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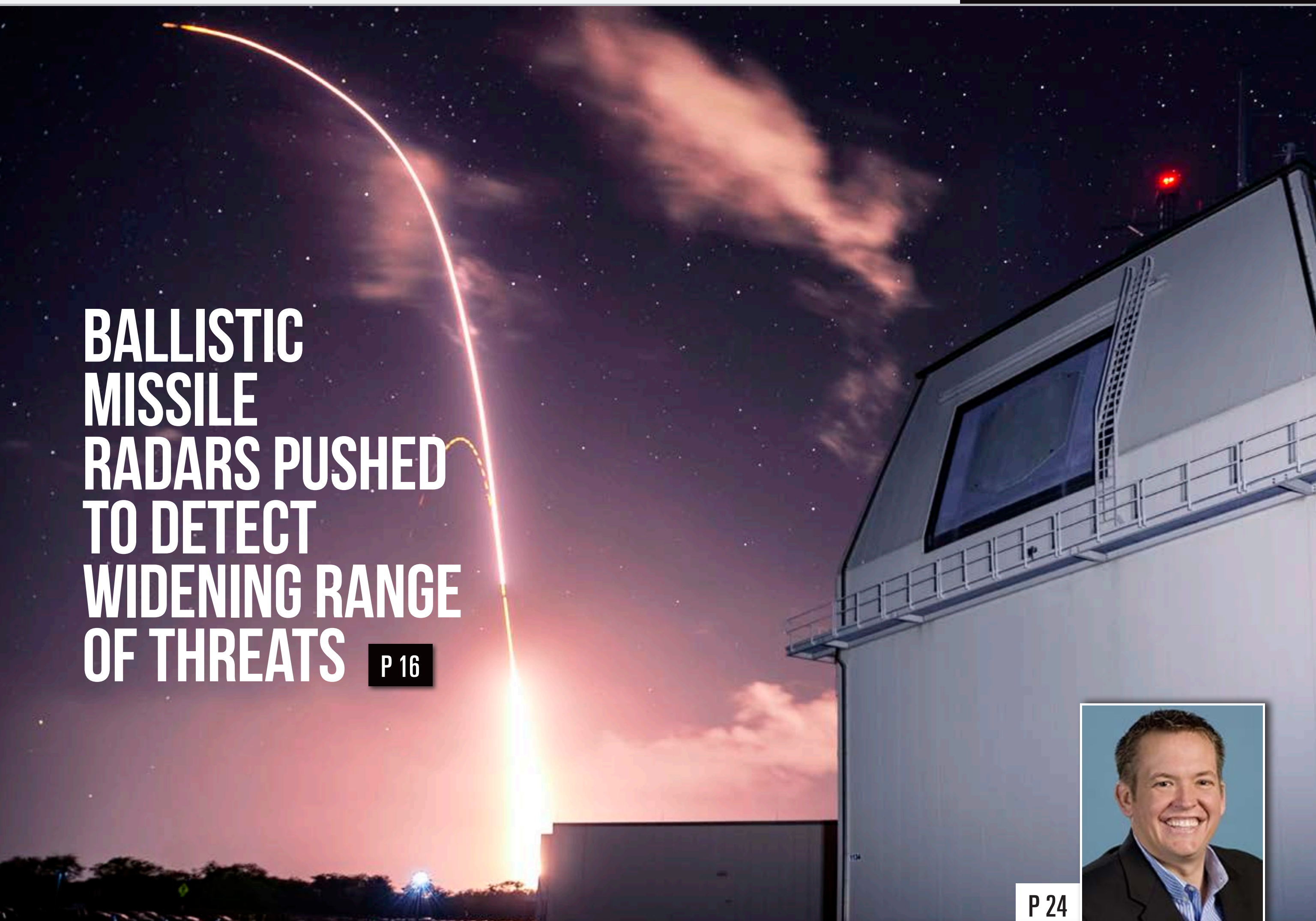

BALLISTIC MISSILE RADARS PUSHED TO DETECT WIDENING RANGE OF THREATS

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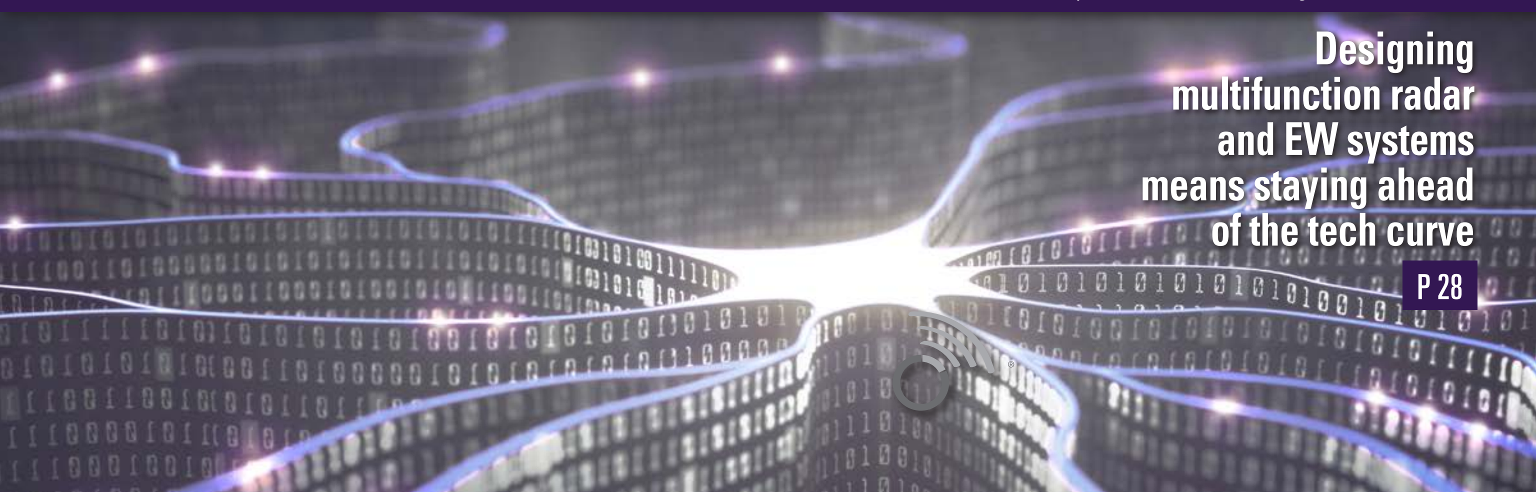
Configurable FPGAs: More than a point solution – By Paul Bundick, Curtiss-Wright Defense Solutions



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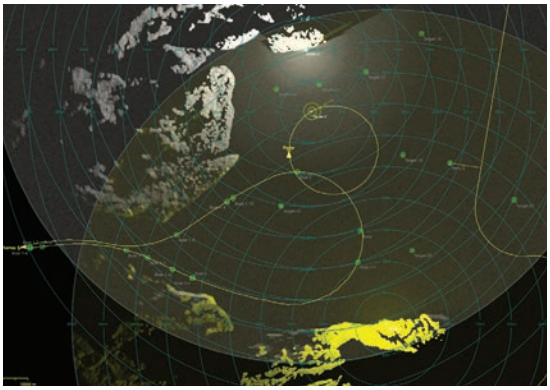

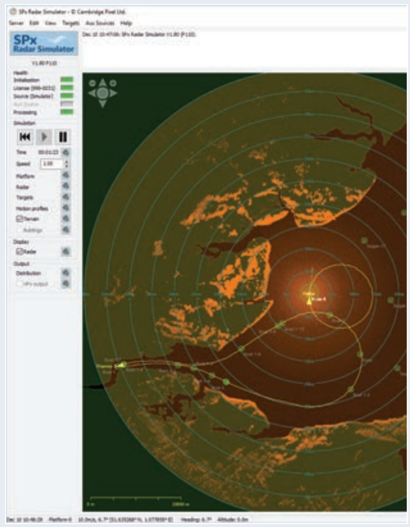

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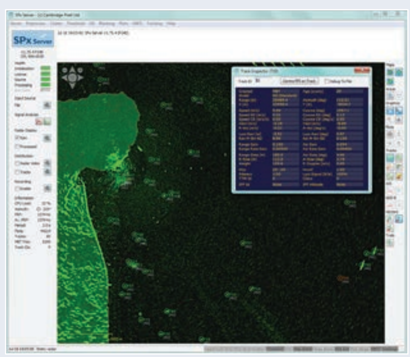

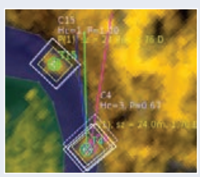

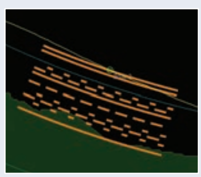

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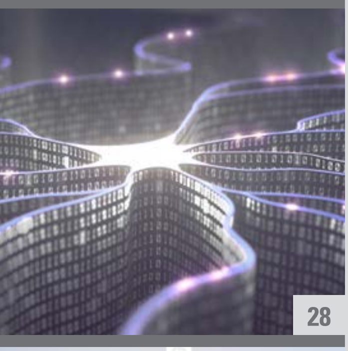

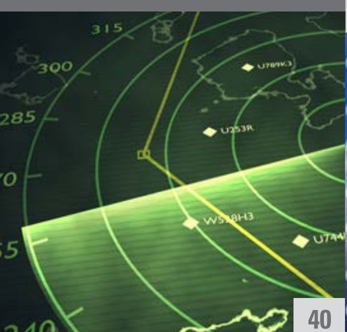

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ON THE COVER:

Top image: The Missile Defense Agency and U.S. Navy sailors manning the Aegis Ashore Missile Defense Test Complex (Pacific Missile Range Facility in Kauai, Hawaii) conducted a successful flight test in December 2018. Photo credit: Missile Defense Agency.

Bottom image: Huge data demands – including those from artificial intelligence (AI) and machine learning (ML) applications – are pushing radar and electronic warfare (EW) developers to seek new ways to deliver multifunction systems that also meet strict size, weight, and power (SWaP) requirements.

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Implementing a common architecture for military systems

By John McHale, Editorial Director

They're playing together nicely – the Army, Navy, and Air Force, that is – in their efforts to bring a common architecture to electronic systems across all three services. These efforts are resulting in three main initiatives: the Sensor Open Systems Architecture (SOSA); Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR)/Electronic Warfare (EW) Modular Open Suite of Standards (CMOSS); and the Hardware Open Systems Technology (HOST).

During the 2019 Embedded Tech Trends conference (held in January of 2019), Mike Hackert of the U.S. Navy's Naval Air Systems Command (NAVAIR) reported that the teamwork and enthusiasm among the services and industry has been remarkable. According to Hackert, the successful tri-service convergence can be seen in the convergence of SOSA and CMOSS's collection of standards for OpenRF applications and also in the alignment of CMOSS and HOST's collection of hardware.

"SOSA has become the focal point of embedded system standardization development," Hackert said. "The objective is to use industry standards wherever possible (e.g., VITA, VICTORY, MORA), then add specificity where necessary for interchangeability or interoperability while creating or extending standards."

Systems that meet the specifications of each initiative have already been deployed, including the Joint Strike Fighter (JSF) F-35 Technology Refresh 31 (HOST) and PEO C3T Rapid Innovation Fund (RIF) Requirement – Hardware and Software Convergence (CMOSS). Meanwhile, many embedded computing suppliers have released SOSA-based board products since last fall.

Hackert and his fellow leads at the Air Force (Dr. Ilya Lipkin, Air Force Life Cycle Management Center [AFLMC]) and the Army (Jason Dirner, Communications-Electronics Research, Development and Engineering Center [CERDEC]), have coauthored a detailed multipart article on the tri-service convergence for a common open architecture and how it will affect systems design, enable tech reuse, speed up refresh cycles, and lower life cycle costs. The first installment of this article will appear in our March issue.

I've banged the drum on this subject many times in this space over the last few years – that commonality in hardware and software systems makes economic sense. Hardware initiatives like SOSA, CMOSS, and HOST – as well as software efforts like the Future Airborne Capability Environment (FACE) – are successful today because they solve the long-term cost challenge faced by every service.

The fact is that the Department of Defense (DoD) cannot afford years of development on another platform like the F-35 – it takes too long and costs too much. That cost struggle, which was shaped during sequestration and the budget constraints of the last administration, was another factor that spurred the enthusiasm of the three services toward collaboration. While their internal schedules and approval processes may vary in length and depth, their need to drive down costs while speeding up the deployment of technology to the warfighter remains paramount.

The three services are engaging industry and media in this effort as well, with outreach programs and committees dedicated to educating others about the benefits of reuse at the hardware and software levels. Part of that outreach endeavor includes the reality that the military services are taking active roles in various standards bodies, such as CERDEC being a board member of the VITA standards organization, or one of the services driving the initiatives, such as NAVAIR did with FACE.

The Open Group's role should not be overlooked either, as they provide the organizational framework for both SOSA and FACE. (www.opengroup.org)

Hackert announced in his presentation that next year at ETT 2020 (to be held in Atlanta), SOSA, HOST, and CMOSS will be partnering with the Georgia Tech Research Institute to host the Tri-Service Open Architecture Plugfest: Interoperability Demo (scheduled for January 29, 2020). Stay tuned to mil-embedded.com to learn more about this event as info becomes available.

For more discussion on commonality in military electronics systems and speeding up the DoD acquisition process, please listen to my McHale Report Podcast with Bill Guyan, VP and general manager of DRS Land Systems for Finmeccanica at https://bit.ly/2DbYFzP.

Guyan and I continue a conversation we've had over the years on how reduced budgets drove commonality in technology, not only on the front end but also on the back end with maintenance, supportability, and training. He tells me that these "supporting costs are often far greater than acquisition costs … such as training people to operate systems, buying spares for systems, and making sure they are available in the field and on home base. There are a lot of costs associated with having lots of variety."

Standardization at the box and component level will enable technology to be fielded more quickly, get users proficient more quickly, and be easier to sustain over the long haul, he adds.

We also discuss how adversarial threats are growing more sophisticated and the reality that the U.S. military – to maintain and grow its battlefield advantage – must have a more agile acquisition process and embrace game-changing technologies such as artificial intelligence.

Shape-shifting, foldable drones are on the way

By Sally Cole, Senior Editor

Shape-shifting, foldable drones are on the way, thanks to a team of researchers from the Robotics and Perceptions Group at the University of Zurich (UZH) and the Laboratory of Intelligent Systems at École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland.

The Swiss researchers have created a foldable drone that changes its shape to fit through gaps, cracks, or windows and then morphs back into its previous shape, all while continuing to fly.

The UZH team set out to create a drone that could go in and quickly inspect a damaged building after an earthquake, fire, or other types of disasters or emergencies instead of sending human rescuers into these dangerous situations. To do this, they wanted the drone to be able to enter a building by changing its shape to squeeze through a crack in a wall, a partially open window, or through bars, which is something that typical drones can't do because of their size.

Although not touted as something for military use, as you can imagine that warfighters could easily find applications for this new type of drone because it can tailor its shape for specific environments or tasks on the fly.

Birds that fold their wings in midair to fly through narrow passages provided the inspiration for the drone's design, which features a quadrotor with four propellers that rotate independently, mounted on mobile arms that can fold in around the main frame (thanks to servo motors). Another intriguing design feature is that the drone's control system can adapt in real time to any new position of the arms by adjusting the thrust of its propellers as the center of gravity shifts.

