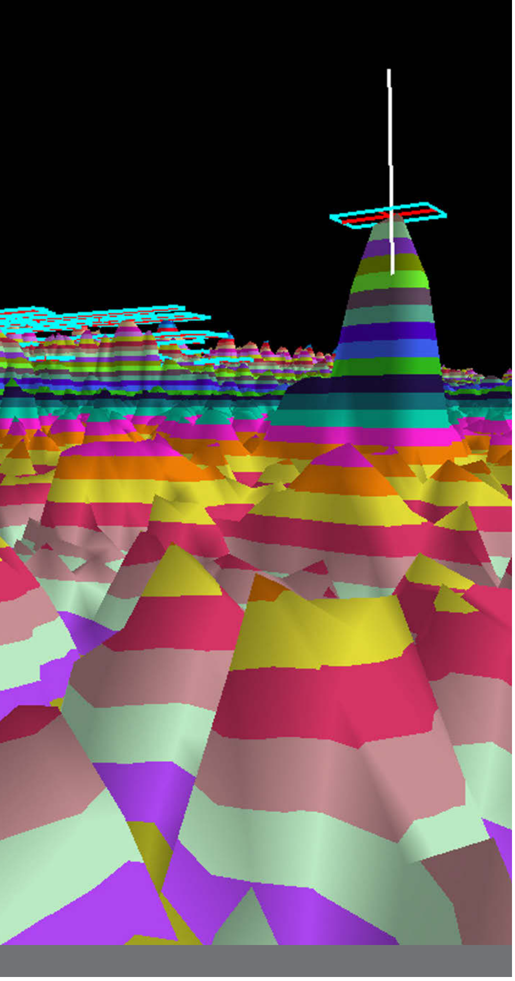
RADFORD: When designing Blighter radar, the hardware engineers took a modular approach that allowed both off-the-shelf and custom-designed modules to be used. For instance, the processor, synthesizer, and FPGA processing modules are all designed in-house and have a fully customized form factor. Modules such as the compass and GPS are 'bought-in,' off-the-shelf.

MIL-EMBEDDED: ***Do the Blighter radar products use many off-the-shelf solutions?***

RADFORD: Our radar doesn't use many embedded, off-the-shelf systems because there is insufficient control of all of the parameters that affect performance within the system. For example, all clocks used within the design need to be phase-locked to one another to avoid spurious internal emissions that could reduce radar sensitivity or create false targets.

MIL-EMBEDDED: ***How do you handle the cooling of electronics in the radar design?***

RADFORD: Blighter radars neither use nor require any active cooling and don't need to be placed or operated from inside any sort of protective radome enclosure. Instead, the complete radar unit – including the antennas, signal processing, and plot extractor – is typically just mounted at the top of tall, fixed



surveillance towers or on extendable pump-up vehicle masts. As such, much of the outer case of the radar is exposed to heavy solar loading during daylight hours, so it was important to keep the radar's power consumption and dissipation to a minimum (see Figure 1).

From the outset, our radars were designed with the goal of consuming and dissipating only very small amounts of power, compared to both traditional mechanically scanned radars and active electronically scanned (AESA) radars.

Power consumption is kept low by using the much more efficient frequency modulated continuous wave radar processing technology instead of the traditional 'pulse' radar technology used since the invention of radar. Whereas pulse radars generally emit many kilowatts of radar energy, Blighter emits 4 Watts in its highest power version and just 1 Watt in its standard power version. So while a pulse radar can consume – and dissipate – between 500 Watts to 2 kWm, ours consume 40 to 100 Watts, which is roughly equivalent to the power consumption of a standard household incandescent light bulb.

Figure 1 | Pictured is the Blighter B400 radar.

Our radars also use low-power passive electronically scanned array (PESA) technology on its transmit and receive channels to electronically steer the radar beam in azimuth. Adoption of such digital beam forming allows the radars to detect both small and slow-moving targets that mechanically scanned radars would be unable to detect. PESA technology is also more power efficient than competing AESA technology. Implementing an AESA-based e-scan radar would necessitate the use of many tens of active transmit and receive radar modules/elements, which would each be power-hungry and costly to manufacture.

MIL-EMBEDDED: ***How do these radars enable detection of objects or people within coastlines and coastal zones?***

RADFORD: Our Blighter B400 e-scan radar's algorithms – including a sea wave clutter filter and non-moving target detector – and its frequency modulated continuous wave transmission technology, combined with sensitive Doppler signal processing target detection, enables it to detect the small and uncooperative targets that traditional coastal surveillance radars such as vessel traffic systems and maritime radars are simply not designed to detect.

These features enable protection for complex coastlines from intruders such as smugglers, pirates, illegals, and terrorists at ranges of as far away as 16 kilometers. It can detect and locate small targets day and night, in almost all weather conditions, including rough seas, heavy rain, or dense fog.

In terms of size, it's about the equivalent of a large briefcase and transmits 4 Watts of power, while consuming 100 Watts. This allows operation via solar panels and easy installation in difficult to reach areas such as rocky or inaccessible coastal regions. The radar's low data bandwidth requirement also allows remote operation over narrow-band wireless links or satellite communication systems. **MES**

Mark Radford *has worked in the radar industry since 1985, initially as a designer of high-performance signal processing solutions for naval radar systems, and then later as a system designer and development manager. Since joining Blighter Surveillance Systems in 2000, he has been involved in various radar development projects, including the specification, design, and development of the electronic-scanning frequency modulated continuous wave (FMCW) Doppler surveillance radar.*

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Multifunction, high-performance AESA radar leads a transformation of the battlefield sensor network

By Doug Carlson

Active electronically scanned array (AESA) radar systems built with gallium nitride (GaN)-based radio-frequency (RF) power components are helping to elevate the capabilities of the modern networked battlefield.

The SBX-1 is a floating, self-propelled AESA radar station that is able to move to areas where it is needed for enhanced missile defense. Part of the Department of Defense's Ballistic Missile Defense System, the SBX-1 has as its primary task discrimination/identification of enemy warheads from decoys, followed by precision tracking of identified warheads. The floating radar station – mounted on a twin-hulled semi-submersible drilling rig – measures 279 feet (85 meters) from its keel to the top of its radar dome. (Photo courtesy of MACOM and U.S. Department of Defense/Missile Defense Agency.)

Multifunction active electronically scanned array (AESA) radar is making significant inroads into the modern networked battlefield. AESA radar is featured in technologies such as the Next Generation Jammer (NGJ) capability – developed by Raytheon and soon to be installed on the U.S. Navy's EA-18 Growler air fleet – bringing conventional electronic warfare and advanced cyber defense capabilities together via an AESA radar-based platform.

Advanced AESA radar is also coming to U.S. Air Force F-16s by way of Northrop Grumman's Scalable Agile Beam Radar (SABR) technology; Raytheon's Advanced Combat Radar (RACR) has also emerged as a similar AESA technology platform, offering the ability to simultaneously detect, identify, and track multiple air and surface targets. Every member of NATO has announced AESA upgrade programs based on these and other platforms.

Next-gen radar for increased situational awareness

This evolution of the modern battlefield is being driven by the need for improved connectivity and situational awareness to ensure mission success in the face of unpredictable and dynamic adversaries. The modern fighting force needs to be equipped with advanced sensor and communication infrastructure designed to operate as a unified, highly versatile mesh network that distributes critical data across ground, sea, and air domains at previously unimaginable speeds and bandwidths.

To enable continuous, high-performance data distribution throughout the modern battlefield, the underlying sensor mesh must operate as a homogenous network, adapt quickly to changing operating conditions, and be highly resilient to ensure that the loss of individual sensor nodes throughout the network doesn't compromise the integrity or effectiveness of the network itself. Next-generation radar systems are therefore critical to providing situational awareness beyond the single platform of operation to the entire networked battlefield. To meet these complex needs, advanced radar systems are transitioning away from conventional radar architectures that rely on mechanical steering – which are prone to limitations in agility and reliability due to size, weight, and functionality – and turning toward AESA radar systems that offer key performance advantages and multifunction capability.

With AESA technology, the mechanical gimbal is eliminated. Scanning is handled electronically via stationary arrays comprised of hundreds to thousands of transmit and receive elements. This array architecture enables simultaneous functions ranging from radar surveillance and fire control to jamming and advanced data link communications. Based on incoming information from nodes across the network, an AESA radar system can be called upon to aid a battle scenario by providing surveillance, jamming an enemy signal, or targeting and eliminating a threat.

Multifunction AESA versatility also enables dramatic improvements in target tracking. Conventional radar systems are optimized for either ultra-high-speed tracking of immediate threats, or long-range tracking of distant targets, but typically not both. Multirole AESA radar can combine these capabilities to allow for high-precision, multi-target tracking spanning both short- and long-range threats. It is easy to imagine how this advanced tracking capability could be applied in a fighter jet cockpit, enabling pilots to detect and visualize a considerably higher number of approaching enemy aircraft and missiles than they can today.

Power for performance

Accelerating the forward progress toward next-generation multifunction AESA radar that strengthens and expands the battlefield sensor network hinges on the ability to develop and manufacture smaller, lighter, wider-bandwidth, and more energy-efficient RF power components that promote multifunction integration. What is needed in all of these cases is a new approach to power component design and packaging that provides greater overall power performance in a smaller form factor with the greatest possible ease of assembly.

AESA radar system designers can achieve high-power operation with improved efficiency while accelerating time to market by using the newly emerging GaN-based RF power components that can be assembled using highly automated commercial techniques. Improved efficiency and lighter-weight system design also enable AESA systems to be placed onto smaller operational platforms – such as unmanned aerial vehicles (UAVs) – that would otherwise be unable to provide critical sensor data in the battlefield.

These new GaN-driven capabilities are yielding a new generation of agile AESA radar systems optimized to meet the increasingly demanding performance and multifunction flexibility requirements of the modern battlefield. Among the many advantages that GaN offers for multifunction AESA radar systems are high-power operation, improved power efficiency, reduced system size and weight, and wide-bandwidth operation (see Figure 1).

