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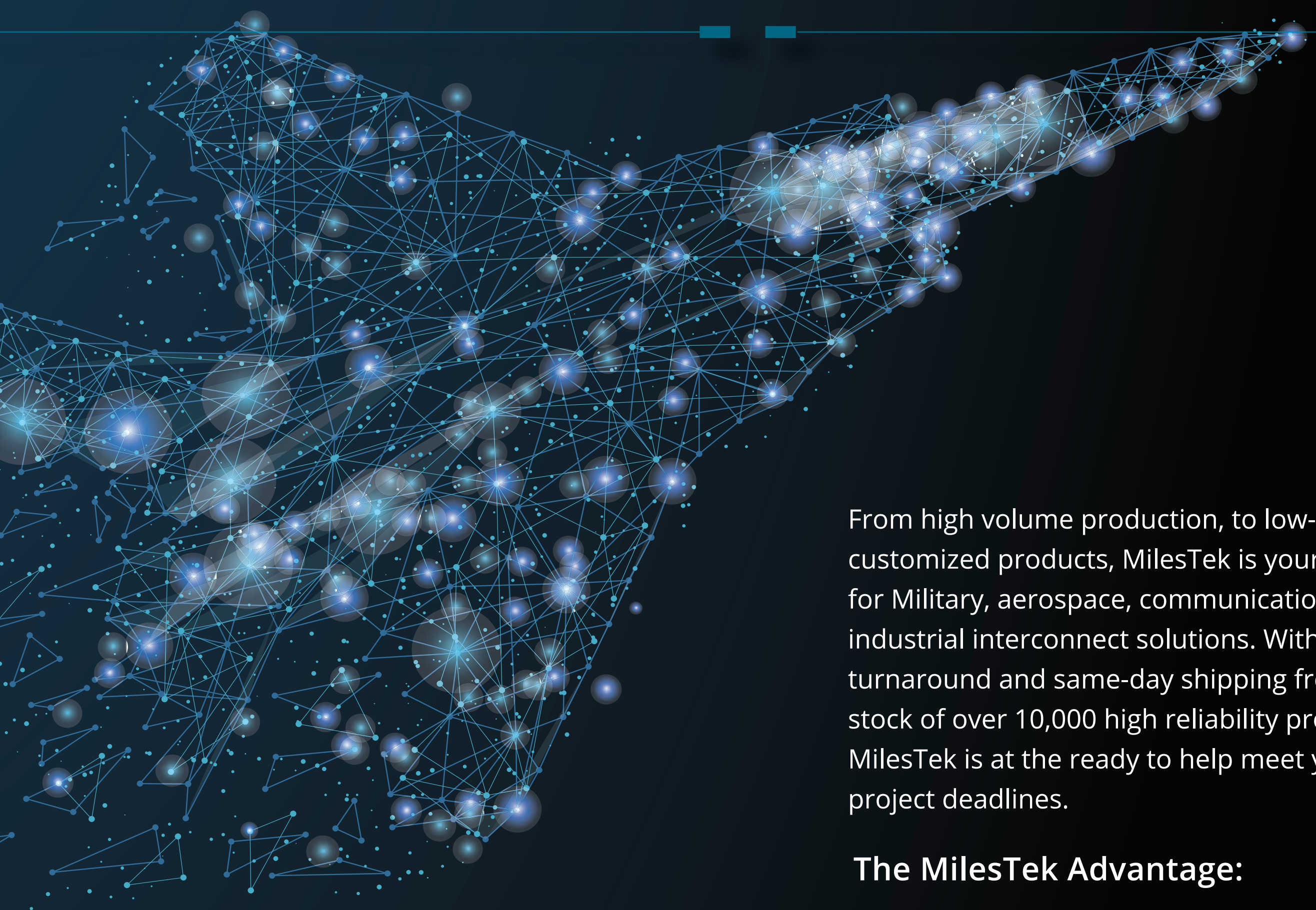

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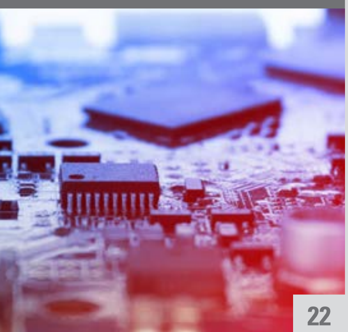

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ON THE COVER:

Top image: GaN tech is driving innovation in radar and EW systems. In the photo, two F-16 Fighting Falcons test APG-AESA radar as they fly over Edwards Air Force Base, California. Photo courtesy of the U.S. Air Force/Christopher Okula.

Bottom image: ISR sensor platforms like the U.S. Navy E-2C Hawkeye are requiring more and more signal-processing capability. This aircraft prepares to land on the flight deck of the Nimitz-class aircraft carrier USS John C. Stennis (CVN 74). (U.S. Navy photo by Mass Communication Specialist Seaman Angelina Grimsley/Released)


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Speeding innovative tech to the warfighter

By John McHale, Editorial Director

Whether it's referred to as speeding up the acquisition process, speeding up the bureaucracy, or eliminating red tape, it all comes down to the same point – the Department of Defense (DoD) needs to pick up the pace when it comes to getting technology innovation into the hands of warfighters.

Too often young sailors, Marines, soldiers, and airmen find that their families' cell phones have more tech than what they're issued prior to a mission.

About a decade ago I asked a friend, a retired Green Beret, if he had ever been to the Special Operations Forces International Conference (SOFIC), which I was attending at the time. I was curious about what he thought of the tech he may have seen there. He told me to have fun and enjoy the gadgets, but that he had never been to that show and that it would be rare if anything I saw there ever made it into the field and made it quickly.

The various services are aware of the glacial pace of tech adoption and have in recent years made inroads to get technology to the troops more quickly through various rapid acquisition programs dating back to the Obama administration.

Open architecture initiatives such as the Sensor Open Systems Architecture (SOSA) and the Future Airborne Capability Environment (FACE) are examples of not only the DoD partnering better with industry to drive innovation, but also a spirit of cooperation among the services – Army, Navy, Marine Corps, and Air Force – to work together so these initiatives can work across platforms and domains regardless of service. However, more still needs to be done.

What you see is a certain amount of inertia in acquisition policy," Ken Peterman, President of Viasat's Gover ment Systems division, told me in a Q & A earlier this year. (See: https://bit.ly/2Ocngfm] "For 50 to 60 years the government has been an inventor of technology. It doesn't know how to buy a turnkey service. Its model is based on breaking down an ecosystem into parts such as waveforms, modems, etc. This encourages long developmental cycles and higher costs. By leveraging commercial solutions, the government is able to do the opposite; because by purchasing a service the government can access a complete, functioning system all at the same time, with no risk and no delays.

"Our nation's warfighters deserve to have the best technology available when they deploy," he added. "Early adoption of these cutting-edge, commercially driven technologies can help solve warfighter problems now."

One way the services accomplish this is with demonstrations such as a U.S. Navy activity, titled Advanced Naval Technology Exercise (ANTX) 2018, Human Machine Interaction (HMI-18), held at the end of summer 2018 in Newport, Rhode Island. According to Navy officials at the ceremony, the Navy is seeking innovative solutions in areas such as hypersonic wepaons, directed energy, machine learning, quantum science, microelectronics, and more. The demonstration was preceded by the Defense Innovation Days conference/exhibition, run by the Southeastern New England Defense Industry Alliance (SENEDIA).

During the conference and ANTX opening ceremony, speakers and exhibitors from the Navy, MIT, the U.S. Small Business Administration, Northrop Grumman, Raytheon, Mercury Systems, TE Connectivity, Evans Capacitor, and more discussed how the DoD can speed technology to the warfighter.

According to the Navy, ANTX provides a low-risk environment in which scientists and engineers may evaluate their technological innovations at the research and development (R&D) level before they become operational. It also provides a feedback loop for the Navy requirements community and industry, academia, and Warfare Center R&D.

One way the DoD enables such tech innovation is through Other Transaction Authority (OTA) agreements. These arrangements are designed to get solutions to the warfighter as fast as possible, said Thomas Carroll, OTA Director, Naval Undersea Warfare Center Newport Division, during his presentation at the ANTX opening ceremony. OTAs also promote transparency and open cooperation between government and industry, he added.

Work at the ANTX demonstrations may also result in Cooperative Research and Development Agreements (CRADAs), which enable researchers to work with nonfederal partners.

During an industry panel, some leaders spoke bluntly, saying that although the demonstrations are nice, more needs to be done. Industry appreciates the opportunities enabled by events like ANTX, but "we'd like to see more money and more CRADAs come out of the demonstrations," said Thomas Reynolds, business development manager, defense, for Hydroid. He added that there is also value in telling engineers "no thanks," because it provides direction on what not to work on, so "we can spend our money more wisely."

Reynolds also called on the Navy to push for more common architectures and common interfaces, enabling more commonality, which would go a long way toward fulfilling the goals of technology demonstrations like this one.

Well said.

Foreshadow: Researchers discover another Intel processor vulnerability

By Sally Cole, Senior Editor

Two international teams of security researchers have independently and concurrently discovered "Foreshadow," a new variant of the hardware vulnerability known as "Meltdown" that was announced earlier this year. Meltdown can be exploited to bypass Intel processors' secure regions to access memory and data.

The Foreshadow vulnerability affects Intel's Software Guard Extension (SGX) technology, a feature in modern Intel CPUs that enables computers to protect users' data within a secure "fortress" even if the entire system falls under an attacker's control. Foreshadow is similar to Spectre and Meltdown, both hardware-based attacks that shook the computer security world in early 2018 when researchers were able to break several security features that are present in most Intel-based machines.

As a group effort, researchers from the University of Michigan, the Belgian research group imec-Distrinet, Technion Israel Institute of Technology, the University of Adelaide (Australia), and Data61 (Canberra, Australia) published a report (foreshadowattack.eu/foreshadow-NG.pdf) about the vulnerability, which causes the complete collapse of the SGX ecosystem and compromises users' data.

"SGX can be used by developers to enable secure browsing to protect fingerprints used in biometric authentication or to prevent content being downloaded from video streaming services," says Yuval Yarom of Commonwealth Scientific and Industrial Research Organisation (CSIRO)'s Data61 and the University of Adelaide's School of Computer Science. "Foreshadow compromises the confidentiality of the 'fortresses,' where this sensitive information is stored; once a single fortress is breached, the whole system becomes vulnerable."

Intel was alerted about the vulnerability earlier this year. The company's own investigation led it to discover a new variant of Foreshadow, called Foreshadow-NG, which affects nearly all Intel servers used in cloud computing. The NG type targets the Intel-based virtualization environments used by cloud computing giants Amazon and Microsoft to create thousands of virtual PCs on a single large server.

Foreshadow-NG essentially breaks the digital wall that keeps individual cloud customers' virtual PCs isolated from one another on large servers. This breakdown could enable a malicious virtual machine running in the cloud to read data belonging to other virtual machines, according to the researchers. The virtualization code is present in every Intel-based computer manufactured since 2008.

"Foreshadow-NG could break the fundamental security properties that many cloud-based services take for granted," says Baris Kasikci, a University of Michigan assistant professor of computer science and engineering.

Foreshadow-NG is theoretically capable of bypassing the earlier fixes for Meltdown and Spectre vulnerabilities, potentially re-exposing millions of computers across the globe to attacks.

Both variants of the vulnerability gain access to the victim's machine via a side channel attack. These attacks infer information about a system's inner workings by observing patterns in seemingly innocuous information – such as how long it takes the processor to access the machine's memory. This information can be used to gain access to the inner workings of the machine.

The attack then confuses the system's processor by exploiting a feature called speculative execution, which is used in all modern CPUs: It speeds processing by enabling the processor to essentially guess what it will be asked to do next and plan accordingly.

The attack feeds in false information that leads speculative execution into a series of wrong guesses. Akin to a driver following a faulty GPS, the processor becomes hopelessly lost. This confusion is then exploited to cause the victim's machine to leak sensitive information. In some cases, the researchers say that it can even alter information on the victim's machine.

While these vulnerabilities are caught before causing major damage, Ofir Weisse, a University of Michigan graduate student research assistant involved in the work, points out that such gaps expose the fragility of secure enclaves and virtualization technologies. He believes that the key to keeping technologies secure is to make designs open and accessible to researchers so that they can identify and repair vulnerabilities quickly.

"The SGX feature is widely used by developers and businesses globally, and this opens them up to a data breach that can potentially affect their customers as well," says Data61's Yarom. "Intel will need to revoke the encryption keys used for authentication in millions of computers worldwide to mitigate the impact of Foreshadow. Their discovery of the Foreshadow-NG variant is even more severe, but will require further research to gauge the full impact of the vulnerability."

Intel has since released software and microcode patches to protect against both varieties of attack. Cloud providers will need to install updates to guard their machines and, on an individual level, the owners of every SGX-capable Intel PC manufactured since 2016 will need an update to protect their SGX.

Researchers are now exploring whether similar flaws exist in other manufacturers' processors.

New rotorcraft designs, silent operations are key goals in Army, Uber partnership

By Mariana Iriarte, Technology Editor

Warfighters on missions and Uber passengers hitching rides will soon have something in common – both getting done thanks to what are essentially unmanned, flying cars. The U.S. Army Research Laboratory (ARL) and transportation company Uber are partnering to advance future vertical lift technologies to push forward the U.S. Army's modernization efforts.

Officials signed a cooperative research and development agreement (CRADA), which aims to bring into the field a quieter unmanned aircraft with a unique rotorcraft design that can carry higher payloads.

Both the warfighter and the everyday Uber customers will see advances in unmanned aerial vehicle (UAV) designs, say the partners; such collaborations can help to address tech gaps such as having a quieter UAV that can fly around neighborhoods, or a stealth UAV that can operate in threat environments where silence is a must.

"The research that we will collaborate on with Uber will actually deliver unprecedented capability for quieter rotor systems in a unique configuration," said Dr. Jaret Riddick, director of the U.S. Army Research Laboratory's Vehicle Technology Directorate (VTD), in an Army release.

The collaborative efforts made possible by CRADAs present the defense industry with an easy way to work with ARL, according to ARL documents. Funding of the first agreement will be equally shared by Uber and ARL.

This particular CRADA research effort also fulfills the needs of the U.S. Army's modernization efforts to "Build a More Lethal Force." Army documents state its intention to continue these types of partnerships, which it says will enhance both governmental and private efforts to build next-generation designs: "Future vertical lift will integrate situation awareness, supervised autonomy, advanced manned/unmanned teaming, and scalable and tailorable lethal/nonlethal fires and effects."

By working with Uber Elevate – an Uber business unit that aims to bring air taxis or uberAIR to the masses – ARL researchers will not only focus on reducing the noise of the aircraft, they will also work on rotorcraft designs that were previously developed with the University of Texas at Austin (UT Austin).

Plans are underway to test and analyze these designs and to uncover opportunities such as the one between Uber and UT Austin's stacked "co-rotating prop-rotor testing effort, which may lead to ground-breaking discoveries to support Army Modernization Priorities," Army officials state.

Figure 1 | Dr. Jaret Riddick, director of the U.S. Army Research Laboratory's Vehicle Technology Directorate, welcomes the audience at the ARL and Uber Elevate kickoff event held in August 2018 at the University of Texas at Austin. Photo courtesy of the University of Texas.

