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Top military enabling technologies to watch in 2022



BY **John Keller**
EDITOR IN CHIEF

Here it is, 2022, so what should the aerospace and defense industry look out for this year? Among the first is hypersonics — or the ability to propel missiles and aircraft faster than five times the speed of sound: nearly 4,000 miles per hour.

Recent news reports have it that China and Russia are perhaps a year or more ahead in the U.S. in hypersonic technology development. Maybe that's the case, and maybe it's not, but it's clear the U.S. military has its work cut out to stay relevant in the new hypersonic era of the 21st century.

Hypersonics isn't all about propulsion — although that's a big part of it. Hypersonics is about shielding sensitive electronic and electro-optical components and subsystems from some of the most extreme environmental conditions known.

Do you may remember those TV animations saw during the Apollo and Space Shuttle programs of spacecraft re-entering the atmosphere? The returning spacecraft was surrounded by fire, and subjected to temperatures as high as 3,000 degrees Fahrenheit.

That's tame compared hypersonics.

Munitions and aircraft that travel at least several times the speed of sound sometimes must endure and operate through temperatures as high as 4,000 degrees Fahrenheit. You see, hypersonic munitions and aircraft must operate at these high speeds for nearly the entire duration of their flights, and at relatively low altitudes where the atmosphere is dense. Re-entering spacecraft, on the other hand, start entering the atmosphere at nearly Mach 23, but in high altitudes where the atmosphere is thin, and decelerate quickly.

So what does this mean for the electronics and electro-optics that provide hypersonic missiles and aircraft with sensors, navigation, guidance, flight

control, communications, and many other critical functions? These components not only must be cooled, but also must be designed from the ground-up to withstand temperature extremes, and we haven't even started on shock and vibration.

It's a big challenge for systems designers to create reliable hypersonic vehicles — especially if it's true that the U.S. is behind in the hypersonics race.

What else is a big priority for 2022? High-energy laser and electromagnetic weapons are high on the list. The defense industry has developed deployable laser weapons able to destroy or disable enemy light unmanned aerial vehicles and attack boats, but that's just the beginning.

The real goals involve the ability to replace machine guns and rapid-fire cannon on combat aircraft, surface warships, and armored vehicles with high-energy lasers.

Electromagnetic weapons will usher-in a new kind of combat called electromagnetic warfare. This involves the ability to control electromagnetic energy much like the electromagnetic pulse (EMP) of a nuclear explosion to target the enemy and keep friendly forces out of harm's way.

Today these weapons involve so-called "nonlethal weapons" used for crowd control and perimeter security. They can heat an opponent's skin much like a microwave oven to cause pain and sometimes bodily damage. Like laser weapons, challenges revolve around increasing the power of electromagnetic weapons sufficiently to kill or disable enemy electronics at standoff distances.

There are more applications and enabling technologies to watch in 2022, yet these three arguably top the list. We'll see how things unfold as we see the latest contracts and solicitations from the Pentagon early this year. ◀

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- Free space communications links





Marine Corps goes all-in on CMOSS and SOSA for infantry, vehicles, and command posts

BY John Keller

QUANTICO, Va. — U.S. Marine Corps electronics systems integrators are surveying industry to find companies able to design and build circuit cards, chassis and enclosures, and electronic subsystems that align to the CMOSS and SOSA open-systems standards for a wide variety of future combat applications.

Officials of the Marine Corps Systems Command at Quantico Marine Base, Va., issued a request for information in November for companies with CMOSS – and SOSA-aligned products to help the Marines move away from stove-piped solutions for

▲ **The Marine Corps is looking for companies with CMOSS – and SOSA-aligned products to help the Marines move away from stove-piped solutions for communications, tactical electronic warfare (EW), cyber, and intelligence technologies.**

communications, tactical electronic warfare (EW), cyber, and intelligence technologies.

CMOSS and SOSA are acronyms for Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance / Electronic Warfare (C4ISR/ EW) Modular Open Suite of Standards / Sensor Open Systems Architecture.

Marine Corps leaders want to start deploying CMOSS – and SOSA-aligned system variants as soon as possible, ranging from forward bases, to tactical vehicles, and to infantry technology down to the rifle platoon and squad level.



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Marines particularly are interested in CMOSS – and SOSA-aligned technologies for communications; EW support; position, navigation, and timing (PNT); data storage; local computing infrastructure; and sensor capabilities.

CMOSS – and SOSA-aligned electronic equipment has the potential to reduce development time, lower costs, and access a wide variety of vendors for radios, video displays, sensors, EW tools, antennas, and other communication technologies.

While systems may use many of the same building blocks today, they are not shared or distributed among systems, resulting in overburdened platforms, and infantry equipment that is bulky and heavy.

CMOSS – and SOSA-aligned systems will represent a distributed network of multi-function nodes operating across an ad-hoc mesh data network using messaging protocols such as Internet Protocol (IP), J-series message, K-series message, Variable Message Format (VMF), Named Data Network (NDN), and MIL-STD-1553.

These networks and communications systems must provide a low probability of intercept (LPI) and low probability of detection (LPD). CMOSS – and SOSA-aligned electronic components will be present in all command elements, and at every echelon, Marine Corps officials say.

Of particular interest are CMOSS – and SOSA-aligned systems for battlefield command posts with powerful receive and transmit range capabilities that enable operators to control other nodes from a remote location, as well as for infantry warfighters, and military vehicles.

Marine Corps experts say they expect to apply CMOSS – and SOSA-aligned equipment for direction finding; precision geolocation; counter-unmanned aerial systems; counter radio-controlled improvised explosive device electronic warfare; command and

control; communications; computers; cyber, intelligence, surveillance, reconnaissance, and targeting; counter PNT, and to enable EW capabilities against terrestrial and non-terrestrial communication systems and radar systems.

CMOSS – and SOSA describe layered standards that includes software, hardware, and network layers using a modular open-systems approach for all chassis and electronic circuit cards. Variant configurations will minimize the need for platform-specific integration, and enable the Marines to field new or improved capabilities with new circuit cards without the need of additional cabling or mounts.

CMOSS – and SOSA-aligned capability happens when compliant plug-in circuit cards integrate into chassis and peripheral devices like antennae, amplifiers, and user interfaces. CMOSS – and SOSA-aligned will make it simpler and more cost-effective to upgrade capabilities or keep pace with commercial technology.

From industry, the Marine Corps wants to know current and future CMOSS – and SOSA-aligned-compliant capabilities for team portable, mounted, dismounted, and body worn configurations. Vendors with compliant cards and compatible EW accessories related to transceivers, networking, counter-unmanned systems, counter improvised explosive device systems, geolocation, position navigation and timing (PNT), and direction finding are encouraged to respond.

Vendors with artificial intelligence and machine learning capabilities that would support EW data processing, recognition, and graphic user interface software also are encouraged to respond. ←

Companies interested should email white papers to the Marine Corps's Brittney Moore at brittney.moore@usmc.mil no later than 23 Nov. 2021. More information is online at <https://sam.gov/opp/8cacc25d09424341bfbf9e6686d52838/view>.

Mercury boosts RF, EW, and embedded computing with Atlanta Micro buy

Executives of embedded computing and RF specialist Mercury Systems Inc. in Andover, Mass., are expanding the company's expertise in RF and microwave enabling technologies with their acquisition of Atlanta Micro Inc. in Peachtree Corners, Ga. Atlanta Micro designs and builds high-performance RF and microwave products such as monolithic microwave integrated circuits (MMICs) for high-speed data acquisition, electronic warfare (EW), radar, trusted microelectronics, and weapons. Mercury specializes in trusted, secure mission-critical technologies for aerospace and defense applications such as sensor and processing technologies for mission-critical applications. The company designs secure

embedded processing modules and subsystems, mission computers, secure and rugged rack-mount servers, safety-critical avionics, RF components, multi-function assemblies, subsystems and trusted custom microelectronics. Atlanta Micro Atlanta Micro specializes in broadband RF solutions for portable and low-power platforms using integrated functions and simplified interfaces. the company builds components, receivers, transceivers, and systems for the military, government agencies, and the test equipment community. Details of the all-cash deal were not released. For more information contact Atlanta Micro online at www.atlantamicro.com, or Mercury Systems at www.mrcy.com.

Lockheed Martin to design Stryker vehicle with EW and cyber capabilities

U.S. Army leaders seek to wrap command, control, communications, intelligence, and electronic warfare (EW) into one combat vehicle for the future battlefield. The Army in September awarded \$9.6 million to Lockheed Martin to equip several Stryker armored vehicles with an EW system combining cyber warfare, signals intelligence (SIGINT) and electronic attack.

The electronic warfare Stryker is designated the Terrestrial Layer Systems-BCT because it will have the mobility and armor protection to accompany on the ground mechanized brigade combat team at the forefront of the fighting. TLS-BCT armored combat vehicle has an open-systems C5ISR/EW Modular Open Suite of Standards (CMOSS) avionics architecture. Lockheed Martin's concept art for the Stryker BCT-TLS shows three large dome antennae on the vehicle's center and rear hull, as well as side hull-mounted sensors.

Army considers PNT and 3D terrain mapping for GPS-denied environments

The U.S. Army Applications Lab in Austin, Texas, is seeking network-aided capabilities to let soldiers know exactly where they are, how to get where they're going, and when to move on the battlefield — especially when they can't depend on GPS. A special notice posted in October says, "The intent of this special topic is to develop Network Aided devices, including component, sub-component, and associated technologies, to allow dismounted Soldiers to continue to operate without using standard GPS signals." The notice is part of a larger push in the Army to develop new tools for position, navigation, and timing (PNT) that enable soldiers to operate in extremely remote environment or in places where adversaries could interfere with GPS. One potential option is the use of extremely

detailed global 3D terrain mapping to enable soldiers to track their positions by analyzing their own surroundings.

NATO hammers-out first artificial intelligence (AI) strategy

NATO defense ministers have agreed to NATO's first-ever strategy for artificial intelligence (AI). The strategy outlines how AI can apply to defense and *Continued on page 13*

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Air Force asks industry for AI and machine learning for aerial battle planning

BY John Keller

ROME, N.Y. — U.S. Air Force researchers are asking for industry's help in developing artificial intelligence (AI) and machine learning for planning systems that help commanders adapt quickly to changing conditions in high-intensity aerial battles.

Officials of the Air Force Research Laboratory's Rome Research Site in Rome, N.Y., issued a broad agency announcement (FA875020S7007) last week for the Stratagem: Applying State-of-the-Art Artificial Intelligence and Machine Learning Approaches to Air Battle Management project.

Stratagem seeks new AI capabilities that can reason in real-time about developments in the battlespace during war-time engagements and assist with battle planning and decision making in reacting to those developments.

As the Air Force begins to operate in contested environments against peer and near-peer adversaries, the demands on planners and warfighters will increase quickly enough to require AI and machine learning decision support, researchers say.

◀ **Air Force leaders plan to make broader use of artificial intelligence and machine learning for future aerial battle-planning systems.**

major developments in AI for non-human game-playing agents; this technology might be considered for battlespace decision support.

The Stratagem project has three parts: machine intelligence support for complex military operations; capturing human expertise to augment warfighter capability; and transferring machine-learning models from video gaming to Air Force battle management and simulations.

Only one part, machine intelligence for strategy development, is part of this specific solicitation. This part seeks to explore new and existing algorithms and learning methods that involve a model architecture for an intelligent agent, determining which pieces that absolutely must be included in the design of a reasoning agent in complex environments.

This model should be based computational game theory and machine learning. The goal is to develop an approach to match and then exceed expert human gameplay in advanced wargames.