The drone's components include a Qualcomm Snapdragon Flight onboard computer that runs all of the algorithms necessary to fly, two cameras for localization and exploration, an inertial measurement unit (IMU), an Arduino Nano microcontroller, and the servo motors used to fold the its arms.

"Our solution is quite simple from a mechanical point of view, but it's very versatile and autonomous, with onboard perception and control systems," says Davide Falanga, a researcher at the University of Zurich.

In comparison to other drones, the team's drone can maneuver in tight spaces and guarantee a stable flight at all times. To achieve this, the researchers exploited an optimal control strategy that adapts to the drone's morphology on the fly. This allows the foldable drone to dynamically change its shape

Figure 1 | Pictured are shape-shifting drones performing a gap traverse. Credit: UZH.

while flying. The controller doesn't require any symmetry in the morphology because it can handle randomly generated morphologies. (Figure 1).

This means that the shape-shifting drone "can adopt different configurations according to what's needed in the field," explains Stefano Mintchev, a researcher at EPFL.

What types of shapes can the drone shift into? Its standard configuration is X-shaped, with the four arms outstretched and the propellers at the widest possible distance from each other. But to navigate a narrow passage, it can switch to a "H" shape with its arms lined up along one axis, or to a "O" shape with all arms folded as close as possible to the body. Its "T" shape is particularly useful for getting the onboard camera mounted on the central frame as close as possible to objects so that the drone can inspect them. As an added bonus, the drone is capable of holding onto or transporting objects along the way.

This is the first step toward fully autonomous drone rescue searches, according to the researchers. They now hope to further improve the drone's structure so that it can fold in three dimensions. And another big challenge they'd like to overcome is to develop algorithms that make the drone truly autonomous, allowing it to look for passages (routes) in real disaster scenarios and automatically choose the best way to maneuver through them on its own. "The final goal is to give the drone a high-level instruction such as 'enter that building, inspect every room, and come back,' and let it figure out by itself how to do it," says Falanga.

Both research groups are part of the National Centre of Competence in Research (NCCR) Robotics, which is funded by the Swiss National Science Foundation.

Machine learning, deep learning networks support drone security in UND research project

By Mariana Iriarte, Technology Editor

A research team from the University of North Dakota (UND) has been working since mid-2017 under a grant from Rockwell Collins with the aim of addressing cybersecurity concerns involving unmanned aerial systems (UASs), more commonly called drones. The research, which is concluding in early 2019, has expanded to include a swarm of small-scale UASs, giving UND students real-world, hands-on experience using machine learning and neural networks to detect multiple targets in national airspace.

Dr. Prakash Ranganathan, Director of Cyber Security Programs at UND, is leading the Rockwell Collins-sponsored research project, which is titled "Geo-Fence Detection System (GFDS) for Unmanned Aerial Vehicular Airspace to provide Counter Autonomy."

The growing use of UAS in national airspace requires continued research into security and advances in detection. While the commercial UAS market is not all that concerned with malicious cyberattackers, the military requires systems that to a certain extent are impossible to reverse-engineer. "Small scale UASs, or drones, are simply cyber-physical systems (CPS), which means there is a hardware and software component interplay to achieve a goal," Ranganathan says. "The electronics and software applications embedded in these sUASs [small unmanned aerial systems] are vulnerable."

It's a fact that experienced malicious hackers can have a field day with the types of vulnerabilities to which drones are sensitive: "Vulnerabilities that a hacker can exploit include exploiting communication channels (radio frequency, Wi-Fi, Bluetooth) to access, transfer, and transport messages between one drone to another or to networks," Ranganathan notes.

"In addition, GPS can also be spoofed to take control of these drones," he continues. Ranganathan and researcher Eric Horton – in their coauthored article "Development of a GPS spoofing apparatus to attack a DJI Matrice 100 Quadcopter" – explain that "GPS spoofing is accomplished by a system capable of mimicking the GPS signals associated with every satellite in the GPS constellation visible to the target receive. The GPS transmission power of the fake GPS signals are higher than the real signals, resulting in the receiver locking onto them in favor of the true GPS. At this point the time shift of the fake signals can be manipulated to tamper with both the position and time reported by the receiver."

The UND team dived into cutting-edge technologies such as machine learning to detect multiple targets. (Figure 1.) For example, "In the study, a Robot Operating System (ROS)-based swarm platform is utilized to simulate various communication and control architectures for conditions such as collision avoidance, path planning, and securing communications," Ranganathan explains. "Large imagery data sets that contain nearly 20,000 images from multiple drone vendors were trained and tested using advanced machine learning and convolution neural network (CNN)-based algorithms to detect multiple target types in airspace. The research team is expected to test these approaches soon in a swarm of customized sUAS."

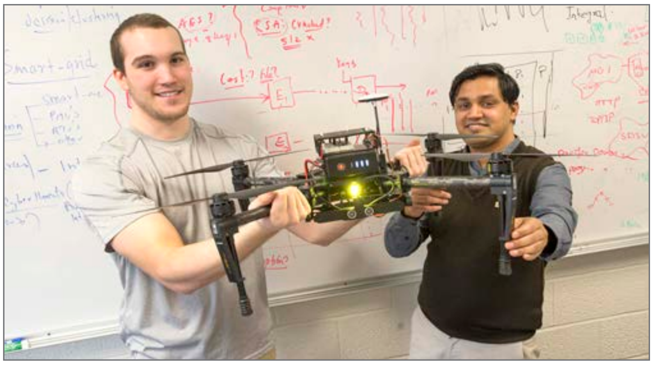


Figure 1 | UND Assistant Professor Prakash Ranganathan (right) with student researcher Eric Horton (left) holds a UAS used in the UND/Rockwell Collins research. Photo: UND/College of Engineering.

Although researchers, UAS developers, and students alike are using these cutting-edge technologies, they still face certain constraints. "Drone security technology must be robust in order to fit within the constraints of the drone's limited size, weight, and power (SWaP)," Ranganathan says. "Security software and hardware cannot be too taxing in terms of weight and power consumption of the drones."

In addition, he adds that we can longer rely on Wi-FI, radio frequency (RF), and Bluetooth technology when using UASs: These main lines of communication are no longer effective, which means that UAS "design considerations need to include a combination of, and switching between, cellular infrastructure and other communication modes."

Because of these issues, ongoing research and development is paramount. Unfortunately, "Very little effort has gone into the security side of drones," Ranganathan comments. "Literature is evolving on the deployment of encryption methods between the ground-control station, drone, and its data-storage units."

The security challenges continue to mount when users seek to add additional drones to the mission or look to integrate emerging technologies, Ranganathan says. But those will be addressed, he says. "There's a deepening understanding of how to ensure security when multiple drones are involved, and how security methods can use existing distributed computing methods such as blockchain or other encryption methods to offer a robust fault-tolerant sUAS."

MACsec encryption extends the value of copper-based Ethernet LANs

By Mike Southworth

An industry perspective from Curtiss-Wright Defense Solutions

There is vastly more copper-based twisted-pair Ethernet infrastructure deployed on military and aerospace platforms than there is fiber-optic cable-based wiring. For one thing, the cost of copper cabling and its related connectors keeps being driven downward by the economies of scale brought about by its widespread use, helping to make it virtually ubiquitous. But fiber-optic cabling, until fairly recently, was the only practical choice for applications that required high-speed 10 Gbit/s connectivity. Driving demand for higher-speed Ethernet is the increased use of applications such as HD video surveillance on deployed platforms, resulting in ever-larger high-resolution file sizes.

One downside to fiber optics compared to copper wiring – since it uses thin strands of ultrapure glass to transport photons in a digital pattern – is the need for specialized knowledge and equipment for its installation and maintenance. The comparatively fragile glass fibers are fairly unforgiving, limiting, to take one example, the amount of curvature that can be reliably supported, which means that fiber-optic cabling is unsuitable in some applications. Since its introduction, however, fiber-optic cabling has been able to boast one unassailable advantage over copper: Light traveling down the glass strands emits no electromagnetic interference (EMI) signal, making it impervious to hacking. In comparison, the electrical signals used in traditional copper Ethernet network cable are more prone to radio-frequency disturbance and EMI, especially in longer cables or those that are bundled with other copper cables. That has helped make fiber optic the go-to architecture for secure deployed applications.

In recent years, fiber optics has lost its exclusivity in regards to 10 GbE support. Formerly limited to 1 Gbit speeds, copper is now a viable alternative to fiber for 10 GbE. When 10GBase-T was first introduced, it was limited to very short cable length distances, finding use mainly in applications such as server farms, where a one-foot distance between devices is sufficient. Further hampering its widespread utility was the fact that 10GBase-T PHYs were only available in commercial temperature versions. Today, 10GBase-T supports industrial temperature ranges and cable distances up to 100 m, making it a great solution for many embedded applications.

What's more, thanks to a recent technology advancement, copper-based Ethernet can now be made far more secure. Two years ago, the IEEE MAC Security standard, known as MACSec (IEEE 802.1AE), was added to the mainline Linux kernel (as of kernel 4.6). MACSec provides MAC-layer point to point encryption on an Ethernet link between two devices on local area networks (LANs). MACsec is used for authentication and encryption of traffic over Ethernet on Layer 2 LAN networks. For Layer 3 networks, IPSec is used instead. MACsec and IPsec operate on different network layers, with IPsec working on IP packets and MACsec working on Ethernet frames, enabling it to protect all DHCP and ARP traffic. IPsec, on the other hand, is able to work across routers, while MACsec's utility is targeted at LANs.

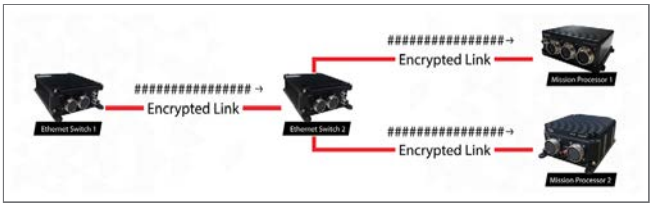


Figure 1 | MACSec-enabled switches and computers encrypt Ethernet traffic between LAN devices to prevent data loss or transmission/reception by unauthorized devices.

Although, MACsec, which uses GCM-AES-128 or -256 cryptographic cyphers, has been around for more than a decade, there has been a huge increase in its implementation since its inclusion in Linux. When encryption is enabled, MACSec does not allow any unencrypted packets to be transmitted or received from the same physical interface. Like IPsec and SSL, MACsec defines a security infrastructure to provide data confidentiality, data integrity, and data-origin authentication. The combination of low cost, support for high-speed Ethernet, and the encryption provided by MACsec means that copper-based networks now provide system designers with a compelling cost-effective alternative in applications where fiber optics once reigned supreme. (Figure 1.)

Fiber-optic cabling does have a significant weight advantage over the much heavier copper wiring. But one advantage that MACsec offers for SWaP [size, weight. and power] reduction is that it can eliminate the need for a standalone encryptor on some copper-based networks. Moreover, copper, unlike fiber optics, can support Power over Ethernet (PoE), eliminating the need for individual power cables for each device. Network devices based on the Cisco Systems' IOS management software often enable users to easily control power to each Ethernet port via PoE, providing great flexibility for assigning wattage limits and selecting which ports can be used to power devices.

Switching solutions that support both copper-based and fiber-optic interfaces enable military and aerospace system integrators to leverage the unique advantages of both technologies.

Mike Southworth is product line manager for Curtiss-Wright Defense Solutions.

Curtiss-Wright Defense Solutions
www.curtisswrightds.com

By Mariana Iriarte, Technology Editor

NEWS

Wright-Patterson AFB to host F-35 support organization

U.S. Air Force officials selected Wright-Patterson Air Force Base (AFB), Ohio, as the preferred location for the F-35 Lightning II Hybrid Product Support Integrator (HPSI) organization, which supports the entire F-35 enterprise to include joint and international partners.

The F-35 HPSI's primary role is to integrate support across the supply chain, maintenance, sustainment engineering, logistics information technology, and training disciplines. It delivers global support for fielded F-35s while preparing for future force expansion, Air Force officials state.

Air Force officials said Robins AFB, Georgia, was named as a reasonable alternative. The Air Force will now conduct the requisite environmental analysis. The final basing decision will be made by the secretary of the Air Force after the analysis is complete.

Figure 1 | A formation of F-35 Lightning II craft. U.S. Air Force photo by Staff Sgt. Cory D. Payne.

GDIT will provide commercial cloud services to U.S. Navy

General Dynamics Information Technology (GDIT) has signed a $22.4 million blanket purchase agreement (BPA) with the U.S. Navy's Program Executive Office for Enterprise Information Systems (PEO EIS), under which CSRA LLC, a managed affiliate of GDIT, will deliver commercial cloud services for the U.S. Navy to accelerate cloud adoption.

The award includes a one-year base period with four one-year options; if exercised, the options would bring the estimated cumulative value of the contract to $96 million.

GDIT will deliver commercial cloud services to the Navy through the General Services Administration's Schedule 70, which includes Amazon Web Services (AWS) and Microsoft Azure, both of which are Strategic Alliance Partners with GDIT.

CubeSat market to reach $375 million by 2023, says report

The global CubeSat market is projected to grow from $152 million in 2018 to $375 million by 2023, at a CAGR of 19.87 percent, according to a new report from MarketsandMarkets, "CubeSat Market by Application (Earth Observation & Traffic Monitoring, Communication, Science & Technology and Education), End User (Government & Military, Commercial, Non-profit Organizations), Size, Subsystem, and Region – Global Forecast to 2023."

The study found that the factors expected to fuel the growth of the market includes an increased focus on reducing mission costs plus the rise in demand for CubeSats in applications related to earth observation, communication, science, and technology.

Based on size, the report states that the 3U segment is estimated to account for the largest share of the CubeSat market in 2018.

Phase II receiver certification testing complete on KC-46 Tanker program

The U.S. Air Force and Boeing recently completed Phase II receiver certification under the KC-46 Tanker program following three weeks of flights tests with F-15E aircraft out of Edwards Air Force Base, California.

During the certification flight tests, KC-46 and receiver aircraft flew at different airspeeds, altitudes, and configurations to ensure compatibility and performance throughout the refueling envelope of each receiver. Moving forward, the Air Force and the Aerial Refueling Certification Agency will review all test data and paperwork before ultimately "certifying" each aircraft.

Phase III receiver certification testing will be conducted by the Air Force at Edwards Air Force Base during 2019. That testing will include additional receiver aircraft.

Figure 2 | Boeing's KC-46A Pegasus tanker refuels an F-15E aircraft. Photo courtesy of Boeing.

NEWS

AI to augment soldier's strength, endurance via new exoskeleton contract with Lockheed Martin

Officials at the U.S. Army Natick Soldier Research, Development and Engineering Center (NSRDEC) selected Lockheed Martin to enhance the ONYX exoskeleton for future soldier demonstrations under a new contract valued at $6.9 million.

Under the two-year, sole-source agreement, Lockheed Martin will optimize ONYX components. The improvements will be evaluated by the University of Florida in advance of NSRDEC soldier demonstrations scheduled for 2019. ONYX is a powered, lower-body exoskeleton with artificial intelligence (AI) technology that augments human strength and endurance. Developed by Lockheed Martin through a license from B-TEMIA, ONYX counteracts overstress on the lower back and legs. Using electromechanical knee actuators, a suite of sensors, and an AI computer, ONYX learns user movements and delivers the right torque at the right time to assist with walking up steep inclines, lifting or dragging heavy loads.