GaN delivers minimally eight times the raw power density of incumbent GaAs technology, while boosting efficiency from mid-40 percent to as high as 70 percent depending on the frequency of operation. At the radar system level, the high-output power enabled by GaN-based RF components ultimately enables increased range surveillance with improved resolution in smaller platforms. This capability ensures that AESA radar systems are better equipped to distinguish real from false targets more accurately and alert the operator of threats more quickly. The ability to emit higher power also enables greater flexibility with regard to shaping the signal pulses without compromising on overall system performance.

The higher breakdown voltage performance of GaN allows for scaling to higher operational voltages, which leads to improved efficiency in the device and therefore the radar system's power supply. Higher efficiency reduces system-cooling requirements, which are a significant contributor to weight and power consumption, and enables longer mission operation before refueling in mobile platforms such as UAVs and ground units.

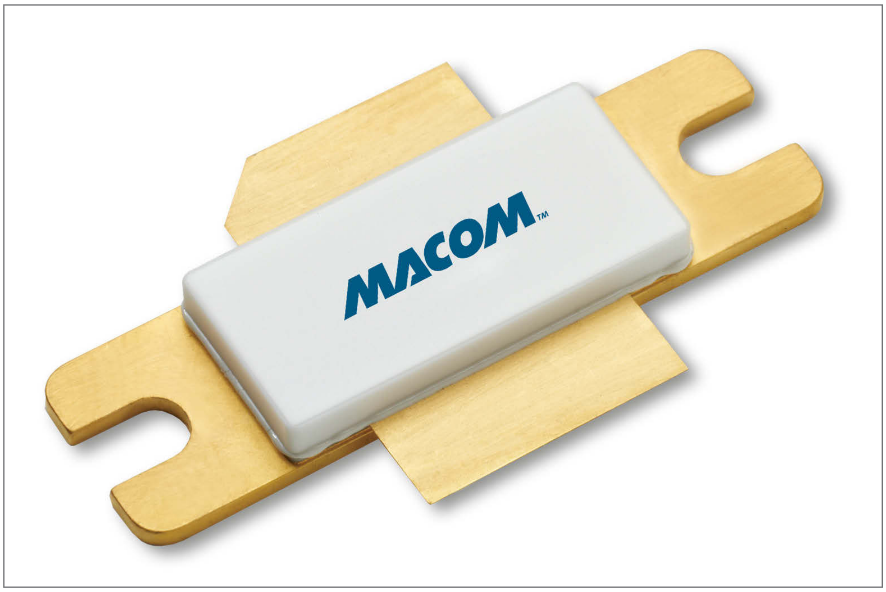

Figure 1 | The gallium nitride on silicon carbide (GaN on SiC) pulsed power transistor for military and civilian radar pulsed applications offers designers a typical 17 W of peak output power with 63 percent efficiency.

GaN in plastic-packaged RF power components has set a new standard for harnessing high power in small enclosures implementing surface-mount assembly, thereby eliminating many of the size and weight limitations of conventional ceramic-packaged GaN-based offerings. This aspect is particularly important given the accelerating proliferation of UAV-mounted AESA radar systems. For UAVs, any reduction in the size and weight of the underlying components has a direct, positive impact on the aircraft's flight range and operational versatility.

Moreover, the high voltage thresholds of GaN-based RF power components enable increased wideband impedance matching. This capability enables an AESA radar system to perform multifunctional roles across a broader frequency spectrum with increased operational flexibility.

The need for speed

Time to market is a critical consideration for modern military systems, with multifunction AESA radar systems no exception. Design and manufacturing cycles must be accelerated wherever possible to keep pace with rapidly evolving threats. In the electronic warfare domain, the proliferation of improvised explosive devices (IEDs) in urban battle zones has necessitated ever-faster prototyping, testing, and manufacturing of sophisticated IED-jamming devices that aim to minimize roadside casualties and equipment damage. The five- to 10-year design cycles that currently characterize large radar development programs – targeted at large platforms such as aircraft carriers, other warships, and fighter aircraft – will undoubtedly become increasingly compressed as new threats emerge with increasing frequency and are countered with more agile and flexible platforms such as UAVs.

The clear battlefield advantages enabled by multifunction AESA radar make this technology a prime candidate for intensified attention to design and manufacturing efficiency. GaN-based RF power components that support standard surface-mount technology (SMT) assembly lets developers accelerate time to market by leveraging commercial best practices for high-volume manufacturing, ensuring a host of additional benefits including improved assembly yield, lower component count, and reduced-touch labor. By enabling the use of SMT throughout the manufacturing process, radar system manufacturers can avoid the need for cumbersome cutouts, coining, and flange assembly (see Figure 2).

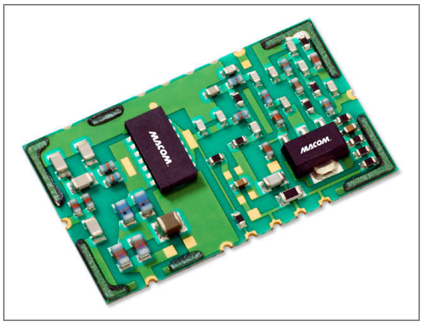

Figure 2 | MACOM's family of gallium nitride on silicon carbide (GaN on SiC) RF power hybrid amplifiers – optimized for military radar applications – supports standard surface-mount assembly, enabling designers to realize improved assembly yield, lower component count, and reduced-touch labor.

Tight integration at the embedded component level reduces the space required for each RF element and reduces the number of overall components needed to be procured, which naturally helps accelerate lead time. Aggregate reduction in part count also minimizes the risk of performance variation from component to component.

Innovation advantage

Continued innovation in GaN-based RF power components promises to accelerate the trend toward advanced, multifunction AESA radar systems by introducing significant benefits including improved power, efficiency, and operational agility; reduced system size and weight; and shorter time to market. As this technology makes its way into the integrated mesh network of sensors that underpins the modern battlefield, it will enhance the potency and agility of our fighting forces for decades to come. **MES**

Dr. Douglas J. Carlson *received his Sc.B. in Electronic Material from Brown University in 1983 and his Sc.D. in Electronic Materials from the Massachusetts Institute of Technology in 1989. Dr. Carlson subsequently served on the research staffs of MIT and Bell Laboratory. In 1990, Dr. Carlson joined MACOM in its Advanced Semiconductor Division; his current position is Vice President of Strategy. Readers may contact him at douglas.carlson@macom.com.*

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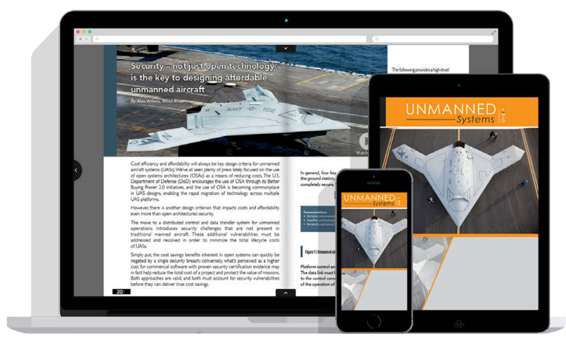

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Qorvo GaN technology is leading the way forward for RF and high-density power

Q&A with James Klein, President and General Manager for Qorvo's Infrastructure and Defense Group

This January, RF Micro Devices and TriQuint Semiconductor completed their merger of equals to form Qorvo™, a new leader in RF solutions. Qorvo offers the core technologies that bring together critical RF developments and solutions, to improve system performance across mobile, infrastructure and aerospace and defense applications.

Qorvo's development of GaN-based devices is leading to smaller, more efficient power amplifiers used for military radar and electronic warfare programs. Qorvo provides strategic foundry services and products to support Department of Defense programs including airborne radar on the F-15, F-18, F-22 and F-35. James Klein is the president and general manager for Qorvo's Infrastructure and Defense business and answers some questions about the future of the industry below.

MIL EMBEDDED: ***What is your outlook for the military radar market from an RF component perspective? Is it healthy with a mix of upgraded new design-in opportunities?***

The global radar market itself is growing at a moderate, single-digit rate, providing great opportunities in all sectors. The fastest growth rate appears to be in the Asia-Pacific region, followed closely by the Middle East-Africa region. The airborne market is the largest current size, but we are also seeing growth in the land and ship segments.

Our outlook for this market is very positive, especially from the RF component perspective. The RF front-end components content is growing at a high rate, and Qorvo continues to enjoy a very competitive position in many of the major current and upcoming military radar procurements.

Qorvo sees new design opportunities with the overall shift to more AESA-technology based systems, containing more GaAs/GaN sockets. In addition, the increasing maturity and higher GaN adoption rate than anticipated is occurring globally.

The new/major upgrade opportunities are obviously driving the market, but there appears to be some healthy growth in the minor upgrade opportunities and the rise of TWTA replacement technologies as well.

MIL EMBEDDED: ***Where do you see the most activity in military radar designs – airborne? ground? shipboard? other?***

For land-based and shipborne radars, S-band radar systems appear to be in particular demand to cover long-range capabilities. On the airborne front, low cost AESA-based radars are positioned to address retrofits and international markets at a very healthy rate, such as Northrop Grumman's SABR and Raytheon's RACR technologies.

MIL EMBEDDED: ***How are the latest innovations in RF technology fueling capability in modern military radar systems?***

Advancements in GaN technology allow radar systems to reach higher levels of RF power with reduced DC power, circuit area, component count and cost – resulting in greater functionality for a lower overall radar system cost. The orders of magnitude improve the reliability of GaN over other semiconductor technologies, revolutionizing field performance and life cycle costs.

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No such thing as too much signal processing for radar & EW systems

By John McHale, Editorial Director

Engineers at Lockheed Martin in Syracuse, N.Y. used a Wildfire FPGA board from Annapolis Microsystems and the company's CoreFire FPGA development tool to program the boards to do the digitization and digital filtering inside the upgrade of 29 U.S. Air Force AN/FPS-117 long-range surveillance radars.

Signal processing fuels radar and electronic warfare systems as each application has an unquenchable thirst for more and more bandwidth and performance that is more often than not met by FPGA-based VPX computing systems.