It seeks to produce blue/red agents that can assist and play against planners in real-time and run many games to produce plan options for operators.

Air Force researchers are considering wargames with an operational area of as little as 50 by 50 miles, and as large as 500 by 500 miles, that last for as long as 100 days, at the squadron, brigade, battalion, and naval ship level of granularity. Games will include terrain, cities, and weather.

Related: Raytheon to develop large-scale battle management software to enable military planning at the theater level

Companies interested should email white papers no later than 31 March 2022 to the Air Force's Nathaniel Gemelli at nathaniel.gemelli@us.af.mil, with copies to warren.geiler.1@us.af.mil.

One source of this kind of technology is advanced video gaming. In recent years, game designers had made

Those who send promising white papers will be invited to submit formal proposals. The project stays open through 29 Sept. 2023. Email technical questions or concerns to Nathaniel Gemelli at warren.geiler.1@us.af.mil, and contracting questions to Amber Buckley at amber.buckley@us.af.mil. ←

More information is online at <https://sam.gov/opp/0c48744fc48f4967a45612dad94cac24/view>.

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Lockheed Martin to continue upgrading Mark 48 torpedo guidance and sonar

By John Keller



WASHINGTON — U.S. Navy submarine warfare experts are asking Lockheed Martin Sippican Inc. in Marion, Mass., to upgrade sonar and guidance systems on the submarine-launched Mark 48 torpedo under terms of a \$105.7 million order.

Officials of the Naval Sea Systems Command in Washington are asking Sippican to provide new guidance and control sections,

as well as sonar upgrade kits, for the Mark 48 Mod 7 torpedo, which is standard armament for the Navy's fleet of Los Angeles-, Virginia-, and Seawolf-class fast attack submarines, as well as Ohio-class ballistic – and cruise-missile submarines.

Sippican will provide Common Broadband Advanced Sonar System (CBASS) upgrades, MK 48 Mod 7 heavyweight torpedo

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guidance and control sections, and related engineering services, Navy officials say.

The Lockheed Martin Corp. Rotary and Mission Systems segment is building the Mark 48 Mod 7 CBASS heavyweight torpedo with advanced common broadband advanced sonar system for expanded operational capabilities for shallow waters along coastlines and inside harbors, as well as in the deep-water open ocean.

◀ **Sippican will provide Common Broadband Advanced Sonar System (CBASS) upgrades, and MK 48 Mod 7 heavyweight torpedo guidance and control sections.**

The CBASS broadband sonar enhancement makes the torpedo more effective against new enemy submarines in the harshest of acoustic environments, Lockheed Martin officials say.

The Mark 48 Mod 7 CBASS torpedo uses modern commercial-off-the-shelf (COTS) technologies in an open-architecture computing environment, and can be improved with regular hardware and software upgrades, Lockheed Martin officials say.

The Mark 48 Mod 7 CBASS kit's evolutionary design and modular nature makes the upgrade of older version Mark 48 torpedoes to the Mod 7 CBASS capability a relatively straightforward effort without requiring significant torpedo redesign and certification, Lockheed Martin officials say.

The CBASS torpedo also has the ability of multi-band operation with active and passive homing; advanced counter-countermeasure capabilities; effectiveness against low-Doppler shallow submarines, fast deep diving submarines, and high-performance surface ships; autonomous fire-and-forget operation or wire-guide capability to enable post-launch monitoring and updates via the submarine combat system; and running Otto Fuel II as the propellant.

The Mark 48 Mod 7 CBASS provides the ability to transmit and receive over a wide frequency band and use broadband signal processing techniques to improve the torpedo's search, acquisition, and attack effectiveness, Lockheed Martin officials say.

The Mark 48 torpedo is 19 feet long, 21 inches in diameter, and weighs 3,500 pounds. It can be used as deep as 1,200 feet at distances as far as five miles. The torpedo can travel as fast as 28 knots and has a 650-pound high-explosive warhead. ◀

On this order Sippican will do the work in Syracuse, N.Y.; Clearwater, Fla.; and in Marion and Braintree, Mass., and should be finished by December 2025. For more information contact Lockheed Martin online at www.lockheedmartin.com, or Naval Sea Systems Command at www.navsea.navy.mil.

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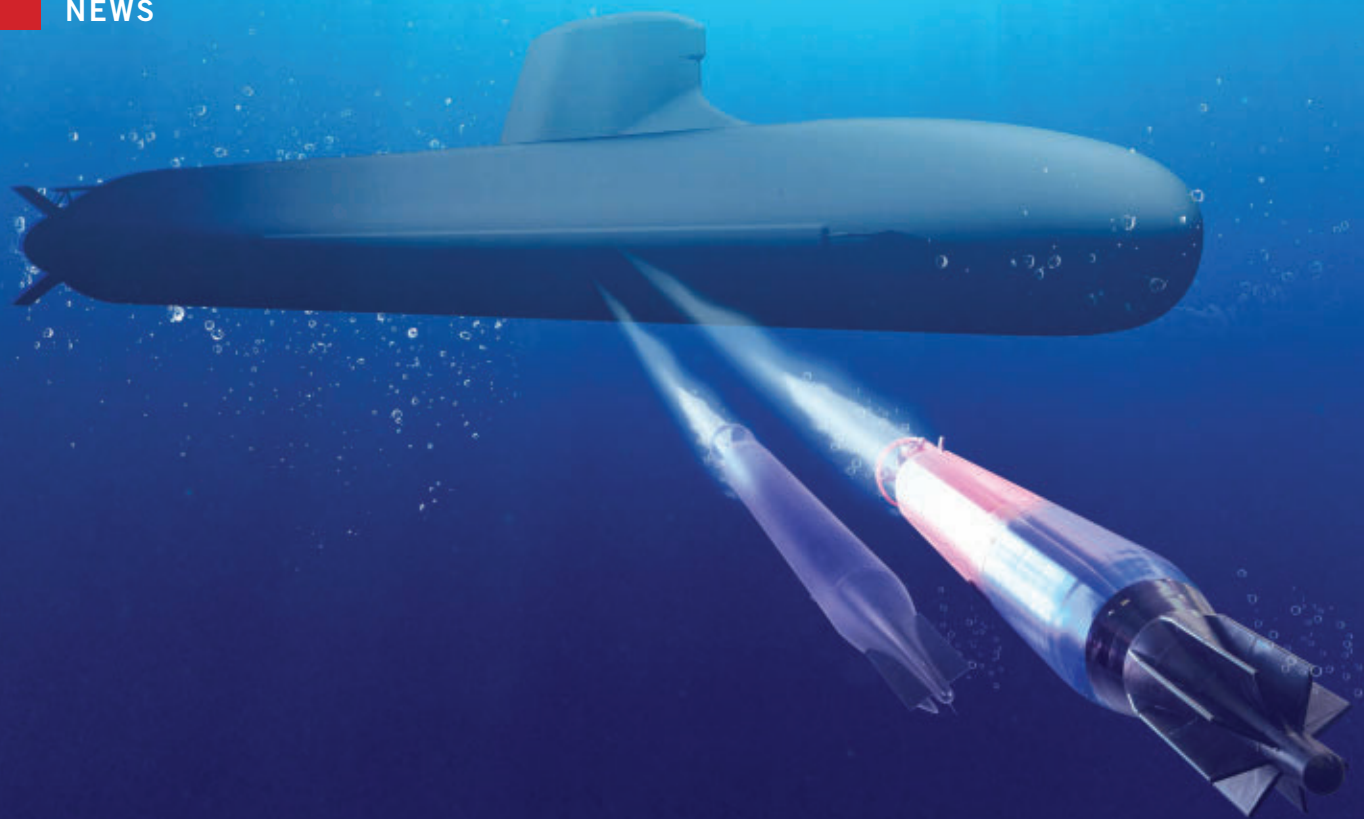
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Leidos developing acoustic countermeasure as torpedo decoys to protect U.S. submarines

BY John Keller

WASHINGTON — U.S. Navy undersea warfare experts are asking Leidos Inc. in Reston, Va., to continue development of an advanced active acoustic countermeasure to help defend U.S. and allied submarine forces against modern acoustic-homing torpedoes.

Officials of the Naval Sea Systems Command in Washington announced a \$9.4 million order to Leidos to continue designing, building, and testing an acoustic device countermeasure (ADC) called the ADC MK 5.

This torpedo-defense countermeasure will generate noise to deceive the sonar guidance systems of incoming torpedoes that are homing-in on the sounds of the target submarines, as well as the acoustic returns of active sonar pings.

This project calls for Leidos to design and develop ADC MK 5 torpedo defense developmental devices, as well as provide technical and non-recurring engineering services. This includes software and hardware development. The contract has options that could increase its value to \$36.1 million.

The ADC MK 5 project is part of the Navy's Next-Generation Countermeasure (NGCM) program to replace existing ADC MK 3 submarine acoustic countermeasures systems.

The ADC MK 5 is to be a 3-inch-diameter expendable device that submarines launch from external launchers have advanced features that submarines can employ as static or mobile devices with adaptive countermeasure (ACM) technology.

The project for Leidos is a follow-on to research contracts awarded in late 2010 to Ultra

Electronics Ocean Systems in Braintree, Mass., and to the Argon ST subsidiary of the Boeing Co. in Fairfax, Va., to develop the Navy's NGCM anti-torpedo submarine defense system.

The NGCM ADC MK 5 will have acoustic communications links to connect separate countermeasures devices to enable group behavior to defeat incoming torpedoes. It will be launched in-groups of as many six units — some of which will act as stationary broadcast jammers, while others will be mobile and function as sophisticated torpedo decoys.

▲ **This torpedo-defense countermeasure will generate noise to deceive the sonar guidance systems of incoming torpedoes.**

The ADC MK 5 countermeasures will have receivers that can operate in full duplex mode, and an acoustic communication link will pass tactical information and updates among the deployed countermeasures, submarines, and surface ships.

The ADC MK 5 will be re-programmable to operate together with U.S. and allied torpedoes or anti-torpedo systems, and will be able to change tactics in response to changing tactical or environmental conditions via the acoustic communication link.

The countermeasures will have advanced tactical embedded processors and a built-in threat torpedo classifier. The system's new technologies will include mobile countermeasure operations and tactics; acoustic communications; group behavior and the ability to work against incoming torpedoes cooperatively; the ability to classify incoming torpedoes; full-duplex receive and transmit sensor capability; and single-crystal transducers. ◀

The NGCM program seeks to insert new countermeasure technologies into submarine defenses against threat acoustic-homing torpedoes. On this order Leidos will do the work in Reston, Va., and should be finished by November 2022. For more information contact Leidos online at www.leidos.com, or Naval Sea Systems Command at www.navsea.navy.mil.

Continued from page 7 security in a protected and ethical way. As such, it sets standards of responsible use of AI technologies, in accordance with international law and NATO's values. The NATO AI strategy also addresses the threats of AI from adversaries and how to establish trusted cooperation with the innovation community on AI. AI is one of the seven technological areas that NATO Allies rank highly for their relevance to defense and security. These include quantum-enabled technologies, data and computing, autonomy, biotechnology and human enhancements, hypersonic technologies, and space.