Uber is also partnering with LaunchPoint Technologies (Goleta, California), a technology company that focuses on developing novel electric motors. "LaunchPoint's design approach will lead to motors best suited to power eVTOL [electrical vertical takeoff and landing] technology with stacked co-rotating propellers," according to Army documents. "In the future, all three entities will exploit the experimental data and lessons learned from stacked co-rotating rotor testing. The result will be more predictive models and higher-performing next generation co-rotating propellers."

Army officials want UAV designs that are lighter but yet can carry larger payloads – all in a craft that needs no runway. Uber plans to launch uberAIR by 2023 in its initial U.S. Elevate cities: Dallas and Los Angeles.

The official kickoff of the Uber/ARL partnership was held in August 2018 at UT Austin.

The ARL/VTD's Dr. Riddick welcomed attendees at the UT event: "It is a confirmation that ARL is pushing forward the state of the art," Riddick said. "ARL and Uber Elevate subject-matter experts have met before at ARL at Aberdeen Proving Ground and at the Elevate Summit in ARL West, but this kickoff is a formal start to the relationship in ARL South that we hope will motivate multiple collaborations on technology of mutual interest that will benefit the future warfighter."

These government/private joint efforts are key for the development of new and innovative tools for the warfighter. "The greatest benefit [of this project] is collaboration with the ecosystem of industry and academic partners associated with Uber Elevate to accelerate development of Army-relevant technology; going from the discovery phase into the hands of the warfighter faster," Riddick added.

Milestone in abstracting the hardware: Realizing the promise of FACE

By Mark Grovak

An industry perspective from Curtiss-Wright Defense Solutions

The Future Airborne Capability Environment (FACE) Consortium, part of The Open Group, was formed to establish a standard common operating environment to support portable capability-based applications across Department of Defense (DoD) avionics systems. Key to the common operating environment envisioned by FACE is the definition of an interface for operating systems and board support packages (BSP) that enables the hardware portion of a system to be abstracted, greatly increasing the portability and reusability of software applications. With the wide adoption of FACE, system integrators can reap tremendous benefits in interoperability and cost.

The FACE Consortium is a government/industry partnership that manages technical standards and business strategies for acquisition of affordable software systems; it exists to promote innovation and rapid integration of portable capabilities across global defense programs. To be verified in accordance with the FACE Technical Standard and FACE Conformance Policy, software needs to be approved by an approved FACE Verification Authority. FACE conformance does not cover hardware, although hardware solutions can be designed to comply with FACE-approved software applications. U.S. Army Aviation, with thousands of helicopters to maintain and deploy, has been a leading advocate of the new standards, as has NAVAIR.

Figure 1 | The demo at the FACE TIM featured Harris's FliteScene Digital Moving Map software and Green Hills' INTEGRITY-178 tuMP real-time multicore OS running on Curtiss-Wright's Power Architecture-based VPX3-152 DO-254 safety certifiable SBC, and the Intel-based Parvus DuraCor 8042 mission computer.

The last few years have seen a number of vendors demonstrating FACE-approved software running on a wide range of open architecture hardware designed to be compliant with the FACE standards. To demonstrate the true promise of FACE, though, requires the same FACE-approved application simultaneously operating in systems that are running different processor architectures (i.e., Intel, Power, ARM, etc.). Such a demonstration would establish the true abstraction of the underlying hardware that the effort seeks.

Each year, the U.S. Army hosts the FACE Technical Interchange Meeting (TIM), enabling FACE Consortium members to demonstrate FACE-certified software products and products aligned to the FACE Technical Standard. The Army FACE TIM 2018 (held on September 18 in Huntsville, Alabama) allowed vendors to showcase their FACE efforts for the warfighter. While the FACE target audience is the Army community, other customer communities are also invited, and previous events have seen hundreds of Army, Navy, and Air Force attendees.

At this year's FACE TIM, Curtiss-Wright, Green Hills Software (GHS), and Harris Corp. publicly demonstrated what is believed to be the first working example of a FACE-conformant software application running simultaneously on two completely different 3U OpenVPX single-board computers, each of which was based on different processor infrastructures (Intel and power architecture). The demo featured Harris's FACE-approved FliteScene Digital Moving Map software running on top of GHS's INTEGRITY-178 tuMP real-time multicore operating system. The commercial off-the-shelf (COTS) module hardware solutions showcased in the demonstration included Curtiss-Wright's NXP Power Architecture QorIQ Quad-core AltiVec-enabled T2080 processor-based VPX3-152, a DO-254 safety-certifiable 3U OpenVPX single-board computer (SBC), and the VPX3-1258, a 4th-generation Intel Core i7 (Haswell) processor-based 3U OpenVPX SBC.

The demonstration of the two completely different hardware instantiations highlighted how the use of a FACE-conformant software infrastructure enables operators of different aircraft types to run common capabilities on hardware that is SWaP-C [size, weight, power, and cost]-optimized for each individual platform. Today, as 3U VPX becomes the industry standard (replacing the ubiquitous 6U VME form factor), leading COTS vendors offer a wide range of 3U OpenVPX processors based on Intel, PowerPC, and ARM architectures, some available as DO-254 safety-certifiable solutions, that can be embedded in a rugged chassis for applications in fighters, cargo aircraft, and helicopters. As the FACE-conformant OS supports all of these processor types, it enables designers to choose their optimal mix of processors and OS when integrating a FACE-conformant SWaP-C-optimized system.

For some applications, the 3U LRU approach may prove too heavy, hot, or costly to meet unique platform requirements; for example, on small unmanned aerial vehicles or in environments where space and power on a larger platform is very limited. For those cases, non-backplane-based small-form-factor (SFF) LRUs can reduce SWaP-C. When the SFF subsystem can also host a FACE-conformant OS, the system integrator gains the added flexibility to run the exact same applications on both the SFF and larger 3U VPX systems and still meet restrictive SWaP-C limitations.

The promise of FACE: To deliver greater flexibility to system designers while simplifying logistics, boosting interoperability, and eliminating costly proprietary solutions. With the demonstration of the same FACE-compliant OS and application software running on heterogeneous hardware platforms, the promise becomes a reality.

Mark Grovak is Director, Avionics Business Development, at Curtiss-Wright Defense Solutions.

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DEFENSE TECH WIRE

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By Mariana Iriarte, Technology Editor

NEWS

U.S. Air Force F-16 avionics product support contract won by Leidos

Officials at the U.S. Air Force Sustainment Center selected Leidos to provide single-point integration services for F-16 fighter jet avionics shops. The single-award, indefinite delivery/indefinite quantity (ID/IQ) contract has a three-year base period, two one-year option periods, and a total contract ceiling value of $620 million.

Under contract, Leidos will support the Air Force Avionics Intermediate Shop Product Support Integration program. The company will be an independent nonmanufacturing product support integrator for the Air Force's F-16 avionics shops that perform maintenance on the electronics of the fighter aircraft.

Additional services include the sustainment and procurement of test program set system hardware and software, along with management of automated test equipment components and support equipment for the F-16.

Figure 1 | F-16 Fighting Falcon aircraft. Photo courtesy of the U.S. Air Force/Master Sgt. Andy Dunaway.

U.S. Air Force bent on improving test & evaluation processes for all DoD weapons systems

Officials at MacAulay-Brown, Inc. (MacB) received a $47 million task order by the U.S. Air Force Installation Contracting Agency (AFICA), under the U.S. Department of Defense (DoD) Information Analysis Center's (DoD IAC), Defense Systems Technical Area Task (DS TAT) Multi-Award Contract (MAC).

The four-year award continues MacB's work over the last five years assisting the Office of the Secretary of Defense designated Scientific Test and Analysis Techniques (STAT) Center of Excellence (COE).

The objective is to improve the Test and Evaluation (T&E) strategy development and analysis for all DoD weapon systems programs. The majority of work will be performed at Wright-Patterson Air Force Base near Dayton, Ohio.

GPS-based system for ground troops to be evaluated by U.S. Army

Ravenswood Solutions won a $1.3 million contract in support of the U.S. Army Joint Modernization Command [JMC – a subordinate of the larger Army Capabilities Integration Center (ARCIC)] for communications support services during a Network Integration Evaluation (NIE) to take place during fall 2018 at Fort Bliss, Texas, and the White Sands Missile Range, New Mexico.

Under the contract, Ravenswood will supply the Army with its proprietary Mobile Ground Truth System, a GPS-based instrumentation system that tracks vehicles, units, and individual participants during training or testing exercises.

The system presents users with real-time casualty assessment, a record of the factors that cause changes in troop capabilities, and a common operating picture that shows both live and constructive elements.

FACE-conformant navigation systems coming to U.S. Navy, Marine aircraft

Rockwell Collins will equip multiple U.S. Navy and U.S. Marine Corps aircraft with safety-critical Required Navigation Performance Area Navigation (RNP-RNAV) capabilities through a contract issued by the Naval Air Systems Command (NAVAIR) Air Combat Electronics program office (PMA-209).

Rockwell Collins will install its Mission Flight Management Software (MFMS-1000) and Localizer Performance with Vertical Guidance (LPV) Calculator (LPVC-1000) applications, which will enable the aircraft to meet RNP-RNAV requirements, obtain access to civil and military airspace around the globe, and perform GPS approach procedures. The technology is compliant with the Future Airborne Capability Environment (FACE) specifications.

These procedures, say Rockwell Collins officials, boost airspace use; reduce congestion, delays, and fuel burn; and improve safety by providing more precise aircraft navigation.

Figure 2 | Rockwell Collins' Mission Flight Management Software (MFMS-1000). Photo courtesy of Rockwell Collins.

F-35C Lightning II aircraft undergoes testing on carrier USS Abraham Lincoln

The U.S. Navy reports that F-35C Lightning II aircraft from Strike Fighter Squadron (VFA) 125 are conducting their Operational Test-1 (OT-1) with Carrier Air Wing (CVW) 7 and Carrier Strike Group 12 aboard the Nimitz-class aircraft carrier USS Abraham Lincoln (CVN 72), currently underway in the Atlantic Ocean.

OT-1 evaluates the full spectrum of the F-35C's suitability for operation within a carrier air wing and examines its mission effectiveness.

Navy officials state that the F-35C can pass on the information it collects not only to other F-35s in the air, but also to legacy aircraft, carrier air wings, strike groups, and ground troops. During the OT-1, evaluators assess the suitability of the F-35C aboard carriers by defining how well it performs with other aircraft and air plans, monitoring maintenance, and identifying its logistics footprint.

Figure 3 | An F-35C Lightning II assigned to the Rough Raiders of Strike Fighter Squadron. Photo courtesy of the U.S. Navy/ Mass Communication Specialist Seaman Maxwell Anderson.

Precision-guided munitions added to NATO allies' toolkit

The NATO Support and Procurement Agency (NSPA) recently received the first lot of Precision Guided Munitions (PGMs), a group of weapons acquired through a NATO project involving 11 allies and one NATO partner at a cost of approximately $20 million.

This initial delivery is the first to emerge from a cooperation effort, launched in 2014 at the NATO Summit in Wales, offering NATO allies a framework to acquire air-to-ground PGMs in a cost-effective and flexible way that will also allow the allies to draw upon each other's PGM stocks in case of need during air operations or in a possible crisis. NATO officials also say that the move will help NATO and its allied nations to reduce dependence on the U.S. for air missions.

Demo runs high-speed data link over 20 kilometers

Defense Advanced Research Projects Agency (DARPA) and Northrop Grumman Corp. engineers operated a data link at 100 gigabits per second (Gbps) over 20 kilometers in a city environment.

The two-way data link was demonstrated early in the year in Los Angeles. According to Northrop Grumman officials, the data rate is fast enough to download a 50 Gigabyte Blu-ray video in four seconds. The demonstration marked the completion of Northrop Grumman's Phase 2 contract for DARPA's 100 Gbps (100G) RFBackbone program. The 100G system is capable of rate adaptation on a frame-by-frame basis from 9 Gbps to 102 Gbps to maximize data rate throughout dynamic channel variations. Extensive link characterization demonstrated short-term error-free performance from 9 to 91 Gbps, and a maximum data rate of 102 Gbps with just one erroneous bit received per ten thousand bits transmitted.

Northrop Grumman's 100G industry team includes Raytheon, which developed the millimeter wave antennas and related RF electronics; and Silvus Technologies, which provides the key spatial multiplexing and MIMO signal-processing technologies.

Synchronized UAVs complete flight tests with new Boeing command and control

Boeing engineers in Australia completed a series of synchronized unmanned aerial vehicle (UAV) flight tests using new onboard autonomous command and control technology.

The flight test was conducted at a regional Queensland airfield. During testing, five UAV test beds equipped with Boeing's new onboard system completed in-air programmed missions as a team without input from a human pilot. Over the coming months, the Boeing Australia team will integrate and test more advanced behaviors on high-performance air vehicles before exploring other domains, such as unmanned ocean vehicles.

This activity is delivered in partnership with the Queensland Government as part of Boeing's Advance Queensland Autonomous Systems Platform Technology Project.

Figure 4 | Australian-developed onboard command and control system automatically perceives, processes, and reacts in coordination with other unmanned vehicles. Photo courtesy of Boeing.

NEWS

FAA avionics certification is complete for the Boeing-built KC-46 aircraft

Federal Aviation Administration (FAA) officials granted the Boeing-built U.S. Air Force KC-46 tanker program a Supplemental Type Certificate (STC), verifying that its refueling and mission avionics systems meet FAA requirements. The milestone marks completion of KC-46 FAA certification.

The Air Force/Boeing test team completed a series of lab, ground, and flight tests, which commenced in 2015. As part of the required flight testing, the team validated the KC-46's boom and the drogue aerial refueling systems met FAA certification criteria. The STC is one of two required FAA airworthiness certifications. Boeing received an Amended Type Certificate for its core 767-2C aircraft configuration in December 2017. The U.S. Air Force also must grant a Military Type Certificate (MTC), which is expected around the end of 2018. Boeing's team concluded MTC flight testing, which included the jet's aerial refueling, defensive and other military-specific systems, in early July.

The KC-46, derived from Boeing's commercial 767 airframe, is built in the company's Everett, Washington facility. Boeing is currently under contract for the first 34 of an expected 179 tankers for the U.S. Air Force.

Figure 5 | Boeing KC-46 tanker program completes FAA certification. Photo courtesy of Paul Weatherman/Boeing.

Force-protection contract against CBRN threats garnered by Leidos Australia

Leidos Australia won a contract for Land 2110 Phase 1B from the Australian Department of Defense in a deal set to deliver critical capability in the area of chemical, biological, radiological, and nuclear defense (CBRND).

The primary objective of the joint CBRND capability, according to materials from Leidos Australia, is to provide force protection to deployed Australian Defence Force (ADF) personnel, assigned coalition personnel, and designated civilians against existing and emerging CBRN threats.

The project – with a total value of $243.5 million over the acquisition and initial support phase of five years – will deliver and sustain capabilities in detection, identification and monitoring, warning and reporting, physical protection, hazard management, and medical support.

Drone challenge aims to push autonomous flight, AI, ML technology into high gear

Lockheed Martin and Drone Racing League (DRL) announced an innovation competition at the recent Tech Crunch 2018, challenging teams to develop artificial intelligence (AI) technology that will pit an autonomous drone in a race against a pilot-operated drone and win.

