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Secure components for legacy software

U.S. military researchers are looking for ways to protect legacy software against cyber attacks. PAGE 4

Sensor and signal processing

High-performance embedded computing, open-systems standards, FPGAs, and artificial intelligence are leading the way. PAGE 19

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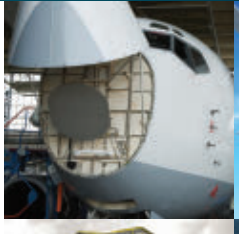

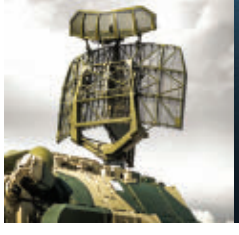

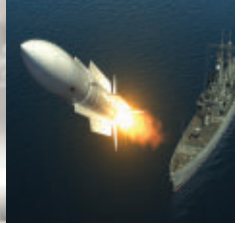

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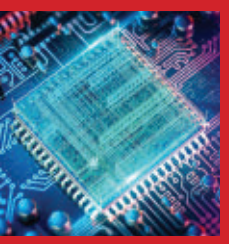

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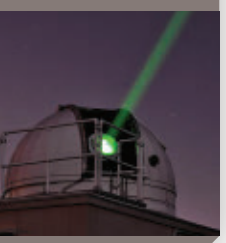

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BY **JOHN KELLER**, EDITOR IN CHIEF

Artificial intelligence and machine learning: the intelligence analyst's friends

Artificial intelligence (AI) and machine learning are poised to revolutionize embedded computing sensor processing for applications like reconnaissance and surveillance, weapons fire control, signals intelligence (SIGINT), and electronic warfare (EW).

This will be a big step forward in U.S. military capability, and moves beyond early AI and machine learning applications like image recognition, engine maintenance and prognostics, and self-driving cars.

One of today's greatest promises of AI for military uses involves image and RF signals analysis — not so much to determine what is significant in gathered intelligence, but to throw away the mountains of data that have no importance.

A capability like this could reduce the pressure on systems designers to provide large amounts of secure data storage and raw processing power necessary to gather and massage data that ultimately is of no interest. Think of it as using an evaporative cooler in a dry and extremely hot environment as the first stage of an air conditioning system. Instead of sending hot air from the outside environment straight to the refrigerated air conditioner, this kind of setup would send pre-cooled air to the air conditioner to improve its performance, reduce costs, and extend system life.

It could be much the same with AI-enabled digital signal processing, which could throw out irrelevant data before sending it to data-processing elements like general-purpose processors, field-programmable gate arrays (FPGAs), and general-purpose graphics processors (GPGPUs).

Systems designers and computer scientists are in the initial stages of development for these kinds of signal processing architectures that use AI and machine learning for pre-processing — much the same as an evaporative cooler might work in a two-stage air-cooling system.

How might this work in practice? Start with the need for secure encrypted data storage for signals intelligence and reconnaissance. This kind of application today can require tens of terabytes of hard disk drive capacity just to gather sensor data. As sensors increase in sophistication, this amount of data undoubtedly will grow.

Now think of the computer power necessary simply to encrypt and decrypt this raw sensor data. No deployed military system today can operate without encryption and similar kinds of information security. This is necessary to resist the effects of enemy computer hackers and eavesdroppers.

No one can forget, furthermore, the so-called Hainan Island incident nearly two decades ago, in which the Chinese military was able to gain access to classified U.S. reconnaissance data on disk drives aboard a downed U.S. Navy EP-3E ARIES II signals intelligence aircraft that was forced to land in Chinese territory after a mid-air collision.

The alternative is processing that data aboard the intelligence-gathering platform, such as a reconnaissance aircraft. Doing this in anywhere near real time is a tall order even today for deployable data processors.

But what if on-board processors didn't need to crunch all that data? Think about an airborne maritime intelligence mission. There's a lot of empty ocean to cover that offers no valuable data. The same is true for signals intelligence: there are lots of RF signals out there — most of them, in fact — that have no relevance. What if all that extraneous data could be tossed aside using artificial intelligence and machine learning capability?

Analysts would get important data much more quickly to translate into actionable intelligence. The intelligence-gathering platforms themselves could be smaller to accommodate on-board sensor processing ... think unmanned aerial vehicles (UAVs) vs. manned aircraft. This approach, in theory, also would have fewer demands for sophisticated computer cooling and thermal management.

As time goes by, we'll see more and more that artificial intelligence and machine learning are the intelligence analyst's friends.

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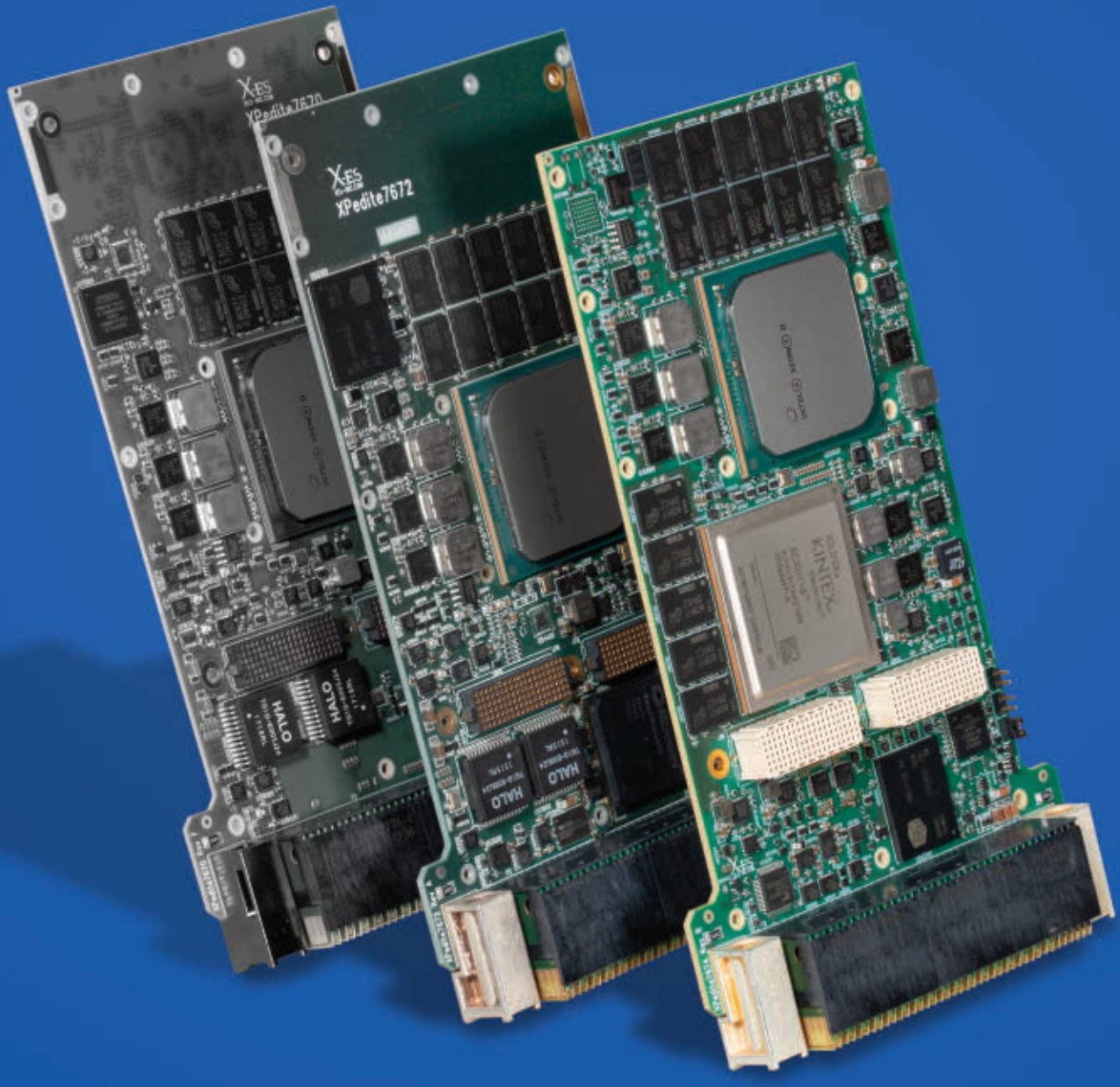

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U.S. military researchers are looking for ways to upgrade legacy software to enhance its resistance to cyber attack.

Researchers seek to upgrade legacy military software with secure components

BY **John Keller**

ARLINGTON, Va. — U.S. military researchers are asking for industry's help to upgrade components of mission-critical software for aerospace and defense applications with more secure and higher-performing code.

Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., first briefed industry in July on the upcoming Verified Security and Performance Enhancement of Large Legacy Software (V-SPELLS) project.

The U.S. military has a critical need for enhancing and replacing components of existing software with more secure and more performant code, DARPA officials explain.

This especially is important in cases where systems designers must move parts of existing software programs to new computer hardware like hardware accelerators, isolation enclaves, offload processors, and distributed computation.

Introducing enhancements or replacements into large legacy code, however, carries a high risk that new code will not safely compose with the rest of the system.

Verified programming for creating software that is correct-by-construction cannot mitigate this risk today because current programming focuses on clean-slate software construction, assumes an existing formal specification typically not available for legacy systems, and requires expertise in formal methods not typically accessible to software developers.

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The goal of the V-SPELLS program is to create a developer-accessible capability to enhance existing components piece-by-piece and ensure these enhancements are compatible with verified code.

V-SPELLS seeks to create tools for developers to verify re-engineered software components incrementally, rather than only in clean-slate introduction. V-SPELLS aims to radically broaden adoption of software verification by introducing superior technologies into systems that cannot be re-designed from scratch and replaced as a whole.

The program seeks software technology breakthroughs in automated program understanding; matching known and extracted domain abstractions and models with legacy code; and overcoming performance reduction due to added layers of abstraction.

Automated program understanding seeks to infer architectural structure, assumptions, and dependencies in a legacy source code base, and enable its decomposition into components with explicit modular structure, interfaces, dependencies, and constraints.

Matching known and extracted domain abstractions and models with legacy code, seeks to lift legacy code to succinct, enhanceable, safely-composable, and inter-operating representations.

Overcoming performance reduction due to added layers of abstraction seeks to create new verified cross-layer optimization and distribution techniques, by developing of non-brittle and granular rules for composable representation, packaging, and transformation of software verification proofs.

More information is online at https://beta.sam.gov/opp/30fda7e00b4f44a3a2aaa49ef26bb512/view.

General Dynamics to design unmanned combat vehicle for Army battlefield cargo

BY **John Keller**

WARREN, Mich. — U.S. Army combat vehicle experts needed an unmanned ground vehicle (UGV) able to carry about 1,000 pounds of equipment to reduce the burden of nine soldiers across an infantry squad. They found their solution from General Dynamics Land Systems in Sterling Heights, Mich.