An independent study by the University of Michigan confirmed these benefits by showing how ONYX users exerted less energy while walking up an incline with a 40-pound backpack, Lockheed Martin reports.

Figure 3 | Lockheed Martin's ONYX tech demonstration. Photo courtesy of Lockheed Martin.

B-21 weapon system undergoes critical design review

The U.S. Air Force B-21 Raider program conducted a critical design review on its weapon systems in November 2018. The event served as a multidisciplined technical review to ensure the Air Force's newest bomber has a stable and mature design as the program moves forward into manufacturing and flight test.

"This critical design event is key to maturing the design of the new bomber and to identifying risks that are consistent with all large acquisition programs across the DoD," says Randall Walden, program executive officer at the Air Force Rapid Capabilities Office.

The B-21 bomber is a long-range aircraft designed to operate in future an antiaccess area denial (A2AD) environments. The B-21 is expected to begin delivering initial capability in the mid-2020s.

Nanosatellites will extend communications reach for military forces

The U.S. Navy has launched a nanosatellite from the Vandenberg Air Force Base that is intended to expand the range of ultra-high frequency (UHF) communications into the polar regions.

Officials at the Navy's Program Executive Office (PEO) Space Systems in conjunction with developers at Space and Naval Warfare Command Systems Center Pacific are leading the effort – known as the Integrated Communications Extension Capability (ICE-Cap) – which will demonstrate the ability of low-Earth-orbit satellites to extend the geographic coverage of the Mobile User Objective System (MUOS) and legacy UHF Follow-On (UFO) satellite constellations to the polar regions.

MUOS gives mobile forces in the field cellphone-like capabilities via the Wideband Code Division Multiple Access (WCDMA) while also supporting the legacy UHF currently provided by the UFO satellites. The ICE-Cap satellite will act as a relay to the existing MUOS constellation and – based on its orbit – extend communications into the polar regions for mobile forces.

JLTV order valued at $1.69 billion placed by U.S. Army

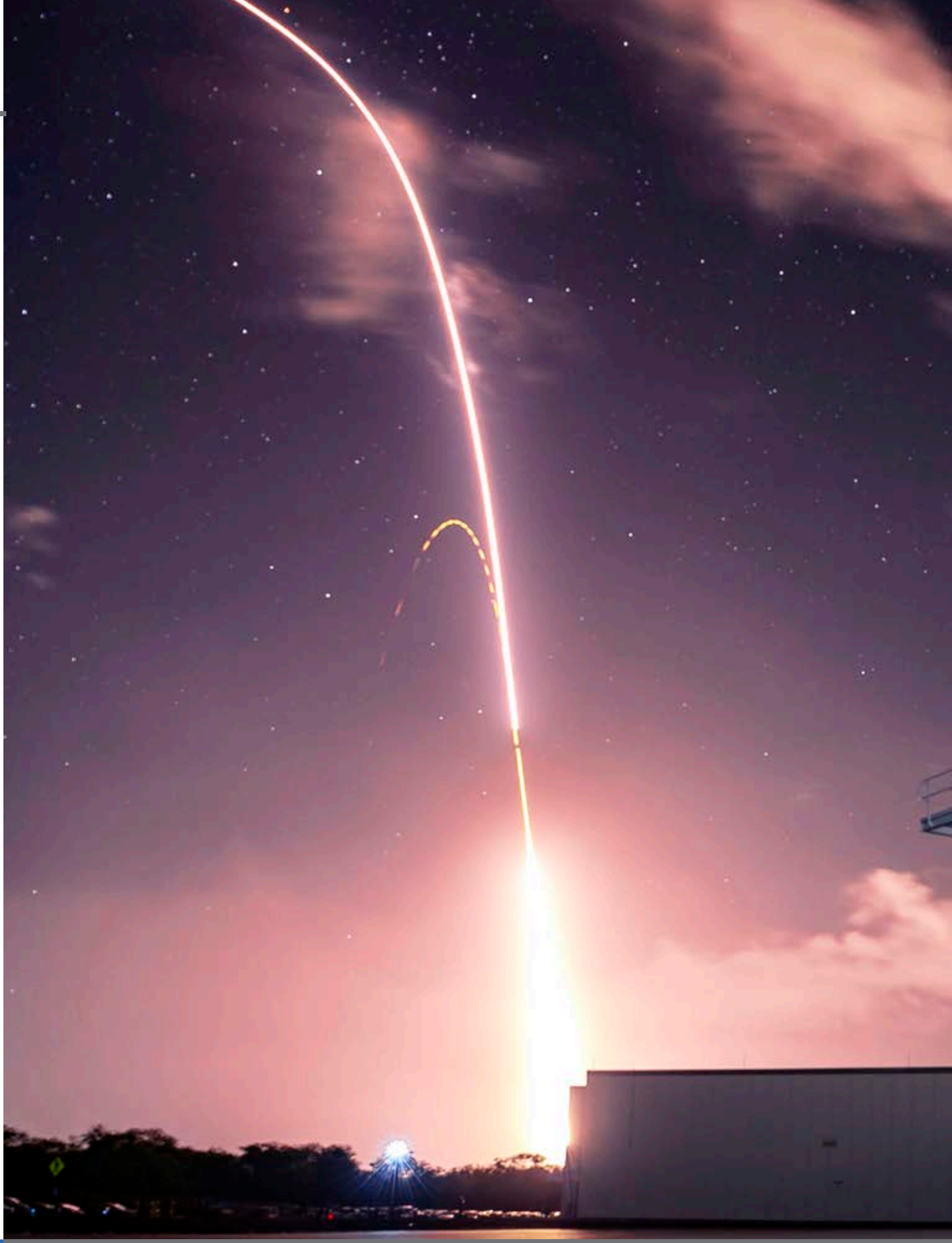
U.S. Army officials placed a $1.69 billion order with Oshkosh Defense, LLC, an Oshkosh Corp. company, for 6,107 Joint Light Tactical Vehicles (JLTV) and associated installed and packaged kits.

To date, Oshkosh has delivered more than 2,600 vehicles. Oshkosh expects that the first Army unit will be equipped with the vehicles in early 2019.

The JLTV also features a VICTORY-compliant modular, scalable open architecture system to support rapidly evolving C4ISR [command, control, communications, computer, intelligence, surveillance, and reconnaissance] suites," says George Mansfield, vice president and general manager of Joint Programs at Oshkosh Defense. "This provides our soldiers and marines a vehicle that is capable of serving as a mobile command center."

Figure 4 | LTV can handle extreme environments. Photo courtesy of Oshkosh Corp.

RADAR DESIGN TRENDS



Ballistic missile radars pushed to detect widening range of threats

By Sally Cole, Senior Editor

As adversaries develop missile technology to attack the U.S. in ways that can challenge our missile defense – such as conventional and nuclear intercontinental ballistic missiles, sea-launched land-attack missiles, hypersonic weapons, and space-based missiles that orbit Earth – it's critical to have radar systems capable of providing early detection.

The Missile Defense Agency and U.S. Navy sailors manning the Aegis Ashore Missile Defense Test Complex (Pacific Missile Range Facility in Kauai, Hawaii) conducted a successful flight test in December 2018. Photo credit: Missile Defense Agency.

The U.S. Department of Defense (DoD) budget for Fiscal Year (FY) 2019 highlights the importance of missile defense programs and calls for investments that "focus on layered missile defenses and disruptive capabilities for both theater missile threats and North Korean ballistic missile threats."

Missile defense technology now under development by the U.S. is designed to counter all types of ballistic missiles – including short, medium, intermediate, and long ranges. Because ballistic missiles used by various players have different ranges, speeds, size, and performance characteristics, the Ballistic Missile Defense System is by design "an integrated, layered architecture that provides multiple opportunities to destroy missiles and their warheads before they can reach their targets," according to information from the Missile Defense Agency.

The U.S. Air Force maintains three Ballistic Missile Early Warning System (BMEWS) radars that can detect attacks as well as carry out general space surveillance and satellite tracking. These BMEWS radars are at located at Thule Air Force Base in Greenland, Clear Air Force Base in Alaska, and Fylingdales Royal Air Force Station in England. (Figure 1.)

Phased-array antenna technology sets these systems apart from mechanical radars, which require being physically aimed at an object for tracking and observation. Phased-array antennas remain in a fixed position, and Space Command describes its aiming or "beam steering" as being done in millionths of a second by electronically controlling the timing or "phase" of incoming and outgoing signals.

By controlling the phase through the numerous segments of the antenna system, the beam can be rapidly projected in different directions to enable interweaving of tracking pulses with surveillance pulses – so multiple targets, indicative of a massive missile attack, can be tracked at once.

BECAUSE BALLISTIC MISSILES USED BY VARIOUS PLAYERS HAVE DIFFERENT RANGES, SPEEDS, SIZE, AND PERFORMANCE CHARACTERISTICS, THE BALLISTIC MISSILE DEFENSE SYSTEM IS BY DESIGN "AN INTEGRATED, LAYERED ARCHITECTURE THAT PROVIDES MULTIPLE OPPORTUNITIES TO DESTROY MISSILES AND THEIR WARHEADS BEFORE THEY CAN REACH THEIR TARGETS," ACCORDING TO INFORMATION FROM THE MISSILE DEFENSE AGENCY.

Northrop Grumman and the 'SMORS' project

In 2018, the U.S. Air Force awarded Northrop Grumman with a contract to sustain and modify a worldwide network of ground-based radars deemed critical for missile warning and defense, as well as for space tracking missions.

Figure 1 | Pictured: The U.S. Air Force Ballistic Missile Early Warning System. Photo: U.S. Air Force Space Command.

Northrop Grumman's work on the Sustainment and Modification of Radar Sensors (SMORS) project "will uphold and enhance the Air Force's ability to detect missile attacks early, while also providing forces with critical situational awareness of objects in space," says Joseph J. Ensor, vice president and general manager, space and intelligence, surveillance, and reconnaissance systems division, Northrop Grumman.

The goal is to ensure the high availability of ground-based radar systems for Space Command, including not only the BMEWS, but also the Precision Acquisition Vehicle Entry Phased Array Warning System (PAVE PAWS), and Perimeter Acquisition Radar Attack Characterization System (PARCS) radars, along with associated support systems.

The Air Force operates two PAVE PAWS radars, at Beale Air Force Base in California and Cape Cod Air Force Station in Massachusetts, both of which can detect submarine-launched ballistic missile attacks and also do space surveillance and satellite tracking. These are ground-based, two-faced UHF-band phased array radars.

PARCS, based at Cavalier Air Force Station in North Dakota, is a single-faced UHF-band phased array radar.

Hypersonic weapons call for longer-range radar, space-based sensors

Hypersonic vehicles and missiles demand different detection

A blisteringly fast threat that requires longer-range radars and space-based sensors looms on the horizon in the form of hypersonic vehicles and missiles.

Busting out of Earth's lower orbit requires hypersonic vehicles to reach speeds in excess of Mach 5 (about 3,836 mph) and, at hypersonic speeds, they take an absolute beating from the air particles and gases that flow around and interact with their surfaces – particularly on their leading edge. This generates extreme heat and shock waves, which disturb the flow's equilibrium, and is a materials and design nightmare.

But it hasn't stopped Russia from reportedly developing a few hypersonic vehicles, one of which is claimed to be capable of reaching Mach 20 (about 15,345 mph), while the U.S. has been quietly working on hypersonics for decades and now appears to be keeping a really tight lid on its capabilities; either that or it is perhaps actually still working on it. China also reportedly has hypersonic weapon capabilities.

In 2018, the U.S. Air Force awarded Lockheed Martin contracts to develop a Hypersonic Conventional Strike Weapon (HCSW), an air-launched missile that will travel more than five times faster than the speed of sound, and an Air Launched Rapid Response Weapon (ARRW). The U.S. Navy is also pursuing submarine-launched hypersonic weapons.

Many other defense contractors – including Raytheon and Northrop Grumman – have been exploring or working on hypersonic vehicles or weapons for years.

No countermeasures for hypersonic weapons exist yet

The U.S. could develop a workable defensive capability against hypersonic weapons by the mid 2020s, said Michael Griffin, undersecretary of defense for research and engineering, at a National Defense Industrial Association event in December 2018. He explained that this requires developing "longer-range radars and new space-based sensors" that can track and target adversaries' weapons – in the event that an attack is launched.

One huge problem is that today's radar systems aren't capable of seeing far enough out to detect hypersonic weapons. Radar systems will need to be developed to see thousands of kilometers (rather than hundreds) out to provide an advanced warning about incoming hypersonic threats.

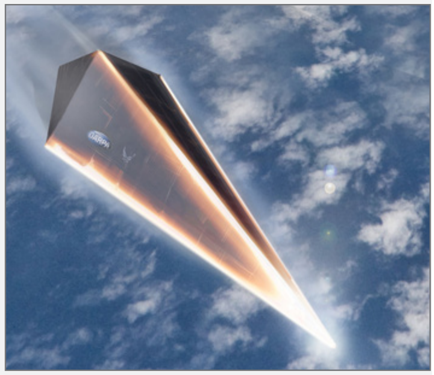
Hypersonic weapons are being pursued – despite the extreme materials and engineering challenges involved – because their speed, altitude, and maneuverability may defeat most missile defense systems, according to a recent U.S. General Accounting Office (GAO) report. These weapons may also be used to improve long-range conventional and nuclear strike capabilities. The really bad news: There are no existing countermeasures.

DARPA seeks thermal solutions for hypersonic vehicles

The Pentagon's Defense Advanced Research Projects Agency (DARPA) is actively seeking designs for cooling vehicles' superhot leading edges that rip through the air at more than five times the speed of sound. Developing structures that can withstand furnace-like temperatures at such high speeds is an enormous technical challenge, primarily for leading edges that are subjected to the brunt of the heat.

To address this thermal challenge, DARPA recently announced a Materials Architectures and Characterization for Hypersonics (MACH) program. The MACH program aims to develop and demonstrate new design and materials solutions for sharp, shape-stable, cooled leading edges for hypersonic vehicles. (Sidebar Figure 1.)

For decades, researchers have "studied cooling the hot leading edges of hypersonic vehicles but haven't been able to demonstrate practical concepts in flight,"



Sidebar Figure 1 | Pictured is an artist's concept of a hypersonic vehicle. Credit: DARPA.

says Bill Carter, program manager in DARPA's Defense Sciences Office.

The key, Carter adds, "is developing scalable materials architectures that enable mass transport to spread and reject heat. In recent years, we've seen advances in thermal engineering and manufacturing that could enable the design and fabrication of very complex architectures not possible in the past. If successful, we could see a breakthrough in mitigating aerothermal effects at the leading edge that would enhance hypersonic performance."

DARPA's MACH program encompasses two technical areas. The first area aims to develop and mature a fully integrated passive thermal management system to cool leading edges based on scalable net-shape manufacturing and advanced thermal design. The second area focuses on next-generation hypersonic materials research, applying modern high-fidelity computation capabilities to develop new passive and active thermal management concepts, coatings, and materials for future cooled hypersonic leading-edge applications. (See go.usa.gov/Dom)

The MACH program is seeking expertise in thermal engineering and design, advanced computational materials development, architected materials design, fabrication and testing (including net-shape fabrication of high-temperature metals, ceramics, and composites), hypersonic leading-edge design and performance, and advanced thermal-protection systems.