According to materials from Lockheed Martin, the AlphaPilot Innovation Challenge will enlist university students, technologists, coders, and drone enthusiasts to innovate and push the boundaries of AI, machine learning (ML), and fully autonomous flight. AlphaPilot participants will design an AI/ML framework powered by the NVIDIA Jetson platform for AI at the edge, capable of flying a drone through challenging multidimensional race courses in DRL's new Artificial Intelligence Robotic Racing (AIRR) Circuit.

The Lockheed Martin AlphaPilot Innovation Challenge will open for entries in November. The teams chosen to compete are eligible for over $2 million in cash prizes, including an extra $250,000 award for the first team that outperforms a professional DRL human-piloted drone. Those interested in learning more and applying to participate can visit lockheedmartin.com/alphapilot.

U.S. Navy sensor module completes CDR, production begins

Engineers at Northrop Grumman Corp. completed the Critical Design Review (CDR) phase of the U.S. Navy's WSN-12 Inertial Sensor Module and will begin production of ten preliminary units. The Inertial Sensor Module is a primary subsystem of the WSN-12 that includes the inertial sensors, electromechanical equipment supporting them, and software to compute the navigation solution. The shipboard inertial navigation system measures, computes, and distributes navigation data to all users, including attitude, velocity, and position information.

The WSN-12 has the potential to become the primary shipboard inertial navigation system for most U.S. combatant vessels and will be installed on all vessels of the DDG, CG, CVN, and SSN classes, Northrop Grumman officials say.

Figure 6 | The U.S. Navy WSN-12 Inertial Navigator will be used on the Virginia-class subs and Arleigh-Burke class destroyers, as well as a host of other ships. Photo courtesy of U.S. Navy.

New range-support aircraft replacement for Navy passes first phase

The U.S. Navy's Tactical Airlift Program Office (PMA-207) Commercial Modifications and Range Support (CMARS) Team recently accepted delivery of its newest commercial-derivative aircraft platform.

The Gulfstream G550 is slated to serve as the replacement for one of the aging P-3 range support aircraft operated out of Naval Air Warfare Center Weapons Division (NAWCWD) in Point Mugu, California. Program Manager Capt. Steven Nassau spoke about the complexity of this acquisition: "The team had to coordinate with AIR-5.0 Test and Evaluation leadership, AIR-2.0 Contracts, AIR-5.2 Ranges, and AIR-5.1 test squadrons for mission equipment and airframe expertise, as well as AIR-6.0 Logistics for sustainment to keep this acquisition on schedule. Delivering the aircraft under cost and on schedule is a major milestone for such a complicated project."

Navy personnel say that Phase Two of the project will begin with the Phase II Integrator, Raytheon, receiving the G550 aircraft as government-furnished property; Raytheon will then develop, procure, and integrate systems that will give the aircraft a multirole capability in telemetry data collection, range safety and surveillance, and communications relay.

Figure 7 | The Gulfstream G550 with structural modifications will replace the aging range support aircraft in Point Mugu, California. Photo courtesy of U.S. Navy.

Aviation engineering contract signed between Engility, U.S. Navy

Engility announced that it won earlier this year an $85 million Naval Air Warfare Center Aircraft Division (NAWCAD) Code AIR-4.1 – Systems Engineering Department contract that will support NAWCAD Code AIR 4.1 by providing systems engineering, analysis, development, and testing of naval-aviation warfare systems.

Under the terms of the contract, Engility will work out of its Model Based System Engineering Lab in Lexington Park, Maryland, to support NAWCAD's Program Executive Offices and the Program Managers, Air. This support will take the form of systems-engineering activities, including providing multidisciplinary integrated technical baseline evaluations and conducting program engineering assessments. Engility will also help introduce these systems into naval aircraft and support them over their life cycle.

Free flight demonstrations in MALD-X project complete

A Department of Defense (DoD) team including the Office of the Under Secretary of Defense for Research and Engineering's Strategic Capabilities Office (SCO), with Air Force Miniature Air Launch Decoy (MALD) Program Office, and Naval Air Warfare Center Point Mugu completed a series of free flight demonstration under the MALD-X project this month.

The MALD-X project seeks to demonstrate operational effectiveness and tactical advantage provided by large numbers of collaborative, expendable platforms highlighted with the completion of a complex free flight demonstration of advanced electronic warfare techniques.

"MALD-X gives future warfighters the ability to focus on the nature of the emerging threats rather than being encumbered by the burden associated with making a system interact with mission elements and mission supporting actions," says Matthew O'Connell, MALD-X Program Manager.

Advanced propulsion technology demo shows promise for future deep-space exploration

Aerojet Rocketdyne completed its early systems-integration test for NASA's Advanced Electric Propulsion System (AEPS) program, a next-generation propulsion capability that will further enable missions to deep space.

Under the terms of the AEPS contract, Aerojet Rocketdyne is charged with developing and qualifying a 13-kilowatt Hall thruster string for NASA. In the latest test, the team focused on the power elements of the AEPS Hall thruster string – the discharge supply unit (DSU) and the power processing unit (PPU) – with the test showing the system's ability to successfully convert power at a high efficiency level, producing minimal waste heat.

With the early systems-integration test behind it, the team can now move into the design finalization and verification phase leading up to the critical design review (CDR), in which the design will be finalized and cleared for production.

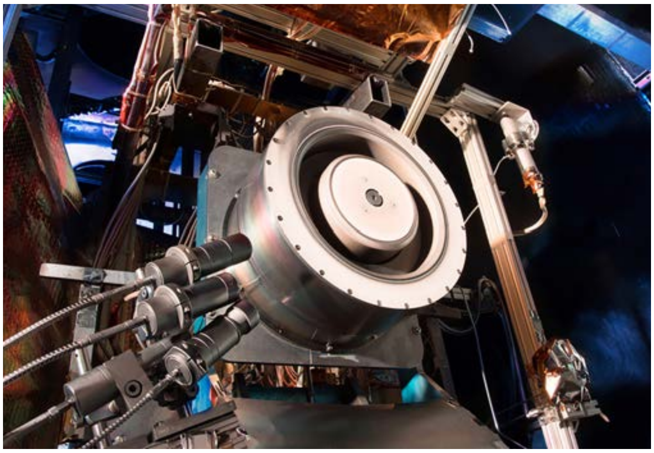


Figure 8 | A 13-kilowatt Hall thruster being evaluated at NASA's Glenn Research Center in Cleveland. Photo courtesy of NASA.

ISR signal processing brings performance to sensors and enables AI at the edge

By John McHale, Editorial Director

ISR sensor platforms like the U.S. Navy E-2C Hawkeye are requiring more and more signal-processing capability. This aircraft, assigned to the "Liberty Bells" of Carrier Airborne Early Warning Squadron (VAW) 115, of Carrier Air Wing (CVW) 11, prepares to land on the flight deck of the Nimitz-class aircraft carrier USS John C. Stennis (CVN 74). (U.S. Navy photo by Mass Communication Specialist Seaman Angelina Grimsley/Released)

Military intelligence, surveillance, and reconnaissance (ISR) applications continue to make demands on signal-processing designers for more performance, better thermal management, and reduced size, weight, and power (SWaP). These systems – as they move closer to the sensor on various platforms – are also starting to enable artificial intelligence (AI) solutions at the edge.

Speeding up "sensor to shooter" time is a bit of a blunt term, as ISR sensor data sent to a warfighter does not always end with shots being fired. However, speeding up the filtering of data at the sensor level does shorten the time that it takes for actionable intelligence actually gets to warfighters, enabling them to make better, faster, and more informed decisions. Some call this new reality "shortening the sensor chain."

To enable such performance, sensor systems integrators rely on high-performance embedded signal-processing solutions that leverage the latest commercial processors and FPGAs [field-programmable gate arrays].

"Our [defense] customers want wider signal bandwidths, improved dynamic range, higher channel density, and lower cost per channel," says Rodger Hosking, Vice President and Founder, Pentek (Upper Saddle River, New Jersey). "There is no ultimate 'good-enough target' for any of these parameters because each step of improvement opens up new applications, extends the range of deployment environments, increases detection range, improves acquisition of small signals in the presence of large ones, and accommodates the newer wideband spread-spectrum and encryption techniques for signals that must be captured and generated.

"As technology moves on wider bandwidths, applications can be deployed in different ways and with different cost profiles," Hosking continues. "For example, lower-cost form-factor profiles now have functionality that was unaffordable before. Applications such as small drones are driving this. The drone needs to be able to detect a faraway small signal while there are large signals right next to it. Capturing that small signal is akin to pulling something out of a noisy environment – a difficult task, made easier by modern signal-processing techniques."

Increased bandwidths also mean increased use of all types of commercial processing elements. "Higher bandwidths mean more data and a larger variety of data set sizes," says Tammy Carter, Senior Product Manager for OpenHPEC products for Curtiss-Wright Defense Solutions (Ashburn, Virigina). "We are seeing more systems that mix DSPs [digital signal processors], GPGPUs [general-purpose graphics processing units], and FPGAs, with no single technology taking over the whole signal-processing chain. Four or five years ago, I would've said that GPUs, as far as signal processing, were totally dead, but there has been a resurgence as defense integrators embrace the

Figure 1 | The HPERC-IBR rugged small-form-factor computer from ADLINK leverages third-generation Intel Core i7 processor and optional GPGPU parallel processing engine.

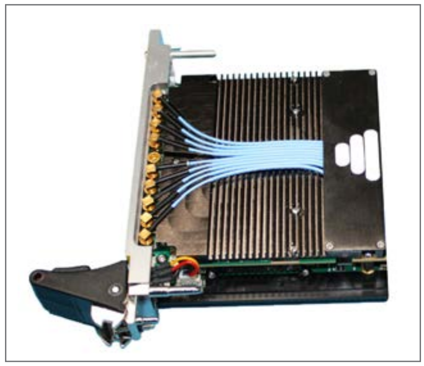


Figure 2 | The WILD FMC+ GM60 ADC & DAC card from Annapolis Micro Systems leverages Xilinx RF SoC technology.

increasing throughput and decreased SWaP that GPUs bring to a system when compared to CPU-only solutions. Other factors include the ease of reconfigurability when compared to FPGAs and latency gains that can be achieved by data transfer directly to the GPU without having to go through the CPU."

In addition to demanding more processing and performance, defense integrators are also requiring all of this functionality to be "on an inherently secure platform built on open architectures capable of supporting multiple channels," says Peter Thompson, Vice President, Product Management, at Abaco Systems (Huntsville, Alabama). "And they want all this at lower cost, delivering lower latency with less jitter – and with minimal NRE [non-recurring engineering cost]."

Packaging processing power with the sensor

The military's seemingly unquenchable thirst for ISR data has naturally resulted in even more information being gathered by the sensors; there's so much data, however, that it can't get down the current data links fast enough. Designers are therefore looking to pack increasing amounts of processing capability next to the sensor to filter some of that data before it gets sent to human operators.

"The need for more processing power is always there," Thompson notes. "It manifests itself in different ways, though – raw FLOPS [floating-point operations per second], core count, cache sizes for FPGA solutions, more gates, more DSP slices, tighter integration of programmable logic, processors and analog conversion, bigger memories with higher bandwidth, and so on. We're regularly deploying 16 lanes of PCIe Gen3 for a bandwidth of 15.75 GB/second, and 40 Gb Ethernet, with 100 GbE around the corner."

More defense customers are requiring their equipment be able to analyze, quantify, and packetize data at the sensor level before it is downlinked – which also affects the SWaP requirements, says Roy Keeler, Senior Product and Business Development Manager, Aerospace & Defense, ADLINK Technology (San Jose, California). "We also see the envelope being pushed to reduce SWaP as existing processing power is right at the limit for conventional packaging technology today." For these applications, ADLINK offers the HPERC-IBR rugged small form factor computer. (Figure 1.)

Fiber and FPGAs are essential for adding processing at the sensor level: "We are seeing a strong desire to minimize data movement, and maximize the use of fiber," says Noah Donaldson, Vice President of Product Development at Annapolis Micro Systems (Annapolis, Maryland). One of the ways Annapolis addresses these requirements is with its WILD FMC+ GM60 ADC & DAC card, which is designed for positioning closer to the sensor, he continues. It is one-third smaller and lighter than 3U VPX, yet using the Xilinx Zynq UltraScale+ RF System-on-Chip (RFSoC) technology, it has full FPGA processing and converter capability. (Figure 2.)

Active electronically scanned array (AESA) "radar data is processed initially with smart sensors, and then the resulting sensor data is aggregated over fiber to larger FPGAs," says Denis Smetana, Senior Product Manager, FPGA Products, Curtiss-Wright Defense Solutions. "It is becoming more important for FPGA modules and processor modules to be able to directly interface to fiber connections, such as 40 GbE, to better support these fat pipes of data coming from the sensors." Curtiss-Wright offers the VPX3-534 3U VPX Kintex UltraScale FPGA 6 Gsps transceiver for ISR applications. It combines high-speed multi channel analog I/O, user-programmable FPGA processing and local processing in a single 3U VPX slot for direct RF wideband processing to 6 Gsps.

Many in the industry agree that the RF SoC FPGA released by Xilinx this year has also made it easier to get signal-processing capability next to the sensor. "The RF SoC is a key enabler to getting more signal-processing functionality closer to the antenna," Hosking says. "Our Model 6001 RFSoC Module (RFSoM) uses the Xilinx RFSoC Zynq UltraScale+ FPGA that has eight A/D and D/A converters, a quad-core ARM processor, dual 100 GbE interfaces, and FPGA resources."

The deployment of multiple-input and multiple-output (MIMO) RF systems is driving huge interest in RF SoC products such as the Abaco VP430 which leverages the Xilinx ZU27DR RF system-on-chip (RFSoC) technology and combines eight input and eight output channels, a large FPGA fabric, and multiple processor cores into a single slot, Thompson says.

"We are seeing adoption of the Xilinx RF SoC as being a big factor in reducing latency for [electronic warfare] applications," Smetana notes. "It can also enable a higher number of sensors, and it solves the latency issue by burying it in a low latency path inside the FPGA."

However, placing more capability with the antenna and sensor is also an RF challenge: "The closer you get to the antenna, the less you have to rely on sending RF signals through coaxial cables, which often becomes the limiting factor on system performance," Hosking says. "One brute-force solution is putting big heavy boxes up next to the antenna. A far better strategy is the use of small digitizer pods near the antenna and new optical interface standards that enable optical links to move the data up and down the link. This gets rid of the degradation problem while also supporting wide bandwidths.

"Due to advances in data converters and DSP engines, the well-known degradation of RF signals traveling through long coaxial cables from an antenna is often the limiting factor in system performance," Hosking explains. "Secondly, new monolithic signal devices that integrate the functions of RF, data conversion, and signal processing make it more practical to perform these previously bulky elements in smaller subsystems mounted closer to the antenna. Thirdly, the new, open standards for high-speed optical digital links capable of delivering digitized RF signals are now being widely adopted. Lastly, the adoption of digital RF protocol standards like VITA 49 help remove the barriers of incompatibility between vendors and boost confidence in defense customers so that they take advantage of this new technology."

Efforts to add processing capability at the sensor level are also "coupled with a demand for an increase in AI capability at the edge, near the sensor, to enable immediate data analysis," Keeler says.

AI at the edge

One way to leverage all of that signal-processing capability is to have the hardware enable AI algorithms that will help better filter the data the sensors collect.