Signal processing technology continues to evolve in both radar and electronic warfare (EW) applications as embedded computing designers work to meet the insatiable demand their military customers have for more bandwidth capability. The nature of their demands are the same year to year, but there will never be a point when they have enough signal processing to meet their needs.

Signal processing requirements from radar and EW programs are always about the same each year, but with new twists, says Rodger Hosking, vice president and co-founder of Pentek in Upper Saddle River, N.J. "In general military radar and EW designers want faster data converters with a higher sampler rate in and out. They also want higher resolution inverters for improved dynamic range and better signal detection in large and small signals. All of these demands are consistent with the need for wider bandwidth.

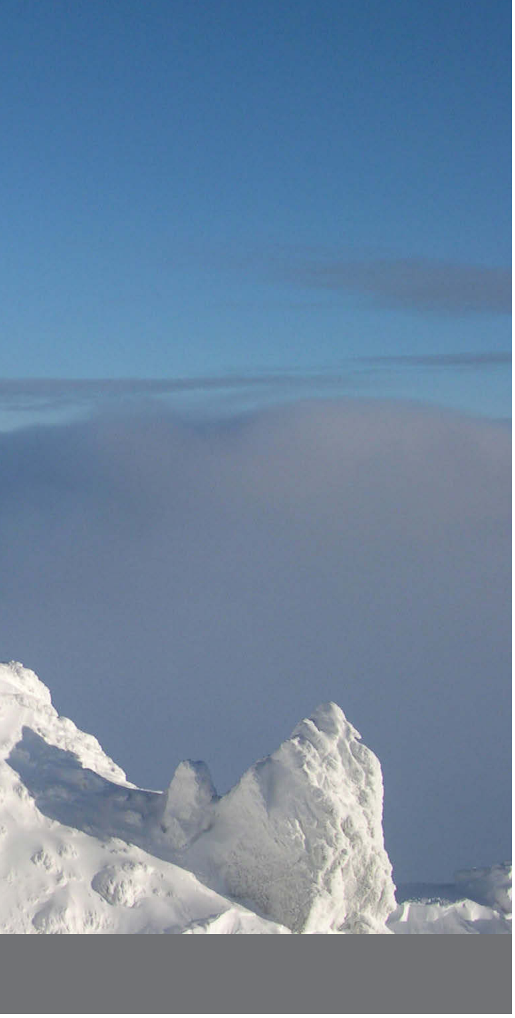
"People are constantly asking for faster speeds and more resolution because all the signals basically occupy the same spectrum and wider bandwidth is needed to accommodate higher-definition videos, transferring data for network traffic, etc.," Hosking says. "The waveforms also get more complicated every year as military system designers want better algorithms to get more information, to improve signal to noise performance, and to extract signals from noisy environments."

Application trends: EW

Each application has unique processing challenges; for EW systems, designers are pressured to keep latency low.

"While there is much commonality between signal processing solutions for radar and EW, there are differences as well, particularly when it comes to latency on EW, which is one of the biggest drivers in that field," says Peter Thompson, senior business development manager for high performance embedded computing at GE Intelligent Platforms in Huntsville, Ala. "For EW there is also a need for increased A-D and D-A performance and resolution. Getting data in and out as quickly as possible is paramount."

"For general EW signal processing designs there are two things we are seeing – wider bandwidth for the A-D converters and higher resolution – moving from eight to nine or 10 bits," says Noah Donaldson, VP of product development at Annapolis Micro Systems in Annapolis, Md. "For EW applications the main thing our customers want is low latency. You want it to be as low as possible – less than a few dozen nanoseconds. It is difficult to achieve, and you have to design a number of things just right. The A-D converter and D-A converters have to be properly designed along with the firmware, if not then often users will have to redesign



everything. To get minimum latency the hardware and firmware must be designed in sync."

Typically server-class signal processing solutions are being leveraged for advanced electronic countermeasures in EW applications, says Shaun McQuaid at Mercury Systems in Chelmsford, Mass. "Advanced deep signal analysis is also starting to be talked about by our customers. The number of EW threats continues to grow and the only way to combat them is with a broad-based, multithreaded signal processing approach that handles cognitive challenges with Xeon server-class systems that have GPUs on the back end and FPGAs handling the front end. The FPGA is key to tackling low latency challenges in EW systems," he continues.

"FPGAs are enabling much of the gains in signal processing performance on the front end," Thompson notes. "It is a case of horses for courses. Huge bandwidth of data coming in through FPGAs on front end while on the back end parallel processing through GPUs are key." The IPN 251 is GE's latest 6U OpenVPX

Driving down the cost of ESAs

By Sally Cole, Senior Editor

Decreasing the cost of electronically scanned arrays (ESAs) is a big concern for the U.S. military and, as part of the U.S. Defense Advanced Research Projects Agency's (DARPA) Arrays at Commercial Timescales (ACT) program, Rockwell Collins engineers are exploring ways to make it happen.

ESAs, which are used primarily for tactical aircraft to detect and jam signals, justify $1M price tags for radars. "But this same technology would be useful in communications and other applications if we could drop the cost by a factor of about 1,000," says John Borghese, vice president of Rockwell Collins' Advanced Technology Center in Cedar Rapids, Iowa. "It's the key challenge we're working on as part of DARPA's ACT program."

The company is seeing "demand in the defense radar space from defense customers and Department of Defense (DoD) contractors working in complementary roles in terms of developing low-cost array technology," points out Lee Paulsen, principal electrical engineer for Rockwell Collins.

This trend is expected to proliferate as the costs of these arrays decrease. "Expect to see them in automobiles in the near future to detect children or objects in front of or behind the vehicle," notes Borghese. "And at least one cellphone company is actively exploring using ESAs in their phones."

As standards discussions continue for 5G technologies, ESAs will be involved. "To get access to open bandwidth, we'll need to move into more sophisticated millimeter-wave-type frequencies with available spectrum. It's one of the means to achieve the 10 or 100x improvements in bandwidth for 5G," Paulsen says.

So, how is Rockwell Collins targeting lower-cost antennas? With a few different approaches. "Sense-and-avoid radar is one of the tools in the toolbox for making UAVs safe for national airspace or search-and-rescue radars. This market will be well regulated and slow to change," explains Paulsen. "It has lots of volume, with thousands of systems per year. In this case, our approach is to integrate very-low-profile phased array systems and get rid of interconnect costs by soldering components together instead. We can collapse multiple different layers of the phased array subsystem into a single laminated PCB, which will have a radiating layer, a beam-forming layer, a control layer, and a power distribution layer – all as separate planes."

Another aspect involves exploring lower cost material sets. "Instead of some of the expensive high-linearity gallium nitride (GaN) components, silicon-based solutions or chipsets can be used in the military," Paulsen adds. From his perspective, there's a huge advantage to "being vertically integrated in these spaces and able to keep the overhead for each of the subcomponents relatively shared. Moving in that direction will enable us to create lower-cost phased arrays for some of these emerging radars."

Then there is the DARPA ACT program, which is trying to solve two problems simultaneously. "We're working on developing an array architecture that can be used for numerous platforms, a 'one-size-fits-most' approach, which will help drive volume," explains Paulsen. "Everyone wants the ability to update the architecture regularly, so we're leveraging next-gen FPGA technology to help coalesce multiple layers of existing phased arrays – essentially pushing them into a common module." To do this, they're targeting making the most expensive pieces of technology within the phased array software-definable in a power-efficient way.

One of Paulsen's visions for ACT is to end up with software-defined arrays with only power and digital interfaces. "All of the RF interfaces and signal processing – even adaptive beam forming – will be done inside the array box," he elaborates. "Similarly, for radars, you can imagine moving all of the processing inside the same box. Moving these things out onto the face of the array frees up space inside UAVs and electronics bays in aircraft."

Rockwell Collins' overall goal for ACT is to "show that we can develop the technology to build these things…that it's physically possible and the math works and holds up," says Borghese.

"The reality is that it brings substantial differentiating capabilities to the warfighter and the DoD in general," Paulsen adds. "We're talking about moving into spaces where communications systems will need directional antennas to avoid being shot down, because we're facing or posturing to face more sophisticated adversaries than in the past."

Within the context of sequestration, pursuing 'cost-neutral ESAs' is necessary. To do this, they're focusing on removing expensive, mechanically clunky dish antennas, for instance, and replacing wave guide slot antennas with ESAs at no net price increase so that when technology upgrades or refreshes roll around for the platform, it should be affordable.

platform and combines Intel quad core and a Nvidia GPU for a design popular with radar users, he adds. (See Figure 1.)

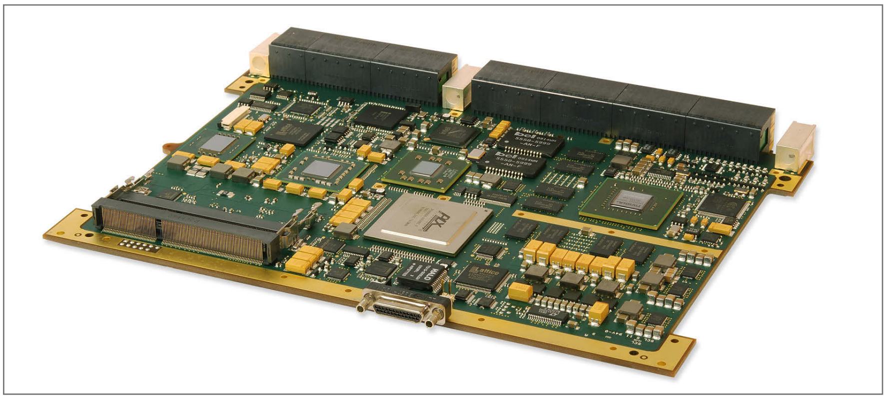


Figure 1 | The IPN 251 is GE Intelligent Platforms' latest 6U OpenVPX platform and combines Intel quad core processors and a Nvidia GPU.

Application trends: Radar

The insatiable need for data is what drives radar system signal processing requirements. "The military does not have a 'good enough' point in these applications," Hosking says. "They want to be able to detect targets as far away as possible.