Achieving an LRDR milestone

In other missile defense radar news, in 2018, Lockheed Martin's long-range discrimination radar (LRDR) completed a closed-loop satellite track with tactical hardware and software; it is now being built at the Missile Defense Agency's site in Clear, Alaska. It's expected to be operational in 2020.

To make the project happen, Lockheed Martin invested in a solid-state radar integration site (SSRIS) in Moorestown, New Jersey, to conduct testing. The SSRIS is a scaled version of the final LRDR radar and the company plans to continue using it for solid-state radar development.

"We designed and produced a scaled LRDR system that's running with the actual tactical processing equipment and tactical software successfully," says Chandra Marshall, LRDR program director for Lockheed Martin.

The SSR concept centers on a scalable, modular, and extensible gallium nitride (GaN)-based radar building block. Once completed, the radar system will serve as a critical sensor within MDA's layered defense strategy to protect the U.S. from ballistic missile attacks. LRDR will provide acquisition, tracking, and discrimination data to enable defense systems to lock on and engage ballistic missile threats, according to Lockheed Martin.

Importantly, LRDR adds the capability of discriminating threats at extended distances by using the inherent wideband capability of the hardware combined with advanced software algorithms. LRDR integrates proven SSR technologies with proven ballistic missile defense algorithms, which are all based upon an open architecture platform. Lockheed Martin views SSR as the cornerstone of its current and future radar development and in its development of LRDR.

Putting missile defense to the test

In yet another example of ballistic missile radar advances during 2018, an operational live-fire test of the Aegis Weapon System Engage On Remote capability in Kauai, Hawaii, demonstrated its ability to track and intercept an intermediate-range ballistic missile (IRBM) target with an Aegis Ashore-launched Standard Missile-3 (SM-3) Block IIA interceptor.

The flight test involved an IRBM target launched by a U.S. Air Force C-17 in the ocean thousands of miles southwest of the Aegis Ashore Test site that launched the SM-3 Block IIA interceptor. Engagement relied on a ground, air, and space-based sensor/command and control architecture linked by the Ballistic Missile Defense System's Command and Control, Battle Management, and Communications suite.

The flight test demonstrated "the effectiveness of the European Phased Adaptive Approach Phase 3 architecture," says Missile Defense Agency Director Lt. Gen. Sam Greaves. "It was also of great significance to the future of the multi-domain missile defense operations and supports a critical initial production acquisition milestone for the SM-3 Block IIA missile program. This system is designed to defend the U.S., its deployed forces, allies, and friends from a real and growing ballistic missile threat." **MES**

Stacked, high-speed DDR4 and DDR5 memory useful in harsh battle environments

By Jennifer Keenan

Today's autonomous and artificial intelligence (AI) military systems process an ever-growing amount of sensor data. To handle this extreme workload, system architects must design boards using the fastest FPGA [field-programmable gate array] devices and Intel multicore processors. These devices cannot provide peak performance without massive amounts of high-speed double-data rate fourth generation (DDR4) memory for resident data and real-time execution.

Faced with huge data asks, architects must engineer their systems to meet the size, weight, and power (SWaP) constraints of smaller, more agile platforms integral to our warfighters' mission success. To support the system requirements, each embedded board within the system may need a minimum of 64 GB of memory per processor, equating to more than 128 separate commercial-grade memory devices or multiple dual inline memory modules (DIMM) for layout on a printed circuit board.

This is not a feasible solution for the embedded boards inside ultra-compact military systems operating in harsh, forward-deployed environments. High-density, military-grade memory using die-stacking technology must be utilized for space and power savings while maintaining reliability in harsh environments.

The problems are stacking up

The complexity of die stacking and wire bonding increases with each additional die needed to engineer high-density memory, such as a single 16 GB DDR4 device. With so many circuits in a tightly stacked configuration, signal integrity is at the forefront of design considerations. The two main components of compromised signal integrity in the context of this discussion are crosstalk and return loss performance.

- Crosstalk is the unwanted voltage noise coupling due to strong mutual inductance and mutual capacitance. More simply stated, it is the interference to a signal in one circuit caused by the signal transmission in an adjacent circuit in the die stack.
- Return loss is the signal distortion caused by the portion of a signal reflected back to its origin instead of carrying through to the final termination. It is caused by an impedance mismatch or discontinuity in a transmission line.

These performance issues limit data speeds in stacked-memory devices, comprising overall system performance and reliability. In mission-critical military applications, they may also lead to catastrophic events.

Traditional die-stacking design topologies have their limits

Traditional multichip stacking design methodologies use a branch or star topology. This is an effective design method

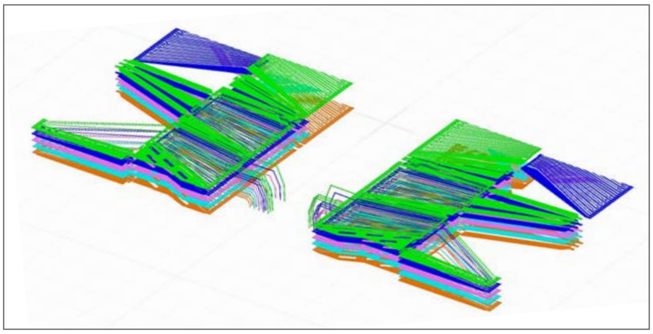


Figure 1 | DDR die stacking and wire bonding using branch topology with stubs.

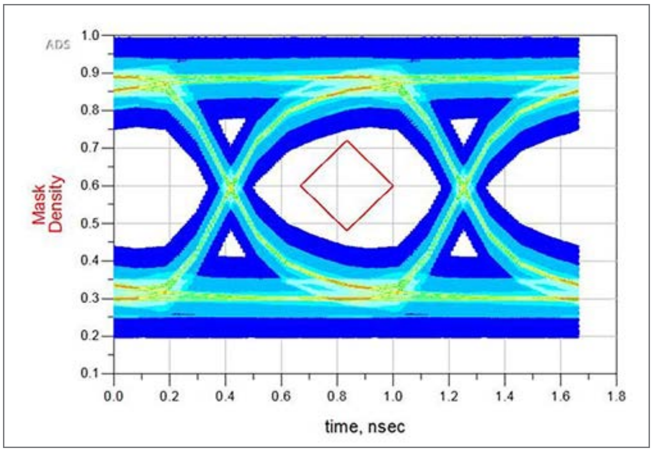


Figure 2 | 2400 Mbps DDR4 using branch topology.

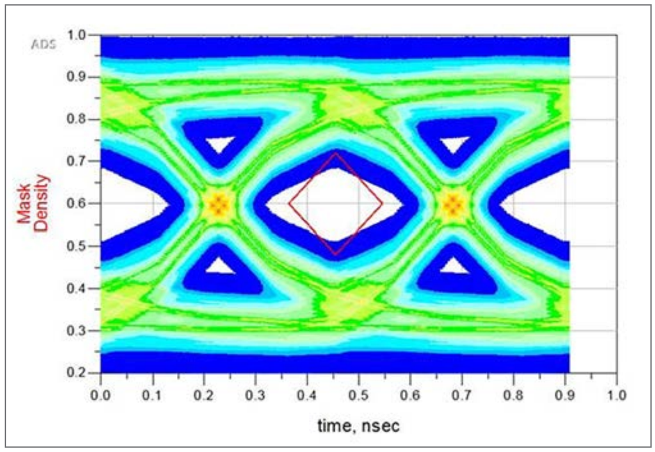


Figure 3 | 4400 Mbps DDR5 using branch topology.

for DDR2 and DDR3 devices as it enables the required data rates and densities those generations of devices can deliver. (Figure 1.) Skillfully designed stacked DDR4 devices could be feasible with this method. However, there are inherent limitations for high capacities as the increased termination path or bus length causes signal distortion and limits the maximum bandwidth of the transmission line due to reflections. As the number of stacked die increases, these continue to degrade to a detrimental point. Branch topology reaches its maximum capability thereby ruling out this method for use in highly dense, high-speed DDR4 and DDR5 devices. (Figure 2 and Figure 3.) Signal-integrity engineers must look at alternative design methodologies to enable the next generation of smaller, more agile military systems.

High-density DDR4 realized

To reach the high-speed requirements of DDR4, the signal-integrity engineer faces two main challenges: First, reducing crosstalk, prominent with designs using non-transverse electromagnetic (TEM) conduits such as a redistribution layer (RDL) and bond wire; and second, meeting a minimum of -12 dB return loss performance.

Enhancements to the interconnect layer by way of a coplanar topology that supports higher frequency operations than branch topology is needed. This shortens the path between the two terminations while eliminating stubs, consequently improving signal integrity and timing. To achieve this, routing signals sequentially from one die to the next eliminates reflections associated with stubs or extra traces previously seen in branched designs. Creating a contiguous signal return path and linear bus path by adding a microstrip transmission line enables high-speed data rates. Additionally, considerations made to signal and signal-return trace widths further enable higher data rates and improvements to return loss.

With this topology, achieving a return loss of -16 dB through a delicate balance with crosstalk enables the miniaturization of 18 memory devices in a single compact package while offering 2666 Mbps date rates over military temperature ranges. However, while return loss is optimized with this method, improvement to crosstalk performance is still needed to meet DDR5 data speeds. (Figure 4 and Figure 5.)

The path to military-grade DDR5

With expected double bandwidth and density over DDR4 along with improvements to power and channel efficiency, advanced military systems will use DDR5 devices to increase performance. However, even with the advancements in the coplanar topology for a high-density multichip package previously introduced, the higher data speeds for DDR5 still cannot be attained. Further improvements to crosstalk performance and the inter-die network are necessary. Developing a unique multiplanar ground and signal trace layout applied to the RDL increases crosstalk isolation resulting in a performance improvement of 6dB. No other known die-stacking design methodology is available today for the commercialization of high-density DDR5 in a singular device with data rates as fast as 6400 Mbps. (Figure 6.)

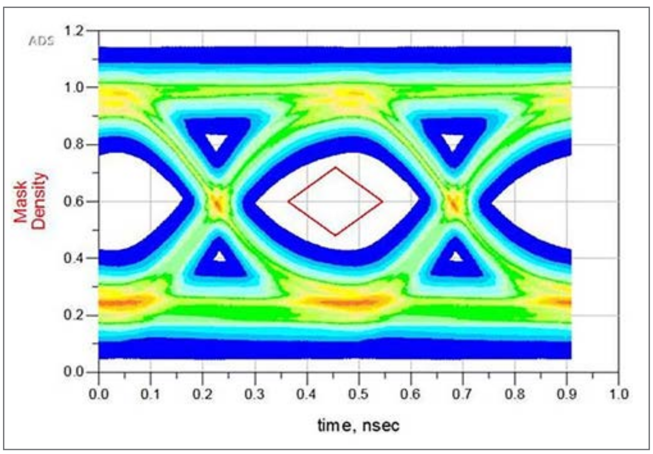


Figure 4 | 4400 Mbps DDR5 using advanced coplanar topology

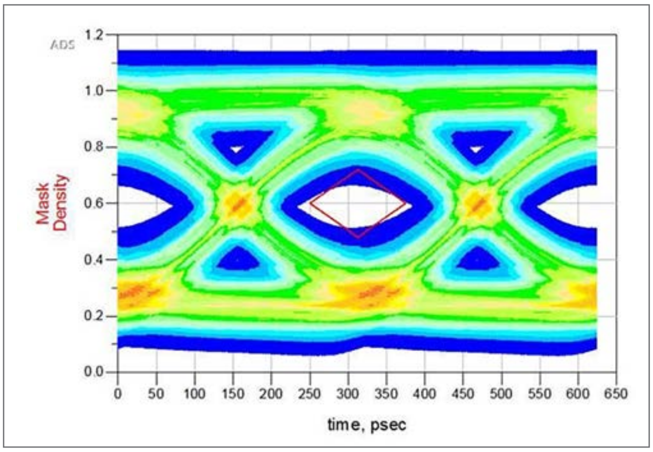


Figure 5 | 6400 Mbps DDR5 using advanced coplanar topology.

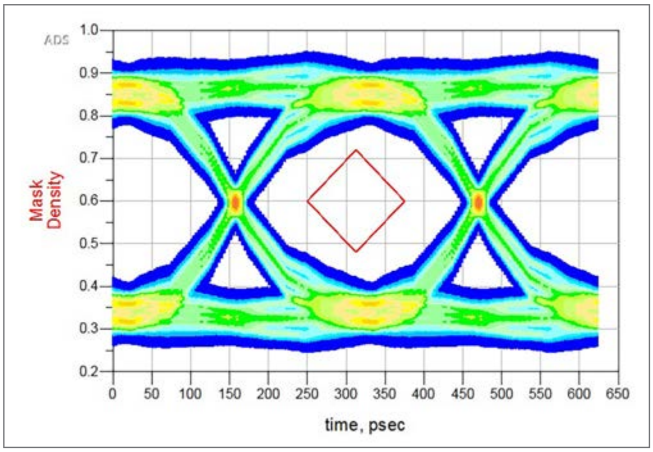
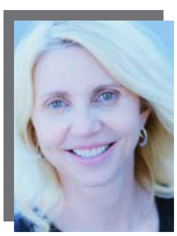


Figure 6 | 6400 Mbps DDR5 using advanced multiplanar topology.