"AI will be part of the trend towards adding more processing at the sensor level, especially for target classification," Carter says. "The processor will perform the classification to identify an object such as a tank, determine whether it is friend or foe, consider the speed and the direction of the movement, and even determine the level of the threat. Performing all these tasks on the platform reduces the amount of data that must be transferred to the central control station and its commands. These AI systems will enable more actionable intelligence to get to the operators in the field faster and enable them to make better decisions. This will be especially true with airborne radar systems, as much more of the classification and the resulting actions will be done in the air."

AI is starting to make an impact "in areas such as autonomously operated vehicles and cognitive systems such as radars and EW systems that adapt to changes in the electromagnetic spectrum autonomously and intelligently," Abaco's Thompson says. "There are many technologies being applied to such problems, including GPUs and FPGAs. There are many dedicated sensor-processing chips that are designed specifically for this domain, and we are constantly exploring their applicability to the rugged mil/aero environment."

"The key enabler for many AI applications is the tight coupling of the RF, data converter, and DSP functions within an FPGA-based product," Hosking says. "This is an ideal platform for custom development of sophisticated, real-time analysis and decision-making AI algorithms. Algorithms are being designed for FPGAs to adapt to particular signals that might never have been seen before and then track or dissect them."

AI is also part of the concept known as deep learning that is gaining much traction in defense circles. "Every year we are receiving more questions about deep learning," Carter notes. "People are unsure exactly how to utilize it yet, but you trying to get ahead of the curve by picking the processors, GPUs, FPGAs, etc. that will enable the deployment of deep learning applications once the neural networks are more mature for the ISR arena."

Getting rid of the heat

If only AI systems could cool off the electronics that make them possible – alas, not yet. Until the AI can cool their own systems, it will be up to hardware designers to manage the thermals generated by high-performance processors and FPGAs; they are actually coming up with some innovative solutions.

"We are definitely seeing (an enhanced focus) on thermal management requirement across the board along with a demand for more liquid cooling in smaller systems," Curtiss-Wright's Carter says. "Liquid cooling has been around for years but could be fairly messy from a COTS [commercial off-the-shelf] standpoint. For new higher-powered devices, Air-Flow Through (AFT) cooling is being adapted, as it is currently the only way to effectively cool high-power systems."

Constant innovation is needed to keep up with the thermal densities today and tomorrow, Thompson says. "We take an end-to-end approach to reduce thermal resistance at all points of a system – die to heat spreader, heat spreader to heat sink, heat sink to wedgelock, wedgelock to chassis, chassis to environment. We employ novel materials and assembly techniques, embedded heat pipes, controlled tolerances, self-adjusting interfaces, and more. The aim is to allow our processors to perform at maximum clock rates, even at the highest ambient temperatures, and to increase reliability."

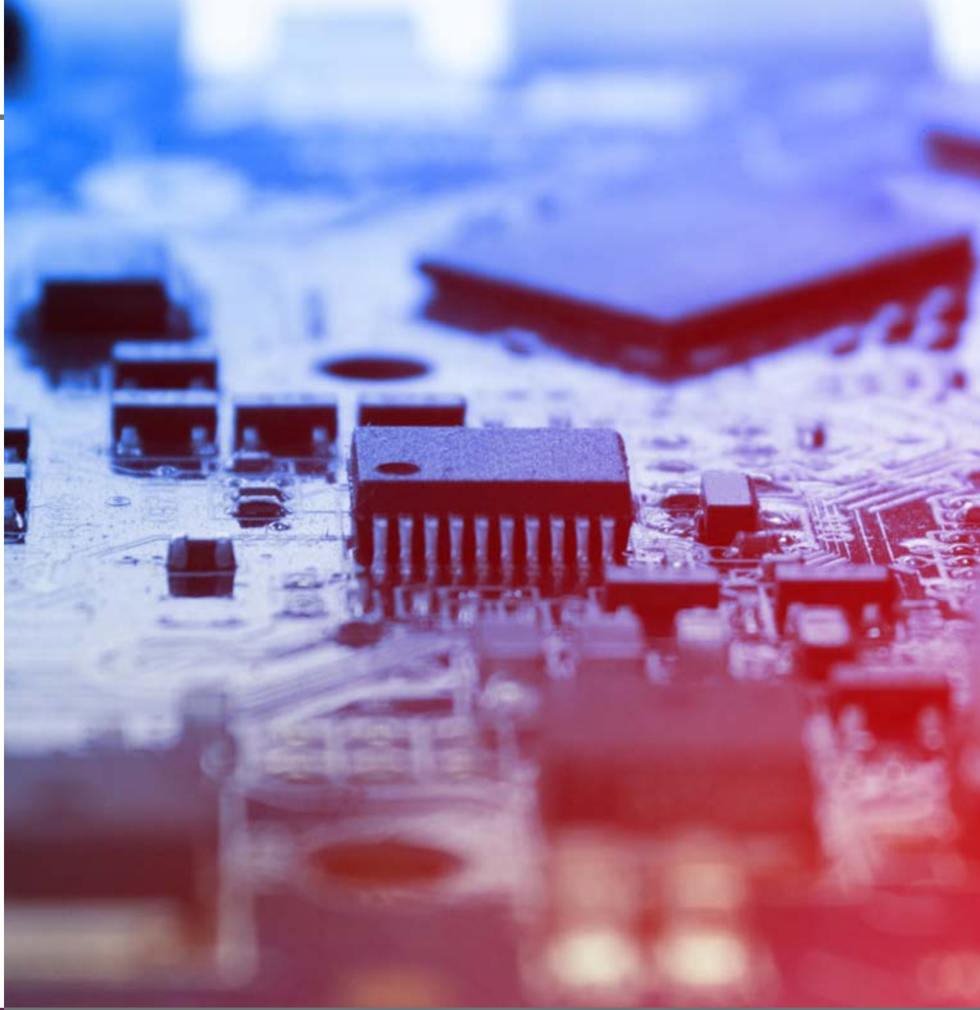
At Annapolis Micro Systems, "our cooling capability has evolved as our boards' processing capabilities – and attendant cooling requirements – have increased. It's gone from air to conduction to AFT," Donaldson says. "And now, for our highest performing systems, we are getting into liquid-flow-through (LFT) cooling."

"[The] LFT cooling standard – VITA 48.4 – that was recently released will also be used for these high-power systems where possible," Smetana says. "LFT cooling will most often be applied where the infrastructure already exists. Previously LFT hardware was developed as custom hardware, but now this is starting to migrate to COTS."

Managing thermals, say experts, must begin with early board development and not be an after-the-fact add-on.

"Often, with a real high-density device that generates much heat, it's too late to design thermal management – the product is done," Hosking notes.

"Thermal management needs to start with the product-development phase. Taking care of this up front also makes it easier for defense system integrators. Today, it is virtually impossible to tack on thermal-management provisions after the product is designed. System integrators look to vendors of board-level products with good thermal design, so that they can cool their systems without impacting schedules to develop a custom solution." **MES**



FMC enhancements for growing high-speed data needs

By Dylan Lang

Field-programmable gate array (FPGA) technology has proven to be invaluable to embedded designers for many years. Often acting as an all-in-one solution, FPGAs negate the need for ASIC [application-specific integrated circuit] technology and reduce the cost of custom IP algorithms in silicon. FPGAs have even aided in derisking designs by allowing engineers to modify their logic after silicon is on the board. This approach allows for more efficient prototyping and a faster time to market.

Due to such diverse flexibility, the demands of end users for a specific configuration or interface layout could drag on indefinitely. This presents an additional challenge for commercial off-the-shelf (COTS) manufacturers to design a standard product that will please most users.

Why FMC and how it has sustained since its inception

If FPGA technology was to be a viable product for a mass market, the need to offer many different configurations on a common platform had to be addressed. Thus, a modular approach and defining standards were needed. VITA saw an opportunity to drive such a standard, and FMC was born with VITA 57.1.

Although the FMC standard has now been in existence for about 10 years, it continues to sustain extensive use by a wide variety of COTS manufacturers and FPGA developers such as Xilinx and Altera. Thanks to features such as its small form factor and user-defined pins on the connector, FMC provides features to the end user while ensuring reliable I/O signal integrity at speeds up to 14 gigabits per second (Gb/sec).

FMC to FMC+: What has FMC enabled for system developers?

FMCs are an I/O mezzanine module in a small, standardized form factor that allows for greater design flexibility in many applications. Moreover, FMCs are host carrier-independent, supporting everything from motherboards and 3U/6U VME to VPX and CompactPCI carrier cards, which means that it's versatile to deploy in development and finished products.

These features are reflected in the upcoming VITA 57.4 FMC+ Standard, as well, where the number of multigigabit interfaces increases from 10 to 24.

In addition, there is an optional extension connector (the High Serial Pin Connector extension, or HSPCe) to boost pin count by 80 positions, arranged in a 4-by-20 array. This configuration brings the maximum multigigabit interfaces to 32 full-duplex channels. Additionally, throughput per multigigabit interface has increased to 28 Gb/sec in each direction.

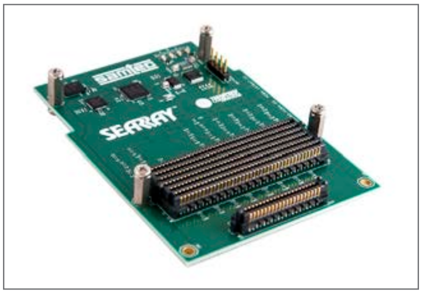


Figure 1 | FMC+ mezzanine from Samtec. Photo courtesy of Samtec.

By adding these high-speed serial lanes, FMC+ will enable designers to use the highest-performance serial devices from suppliers such as Texas Instruments and Analog Devices.

Just as FMC has become widely adopted due to its small form factor and design flexibility, FMC+ is due to follow suit: As most FMC applications are predominantly ADC/DAC and memory-based, FMC+'s serial connectivity is well-positioned to further these objectives. The VITA 57.4 Standard extends support from 10 gigabit transceivers (GTs) to 32 GTs, when using the optional expansion connector. This setup will allow for higher data rates and expanded bandwidth, all of which will fit within the same form factor as FMC.

FMC: Application overview across different industries

Being a connector company, Samtec is positioned to observe FMC and FMC+'s applications across various industries. Since we have begun involvement in these standards, we have seen FMC technologies continue to thrive along with the emergence of FMC+ (Figure 1).

VITA 57.1 is continuing to garner interest from all fields of embedded hardware, from developers designing custom carrier-mezzanine architectures to deployments in space stations. Other applications we have seen include COTS manufacturers employing FMC in rugged designs, as well as FPGAs being used in machine vision standards such as GigE.

As an enabling technology of next-generation rapid prototyping and deployment, FMC is likely to see continued growth well into the future. FPGA technologies, especially with the coming addition of FMC+, should see adoption in software-defined radio, optics, and advanced sensor/radar applications.

Each of these applications shares common requirements, such as more bandwidth, more channels, and the need for a more complete solution. FMC+ should excel in these areas as systems developers can take advantage of its speed and cost-effective approach. **MES**

***Dylan Lang** is Standards Development Manager at Samtec, Inc. and is the Chairman, ANSI/VITA 57 FMC Community.*

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LEVERAGING GALLIUM NITRIDE (GaN) TECHNOLOGY FOR MILITARY RADAR

GaN adoption solves power, performance issues in military applications

By Mariana Iriarte, Technology Editor

Two F-16 Fighting Falcons test APG-AESA radar as they fly over Edwards Air Force Base, California. Photo courtesy of the U.S. Air Force/Christopher Okula.

Radar, electronic warfare (EW), and communication systems are increasingly leveraging gallium nitride (GaN) technology to meet stringent high-performance, high-power, and long life cycle demands of these systems Meanwhile, increased commercial volumes is resulting in price reductions for GaN components across multiple markets.

GaN is a semiconductor material that in recent years has become a key component in enabling higher performance systems in military applications such as active electronically scanned array (AESA) radars and electronic warfare systems that require more power, reduced footprints, and more efficient thermal management.

In a nutshell: "There are a lot of different aspects of GaN, and we've just started to tap the possibilities," says Dean White, Director of Defense & Aerospace Marketing Strategy, at Qorvo (Greensboro, North Carolina).

GaN delivers because "at a high level, GaN is really being considered for military applications because of its high power density, high efficiency, wide bandwidth, and exceptionally long life," says Jim Milligan, Senior Director Foundry, Aerospace and Defense, at Wolfspeed, a Cree company (Research Triangle Park, North Carolina).

GaN applications abound from electronic warfare to radar to communications: Popular applications such as "wideband communications [are] especially benefitting from GaN technology, because it can enable a radio that traditionally would use two transistors operating multioctave to move to just a single device," says Gavin Smith, Product Marketer for the NXP RF Multi-Market Team (Chandler, Arizona). "This is important, because it helps save space and – in some cases – complexity of a design."

Radar systems – to take another example – are requiring wider bandwidths and more power for operation. "GaN is proving to be an ideal technology for AESA radar systems," says Deepak Alagh, Senior Director & General Manager, Mercury Systems RFM Group (Andover, Massachusetts). "The high power density allows the solid-state power amplifier (SSPA) to be much closer to, or even integrated with, the radar tile. By reducing the line lengths, losses are kept to a minimum. Additionally, compared to a one large traveling wave tube (TWT) amplifier and multiple phase shifters and power splitters, GaN SSPAs near the tile enable digital beam steering. Through the use of these multiple, compact GaN amplifiers paired with FPGA modules, the AESA achieves a much higher level of flexibility. Also, since GaN-based SSPAs are much smaller than the alternative technologies, it helps control the total size of the radar system." (Figure 1.)

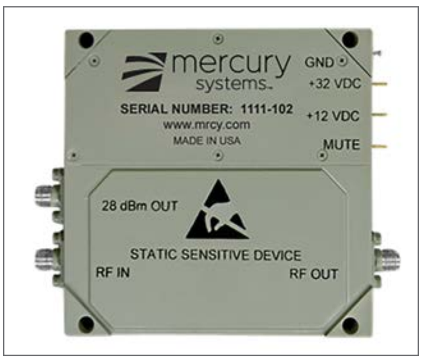


Figure 1 | Mercury Systems' amplifiers cover most radar and communications bands as well as other popular frequencies, including millimeter wave. Photo courtesy of Mercury Systems.

Putting GaN in radar systems helps reduce footprints while still increasing system efficiency. "Designers need higher-power solutions that fit into size-constrained spaces, that also don't require too much heatsinking," NXP's Smith says. "Like LDMOS [laterally diffused metal oxide semiconductors], customers using GaN continue to ask for higher-power solutions. To meet such size requirements, some applications require higher-power transistors, cutting out the need to combine several devices to achieve desired power levels. We also see applications that aren't as concerned with SWaP requirements but are determined to achieve certain levels of efficiency for their systems."

GaN enables smaller footprints in EW systems

GaN technology is helping designers meet reduced size, weight, and power requirements for EW systems. Like radar systems, EW applications are benefitting from the reduced footprints GaN enables. "You go from having large systems that are vehicular-mounted in the old days, to systems now that a soldier could actually carry in a backpack," says Dean White, Director of Defense & Aerospace Marketing Strategy, at Qorvo (Greensboro, North Carolina). "The broader bandwidth allows them to get voice and video, very similar to what you'd have in a handheld smartphone. There's also less concern about cooling because of GaN's ability to operate at higher channel temperatures.