Royal Navy to boost EW and anti-ship missile defense capability on surface warships

The United Kingdom Ministry of Defence (MoD) has awarded a 100-million-pound (\$133 million) contract through Defence Equipment and Support (DES) to deliver electronic warfare (EW) to *Continued on page 15*

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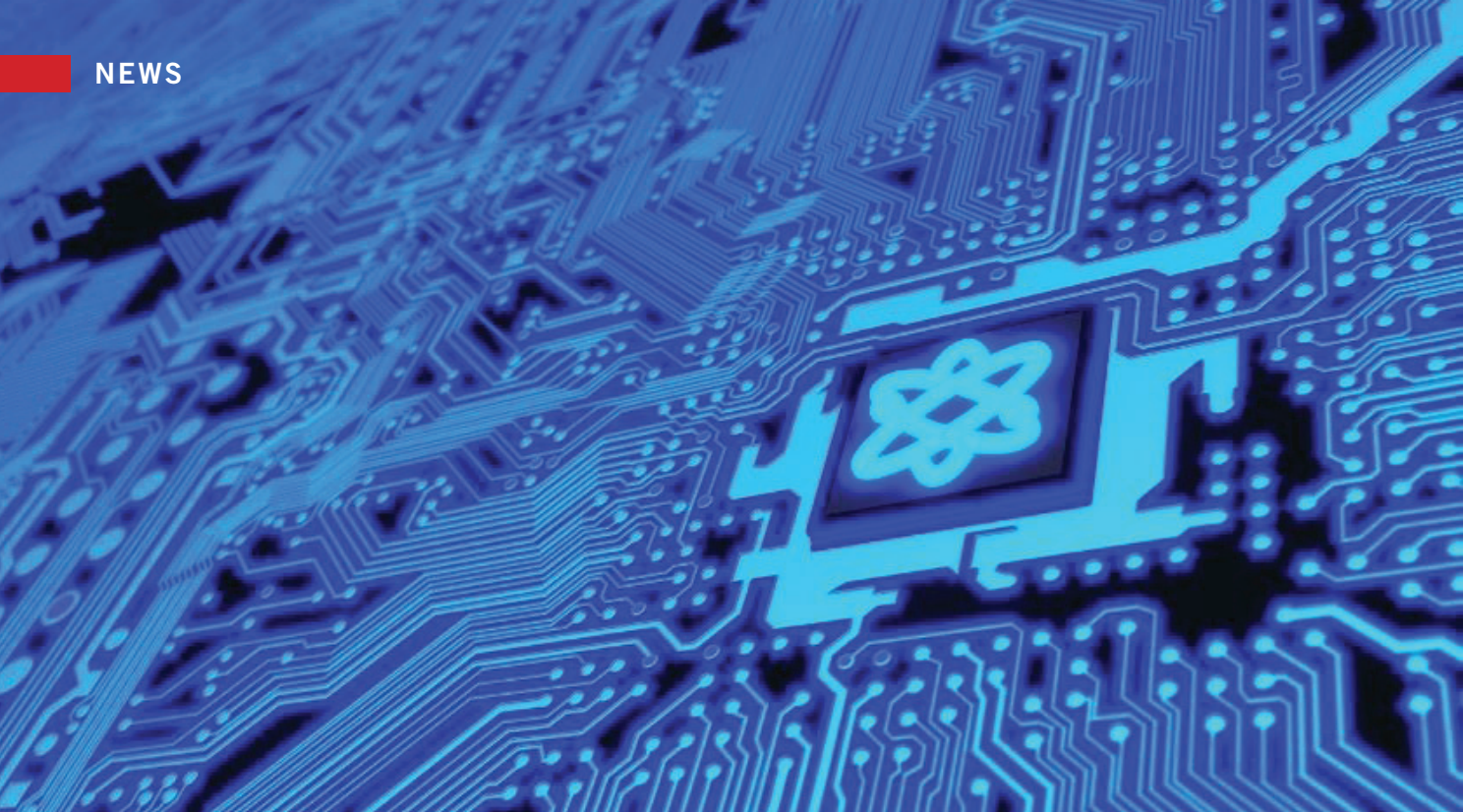
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Wanted: quantum computing with SWaP small enough for military missions

BY John Keller

ARLINGTON, Va. — U.S. military researchers are asking industry to find ways of improving high-performance computing performance by at least two orders of magnitude using quantum computing techniques called quantum-inspired solver systems. Quantum computing harnesses the phenomena of quantum mechanics to deliver a huge leap forward in computation to solve certain problems.

Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., have issued a solicitation (HR001121S0041) for the \$58 million Quantum-Inspired Classical Computing (QuICC) program.

DARPA researchers are looking for quantum-inspired solver systems that solve realistic problems for military missions. Quantum-inspired solvers are hybrid: they are classical mixed-signal systems that consist of analog hardware and digital logic.

The analog hardware typically emulates interacting dynamic systems, and the digital logic processes the analog results to obtain quality solutions.

The objective is to deliver system prototype that can improve computational efficiency by at least 50 times for intermediate

problem sizes and to show the feasibility of improving efficiency by at least 500 times for mission-scale problems. The QuICC program will focus on classical hybrid mixed-signal systems; all-digital solvers or quantum computing are not part of the program.

Many U.S. Department of Defense (DOD) missions are limited by available computing resources. Quantum computing may be

a potential solution, yet there is nothing to suggest that quantum computing every will be feasible for military size-, weight-, and power- (SWaP)-constrained environments.

Detailed analysis of quantum computing has led to new algorithms and hardware, while delivering significant advantages over all-digital computing. This is where quantum-inspired solvers may come in.

Quantum-inspired analog hardware typically emulates interacting dynamic systems like magnetic spins, and the digital logic processes the results.

Experts predict that prototype quantum-inspired could outperform conventional and quantum computers by a factor of 10,000, but have been demonstrated on small problems not typical of what the military needs.

▲ DARPA researchers seek to apply quantum computing principles to embedded computing able to handle military missions in the field.

Continued from page 13

Royal Navy. Under the Babcock-led partnership with Elbit Systems UK and QinetiQ, the electronic warfare (EW) systems will aim to improve the simultaneous detection and identification of radar signals over a greater frequency range than current capabilities. The technology is expected to enable faster decision-making, enhanced situational

awareness, and anti-ship missile defense capability. The 13-year contract also is expected to drive job creation from software development to manufacturing roles. The increment to EW systems for Royal Navy surface warships systems is the first phase of a 500-million-pound program to further equip frigates and aircraft carriers with EW capability. ◀

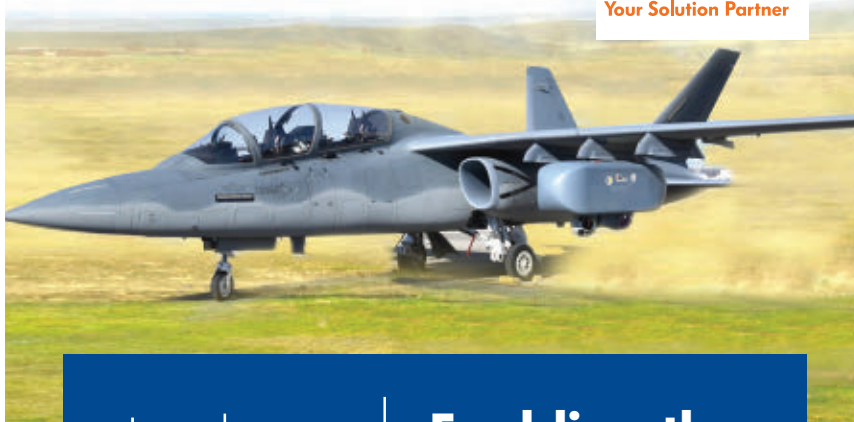
A key QuICC metric will be computational efficiency. To overcome scaling challenges, the program seeks solutions with algorithmic and analog hardware co-design, alongside application-scale benchmarking applications like Boolean satisfiability (SAT), maximum likelihood estimation (MLE), maximum-fault minimum-cardinality (MFMC) sampling, and mixed-integer linear programming (MILP).

The program has three technical challenges: scaling analog hardware advantages to mission relevant problems; limiting the growth of digital computations with problem size; and realizing predictive benchmarks at prototype system scales.

The QuICC program is five-year effort with a two year first phase, an 18-month second phase, and an 18-month, and an 18-month optional third phase. The program milestones will advance the scaling of quantum-inspired solver technology progressively toward mission-relevant problems and sizes. ◀

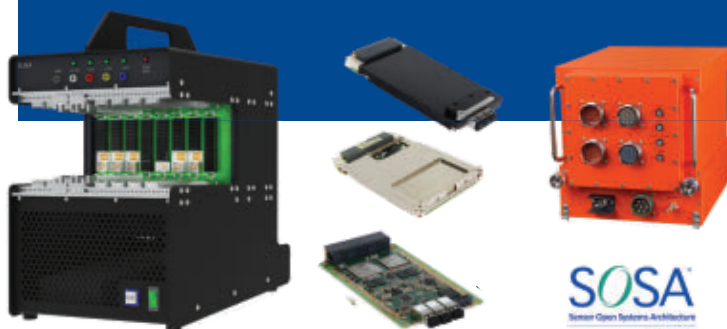
The program comprises two technical areas: solver co-design and mission relevant benchmarking; and analog hardware prototyping. Companies interested were asked to upload proposals by 12 Jan. 2022 to the DARPA BAA website at <https://baa.darpa.mil>. Email questions or concerns to Bryan Jacobs at HR001121S0041@darpa.mil. More information is online at <https://sam.gov/opp/2469bc38c8934ee2ad32552b-290b9ea8/view>.

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A large, grey, angular radar or sensor structure, likely a Phalanx CIWS or similar defense system, is mounted on a ship's deck. The structure is composed of several large, flat panels and a prominent, dark, rectangular sensor or radar face. A metal staircase with railings is attached to the right side of the structure. The background is a clear blue sky. The word "NAVY" is overlaid in large, bold, white capital letters across the upper portion of the image.

Moves Out

on Future Force, Digital Transformation

BY Edward J. Walsh

Facing continued budget austerity and new operational demands, the Navy in 2021 pushed forward on construction of new Flight III Arleigh Burke-class (DDG-51) destroyers, awarded a contract for engineering support for design of a new frigate class, and created a transformational strategy for building and upgrading ship combat systems. New destroyers and littoral combat ships (LCSs) joined the fleet, even while the

Navy started decommissioning relatively new LCSs.

◀ **The Raytheon SPY-6(v) air and missile defense radar (AMDR) was installed aboard Flight III Burke-class destroyer USS Jack H. Lucas at Huntington Ingalls shipyard prior to the ship's June launch.**

Last June Acting Navy Secretary Thomas Harker faced tough questions from the Senate Armed Services Committee about the Navy's plans for building force structure. He told the committee that the service's Plan and Force Design 2030 will

advance the Navy's vision of a "more integrated, all-domain force within existing resources," adding that the Navy has "had to make some very hard choices in this budget." (Carlos Del Toro was sworn in as Secretary of the Navy on August 9.)

Harker said maintenance costs have growth 2.5 percent above inflation; personnel costs also are increasing above the inflation rate. As a result the Navy has delayed some ship buys to future years and divested less-capable assets.

The acting SECNAV stressed that "effective use and management of data is key to our digital transformation and will change how we fight and win at every level."

Chief of Naval Operations Adm. Michael Gilday told the SASC that five years of analysis shows that "America needs a larger, more capable fleet." He pointed out that in 2010 the Navy had 288 ships, today it has 296. He said that "if the Navy's top line remains flat or if it goes down, the size of the fleet will definitely shrink."

Gilday warned that "the Chinese battle force is the largest in the world," now commanding a modern fleet of surface combatants, submarines, aircraft carriers, amphibious ships, and next-generation fighters.

China's naval strength now is critical to mapping Navy acquisition plans. The Pentagon report, "Military and Security Developments Involving the People's Republic of China," released in November 2021, found that the PRC is developing capabilities

for joint long-range precision strikes across domains, increasingly sophisticated space, counter-space, and cyber capabilities, speeding up expansion of its nuclear forces.