With the DDR5 JEDEC standard still in development, commercial DDR5 devices are set to release in 2019. Military-grade, high-density devices supporting speeds as fast as 6400 Mbps using advanced topology techniques will follow shortly after, set to release in 2020. Designers and users of next-generation military embedded systems will soon realize the maximum performance of their high-speed multicore processing systems due to the integration of high-capacity, high-speed stacked DDR5 while simultaneously benefiting from a much smaller system footprint. **MES**



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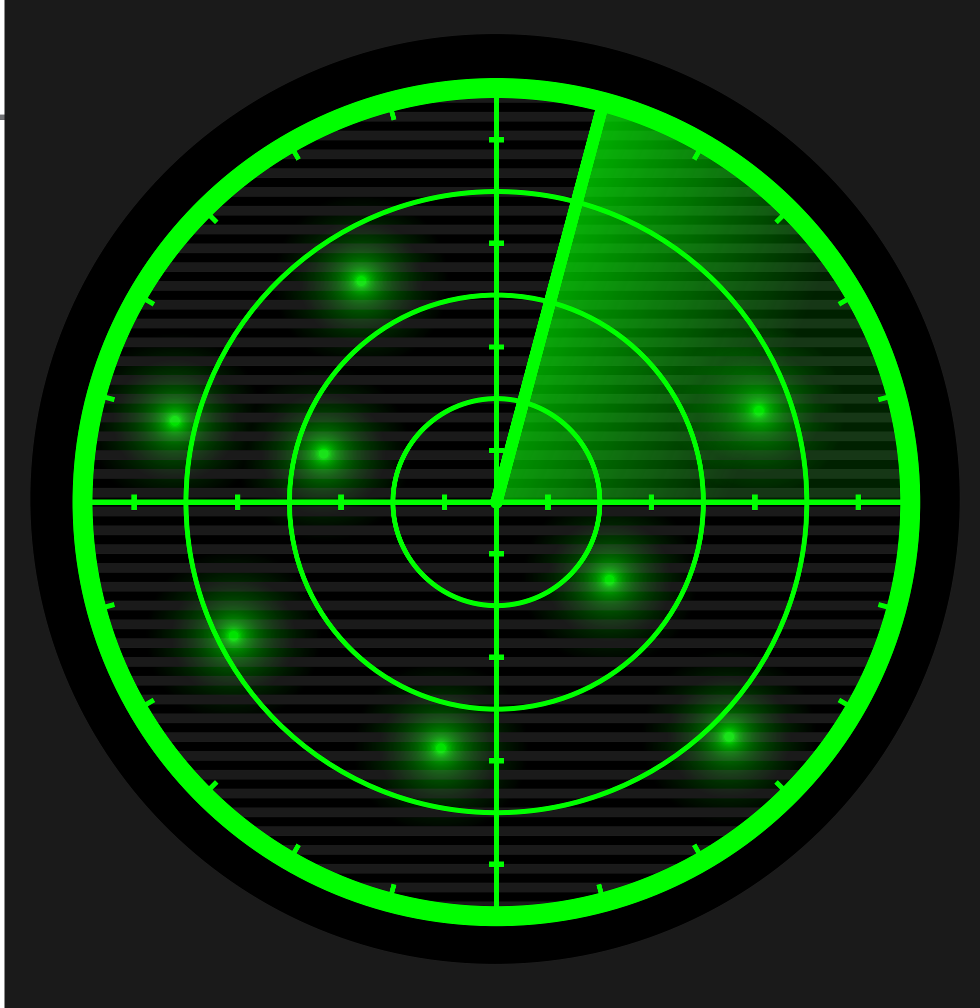

Configurable FPGAs: More than a point solution

By Paul Bundick

Two major challenges confront developers of military radar-processing systems. The first challenge is that modern multiband radar sensors produce huge amounts of data that need to be brought into the system's digital-processing stage as accurately and rapidly as possible in order to generate actionable data for the warfighter. The second challenge in this arena is the rapid rate of change that missions must respond to, as adversaries continually morph and evolve their tactics and develop more sophisticated technologies.

As recently as ten years ago, legacy radar sensors might have only supported a single band, such as KU-Band, X-Band, or S-Band. These single-band point solutions produced a particular data rate which had specific downstream data and processing effects. Each radar system would have a fixed set of functions and attack only a particular band of operation within which intelligence had identified that adversaries were operating.

As threats have become more sophisticated, radar sensors have, too. Now, radar signal detection must be performed over multiple bands, meaning that the sensors have had to become much smarter and more sensitive. The result? Radar sensors today are collecting and sending significantly more data to the radar processor. To support these new sensors, radar-system developers want to use underlying digital processing technology that can accept and handle data from a broad variety of different sources. This approach, compared to the earlier point solution, effectively eliminates the cost and time needed to develop a unique digital processor every time a new threat is identified.

The point solution

Sensor requirements for radar, electronic warfare (EW), and signal intelligence (SIGINT) applications usually differ from application to application. The investment required to develop a new system from the ground up for every application can be costly and time-intensive. For instance, every antenna design differs depending on the application space or where in the electromagnetic spectrum the system designer is trying to attack, sense, or operate.

FPGA [field-programmable gate array] devices, a key component in radar-processing systems, are continuing to evolve and add more capability such as floating-point math, increased local memory, faster sensor I/O channels, local processors, and embedded RF analog I/O. Functions such as digital down converters (DDC) are particularly well suited for FPGAs, enabling extraneous data to be removed or dynamically scanned, ensuring that later processing chains are not flooded with data that slows the system down. FPGAs almost uniquely have the ability to support the high processing speeds needed to handle and process the vast sensor data bandwidths typical

> TO COMPLEMENT THE FPGA PROCESSING CAPABILITY, LARGE AMOUNTS OF BACKPLANE I/O BANDWIDTH IS USEFUL IN INTERCONNECTING DIFFERENT SYSTEM ELEMENTS. THE AMOUNT OF ONBOARD MEMORY, AS WELL AS ITS TYPE, SPEED, AND DEPTH, ARE ALSO KEY CONSIDERATIONS.

of radar-system applications. That capability makes these devices exceptional technology for the front end of any high-performance system.

FPGAs are ideal for performing math-intensive algorithms such as Fast Fourier Transforms (FFT) on the incoming raw sensor data stream. After the key data has been extracted by the FPGAs, it can be sent to devices such as DSPs [digital signal processors] or GPGPUs [general-purpose graphics processing units] that can provide even more sophisticated processing, but on smaller data sets better suited to the throughput limits of those device types.

For many years, radar system designers turned to in-house-designed FPGA module solutions that targeted a specific application. In the past, radar systems often used costly custom or semicustom FPGA technology, in a system designed with a specific program or purpose in mind. While dedicated point solutions have their place, such systems lack the flexibility needed to address a wide variety of applications. To support multi-band radar, a processing system needs to be flexible and – ideally – reconfigurable. One downside to custom and semi-custom FPGA module developments is that they tend to require large amounts of resources to develop and maintain. Moreover, because they are typically designed for a specific point solution, it's rarely practical to leverage the investment in these devices across multiple applications.

Today, due to more sophisticated mission requirements and the costs associated with point solutions, system designers are increasingly turning to commercial off-the-shelf (COTS) reconfigurable FPGA modules. Using a commercially available and reconfigurable FPGA processor hosted on an open architecture form factor such as 3U or 6U VPX, the system designer is freed from the hassle of developing independent and unique sensor-processing solutions for every antenna design. What's more, investment in flexible FPGA technology often leads to downstream benefits with respect to system reuse. Another benefit is that using COTS FPGAs enables designers to track future technology roadmaps to help future-proof their application.

Configurable COTS FPGA solutions can handle the performance

Today's configurable, user-programmable FPGA solutions are designed to meet the needs of challenging embedded high-performance sensor-processing applications. To complement the FPGA processing capability, large amounts of backplane I/O bandwidth is useful in interconnecting different system elements. The amount of onboard memory, as well as its type, speed, and depth, are also key considerations. Standard interfaces such as PCI Express (PCIe), Ethernet, and Aurora provide a reliable connection to other system processing elements. The combination of a sizeable amount of processing density and flexible I/O, as well as expansion sites for daughtercards like FPGA mezzanine cards (FMCs), help to make configurable FGPA modules ideal for use in wide variety of rugged embedded applications.

Let there be light: the optical fiber advantage

Another recent development that helps to make COTS FPGA modules a compelling choice for radar-system designers is the availability of optical fiber interfaces on the modules themselves, enabling huge amounts of sensor data to be brought directly into the VPX backplane and then sent to the FPGA for digital processing. This approach enables the radar system to absorb as much of the raw sensor data as possible without having to introduce any intermediary conversion stages. Instead, data is sent directly from the sensors and over the backplane to the optical sensor on the FPGA.

At that point, the sensor data has entered the digital-processing realm, and the algorithms can be performed. This approach – defined by the VITA 66 standard – completely eliminates the need for fiber-optic rear-transition modules that plug into the back of VPX backplane or a separate media-conversion module. Formerly, such a module would be required to perform the fiber-optic conversion before sending the data over the VPX backplane to the digital processor. This intermediary transition

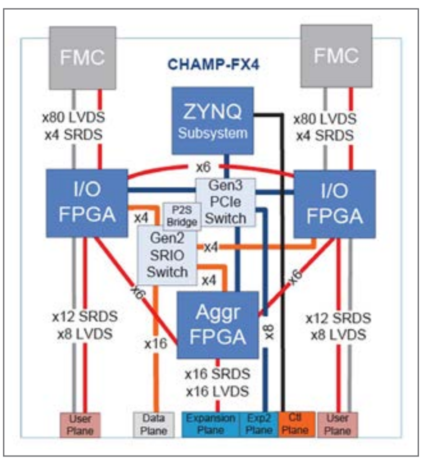

Figure 1 | Block diagram shows FX4 configuration.

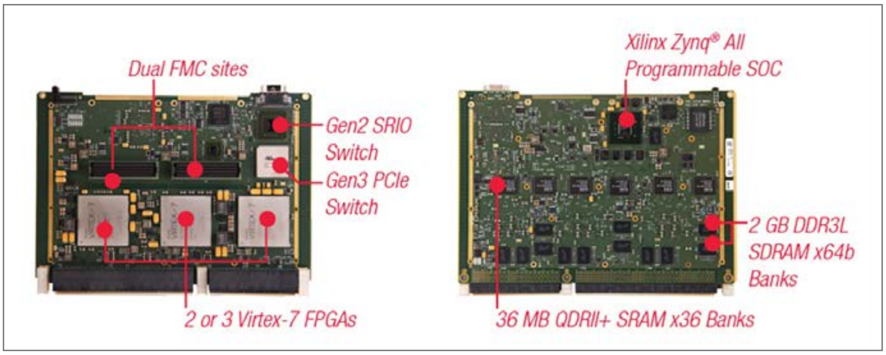

Figure 2 | Configurable FPGA modules can enhance sensor-processing capability for multiple applications.

module took up space, introduced complexity, and complicated logistics. Instead, using VITA 66, the transition module goes away, enabling the chassis depth to be reduced and improving overall size, weight, and power (SWaP) stats. In addition to being able to handle huge amounts of bandwidth, optical fiber connectivity delivers major benefits such as enhanced security because they create no EMI or noise that might enable hacking. For the warfighter, the faster access to greater amounts of radar data delivers the possibility for longer fields of view, a more accurate and quicker ability to locate targets in the environment, and the ability to operate over a much wider spectrum.

Example of a reconfigurable FPGA solution

To address rapidly changing requirements, a COTS configurable FPGA module, such as Curtiss-Wright's CHAMP-FX4 (Figure 1), offers system designers a solution that enhances sensor processing capability for multiple applications. The 6U OpenVPX board hosts three Xilinx Virtex-7 FPGAs, and is designed to serve as the core of a sensor-processing subsystem that can integrate with multiple antennas or applications for radar systems.

Another key element in a flexible radar-processing system is a high-speed transceiver module to handle the synchronization of analog-to-digital and digital-to-analog conversion synchronization. The 3U VPX VPX3-534 module is a 6 Gs/sec transceiver card that provides multiboard synchronization. Powered by a Kintex UltraScale FPGA, the module combines high-speed multichannel analog I/O, user-programmable FPGA processing, and local processing in a single 3U VPX slot for direct RF wideband processing to 6 Gs/sec. (Figure 2.)

A moving target

As threats become more complex and sophisticated, the use of reconfigurable FPGAs in radar systems provides a flexible technology that helps system designers keep up with rapidly evolving challenges. Support for direct input from the sensor via optical fiber connectivity speeds the ability to turn greater amounts of analog sensor data into actionable intelligence. The nature of these applications is that the amount of sensor data will continue to grow while the sophistication of the adversary will continue to expand. COTS FPGAs help system designers keep pace with this rapidly changing landscape. **MES**

Paul Bundick is a district manager for Curtiss-Wright Defense Solutions. He has been involved in the defense/ rugged embedded computing industry for two decades, having held positions in leadership, engineering, and customer management. Paul earned a BS in computer science from Virginia Tech.

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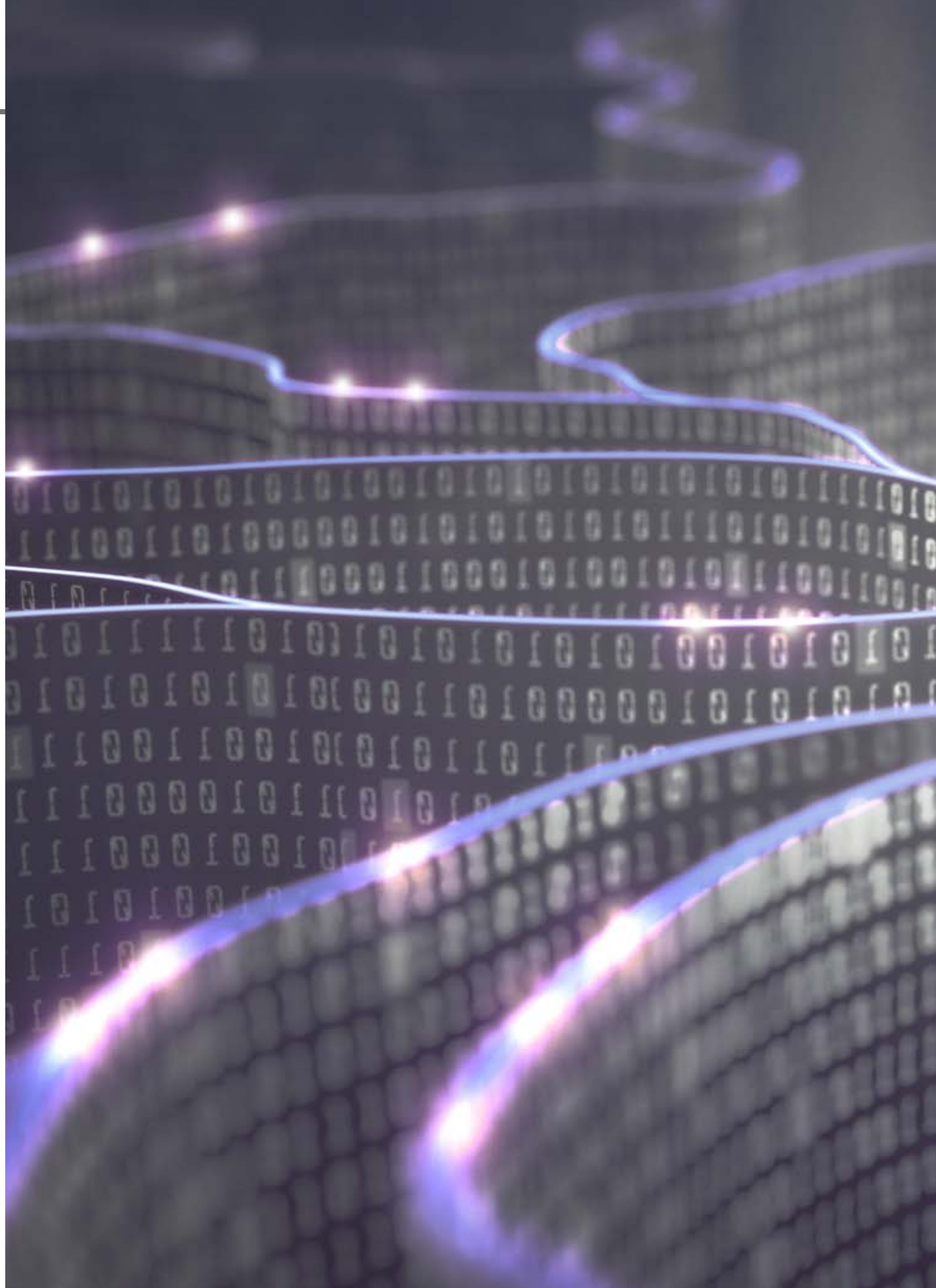


Designing multifunction radar and EW systems means staying ahead of the tech curve