"Most EW systems are very broadband, requiring high amounts of RF output power, but these are key areas where GaN really performs well," White continues. "Because of the impedance on the input of the transistor of GaN, it's easier for designers to match to it. Many EW systems used to have to use switches to switch from band to band; it's better now that they have a continuous bandwidth to operate over. What used to be broadband amplifiers in a fairly large brick module, are now condensed into a single mimic or maybe two mimics in a single package. Things are becoming smaller."

GaN technology is good in general for EW systems, explains Alagh: "Since a GaN device is smaller than its equivalent GaAs device, the parasitic gate capacitance is reduced. This yields a smaller input impedance that makes broadband matching much easier. Also, the high power density of GaN-based devices results in smaller EW systems, which enables their deployment on a wider range of platforms."

GaN power benefits

"As a general trend, we're starting to see higher-powered transistors," Milligan says. "When we first introduced GaN transistors for high-power applications such as radar applications, they were at the 100- to 200-watt level for a single package transistor. Now we're starting to see the trend going to larger and larger power levels."

Radar systems are now seeing "a kilowatt or more per package transistor for some L-band radar applications," he adds. "We're starting to see that trend in general as you go through L, S, C-band, X-band radar. This is really to service a lot of centralized transmitter type of applications."

One significant GaN application is in power amplifiers, White says. "They are the number-one choice because of the power density of GaN and its high level of power efficiency over a wideband bandwidth." In addition, he continues, there is also the move toward using GaN for low-noise amplifiers (LNAs): "GaN surprisingly has very good noise performance. A typical GaN device may be able to withstand anywhere from 50 milliwatts to 100 milliwatts, whereas a GaN LNA could be anywhere from two to four watts of incident power on the input, thereby reducing or eliminating the need for a limiter on the input of an LNA."

Phased-array radars are also benefiting from GaN power devices, Milligan says. "Phased-array radar has really sort of come of age over the last decade or so. For those applications you are using a GaN power transistor in every element of a phased array. In other words, it's distributed elemental power. As a result of that, for those applications, you deal with lower power levels anywhere from 10 watts to 50 watts peak power, depending on the application."

For example, Milligan states, Wolfspeed developed two C-band products for use in phased-array antennas. "One will be a 25 watt part, the other is a 50 watt part, that will cover 5.2 to 5.9 gigahertz, which is within the C-band radar operating band." (Figure 2.)

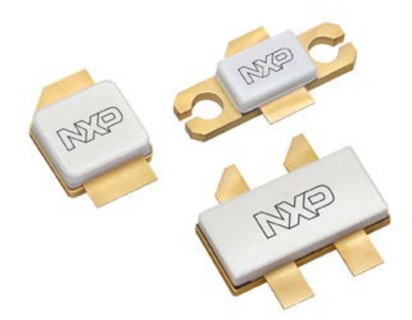
Basic economics

The commercial world is embracing GaN more than ever, resulting in increased production volumes, which results in reduced GaN component costs for everyone.

"Historically, Cree Wolfspeed has seen exposure to the entire supply chain from a transistor perspective," says Jim Milligan, Senior Director Foundry, Aerospace and Defense, at Wolfspeed, a Cree company (Research Triangle Park, North Carolina). "We manufacture the SiC material, the actual wafers. We do the GaN epitaxy, as well as fabricating the GaN devices."

What that means, Milligan says, is that over the past three to five years "we've seen some pretty dramatic cost reductions, largely driven by GaN adoption into some of the higher-volume commercial segments, telecom infrastructure being one of them. GaN was introduced into the telecom infrastructure as 4G was really being rolled out, approximately in the 2012 timeframe. That drove volumes across both the material system as well as the device, package assembly, and test perspective, so that they're substantially lower today than they were now. Now the military and aero segments directly benefit from the volume price reductions that we've seen in the commercial segment."

"GaN was known as a premium product targeted for defense applications. LDMOS has been around for 25 years and was optimized to hit commercial price points. It takes time to adopt and drive those costs down [in GaN's case]," says Gavin Smith, Product Marketer for the NXP RF Multi-Market Team (Chandler, Arizona). An example is NXP's GaN and silicon laterally diffused metal oxide semiconductor (Si-LDMOS) products (Sidebar Figure 1). "Commercial applications, like cellular base stations, are continuing to move to higher frequencies. As the frequency requirements move to S-band and beyond, GaN has become an attractive option. With commercial-type volumes, the gap between the GaN and LDMOS price point will reduce."



Sidebar Figure 1 | NXP's GaN chip trio. Photo courtesy of NXP.

As GaN adoption increases, volume will increase, which in turn will drive down costs. "We are seeing a decrease in the prices as more semiconductor manufacturers mature their processes and increase their volumes," says Deepak Alagh, Senior Director & General Manager, Mercury Systems RFM Group (Andover, Massachusetts). "Additionally, we are seeing the availability of more accurate nonlinear device models, which helps control our costs by reducing the design time."

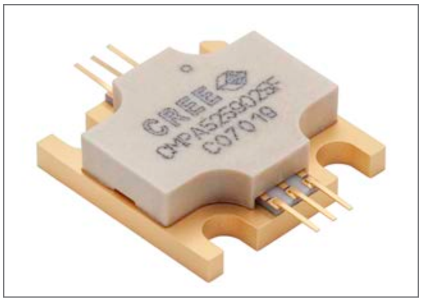


Figure 2 | CMPA5259025F – 25 W, 5.2-5.9 GHz, GaN MMIC power amplifiers for C-band radar applications. Photo courtesy of Wolfspeed.

Thermal management benefits

Increased power can also mean increased thermal management challenges, but GaN has upsides when it comes to keeping the system cool. "When you start to migrate to the use of GaN transistors, you can operate those at much higher channel temperature," Milligan explains, citing this example: "Our standard operating channel temperature, junction temperature is 225 °C, which is merely 100 degrees higher than the equivalent LDMOS part. As a result of that, you're able to operate GaN at higher power levels and do it in a way that sort of liberates the system designer from a thermal design prospective."

In addition, he adds, "applications where you might have to use liquid cooling, if you're using a silicon-based transistor, you can now migrate to air cooling if you're going to use the GaN part."

Specifically, "GaN has a clear advantage in short-pulse/low-duty-cycle radar," explains Paul Scsavnicki, applications engineer, at NXP (Eindhoven, Netherlands). "From the higher power densities, drain efficiencies, and lower am/pm distortion at P-3dB, GaN demonstrates better performance than LDMOS."

GaN enables better thermal management and offers new options, White says. "In particular, Qorvo uses GaN on silicon carbide (SiC) because it is an excellent thermal conductor. It's better than many of the metals that are used to attach to it and much better than silicon. With GaN and SiC, you can operate at 200, 225 °C channel temperatures, as opposed to other technologies, in particular like GaAs, which you can operate at only about 150 °C, without giving up the reliability of the device."

LDMOS versus GaN: When is GaN the better choice?

Many see GaN as a replacement for LDMOS technology, but is that the case for every application? "I wouldn't say GaN is always the better choice than LDMOS for all radar systems," NXP's Smith says. "When choosing GaN or LDMOS, it depends on the frequency, power level, efficiency, and price."

"LDMOS has been around for many years, especially for lower frequencies; S-band, L-band, and even down in the low L-band, the UHF bands. GaN originally started out replacing LBMOS S-band," Qorvo's White explains.

What GaN accomplishes and LDMOS does not is delivering the power that radar systems demand in certain frequencies. Alagh agrees: "GaN is the better choice since it balances bandwidth, power, and size. LDMOS can provide high output power in a small package, but only for low frequencies. GaAs can provide high frequencies, but not high power." **MES**

LEVERAGING NEWER
ADC TECHNOLOGY FOR
MILITARY APPLICATIONS

Newer 28 nm ADCs enable next-generation EW receiver systems

By David Brown and Peter Delos

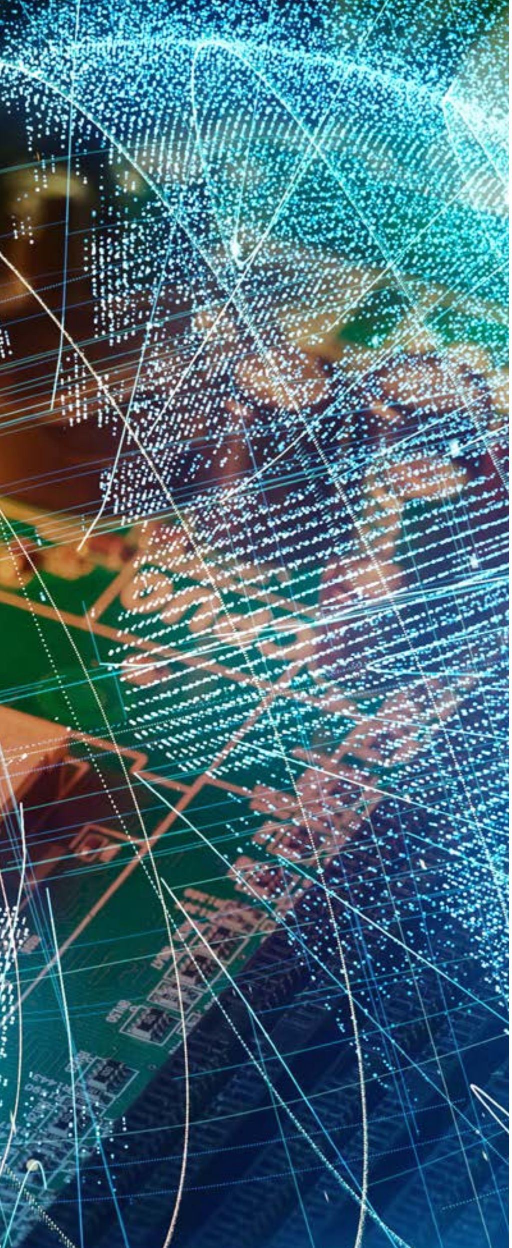
The high-speed ADC [analog-to-digital converter] is a primary design consideration in all wideband electronic warfare (EW) receivers; it largely determines system architecture and overall detect-and-observe capability.

The ever-present need for higher bandwidth and lower size, weight, and power (SWaP) in electronic warfare (EW) receivers, specifically those for signal intelligence (SIGINT) applications, has EW system designers continually looking for new developments and improvements in high-speed ADC technology. While 65 nm ADCs approach their inherent, process-related performance and bandwidth limitations, newer 28 nm RF [radio-frequency] ADCs surpass these boundaries and form a new foundation for next-generation wideband receiver systems. A 28 nm process node's smaller transistor widths and lower parasitics enable faster sample rates, wider analog input bandwidth, integrated digital functionality, and new receiver architectures, all while reducing power consumption and overall size.

The high-speed ADC is one of the primary design considerations in all wideband EW receivers, as it largely determines system architecture and overall detect-and-observe capability. Many performance characteristics of the high-speed ADC – including sample rate, bandwidth, and resolution – determine how the rest of the receiver is designed, from the analog RF domain to the DSP requirements.

As EW system designers continue to develop the next-generation receivers, the need for higher ADC bandwidth and greater resolution remains the perpetual industry trend. Higher sample rates and bandwidth allow for more spectrum to be digitized at once, easing design challenges in the RF domain and reducing sweep times. Greater bit depth leads to increased performance and fewer false alarms and detections. The insatiable need for higher sample rate and better resolution has led high-speed ADC vendors to move to increasingly smaller transistor lithographic nodes (currently 28 nm and 16 nm) that enable these requirements without increasing device power consumption.

The fundamental benefits of 28 nm ADCs are integral in enabling the next generation of wideband EW receivers and form a new foundation on which future systems will be built. The 28 nm transistors have reduced parasitic gate capacitance, enabling faster switching due to the lower energy needed to drive the switching. Because of this and the smaller physical transistor size, ADCs can pack in more transistors per square



THE INSATIABLE NEED FOR HIGHER SAMPLE RATE AND BETTER RESOLUTION HAS LED HIGH-SPEED ADC VENDORS TO MOVE TO INCREASINGLY SMALLER TRANSISTOR LITHOGRAPHIC NODES (CURRENTLY 28 NM AND 16 NM) THAT ENABLE THESE REQUIREMENTS WITHOUT INCREASING DEVICE POWER CONSUMPTION.

millimeter, leading to potentially greater digital processing capabilities.

Taking the inherently lower power consumption into consideration, the 28 nm ADCs offer performance and capability requirements previously considered impractical on the ≥65 nm process. The greater sample rates (several Gsamples/sec) and above) are attractive to EW system designers, especially for SIGINT, electronic protect (EP), and electronic support (ES) applications. Just as important as ADC bandwidth is the resolution, which allows for greater SNR/SFDR [signal-to-noise ratio/spurious free dynamic range] and subsequent ability to detect, observe, and process a target signal. Undersampling beyond the first Nyquist is also possible as a result of higher analog input bandwidths.

Enhanced integration

Moving to a 28 nm process lets allows mixed-signal semiconductor vendors integrate increasing amounts of digital signal processing and functionality into their high-speed ADCs with no increase in (or even a reduction of) system SWaP. Digital features like integrated NCOs [numerically controlled oscillators] and DDCs [digital downconverters] push converter performance boundaries and allow for easing of system design challenges related to the higher converter data rates and high digital interface power consumption. Taking advantage of the 28 nm process and increasing the on-chip DSP capabilities can also offload much of the processing load and power consumption from the processor.

While the 28-nm ADC enables a larger piece of the RF spectrum to be captured and observed, the signal of interest might still be of relatively small bandwidth compared to the ADC Nyquist bandwidth. Additionally, the vast amounts of data throughput from GSPS ADCs can lead to challenges finding a suitable processor and physically interfacing it to the ADC. Many 28 nm converters currently on the market use the JESD204B interface standard at lane rates above 10 Gbits/sec, which can introduce board layout and signal-integrity challenges associated with routing Gbit SERDES [serializer/deserializer] JESD lanes.

Fortunately, through integrated NCOs/DDCs and on-chip DSP, the ADC can convert the signal of interest down to a lower frequency or baseband, apply digital filtering, and decimate the digital data output rate so that more intensive processing can be performed on portions of the captured spectrum. Tunable NCOs let the DDC sweep across the digitized spectrum so that the entire spectrum can still be analyzed, but with the added benefits of processing gain and lower digital data output rates. Adding multiple NCOs and DDCs in parallel allows the user to preconfigure and quickly switch and fast hop between the DDCs, further reducing sweep times since NCO tuning is removed from the equation.

The integrated DDCs offer a power savings in the digital JESD204B interface. JESD SERDES running at such high rates can add a watt or more, so decimating the data rate down to lower speeds is beneficial. As high-speed ADCs continue to push to higher sample rates, bit depths, and bandwidth, integrating DDCs and ADCs becomes more attractive for wideband EW receivers since the enormous amount of digital data from the ADC can become difficult to process with a low SWaP processor.

Realizing new receiver architectures

Heterodyne receiver architectures are well understood and have been proven over time. Historically, many microwave receivers have been implemented with dual downconversion architectures. With the ADCs available in previous generations, the large ratio of operating band frequencies to ADC input frequencies made image filtering impractical with one downconversion receiver architecture. New ADCs increasing in both sample rate and analog input bandwidth now make high-performance wideband single downconversion architectures practical and easily realizable.