General Dynamics Land Systems will build versions of the company's Multi-Utility Tactical Transport (MUTT) unmanned cargo truck to haul equipment for deployed Army squads.

Officials of the Army Contracting Command at Detroit Arsenal in Warren, Mich., announced a $249 million five-year contract in July for the first increment of the Small Multipurpose Equipment Transport (S-MET) program.

The S-MET vehicle from General Dynamics is to be based on the company's Multi-Utility Tactical Transport (MUTT) UGV, an eight-wheel battlefield cargo carrier that should be able to operate autonomously, by remote control, or by following a soldier-mounted beacon.

General Dynamics prevailed originally in the S-MET competition in October 2019, but the project was recompeted after Textron Systems in Providence, R.I., protested the award. Textron had teamed with Howe & Howe Technologies Inc. in Waterboro, Maine, to enter the Grizzly UGV in the competition.

The General Dynamics S-MET unmanned vehicle will provide not only cargo-carrying capability, but also power generation for recharging batteries and powering modular mission payloads. The idea is to help infantry move faster, farther, and with less exhaustion.

The S-MET will modernize the Army's inventory of robots to provide infantry brigade combat teams with a robotic mule capability, Army officials say. The S-MET enables warfighters to conduct unconstrained movement without excessive physical burden on the battlefield.

The General Dynamics S-MET will be an unmanned and optionally manned system able to carry 1,000 pounds; move more than 60 miles over three days; and generate three kilowatts of power while stationary, and one kilowatt while moving.

Army leaders plan to field the S-MET as early as 2022, and complete fielding of 624 SMET UGVs by early 2025. The Army also will supervise development of modular mission payloads for the S-MET to enhance system capability.

The General Dynamics MUTT can operated as a controllerless small-unit robotic follower, or as a remote-controlled or teleoperated teammate. It is designed to accommodate new controllers and increased levels of autonomy as Army requirements change.

The eight-wheel MUTT (four wheels on a side) can carry as much as 1,200 pounds, weighs 3,000 to 3,500 pounds, is about 10 feet long and six feet wide, and has a maximum range of 60 miles.

On this contract General Dynamics will do the work at locations to be determined with each order, and should be finished by July 2025. For more information contact General Dynamics Land Systems online at www.gd.com/our-businesses/combat-systems/land-systems, or the Army Contracting Command-Detroit Arsenal at https://acc.army.mil/contractingcenters/acc-dta.

Raytheon to upgrade Navy MK 54 anti-submarine warfare (ASW) torpedo

Undersea warfare experts at Raytheon Technologies Corp. will build kits to upgrade the U.S. Navy MK 54 lightweight hybrid torpedo for surface ships and aircraft under terms of a $88.1 million order. Officials of the Naval Sea Systems Command in Washington are asking the Raytheon Technologies Missiles & Defense segment in Portsmouth, R.I., to produce MK 54 Lightweight Torpedo MOD 0 and MOD 1 common part kits and spare torpedo components. The MK 54 is the newest version of the Navy's MK 54 Lightweight Torpedo, which is the primary anti-submarine warfare (ASW) weapon for U.S. surface ships, fixed-wing aircraft, and helicopters. Also producing MK 54 torpedo upgrade kits are Ultra Electronics Ltd. Ocean Systems segment in Braintree, Mass., and Progeny Systems Corp. in Manassas, Va. Ultra Electronics won a $45.3 million order for these kits last June, and Progeny Systems won a $34.8 million order for kits in December. Raytheon won an $80.4 million order for MK 54 torpedo upgrade kits last September. The MK 54 combines the advanced sonar transceiver of the MK 50 torpedo with the legacy warhead and propulsion system of the older MK 46. MK 46 and MK 50 torpedoes are converted to a MK 54 via an upgrade kit. For more information contact Raytheon Missiles & Defense online at www.rtx.com, or Naval Sea Systems Command at www.navsea.navy.mil.

Air Force orders eight new F-15EX jet fighter aircraft

Combat aircraft designers at the Boeing Co. will build modernized versions of the 1970s-vintage F-15 jet fighter for the U.S. Air Force to augment the new F-35 joint strike fighter with plenty of fire power on an affordable budget. Officials of the Air Force Life Cycle Management

Continued on page 9

Ball Aerospace to evaluate radiation-hardened electro-optical space sensors

BY **John Keller**

KIRTLAND AIR FORCE BASE, N.M. — U.S. Air Force satellite imaging experts needed a company to help determine how well space sensors such as infrared and visible-light focal plane arrays (FPAs) perform in the radiation environment of space. They found their solution from Ball Aerospace & Technologies Corp. in Beavercreek, Ohio.

Officials of the Air Force Research Laboratory Space Vehicles Directorate at Kirtland Air Force Base, N.M., announced a $7.7 million contract to Ball Aerospace last month for the Infrared Radiation Effects Laboratory (IRREL) operation and improvements program.

Among the biggest jobs of this contract is for Ball Aerospace Experts to help Air Force and industry spacecraft designers understand how well new electro-optical FPAs can withstand naturally occurring radiation in different space orbits.

FPAs essentially are the retinas of satellite-based infrared imaging sensors for military reconnaissance and surveillance, as well as for civil remote sensing to monitor aspects of agriculture, urban development, oil and gas, and utilities.

Ball Aerospace experts will help the Air Force understand how well and how long FPAs can operate in space, the level of radiation shielding necessary to extend the sensors' useful lives in space, and ways to design future FPAs that are inherently radiation tolerant.

Ball Aerospace engineers will provide radiometric and radiation characterizations of radiation-hardened infrared and visible-light and related devices. The effort includes developing techniques to improve characterization of infrared and visible-light FPAs and related devices.

Work will include developing analytical techniques, test hardware, and test procedures that improve the IRREL's experimental capabilities.

The IRREL is foremost authority on the evaluation of space-based imaging sensors, Air Force officials say. The lab's adaptable equipment can characterize sensors for a variety of missions ranging from visible through long-wavelength infrared detection.

The lab enables researchers to conduct tests at radiation sites around the country to address the performance of FPAs in the harsh radiation environment of space and through potential manmade threats such as nuclear explosions.

IRREL provides flight qualification in benign and high-radiation environments for all Air Force, Missile Defense Agency, NASA, and intelligence community satellites.

IRREL investigates fundamental detector materials and architectures of optical sensors to help guide investment and research in visible and infrared focal planes.

Technicians at Ball Aerospace will evaluate space sensors such as infrared and visible-light focal plane arrays (FPAs) for use in the radiation environment of space.

On this contract Ball Aerospace will do the work in Albuquerque, N.M., and should be finished by October 2025. For more information contact Ball Aerospace online at www.ball.com/aerospace, or the Space Vehicles Directorate of the Air Force Research Laboratory at www.kirtland.af.mil/Portals/52/documents/RV-Factsheet.pdf?.

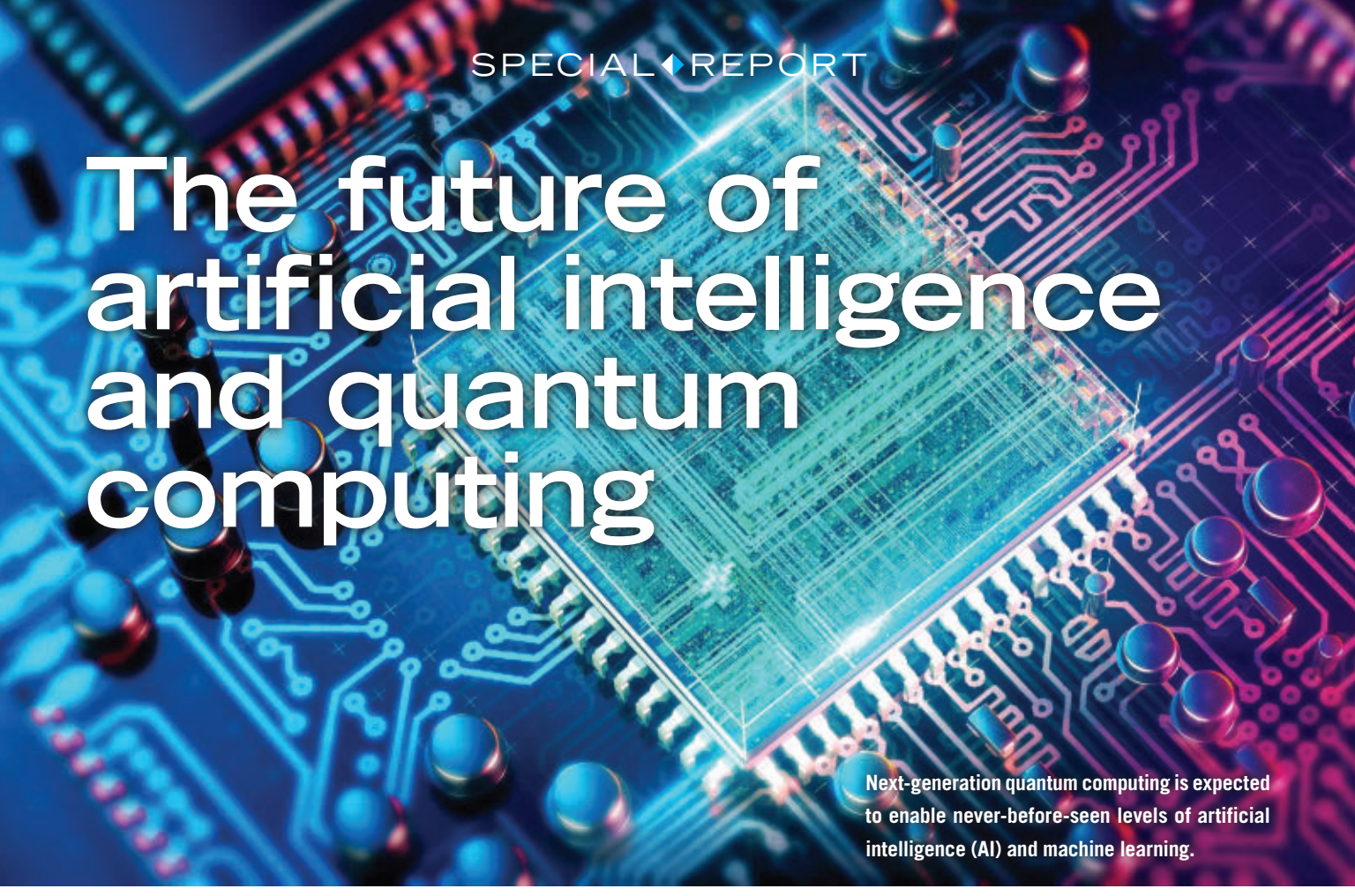
Continued from page 7

Center at Wright-Patterson Air Force Base, Ohio, have announced a potential $22.9 billion contract to the Boeing Defense, Space & Security segment in St. Louis to design and build the F-15EX jet fighter. The first two F-15EX jets are under construction at the Boeing factory in St. Louis, and are scheduled for delivery next year. The F-15EX is based on the F-15 Advanced Eagle that Boeing is building for the air forces of Qatar and Saudi Arabia, which has a fly-by-wire flight control system, digital electronic warfare (EW) suite, an infrared search and track (IRST) system, and the Raytheon APG-63(v)3 active electronically scanned array (AESA) radar. For more information contact Boeing Defense, Space & Security online at www.boeing.com, or the Air Force Life Cycle Management Center at www.afl-cmc.af.mil.