By Mariana Iriarte, Technology Editor

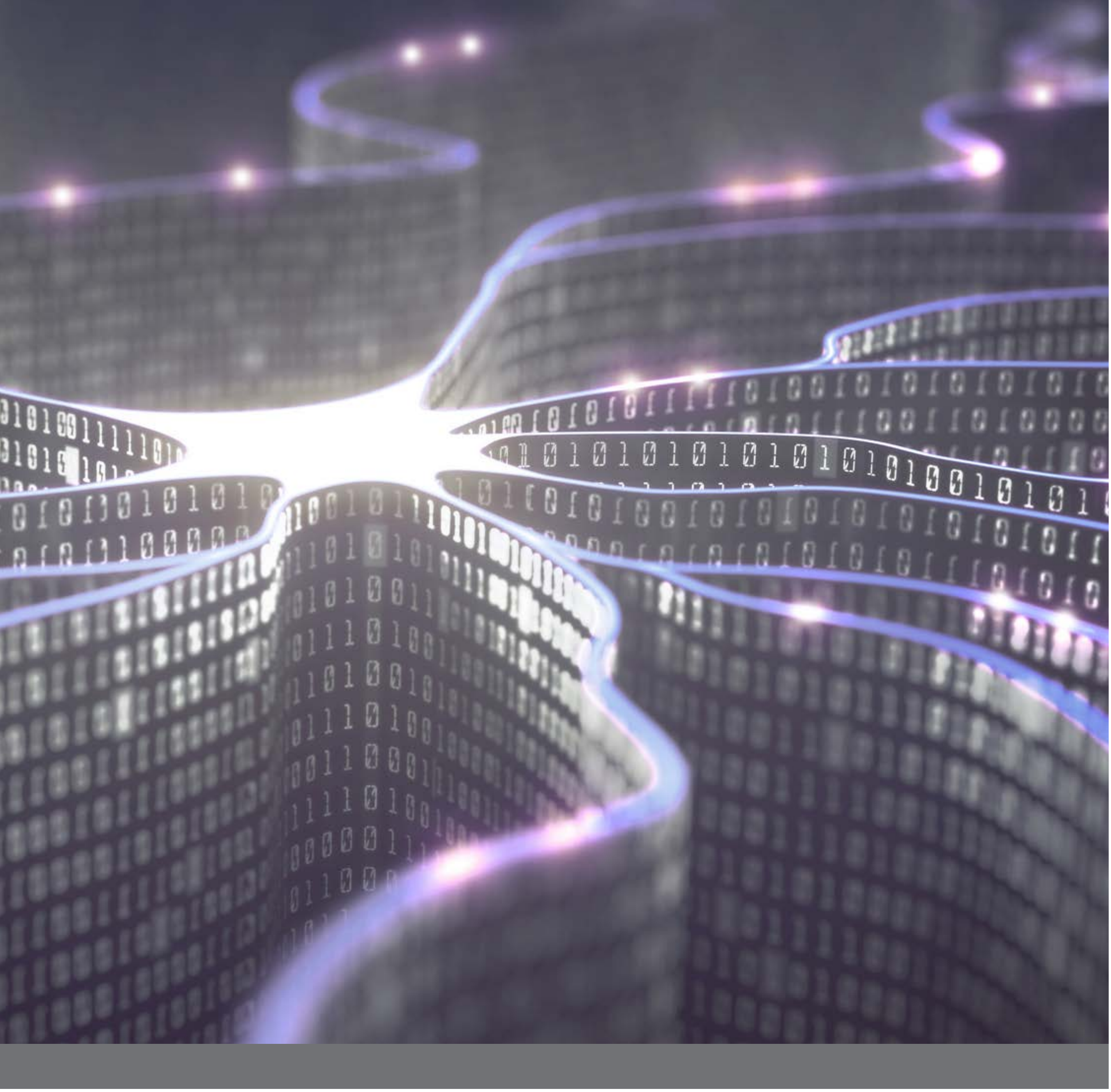
Huge data demands – including those from artificial intelligence (AI) and machine learning (ML) applications – are pushing radar and electronic warfare (EW) developers to seek new ways to deliver multifunction systems that also meet strict size, weight, and power (SWaP) requirements.

Radar and electronic warfare (EW) developers are leveraging high-speed signal-processing devices such as field-programmable gate arrays (FPGAs) and general-purpose graphics processing units (GPGPUs) to meet the U.S. military's insatiable desire for data. Meanwhile artificial intelligence (AI), neural networks, and machine learning (ML) concepts are more and more being embraced in EW and radar applications to ensure the U.S. maintains that tactical edge over its adversaries for years and decades to come.

"Since the enemy will pursue similar strategies and weapons, the challenge is to keep outperforming them with better technology and methods," says Rodger Hosking, vice president and cofounder at Pentek, Inc. [Upper Saddle River, New Jersey].

To stay ahead, the defense industry is working at addressing the technical challenges it faces. "Said simply, it is 'big data,' says Chris Rappa, product line director for Radio Frequency, Electronic Warfare and Advanced Electronics within BAE Systems FAST Labs [Arlington, Virginia]. "EW and radar systems throw away loads of data that could be useful. It is all about power. We are getting smart on how to optimize power modes to handle these gigantic increases in data, but the challenges on how to process more and more data are not going to be solved over the next three years."

Addressing these data pain points means getting down to the nitty-gritty of radar and EW systems. And, "One of the greatest challenges will be in the exponential increase in sensor data," says Tammy Carter, senior product manager for OpenHPEC products for Curtiss-Wright Defense Solutions [Ashburn, Virginia]. "This will drive the need for even faster backplanes, memory/data management, and the associated challenges of reliability. This in turn will drive the need for faster and larger data recorders with



more focus on security. The development cycle of these new systems will require more analysts and data scientists to design and verify the new algorithms."

Staying ahead of adversaries and getting past technical challenges also means upgrading and taking into account obsolescence issues, Noah Donaldson, chief technology officer at Annapolis Micro Systems, explains. "How do customers upgrade to the latest technology quickly? Traditionally, it has taken five to 10 years to upgrade a platform, but that is too long. That's where commonality and open standards come into play. We work closely with SOSA [Sensor Open Systems Architecture consortium] and VITA [standards organization] to develop modular open architecture products that have standardized hardware profiles. As an example, our WILDSTAR 6XB2 6U Board was developed in alignment with SOSA and VITA standards." (Figure 1).

Industry players have begun to collaborate to support the advancement of radar/EW systems, says Roy Keeler, senior product and business development manager, Aerospace and Defense, at ADLINK Technology [Washington D.C.]. Keeler says,

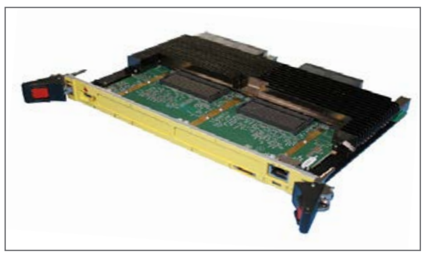


Figure 1 | WILDSTAR 6XB2 6U board. Photo courtesy of Annapolis Micro Systems.

"You're seeing partnerships in industry at the chip-level manufacturing, at the manufacturing level for chips and for systems that will enable us to overcome some of the technical challenges that we're facing.

What tech is necessary and what isn't?

"The military is now starting to question why we need dedicated pieces of hardware that just do one job in particular," Keeler says. "For that reason, the trend in signal-processing designs for radar and EW systems is leading towards more configurable-type of systems where for example, the end user can utilize a radar as an EW receiver or transceiver."

Requirements for power consumption, efficient data management, and limited space are playing a role in designing these systems. Essentially, some U.S. Department of Defense (DoD) requirements include the addition of "higher-density solutions to support multielement antenna arrays, where each element requires a separate signal processing channel for phased array beam steering," Hosking says. "Each element may require both receive and transmit functions to support radar and EW countermeasures applications. While size and weight of the electronics for each channel are important, so are power requirements and cost per channel."

Figure 2 | Abaco VP430 Direct RF processing system. Photo courtesy of Abaco Systems.

In addition, users want "to install these functions as close to the antenna as possible to minimize cabling that imposes performance penalties due to signal loss and interference," Hosking continues. "By incorporating RF circuitry, data conversion, and DSP [digital signal processing] functions in a housing near the antenna, wideband digitized signals can be delivered through optical cables, maintaining optimum signal fidelity."

There is a definite need to readjust components in order to have a cognitive radar or EW system on the field. "We're also seeing requests for moving general processing to the ARM cores on many FPGA SoCs [field-programmable gate array system-on-chip], pulling out the SBC [single-board computer] and handling general processing elsewhere in the system via a networked processor," says Peter Thompson, vice president, product management, at Abaco Systems [Huntsville, Alabama]. "Abaco's VP430 Direct RF [radio-frequency] Processing System is a 3U VPX COTS [commercial off-the-shelf] solution that leverages the Xilinx ZU27DR RF system-on-chip (RFSoC) technology," Thompson says (Figure 2).

SWaP and multifunction systems

SWaP requirements are pushing designers to the max, with users desiring "more capability at a lower cost in shrinking form factors," Rappa explains. "Increases in bandwidth and data rates with lower latency continue to be recurring themes. Lower size, weight, power, and cost desires drive the industry towards multifunction systems, where radar, EW, and other functions need to be combined with minimal performance sacrifice."

The market has been using GPGPUs and FPGAs to make all these demands a reality: "I am seeing increased interest in using GPGPUs and direct transfer of data from the FPGA to the GPGPUs using GPUDirect to reduce latency," Carter says. "More systems will have GPGPUs because of their power efficiency and the possibility for reduced SWaP because of the better throughput. For example, a 6U OpenVPX chassis with five server-class Xeon boards and a switch card yields around 5.6 TFLOPS for approximately 1000 watts. In comparison, a 6U OpenVPX single Xeon server-class CPU card paired with two OpenVPX dual NVIDIA Pascal P5000 GPGPU boards pumps out over 13 TLFOPS for around 550 watts."

Convergence of systems

Without a doubt, "the military has turned the heat up on these trends to converge systems that utilize RF such as radar and electronic warfare into one," says David Jedynak, chief technology officer at Curtiss-Wright [Austin, Texas]. "The military is looking to converge signal-processing tech that does multiple things into one system. From a bird's-eye view that sounds really easy. However, from a technical level, that proves to be a challenge."

From a technical perspective, "Combining these capabilities requires smart techniques," Rappa says. "Adaptive, adaptable, or cognitive capabilities can adjust the function according to the mission demands, potentially reducing the computational requirements to do everything at once."

Enter AI and ML …

Data and the role of AI, ML tech

The ripple effect of the AI push is resulting in adaptive cognitive radar and EW systems. When it comes to the big data challenge, AI may have the answer.

"The end-all goal for electronic warfare is to realize the concept of cognitive EW," Jedynak explains. "The question is: How does artificial intelligence enable signal processing? Artificial intelligence and machine learning techniques are helping to automate tasks to ease the end user's workload."

"WHAT WE'RE TRYING TO DO AND WHAT THE INDUSTRY IS TRYING TO DO IS SEE THROUGH THE NOISE, SEE THROUGH THE CLUTTER IN A VERY CONGESTED ELECTROMAGNETIC ENVIRONMENT. WHAT AI WILL ENABLE IS TO PREPROCESS DATA BY USING MACHINE LEARNING TECHNIQUES TO LEARN THE ENVIRONMENT, THEN MAKE DECISIONS FROM THE SENSOR-COLLECTED DATA."

– ROY KEELER, ADLINK

"What we're trying to do and what the industry is trying to do is see through the noise, see through the clutter in a very congested electromagnetic environment," Keeler adds. "What AI will enable is to preprocess data by using machine learning techniques to learn the environment, then make decisions from the sensor-collected data.

"This way, gobs of data are not being sent back to be filtered in the rear echelons," Keeler continues. "Artificial intelligence will put more intelligence at the edge, at the forward edge of the battle area, and allow the sensors to filter through all of that noise and unwanted data. Specifically, the user community would like to employ AI to reduce that sensor-to-shooter timeframe. AI will enable that by allowing preprocessing to take place."

Yet engineers still face a challenge even when putting AI into radar and EW systems. Processing demands will continue and "there are always processing constraints," Rappa adds.

"Classically, heavy filtering has been used to reduce the processing demands," he continues. "Filtering, unfortunately, destroys features that AI might use to make better decisions. Therefore, any capability that reduces the necessity to filter becomes an enabler for artificial intelligence, and power efficiency is a big driver. The adjacency of processing with data needs to be prioritized as data transport has a huge power cost. Improvements in the power added efficiency of the front end are mandatory. We have prioritized investment in more efficient front-ends with capabilities like short gate GaN-on-SiC (gallium nitride on silicon carbide) and have a qualified 6-inch GaN-on-SiC foundry. Computation in memory enabling minimal data transport is also technology that we are very interested in adopting to enable AI."

To continue enabling all these technologies, "BAE Systems signed a cooperative agreement with AFRL to transition their short gate GaN technology to our foundry," Rappa adds. When it comes to the power needs, "This technology has significant improvements in power-added efficiency over the current state of the art."

For radar and EW systems, "the most important factor in artificial intelligence signal processing is high bandwidth," Donaldson says. There is a market for systems that require a high volume of data coming in, so much so that "there are new processors coming out that are focused solely on AI."

With so much investment going into AI, "The idea is to teach and train these systems to automate more tasks," Jedynak says. "With cognitive EW, if we've got the right silicate on platforms, which is suited for machine learning approaches – also meaning deep neural networks, convolutional neural networks, and LSTM [long-short-term memory]-type systems – with the right foundation on the platform, we can start enabling more of these capabilities."

"The increase in available memory on the processor, communication bandwidth for passing data, and overall throughput in embedded signal processing systems enable artificial intelligence for radar and EW applications," Carter says. "A deep learning reference optimizer and run-time, NVIDIA's TensorRT, can help radar and EW applications achieve low latency and higher throughput."

Power also needs to be addressed when incorporating AI or neural networks in radar and EW systems: "What it takes to train a neural network is not the same as what it takes to run it," Jedynak explains. "It takes a lot of horsepower to train a neural network and a lot of effort needs to go into it. However, once you have a trained network it can run at a much more modest hardware."

Therefore, emphasis is being placed on the software side of developing radar and EW systems, says Keeler. "When you look at, for instance, NVIDIA and their frameworks for their software, when they first started releasing this in 2015, they had approximately 400,000 downloads. Then, in 2016, that jumped to two million downloads. Then, last year, they had over eight million downloads of their frameworks that deal with artificial intelligence. It's just starting to ramp up. It's just starting to gain traction in the industry. AI will really have an impact on EW and radar applications in the future."

Ramping up AI and ML for military

A glimpse of what AI will be able to do for the military: "The long-term results, if we look at commercial areas that are applying AI and machine learning in systems, such as what DeepMind is doing with AlphaGo and now AlphaGo Zero, these are now teaching themselves how to play games all alone without any other direction," Jedynak says. "That gives you an idea of where the technology is heading." **MES**

Engineering integrity into critical data-rate connectivity

By Gregory Powers

Think about the anxious feeling you get when you're doing a presentation for an important audience and your laptop freezes. Now imagine you're a pilot flying above contested territory and relying upon cutting-edge defensive systems to protect your mission, your team, and yourself. Which are the most important components of the system – the sensors, the processors, the displays, or the network of cabling connecting everything? As you peer down upon a missile plume, clearly the answer is all of the above.