In an example single downconversion receiver architecture, the front-end LNA is chosen for noise figure performance. If needed, a limiter is added in front of the LNA to increase the front end's survive-power capability. An operating band filter is next to attenuate any out-of-band interference. Next, additional gain and/or gain control can be added as needed. Prior to the mixer, a low-pass filter can reduce RF harmonics that add to mixing spurious output.

The mixer is a critical building block and chosen to optimize performance in the frequency translation bands of interest. Another low-pass filter following the mixer filters upper sidebands prior to amplification. Additional IF gain is added as needed. The antialiasing filter is typically the final component prior to the ADC and rejects any frequencies that can fold in band through the sampling process. The ADC is next and, although it's last in the chain, is typically the first component chosen while the rest of the receiver is built around the ADC.

Now let's review some considerations for selecting frequency plan options. Frequency planning is the process of selecting a frequency translation approach that, when implemented with the components available, yields the lowest spurious performance with reasonable filter designs. As RF engineers enter this decision for the first time, the number of options and repercussions of a suboptimal frequency plan can make this a daunting task. Fortunately, modern advances in both CAD tools and the available components have made frequency planning more manageable.

In general, a higher IF frequency in the second or third ADC Nyquist zone is preferred from a spurious perspective. Here, we'll outline the benefits by first showing a frequency plan translating a 10 GHz operating band to the first Nyquist of a 3 GHz ADC, then show the benefits when operating in the second Nyquist zone.

Two primary issues occur during the frequency translation of a 1 GHz operating band at 10 GHz to the first Nyquist zone of a three-Gsample/sec ADC: First, the RF image frequency is closely spaced to the operating band, requiring a difficult filter for image suppression. Second, any IF created from the IF amplification stages are in band and unable to be filtered by the antialiasing filter.

When the same RF operating band is sampled in the second Nyquist zone, the higher IF frequency results in the image frequency that's further from the operating band, and the RF image filters are easier to implement. In addition, any harmonics created in the IF amplifiers can be filtered by the antialiasing filter and the only IF harmonics that will be created are the ones inside the ADC itself.

Component enablers

As a follow up to any frequency plan analysis, mixers and ADCs should be evaluated under their intended operating conditions in the receiver to validate the spurious and noise performance. Recently released high-performance 3 to 20 GHz mixers include the LTC5552 and LTC5553. The primary difference between them is that the LTC5552 has a differential IF output, while the LTC5553 is single-ended on all ports. The differential IF output allows the entire IF chain to remain differential, thus eliminating the balun (transformer) that's normally added to the ADC input. Differential IF amplifiers are readily available by making a completely differential IF section realizable with the only design adjustment being the introduction of differential filters into the IF signal chains.

A continual challenge for the RF receiver designer is that every critical ADC metric degrades with input frequency. This is true for both noise and spurious-free dynamic range. In addition to silicon limitations, careful packaging design accommodating for the RF launch from the silicon to the packaging laminate and from the package to the PWB is required to maintain input bandwidths for GHz converters.

Design for high IF sampling requires validating that the selected ADC doesn't significantly degrade with the required input frequencies. In addition, careful RF layout techniques are required with the implementation in a PWB design. A well-designed RF I/O structure will have gradual degradation versus input frequency. Without these considerations, there's typically an input frequency where the performance drastically degrades. When screening converters for an application, much effort is spent validating performance prior to committing to a design. For RF sampling ADCs operating well into the GHz frequencies, this is more important; the performance response versus frequency should be well understood prior to ADC selection for a given application.

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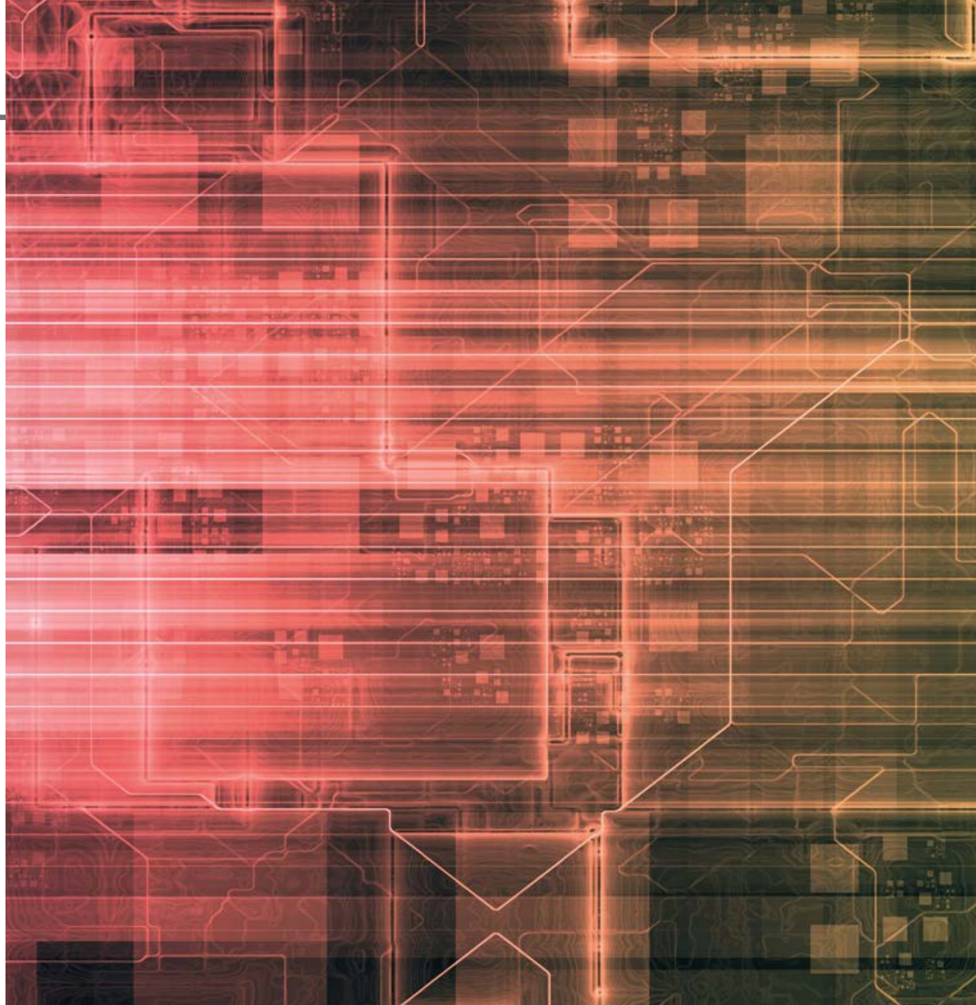
VIRTUALIZATION FOR
EMBEDDED COMPUTING DESIGN

The future of military systems is software-defined and virtualized

By Sally Cole, Senior Editor

Software-defined open virtualization solutions are a smart way to implement next-gen military systems: They're easier to maintain and enable future software and hardware upgrades with minimal risks, costs, and downtime.



Network virtualization and software-defined networking (SDN) are being embraced as easier ways to maintain and secure military systems. Software virtualization, not intended for network virtualization, is also helping to manage complexity and improve system security.

Virtualization, by its design, can increase network security. "Instead of having a fixed attack surface that traditional compute platforms expose, a virtualized platform presents a dynamic environment that is more challenging to compromise," says Chip Downing, senior director of aerospace and defense for Wind River (Alameda, California).

As you can imagine, this is ideal for military platforms "because as the warfighter situation changes and evolves, the platform can dynamically evolve with the capabilities and demands required to execute a mission," he adds. "This real-time, dynamic evolution of platform capabilities reduces the attack surface of security threats and vastly reduces the threat of 'canned' attacks on statically configured systems."

Virtualization can address many of the military's security concerns

Platform security "improves the more the virtualization platform responds to mission demands, because new applications and capabilities change the composition of the virtualization platform and the attack surface, making it harder to execute an attack," Downing says.

That's why he believes that the future of all military systems is virtualized. "The traditional federated, statically defined, hard-to-change, hardware-defined, vendor-locked system of the past must yield to a new architecture – a design based on open standards, like FACE [Future Airborne Capability Environment], which is software-defined and enables rapid implementation of new capabilities regardless of hardware or operating system constraints."

The virtualization of military systems is already well underway. While most of these success stories aren't made public, Downing points to the Northrop Grumman Black Hawk UH-60V cockpit digitization program as a good public example of using an open virtualization platform to solve upgradability, safety, security, reduced lifestyle costs, and standards-adherence requirements. (Figure 1.)

Emerging trends in network virtualization

One of the biggest trends is software-defined networking (SDN), which was created specifically to solve security issues and relies on a zero-trust model that assumes all guests are untrusted and limits the code base.

Another trend Downing is seeing in military avionics is an increasing use of open virtualization standards like FACE, run by the Open Group. "The OS foundation of FACE is the ARINC 653 time and space partitioning standard that robustly separates applications from different suppliers into separate virtual address spaces or virtual machines," he adds.

Figure 1 | Northrop Grumman's UH-60 V digital cockpit design is modernizing the Army's fleet of Black Hawk helicopters, giving pilots improved situational awareness and enhancing mission safety. Photo: Northrop Grumman.

"The future of networks is software-defined," Downing says. "These systems are open, less costly, and support more capability and high levels of safety and security. They're also easier to maintain and enable future hardware and software upgrades with minimal cost, risk, and downtime. Software-defined open virtualization solutions are the smart way to implement next-generation military systems."

Network virtualization for defense customers

Open architectures and open source are important to the defense community when it comes to virtualization.

"Our Titanium Cloud capabilities are open and based on multiple open source components such as OpenStack, Linux, CEPH, KVM, and DPDK," Downing explains. "We also provide full support for OpenFlow-based controllers like OpenDaylight. Titanium Cloud was the seed code for the OpenStack edge cloud project StarlingX, which will also be used in the Akraino Edge Stack project from the Linux Foundation."

Open architectures are important so that hardware virtualization can be leveraged to assist in creating virtual machines that support simultaneous guest OS environments on advanced multicore hardware platforms from ARM, Intel, and PowerPC architectures, Downing adds.

Use of virtualization software, not intended for network virtualization, also on the rise

How is virtualization software – not intended for network virtualization – for embedded components being used in avionics and security applications for defense customers? "The primary use case is separation enabled by the current generation of central processing units (CPUs) with on-chip support for hardware virtualization," says Lee Cresswell, vice president of worldwide sales for Lynx Software Technologies (San Jose, California). "Today's complex multicore processors are moving toward becoming networked systems-on-a-chip, so many of the assumed attributes of distributed systems like isolation and separation that were previously achieved by physical means may no longer apply when shared resources such as memory and input/output need to be managed in new ways. Yet many of our development methods and legacy systems need this separation to function. Hosting a guest OS is one example of this broader use case, and systems may only need to facilitate the separation of safety-critical or security-critical modules running on bare metal."

The main challenges in this area revolve around system security, Cresswell adds. "The systemwide objective is usually system security, which is often the baseline for safety certification when partitioning is required. But it goes deeper than that; it's about managing the complexity of development that complex processor integrations force upon the systems software environment," he explains. "Separation through using processor virtualization tools in new ways is a steppingstone toward modularization of software capabilities, usually to facilitate independent parallel development on these shared MCPs and maximum code reuse across programs."

Within five years, Cresswell envisions that "the smart use of virtualization technology will become a fundamental enabler for a shift away from kernel and OS-centric system designs and toward modular system development capability in which the OS/kernel is hosted to support legacy systems integration." **MES**

"Moving target"' defense within software-defined networks

A new technique developed through a research collaboration uses flexible random virtual IP multiplexing to protect networks against attacks.

A moving target defense (MTD) technique within software-defined networks (SDN) is being developed by a group of researchers from the U.S. Army Research Laboratory (ARL), the University of Canterbury (UC) in New Zealand, and the Gwangju Institute of Science and Technology (GIST) in South Korea.

Typical defensive responses to attacks on networks tend to be passive, which leaves victims reacting only after an intruder breaks into a computer system.

This is a less than ideal approach, and it's why the researchers are exploring MTD as a proactive form of defense to better safeguard important information in computer systems.

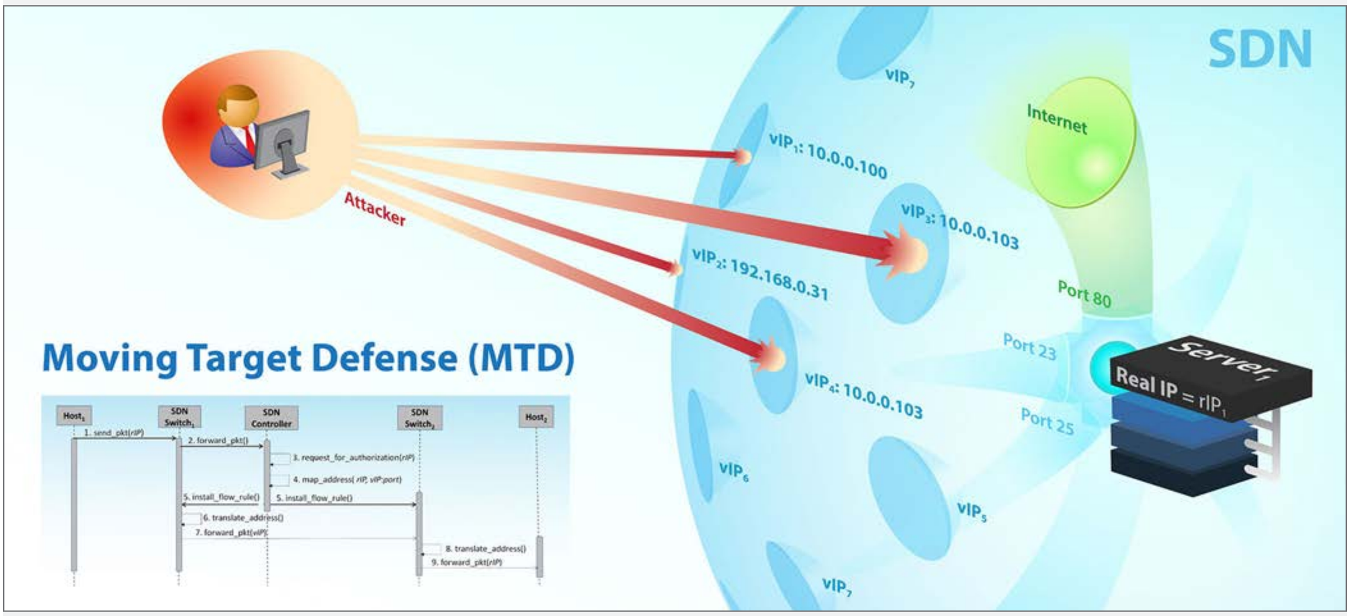
"The concept of MTD has been introduced with the aim of increasing the adversary's confusion or uncertainty by dynamically changing the attack surface, which consists of the reachable and exploitable vulnerabilities," says Jin-Hee Cho, an ARL researcher who is now working at Virginia Tech in the Department of Computer Science. "MTD can make the adversary's intelligence gained from previous monitoring no longer useful and, accordingly, it results in poor attack decisions."

The basic concept as it applies to internet protocol (IP) addresses on computer networks is to change the address frequently enough so that the attacker loses sight of where their victim is. But since this can be expensive, the researchers wanted to explore using software-defined networking (SDN) to do it instead.