"For radar systems larger Fast Fourier Transforms (FFTs) are needed for more precise Doppler processing, where the radar systems track the speed and direction of targets," he continues. "Improving resolution at a given range yields more accurate target information, including the mass of an aircraft and detection of unique structures and reflection characteristics of a jet. This rich set of information in the received signal can absolutely identify a target. It's akin to looking at fingerprints 10 feet away vs. examining it under a microscope." Pentek offers the 5973 Flexor Virtex-7 VPX-based FMC for radar applications. It features the emerging VITA 66.4 optical backplane interface to deliver systems to customers that interconnect between modules in a chassis and between chassis via high-speed optical links with the ability to connect system elements as far as 10 kilometers apart, Hosking says. (See Figure 2.)

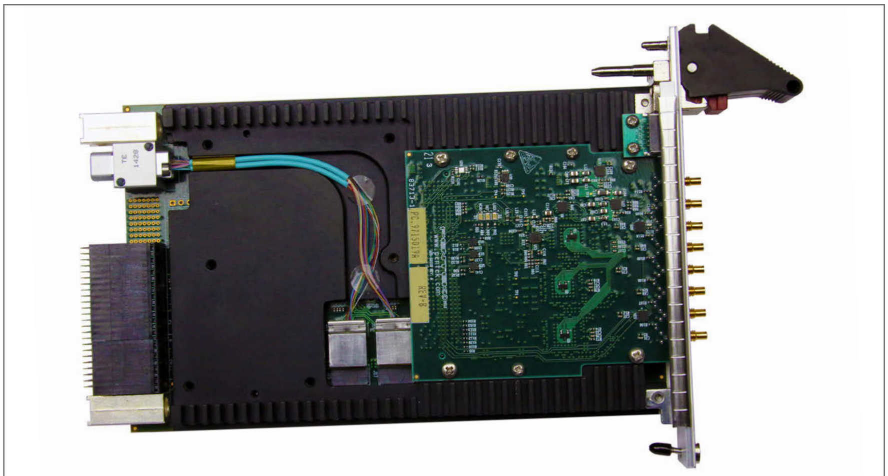


Figure 2 | The 5973 Flexor Virtex-7 VPX-based FMC from Pentek features the emerging VITA 66.4 optical backplane interface.

"On the radar side you need agility in frequency and waveforms, and the capability to defeat countermeasures," Thompson says. "Bigger and faster memories are also required with higher and higher resolutions to track more and more objects on the ground. There is a constant push to do more and to reduce SWaP at the same time. For radar we also see a lot of demand for open systems architecture now. We don't see radar program managers wanting to be locked into a specific architecture and vendor for hardware and software. This is not necessarily true in EW as they want to do whatever it takes to meet their latency goals."

What radar system designers want most is speed. "For radar systems, people want more channels, faster A-D converters for wider bandwidths, and then they are looking for A-D converters with the highest resolution," Donaldson says. "For example, with phased array radar, dozens, hundreds, or thousands of A-D converters are needed and we have come up with a COTS architecture to support synchronization of that many channels."

"A number of our radar customers are also focusing on enabling more raw processing performance onboard aircraft platforms for real-time exploitation of data before it has to be sent to the ground via weak data links," McQuaid says. "In the radar space the appetite for more processing performance will only continue to grow." For signal processing applications Mercury offers the HDS6603, a blade with more than one Teraflop (TFLOP) of general processing power in a single OpenVPX slot, McQuaid says. It uses two 1.8 GHz Intel Xeon E5-2600 v3 processors with 12 cores each to provide a total of 1.38 TFLOPS.

VPX

VPX, or VITA 46, based on signal processing systems are dominating the embedded niche for radar and EW systems as it is easily the best form factor for engaging switched fabrics and enabling super computing functionality for these applications.

"The data from radar and EW applications all feeds into what the DoD is calling the tactical cloud of big data that enables U.S. warfighters to have decision superiority on the battlefield," McQuaid continues. "So in a way OpenVPX is fueling the tactical cloud as it enables the supercomputing capability and sheer processing power needed

Upgrades vs. new programs

While recent budget constraints have curtailed many large ticket programs in the U.S. Department of Defense, funding for radar and electronic warfare have remained relatively flat – but the question remains, is the funding going toward more new systems or technology refreshes/upgrades?

"Most times it is hard to call something an upgrade when you are replacing old technology with a system, such as VPX, that is significantly superior to what was there before," says Rodger Hosking, vice president and co-founder of Pentek in Upper Saddle River, N.J. "The aircraft or radar platform may be the same, but the processing solution being designed in is totally new. For radar systems that are 20 years old, a new system with the same footprint can deliver 10 times the functionality. Taking advantage of today's technology makes it almost not fair to compare them to systems 10 or even five years old. Functional performance is moving so quickly it's wonderful."

"We see a mixture of both round of radar designs and upgrades to existing radars at the platform level," says Peter Thompson, senior business development manager for high performance embedded computing at GE Intelligent Platforms in Huntsville, Ala. "However, it is true that radar processing upgrades don't look much different from new designs because of the improvement in performance over the older system is so significant.

"Development time and cost are the biggest drivers in upgrade designs, which is why they trend toward modular systems that enable system integrators to find the best product and vendor," Thompson continues. "It also means they can upgrade platforms piecemeal. Instead of changing an entire processing chain, they can leave the rest of it as is, defining interfaces between subsystems."

to generate the data it needs to exist. VPX is able to deliver the kind of architecture and ruggedization necessary for this tactical environment."

"We're seeing a lot more requests for VPX in radar and EW systems, more than CompactPCI and more than AMC or MicroTCA," Donaldson says. "Some customers are also looking for 3U VPX due to a requirement for a smaller form factor. The 3U form factor provides a smaller Line Replaceable Unit for easy upgrades and maintenance. However, those who do not have the space constraints and need the better density still go with 6U VPX designs. Annapolis offers the WILDSTAR 7 Conduction Cooled OpenVPX 6U product, which is hot-swappable and has as many as two Xilinx Virtex 7 FPGAs per board with VX690T or VX980T FPGAs and as much as 8 GB of DDR3 DRAM for 51.2 GBps of DRAM bandwidth or up to 64 MB of QDRII+ SRAM for 32 GBps of SRAM bandwidth. It may also be air-cooled." **MES**

Flexible military radios balance SWaP, cost specs

By Paul Dillien

Over the last decade, engineers working to create software-defined radio (SDR) systems have found it challenging to design a very flexible wireless system that meets the military requirements for space, weight, and power (SWaP) at an affordable cost.

U.S. Marine Corps Capt. Michael Fox, a forward air controller with Fox Company, 2nd Battalion, 8th Marines (2/8), Regimental Combat Team 7, talks over the radio during Operation Nightmare in Nowzad, Afghanistan. (U.S. Marine Corps photo by Kowshon Ye.)

The SDR sector was given a big boost when the U.S. military Joint Tactical Radio System (JTRS) program was initiated in 1997. The program's ambitious objective was to allow mobile ad hoc networks to link together disparate wireless systems from the various branches of the military, other NATO armed forces, legacy radios, and some civilian systems. These systems included ground mobile radios (GMR), ground-to-air, and satellite communications.

The JTRS specification featured a wide range of what were termed "waveforms" that would be modulated onto any RF frequency over a huge range from high frequency (HF) to ultra-high frequency (UHF). The spec's physical layer included orthogonal frequency division multiplexing (OFDM) and wideband code division multiple access (WCDMA) technologies to enable users to communicate via voice, data, and video simultaneously at all levels of security. The system was designed to support the need for mobile Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) and to stay connected in the chaotic environment of a battlefield by using a self-healing network.

These technologies required complex processing of the baseband signal to realize the various waveforms. In order to achieve both the speed of processing and low power consumption, the design requires some form of hardware acceleration. The two most suitable options would be a hardwired mask programmed gate array or field programmable logic, such as a field programmable gate array (FPGA). The advantages of the "classic" gate array include optimized performance and low power; however, once the design is committed to silicon it has permanently fixed functionality. Moreover, non-recurring engineering (NRE) costs have escalated dramatically for leading-edge technology, due to the long production timescales typical of defense procurement. The FPGA option provided a flexible logic fabric; because it is reprogrammable, it allowed design iterations to be tested in hardware with no NRE.

The RF challenges also proved to be very difficult. The design of an RF chain that could span a wide range of frequencies is far from easy, with different frequencies requiring tunable components and an agile antenna. The bandwidth required for voice is much narrower than that needed for video, which gave added complexity to the design. Fast frequency hopping, spread spectrum, or OFDM further compounded the problems.

Unfortunately, the specification proved too complex and difficult for the technology of the day and the JTRS program was finally cancelled in late 2011. The program also suffered from feature creep and bloated requirements during the 15 years of

development, which rendered much of the earlier work obsolete. When the cancellation of the program was announced, the Defense Undersecretary was quoted as saying, "Our assessment is that it is unlikely that products resulting from the JTRS GMR development program will affordably meet service requirements, and may not meet some requirements at all. Therefore termination is necessary."

JTRS program elements live on

Fast forward to 2014: Many of the requirements from the JTRS program remain relevant today.

The advance of Moore's Law has been relentless, so that FPGAs fabricated using 20-nm planar technology are currently shipping, with 14-nm Tri-Gate (FinFET) technology just around the corner. This update has dramatically boosted both complexity and performance. For example, the midrange Altera Arria 10 SX family expands to 660k logic elements, alongside well over 40 Mbits of on-chip memory and more than 1k DSP accelerators. The 20-nm SX devices also feature dual high-performance ARM processors.

A question: How could a designer use an Arria 10 device to meet the baseband requirements of an SDR? The first decision is to partition the tasks between the software running on the ARM processors and the hardware accelerators and interfaces that will be built in the logic fabric. The general rule is that compute-intensive functions, such as Fast Fourier Transform (FFT) encoding and decoding or Forward Error Correction (FEC), are typically more efficient in hardware. The processor is ideal for activities like data moves to memory and protocol checking and manipulating.

MANY OF THE REQUIREMENTS FROM THE JOINT TACTICAL RADIO SYSTEM (JTRS) PROGRAM REMAIN RELEVANT TODAY.