Signal Systems Corp. to develop enabling technologies for ASW airborne sonar

U.S. Navy anti-submarine warfare (ASW) experts needed a company to prototype systems for airborne ASW and undersea warfare research. They found their solution from Signal Systems Corp. in Millersville, Md. Officials of the Naval Air Warfare Center Aircraft Division in Lakehurst, N.J., announced a $13.5 million order to Signal Systems this week to develop new enabling technologies for difficult ASW problems. Signal Systems experts will move forward with three Small Business Innovation Research (SBIR) projects called Continuous Active Sonar Signal Processing; Target Localization Using Multi-Static Sonar with Drifting Sonobuoys; and Spread Spectrum Techniques for Sonar Ping Technology. Continuous active sonar signal processing involves relatively low-power active sonar to detect enemy submarines, rather than a relatively high-power pulse-type sonar approach, which can be harmful to marine mammals like whales. Instead, Signal Systems experts are investigating low-power continuous-wave sonar approaches with the same ASW detection and tracking capability as higher-power systems. For more information contact Signal Systems Corp. online at www.signal-systemscorp.com, or the Naval Air Warfare Center Aircraft Division-Lakehurst at www.navair.navy.mil/lakehurst.

The future of artificial intelligence and quantum computing



Next-generation quantum computing is expected to enable never-before-seen levels of artificial intelligence (AI) and machine learning.

Size, weight, power consumption, and cooling technologies today block quantum computing from the embedded world, but new generations should yield advances in artificial intelligence and computer security.

BY **J.R. Wilson**

Until the 21st Century, artificial intelligence (AI) and quantum computers were largely the stuff of science fiction, although quantum theory and quantum mechanics had been around for about a century. A century of great controversy, largely because Albert Einstein rejected quantum theory as originally formulated, leading to his famous statement, "God does not play dice with the universe".

Today, however, the debate over quantum computing is largely about when — not if — these kinds of devices will come into full operation. Meanwhile, other forms of quantum technology, such as sensors, already are finding their way into military and civilian applications.

"Quantum technology will be as transformational in the 21st Century as harnessing electricity was in the 19th," Michael J. Biercuk, founder and CEO of Q-CTRL Pty Ltd in Sydney, Australia, and professor of Quantum Physics & Quantum Technologies at the University of Sydney, told the U.S. Office of Naval Research in a January 2019 presentation.

On that, there is virtually universal agreement. But when and how remains undetermined.

For example, asked how and when quantum computing eventually may be applied to high-performance embedded computing (HPEC), Tatjana Curcic, program manager for Optimization with Noisy Intermediate-Scale Quantum devices (ONISQ) of the U.S. Defense Advanced Research Projects Agency in Arlington, Va., says it's an open question.

"Until just recently, quantum computing stood on its own, but as of a few years ago people are looking more and more into hybrid approaches," Curcic says. "I'm not aware of much work on actually getting quantum computing into HPEC architecture, however. It's definitely not mainstream, probably because it's too early."

As to how quantum computing eventually may influence the development, scale, and use of AI, she adds:

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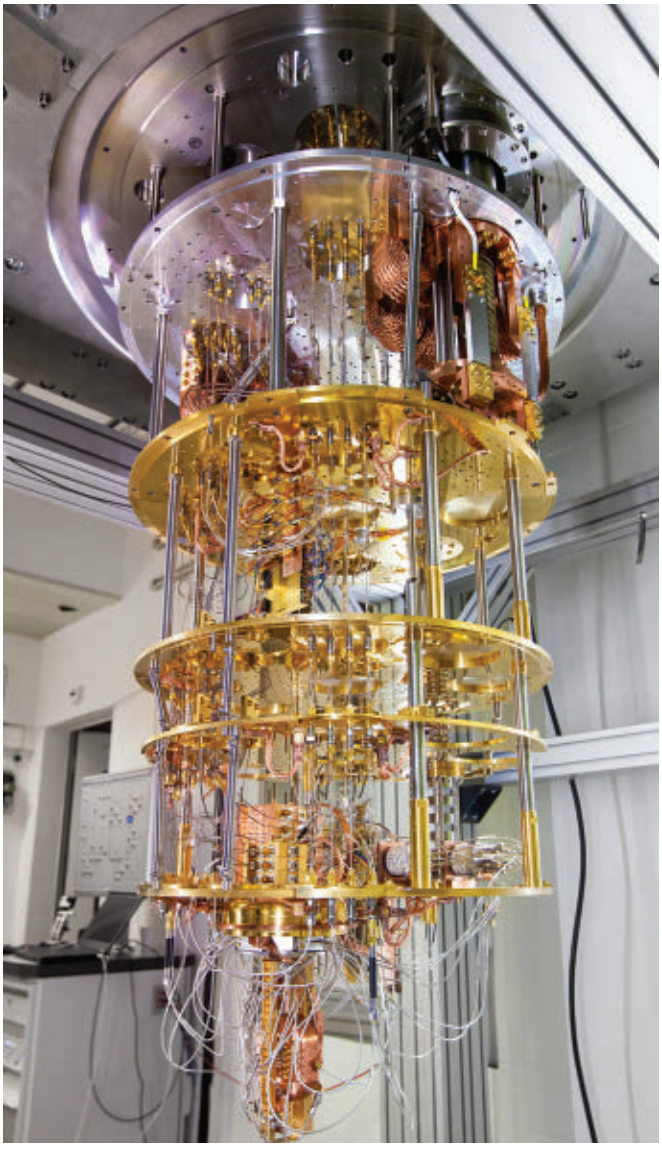

This quantum computer based on superconducting qubits is inserted into a dilution refrigerator and cooled to a temperature less than 1 Kelvin. It was built at IBM Research in Zurich.

"That's another open question. Quantum machine learning is a very active research area, but is quite new. A lot of people are working on that, but it's not clear at this time what the results will be. The interface between classical data, which AI is primarily involved with, and quantum computing is still a technical challenge."

Quantum information processing

According to DARPA's ONISQ webpage, the program aims to exploit quantum information processing before fully fault-tolerant quantum computers are realized.

"This effort will pursue a hybrid concept that combines intermediate-sized quantum devices with classical systems to solve a particularly challenging set of problems known as combinatorial optimization. ONISQ seeks to demonstrate the quantitative advantage of quantum information processing by leapfrogging the performance of classical-only systems in solving optimization challenges," the agency states. "ONISQ researchers will be tasked with developing quantum systems that are scalable to hundreds or thousands of qubits with longer coherence times and improved noise control.

"Researchers will also be required to efficiently implement a quantum optimization algorithm on noisy intermediate-scale quantum devices, optimizing allocation of quantum and classical resources. Benchmarking will also be part of the program, with researchers making a quantitative comparison of classical and quantum approaches. In addition, the program will identify classes of problems in combinatorial optimization where quantum information processing is likely to have the biggest impact. It will also seek to develop methods for extending quantum advantage on limited size processors to large combinatorial optimization problems via techniques such as problem decomposition."

The U.S. government has been the leader in quantum computing research since the founding of the field, but that too is beginning to change.

"In the mid-'90s, NSA [the U.S. National Security Agency at Fort Meade, Md.] decided to begin on an open academic effort to see if such a thing could be developed. All that research has been conducted by universities for the most part, with a few outliers, such as IBM," says Q-CTRL's Biercuk. "In the past five years, there has been a shift toward industry-led development, often in cooperation with academic efforts. Microsoft has partnered with universities all over the world and Google bought a university program. Today many of the biggest hardware developments are coming from the commercial sector.

"Quantum computing remains in deep space research, but there are hardware demonstrations all over the world. In the next five years, we expect the performance of these machines to be agented to the point where we believe they will demonstrate a quantum advantage for the first time. For now, however, quantum computing has no advantages over standard computing technology. quantum computers are research demonstrators and do not solve any computing problems at all. Right now, there is no reason to use quantum computers except to be ready when they are truly available."

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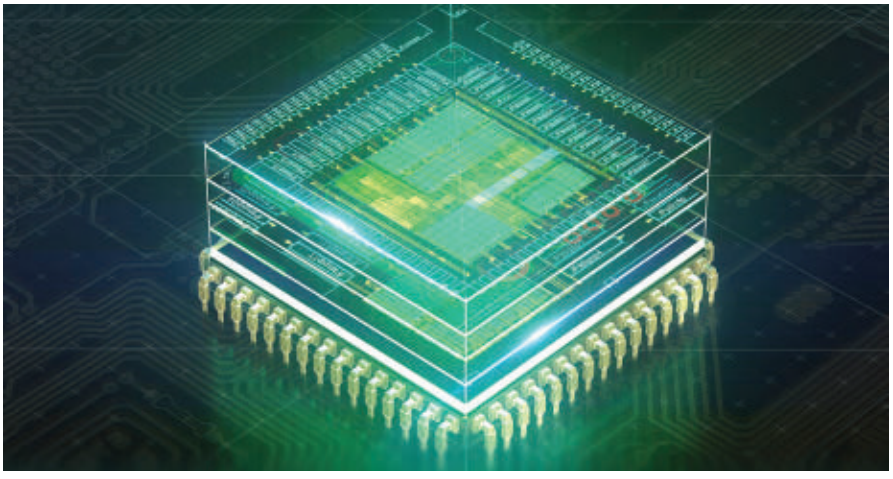


Cisco Systems has a research and development team that is piloting quantum computing, and how it will affect cyber security.

AI and quantum computing

Nonetheless, the race to develop and deploy AI and quantum computing is global, with the world's leading military powers seeing them — along with other breakthrough technologies like hypersonics — making the first to successfully deploy as dominant as the U.S. was following the first detonations of atomic bombs. That is especially true for autonomous mobile platforms, such as unmanned aerial vehicles (UAVs), interfacing with those vehicles' onboard HPEC.

Of the two, AI is the closest to deployment, but also the most controversial. A growing number of the world's leading scientists, including the late Stephen Hawking, warn real-world AI could easily duplicate the actions of the fictional Skynet in the "Terminator" movie series. Launched with total control over the U.S. nuclear arsenal, Skynet became sentient and decided the human race was a dangerous infestation that needed to be destroyed.