Their SDN approach allows computers keep their real IP addresses fixed but masked from the rest of the Internet via virtual IP addresses that change frequently.

It's harder to hit a moving target, notes Terrence J. Moore, a researcher at ARL. "MTD increases uncertainty and confuses the adversary, because time is no longer an advantage," he says. "The adversary has to expend more resources – such as time or computational power – to discover vulnerabilities of a target system and will experience more difficulty in exploiting any vulnerabilities found in the past since their location or accessibility is constantly changing."

The group's approach is a paradigm shift because it provides defense services before attackers get into a target's system. "Taking actions proactively requires extra overhead to add another layer of defense," explains Professsor Hyuk Lim of GIST. "Deploying proactive defense and security systems isn't free; it brings a cost because the system needs to constantly change the attack surface such as IP addresses. This cost can be mitigated to some extent by leveraging SDN technology, which provides highly efficient programmatic and dynamic management of the network policy by removing the network control from individual devices in a network to a centralized controller. The network configuration can be



Sidebar Figure 1 | Moving target defense increases uncertainty and confuses the adversary, who has to expend more resources to discover the vulnerabilities of the target system. Illustration courtesy Army Research Laboratory.

defined by the SDN controller, enabling more reliable and responsive network operations under variable conditions."

How can this technique support the vision of the Army and warfighters? "The key technology of SDN-based MTD techniques is highly relevant to support the warfighters' mission by proactively thwarting potential attacks, which can protect the defense system so that the warfighters can properly execute the mission in the presence of highly dynamic, hostile, and innovative adversaries within contested environments," says Frederica Nelson, a researcher at ARL.

The UC team in New Zealand led the development of the MTD technology called "flexible random virtual IP multiplexing" (FRVM).

"In FRVM, while the real IP address of a server-host remains unchanged but stays hidden, a virtual IP address of the server-host keeps being randomly and periodically changed where the IP mapping/remapping (multiplexing/demultiplexing) is performed by an SDN controller," says Dilli P. Sharma, a doctoral student within Professor DongSeong Kim's cybersecurity research group at UC, New Zealand. "This effectively forces the adversary to play the equivalent of an honest shell game. But instead of guessing among three shells (IP addresses), to find a pea (a running network service), the adversary must guess among 65,536 shells, given address space 2^{16}. This MTD protocol is novel because it provides high flexibility to have multiple, random, time-variant IP addresses in a host, which implies the adversary will require more time to discover an IP address of the target host."

The researchers' work also involves formulating the architecture and communication protocols for the proposed IP (de) multiplexing-based MTD to be applied within SDN environments. And they were able to validate the effectiveness of FRVM under various degrees of scanning attacks in terms of the attack success probability.

Next on the team's docket: They'll "study the tradeoff in the FRVM between the dual conflicting goals of system security and performance, because proactive defense may introduce adverse effects when running MTD techniques while achieving enhanced security," says Kim.

How "near-peer" adversaries are changing command posts and battlefield network requirements

By Chris A. Ciufo

A traditional U.S. military forward command post: Tents, generator trucks, SATCOM links, antennas, and the personnel needed to run all of it. (Photo Credit: U.S. Army/Amy Walker, PEO C3T Public Affairs.)

Future battles may be fought against so-called "near-peer" adversaries who may already be ahead of America's best technologies. It's time to adopt the latest consumer technologies in the command post by making the post more mobile or by making it virtual, like unmanned aerial vehicle (UAV) pilots who operate far from the front lines. That strategy requires that an entire tent worth of analysts, radio operators, and personnel – plus their generators, SATCOM [satellite communications] gear, and miscellaneous hardware – be shrunk down to something that fits in the back of a Humvee, an MRAP [Mine-Resistant Ambush Protected] vehicle, or a Stryker armored vehicle.

America's military doctrine since World War II has been to decisively defeat the enemy with overwhelming force in both manpower, materiel, and Department of Defense (DoD) budget. Along with this objective came the understanding that the U.S. military could successfully prosecute two wars simultaneously, and that warfighters would be equipped with the world's best and most sophisticated technology. So equipped, the U.S. was unstoppable.

Until it wasn't. Recent skirmishes with Russia and China have shown that both of these nations' forces are equally well-equipped with the latest technologies – and the will to use them when needed. Far from the ill-equipped Iraqi army and asymmetric urban warfare in Afghanistan, future battles may be against so-called "near-peer" adversaries who may already be ahead of America's best technologies.

These threats require new battlefield technologies and doctrines as quickly as the Army, Air Force, Navy and Marines can field them. The threat to our battlefield networks is one area where "near-peer" is acutely visible.

From Russia, with love

When Russia invaded the Crimean Peninsula in 2014, U.S. observers were shocked to discover that Russia was quickly able to find, defeat, and kill Ukraine's installed command and control (C2) structure. Not only was Russia able to triangulate and locate Crimea's battlefield communications networks and defensive weaponry with pinpoint accuracy, Russian jamming and eventual precision artillery successfully rendered those

THE IDEA IS THAT AS THE ARMY DRIVES FORWARD, AN ENTIRE TENT'S WORTH OF ANALYSTS, RADIO OPERATORS, AND PERSONNEL – PLUS THEIR GENERATORS, SATCOM GEAR, AND MISCELLANEOUS HARDWARE – CAN BE SHRUNK DOWN TO SOMETHING THAT FITS IN THE BACK OF A HUMVEE, AN MRAP, A STRYKER, OR PERHAPS SOMETHING AS BIG AS AN 8 BY 8 TRUCK.

technologies moot (and neutralized). The lesson was that if you can find it, you can kill it. Recent examples in Syria are similar.

The U.S. had long assumed that Russia was not this well-equipped. DoD strategists and planners remember the not-so-long ago early 1980s, when it was publicly leaked that Russian aircraft still relied on vacuum tubes for critical on-board systems. It was later learned that this was as much about trailing-edge technology as it was for radiation mitigation (semiconductors are exceptionally vulnerable to electromagnetic pulse alpha particles compared to vacuum tubes). In 2014, if Russia could electronically jam, defeat, and kill technology used by quasi-allies such as the Ukraine, then U.S. forces themselves might someday be equally vulnerable. America took notice.

The battlefield changes but some things stay the same

Our Army commands battle much as one sees in World War II movies: A forward command post is set up, RF and SATCOM tactical communications extend forward to the front lines and rearward to supply depots or the continental U.S. (CONUS). Joint links are set up with naval and Air Force airborne assets, although direct communication is rare – requiring intermediaries to relay instructions or transpose disparate tactical radio and data links. Standoff and relatively nimble airborne platforms such as AWACS [Airborne Warning and Control System, the E-2C Hawkeye, E-8 JSTARS [Joint Surveillance Target Attack Radar System], and the RC-135 V/W Rivet Joint coordinate, interrogate, and conduct surveillance but the Army must still set up tents, air conditioning, generator trucks, server racks, and big satellite communications gear. And a whole lot of personnel to operate it. When the U.S. was assured of battlefield and technology dominance, this made perfect sense.

This ground doctrine relies on the capable Warfighter's Information Network (WIN-T) tactical LAN between assets, and the command post architecture of Tactical Server Infrastructure (TSI). While these core technologies get the job done, hours or even days are required every time a command post (CP) is established or torn down. Once up and running, they radiate RF and EM emissions, making them visible and vulnerable to the enemy's sensors and weapons.

The need for shoot and scoot

Army planners are now looking for a way to mimic this tactical command post concept, but have it set up, operating, and torn down in as little as 30 minutes. The idea is that as the Army drives forward, an entire tent's worth of analysts, radio operators, and personnel – plus their generators, SATCOM gear, and miscellaneous hardware – can be shrunk down to something that fits in the back of a Humvee, an MRAP, a Stryker, or perhaps something as big as an 8 by 8 truck.

Another possibility is that the command post is not all in one spot; perhaps it's disaggregated and distributed and made redundant across multiple platforms but networked together in real time with shared databases and joint intelligence provided from all battlefield and joint sensors. Maybe some of the equipment is mounted in autonomous vehicles, remotely controlled, but "expendable" should the enemy locate and send a precision shell or missile into the EM radiation source (Figure 1). Although unfortunate, killing a truck's worth of gear rather than personnel is an obvious benefit when the truck is robotic. This is why the Air Force relies nearly as much on UAVs as on fighter aircraft these days. Real pilots still fly those UAVs; they're just out of harm's way and rely on battlefield networks to control their unmanned aerial system.

Back on the ground, this networked, distributed, mobile, agile "shoot and scoot" strategy is not foreign to the Army. It is already practiced with mobile artillery that can set up, lob 155 mm smart munitions, then quickly move to a new location before the enemy can triangulate a reverse trajectory from the incoming shells. It's time to adopt this same strategy to the command post by making it either more mobile – or making it virtual, just like UAV pilots who may operate far from the front lines.

Core technologies for future battlefield networks and CPs

The Army has two obvious choices for future battlefield command posts and their associated networks: One, make them lighter, smaller, integrated into other systems or disaggregated out to other existing systems; or two, virtualize them such that the same functions are handled remotely, possibly in a secure cloud and essentially far from the battlefield.

Regardless of which approach is used, higher-bandwidth networks will be required if massive amounts of data need to be moved from points A to B – even if A and B are localized on the battlefield as opposed to A in battle and B in CONUS. While SATCOM and mesh network research continues at a fever pace, the state of the art in networking remains the civilian terrestrial mobile networks. Migration to 5G cellular technology, MIMO antennas, and femto cells (repeaters) is driven by the world's voracious appetite for sharing content – primarily pictures and streaming movies. It's unlikely DARPA, NASA, or the DoD can outspend or out-innovate commercial off-the-shelf (COTS) civilian mobile technology. The best hope for battlefield networks is to adopt COTS and harden it.

On the other hand, more efficient use of existing defense networks and server infrastructure is one way to free up bandwidth to change the rigid CP doctrine to something new. Localized compression can free up congested networks. For electro-optical sensors that blast out full-motion video, technology already used by Amazon, Google,

Figure 1 | U.S. Army concept of future autonomous vehicle demonstrator. Could this be the command post of the future? (Courtesy U.S. Army.)

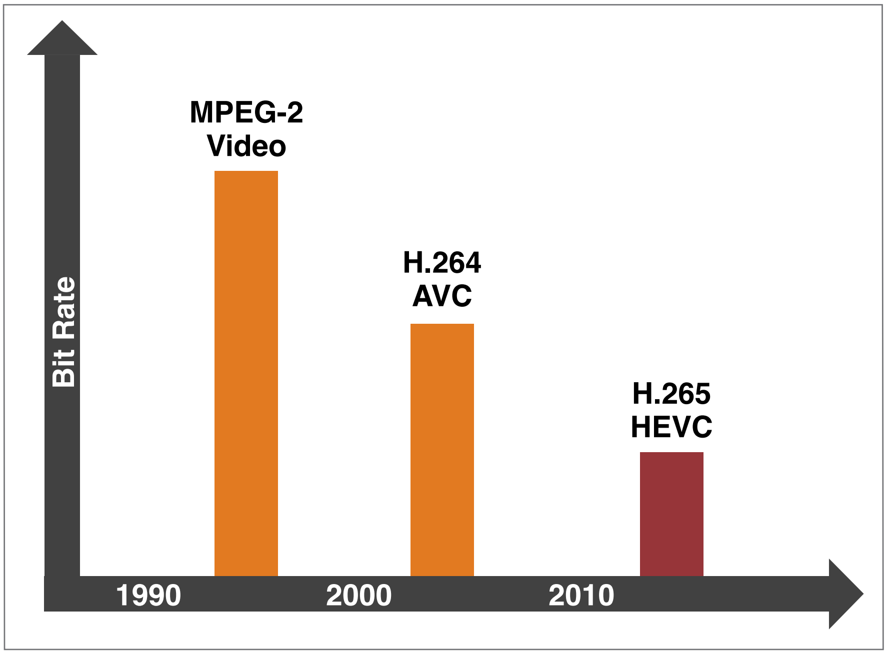


Figure 2 | Modern video CODECs like H.265 have double the compression of the previous generation H.264. Implemented in video-centric mobile phones running ARM-based CPUs, half of the bit-rate throughput is required. This doubles available channel bandwidth or halves the amount of CPU cycles required to stream video. (Courtesy ARM).


WHERE TECHNOLOGY
EXPERTS GATHER
Mil Tech Trends
Next-gen aviation systems see push for automation, multicore processors in the certification process
MARKET TRENDS, TECHNOLOGY
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Netflix, and other content providers realizes massive compression benefits while still maintaining high-def and soon ultra-high-def (4K) content.

Using MPEG-4 or newer H.265 (HEVC) compression on existing networks will free bandwidth, allowing portable, mobile, or even virtual CP access far from the front lines (Figure 2). The current 7th-generation Intel Core i7 Kaby Lake CPU has native H.265 CODECs built in. Small-form-factor systems consume as little as 35 watts (min) and can accept direct sensor input and output highly compressed video-over-IP to LAN ports.

Rackmount servers and their associated disk farms – a mainstay in tactical command post tents – have already been shrunk from 19-inch racks to shoebox-sized conduction-cooled chassis. The Army's Multi-Function Video Display (MVD) program out of the U.S. Army's Product Manager Mine Resistant Ambush Protected Vehicle Systems (PdM MRAP VS) mounts an Intel Xeon server with disk storage and video processing inside a Type II MRAP vehicle equipped with myriad EO/IR [electro-optic/infrared] sensors (Figure 3). It's not too far a stretch to imagine more boxes like these replacing a tentful of 19-inch racks or transit cases.

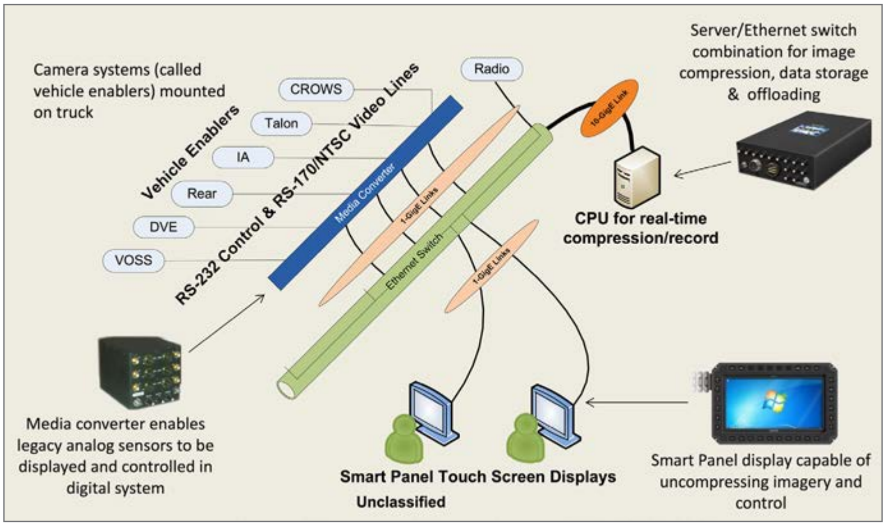


Figure 3 | The GMS S402-NV server (upper right) eliminates a rackmounted server in a Type II MRAP. Used in the Army's Multi-Function Video display program shown here, the small-form-factor server processes and distributes sensor video data as IP packets over a LAN. (Courtesy U.S. Army PdM MRAP VS and Night Vision Labs NVESD.)