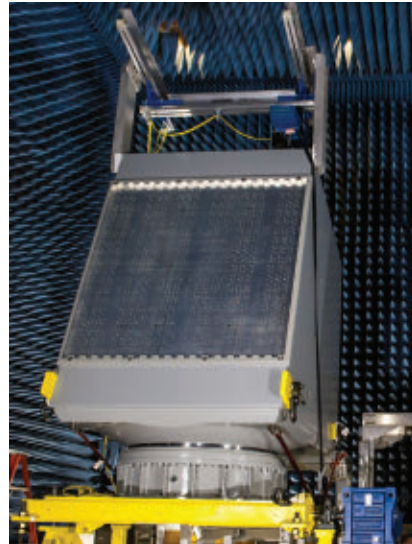
In August China conducted two tests of a hypersonic weapon system, including launching a missile potentially capable of carrying a nuclear warhead. Joint Chiefs of Staff Chairman Gen. Mark Milley called the tests “very significant, and very concerning.” Hypersonic missiles may travel at Mach 5, five times the speed of sound. In October Raytheon Technologies chairman Gregory Hayes said the U.S. is “several years behind” China in developing hypersonic weapons.

The DoD report said that the People’s Liberation Army Navy (PLAN) now has 355 ships and submarines, including more than 145 major surface combatants. The report says the PLAN soon will be capable of long-range strikes against land targets from surface ships and submarines.

The Navy also is watching Russian naval strength. The Defense Intelligence Agency has reported that the Russia’s navy has been improving its preparedness and building new surface ships and subs. DIA said the Russian navy now has about 32 major ships, including an aircraft carrier, three cruisers, 12 destroyers, and 11 frigates, along with 70 submarines.

The agency notes that while most of the Russian ships are between 20 to 25 years old, even older ships can launch the navy’s 3M14 Kalibr cruise missile thereby “increasing its ability to deliver precision strikes.”

According to Missiles of the World, the 3M14 Kalibr is a land-attack cruise missile able to carry a nearly 1,000-pound payload more than 1,500 miles. In late November the Russian frigate Admiral Gorshkov fired a Zircon hypersonic missile in the White Sea some 400 kilometers at a seaborne target.



◀ Experts test the SPY-6(v) air and missile defense radar (AMDR) in an anechoic chamber during the shipboard radar’s development.

Shipbuilding

In June 2021 the Navy announced a new shipbuilding plan. The Congressional Research Service, in its December background and issues analysis on Navy force structure, reported that the new plan modifies the 2016 total force structure target from 355 ships to 321 to 372 manned ships, augmented by 77 to 140 large unmanned vehicles.

The Navy says also that the future fleet “architecture” will have fewer large aircraft carriers, amphibious ships, cruisers, and destroyers, and more small carriers, amphibs, frigates, and unmanned vessels. This “distributed” fleet will include new Constellation-class (FFG-62) frigates, a light amphibious warship, and a next-generation medium logistics ship.

Last September the Congressional Budget Office estimated that the proposed fleet structure would cost between \$25.3 billion

and \$32.7 billion per year, considerably higher than the \$22.9 billion appropriated for the past five years for new ships.

The FY 2022 budget sought funding for eight ships: two Virginia-class attack subs, one Burke-class destroyer, the



◀ The Lockheed Martin 60-kilowatt high-energy laser and integrated optical dazzler and surveillance unit (HELIOS) laser weapon is to be installed on a Navy Burke-class destroyer.

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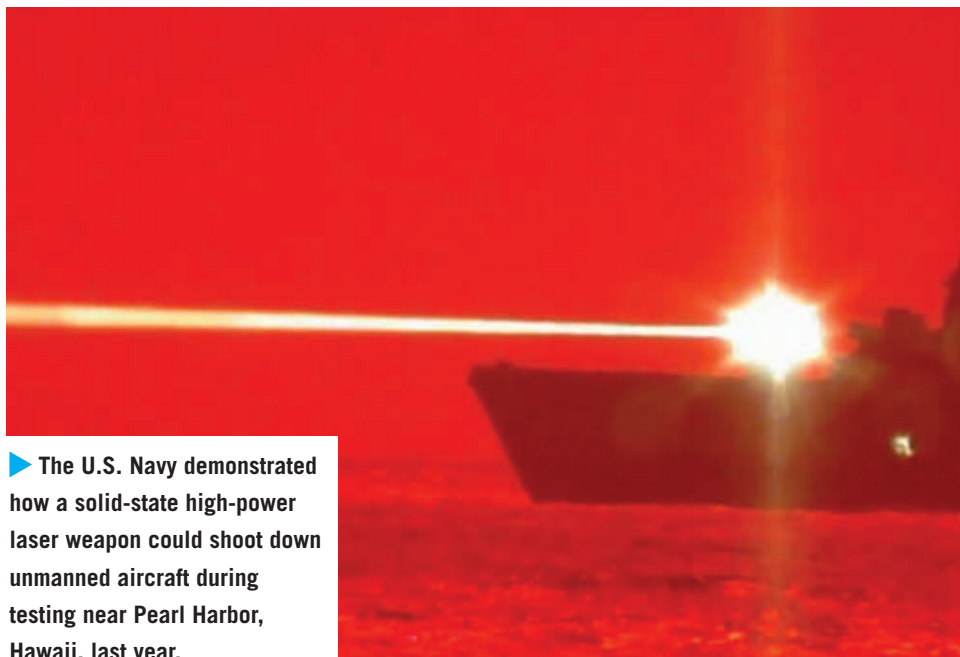
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► The U.S. Navy demonstrated how a solid-state high-power laser weapon could shoot down unmanned aircraft during testing near Pearl Harbor, Hawaii, last year.

first Constellation-class frigate, one oiler, two towing/salvage/rescue ships, and one surveillance vessel. The Navy requested \$18.8 billion for shipbuilding, increased from the \$17.8 billion sought for FY 2021. The Navy sought \$3 billion for the first Columbia-class ballistic missile submarine.

CRS notes that the 355-ship target was for manned ships only, even though the Navy has fielded a number of unmanned surface and unmanned undersea vehicles (USVs and UUVs). Because most of them deploy from ships, subs, or aircraft, they weren't counted in the ship total. Current plans to build larger USVs and UUVs that could deploy independently could mean they are counted within the force structure.

The shipbuilding plan released a year ago projected procurement of Flight III Burke destroyers through FY 2025. The FY 2022 request sought \$122 million for concept work on a future surface combatant, now called DDG(X). Last summer the Program Executive Office for Ships established a DDG(X) program office to explore a DDG(X) follow-on to the Burke class. The PEO said the Navy wants to buy the first DDG(X) in FY 2028.

In early December the House of Representative passed the FY 2022 defense authorization bill, adding five ships to the Navy's request: two Burke destroyers, two Expeditionary Fast Transport ships, and one oiler. The bill also directs the Pentagon to report to Congress on progress developing and testing hypersonic missile defenses.

In a key step toward creating the new fleet, the Navy last August awarded a \$38.1 million contract to Fincantieri Marinette

Marine for engineering support for detail design and construction of Constellation. The company won the construction award in April 2020.

The Navy in December commissioned Burke-class destroyer Daniel Inouye (DDG-118), built by General Dynamics Bath Iron Works. In October Bath christened Carl M. Levin (DDG-120).

The BIW yard also is building three Flight III ships, Louis H. Wilson Jr., William Charette, and Quentin Walsh (DDGs-126, -130, and -132). Huntington Ingalls Industries is working on Flight III hulls

Jack H. Lucas, Ted Stevens, and Jeremiah Denton (DDGs-125, -128, and -129).

In September the third and last Zumwalt-class destroyer, Lyndon B. Johnson (DDG-1002), completed sea trials at Bath. The ship then transited to Huntington Ingalls for combat systems and weapons integration. The first two ships, Zumwalt and Michael Monsoor (DDGs-1000 and -1001) have been delivered.

In October Huntington Ingalls conducted builder's trials for San Antonio-class amphib Fort Lauderdale (LPD-28). The LPDs will transport 650 Marines, who can be deployed by helicopters, MV-22 tiltrotor aircraft, or by air-cushion vehicles. Fort Lauderdale and Richard S. McCool (LPD 29) are transition ships to Flight II of the class, which begins with Harrisburg (LPD-30), now also in production. The Navy wants 13 Flight II ships.

In November the company received \$113.6 million in additional advance procurement funds for America-class amphibious assault ship LHA-9. The Navy plans a construction contract for the ship in 2024.

Huntington has delivered America and Tripoli (LHAs-6 and -7), called Flight 0, which were designed primarily for aviation operations and do not have a well deck for launching landing craft. Because of Marine Corps concerns, Bougainville (LHA-8), now under construction, and later LHAs will have welldecks.

The Flight 0 ships are built with a hybrid propulsion plant that uses twin electric motors for low speeds then switches to the General Electric LM2500+ gas turbine for higher speeds.

In October the Navy christened the LCS Santa Barbara (LCS-32). The ship is the 16th of the Independence variants,

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which are built to a “trimaran” hull design. Freedom variants are built with conventional hulls by Fincantieri Marinette Marine. The Navy christened Freedom-variant Nantucket (LCS-27) in August.

Through 2021 the Navy dealt with stubborn problems with the gear system on the Freedom variants. Last January the Navy advised systems integrator Lockheed Martin that it would not accept delivery of ships until flaws in the combining gear, built by a German company, RENK AG, have been repaired. The gear links the diesel and gas turbine engines to enable the ship’s 40-knot speed. Thirteen of the Freedom variants require the gear repair.

Although the lead ship, Freedom and Fort Worth (LCS-3) were built with a different gearing system, the Navy decommissioned Freedom in September after 13 years of a planned 25-year service life. The Navy plans to decommission three more Freedom ships and Independence variant Coronado (LCS-4). Independence (LCS-2) was decommissioned in last July.

the glide body into initial flight. Both the Navy and Army would deploy the weapon and launch system in service-specific configurations. The services would use a common all-up round that could be launched from ships, submarines, and ground sites.

In an October SSP test, a Lockheed Martin-Northrop Grumman team successfully fired a first stage solid-rocket motor of a hypersonic strike system as part of the Navy’s CPS and the Army’s Long-Range Hypersonic Weapon initiatives. The test followed earlier tests in May and August. Lockheed is the team systems integrator and Northrop Grumman developed the motor used in the test.

SSP director Vice Adm. Johnny R. Wolfe Jr. said after the test that “today’s successful test brings us one step closer to the design validation of our new hypersonic missile.”

Raytheon Technologies is teamed with Northrop Grumman on an Air Force/DARPA Hypersonic Air-breathing Weapon

Concept, integrating a Raytheon hypersonic air-breathing missile with Northrop Grumman scramjet combustors. Last September the team conducted a successful flight test in which the missile, fitted with the scramjet motor, was released from an aircraft. The motor then ignited and propelled the missile to hypersonic speed.

The Naval Surface Warfare Center (NSWC) Dahlgren Division has pursued extensive research on hypersonic weapons technologies. Officials say that in the early 1970s Dahlgren engineers developed an eight-inch gun-launched ramjet that could reach Mach 4, near-hypersonic speed. More recently, Dahlgren modeled, designed, and test-flew a hypervelocity projectile capable of reaching hypersonic speed. Dahlgren officials say that the NSWCDD Strategic Plan for

2021-2025 “thrusts hypersonic weapons advancement into the forefront with a goal to establish Dahlgren as the Surface Navy Lead for offensive and defensive hypersonic weapon systems integration.”