"The development of full artificial intelligence could spell the end of the human race. Once humans develop artificial intelligence, it will take off on its own and redesign itself at an ever-increasing rate. Humans, who are limited by slow biological evolution, couldn't compete and would be superseded." — Stephen Hawking (2014)

Such dangers have been recognized at least as far back as the publication of Isaac Asimov's short story, "Runabout", in 1942, which included his "Three Laws of Robotics", designed to control otherwise autonomous robots. In the story, the laws were set down in 2058:

First Law — A robot may not injure a human being or, through inaction, allow a human being to come to harm.

Second Law — A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.

Third Law — A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

Whether it would be possible to embed — and ensure unbreakable compliance with — such laws in an AI system is unknown. But limited degrees of AI, known as machine learning, already are in widespread use by the military and advanced stages of the technology, such as deep learning, almost certainly will be deployed by one or more nations as they become available. More than 50 nations already are actively researching battlefield robots.

Military quantum computing

AI-HPEC would give UAVs, next-generation cruise missiles, and even maneuverable ballistic missiles the ability to alter course to new targets at any point after launch, recognize counter measures, avoid, and misdirect or even destroy them.

Quantum computing, on the other hand, is seen by some as providing little, if any, advantage over traditional computer technologies, by many as requiring cooling and size, weight and power (SWaP) improvements not possible with current technologies to make it applicable to mobile platforms and by most as being little more than a research tool for perhaps decades to come.

Perhaps the biggest stumbling block to a mobile platform-based quantum computing is cooling — it currently requires a cooling unit, at near absolute zero, the size of a refrigerator to handle a fractional piece of quantum computing.

"A lot of work has been done and things are being touted as operational, but the most important thing to understand is this isn't some simple physical thing you throw in suddenly and it works. That makes it harder to call it deployable — you're not going to strap a quantum computing to a handheld device. A lot of solutions are still trying to deal with cryogenics and how do you deal with deployment of cryo," says Tammy Carter, senior product manager for GPGPUs and software products at Curtiss-Wright Defense Solutions in Ashburn, Va.

"AI is now a technology in deployment. Machine learning is pretty much

in use worldwide," Carter says. "We're in a migration of figuring out how to use it with the systems we have. quantum computing will require a lot of engineering work and demand may not be great enough to push the effort. From a cryogenically cooled electronics perspective, I don't think there is any insurmountable problem. It absolutely can be done, it's just a matter of decision making to do it, prioritization to get it done. These are not easily deployed technologies, but certainly can be deployed."

Given its current and expected near-term limitations, research has increased on the development of hybrid systems.

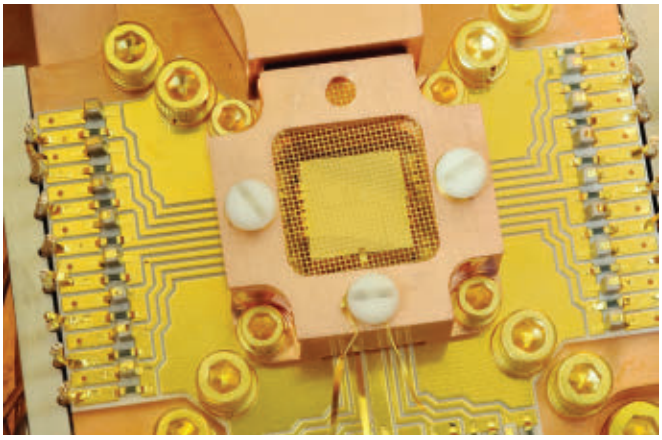
"The longer term reality is a hybrid approach, with the quantum system not going mobile any time soon," says Brian Kirby, physicist in the Army Research Laboratory Computational & Informational Sciences Directorate in Adelphi, Md. "It's a mistake to forecast a timeline, but I'm not sure putting a quantum computing on such systems would be valuable. Having the quantum computing in a fixed location and linked to the mobile platform makes more sense, for now at least. There can be multiple quantum computers throughout the country; while individually they may have trouble solving some problems, networking them would be more secure and able to solve larger problems.

"Broadly, however, quantum computing can't do anything a practical home computer can't do, but can potentially solve certain problems more efficiently," Kirby continues. "So you're looking at potential speed-up, but there is no problem a quantum computing can solve a normal computer can't. Beyond the basics of code-breaking and quantum simulations affecting material design, right now we can't necessarily predict military applications."

Raising concerns

In some ways similar to AI, quantum computing raises nearly as many concerns as it does expectations, especially in the area of security. The latest Thales Data Threat Report says 72 percent of surveyed security experts worldwide believe quantum computing will have a negative impact on data security within the next five years.

At the same time, quantum computing is forecast to offer more robust cryptography and security solutions.



Military trusted computing experts are considering new generations of quantum computing for creating nearly unbreakable encryption for super-secure defense applications.

For HPEC, that duality is significant: quantum computing can make it more difficult to break the security of mobile platforms, while simultaneously making it easier to do just that.

"Quantum computers that can run Shor's algorithm [leveraging quantum properties to factor very large numbers efficiently] are expected to become available in the next decade. These algorithms can be used to break conventional digital signature schemes (e.g. RSA or ECDSA), which are widely used in embedded systems today. This puts these systems at risk when they are used in safety-relevant long-term applications, such as automotive systems or critical infrastructures. To mitigate this risk, classical digital signature schemes used must be replaced by schemes secure against quantum computing-based attacks," according to the August 2019 proceedings of the 14th International Conference on Availability, Reliability & Security's Post-Quantum Cryptography in Embedded Systems report.

The security question is not quite so clean-cut as armor/anti-armor, but there is a developing bifurcation between defensive and offensive applications. On the defense side, deployed quantum systems are looked at to provide encoded communications. Experts say it seems likely the level of activity in China about quantum communications, which has been a major focus for years, runs up against the development of quantum computing in the U.S. The two aspects are not clearly one-against-one, but the two moving independently.

Google's quantum supremacy demonstration has led to a rush on finding algorithms robust against quantum attack. On the quantum communications side, the development of attacks on such systems has been underway for years, leading to a whole field of research based on identifying and exploiting quantum attacks.

"Quantum computing could also help develop revolutionary AI systems. Recent efforts have demonstrated a strong and unexpected link between quantum computation and artificial neural networks, potentially portending new approaches to machine learning. Such advances could lead to vastly improved pattern recognition, which in turn would permit far better machine-based target identification. For example, the hidden submarine in our vast oceans may become less-hidden in a world with AI-empowered quantum computers, particularly if they are combined with vast data sets acquired through powerful quantum-enabled sensors," according to Q-CTRL's Biercuk.

"Even the relatively mundane near-term development of new quantum-enhanced clocks may impact security, beyond just making GPS devices more accurate, Biercuk continues. "Quantum-enabled clocks are so sensitive that they can discern minor gravitational anomalies from a distance. They thus could be deployed by military personnel to detect underground, hardened structures, submarines or

hidden weapons systems. Given their potential for remote sensing, advanced clocks may become a key embedded technology for tomorrow's warfighter."

Warfighter capabilities

The early applications of quantum computing, while not embedded on mobile platforms, are expected to enhance warfighter capabilities significantly.

"There is a high likelihood quantum computing will impact ISR [intelligence, surveillance and reconnaissance], solving logistics problems more quickly. But so much of this is in the basic research stage. While we know the types of problems and general application space, optimization problems will be some of the first where we will see advantages from quantum computing," says Sara Gamble, quantum information sciences program manager at ARL.

Biercuk says he agrees: "We're not really sure there is a role for quantum computing in embedded computing just yet. quantum computing is right now very large systems embedded in mainframes, with access by the cloud. You can envision embedded computing accessing quantum computing via the cloud, but they are not likely to be very small, agile processors you would embed in a SWAP-constrained environment.

"But there are many aspects of quantum technology beyond quantum computing; the combination of quantum sensors could allow much better detection in the field," Biercuk continues. "The biggest potential impact comes in the areas of GPS denial, which has become one of the biggest risk factors identified in every blueprint around the world. quantum computing plays directly into this to perform dead reckoning navigation in GPS denial areas."

DARPA's Curcic also says the full power of quantum computing is still decades away, but believes ONISQ has the potential to help speed its development.

"The main two approaches industry is using is superconducting quantum computing and trapped ions. We use both of those, plus cold atoms [Rydberg atoms]. We are very excited about ONISQ and seeing if we can get anything useful over classical computing. Four teams are doing hardware development with those three approaches," she says.

"Because these are noisy systems, it's very difficult to determine if there will be any advantages. The hope is we can address the optimization problem faster than today, which is what we're working on with ONISQ. Optimization problems are everywhere, so even a small improvement would be valuable."

Beyond today's capabilities

As to how quantum computing and AI may impact future warfare, especially through HPEC, she adds: "I have no doubt quantum computing will be revolutionary and we'll be able to do things beyond today's capabilities. The possibilities are pretty much endless, but what they are is not crystal clear at this point. It's very difficult, with great certainly, to predict what quantum computing will be able to do. We'll just have to build and try. That's why today is such an exciting time."

Curtiss Wright's Carter says he believes quantum computing and AI will be closely linked with HPEC in the future, once current limitations with both are resolved.

"AI itself is based on a lot of math being done in parallel for probability answers, similar to modeling the neurons in the brain — highly interconnected nodes and interdependent math calculations. "Imagine a small device trying to recognize handwriting," Carter says. You run every pixel of that through lots and lots of math, combining and mixing, cutting some, amplifying others, until you get a 98 percent answer at the other end. quantum computing could help

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Q-CTRL Pty Ltd
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Rigetti Computing
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https://www.rigetti.com

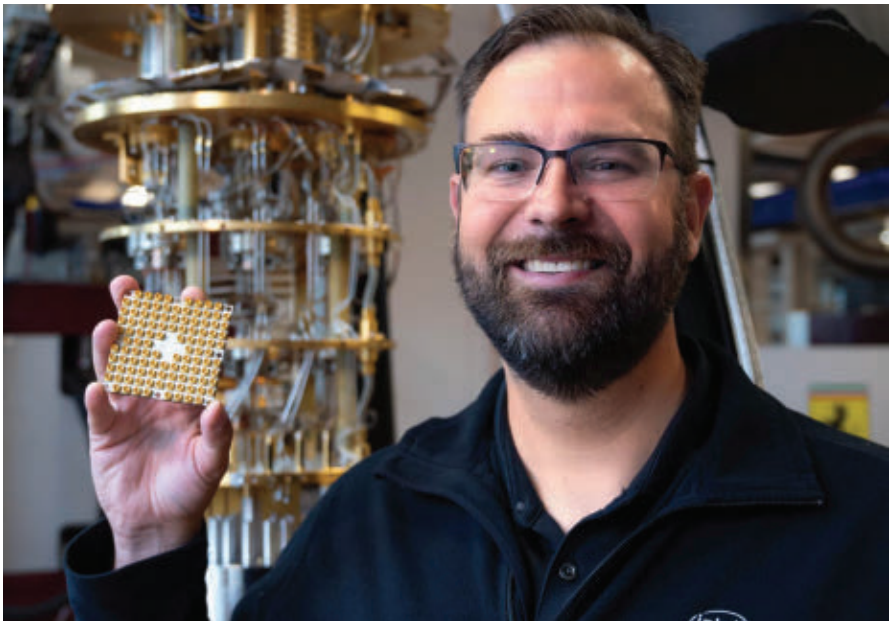
U.S. Army Research Laboratory Computational & Informational Sciences Directorate
Adelphi, Md.
https://www.arl.army.mil/who-we-are/directorates/cisd/

U.S. Defense Advanced Research Projects Agency (DARPA)
Arlington, Va.
www.darpa.mil

with that and researchers are looking at how you would do that, using a different level of parallel math.