Mission critical

The reality is that we have become highly dependent upon seamless datacom technology to the extent that we trust it to safeguard missions and lives. This trust is not a bad thing, and in a world of emerging threats, it is indeed a necessity. However, as high-tech systems are deployed and continue to evolve, engineering integrity into every link of the system – including the vital cables connecting embedded electronics – is essential. A lack of signal integrity, often brought about by compromised mechanical integrity through poor installation or post-installation damage, can bring even the most sophisticated system to its knees.

Applications, trends, and economics

As system capabilities grow, data rates are climbing and system density is increasing. Sensor count in both manned and unmanned systems is growing dramatically. Some of this increase is due to the megatrends of automation and electrification, both of which involve the replacement of reliable but heavy mechanical systems with electric alternatives. Some of the mounting number can be ascribed to more sophisticated and higher-resolution sensor systems for situational awareness, including things like persistent wide-area surveillance, which deploys large arrays of sensors. In most cases, any single sensor does not carry overwhelming data requirements, but significant bandwidth and packaging challenges can arise when you aggregate 16, 32, or 96 sensors.

For the designer, the necessity to reduce size, weight, and power (SWaP) remains a primary task. The end user needs that next-generation sensor, but they also need their vehicle to have the same range of operation, be the same size, or still be stealthy, plus it needs to hit the price point. In this context, system value is a significant differentiator. The customer will definitely want to avoid paying 96 times more for the latest array of 96 sensors. The expectation: The system must meet the program's key metrics and attain higher system functionality with each new generation, thereby maximizing the system functionality-to-cost ratio.

Nice system … will it work and if so for how long?

The situation: Your chief architect has designed the next-generation sensor-intensive system that will take your customer and your company into a new era. Will it work

after it's installed and then for years in situ? Engineering electrical and mechanical reliability into extreme data connectivity is possible, but it is not easy, is not always effectively deployed and can be susceptible to hazards that can arise along the way. High-data-rate connectivity depends on optimized waveguides, which in turn depend upon a variety of material and mechanical attributes, no matter whether the cabling is copper- or fiber-optic based.

The minute a high-data-rate cable – even though designed and simulated to perfection on computer-aided design (CAD) stations – is produced, its ideal performance is under attack. Because no manufacturing process is perfect, material characteristics, geometries, and integration processes all take a toll on ultimate performance.

Integration of the high-data-rate cabling into its platform and application is a tricky area, one that can severely affect its ultimate performance. All kinds of issues during installation – such as outer-jacket damage due to cable-pulling abrasion, distorted geometries due to mounts, repeated flex, overly severe bend radii, and improper shield or conductor termination – can all negatively affect performance.

Damage while deployed – including chafing, pinching, environmental exposure, errant tool impacts, or other human-related damage – can all add up to a cable that superficially appears intact but fails to support intended design-performance levels.

Finally, if all of the technical challenges have been met, will the system support the various stakeholders' expectations relative to longevity and return on investments by being scalable and upgradable? Most defense agencies are putting forward program requirements mandating open architecture as a baseline for systems involving electronics and optics. This condition sets the stage for enhanced longevity and is usually fundamental to making the original business case. To ease the way, agencies are working hand-in-hand with the defense community and a variety of standards organizations to assure that high-performance open standards are in place as advanced architectures are conceived and deployed.

Good news comes in copper ...

The good news is that aerospace and defense engineers have learned how to ruggedize high-performance wire and cable as the infrastructure of open architecture. They have collaborated with multiple organizations in a broad ecosystem-wide initiative to standardize the most popular physical-layer configurations and are working to fill in missing links of the ever-evolving connectivity chain.

Today it's pretty common to see 1 gigabit Ethernet (GbE), in the form of a category 5e (Cat5e) or better cable, in defense and aerospace vehicles. Architects are now considering taking the next step in bandwidth, with many exploring and a few already deploying 10 GbE as system functionality, aggregation, and data-rate requirements continue to grow. The 10 GbE (Cat6a) copper solution – an example of which is detailed in Society of Aerospace Engineers (SAE) standard AS6070/5 & /6 – is an easy drop-in replacement for lower-performing varieties of 10 GbE, 1 GbE, and Cat5e. It is approximately the same size and (similar to the 1 GbE cable) has four twisted-pair conductors, but represents a large step forward in signal integrity and data rate. With advanced materials and dual-shielding strategy, this cable variety exists in open architecture form to transparently enable the migration of avionic and vetronic architectures from 1 GbE to 10 GbE. The future of copper continues to be bright, with parallel implementation of 10 GbE channels enabling configurations of 40 GbE, 100 GbE, and higher. (Figure 1.)

... and fiber

In box-to-box connectivity applications, many packaging engineers consider 10 GbE as the point to transition from copper-based cable to simplex fiber-optic. As copper functionality continues to be stretched, this is prime trade study territory. Although cost is always a consideration, there are also several performance advantages of fiber that make it very attractive as the ultimate solution: nearly unlimited bandwidth, electromagnetic interference (EMI) immunity, minimala SWaP, and the high availability of standard hardware enabling open architecture. However, some reluctance on the part of systems providers has hampered the deployment of fiber-optic cabling in mission-critical, adverse-environment applications. Thankfully, the latest generation of fiber-optic cabling has proven itself to be highly robust and is alleviating the concerns of the system designers.

A prime example of state-of-the-art simplex fiber-optic cabling finding its way into leading-edge platforms can be found in the standard ARINC 802-2. Supporting open architecture systems, ARINC 802-2 checks all of the boxes for adverse-environment suitability, including wide temperature range, corrosionresistant construction, incorporation of strength members, and in some varieties the incorporation of crush-resistant features to assure resilience and operational readiness. As a result, mission and flight-critical applications are able to confidently play the fiber-optic card when needed. (Figure 2.)

Rugged, fast, and ready

Challenges remain for packaging engineers, but highly reliable, extreme-data-rate connectivity is a reality. Cables used in these applications must be designed properly, installed properly, ideally tested after installation, and be treated as sensitive wave guides throughout their intended life cycle. As with the latest generation of embedded electronics, operators and technicians must be trained on the sensitivity of the cables, in order to recognize any damage and call out suspect areas in advance, but today's high-performance copper- and fiber-based cables have the engineered integrity to enable extreme connectivity in extreme applications. **MES**

__Gregory Powers__ is the Global Market Leader, Aerospace & Defense, for W. L. Gore & Associates. Greg has spent the majority of his 33 years in industry focused upon aerospace and defense connectivity and packaging, starting his career as an advanced development engineer in electro-optics at AMP Inc. then progressing through a variety of technical and technical marketing positions at TE Connectivity, Crane Aerospace, and now W.L. Gore & Associates. Mr. Powers received a Bachelor of Science degree in engineering from Syracuse University, has completed numerous graduate-level studies, and holds two patents relative to optic datacom devices.

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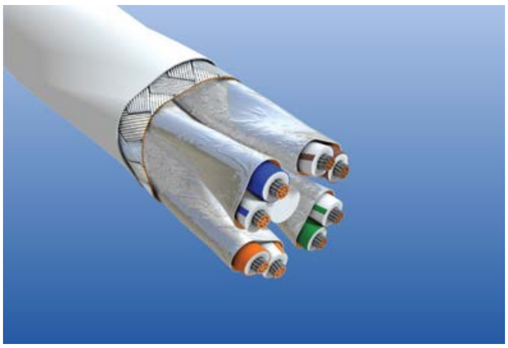
Category 6a Ethernet Cable

Features & Benefits

- Ideal for rugged avionic & vetronic architectures
- High Performance Dielectric for Enhanced Signal Integrity, Mechanical Integrity and Minimum SWaP
- Dual Shielding for Optimum Signal Integrity and Installed Performance
- Small Diameter Allows for Easier Installation and Tighter Bend Radii



Specifications

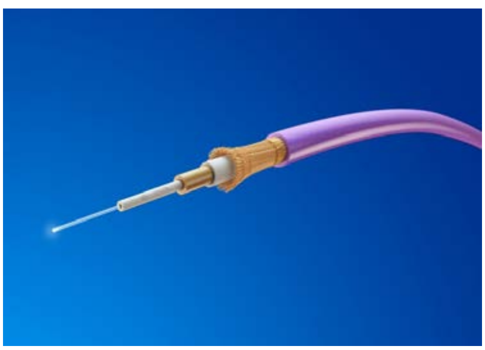
- Open Architecture per SAE AS6070/5 & /6
- 100 +/- 10 Ohm
- 24 & 26 AWG Configurations
- 1/10 GbE Compatible
- Cross Talk Performance Surpassing TIA 568 C.2 Cat6A
- Temperature Range -65 to +200C

Figure 1 | Category 6A Ethernet cables.

1.8 mm Simplex Fiber Optic Cable

Features & Benefits

- Flight qualified design ideal for rugged avionic & vetronic architectures
- Dual buffer allows fiber to float alleviating mechanical or environmental stress
- PEEK secondary layer provides crush resistance & reinforces fiber in bending
- Aramid strength members to protect fiber under tension
- Robust PFA outer jacket for abrasion resistance and environmental protection



Specifications

- Open Architecture per ARINC 802-2
- EN4641-301 Compliant
- 1.8 mm outer diameter
- Selection of OM ratings and core/clad ratios
- 250 um primary buffer
- Temperature Range -65 to +135 C

Figure 2 | 1.8 mm simplex fiber-optic cable.

Radar and electronic warfare system modeling

By Honglei Chen, Rob Graessle, and Rick Gentile

Active electronically steered phased array (AESA) systems provide the technology platform for multifunction radio-frequency (RF) systems. Today's systems can include a combination of radar, electronic warfare (EW), and communications functionality within the same physical system using a common antenna array front end. To reduce the risk of system errors and overcome challenging interference sources, system modeling techniques can be used to design a system before any equipment is developed. These techniques can also be used for analysis during the up-front requirements phase of a program. The same types of systems can also be used to model an adversary's system capability.

Let's examine models for simulating an EW and radar scenario. To build the scenario model, we start with the phased-array antenna design and show some of the parameters in the system model that can be updated on a pulse-by-pulse basis, including waveform selection, frequency agility, and pulse repetition frequency (PRF). With a phased-array front end, beamforming and direction-of-arrival (DOA) estimation can be used to improve operations in an interference-rich environment. The ability to change key system parameters enables a dynamic, closed-loop model between detections and scheduling.

AESA systems offer system-level flexibility

AESA systems provide spatial information in the field of view without physically moving the antenna. By electronically steering beams, system-level flexibility is possible on a pulse-by-pulse basis. Mode and beam patterns can be changed much more quickly than with mechanically steered arrays. In addition, beam-pattern flexibility is greatly enhanced by applying digital and RF weighting to control where the system looks and listens. System resources in a multifunction system can be used to transmit and receive radar and communications signals, while other processing intervals can be dedicated to listen for emissions from other sources.

Modeled using MATLAB and Simulink, the examples described below are based on a monostatic X-band radar system. The radar receiver for this system can also function as an EW receiver. The RF front end is designed as a 64-element (8 x 8) phased array. Antenna elements designed specifically for EW applications can also be used within the antenna array to improve the model fidelity. Users will be able to see the 3D directivity pattern for an individual element designed using a cavity-backed spiral, an antenna element that is commonly used in EW applications for improved direction-of-arrival performance.

With a two-dimensional array, spatial signal processing algorithms including direction-of-arrival and beamforming can be implemented without having to mechanically steer the physical array.

Multifunction system parameters: Frequency, waveform, and PRF

Radar and EW systems that perform multiple functions require flexibility in waveform generation and processing, frequency of operation, and pulse repetition

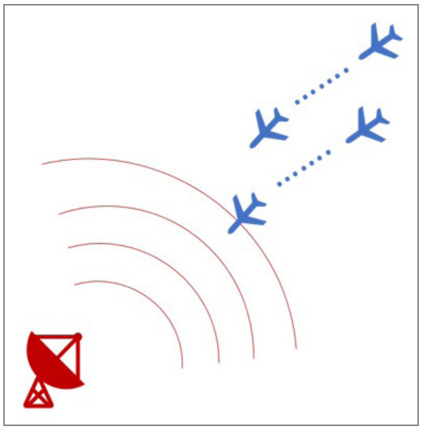


Figure 1 | Scenario with two aircraft approaching a surveillance radar. Image: The MathWorks.

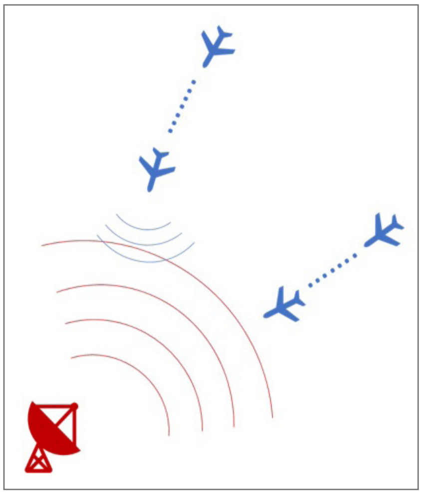


Figure 2 | Scenario with two aircraft approaching surveillance radar separated in angle. Image: The MathWorks.

frequency. Figure 1 illustrates two aircraft approaching a radar, in which the aircraft are located at different distances. Waveforms and PRFs are selected based on what the radar or EW sensor detects.

A user can plot two targets covered by radar. During this time, the targets are far away from the system, so a search waveform at a lower PRF is used. In this case, free system resources can be allocated to other tasks such as searching additional sectors. As the closer target continues its approach, a threshold is crossed (we'll say 2 km), and the waveform selection shifts to a track waveform at a much higher PRF. Less energy is available to be used on the target further away, as well as for other functions.

In addition to system parameters, multifunction systems also switch between modes and operational mission types. The next example includes both radar and EW operations.

Intelligent nulling to remove interference sources

In Figure 1, the two aircraft approaching the radar are targets that appear as detections to the radar. When a radar system is monitoring a region of airspace, and the jammer and target are not located within a receive beam, the AESA beam steering capabilities can be used to resolve targets in range and angle. In the scene shown in Figure 2, the target and jammer are separated by many beam-width multiples.