The Navy also is pursuing lasers, railguns and hypervelocity deck guns, which require far greater levels of power than conventional weapons. Lockheed Martin’s 60-kilowatt HELIOS (high-energy laser and integrated optical dazzler and surveillance unit) was scheduled to be installed on a Burke destroyer late last year.

▼ **Flight II Arleigh Burke-class destroyers will receive a variant of the SPY-6 air and missile defense radar (AMDR). Shown here is the USS William P. Lawrence operating in the Pacific Ocean.**



Hypersonics, Advanced Weapons

China’s hypersonic missile tests last summer added urgency to Navy efforts to develop a conventional hypersonic weapon. The Navy requested \$1.1 billion for FY 2022 for collaborative work with the Army on hypersonics. The Navy’s Strategic Systems Program Office, which is managing the CPS program, says the program seeks to “design, build, and sustain an evolving multi-service hypersonic capability.”

SSP says the Navy system is a hypersonic glide body that travels to its target at hypersonic speed and a booster that launches

The company won a \$150 million contract in January 2018 for one HELIOS system for a ship installation and a second for land-based testing with options for 14 more.

Joe Ottaviano, a Lockheed Martin business development director, said that a laser system amounts to an “endless magazine that never runs out of power.” The company developed the HELIOS for Increment 1 of the Surface Navy Laser Weapon System (SNLWS) program, aimed at a 60-KW system that potentially could be increased to 150 KW.

Navy officials say the system could be used to counter UAVs, small craft, and hostile sensors, and for combat identification and battle damage assessment.

The effort is part of the Navy’s Laser Family of Systems program, which includes a solid-state laser technology maturation initiative of the Office of Naval Research and an optical dazzling interdictor called ODIN. ONR also funded work on a 30-kilowatt laser weapon system (LaWS) demonstrator and Mk 38 tactical laser system. Raytheon, Northrop Grumman, and BAE Systems developed concepts for a 100-150 KW prototype LaWS.

A critical challenge has been generating adequate ship power. In March 2021 the NSWC Dahlgren and Philadelphia divisions started collaborating on an initiative called PEGASUS (Power and Energy Generation Analysis Simulation System) to integrate high-powered electric weapons and shipboard electric propulsion systems.

Team Leader Thomas McKelvey said the team demonstrated the integration of a ship combat system with ship machinery, aiming at coupling high-energy weapons with power systems. He said the team used a 50-KW laser to measure voltage and thermal characteristic data and developed lessons for testing a 300-KW High Energy Laser Counter Anti-ship Cruise Missile Project (HELCAP) test bed. NSWC officials say the testbed is used to demonstrate laser technologies to defeat anti-ship cruise missiles.

Ship Systems, Weapons

The Navy in 2021 moved to transform its processes for development and upgrade of ship combat systems, the computer hardware and software architectures that control sensors, process received sensor data, and launch weapons. The Aegis system aboard Ticonderoga cruisers and Burke destroyers has evolved over years through “baselines” to provide new capabilities. Baseline development has been an onerous, expensive process of software code-writing, troubleshooting, and testing.

In recent years the Navy moved to a common software library (CSL) as a repository for combat system modules that can be mixed and matched to meet new requirements. The

CSL is the starting point for what Navy officials now call the fleetwide “digital transformation” strategy for combat-system software development.

In March 2021 the Program Executive Office for Integrated Warfare Systems (PEO IWS) set up a “software factory ecosystem” named the Forge in Riverdale, Md., modeled after the Air Force’s Kessel Run facility near Boston. The Forge acts as nerve center for streamlining software development in order to move new combat systems software rapidly to ships.

Industry has jumped in. Northrop Grumman has supported the Air Force’s digital transformation initiatives. Jim Sheridan, until recently manager of Lockheed Martin’s Moorestown, N.J., site, says that digital transformation aims to shatter the paradigm of taking years to introduce upgrades and to get them to ships in as little as 24 hours.

In September Lockheed Martin demonstrated a Virtual Aegis Weapon System (VAWS) during the Indo-Pacific Command’s Valiant Shield exercise. The VAWS provided targeting data for Army and Air Force operations centers to demonstrate weapons launches.

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◀ **Lockheed Martin and Raytheon are collaborating on the SPY-6(v) air and missile defense radar and the Aegis combat system. Shown is the radar arriving at the Lockheed Martin site in Moorestown N.J.**

The company also demonstrated the VAWS in the Air Force's Northern Eagle exercise in Alaska last May and in the Australian-run Talisman Shield in June through August.

Sheridan says that Aegis "virtualization" allows the system to be distributed in multiple nodes and used in air, land, and naval domains, without the need for an Aegis-equipped ship.

The company has teamed with SOLUTE to improve cybersecurity for Aegis software and formed a partnership with Innovative Defense Technologies to create an "Aegis Enterprise Platform as a Service" to use digital technologies to deliver updates to test sites. The company also is using Amazon Web Services cloud technology for data-engineering tasks.

The Navy moved critical new ship systems toward deployment and upgraded fielded systems. The SPY-6(v) air and missile defense radar (AMDR), built by Raytheon, was installed aboard Flight III Burke DDG Jack H. Lucas at Huntington Ingalls shipyard prior to the ship's June launch. SPY-6(v) variants also will be go aboard America-class amphibies, Nimitz – and Ford-class carriers, Constellation frigates, and Flight IIA Burkes. In December Raytheon won contracts worth about \$290 million for additional work on AMDR.

Although Raytheon won the SPY-6(v) contract, ousting Lockheed Martin from its long-held position as the builder of the SPY-1(v) radar for the Burke class, Lockheed will provide the

Aegis combat system for the new radar. Both companies are working on integrating the Aegis Baseline 10 program with the radar.

Lockheed Martin also is the combat systems integrator for the new Constellation class, using Aegis Baseline 20, and for the ship self-defense system aboard Wasp – and San Antonio-class amphibies.

The Missile Defense Agency is funding Lockheed for work on the ballistic missile defense computer program called Baseline 5.4. The company is developing a low-noise amplifier, along with a digital LNA that will enable future software upgrades to the SPY radars aboard in-service Burkes.

Lockheed Martin also is building its new SPY-7 Aegis radar for Spain's F-110 frigate program and Canada's new Surface Combatant. The MDA's Aegis Ashore sites in Romania and

Poland also will get the SPY-7. The Aegis system in Deveselu, Romania site is operational; the site in Redzikowo, Poland is expected to be operational by late 2022. Control then will transition to NATO.

Between September and December Raytheon won more nearly \$330 million in contracts for engineering services and baseline support for the USG-2/3 Cooperative

Engagement Concept (CEC), the latest in a long series of awards for CEC support.

The Navy started fielding CEC in late 2001. It consists of a CEC processor, data-distribution system or DDS, and a directional active-array antenna. The system creates a comprehensive sensor network that allows CEC-equipped ships and aircraft to share target-track data. In October DRS Laurel Technologies received a \$12.3 million award for CEC components. In July DRS won a \$28 million award for consoles, displays, and peripherals for future surface ship combat systems.



▲ **The Navy extended production of the San Antonio-class amphibious transport dock, and will build a lower-cost flight-two variant. Shown is the USS Portland (LPD 27) conducting sea trials in the Gulf of Mexico.**



▲ The U.S. Navy's three Zumwalt-class (DDG 1000) destroyers are powered by an intermediate type integrated power system — perennial goal for the surface fleet.

Also in October Raytheon's Missiles and Defense unit won \$30 million for two contracts for upgrades for the Tomahawk ship – and sub-launched cruise missile. The Navy is recertifying its inventory of 15-year-old Block IV missiles to a new Block V configuration by adding communications and navigation upgrades. The company has started delivering Block V missiles.

The October awards fund Raytheon for development of a Block Va variant, called the Maritime Strike Tomahawk (MST), which will be fitted with a multimode seeker to enable it to hit moving seaborne targets. A Block Vb Tomahawk will receive a Joint Multiple Effects Warhead system or JMEWS, capable of attacking additional land targets. Navy Tomahawk program manager Capt. John Red says the MST will start fielding in 2024 and JMEWS in 2027.

The Navy is looking to augment ship torpedo-defense with a new very lightweight torpedo (VLWT), based on longtime work by Penn State's Applied Research Laboratory. A Penn State design for a Compact Rapid Attack Weapon (CRAW) was shown to industry in 2016.

Northrop Grumman Naval and Oceanic Systems has designed a VLWT torpedo only 171mm or 6.75 inches in diameter. The weapon will be capable of attacking submarines but also of rapidly identifying, classifying, and engaging approaching torpedoes.

The Penn State CRAW work was funded by ONR for many years. The Navy plans to select a contractor to develop a design for rapid manufacture.

Ship Power Systems

The Navy made modest progress in transitioning surface ships from conventional power systems to integrated electric power. PEO Ships, in setting up the DD(X) office in June, declared that NAVSEA's Electric Ships program office would merge with

the new office to “leverage expertise in developing and implementing an integrated power system (IPS), a key foundation of these future surface combatant ships.”

In June 2020 NAVSEA published a Naval Power and Energy Systems Technology Development Roadmap that proposed strategies for expanding ship power capacity to support the power-hungry SPY-6(v) radar, rail guns, and lasers. The hybrid systems aboard America-class amphibians and the modified IPS aboard Zumwalt destroyers are key steps to the all-electric power architectures defined in the 2020 Roadmap. The Navy also wants to shift to an IPS for the Columbia-class ballistic missile sub.

In September the NSWC Philadelphia lab awarded DRS Naval Power Systems a \$57 million contract for upgrades to switchboard circuit breakers aboard the LSD, LCC, LPD, and LHD amphib classes. The Philly lab also awarded \$15 million to Rolls-Royce Solutions America for modernization and in-service support for MTU engines and shipboard auxiliary systems. In June NAVSEA awarded \$77 million to Timken Gears & Services for main reduction gear shipsets for Flight III Burke destroyers Richard G. Lugar and John F. Lehman (DDGs-136 and – 137). ←



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Aircraft maintenance Airmen work on a computer in front of an F-22 Raptor at Tyndall Air Force Base, Fla.

Rugged computing takes on the battlefield networking challenge

Connectivity, networking, SWaP, and thermal management are among the highest priorities of rugged computing designers to support mobile warfighters at the edge.

BY Jamie Whitney

Warfighters and the experts that support them have a dizzying amount of computing power thanks to small, rugged mobile computers designed for the modern battlefield. Today's forward-deployed rugged computers, servers, and network equipment also need to have security at top priorities.

Aneesh Kothari, the vice president of marketing for Systel Inc. in Sugar Land, Texas, says the military's focus on Joint All-Domain Command and Control (JADC2) connectivity is a large trend, as the military-aerospace rugged computing sector rolls into the year 2022. The goal of JADC2 is to share data in all domains across all branches, quickly and securely.

According to the nonpartisan Congressional Research Service in Washington, "traditionally, each of the military services developed its own tactical network that was incompatible with those of other services (i.e., Army networks were unable to interface with Navy or Air Force networks). DOD [Department of Defense] officials have argued that future conflicts may require decisions to be made within hours, minutes, or potentially seconds compared with the current multiday process to analyze the operating environment and issue commands."

Dominic Perez, technical fellow and chief technical officer of Curtiss-Wright Defense Solutions, says he agrees that JADC2

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is the biggest programmatic driver of trends in small rugged computers and network equipment for aerospace and defense electronics, including the U.S. Air and Space Force's Advanced Battle Management System (ABMS).