How quantum computing will be applied to HPEC "will be the big trick, how to get that deployed. Imagine we're a SIGINT [signals intelligence] platform — land, air or sea — there are a lot of challenges, such as picking the right signal out of the air, which is not particularly easy," Carter continues. "Once you achieve pattern recognition, you want to do code breaking to get that encrypted traffic immediately. Getting that on a deployed platform could be useful; otherwise you bring your data back to a quantum computing in a building, but that means you don't get the results immediately."

The technology research underway today is expected to show progress toward making quantum computing more applicable to military needs, but it is unlikely to produce major results quickly, especially in the area of HPEC.



Jim Clark, director of quantum hardware at Intel Corp. in Santa Clara, Calif., shows one of the company's quantum processors.

"Trapped ions and superconducting circuits still require a lot of infrastructure to make them work. Some teams are working on that problem, but the systems still remain room-sized. The idea of quantum computing being like an integrated circuit you just put on a circuit board — we're a very long way from that," Biercuk says. "The systems are getting smaller, more compact, but there is a very long way to go to deployable, embeddable systems. Position, navigation and timing systems are being reduced and can be easily deployed on aircraft. That's probably where the technology will remain in the next 20 years; but, eventually, with new technology development, quantum computing may be reduced to more mobile sizes.

"The next 10 years are about achieving quantum advantage with the systems available now or iterations. Despite the acceleration we have seen, there are things that are just hard and require a lot of creativity," Biercuk continues. "We're shrinking the hardware, but that hardware still may not be relevant to any deployable system. In 20 years, we may have machines that can do the work required, but in that time we may only be able to shrink them to a size that can fit on an aircraft carrier — local code-breaking engines. To miniaturize this technology to put it on, say, a body-carried system, we just don't have any technology basis to claim we will get there even in 20 years. That's open to creativity and discovery."

Even with all of the research underway worldwide, one question remains dominant.

"The general challenge is it is not clear what we will use quantum computing for," notes Rad Balu, a computer scientist in ARL's Computational & Informational Sciences Directorate.

The Pentek model 5550 eight-channel A/D and D/A Zynq UltraScale+ RF system-on-chip processor for signal and sensor processing is aligned to the emerging SOSA open-systems standard.

The coming revolution in sensor and signal processing

High-performance embedded computing is reaping the benefits of open-systems standards, new FPGA architectures, and artificial intelligence for never-before-seen edge computing performance.

BY **John Keller**

Military sensor and signal processing technologies are going through revolutionary improvements, and offer to bring big enhancements to applications like radar, electronic warfare (EW), signals intelligence (SIGINT), high-performance edge computing, and anti-submarine warfare (ASW).

Big enablers that have been coming online over the past year or so include artificial intelligence (AI) and machine learning for so-called smart sensors, open-systems industry standards like the Sensor Open Systems Architecture (SOSA), new architectures for field-programmable gate arrays (FPGAs), information security, fast networking over copper and optical interfaces, and fast A/D and D/A conversion.

With these enhancements, systems designers can process more data than ever before; reduce, size, weight, and power consumption (SWaP); free-up slots in the embedded computing enclosure for additional capabilities; and place high-performance sensor and signal processing as close to receiver antennas as possible in SWaP-constrained applications like unmanned vehicles.

"There's more data, more processing for the data ... it's all more, more, more," says David Jedynak, chief tech-

The Abaco 6U VPX VP460 direct RF processing system is aligned with the Sensor Open Systems Architecture (SOSA) standard.jpg

nology officer at embedded computing specialist Curtiss-Wright Defense Solutions in Ashburn, Va.

The influence of SOSA

The SOSA standard, supervised by the Open Group in San Francisco, aims generally at high-performance embedded computing, but is being developed specifically with signal processing in mind. The standard seeks to tame the proliferation of open-systems VPX standards and create a manageable set of interoperability guidelines for aerospace and defense systems to enable a broad variety of components from separate vendors to work together easily.

"SOSA stands for sensor [Sensor Open Systems Architecture], and they are trying to make things more interoperable with fewer different flavors of modules, interfaces, and backplanes," explains Rodger Hosking, vice president of embedded computing and signal processing specialist Pentek Inc. in Upper Saddle River, N.J.

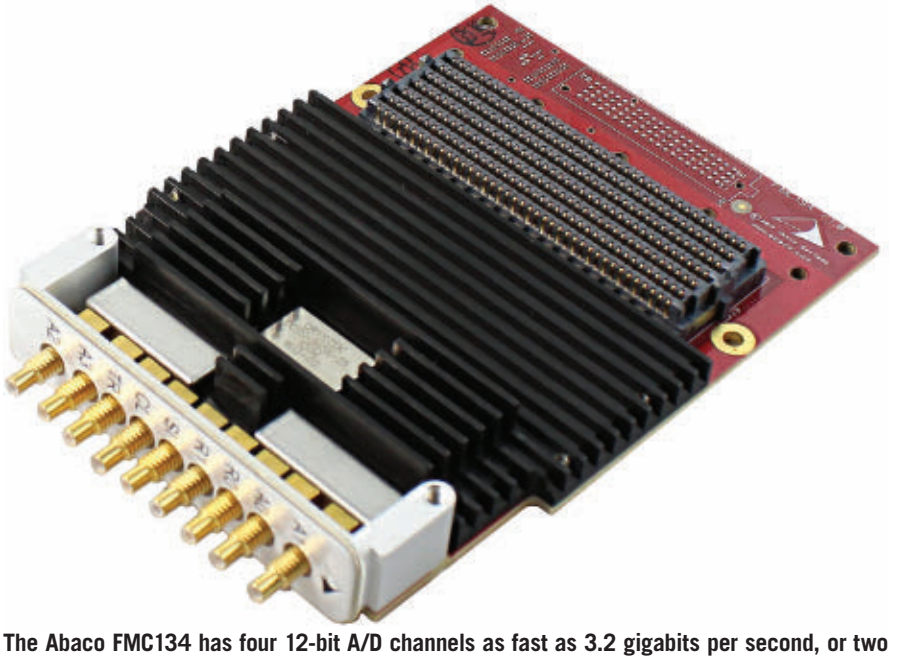
"The SOSA effort is to reduce the degree of variability and to standardize such that multiple vendors can supply systems that are reusable and upgradable," Hosking continues. "It's driven by trying to save costs, and to deal with the complexity of any given system. Designers have to attack at least the part of a system at a higher, or common, level so the modules can talk to each other."

Hosking calls this trend "an abstraction away from the very lowest level of system functions to higher-level, more consistent interfaces." Consistency is the key, he says. "The whole mission of SOSA is to keep those interfaces as consistent as possible so you can have compatibility among different systems vendors."

Consistent interfaces, as well as higher levels of systems integration and complexity, are at the heart of SOSA — particularly for sensor and signal processing applications — says Predrag Mitrovic, senior systems architect at high-performance embedded computing expert Abaco Systems in Huntsville, Ala.

"Everything is becoming more dense and integrated, which is reflected in the RF and optical backlink connectivity in the VPX ecosystem," Mitrovic says. "In the past you have four to eight RF connects in a very dedicated space on the VPX backplane. Now this is going to 10 or 20 of those. This will allow for more connections over the backplane to ease maintenance in the future without worrying about doing the pre-wiring up-front."

SOSA is catching on so quickly in the embedded computing industry



The Abaco FMC134 has four 12-bit A/D channels as fast as 3.2 gigabits per second, or two channels as fast as 6.4 gigabits per second for high-bandwidth, multi-channel applications.

THE MOST FLEXIBLE COTS RFSoC SOLUTIONS

The Abaco 3U VPX VP430 direct RF processing system is one of the densest analog FPGA DSP boards available, with eight A/D and D/A synchronized channels.

for sensor and signal processing that some designers who don't yet need SOSA-compliant hardware now are asking for it anyway. "We are seeing that our customers who don't have the need for SOSA are asking for it because it is something they are hearing about," Mitrovic says. "They are willing to take SOSA-aligned hardware today to be ready for the future."

Advancements in FPGAs

One important trend in sensor and signal processing today involves improvements in embedded processors — particularly FPGAs. Xilinx Inc. in San Jose, Calif., offers the Versal Adaptive Compute Acceleration Platform (ACAP), which offers an integrated multicore embedded computer that can adapt to evolving signal and sensor processing algorithms. The Versal ACAP is customizable at the hardware and software levels to fit different applications and workloads.

The Xilinx Versal ACAP "is what they used to call a multiprocessing system-on-chip device, and this is one of those on steroids," says Abaco's Mitrovic.

The device offers heterogeneous acceleration, seeks to change how the FPGA is developed, and change how engineers work with FPGAs. "It's so easy that any software engineer can program the FPGA, rather than requiring a special skillset," Mitrovic says. "Xilinx is targeting four times the compute technology over what has been available from them."

The Versal ACAP has the embedded sensor and signal processing community talking, and is generating substantial interest. "In the future there will be these highly integrated devices that integrate the Arm processor, other real-time processing units, and integrated AI cores," Mitrovic says.

How quickly can these devices take-off in sensor and signal processing applications? It may be a while, but may catch-on more quickly than expected. "Our customers are very much open to this, but it will take time," Mitrovic says. "Take the RFSOC [RF system-on-chip], for example. When it was introduced, it was considered revolutionary; traditional folks in the EW and radar industry were skeptical. For the first generation of RFSOC everyone was trying to understand the technology, but two years later we are seeing significant traction in some of the major government programs. We expect to see the same thing happening with Versal."

One big advantage to the Xilinx Versal ACAP is extremely tight integration. "Versal is seven-nanometer technology, where the previous FPGA technology was 16 nanometers," Mitrovic points out.

The Versal architecture also lends itself to AI and machine learning applications. "Historically signal processing has been done with floating point, but with machine learning you are dealing with lower resolution, and the processors have not been optimized to that kind of math very well," explains Denis Smetana, product manager for the digital signal processing (DSP) product line at Curtiss-Wright Defense Solutions. "Xilinx has their Versal FPGA, which

The combination of the General Dynamics Mission Systems SignalEye threat detection software and the Curtiss-Wright Intel Xeon D processor-based CHAMP-XD1 module provides system designers with a deployable COTS solution for RF spectrum situational awareness that automatically classifies signals using machine learning.

is designed to optimize that lower-resolution math to perform inferencing functions like those in neural networking for sensor and signal processing."