The equivalent of baseband "waveforms" would be various modulation standards. These could be OFDM, which demands complex FFT computations, or Code Division Multiple Access (CDMA), requiring fast spreading code generation and correlators to despread and recover the received data. The DSP blocks in the Arria device form a key element of the hardware accelerator. Modern modulation systems use data in the form of In-phase (I) and Quadrature (Q) bitstreams; this allows the RF carrier to be modulated with quadrature amplitude modulation (QAM) such as 16 (up to as high as 256 QAM), or the simpler quadrature phase shift keying (QPSK). This high-performance task can be implemented in the DSP and logic fabric to save overall system power.

The latest standard is called Multiple-Input Multiple-Output (MIMO), a complex scheme that uses two or more antennas separated by a physical distance. MIMO techniques improve the spectral efficiency and achieve a diversity gain that improves the link reliability. It is expected that MIMO will become an important addition to meet the growing demand for data throughput.

A programmable logic solution offers significant additional advantages. The logic function is defined by a configuration file held in nonvolatile external memory and loaded into the device on power-up; the memory also holds the executable code for the ARM cores. This solution allows the functionality to be updated as a midlife software update, as users could, for example, support new waveforms in the logic or add new features to the ARM code.

The ARM processors can control the data flow into the FPGA cores, using them as specially customized peripherals. As an example, one core may be allocated to controlling the interfaces, such as a display or video screen, while also verifying that the received data packets are valid (see Figure 1 on following page). The second processor can control the hardware accelerators built from the logic and DSP resources. The ARM can select the hardware accelerators that implement the algorithm currently required, for example, to produce QAM16, and to regulate the data transfer to and from the field programmable radio frequency (FPRF) chip.

The ARM can control the FPRF device as well with a simple and fast SPI interface using a two-byte instruction to give it complete control of the RF domain. The processor can also process the received signal strength indicator (RSSI) that indicates the activity level at the chosen frequency. The combination of the FPGA and FPRF devices provides a highly flexible, low power, and above all, cost-effective solution to the logic and RF domains.

The LMS7002M, the second-generation FPRF device from Lime Microsystems, is a newly announced 65-nm CMOS chip that features a dual-transceiver architecture. The frequency range has been extended, so that it now covers 50 MHz to 3,800 MHz, giving support to the lower frequencies often used in legacy military radios. In addition, the upper limit can be easily extended with the addition of an external PLL and mixer, so that it can cover frequencies used in satellite communications.

The LMS7002M includes an on-chip microcontroller; this setup simplifies the calibration of the chip, which otherwise would involve complex interactions with the baseband logic. It calibrates DC offset, the TX/RX LPF bandwidth tuning, transmit local oscillator leakage feedthrough, IQ gain and phase mismatch in both transmit and receive chains, as well as handling on-chip resistor and capacitor calibration. In most applications the initial calibration is sufficient; however, for military wireless systems operating at extreme temperatures and frequencies, then the microcontroller can be instructed to recalibrate to ensure optimum performance. Power-saving features include the ability to selectively power down any block when not required, with settings and calibration retained if power to the SPI memory is retained (see Figure 2). The FPRF chip is housed in an 11.5 mm x 11.5 mm package.

Various tools are available to help designers, either provided by the FPGA vendor or third-party suppliers. For example, Altera is the only FPGA vendor to offer a publicly available, Open Computing Language (OpenCL)-conformant software development kit. OpenCL allows programmers to take OpenCL code and rapidly exploit the massively parallel architecture of an FPGA. It enables kernel code to be emulated and debugged, pinpoints performance bottlenecks, and profiles and recompiles to a hardware implementation. The FPRF design tool from Lime Microsystems takes the form of a graphical user interface (GUI); the GUI is available free of charge and allows complete control of the device. MES

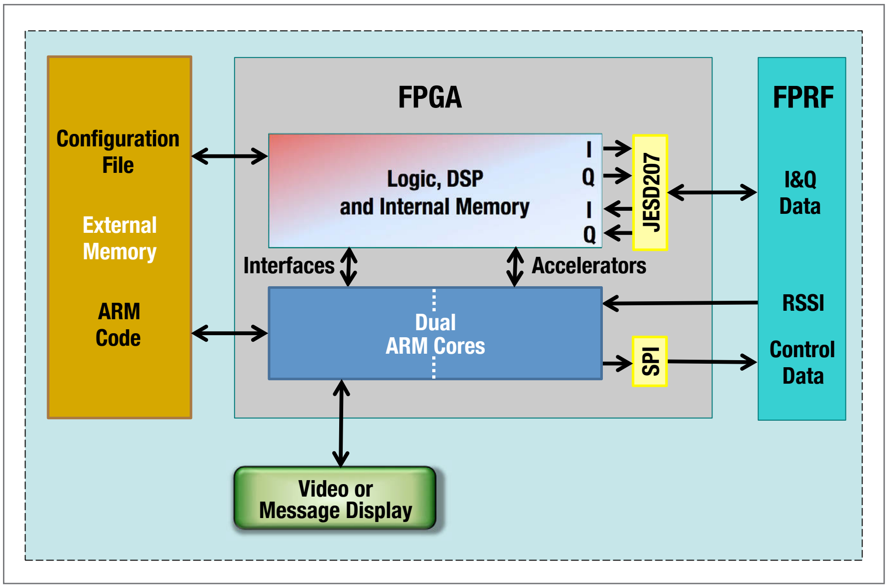


Figure 1 | An FPGA controlling the SDR logic.

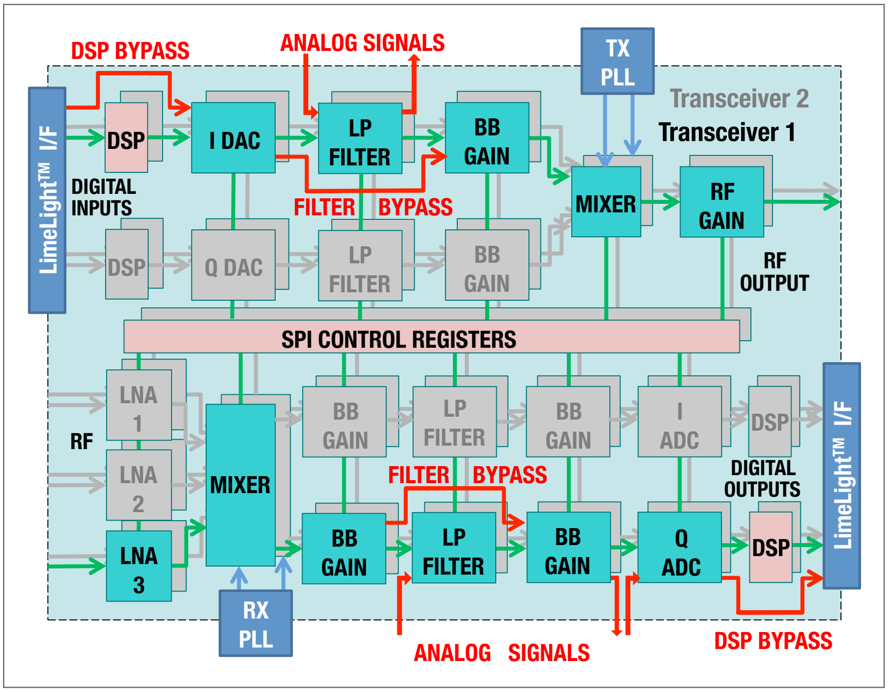
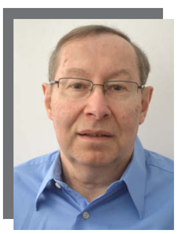


Figure 2 | Each FPRF block can be selectively depowered or bypassed.



Paul Dillien has worked with Lime Microsystems covering a range of marketing projects for the past two years. He previously worked in the FPGA industry for 15 years, and is the author of "The FPGA Market" report. Paul has worked in strategic and tactical marketing roles for leading U.S. and U.K. semiconductor companies and specializes in competitive analysis and negotiation. Readers may reach him at paul@high-tech-marketing.co.uk.

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Beamforming: FPGAs rise to the challenge

By Denis Smetana

Several design approaches exist for implementing beamforming processing tasks, with options ranging from GPUs to multicore CPUs, DSPs, and FPGAs. The unique strengths of FPGAs make them an increasingly appealing choice for beamforming when compared to their counterparts.

The U.S. Marine Corps AN/TPS-80 G/ATOR system uses Northrop Grumman's Active Electronically Scanned Array (AESA) radar technology. Photo courtesy of Northrop Grumman.

The active electronically scanned array (AESA) architecture has transformed what radar can do and how fast it can do it. It has transformed how many threats radar can track and over what instantaneous bandwidth the tracking can be performed. It has also influenced which additional functions radar can handle. Achieving all of these capabilities requires a truly enormous amount of processing power, high-speed memory and interconnects, and it requires analog to digital converters (ADCs) and digital to analog converters (DACs) with high resolution, sampling rate, and dynamic range. Adaptive beamforming, one of an AESA radar's key functions, is a complex process that requires all of the formidable capabilities that today's cutting-edge signal processing can deliver.

Adaptive beamforming, and beamforming in general for that matter, involves spatial filtering techniques. These techniques enable an antenna array to employ its elements in order to form a wave pattern that provides higher sensitivity in specific, desired directions. This allows the control over the shape and steering of the array's directivity pattern (see Figure 1) and increases signal reception or transmission performance in the desired direction. Improved reception and transmission is the result of constructive (in-phase) interference of the desired propagating wave and the destructive (out of phase) interference of waves from all other directions. Beamforming enhances performance in a specific spatial region – in both azimuth and elevation – while nulling out interference, noise, and extraneous signals, including those from jammers, in other regions.