"Underneath JADC2 is ABMS, project convergence, and project overmatch," Perez says. "The military is recognizing the need to share data across domains, top to bottom, left to right. That's going to necessitate, in particular, more edge processing, but also more processing in just about any environment you can conceive of."

Compute power

Perez continues, "The other driver we're seeing is on the technical front. There is more compute power than ever in small form factor systems. Just half a decade ago, you were looking at a very high-powered system with maybe four cores and 32 Gigs of RAM. And now, routinely, in a 2.5-pound package, we're deploying 16 cores and 128 Gigs of RAM. This allows more complex, more compute intensive applications to be pushed out to the tactical edge."

"These technical drivers work hand-in-hand with the programmatic drivers," Perez says. "You can want and proscribe anything at the programmatic level, but if the technology isn't there to fulfill the need it will be unactionable. Now we're seeing a real matchup of what the military's long-held desire is — to have information available across domains in real time or near-real time. Today, there's the computing power to actually achieve that desire. On the networking side, through software defined networking and multi-cloud access the software piece has also fallen into place to allow this information to come out of these silos and be shared across the battlefield."



▶ **Senior Chief Damage Controlman Todd Thomas inputs tag outs into the computer aboard the Freedom-variant littoral combat ship USS Sioux City (LCS 11) during a planned maintenance availability (PMAV) in Ponce, Puerto Rico.**

Systel's Kothari says that Edge AI capabilities and high-speed secure networking are "vital for mission success. As the drive towards JADC2 and multi-domain operations progresses across all service branches, compute and connectivity are critical. On the hardware side, this translates to requirements for higher performance systems in smaller form factors."

Justin Moll, the vice president of sales and marketing for Pixus Technologies USA in Tonawanda, N.Y., says that "lines are blurring" between the traditional radio frequency (RF) and sensor domain and the processing domain.

"We are seeing a shift in the types of enclosure systems for military vehicles and command posts," Moll says. "While there is growth in multi-function, multi-purpose solutions, the space constraints remain compact. A mix of next-generation purpose-built enclosure systems and multi-function designs are emerging."

Open standards

The DOD has long been pushing for vendor-agnostic components through open standards programs like Sensor Open Systems Architecture (SOSA) and Modular Open Systems Approach (MOSA). The latter system is the largest trend driving development in the rugged computing sector, says Jason DeChiaro, systems architect at Curtiss Wright Defense Solutions.

"MOSA is real: not only has it been made law by Congress, the House Armed Services Committee is extremely interested and supportive, asking the Army to implement it and calling it out in a number of reports," DeChiaro says. "The secretaries of the Army, Navy and Air Force have mandated the use of MOSA, but even

▶ **Sgt. Kyle Phillips configures computer equipment to ensure communications and controls connected to a Raven small unmanned aircraft system are working properly at Marine Corps Base Camp Lejeune, N.C.**



more telling is that there is actual funding to support it in the Defense Authorization Bill for 2022. It's law, it's mandated, it's getting funded and we're seeing it as a requirement in RFPs.

"In addition, the Joint Chiefs of Staff is driving policy and programs based on MOSA to Program Managers, DeChiaro says. "On the vendor side, we've been in the VPX world a long time, and now that it's mandated, we're making sure that our products align with the new standards that support MOSA, such as CMOSS and SOSA. For example, we recently updated our VPX3-1260 single board computer, redesigning it with new pinouts that align with the CMOSS and SOSA Technical Standard 1.0. In fact, every new card that we're making is going to be aligned with SOSA."

At the edge

Panasonic Corp. of North America, based in Newark, N.J., celebrated the 25th anniversary of the company's Toughbook brand in 2021.

Scott Heckman, the company's national sales manager for federal civilian and Army applications, says that "edge computing and situational awareness (SA) have become hot topics across the military as the need grows to enable the warfighter with as much tactical visibility as possible. You may be familiar with the Mounted Family of Computer Systems (MFoCS) program that permanently mounts ultra-rugged, purpose-built computers in heavy-duty military vehicles. There is an effort afoot to extend this capability to smaller tactical vehicles — i.e. Polaris mRZR — by leveraging commercial off-the-shelf (COTS) devices that can be used in a mounted or dis-mounted fashion.

Heckman continues, "Following the rise of small, chest-mounted Android devices running Android Tactical Assault Kit (ATAK), there is a natural opportunity to extend this SA capability to small tactical vehicles with rugged Android tablets, such as the TOUGHBOOK A3."

Staying flexible

Curtiss-Wright Defense Solutions' PacStar division in Portland, Ore., are being asked for higher compute density, faster storage,

remote management, automated deployment, and GPU enablement for the tactical edge.

The company's Perez says that "PacStar has seen these trends, and in response we recently released our PacStar 451-NR module that incorporates the highest compute density and RAM and adds very, very fast NVMe storage. It also supports industry-standard IPMI remote management that helps accelerate the deployment of the actual applications on the compute platforms. Likewise, we've addressed to the need for GPU-accelerated devices with our PacStar 453 and PacStar 454 modules that feature NVIDIA GPUs along with the same powerful compute platform that's used in the PacStar 451.

"One thing that our customers are constantly asking for is flexibility in deployment," Perez continues. The modularity of our 400 series really addresses that need. You can scale up and down the number of computers that you take in a system based on the mission need and based on the number of people you will be serving at the edge, and you can mix it that compute power modularly with other non-compute products, like routers and switches, all in the same form factor, all packaged for man-carry and ready-to-mount in vehicles. It's a modular solution that allows you to architect a system based on requirements, and as those needs evolve, you don't have to wholesale replace the system. Instead, you can swap in individual modular components."

Panasonic's Heckman notes that the Toughbook line is built with flexibility in mind as the brand enters its second quarter century in the forward-deployed, ruggedized landscape.

"As edge computing rises, we have also seen an increasing need for flexibility and serviceability in the field," Heckman says. "Our mobile computers are becoming more modular, with our unique 'xPAK' design that allows users to install and swap components, either without tools or with just a couple small screws. This provides flexibility for IT departments and users and keeps weight down as components can be removed from the system when not needed for a particular mission."

Regarding serviceability, Heckman says that Panasonic's "modular designs allow



▲ The new PacStar MDC-NR enhanced configuration of Curtiss-Wright's PacStar Modular Data Center (MDC).



▲ The Parvus DuraCOR 313 from Curtiss-Wright is an ultra-small form factor (USFF) rugged embedded computer based on a low-power, quad-core Intel Atom x6400E Series (Elkhart Lake) processor equipped with modularity for add-on I/O cards and data storage in a fanless IP67-rated miniature design.

users to retain their device if they need service on certain components. Users can also perform certain tasks like replacing keyboards. This is especially impactful in a deployed military environment where IT staffs and service depots are not easily accessible.”

Cooling concerns

Pixus’s Moll notes that modern forward-deployed computers are high powered and produce heat that needs to be dissipated. Moll says that many of Pixus’s customers are evaluating approaches like VITA 48.7 — air flow by — and VITA 48.8 — air flow through — cooling.

“Pixus has developed some solutions for rugged rackmount enclosures that leverage VITA 48.8, directing airflow through the plug-in module for superior cooling,” Moll says, and notes that the industry also must consider SOSA standards as well. “As many applications are leery of liquid-cooling, this approach can give high-power OpenVPX/SOSA based systems the thermal management they require.”

While keeping systems cool may not pique interest quite like eye-popping transfer rates, it is integral to keeping vital information flowing.

“Cooling, while not terribly exciting, is a fundamental challenge that we address every day,” says David Jedynak, general manager of Curtiss-Wright Defense Solutions. “There are emerging new technologies for cooling, but when you get down to it, nobodies changing the laws of physics. As more compute power gets introduced into smaller devices our thinking shifts more to consider what’s possible to achieve in the same power envelope.

“What you can do in terms of cooling in a shirt-sleeve or industrial environment just isn’t possible at the edge of the

battlefield, Jedynak continues. “We have to design to the environment in which our solutions are deployed, and sometimes that dictates limits like no cooling-fans or air intakes, and you have to design for that. Thermal management is always a constraint, but it’s well understood, and as long as we design within the laws of physics and the customer’s environmental and reliability requirements it’s not a problem.



▲ Curtiss-Wright’s new 8-Slot CMOSS/SOSA aligned enclosure provides a configurable rugged platform for Ground Mobile and GCV environments. The powered chassis features 8 3U OpenVPX slots, all aligned with the SOSA Technical Standard 1.0.

Electronics cooling and thermal management are among the most important issues for today’s rugged computers designers, Jedynak says. “Engineers are constantly working to stay ahead of the cooling problem and we leverage that evolutionary, not revolutionary, progress. There’s no magic solution, you just have to understand the constraints of your environment and the solution’s real-world use, while not designing too conservatively where you don’t need to be. For example, model based engineering can introduce biases and limits that encourage over-design and don’t match the art of the possible proven through empirical analysis.”

While warfighters battle enemy personnel and their deployed technology, Panasonic’s Heckman agrees that the rugged computer industry wages a battle against thermal energy.

Heat is the enemy

“Heat is certainly the enemy of rugged mobile computers and it takes some engineering prowess to prevent overheating and performance degradation,” says Heckman. “Unfortunately, not all rugged mobile computers perform as well in extreme temperatures.

Heckman continues, “One trend we’ve noticed from experienced rugged mobile computer users, is testing devices in the

WHO’S WHO IN RUGGED COMPUTERS

Abaco Systems
Huntsville, Ala.
www.abaco.com

Aitech Defense Systems, Inc.
Chatsworth, Calif.
www.rugged.com

Curtiss-Wright Defense Solutions
Ashburn, Va.
www.curtisswrightds.com

Combat Proven Technologies (CP Tech)
San Diego
<https://cp-techusa.com>

Core Systems
Poway, Calif.
<https://core-systems.com>

Crystal Group Inc.
Hiawatha, Iowa
www.crystalrugged.com

Extreme Engineering Solutions (X-ES)
Verona, Wis.
www.xes-inc.com

PacStar
Portland, Ore.
<https://pacstar.com>

Panasonic Corporation of North America
Newark N.J.
<https://na.panasonic.com/us>

Pixus Technologies Inc.
Waterloo, Ontario
www.pixustechnologies.com

Systel Inc.
Sugar Land, Texas
www.systelusa.com

environment in which they will be used. For example, processor and battery performance in an air-conditioned lab are very different than on a 100-degree flight line after an hour. Organizations that make purchasing decisions based on real-world testing are generally rewarded with greater productivity and fewer quality/operational issues.”

Curtiss-Wright’s DeChiaro says he agrees that thermal challenges are “by far” the biggest issue to tackle in CMOSS systems installed in ground vehicles because of the environments those vehicles and systems are being asked to operate in.

“Thermal management is the biggest driver of design decisions because it defines how you break up systems and how much processing and power you actually put in the vehicle,” DeChiaro says. “There are exotic cooling techniques like LFT that are being discussed and considered because of the higher power densities being required to meet the mission. I would say that the Army is now more open to looking at and potentially fielding new cooling technologies that they historically wouldn’t have considered.”

Pixus’s Moll says that The two and three payload slot size “fits a nice sweet spot for many of these applications. These systems can require enclosures in either a rugged rackmount or ATR format styles. Pixus has developed modular 1U-4U horizontal-mount 19” enclosures in both benign environment and MIL-spec COTS versions. The 1U version can accept up to (3x) 3U OpenVPX boards. Obviously, the taller chassis platforms provide more slots.