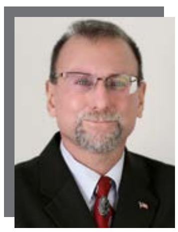
Figure 4 | A CH-47 sling loads a Humvee equipped with WIN-T. GD Mission Systems' TCN-Lite version further reduces the larger, stationary portions of WIN-T to mobile platforms. (Courtesy General Dynamics Mission Systems; U.S. Army photo by Sgt. Bradford Alex.)

Even the existing and already space-optimized WIN-T Increment 2 is being further reduced. The new Tactical Communications Nodte-Lite (TCN-Lite) migrates portions of the at-the-halt CP to an on-the-move convoy. It's mounted in Humvees and integrates both the terrestrial SATCOM of the stationary CP and line-of-sight connectivity (Figure 4).

Real threat, real progress, right now

With Russia and China actively pursuing more aggressive world policies and equipped with technology perhaps on par with U.S. systems, the race is on to change how America fights wars. The stationary Army command post is ripe for innovation, from a rapid "shoot and scoot" quick setup and tear down, to integrating the command-post function into separate battlefield systems, all the way to virtualizing it and moving it far away in a cloud-like architecture.

Technologies such as the latest COTS video compression, civilian 5G mobile networks, conduction-cooled small-form-factor systems, and deployed battlefield servers already exist and are ready to provide the Army and joint services with the new, progressive paradigm that's needed right now. **MES**



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General Micro Systems
www.gms4sbc.com

Faster power switches for aircraft safety: Going from milliseconds to microseconds

By Matthew Mishrikey, TE Connectivity

BLOG

In a few milliseconds, electrical arcing in aircraft wiring can release thousands of joules of energy. This is enough to ignite wire insulation, pierce hydraulic lines, and compromise critical flight-control subsystems.

The aviation industry urgently needs reliable arc-fault detection and mitigation measures. Going on decades now, academic and commercial research on the subject continues because arc detection is such a difficult problem to solve. Sometimes arc currents are indistinguishable from normal operating currents. Although arc fault circuit interrupters are commercially available for AC power systems, they are imperfect and prone to missed detections and nuisance tripping. Furthermore, AC arcing is a different phenomenon than DC arcing: DC detectors do not benefit from the repeated arc ignitions that arise from AC zero-current crossings.

Any detection solution will rely on fast circuit-breaking action to extinguish faults. For high-voltage, high-current, DC power systems, a new generation of solid-state power switches is now available to meet that need.

Conventional approach to power switching

The principal power-distribution switching elements in an aircraft are, conventionally, some form of mechanical switch. Generally, these are circuit breakers or contactors with over-current trip functionality. These devices are engineered to be high-performance and highly reliable. Nevertheless, even with design features to minimize turnoff time, a high current turnoff may last 30 to 50 milliseconds, an effective eternity in which an arc fault can precipitate a major failure.

This turnoff duration is dominated by the lifetime of another type of arcing – drawn arcing established between separating contacts. To minimize this event, high current electromechanical switches often include blowout coils, or blowout permanent magnets (exclusively for DC devices), which accelerate arc quenching. These features exploit the Lorentz force, acting on charged particles moving with velocity through a magnetic field. Arcs are pushed out to the edge of the contacts, then stretched until they extinguish.

While a stronger magnetic field will push the arc out faster, practical devices must contend with size and weight constraints. The larger the current, and the larger the loop inductance, the harder it will be to quench drawn arcs quickly.

Solid-state switching for faster arcing mitigation

Because of these challenges, certain applications benefit from arcless solid-state switching or arcless hybrid switching. Instead of opening a contact gap, a solid-state switch uses transistors to throttle current. This cutoff can happen very quickly – as brief as microseconds – minimizing damage from major arc-faults.

This speed comes with some important penalties:

- First, the cost. High-performance transistors are expensive, especially cutting-edge high-temperature, low on-resistance die made from silicon carbide. Further, some complex electronics are required for bias supplies and gate driving, at a minimum. These factors push the starting cost of a solid-state solution beyond that of a comparable electromechanical one.
- Second, the on- and off-resistances of solid-state devices are inferior to electromechanical ones. Paralleling more transistors will improve the on-resistance but will reduce the off-resistance (increasing leakage). On-state and switching losses can be significant; they also mandate external cooling to prevent transistors from reaching their maximum allowable junction temperatures (Tj,max). Transistors operating near or beyond Tj,max are likely to fail. Generated heat must be evacuated efficiently, requiring expensive packaging materials, which further drive up costs.

... SOLID-STATE DEVICES ARE BECOMING KEY ELEMENTS IN THE MODERNIZATION OF MILITARY AND COMMERCIAL AEROSPACE POWER DISTRIBUTION SYSTEMS.

By way of comparison, a 125 A DC solid-state power controller from TE Connectivity has a nominal on-resistance of 4 milliohms, producing 63 watts of dissipation. A comparable electromechanical contactor might have a contact resistance of 0.5 milliohms, yielding only 8 watts of contact loss, 14 watts if you include coil power. While 63 watts is impressively low for a solid-state switch at these breakdown voltage and current levels, it is still significantly larger than the loss of a conventional contactor. This is proving to be an acceptable tradeoff for customers who recognize that a 30-microsecond arc elimination will cause significantly less damage than a 30-millisecond one.

A best-of-both-worlds approach combines the two solutions. A hybrid contactor electrically straps solid-state transistors across the contacts of a standard contactor. The transistors are switched on during state transitions, effectively absorbing what would have been contact arcing energy. During a turn-on, this means no arcing during contact bounce, further extending contact life. When fully on, the on-resistance is simply the contact resistance. When fully off, the leakage is defined by the contacts and not by the transistors.

A well-designed hybrid contactor can switch faster than a conventional one, and without the cooling required by a solid-state-only solution. A hybrid part can also be smaller for the same rating, with no need for blowout hardware, and with smaller armature spring and drive coil. The primary disadvantage is that the cost for a hybrid contactor will be driven by its solid-state content.

With ever-increasing power requirements, aircraft need a new generation of faster, higher-performance power switches. As a result, solid-state devices are becoming key elements in the modernization of military and commercial aerospace power distribution systems.

__Matthew Mishrikey__ is Principal Engineer, TE Connectivity

www.te.com

Radar simulator with eight switchable delays in L, S, C, X, and Ku radar bands

The Series 3000 radar range simulator from Eastern OptX can be used for radar test to provide multiple programmable delays with front panel and/or remote computer control. Engineers leveraged electro-optics (EO) fiber-optic technology to overcome the shortcomings in projects that include acoustic, digital, and coaxial transmission delay such as quantization errors, triple transit time, and dispersion.

The radar range simulator features ultra-wide bandwidth, low loss, high isolation, and high dynamic range. It is available with time delays up to 500 µsec and a top-end frequency of 40 GHz. It has as many as eight switchable delays and is available in L, S, C, X, and Ku radar bands. Eastern OptX built the radar test system for applications such as radar target simulation, signal-processing extension of radar range sites, and phase noise measurements

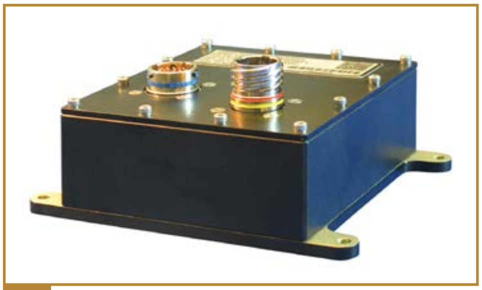
Eastern OptX | www.eastern-optx.com | www.mil-embedded.com/p374758

A mesh network for extreme environments

Rajant's BreadCrumb LX5 is a rugged wireless device – for building and expanding core mesh infrastructure – that forms a mesh network when used in conjunction with other BreadCrumb systems. The LX5 contains as many as four transceivers and six external antenna ports. It provides Ethernet and Wi-Fi access point interfaces to enable data, voice, and video applications. This solution can operate in extreme environmental conditions and has several mounting options. Users can build a reliable, resilient, MIMO-based, private wireless network that will support a wide range of connectivity requirements and integrate with an existing network infrastructure.

The BreadCrumb LX5 features include Rajant's patented InstaMesh networking software, enabling the network to adapt to rapidly deploy amid quickly- or constantly-moving network elements. It has multiple transceiver configurations for high levels of network reliability, redundancy, and diversity, and low levels of interference, congestion, and equipment outages. The system also supports several cryptographic options used for data and MAC-address encryption and per-hop, per-packet authentication.

Rajant | www.rajant.com | www.mil-embedded.com/p374759

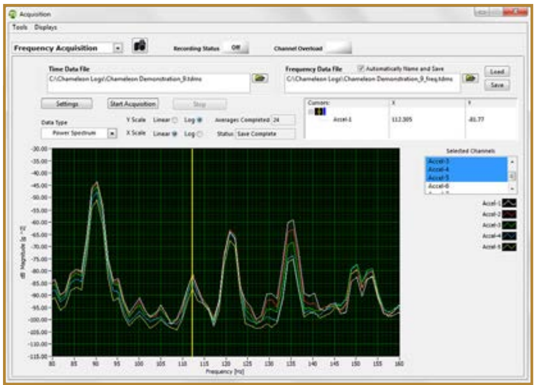


Video converter module extends life of airborne video components

Great River Technology (GRT) engineers developed the Video Converter Module (VCM) to extend the life of airborne video components by quickly linking them to ARINC 818 architecture. The VCM is matched to the user's ICD [interface control document] and can be certified to DO-254 and DO-160. It is a flyable, rugged version of GRT's Stand Alone Module, which has been tested in labs, simulators, and aircraft production facilities.

The system features include flight-ready, EMI-shielded VCM with a four-tab bracket that can be mounted four ways for flexibility. A flight-hardened VCM can be ordered for any one of the following standard configurations: DVI to ARINC 818, ARINC 818 to DVI, and ARINC 818 to VGA. In addition, custom analog conversions are also possible and include ARINC 818 to analog (NTSC, PAL, STANAG 3350, RS-170), and analog (NTSC, PAL, STANAG 3350, RS-170) to ARINC 818.

Great River Technology | www.greatrivertech.com | www.mil-embedded.com/p374760



Data-acquisition software solution for easy configuration

The Chameleon data acquisition (DAQ) software solution was built to provide power and flexibility with an easy-to-use interface. The tool is compatible with a wide variety of National Instruments controllers and data-acquisition modules so users can configure a system to meet their specific application requirements.

Chameleon's features include quick setup and operation; mixed sensor configurations including microphones, accelerometers, bridge sensors, thermocouples, RTDs, and current sensors; and single or multiple chassis configurations using MXI, USB, or Ethernet with cross-chassis time synchronization. It also enables data visualization including multiple traces and graphs, with live or prerecorded data. The system also features data logging at a rate less than the sample rate with on-the-fly logging rate update plus automatic retriggering for repeated measurements with incremental data file naming.

PVI Systems | www.pvisys.com | www.mil-embedded.com/p374768

Video systems enhances live feeds in real time

ZMicro's Insight video-enhancement system enhances live video feeds in real time to improve visibility in fog, rain, dust, smoke, underwater, and more. ZMicro leveraged the parallel-processing capabilities of an advanced field programmable gate array (FPGA) to host its algorithms, resulting in improved video quality in real time with no added latency. The latency is measured at less than 6 microseconds and is not discernible to the human eye.

The Insight system processes videos up to 1920 x 1080 resolution at 60Hz. It comes in a sealed box for use in rugged environments and the front LCD panel is available for immediate status update. The system features user adjustments via published API commands or remote Java client; image sharpening and enhancement; enhancement of surface and edge detail; color enhancement; chroma key functionality for video or text overlays; and selectable video enhancement viewing region.

ZMicro | www.zmicro.com | www.mil-embedded.com/p374769

4U flash storage array for high-performance databases

The FSAn-4 from One Stop Systems is used in data centers for accelerating high-performance databases, Hadoop clusters, and high-performance computing (HPC) applications with large data sets. The ruggedized field-ready FSAn-4R NVMe All-Flash Array is aimed at such uses as real-time HPC, high-speed data recording, analytics, and big data. It uses the highest-performance PCIe NVMe flash (eight PCIe 3.0 lanes) for double the bandwidth of 2.5-inch NVMe.

In addition, the array features hot-swap capabilities and a 4U MIL-STD ruggedized system. It also supports high-density PCIe NVMe flash – including up to 256 TB raw data. It also has four lightweight (each weighing less than 6.5 pounds) removable data canisters with capacities as high as 50 TB and supports as many as 5 million IOPS. The system also supports ISCSI, FC, and SRP protocols.

One Stop Systems | www.onestopsystems.com | www.mil-embedded.com/p374770

CONNECTING WITH MIL EMBEDDED

By Mil-Embedded.com Editorial Staff

CHARITY

Higher Ground

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

This issue we are highlighting Higher Ground, a 501(c)3 nonprofit organization that aims to help returned veterans and their families through recreational therapy and outdoors challenges to achieve what it calls "whole-life healing."

Higher Ground was founded in 1999 as an offshoot of a program begun in Idaho that coached skiers with disabilities how to use adaptive skis and specialized equipment. Program directors were dismayed to learn that of the 22 million veterans who live in the U.S., 22 die by suicide every day; one in three suffers from depression, anxiety, or other mental health challenges; and many family members and children of people with post-traumatic stress are likely to show PTSD symptoms of their own.

Recreational therapy for veterans and their families can take the form of skiing and other snow sports; boating, surfing, and white-water rafting; equine therapy; fishing, ropes courses, and hiking; or other sports including tennis, archery, and martial arts.

The organization runs recreational therapy programs in Sun Valley, Idaho; the Los Angeles area; and New York state. According to Higher Ground, the attendees take on new challenges and share experiences with others in their group. Once the participants head home, Higher Ground guarantees that they can stay active in recreation by providing the equipment and finances needed. The group also commits to three years of follow-up with the veteran and family, with check-ins, community support, and resources to aid them as they integrate back into their world.

For more information on Higher Ground, please visit www.highergroundusa.org.

WEBCAST

Leveraging open standards and C4ISR for multi-domain challenges in modern warfare

Sponsored by Elma and Pentek

For any military force, the key to victory is dominance in multiple battlefield domains – ground, sea, air, space, and now cyber. To achieve such dominance, militaries must leverage communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) technology across those domains.

In this webcast, listen to industry experts cover the ways in which embedded electronics and open standards enable superior C4ISR – from sensors to signal processing to real-time communications.

View archived webcast:
http://ecast.opensystemsmedia.com/816

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WHITE PAPER

Managing life cycle and network interoperability challenges on Navy platforms

By Rick Studley, chief technologist, Mercury Systems – Trusted Mission Solutions

The plethora of disparate computing elements within Navy systems means that each system has its own logistics tail and support requirements and carries its own set of expensive certifications. With this approach, the Navy loses the ability to leverage a truly common processing or display system, not just across the ship or platform, but also across the entire fleet.

In this white paper, consider how a common module library for naval systems – analogous to the NAVSEA Common Source Library – can facilitate ease of replacement; continue on the same path for integration, testing, and certification; and reduce life cycle costs while improving performance.

Read the white paper: https://bit.ly/2xmALQ8

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

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