The combination of beamforming and other radar functions results in enormous signal processing requirements. These requirements will increase further as the number of elements in the array, for example, also grow. As large AESA

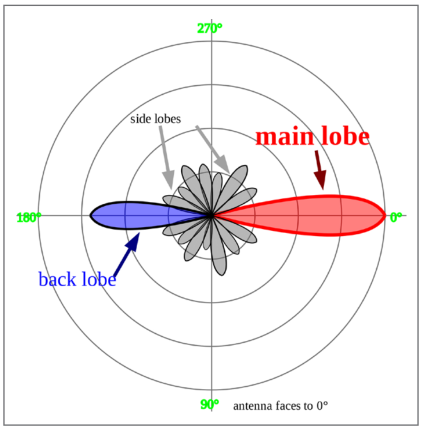


Figure 1 | The effects of beamforming.

arrays already typically have thousands of elements, beamforming can pose an exceptionally difficult processing task, as it requires the least possible latency, with a high level of accuracy, all done in real time. As mentioned earlier, beamforming can be implemented using GPUs, DSPs, and multicore CPUs alone or in combination, as well as with FPGAs. As the floating-point support within

FPGAs continues to increase, they have become capable of delivering performance an order of magnitude greater than what can be achieved by the other approaches.

At the lowest level, beamforming requires digital down-conversion and filtering that requires many multiplications and additions of data with configurable coefficients. Furthermore, matrix mathematics is required to process large arrays of data. Because of the highly modular architecture of FPGAs, they are well suited to solve large problems that require parallel processing. When QDR SRAMs are attached to the FPGAs, additional processing gains can be made as they enable more efficient matrix calculations because these devices permit random access for striding functions and simultaneous read and write operations. SRAMs also have significantly lower latency than DDR3 SDRAMs, the primary memories used with general-purpose processors.

With each new generation of FPGAs, the number of dedicated DSP blocks also increases. The DSP blocks within an FPGA contain hardened multiply-accumulate logic that is designed to support complex fixed-point and floating-point calculations. While FPGA processing is currently best limited to single-precision floating-point (since double-precision cannot be implemented very efficiently), for beamforming applications single-precision floating-point is sufficient. For instance, the 3600 DSP blocks that exist in current generation Xilinx Virtex-7 devices can support approximately five billion multiply-accumulate operations per second when factoring in clock frequency. These blocks play a key role when performing beamforming and other radar functions.

The other important area for beamforming in which FPGAs excel is I/O. Beamforming algorithms require high degrees of interconnectivity to enable the combination of data from many beams. That interconnection matrix grows as the number of beams increase. The largest FPGAs now have 36, 72, or more serializer/deserializers (SERDES), each of which are capable of running faster than 10 Gbps. When interconnecting

FPGAs together, low overhead/latency protocols such as Xilinx's Aurora protocol can be used to efficiently pass data between FPGAs. These SERDES can be used to interconnect multiple FPGAs on the same card or FPGAs on different cards.

Modern AESA radars also use adaptive beamforming. With adaptive beamforming, the coefficients being used to shape the beams are changed based on the data being received. This type of processing requires a view of the whole system, and is typically done by a general-purpose processor (GPP) that better handles sequential processing. FPGAs pass summary data to the GPP to recalculate the coefficients, after which the coefficients are then fed back into the system.

For these reasons, if an adaptive beamforming network is constructed from multiple CPUs it will be larger and heavier, consume significantly greater power, require more devices, and offers limited memory and external interface options compared to an FPGA-based design. AESA radars (and soon, electronic warfare [EW] systems based on the AESA architecture) must accommodate the electrical and physical confines of smaller platforms and stringent size, weight, power, and cost (SWaP-C) demands. For that reason it's not surprising that the capabilities of FPGAs are being exploited for beamforming applications.

Beamforming using CPUs is shown in Figure 2. In this admittedly simple scenario, signals captured from each element are sent to an ADC where they are converted to the digital domain. The digital data streams from each ADC are sent to processors for filtering, decoding, and pulse compression, and then to a single processor for Doppler processing. While not shown in this diagram, there are also paths between the processors to pass data to each other. The number of sensors that can be handled by each processor will be limited by the processing and I/O capability of the processor.

Figure 3 shows a similar simple example with processing performed by FPGAs. Again, the number of sensors that can be handled by a single FPGA will depend on FPGA processing capacity and the amount of I/O. However, because FPGAs can support more parallel processing and I/O than a GPP, fewer FPGAs are required, and therefore less size and power is needed.

Another example of a radar application in which FPGAs are increasingly making an impact is the implementation of space time adaptive processing (STAP) algorithms (see Figure 4). STAP is a two-dimensional (space and time) filtering technique that combines spatial channels and pulse-Doppler waveforms. In dense signal environments, STAP can achieve order-of-magnitude improvements in target detection by effectively extracting and revealing signals of interest below the clutter level.

To achieve this goal, STAP requires increased signal-to-interference-and-noise ratio to suppress noise, clutter, jammers, and other signals while retaining the desired radar return. As there are often multiple potential targets, each of which requires calculations for location and velocity that must be processed simultaneously in real time, intense processing power is essential.

The STAP requirement for intensive numeric processing, low latency, high dynamic range, and floating-point processing has historically made it practical only when high-performance computing resources were available, which has limited its use in many environments. This is unfortunate, as airborne platforms can greatly benefit from STAP. Another critical concern precluding the use of STAP has been the SWaP limitations of airborne platforms.

The processing of STAP algorithms requires Doppler filter processing, weight computation, beamforming, pulse compression, and constant false-alarm rate processing. While FPGAs feature most of the inherent attributes to make them very useful in STAP processing, issues of routing congestion and poor floating-point performance have previously limited their overall performance.

As a result, the overall viability of FPGAs for STAP was not competitive with approaches using GPUs or multicore CPUs. Recently however, major FPGA manufacturers have found ways to overcome this limitation and have circumvented the problems associated with the high-performance computing resources formerly required to implement STAP. The door to using FPGAs for STAP has now opened for the first time. Combined with their aforementioned advantages in SWaP for beamforming applications, today's FPGAs now allow STAP to be implemented where they never could be before.

In both beamforming and STAP applications, which are in fact directly related, OpenVPX cards such as Curtiss-Wright's 6U CHAMP-FX4 (see Figure 5 on page 40) provide all of the required processing power with its three large Virtex 7 FPGAs. Its FPGAs feature both QDR and SDRAM memory, large numbers of SERDES that provide very wide bandwidths for FPGA interconnect, and both PCIe or SRIO support for passing data from the FPGA into an Intel Core i7 or a GPU via an OpenVPX backplane. These boards can scale efficiently to handle a very large number of beams and enable complex subsystems to be constructed using far less hardware while offering substantial high-speed interconnects (SERDES). In contrast, both CPU and GPU-based solutions are limited by their reliance on PCIe. In addition, the huge amounts of data output from the ADC in a broadband radar can only be accommodated by

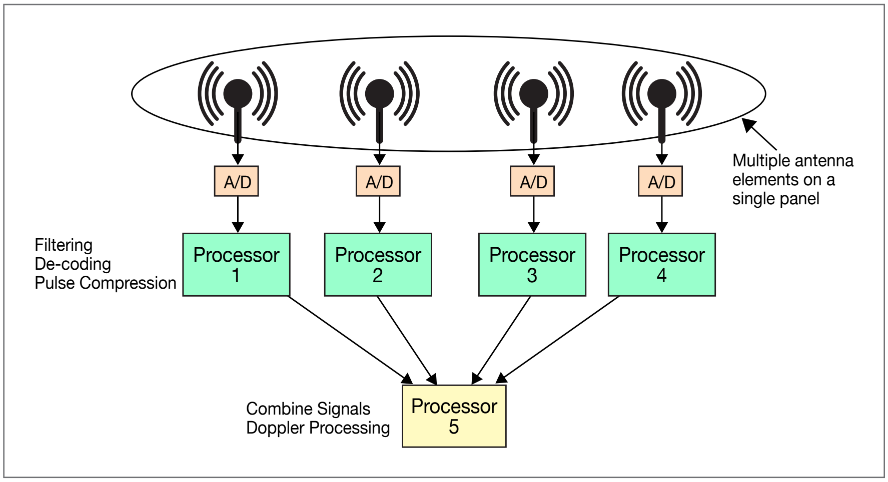


Figure 2 | Beamforming using general-purpose processors (GPPs).

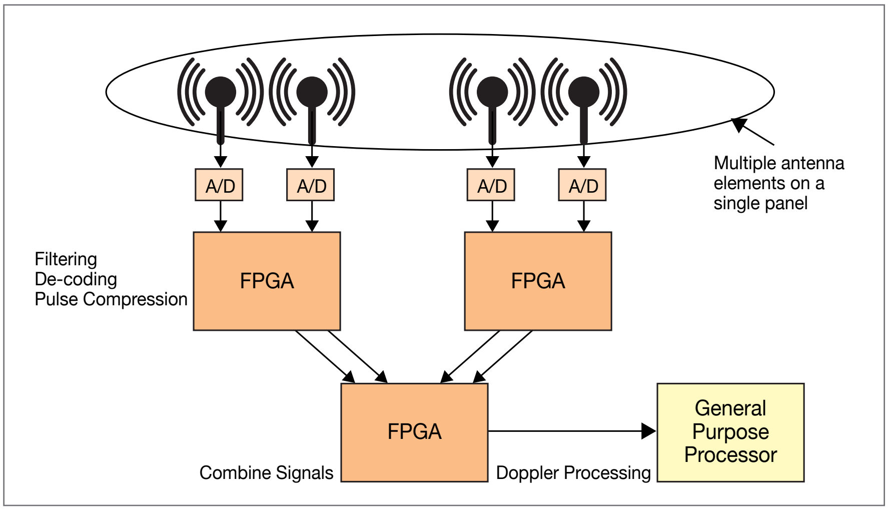


Figure 3 | Beamforming using FPGAs.

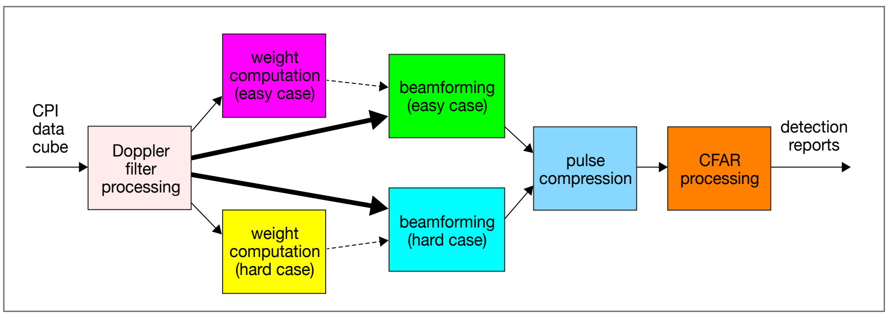


Figure 4 | A parallel-pipelined STAP implementation showing data transfer between tasks.