“The Pixus line of 1U-4U Horizontal mount OpenVPX chassis can be provided in side-to-side or front-to-rear airflow configurations and all can include a mix of 3U and 6U slots in the same enclosure,” Moll says. “Similarly, for mobile rugged requirements, the 1/2 ATR enclosure with 3 OpenVPX and 1 VITA 62 PSU slot is a popular option. Increasingly, versions with supplemental airflow over the fins are required for the higher wattage of today’s OpenVPX and SOSA aligned boards.”

Of course, keeping components cool will do little good if the equipment isn’t built as tough as the warfighters that use them.

“Forward-deployed equipment needs to be fully rugged and fully sealed to reliably perform in austere environments and conditions,” Systel’s Kothari says. “We are increasingly integrating extremely high performance, and consequently high wattage, electronics into ultra-small form factor systems in response to our defense customers’ requirements.”

Cost concerns

While the first military budget under President Joe Biden saw a modest five percent increase over the previous year, branches still have their eyes on the bottom line when it comes to field-deployable computer technology.

Curtiss-Wright’s Jedynek says that from his perspective, size, weight, power, and cost (SWaP-C) of systems still is the biggest trend influencing development.

“Our opportunity, and the customer’s desire, is to increase compute and network capabilities at the edge so the warfighter can do more while detached,” Jedynek remarks. “Think about how our phones can do more and more without being tethered back to some big server. We want to be able to do more processing, data gathering, and analysis at the edge, as

opposed to it being handled post facto by another system in another location. This trend drives things like ML and increased processing capabilities, as well as greater amounts of storage,” Jedynek says.

“Another trend is the move towards unmanned platforms and smaller ground sensors, which then drives the need for smaller compute solutions to support them. Of course,

the challenge is to provide as much processing and connectivity as possible within the limits of the SWaP-C envelope that you are dealing with. The technology trend continues, as always, to be how much can you pack into the same size system, as permitted and realized through levels of integration bounded by Moore’s Law. As you can do more in a smaller package, new applications and capabilities emerge and become possible, for example, imagine target recognition with a pocket computer.

“At the same time, as solutions miniaturize, it becomes not just about new applications, but new platforms as well,” Jedynek says. “Taking some host that previously had no intelligence and now adding smaller, lower power and more affordable compute and network capabilities. Think of a smart doorbell as an example. What becomes interesting and compelling is that once these capabilities become fielded, we then discover new ways of using them. It’s about ubiquitous computing, just like we see in industrial and commercial applications, but introduced into the tactical edge. Now we can bring capabilities, tracking, built-in-test, sensing, etc., to platforms that previously had none.” ◀



▲ The Pixus RX310 has various levels of ruggedization, including IP67 weatherproof, MIL rugged, light rugged, and more.

◀ Lockheed Martin is asking BAE Systems to upgrade the electronic warfare (EW) system for the U.S. F-35 jet fighter-bomber.

BAE Systems to upgrade electronic warfare (EW) hardware and software on F-35 jets

BY John Keller

NASHUA, N.H. — Avionics integrators at Lockheed Martin Corp. needed a company to upgrade the electronic warfare (EW) system for the U.S. F-35 jet fighter-bomber. They found their solution from the BAE Systems Electronic Systems segment in Nashua, N.H.

Officials of the Lockheed Martin Aeronautics segment in Fort Worth, Texas, have announced a \$493 million order to BAE Systems to upgrade the EW system aboard the F-35 to enable the

combat jet to detect and address evolving electromagnetic threats quickly in contested battlespaces, BAE Systems officials say.

Under the contract, BAE Systems will deliver enhanced hardware for the F-35's AN/ASQ-239 high-performance EW mission system, and provide engineering services and test infrastructure.

The upgraded system will superior situational awareness, electromagnetic attack, and countermeasure capabilities with new sensors and more powerful digital signal processing.

“The highly adaptable mission system will allow our warfighters to outpace evolving threats and defend democracy around the globe,” says Lisa Aucoin, vice president of F-35 Solutions at BAE Systems.

The enhanced EW system design will enable rapid future hardware and software upgrades with a modular architecture that also can help reduce life cycle and retrofit costs across the global F-35 fleet. The system also includes the Non-Intrusive Electronic Warfare Test Solution (NIEWTS) fault isolation and diagnostics capability, which enables troubleshooting.

The AN/ASQ-239 EW avionics provides the F-35 with 360-degree situational awareness and end-to-end capabilities. It provides offensive and defensive options to enable the F-35 to identify, monitor, analyze, and respond to threats like radar-guided anti-aircraft missile batteries and air-search radars.

The system makes the most of detection ranges and gives the F-35 pilot evasion, engagement, countermeasures, and jamming

options. The AN/ASQ-239 provides broadband protection to help the F-35 reach well-defended targets and suppress enemy anti-aircraft radar systems.

This system can operate in signal-dense environments and provide the F-35 with radio frequency and infrared countermeasures, and rapid response capabilities. The AN/ASQ-239 has an electronics architecture that enables designers to add new capabilities.

The AN/ASQ-239 on the F-35 fighter-bomber has Integrated radar warning, targeting support, and countermeasures; reduced long-term life cycle cost; increased situational awareness; rapid response capabilities to protect the aircrew; threat warning; and ability to reach well-defended targets. ◀

For more information contact BAE Systems Electronic Systems online at www.baesystems.com, or Lockheed Martin Aeronautics at www.lockheedmartin.com.

Special Operations Command chooses SATCOM terminals from Tampa Microwave

BY John Keller

MacDILL AIR FORCE BASE, Fla. — Satellite communications (SATCOM) experts at U.S. Special Operations Command (SOCOM) at MacDill Air Force Base, Fla., needed lightweight SATCOM equipment for covert use on the battlefield. They found their solution from Tampa Microwave LLC in Clearwater, Fla.



Tampa Microwave will provide U.S. Special Operations Forces with covert RF and microwave communications for the battlefield.

SOCOM officials announced a \$62.1 million order to Tampa Microwave for Special Operations Forces Deployable Node—Lite (SDN-L) terminals, equipment, and spare parts for special forces SDN-L SATCOM.

SDN-L is the sub-one-millimeter variant of a family of special forces lightweight satellite communications (SATCOM) equipment for covert use on the battlefield. SDN-Lite terminals operate in X, Ku, and Ka SATCOM bands, and are part of the SDN family of systems, which represents an evolutionary follow-on replacement for the legacy Special Operations Deployable Node-Family of Terminals (SDN-FoT).

Tampa Microwave won a \$70 million five-year Special Operations Forces contract in 2018 for SDN-Lite, a sub one-meter aperture terminal for U.S. Special Operations Forces (SOF) that consists of modular, portable SATCOM terminal variants that handle secure and non-secure voice, video, and data communications at several classification levels.

The SDN-Lite provides multi-user, multi-classification satellite transmission and reception capabilities, and provide Special Operations users with worldwide connectivity to the SOF Information Environment (SIE) over several classifications via separately acquired baseband equipment.

The primary goal of the SDN-Lite is to reduce the size, weight, and power consumption (SWaP) of special forces SATCOM without compromising performance. The SDN family of SATCOM terminals is an evolutionary, follow-on life cycle replacement for the legacy SOF Deployable Node-Family of Terminals (SDN-FoT).

The legacy SDN-FoT comprised the SDN-Lite, SDN-Medium, and the larger SDN-Heavy terminals. Upgraded terminals comprise several variants: a sub one-meter aperture terminal operating in the X, Ku and Ka frequency bands (SDN-Lite), a terminal in the range of 1.2-1.3 meter aperture with automatic satellite acquisition operating in the X, Ku and Ka bands (SDN-Medium), and a 2.0-2.4 meter aperture with

automatic satellite acquisition and tracking, operating in the C, X, Ku, and Ka bands (SDN-Heavy).

SOF operates in environments with limited or no command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) infrastructure, which necessitates reliance on portable equipment that warfighters carry forward for initial command and control. ◀

On this order Tampa Microwave will do the work at the Tampa Microwave facility Clearwater, Fla., and SOCOM mission units, and will complete work over the life of the contract. For more information contact Tampa Microwave online at www.tampamicrowave.com, or U.S. Special Operations Command at www.socom.mil.

BAE Systems to build 283 IFF transponders for military combat aircraft

BY John Keller

PATUXENT RIVER NAS, Md. — U.S. Navy avionics experts are asking the BAE Systems Electronic Systems segment in Greenlawn, N.Y., to provide hundreds of identification-friend-or-foe (IFF) transponders for military aircraft under terms of an \$17.9 million order.

Officials of the Naval Air Systems Command at Patuxent River Naval Air Station, Md., are awarding this contract modification to BAE Systems, which involves IFF transponders for jet fighter-bombers, helicopters, trainer aircraft, and transport aircraft. IFF transponders transmit coded messages that identify aircraft as friendly and determines their range and bearing from ground – or air-based interrogators.

The order calls for BAE Systems to provide 283 Mode 5 capable AN/APX-117A, 118A, and 123A(V) Common Identification Friend or Foe Digital Transponder Systems and shop-replaceable assemblies for fixed-wing aircraft and helicopters the Navy, Army, U.S. allies.

The AN/APX-117A(V), AN/APX-118A(V), and AN/APX-123A(V) are part of the BAE Systems common transponder (CXP) family that is the Navy's and Army's standard transponder for all new aircraft and aircraft upgrades.

The transponders are built on an open-system architecture and high-density field-programmable gate array (FPGA) technology that provides for system flexibility and future systems improvements through software-only upgrades.



BAE systems will supply IFF transponders for U.S. and allied combat aircraft in \$17.9 million deal.

The CXP family of IFF transponders is configured to replace all AN/APX-100, AN/APX-101, AN/APX-108, AN/APX-64, AN/APX-72 and AN/UPX-28 transponders. All CXP transponders weigh less than 12 pounds with embedded cryptography, and measure 5.375 by 5.375 by 8.375 inches. Their radio control units measure 5.25 by 5.75 by 3 inches. ◀

On this order BAE Systems will do the work in Greenlawn, N.Y.; and Austin, Texas, and should be finished by December 2022. For more information contact BAE Systems Electronic Systems online at www.baesystems.com, or Naval Air Systems Command at www.navair.navy.mil/.

RF & Microwave news briefs are located on page 47



The U.S. Army is ordering new MQ-1C Gray Eagle unmanned combat aircraft from General Atomics for reconnaissance and attack.

Army orders Gray Eagle unmanned combat aircraft and SATCOM from General Atomics

BY John Keller

REDSTONE ARSENAL, Ala. — U.S. Army aviation experts are ordering MQ-1C Gray Eagle unmanned combat aircraft for reconnaissance and attack, as well as satellite communications (SATCOM) air data terminals, maintenance, repair, and support services under terms of a \$103.2 million order.

Officials of the Army Contracting Command at Redstone Arsenal, Ala., are asking General Atomics Aeronautical Systems Inc. in Poway, Calif., for the Gray Eagle attack unmanned aerial vehicles (UAVs), SATCOM terminals, and support.

The General Atomics MQ-1C Gray Eagle is a medium-altitude, long-endurance UAV that is an upgraded MQ-1 Predator for extended-range, multi-purpose unmanned operations. The aircraft can be fitted with the AGM-114

Hellfire missile or GBU-44/B Viper Strike guided bomb for attack missions.

Compared with its predecessor, the MQ-1 Predator, the Gray Eagle has an increased wingspan, and a Thielert Centurion 1.7 heavy-fuel engine that can burn jet and diesel fuel. The UAV can fly for as long as 36 hours at altitudes to 25,000 feet. It has an operating range of 200 nautical miles.

The Gray Eagle UAV has a synthetic aperture radar and ground moving target indicator system, and targeting capability from an AN/AAS-52 multi-spectral targeting system under the nose. The aircraft can carry payloads as heavy as 800 pounds.