Here, the fixed-location monostatic radar can detect and track the target aircraft. Now the second aircraft enters the field of view and generates an interference signal that will confuse the radar. The radar can use some of its processing intervals to listen to the RF environment. As part of this operation, the interference source can be detected. In

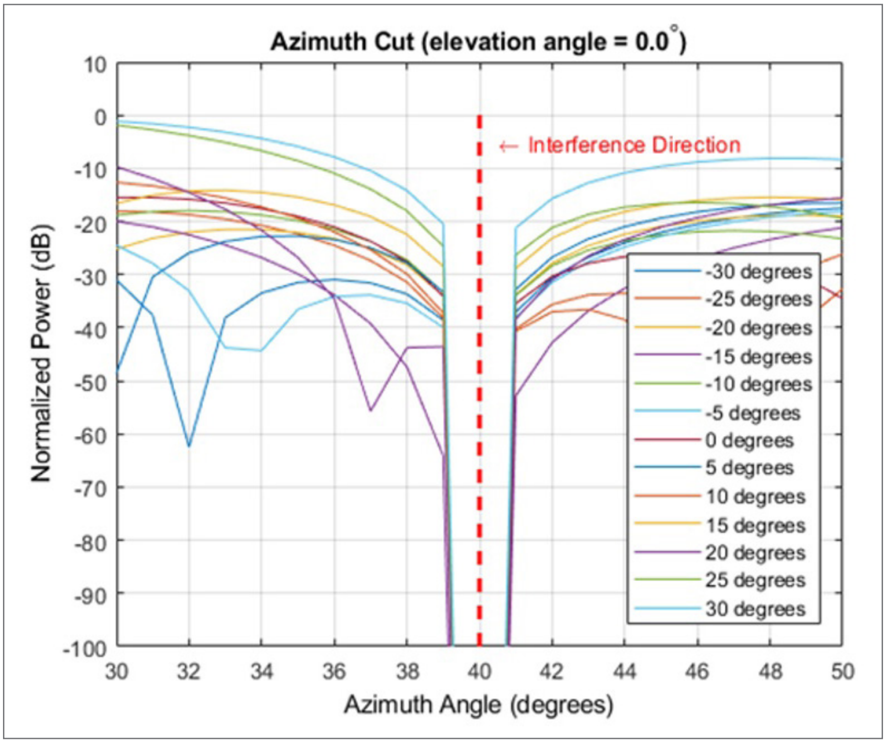


Figure 3 | Null added in beam pattern to remove interference source. Image: The MathWorks.

addition to detection, the phased-array channels can be used to determine an angle in both azimuth and elevation for where the jammer is located.

This information can be used to generate a beam pattern that ensures a null is placed in the same direction of the interference source (40 degrees off the radar boresight in this example). This pattern serves the following two purposes: First, to reduce the effects of the jammer; and second, to strengthen the return of the desired signal coming from the original target. Figure 3 shows the resulting nulling pattern that can be used to reduce the effect of the jammer.

Frequency agility techniques to remove interference

In cases where the jammer and target aircraft are very close to each other in the radar field of view, it may not be possible to eliminate the interface source without also eliminating the desired target. A simple scenario is shown in Figure 4.

For this case, frequency agility techniques enable the radar to avoid the interference generated by a jammer. Figure 5 shows a system model in which jammer interference can be enabled or disabled. The waveform generation can be operated on multiple bands to simulate frequency-hopping.

In this example, the target can determine the signal characteristics transmitted from the radar. The target aircraft can use this information to generate its own transmit pulse with the intent to confuse the radar receiver. That is, the target generates a jamming signal using the same signal characteristics to make it appear to the radar that there are multiple targets.

In Figure 6, note that at baseband, we start with a single target (left-most plot). When the jammer sends its signal, we see multiple targets (middle plot). For both cases, band 2 does not contain any detected signals.

As frequency-hopping is applied, we see in the right plot of Figure 6 how the interference and radar signals show up in different bands. This example can also be extended

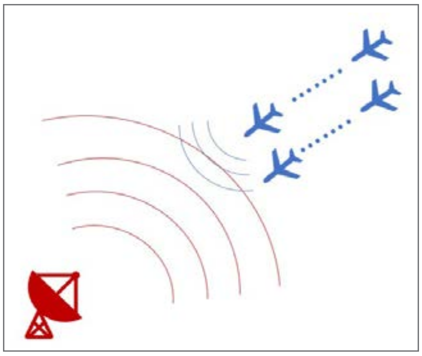


Figure 4 | Scenario with two aircraft located close to each other approaching surveillance radar. Image: The MathWorks.

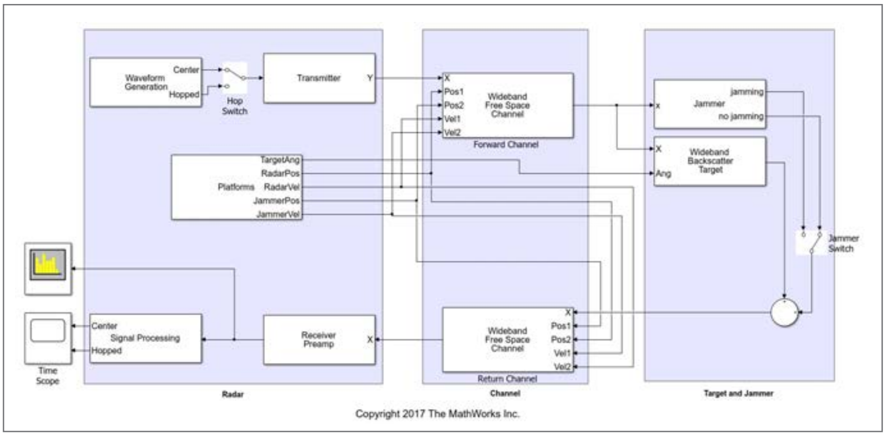


Figure 5 | Radar and EW system model. Image: The MathWorks.

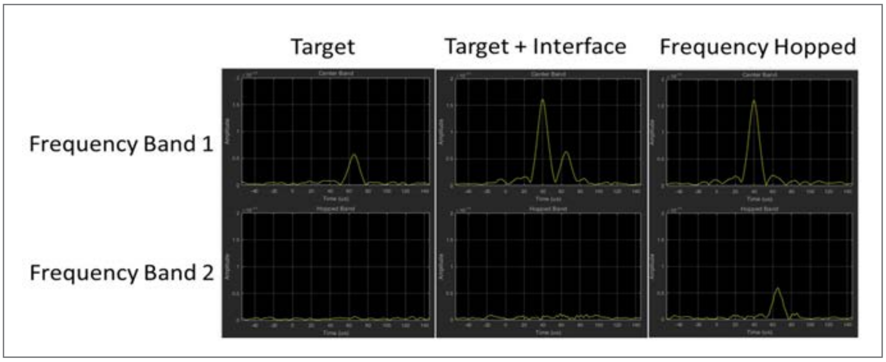


Figure 6 | Plots of processed results for system scenario. Image: The MathWorks.

to a much more complicated frequency-hopping scheme.

Building flexible models

Multifunction systems used for radar, EW, and communications are very complex: System parameters change on the fly and modes change on a pulse basis. Signal-processing and scheduling systems work in a closed loop, in which it is easy to make design errors. Models can be built to represent scenarios of a range of complexity; these models reduce risk, prove out difficult concepts, and improve all phases of the acquisition and development cycle. **MES**

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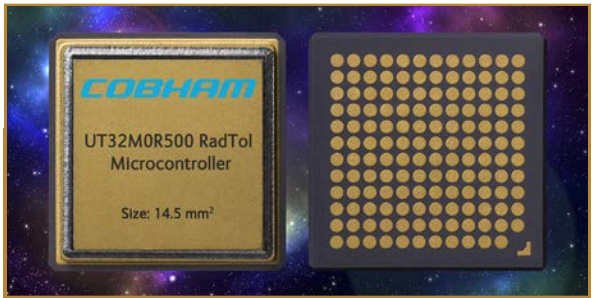
MathWorks • www.mathworks.com



Microcontroller for SpaceVPX, RF signal chain management

The UT32M0R500 microcontroller from Cobham uses the Arm Cortex-M0+ 32-bit processor with a RISC [reduced instruction set computer]-based architecture operating at a 50 MHz frequency. The microcontroller is aimed at applications such as SpaceVPX chassis management, telemetry, distributed command and control, data acquisition, and radio frequency (RF) signal chain management.

The microcontroller includes a memory protection unit (MPU) and embedded memories, with several peripherals including support for CAN 2.0B. For increased design flexibility, the microcontroller includes several analog features such as an analog signal channel with a multiplexed input combined with a programmable gain amplifier and analog-to-digital converter, two digital-to-analog converters, two analog comparators, and precision current source. The UT32M0R500 incorporates power-saving modes to facilitate the design-in of low-power applications. The UT32M0R500 is also supported by the Keil Development Tool Environment.

Cobham | www.cobham.com

Rugged high-speed optical FMC boards work in harsh environments

TECHWAY's Wildcat FMC optical boards extend the modularity of an FPGA (field-programmable gate array) board with onboard mezzanine VITA 57 site by also placing a plug-in and turnkey multichannel optical interface. The addition enables the FPGA board to reach high-speed I/O for applications calling for massive data transfer without needing an expensive redesign.

The board comprises a Radiall 10+ G range D-Lightsys optical transceiver running up to 12 Gbps, in an FMC standard form factor. When air-cooled, it has a temperature range of -20 °C to +70 °C and features an MTP connector. When conduction-cooled, it has a temperature range of -40 °C to +85 °C and has a C-MTITAN connector. The WildcatFMC is aimed at users in harsh defense environments. The TECHWAY board is now being distributed by Radiall, a French company that designs, develops, and manufactures connectors and associated components for use in electronic applications.

Techway | www.techway.fr • Radiall | www.radiall.com

Network encryptor to improve performance over high latency links

The Viasat KG-250X is a rugged, Type 1 Inline Network Encryptor (INE) certified by the National Security Agency to deliver high-speed High Assurance Internet Protocol Encryptor (HAIPE) IP network encryption to tactical and mobile users for applications such as airborne missions. Viasat intends the KG-250X to provide advanced network security past the HAIPE standard requirements. The Viasat KG-250X fits into a rucksack or three-wide in a 1U rack, enabling trusted communications for high-bandwidth TS/SCI-and-below missions.

Features also include the capability to remotely rekey a network of HAIPE devices from a physically secure location with HAIPE-to-HAIPE over-the-air/net keying. The system is also designed to improve performance over high-latency links with embedded TCP/IP [transmission control protocol/Internet protocol] acceleration. Additionally, users can attach a remote front panel to interface with the Viasat KG-250X, via cable, providing control access even if the stowed crypto is not physically within reach.

Viasat | www.viasat.com

Ruggedized RPC24 storage array

Phoenix International's RPC24 is a rugged high-performance Fibre/SAS [Serial-attached SCSI]/iSCSI [internet small computer dystems interface] host channel, SAS solid-state/hard disk drive RAID [redundant array of independent disks] storage array that delivers a level of operational environmental capability not previously available in commercial off-the-shelf (COTS) data storage systems.

The design of the RPC24's rugged, cableless, passive midplane-based high-density 2U chassis provides large storage capacity, a high level of data availability, redundant hot-swap components, and a large environmental operational envelope. The system features single- or dual-active redundant RAID controllers and comes MIL-STD-810G and MIL-STD-461E certified. Designers made the array TCG-compliant and equipped with FIPS 140-2 certified encryption. Other features include battery-free cache backup, enclosed and electrically isolated drive magazines, and operation at altitudes up to 45,000 feet in operational temperatures between 0° to 70° C with rates that range up to 6400 MB/s and 5300 MB/s, respectively.

Phoenix International | www.phenxint.com

Ruggedized SDRs designed to meet MIL-STD-810, 461

The RX310 software-defined radio (SDR) from Pixus Technologies is a ruggedized version of a small-form-factor SDR – using the USRP SDR from Ettus Research – that is aimed at use in airborne, shipboard, ground vehicle, or outdoor applications. The RX310's enclosure and seal is IP67-rated for protection from water and dust ingress. The enclosure also meets MIL-STD-810 certification for shock and vibration resistance and MIL-STD-461 for electromagnetic interference resistance.

The ruggedized SDR has two extended-bandwidth daughterboard slots covering 10 MHz to 6 GHz with as much as 160 MHz of baseband bandwidth, carries dual 1/10 GigE high-speed interfaces, and features a user-programmable Kintex-7 field-programmable gate array (FPGA). The smaller form factor – 302 mm wide by 400 mm long by 98 mm tall – means that it can be mounted for SIG-INT, passive radar, and spectrum monitoring tasks.

Pixus Technologies | www.pixustechnologies.com

VCOs cover frequency ranges between 10 MHz to 11 GHz

Pasternack's line of voltage-controlled oscillators (VCOs) can vary the frequency of the output signal by adjusting the amplitude of the input tuning voltage. The VCOs cover select bands from 10 MHz to 11 GHz in a variety of package options. VCOs have a range of frequencies, and are most commonly deployed in applications such as phase-locked loops, frequency synthesizers, electronic jamming equipment, and function generators.

Some of the models have added features which include integrated buffer amplifiers and input modulation ports. Tuning voltages can range from 0 to 20 volts, with output power ranges from 0 to +12.5 dBm, and all models have an operational temperature range covering -40 °C to +85 °C. These VCOs also boast phase noise performance as low as -125 dBc/Hz at 10 KHz offset. All designs meet a series of MIL-STD-202 environmental test conditions, which include shock, vibration, and temperature cycle.

Pasternack | www.pasternack.com

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GIVING BACK

Fairways for Freedom

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

This issue we are highlighting Fairways for Freedom, a 501 (c)(3) organization that strives to help combat-injured U.S. armed services veterans assimilate back into society through holistic initiatives and through the game of golf. Playing in a peaceful and welcoming environment such as Ireland and Scotland, and continually aiming to improve at a physically and mentally challenging game, provides a positive experience and helps as they overcome their injuries, say organization officials.

Fairways for Freedom was cofounded by Roger Schiffman, who was the managing editor of Golf Digest from 1984 to 2013; and his spouse Dr. Patricia Donnelly, a sport psychotherapist, yoga therapist, and performance coach.

Many U.S. veterans struggle with physical disabilities, including loss of limbs, and with mental-health issues such as post-traumatic stress disorder (PTSD) and traumatic brain injury (TBI). The Fairways for Freedom program, according to organization materials, provides combat-injured veterans with instruction and practice in evidence-informed, clinically tested, self-regulation techniques; opportunities for therapeutic, recreational, and community-building social activities; training on healthy lifestyle choices; and education about community-based resources for post-retreat reintegration.

An additional goal is to connect leaders in the business community (which the organization calls Ambassador/Donors) with combat-injured veterans through the game of golf. Business professionals serve as both sponsors and mentors to the veterans. In turn, say organization officials, the business leaders learn the true meaning of sacrifice.

For more information on Fairways for Freedom, please visit www.fairwaysforfreedom.us.

WEBCAST

Meeting Military Data Signal Analysis Imperatives

By ADLINK and LCR Embedded Systems

Victory in 21st-century electronic warfare demands the ability to aggregate massive amounts of data and process those streams into insightful, actionable outcomes. Modern data processing can distinguish between noise and a viable target; the speed of that processing can mean the difference between real-time intelligence and missed opportunities in battle.

This webcast will discuss the challenges inherent in military signal processing. It will also cover relevant modern radar, sonar, and image-processing solutions for military data signal-processing demands.

View archived webcast:
http://ecast.opensystemsmedia.com/832

View more webcasts:
http://opensystemsmedia.com/events/e-cast/schedule

WHITE PAPER

4 Game-Changing Underlying Technologies for Advanced Radar

By National Instruments

The evolution of the electromagnetic spectrum – an increasingly contentious warfare domain – presents new challenges for scientists and engineers who are designing intelligence, surveillance, and reconnaissance (ISR) systems. Engineers are asked to develop increasingly complex systems using ever more cost- and time-effective methods.

Yet the underlying technologies that enable these sophisticated systems are also evolving to meet these challenges. Four recent innovations will have the biggest enabling impact on radar technology over the next several years: Gallium nitride for front-end components, high-speed data converters for transmit and receive, evolving FPGA technology for cognitive techniques, and high-bandwidth data buses for sensor fusion.

Read the white paper: https://bit.ly/2GkZOJZ

Read more white papers:
http://mil-embedded.com/white-papers/

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