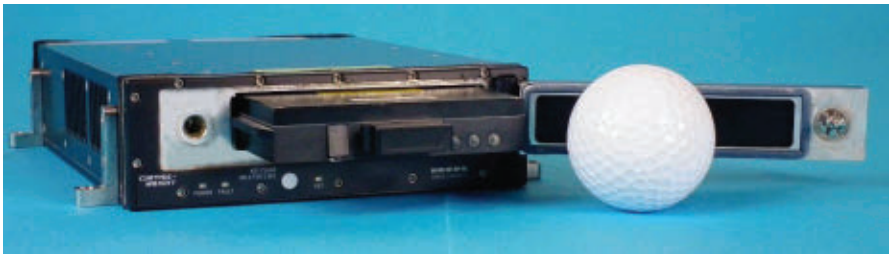
In addition to the Versal ACAP FPGA, Xilinx also is supporting the new Advanced Microcontroller Bus Architecture Advanced eXtensible Interface 4 standard — better-known as AMBA AXI4 — a freely available open standard to connect and manage functional blocks in a system-on-chip to provide a standard interface for FPGA intellectual property (IP) reuse. This can help reduce the risks and costs of developing multiprocessor designs with many controllers and peripherals.

AXI4 is the fourth generation of the AMBA interface specification for the ARM processor, which to a growing extent is being integrated onto FPGAs for sensor and signal processing. Xilinx is offering a range of AXI4-compliant IP that has one standard interface for general-purpose embedded computing, DSP, and logic domains.

Engineers at Pentek also are AXI4 proponents. "We are pushing more standardized FPGA libraries with the AXI4 standard, which defines a standard interface to IP modules for interoperability among multiple vendors of the IP code that goes on FPGAs," says Pentek's Hosking.

"With AXI4, everybody has agreed to play by the same standard, and it is working quite well," Hosking says. "People are becoming more efficient in putting new unique applications on FPGAs. This is really important for our FPGA-development customers."

This kind of design methodology is moving to a graphically oriented design practice. "A designer can put AXI4 IP blocks on his work surface and connect them with a mouse by clicking the output of one block to the input of another," Hosking says. "That saves a tremendous amount of FPGA design time. Doing FPGA design is a rare talent and skill that is hard to find in the marketplace. Anything that can make that easier will help."



Curtiss-Wright's DTS1 Rugged Network Attached File Server is for storing and protecting large amounts of classified data on intelligence surveillance reconnaissance (ISR) aircraft. It supports two layers of full disk encryption (FDE) in one device.

New levels of systems integration

Systems integration today for signal and sensor processing isn't just about shrinking electronic components, but also seeks to add substantial capability to small electronic packaging. Designers at Mercury Systems in Andover, Mass., decided to take this concept a step further by ruggedizing and miniaturizing commercial data center technology for aerospace and defense embedded computing applications.

"We are bringing the entirety of the data center ecosystem into OpenVPX and embedded hardware that can be brought into deployed platforms," says Shaun McQuaid, director of product management at Mercury. "Over the last 18 months we have taken a holistic view of what else is in the data center besides processing, to transpose those algorithms in the commercial world into high-performance edge computing."

So how does Mercury stuff a data center into an embedded computing chassis? "I need processing, but also data storage," McQuaid explains. "We launched a line of storage cards that leverages the M.2 standard." M.2, formerly known as the Next Generation Form Factor (NGFF), describes internally mounted computer expansion

Curtiss-Wright's CHAMP-XD2M 6U OpenVPX Intel Xeon D 16-core DSP processor card delivers 820 gigaFLOPS of processing performance with 128 gigabytes of memory for signal processing applications in harsh environments.

cards and connectors. It replaces the mSATA standard, which uses the PCI Express Mini Card physical card layout and connectors, and is for solid-state storage applications — particularly in small devices like Ultrabook and tablet computers. M.2 solid-state data storage "is about the size of a gumstick," McQuaid says. "It's a lot of NVMe attached storage."

In addition to M.2 data storage, Mercury engineers also designed an embedded PCI Express network switch, and a Switched Mezzanine Card (XMC) processing module on that switch. "Instead of having I/O come into a processor, we enable the I/O to come into the system and from there it can be distributed to the processors, FPGAS, and storage," McQuaid says. "It's all based on the latest generation of PCI Express interconnects to address the kinds of big-data problems that our industry has today."

For complex and demanding military and aerospace applications like radar, EW, and SIGINT, "it's critical to get these capabilities on those platforms," McQuaid says. "You've gotta put that data center technology right on the platform so you can make good decisions based on that data."

Thoughts that went into Mercury's strategic decision to capitalize on data center technologies for high-performance embedded computing involve cost and capability. "Look at the commercial world and how better buying power should work," McQuaid says. "What building blocks are critical?"

For Mercury, those building blocks taken from the data center and adapted to embedded computing consist of processors, I/O, general-purpose graphics processors (GPGPU) coprocessors, PCI Express switching, and FPGAs. "We want to make sure we have large amounts of memory, many cores on the CPU, and full functionality of those GPGPUs," McQuaid says. "We want to leverage best-in-class solutions.

In addition, Mercury designers have focused on widely applicable electronics cooling solutions, including liquid cooling. "It's those kinds of investments from chip-scale at the memory level all the way up through the mechanical structure necessary to cool these components," McQuaid explains. "It's only in the past year that we've had all these pieces come together."

WHO'S WHO IN SENSOR AND SIGNAL PROCESSING

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Crystal Group
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https://www.crystalrugged.com

Curtiss-Wright Defense Solutions
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https://www.curtisswrightds.com

Extreme Engineering Solutions Inc. (X-ES)
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https://www.xes-inc.com

General Micro Systems
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Kontron America Inc.
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Xilinx Inc.
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Artificial intelligence

Yet another trend in sensor and signal processing is blending AI and machine learning into systems designs. "There's a trend in the past couple of years where sensors are gaining more intelligence, and interfaces go between sensors and processing modules sitting behind that," says Curtiss-Wright's Smetana.

"We're moving the decision piece closer to the processor front-end to accommodate algorithms that can automate some of the analysis," he says. "Take SIGINT where you have to identify different signals out there, and sometimes those signals have noise. These algorithms make interpretations more intelligently. If it's never been seen before, it can make some interpretation in an attempt to classify the signal."

Blending AI into signal and sensor processing still is in its infancy, but is gaining momentum quickly. "It's still fairly new, and there's a lot of hype around it," Smetana says. "Still, there's a need to understand how to make the best use of it — where it fits and doesn't fit."

SIGINT applications, in particular, are drowning in data. AI has the potential to make a quick analysis of incoming data streams, determine what data to keep and what to throw out. "Machine learning can be really good at figuring out what data is static, and what you want to look at," says Curtiss-Wright's Jedynak. "It can make our mission a lot more efficient."

Take a typical airborne SIGINT mission, for example. "You have a two-hour mission that gathers 10 terabytes of encrypted data per hour," Jedynak explains. "That 20 terabytes of data take up a lot of storage, but with machine learning we might be able to some triaging and use four terabytes of data."

Military researchers are asking industry to develop arrays of small, low-power, and lightweight communications transceivers for long-range communications.

DARPA eyes arrays of SWaP-constrained transceivers for long-range communications

BY **John Keller**

ARLINGTON, Va. — U.S. military researchers are asking industry to provide long-range communications through mosaic antennas composed of spatially distributed low size, weight, power, and cost (SWaP-C) transceiver elements or tiles.

Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., has issued a broad agency announcement (HR001120S0049) for the Resilient Networked Distributed Mosaic Communications (RN DMC).

The RN DMC program seeks to replace high-powered amplifiers and large directional antennas with mosaics of spatially dispersed tile transceivers.

Transmit power is to be distributed spatially among the tiles, while the system is to achieve gain through signal processing rather by use of a physical antenna aperture to concentrate energy.

Individual tiles could use radio frequency (RF) sounding to estimate channel responses and adjust transmit carrier phases to enable the distributed mosaic antenna to form directional beams and spatial nulls in desired directions.

Signal processing in the SWaP-optimized tiles enables these antennas to form directional beams that enhance signals and reject interference and enemy jamming. The tiles could be on ground vehicles, infantry, unmanned aerial vehicles (UAVs), high altitude aircraft, or low-Earth-orbit satellites.

DARPA researchers say the mosaic approach would work with unmodified military tactical radios and waveforms, and be affordable enough to be expendable. It also can be secure and available only to authorized users.

Because spatial distribution allows for relatively low power from each tile, it is inherently low probability of detection compared to traditional transmitters. Furthermore, the approach will enable computing the relative position of each tile within a mosaic. Because there are several tiles involved that self-form into an array, the loss of individual tiles does not cause the entire array to fail.

In a traditional tactical communications system, a radio connects to a directional antenna through a physical

cable or RF coupler. RN DMC, on the other hand, provides a physical communications connective layer that is independent of nearby tactical networks.

This approach also will provide the relative positions for each local tile a squad leader with a tactical radio and an Android Tactical Assault Kit (ATAK) or other visualization tool to track the locations of his or her squad members — even in environments that deny use of the Global Positioning System (GPS).

Phase-one RN DMC performers will test long link capability in the laboratory, and in controlled outdoor long-range environments to validate the technology's ability to operate over at least 31 miles. The test will have at least two tactical radios; two ground tactical waveforms and one satellite communications (SATCOM) waveform; and 10 SWaP-optimized mosaic tiles.

Phase-two performers will refine their designs, and support a terrestrial test and a relay field test. The terrestrial test will validate distributed-to-distributed coherent communications over a terrestrial link at least 0.6 miles long between two mosaic element antennas and will include static and moving user test cases.

This test will be for about 10 months. The mosaic antennas will have at least ten tiles each — 20 tiles total — and the system will be tested with at least two tactical radios and two terrestrial tactical waveforms. This test will demonstrate an Army use case where two squads separated by about a mile could communicate through RN DMC technology.

A relay test exercise at the end of phase 2 will demonstrate a relay from a ground mosaic antenna to an airborne mosaic back down to a remote mosaic ground antenna about 62 miles away.

The third phase will involve adapting RN DMC technology to U.S. military service needs, and will demonstrate at a service-led field exercise. The end of the third phase will include service-specific systems ready for experimentation, design documents, and performance assessments; as well as a field exercise.

Companies interested should upload proposals no later than 4 Aug. 2020 to the DARPA BAA Website at https://baa.darpa.mil. Email questions or concerns to DARPA at HR001120S0049@darpa.mil. More information is online at https://beta.sam.gov/opp/4a71282a1e0b44c59c57544365371438/view.