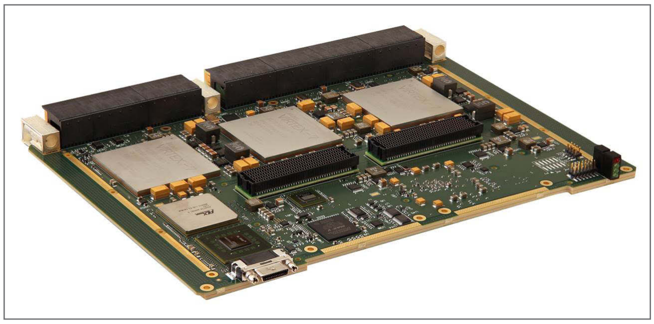


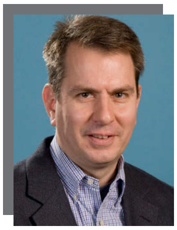
Figure 5 | The Champ FX-4 utilizes the board space available in the 6U form factor to provide resources for multiple beamforming tasks.

FPGAs, such as the CHAMP-FX4's Virtex-7s. The 6U form factor provides ample real estate for these resources.

FPGAs going forward

AESA radars require more processing power, bandwidth, I/O, and other resources than their predecessors. This requirement is likely to grow as their instantaneous bandwidths and elements increase along with the tasks they must perform in order to handle more formidable threats from electronic attack systems. Not surprisingly, beamforming – which has always been a critical element in active phased arrays – has taken on increased importance. With the greater demand for beamforming comes the need to deliver greater performance with fewer devices, consuming less power in less space. Thanks to recent advances in FPGA technology, their DSP processing capability continues to increase, and they are rapidly becoming the device of choice in current designs as well as those in development.

Boards in the 6U OpenVPX form factor are well suited for beamforming, as they can pack extraordinary amounts of the parallel processing, floating-point support, and I/O offered by FPGAs in combination with other resources to dramatically reduce the size and cost of implementing beamforming and related functions.



Denis Smetana *has worked for 10 years on FPGA products for defense applications at Curtiss-Wright, starting as an FPGA designer, rising to product development manager, before moving into his current position as the senior product manager for FPGA products. He has more than 25 years of experience with ASIC, FPGA, and hardware development, starting as an engineer developing ASICs and FPGAs for IBM's Federal Systems Division. He then developed and managed ASIC development for telecom applications utilizing real-time traffic for Integrated Telecom Technology and PMC-Sierra before joining the Curtiss-Wright team. Denis has a BSEE from Virginia Tech. He can be reached at denis.smetana@curtisswright.com.*

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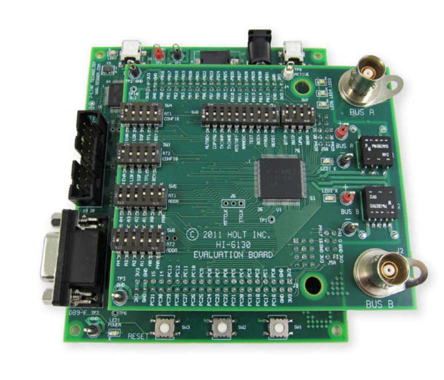


MIL-STD protocol ICs feature user-allocated SRAM

The 3.3V CMOS HI-613x device from Holt Integrated Circuits offers a single- or multi-function interface between a host processor and MIL-STD-1553B bus. Each IC contains a bus controller, a bus monitor terminal, and two independent remote terminals; any combination of the contained 1553 functions can be enabled for concurrent operation. The enabled terminals communicate with the MIL-STD-1553 buses through a shared on-chip dual bus transceiver and external transformer. Users can allocate 64K bytes of on-chip static RAM between devices to suit application requirements, which can range from MIL-STD-1553 terminals and avionics instrumentation to flight control/monitoring and electronic counter-countermeasures.

Two versions of the HI-613x are available for host access to internal registers and static RAM: The HI-6130 uses a 16-bit parallel bus, while the HI-6131 communicates with the host via a four-wire serial peripheral interface (SPI). The chips can also handle extended temperature ranges: -40 °C to +85 °C or -55 °C to +125 °C, with optional burn-in. Programmable interrupts provide terminal status to the host processor. Circular data stacks in RAM have rollover and programmable level-attained interrupts. The HI-613x also can be configured for automatic self-initialization after reset. A dedicated SPI port reads data from an external serial EEPROM to fully configure registers and RAM for any subset of one to four terminal devices.

Holt Integrated Circuits, Inc. I www.holtic.com I www.mil-embedded.com/p372577

OpenGL solution with new driver suite for avionics displays

Core Avionics & Industrial (CoreAVI) engineers enable navigation of safety certification challenges through their AMD Embedded Radeon OpenGL SC and OpenGL ES 2.0 driver suite, DO-254 GPU, and DO-178C driver certification packages. Recently their solutions were used in a safety-certified avionics display system for situational awareness in military and commercial aviation from Airbus Defense and Space. In this case the graphics processing system included support for real-time operating systems and safety critical operation with OpenGL graphics and complete DO-254, DO-178C, and ED-12C certification artifacts.

Initially certified to ED-12C Level C, Airbus and CoreAVI's product alignment includes full user support throughout the DO-254 and DO-178C certification process, including all certification artifacts required for regulatory approval by aviation agencies such as the FAA, EASA, and Transport Canada.

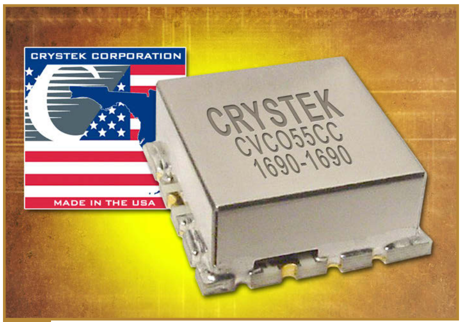
CoreAVI I www.coreavi.com I www.mil-embedded.com/p372580

Semi-rugged notebooks for semi-harsh conditions

The SRNC-17 from VT Miltope is a semi-rugged derivative of the HP ZBook 17 computer, aimed squarely at mobile military and tactical computing needs. The mobile workstation is a high-performance computing platform designed for field environments that still require a degree of ruggedness. The core architecture is based on the 4th-generation Intel Core i7 processor and the mobile-focused Intel 8 Series QM87 Express chipset. The SRNC-17 is factory configured to ship with either Windows 7/8 or Linux 64-bit OS.

Two display options are offered – a 17.3-inch 1600 x 900 diagonal LED HD+ SVA antiglare or a 17.3-inch 1920 x 1080 diagonal LED FHD UWVA antiglare screen – plus an environmentally-sealed and backlit full-size QWERTY keyboard. The notebook conforms to MIL-STD-810 specs for high and low temperature, vibration, shock, blowing rain, sand, dust, humidity, altitude, and salt fog. Allowed interfaces include several USB ports, one eSATA/USB 2.0 combo, one DisplayPort, one each VGA/Thunderbolt/GB Ethernet port, stereo microphone in/headphone/line-out, and AC power. Users can order optional WiFi 802.11 a/b/g/n +BT 4.0, 4G LTE WWAN, and additional GB Ethernet ports. The 13.9-pound notebook has a 75-WHr Li-ion battery, with an option for an 83-WHr Li-ion battery.

VT Miltope I www.mymiltope.com I www.mil-embedded.com/p372579



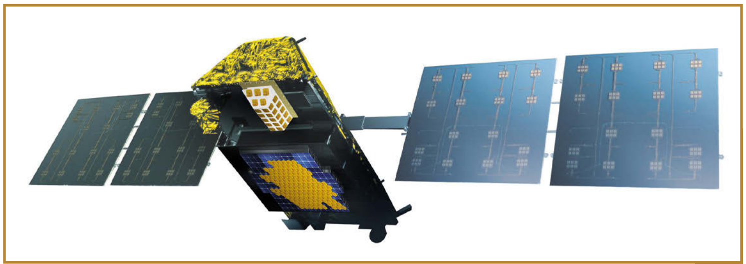
Oscillator designed to handle ultra-low-phase noise

Crystek's CVCO55CC-1690-1690 voltage-controlled oscillator (VCO) operates at 1,690 MHz with a control voltage range of 0.3 V to 4.7 V. This VCO features a typical phase noise of -120 dBc/Hz at 10 KHz offset and has excellent linearity. Output power is typically +2.5 dBm. The VCO – both engineered and manufactured in the U.S. – is packaged in the industry-standard 0.5-inch x 0.5-inch surface-mount package. Input voltage is 5V, with a maximum current consumption of 25 mA. Pulling and pushing are minimized to 1.0 MHz and 0.5 MHz/V, respectively, while the oscillator operates over a temperature range of -40 °C to +85 °C. Second harmonic suppression is -15 dBc (typical).

The CVCO55CC-1690-1690 is aimed at applications such as digital radio equipment, fixed wireless access, satellite communications systems, and base stations.

Crystek Corporation | www.crystek.com | www.mil-embedded.com/p372581

COTS ATCA platforms for satcomm



Experts at Radisys have designed their commercial off-the-shelf (COTS) ATCA platforms for mobile voice and data satellite-communications. Recent installations include the Iridium upgrade of the ground-station infrastructure associated with its next generation global satellite constellation – called Iridium NEXT. The T-Series was chosen because it is a long-life COTS program, designed to be in service for a minimum of seven years. Moreover, the T-Series' hardware-level redundancy features enable high availability for Iridium's upgraded satellite array, with design features supporting plug-in hardware and software upgrades while the equipment is in-service.

The Radisys T-Series platform is based on an open-standards-based ATCA platform architecture that uses merchant silicon and open-source software to provide increased throughput. Iridium will be able to take advantage of deploying as many as five different applications on the Radisys T-Series. The T-40 Ultra is targeted at applications that necessitate high density performance. It has more than 1 Terabit of switching capacity and can provide more than 288 Intel cores. For mid-density node deployments, Radisys offers the T-40 Pro, which is used for policy enforcement, security, and service gateways applications. It has a 40G backplane and as many as four payload slots enabling a variety of network processors and compute resource blade options.

Radisys Corporation | www.radisys.com | www.mil-embedded.com/p372578

Half-brick front end module for use in demanding space-constrained applications

Designers looking for a power module for tight fits in military and commercial aviation applications can consider the PFC-375 from Astrodyne Power Supplies, a half-brick COTS AC/DC power module with an output voltage of 375 V. The module is part of Astrodyne's UniVerter Series of products, which use a boost converter that integrates a solid-state series switch for active inrush and short-circuit current limiting; the modules also feature over-temperature shutdown with automatic recovery.

Aimed at use in military and commercial aviation applications and other environments with tough thermal and shock requirements, the PFC-375 base-plated, potted module features Astrodyne's proprietary insulated metal substrate construction. According to the company, the module is compliant with MIL-STD-704 transient and MIL-STD-461 and RTCA DO-160 total harmonic distortion requirements. The encapsulated 2.3-inch x 2.4-inch x 0.5-inch half-brick power-factor-correction module has an input range of 85 to 265 VAC, a frequency range of 47 to 880 Hz, and a power factor of 0.99. The PFC-375 comes in RoHS-compliant or SnPb solder versions and offers an operating temperature range of -55 °C to +100 °C.

Astrodyne Power Supplies | www.astrodyne.com | www.mil-embedded.com/p372582

Georgia Tech Research Institute lidar project

By Amanda Harvey, Assistant Editor

In this new University Update section of *Military Embedded Systems* magazine, we will be focusing on one military-related university project per issue. This issue focuses on the Georgia Tech Research Institute (GTRI) lidar project. The GTRI research and development program's goal is to produce a smaller, lightweight, real-time bathymetric lidar that can be deployed on unmanned aerial vehicles (UAVs) rather than the heavy manned vehicles they currently require, cutting cost and time. In the following Q&A, we spoke with Grady Tuell, the developer of GTRI's lidar technology and the principal research scientist leading the work. Edited excerpts follow.

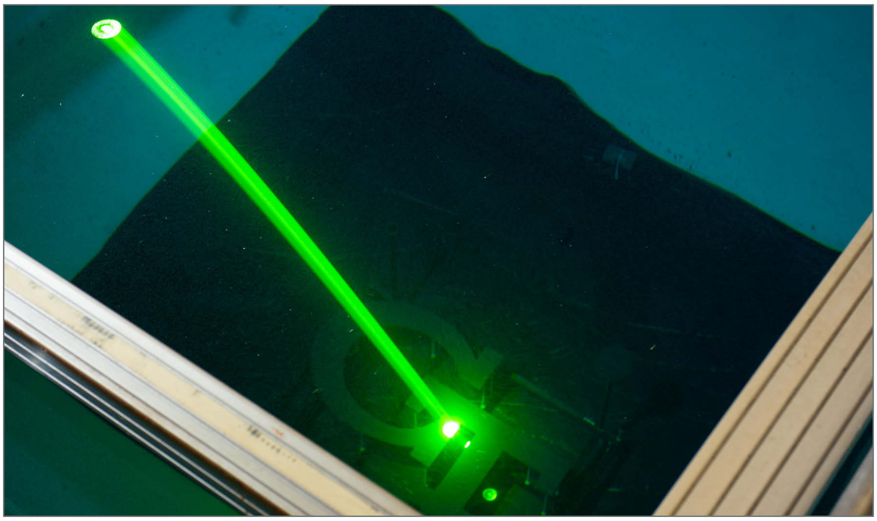


Figure 1 | The Georgia Tech Research Institute (GTRI) lidar prototype uses green lasers to penetrate the water as opposed to infrared lasers.

MIL-EMBEDDED: *Can you give me some background information on bathymetric lidars in general?*

TUELL: Bathymetric lidars are a specialized version of airborne lidars. Typically, they employ green lasers for penetrating the water (as opposed to infrared lasers most often used in topographic applications), and high-speed, high dynamic range detector architectures to produce waveforms representing the intensity of the reflected light from the complete optical path from the airplane to the seafloor (see Figure 1). Signal processing software is used to decompose these waveforms into the "in air" and "in water" distances. These distances are then used with the appropriate pointing angles to compute coordinates on the sea surface and the seafloor. If the lidar is radiometrically calibrated, these waveforms can also be radiometrically inverted to estimate seafloor reflectance at the lidar wavelength, and these estimates of reflectance can be used to generate 3-D images of the seafloor. Most bathymetric lidars are also capable of mapping the beach and therefore simultaneously map the topography and bathymetry of the coastal zone.

MIL-EMBEDDED: *What is the ultimate goal of the GTRI's new approach for lidar?*

TUELL: GTRI's research and development program is designed to produce a smaller, lightweight, real-time bathymetric lidar deployable on UAVs. We are also pursuing the development of techniques to estimate total propagated uncertainty (TPU) in real time. TPU produces an estimate of the accuracy of each lidar point. If these accuracy assessments are produced in real time, operators immediately know if the collected data meet the accuracy requirements of the mission, and can then recollect the data if necessary before the aircraft moves on.

MIL-EMBEDDED: *Can you explain the role of the Active Electro-Optical Intelligence, Surveillance, and Reconnaissance (AEO-ISR) project?*

TUELL: AEO-ISR is a GTRI Internal Research and Development (IRAD) project. This IRAD investment is designed to leverage GTRI's existing lidar infrastructure (established for building atmospheric lidars) toward building airborne lidar systems, and to specifically engage in the effort to build bathymetric lidars for deployment on UAVs. The effort has involved building geometric and radiometric simulators, development of appropriate receiver and detector architectures, development of a high-speed, lightweight circular scanner, and the development of the mixed mode computing architecture enabling the real-time computation of coordinates and TPU.

MIL-EMBEDDED: *What are the latest developments on the project and what do you foresee for the future?*

TUELL: We have continued to refine the design for an air-deployable version of the prototype and have integrated a geiger mode avalanche photodiode detector (GmAPD) into the pathfinder lidar. This integration has produced a hybrid linear mode waveform – GmAPD lidar. We are using this lidar to improve the accuracy of the raytracing through the water's surface, and ultimately, the accuracy of the seafloor images. We are also pursuing the development of a real-time data fusion system. This work involves leveraging the real-time computing capability for the lidar to combine the lidar data with spectral images in real time. We believe this capability is important to ISR [information, surveillance, and reconnaissance] applications ... specifically, detection of targets under forest canopies.

For more information, visit www.gtri.gatech.edu.

CONNECTING WITH MIL EMBEDDED

By Mil-Embedded.com Editorial Staff

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CHARITY

FEHERTY'S TROOPS FIRST FOUNDATION

Troops First Foundation

Each month in this section the editorial staff of *Military Embedded Systems* will highlight a different charity that benefits military veterans and their families. We are honored to cover the technology that protects those who protect us every day and to back that up, our parent company – OpenSystems Media – will make a donation to each charity we showcase on this page.

This month we're featuring Troops First Foundation, a non-profit organization that offers programs and events for wounded warfighters and their families that focus on mentoring, relationship building, reintegration, and looking forward.

While visiting deployed troops in the Middle East with a group of college basketball coaches in 2005, Rick Kell met with several Operation Enduring Freedom/Operation Iraqi Freedom (OEF/OIF) patients. After several visits, friendships were formed, and Kell decided he wanted to give back in a more meaningful way. He spent two years gaining insight on Warrior Care, and started brainstorming ideas for programs to assist OEF/OIF veterans. He shared his experience with fellow troops advocate and popular golf broadcaster, David Feherty, and together they created Troops First Foundation (T1F) in 2008.

Feherty hosts several I.E.D. (Improvised Explosive Days) per year, including activities like golf, deer and pheasant hunting, cycling, and other trips to various locations. T1F has also created several initiatives, such as:

Operation Coaches and Warriors – This initiative provides a Wounded Warrior with a personal message from his/her favorite college basketball coach (inspired by Kell's love of the sport).

Operation Front Door – A housing grant initiative developed to assist OEF/OIF combat-wounded veterans secure home ownership.

Operation Proper Exit – This initiative is for Wounded Warriors who are thriving in recovery and are capable of returning to theater so that they may leave on their own terms. This program stages a meet-and-greet tour to forward operating bases with a group of fellow recovered soldiers.

Operation V.I.P (Visit Important People) – This program is for the patients of the burn unit at Brooke Army Medical Center in San Antonio, Texas. This initiative is responsible for scheduling a celebrity or sports figure to visit the hospital and create connections with the patients to raise spirits and help with the healing process.

To learn more about T1F and its initiatives and information about donating, visit www.troopsfirstfoundation.org.

E-CAST

Two approaches you must consider when architecting radar systems

Presented by RTI

Modern radar systems must keep up with a rapidly changing threat environment, readily adapt to new technologies, and be developed with smaller budgets. How do you architect your future radar systems to meet these challenging requirements? Two different approaches allow new capabilities to be integrated as needed into a scalable, open system: integrate multiple functions; or network simple sensors and systems together. In this webinar, learn how standards-based communications technologies can be used to architect your future radar systems. See how proven examples of open architectures in radar and combat systems for organizations such as the U.S. Navy have improved flexibility and reduced risk and lifecycle costs.

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WHITE PAPER

Re:Vision: A new paradigm for mid-lifecycle design changes

By Sparton

Keep your competitive edge: learn how a mid-lifecycle component change can lead to greater performance and cost savings. Don't wait until the next generation of a product to add new capabilities. Today, technology is simply changing too fast to delay making a change, and advances in design and integration techniques are changing everything. There are a number of scenarios in which implementation of a mid-lifecycle design change makes sense. In this white paper, you will learn: Perceived barriers to change; When and why a mid-lifecycle component change makes sense; How the right strategic partner can optimize your outcome.

Read the white paper: http://mil-embedded.com/white-papers/white-paradigm-mid-lifecycle-design-changes/

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