U.S. Special Operations Command wants more smart-soldier equipment for future warfighters

U.S. Special Operations Command wants to equip small teams of operators with advanced smart-soldier gear to stay connected with intelligence assets anywhere in the world — even if they have to tap into commercial phone networks. The Hyper Enabled Operator program is designed to combine existing communications and data analytics technology into a tactical system that allows isolated special operations teams to gather and analyze battlefield intelligence to help them make decisions faster than ever before. The U.S. Army has developed smart-soldier equipment such as Nett Warrior, a smart phone-based system that plugs into a tactical network to give small-unit leaders access to drone feeds and other battlefield sensors. The Hyper Enabled Operator system is being designed for units such as Special Forces teams that work with partner nations to build their internal defense, as well as communications during unconventional warfare operations in extremely remote areas of the world.

Army asks AeroVironment to build backpackable attack UAV

BY **John Keller**

REDSTONE ARSENAL, Ala. — Unmanned aerial vehicle (UAV) designers at AeroVironment Inc. in Monrovia, Calif., are building manpackable killer drones for the U.S. Army under terms of a $75.9 million contract.

The Army Contracting Command at Redstone Arsenal, Ala., are asking AeroVironment to build the Switchblade — a loitering munition that launches from a small tube that can be carried in a warfighter's backpack.

The Army Contracting Command awarded this Switchblade contract on behalf of the Army Close Combat Weapons Systems Program Executive Office Missiles and Space (PEO MS) at Redstone Arsenal.

The Switchblade attack drone system transmits live color and infrared video wirelessly after launch for display on a small ground-control unit. The operator confirms the target using the live video feed, commands the air vehicle to arm its payload and lock its trajectory onto the target.

Switchblade flies quickly and quietly, and strikes with precision to keep collateral damage to a minimum, experts say. The operator can call off a strike, if necessary, even after the munition is armed. The backpackable system weighs six pounds.

It's like a smart mortar system, yet instead of launching up and then down on a sharp ballistic arc, it lofts into the air, helps the operator search for targets, and attacks targets when found.

For conventional or special operations forces, the Switchblade is for use against beyond-line-of-site targets. Backpackable and rapidly deployable from air, sea or ground, Switchblade provides operators with increased lethality, reach, and precision-strike capabilities with low collateral effects, AeroVironment officials say.

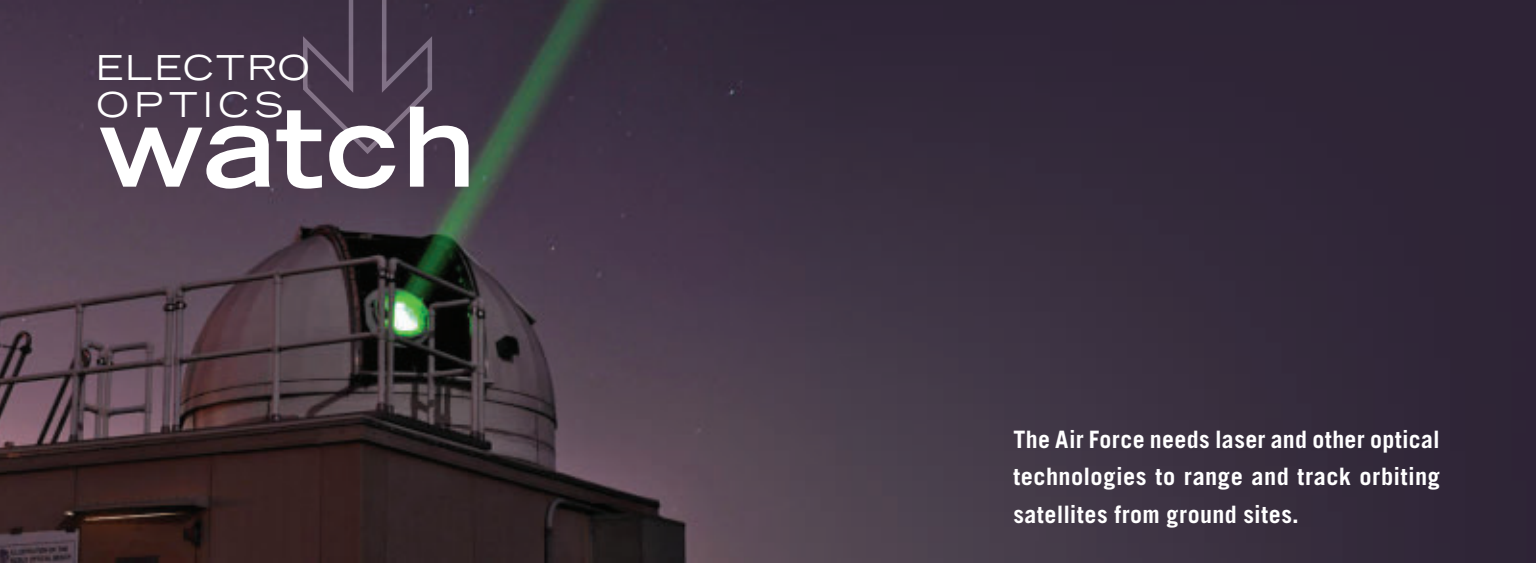
Remotely piloted or flown autonomously, Switchblade can provide real-time GPS coordinates and video for information gathering, targeting, or target recognition. The vehicle's small size and quiet electric motor make it difficult to detect, recognize, and track, even at very close ranges.

The Switchblade warhead has an explosive charge equivalent to a 40-millimeter grenade that is able to destroy light armored vehicles and enemy warfighters.

The Switchblade killer drone operates with a common ground-control station; has a 6.2-mile range; flies at speeds of 55 to 85 knots, at altitudes below 500 feet; and can launch from the ground, from aircraft, from ground vehicles, and from surface vessels.

For more information contact AeroVironment online at www.avinc.com, the Army Contracting Command-Redstone at https://acc.army.mil/contractingcenters/acc-rsa, or the Army PEO MS at www.msl.army.mil.

The 6-pound AeroVironment Switchblade attack UAV enables infantry warfighters to detect and attack hard-to-find targets.



The Air Force needs laser and other optical technologies to range and track orbiting satellites from ground sites.

Air Force asks industry for electro-optical technologies to track orbiting satellites

BY **John Keller**

KIRTLAND AIR FORCE BASE, N.M. — U.S. Air Force space experts are asking industry to develop Earth-based ranging capability to track the precise altitudes and speeds of orbiting satellites.

Officials of the Air Force Research Laboratory Directed Energy Directorate at Kirtland Air force Base, N.M., have issued a broad-agency announcement (FA9451-19-S-0007) for the Active Sensing for Orbital Determination project.

The goal is to develop an active electro-optical ranging and characterization capability for artificial satellites in Earth orbit to facilitate rapid orbit building capabilities and relative ranging information for satellites located in close proximity.

Information from a precision ranging system also might be able to provide unique sensitivity related to slight accelerations or motion of satellite components.

The Active Sensing for Orbital Determination project is part of the Air Force's Technical Applications for Optical Space Situational Awareness (TAOS) project.

The project's first phase will examine design tradeoffs like direct detect vs heterodyne detection techniques in various sky background conditions; linear vs. Geiger-mode detectors; monostatic vs bistatic systems; and laser power vs. telescope aperture diameter trades which consider laser pulse length and AO capabilities.

The second phase of this satellite tracking project involves component testing to mature component technologies and build confidence in candidate system architectures. The third phase, not included in this effort, would be the final integration and testing of a complete system prototype.

Research should compare direct- and coherent-detection approaches; light efficiency; and efficacy in various sky background conditions.

System design should consider linear-mode vs Geiger-mode ranging detectors; laser power and other laser characteristics; aperture size; monostatic vs. bistatic; AO and tracking requirements and design; Rayleigh beacon vs Sodium beacon AO; and available components and technology readiness levels.

A wave-optics simulation model of recommended system design should confirm analytic predictions for the recommended architecture; integrate, characterize, and refine detection algorithms.

Mission-motivated concepts of operation (CONOPS) should involve queuing requirements; acquisition approach and requirements; timelines; and orbit determination for detection of closely spaced objects.

Simulation studies and model validation should consider detectors; laser beacon sources; detection algorithms; orbit determination algorithms; passive trackers; and ranging lasers. Total estimated funding is 8 million through 2022. One or more contracts may be awarded. Expected award date was June 2020.

Companies interested were asked to upload white papers by 1 May 2020 to https://safe.apps.mil. Email questions or concerns to the Air Force's Ryan Coder at ryan.coder.1@us.af.mil, or Kimerie Smith at kimerie.smith@us.af.mil. More information is online at https://beta.sam.gov/opp/aa38d28ec5384b74bb1b3ef19c36a8f6/view.

NASA chooses rad-hard laser diode modules from nLight for use on spacecraft

BY **John Keller**

HAMPTON, Va. — U.S. space researchers needed radiation-hardened laser diode modules in attempts to increase the electrical-to-optical efficiency of optical fiber for spacecraft applications. They found their solution from nLight Inc. in Vancouver, Wash.

Officials of the National Aeronautics and Space Administration (NASA) Langley Research Center in Hampton, Va., announced plans to award a contract to nLight to deliver five fiber couple packaged pump laser diode modules for evaluation at NASA Langley by mid-2021.

NASA will award the contract to nLight sole-source because the company is the only responsible source for this job. The value of the upcoming contract has yet to be negotiated.

nLight currently provides 1,532-nanometer pump laser diode modules for the Erbium YAG pulsed solid state laser that NASA is adapting from an existing high-fidelity airborne prototype for orbiting spacecraft.

NASA researchers are trying to increase the electrical to optical efficiency of existing wavelength-stabilized 1532-nanometer fiber coupled pump laser diode modules from 22 percent to 40 percent while maintaining more than 35 Watts of optical output from a 220-micron-diameter fiber with a 0.22 numerical aperture.

Wavelength-stabilized 1532-nanometer fiber coupled pump laser diode modules couple generated laser light into an optical fiber. Enhancing module efficiency can deliver more laser signal to places in the system that need laser signals.

From nLight, NASA needs pump laser pump diodes housed with mass of 700 grams, not including the optical fiber, and volume of 300 cubic centimeters.

NASA wants nLight to deliver two fiber couple packaged pump laser diode modules for evaluation to NASA Langley within 12 months of contract award, and another three modules within 18 months of award. Modules must be compatible with future space flight operations in the radiation environments of low-Earth orbit.

NASA is ordering radiation-hardened laser diode modules from nLight Inc. to increase the electrical-to-optical efficiency of optical fiber for spacecraft applications.

More information is online at https://beta.sam.gov/opp/1f04978c94424f2c8a9f23ab7c006b5b/view.

Medium-wave infrared camera to counter unmanned aircraft introduced by FLIR

FLIR Systems Inc. in Wilsonville, Ore., is introducing the FLIR Ranger HDC MR high-definition medium-wave infrared (MWIR) border-security surveillance system to counter unmanned aerial vehicles (UAVs), illegal drug smuggling, and human trafficking. The Ranger HDC MR can detect illegal activities even in degraded weather conditions using embedded computing analytics and image processing to reduce the cognitive workload and enable operators to distinguish quickly between true threats and false alarms. The high-performance HD thermal imaging system extends border security mission capability with a built-in fog filter to see through fog and haze, as well as an optional Merlin ASX turbulence filter to see through heat and air turbulence. The system's high-definition thermal imager has a 1280-by-720-pixel detector and a 1920-by-1080-pixel HD color TV camera. The Ranger HDC MR surveillance camera also is ready to host on-board artificial intelligence (AI) image processing for fast decision-making, and includes an cyber security tool that scans each software release to help ensure the system is protected from cyber attacks. For more information contact FLIR Systems online at www.flir.com.

NETWORKING EQUIPMENT

Navy chooses Lyme Computer for rugged networking hardware on surface warships

Navy shipboard electronics experts needed commercial off-the-shelf (COTS) industrial-grade networking hardware for several different Navy ship classes. They found their solution from Lyme Computer Systems (LCS) Inc. in Lebanon, N.H.

Officials of the Naval Surface Warfare Center Philadelphia Division in Philadelphia announced a potential $31.8 million five-year contract to LCS for COTS ruggedized networking equipment aboard several kinds of Navy surface warships.

Ship classes that will receive LCS computer networking gear include Arleigh Burke-class destroyers (DDG 51); Ticonderoga-class cruisers (CG-47); Whidbey Island-class dock landing ships (LSD 41; Harpers Ferry-class dock landing ships (LSD 49); Avenger-class mine-countermeasures ships (MCM 1); Wasp-class amphibious assault ships (LHD 1); Makin Island-class amphibious assault ships (LHD 8); San Antonio-class amphibious transport dock ships (LPD 17); Nimitz-class aircraft carriers (CVN 68; and Ford-class aircraft carriers (CVN 78).

Networking hardware from LCS will be installed aboard these surface ships as part of their hull, mechanical, electrical and navigation network infrastructures. This rugged networking equipment will carry the brand name of Siemens RuggedCom in Concord, Ontario.

Lyme Computer Systems supplies the U.S. government, prime contractors, and other businesses worldwide with information technology (IT) such as secure networking and unified communications. The company provides new equipment, as well as maintaining and upgrading existing computer technology.

On this contract LCS will do the work in Lebanon, N.H., and should be finished by July 2025. For more information contact Lyme Computer Systems online at www.lyme.com, or the Naval Surface Warfare Center Philadelphia Division at www.navsea.navy.mil/Home/Warfare-Centers/NSWC-Philadelphia.

NAVIGATION AND TIMING

Orolia to provide positioning, navigation, and timing (PNT) for hypersonic missile-defense radar

Missile-defense radar experts at Raytheon Technologies Corp. needed a rugged time and frequency system to supply positioning, navigation, and timing (PNT) capability to the U.S. Lower Tier Air and Missile Defense Sensor (LTAMDS) radar program. They found their solution from Orolia USA in Rochester, N.Y.

Officials of the Raytheon Missiles & Defense segment in Andover, Mass., have selected the Orolia Government Systems business to supply a low size, weight, and power consumption (SWaP) time and frequency system for LTAMDS.

Raytheon won a U.S. Army contract in October 2019 to provide the next-generation LTAMDS advanced air and missile defense radar to help defeat advanced missile threats such as hypersonic weapons.

Raytheon chose Orolia based on the company's expertise in resilient timing and configurable ruggedized PNT systems for challenging environments.

LTAMDS is the next generation, 360-degree missile-defense radar that ultimately will replace the current U.S. Army's Patriot missile radars. The radar has gallium nitride components, and is scheduled to reach initial operational capability with the Army in 2022.

The Orolia SecureSync system is on the U.S. Defense Information Systems Agency (DISA) Department of Defense Information Network (DoDIN) products list for a time and frequency reference system for network interoperability.

"Ultra-precise mission timing and sync technology are fundamental building blocks for the Resilient PNT systems that warfighters rely on for continuous operations in contested environments," says Hironori Sasaki, President of Orolia Defense & Security.

Orolia's SecureSync is designed to synchronize critical military and commercial operations where failure is not an option, Orolia officials say.

The system combines precision master clock technology with configurability, and offers high reliability, security, redundancy, and flexibility in a rugged, modular, cost effective form factor.

SecureSync synchronizes to satellite navigation systems like GPS, Galileo, and other GNSS constellations, can add alternative signals to GPS/GNSS input references to improve resilience; offers GPS signal jamming and spoofing detection; can generate time and frequency output signals; and offers internal oscillator options like low-phase noise.

For more information contact Orolia online at www.orolia.com, or Raytheon Missiles & Defense at www.raytheonmissilesanddefense.com.

CHASSIS AND ENCLOSURES

OpenVPX embedded computing chassis with 40 Gigabit Ethernet throughput introduced by Pixus

Pixus Technologies in Waterloo, Ontario, is introducing horizontal-mount OpenVPX embedded computing chassis for 3U, 6U, or hybrid versions. The first in the 1U SlimBox OpenVPX series is a three-slot version for 3U boards. A modular fixed power supply provides up to 600 Watts of power and one Rear Transition Module (RTM) is supported. The chassis offers a hybrid configuration option with 1x 6U slot and 1x 3U slot. In lieu of the fixed-mount power supply option, one of the 3U slots can be replaced with a pluggable 3U PSU slot per VITA 62. This configuration enables designers to use RTMs. The Pixus 1U SlimBox supports various backplane speed options, and the initial design supports speeds as fast as 40 Gigabit Ethernet and PCI Express Gen3. Optional card guides for conduction-cooled modules also are available. For more information contact Pixus Technologies online at https://pixustechnologies.com.

RUGGED COMPUTERS

Rugged laptop computers for military applications introduced by Getac

Getac USA in Irvine, Calif is introducing the B360 and B360 Pro rugged laptop computers for public safety, manufacturing, utilities, and military applications. The B360 and B360 Pro offer 5G communications, computing speed, brightness, and rugged reliability for use in challenging working conditions. These rugged laptop computers run the 10th generation Intel Core Processor, which can run many applications simultaneously without hurting performance. 1,400 nits full HD sunlight-readable displays are standard. These computers are built rugged from the ground up. They are rated to IP66 for dust ingress, high-pressure water jets, and spillages. They also can withstand drops from as high as six feet when in operation, while the latest MIL-STD 810H certification gives users confidence in its rugged reliability. The B360 is 1.4 inches thick and weighs 5.1 pounds. Users can carry and operate it for extensive periods. It has a 13.3-inch LumiBond 2.0 display, 802.11ax Wi-Fi, dual hot-swappable batteries, and optional GPS. The B360 Pro adds high-capacity hot-swappable batteries; additional serial ports; and optional PCMCIA, ExpressCard, or a discrete graphics card; and optional DVD or Blu Ray drive. For more information contact Getac online at www.getac.com.

POWER ELECTRONICS

DC-DC converter for high-voltage applications introduced by TDK Lambda

TDK-Lambda Americas Inc. in San Diego is introducing the PH600A280-24 DC-DC converter for high-voltage direct current (HVDC) equipment in data communications, high-voltage power transmission, renewable energy applications, robot controllers and factory automation. Rated at 24 volts and 600 Watts, the PH600A280-24 is certified to the Over Voltage Category III safety standard EN 62477-1. It does not require an isolation transformer on the distribution panel, reducing cost, size, and weight. The PH600A280-24 DC-DC converter accepts a wide range of 200-to-425-volt-DC inputs delivering 24 volts at 12.5 amps. The output voltage can be set between 14.4 and 28.8 volts using the trim terminal. With an efficiency of 93 percent, the module can operate at full load with baseplate temperatures of -40 to 85 degrees Celsius, derating linearly to 80 percent load at 100 C. Conduction cooling through the baseplate enables designers to use the PH-A for communications and similar applications in outdoor sealed enclosures or liquid-cooled equipment. For more information contact TDK Lambda Americas at www.us.lambda.tdk.com.

GRAPHICS PROCESSING

Rugged XMC graphics card for image processing introduced by EIZO

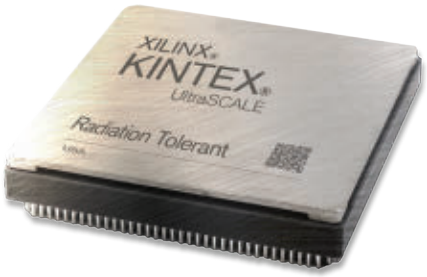
Image processing specialist EIZO Rugged Solutions Inc. in Altamonte Springs, Fla., is introducing the Condor NVP2102AxX six-channel rugged XMC graphics card for high-end surveillance applications. The Condor NVP2102AxX

card simultaneously captures analog and digital video and audio with low latency, and has a chip-down NVIDIA Quadro P2000 (GP107) design supporting four 3G SDI inputs, two CVBS (NTSC/PAL), and two audio inputs, as well as two 3G-SDI and two DVI or DisplayPort video outputs. This rugged XMC graphics card has 768 CUDA cores and 4 gigabytes of GDDR5 memory. At maximum power consumption, the Quadro P2000 GPU delivers 2.3 TFLOPs of single-precision floating point compute performance (FP32). The card also supports CUDA and OpenCL based GPGPU computing, artificial intelligence (AI) processing, deep learning, and H.265/H.264 encoding and decoding. High-speed data transfer and low latency levels come with the Condor NVP2102AxX graphics processor by optimizing NVIDIA's GPUDirect remote direct memory access (RDMA) feature for image processing. For more information contact EIZO Rugged Solutions online at www.eizorugged.com.

SPACE ELECTRONICS

Radiation-tolerant rugged FPGA for space applications introduced by Xilinx

Xilinx, Inc. in San Jose, Calif., is introducing a 20-nanometer space-grade field-programmable gate array (FPGA) for radiation-tolerant on-orbit applications in manned and unmanned spacecraft. The rad-hard FPGA delivers ultra-high throughput and bandwidth performance for satellite and space applications. The radiation-tolerant Kintex UltraScale XQRKU060 FPGA provides unlimited on-orbit reconfiguration and a 10x increase in digital signal processing (DSP) performance. The XQRKU060 also offers high performance machine learning and machine learning development tools that support industry-standard frameworks. These can enable neural network inference acceleration for real-time on-board processing in space. The XQRKU060 provides 5.7 teraoperations per second of peak INT8 performance optimized for deep learning. The XQRKU060 provides customers with a space-resilient device equipped to handle short- and long-duration missions in harsh space environments. For more information contact Xilinx online at www.xilinx.com/products/silicon-devices/fpga/rt-kintex-ultrascale.html.



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