Army commanders deploy the Gray Eagle UAV in platoons, each with four aircraft, support equipment, and payloads like

electro-optical and infrared/laser range finder, laser designator, communications relay, and as many as four hellfire missiles.

The common sensor payload and synthetic aperture radar ground moving target indicator are one per aircraft. Ground equipment per platoon includes two universal ground control stations; three universal ground data terminals; one SATCOM ground data terminal; and one mobile ground control station per company.

Gray Eagle platoons also have an automated takeoff and landing system two tactical automatic landing systems and ground support equipment to include ground-based sense and avoid. ◀

On this order General Atomics will do the work in Poway, Calif., and should be finished by December 2023. For more information contact General Atomics Aeronautical Systems online at www.ga-asi.com, or the Army Contracting Command-Redstone at <https://acc.army.mil/contractingcenters/acc-rsa>.

Boeing to convert F-16 jet fighters to unmanned target drones

BY John Keller

EGLIN AIR FORCE BASE, Fla. — Military avionics experts at the Boeing Co. will convert retired U.S. Air Force Lockheed Martin F-16 jet fighters into sophisticated manned and unmanned target drones under terms of an \$49.7 million contract.

Officials of the Air Force Life Cycle Management Center at Eglin Air Force Base, Fla., are awarding a contract to the Boeing Defense, Space & Security segment in St. Louis to handle the conversion of about 15 F-16 fighters into unmanned QF-16 full-scale aerial targets (FSATs). This order involves QF-16 full-scale aerial target lot 6.

The Air Force has used converted jet fighters as target drones for decades, beginning in the 1960s when the Air Force converted 24 Lockheed F-104 Starfighter jets into target drones. This contract involves converting F-16 Block 25 and Block 30 manned aircraft to unmanned aerial vehicles (UAVs).

Other U.S. jet fighters, including the F-100, F-102, F-106, and F-4, have become target drones. Air Force experts use converted jet fighters as target drones to test sophisticated missiles and electronic warfare systems.

Although some of these retired jet fighter target drones are destroyed during weapons tests, often the drones rely on onboard sensors to calculate the point of missile detonations to record “kills” without destroying the target aircraft.

The QF-16 target drones are replacing the Air Force’s fleet of QF-4 target drones, which are converted from McDonnell Douglas

F-4 Phantom jet fighters, which were phased out of active service in the 1980s.

The newer QF-16s are bringing a new level of sophistication to U.S. supersonic target drone capability. The F-16 is a fourth-generation fighter, and brings new challenges for weapons testing over the third-generation F-4.

Boeing started converting F-16s into the first QF-16 drones in 2010. Company experts strip down retired F-16 fighters to remove unnecessary parts like the jet’s 20-millimeter cannon and APG-66/68 radar. Boeing alters the aircraft to fly unmanned or with human pilots.

Boeing also installs a flight termination system that can destroy the drone if it goes out of control, command telemetry systems so operators can control the drone can be controlled from the ground, a scoring system to gauge the accuracy of air-to-air missiles fired at the drone, as well as avionics packages to enable these plans to fly unmanned.

Air Force leaders are expected to buy a total of 210 QF-16 through 2022. The first manned QF-16 flight was in May 2012, and the plane’s first unmanned flight was in September 2013. On this contract, Boeing will do the work in St. Louis, and should be finished by April 2025. ◀



Engineers from Boeing will convert about 15 F-16 fighters into unmanned QF-16 full-scale aerial targets (FSATs) for advanced pilot air-to-air training.

For more information contact Boeing Defense, Space & Security online at www.boeing.com, or the Air Force Life Cycle Management Center at www.afmc.af.mil.

Second Loyal Wingman unmanned combat jet flies for second time

The Boeing Loyal Wingman prototype unmanned combat jet has reached a new milestone as two of the autonomous aircraft took to the skies recently in separate flights over the Woomera Range Complex in Australia. This marks the first time that the second unmanned combat jet has flown and the first time the landing gear on the craft was raised and engaged. Making its first flight on 17 Feb. 2021, the Loyal Wingman is being developed for and in partnership with the Royal Australian Air Force (RAAF) along with 35 private companies. The recent tests are significant not only because the prototype fleet is growing, but also because it lays the foundation for demonstrating how such drones can work as part of a team. The Loyal Wingman's development and production are accelerated by the use of a digital twin that is refined as aircraft performance data is collected during the test flights to expand its performance envelope. It has flight characteristics comparable to a conventional fighter and uses artificial intelligence (AI) and a modular design.

Persistent surveillance sensor for unmanned helicopters introduced by Logos Technologies

Logos Technologies LLC in Fairfax, Va., is introducing the MicroKestrel sensors for small, tethered, multirotor-type unmanned aerial vehicles (UAVs). When mounted on a tethered UAV and hovering at 200 feet, one MicroKestrel can image three square kilometers, tracking every vehicle and detecting every infantry warfighter within its 180-degree field of view. The wide-area motion imagery (WAMI) persistent surveillance system also can cue high-definition video cameras for close-in inspection should an operator require a positive identification of a target. "At just under five pounds, the new WAMI system is so light that some tethered UAVs can actually accommodate two units, each pointed in a different direction," says Doug Rombough, vice president of business development for Logos Technologies. "You get twice the coverage area and a 360-degree field of view." The idea of getting WAMI on a small tethered unmanned aircraft once seemed impossible. Now, these sensors will be able to go on tethered UAVs or free-flying UAVs that have been connected to a third-party tethering station. This greatly expands the types of operators who will be able to use WAMI. "People who would never have access to runway or catapult-launched UAVs, let alone big Predators, can pop open a container, set up

a tethered UAV, and launch a WAMI sensor into the air," said Rombough. "Think about what that means for base protection, event security, or other mission sets." For more information contact Logos Technologies online at www.logostech.net.

Researchers developing communications networking for unmanned surveillance aircraft

Imagine several dispersed, yet interconnected medium-altitude surveillance drones discover a massive, fast-approaching enemy armored force on the other side of a mountain range, advancing quickly to attack. What if before the drones could send real-time video to command and control centers, communications were jammed, destroyed or disrupted? How could the drones continue the mission? The possibility of encountering this kind of scenario drives a fast-emerging technology program called Distributed Autonomy Responsive Control (DARC), which enables unmanned systems to form mesh networks to perform functions independently of human decision-makers. Described as software by Northrop Grumman developers, DARC pre-programs drones with mission and navigational details to work in denied, jammed, or otherwise inoperable environments.

Lockheed Martin CTO focuses on hypersonics, 5G, and artificial intelligence

There are many ways people can serve their country without joining the military. One is to develop technologies that can be used to defend their nation against adversaries. That's what Steve Walker has been doing his entire career. The IEEE senior member worked for more than 30 years in the U.S. civil service, first for the Air Force Research Laboratory, and then for the Defense Advanced Research Projects Agency (DARPA), the U.S. Department of Defense's research arm. Last year Walker joined the private sector as vice president and chief technology officer at defense contractor Lockheed Martin. Although Walker is not fighting on the front lines, for nearly three decades he has been working behind the scenes to fund a variety of important projects for the military and civilians. The projects have developed fast bombers and fighter jets, inexpensive launch vehicles for satellites, and the mRNA technology used in coronavirus vaccines. He is continuing his focus on military technologies at Lockheed Martin, where Walker is responsible for the company's technology strategy, global research, mission development, and emerging operations technologies. ←



SRI International; the University of California at San Diego (UCSD); and Raytheon BBN Technologies Corp. are working on the DARPA Enhanced Night Vision in eyeglass form factors (ENVision) project.

DARPA hires three groups to develop eyeglass-size direct-view night vision

BY John Keller

ARLINGTON, Va. — U.S. military researchers are asking three organizations to develop night-vision devices far smaller and lighter in weight than today's night-vision goggles, which would be about the same size and weight as a typical pair of eyeglasses.

Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., have awarded contracts to SRI International in Menlo Park, Calif.; the University of California at San Diego (UCSD); and Raytheon BBN Technologies Corp. in Cambridge Mass., for the Enhanced Night Vision in eyeglass form factors (ENVision) project.

Today's night-vision goggles typically are as bulky as 4 inches long and as heavy as 2.2 pounds. This causes a large torque on the wearer's neck, which limits the wearer's agility and often leads to

chronic injury over prolonged use of these electro-optical devices.

Modern night-vision goggles also burden the wearer with a narrow field of view and generally have limited spectral access to the near-infrared spectral band, which limits situational awareness.

This drawbacks from refractive optics for imaging, and image-intensifier tubes — two technologies in modern night-vision systems that have remained largely the same since their inception.

Instead, the DARPA ENVision program is asking SRI International, UCSD, and Raytheon BBN to overcome these limitations by developing enhanced direct-view night-vision systems that are of a size and weight near those of typical eyeglasses.

SRI International won a \$5.2 million ENVision contract

on 3 Nov., UCSD won a \$3 million ENVision contract on 24 Sept., and Raytheon BBN won a \$2.3 million ENVision contract on 23 Sept.

The small and lightweight night-vision eyeglasses that these three organizations will develop are to extend visual access beyond near infrared to include shortwave, midwave, and long-wave infrared spectral bands through a common aperture, giving users access to spectral ranges from 1.5 to 12 microns. These night-vision eyeglasses, furthermore, would widen the user's field of view to natural eyesight of about 100 degrees.

Optical specialists have attempted to widen the fields of view for today's night-vision goggles, but improvements come at the cost of increased systems size, weight, and wear-and-tear on the user. The ENVision project seeks to explore the next technical leap in night-vision technologies by achieving direct vision of the infrared through photon upconversion.

While current night-vision systems use a multi-step process, the physics to upconvert infrared photons directly to visible light in one step has been known since the invention of the laser in 1960.

Currently, these processes are inefficient and are limited in the bandwidth of light that can be upconverted simultaneously. Yet recent advances in material systems such as polaritonic structures and sensitized core-shell nanoparticles have opened up new avenues in exploring photon upconversion.

The process of photon upconversion-based night vision would eliminate the need for several components and could lead to even simpler, all-optical night-vision systems in the future, such as night vision contact lenses, DARPA researchers say.

Planar optics and planar image intensifiers could enable direct vision of several infrared bands through one common aperture. Structured materials such as diffractive optics and metamaterials enable one to embed optical functionalities far beyond those of traditional refractives into one optical element.

While wide field of view, broad bandwidth, and high imaging quality all are achievable individually, combining these traits in practice remains a challenge. In addition to planar optics, image intensification is necessary to convert the often weak infrared light into visible photons detectable by the naked eye.

The ENVision program will last for four years in two two-year phases, and has two technical areas: prototypes and upconversion. ◀

For more information contact SRI International online at www.sri.com, UCSD at <https://ucsd.edu/research-innovation>, Raytheon BBN at www.raytheon-intelligenceandspace.com/capabilities/bbn, or DARPA at www.darpa.mil/program/envision.

Video camera interface board for surveillance introduced by dPict Imaging

Electro-optical sensor specialist dPict Imaging Inc. in Indianapolis is introducing the DP-800S camera interface board for surveillance applications aboard unmanned vehicles. The board converts raw video data from Sony block cameras and to produce 4K SDI video output. The board is designed to output 4K SDI video up to 4K 60 (or 12G), however, all video resolutions of the camera are supported. The DP-800S board also provides power to the camera, USB for camera firmware updates, VISCA, and serial support. HDMI and SDI video are implemented in the onboard field-programmable gate array (FPGA). In addition, the FPGA contains a soft processor that enables the board to overlay data from telemetry devices, live text, and bitmap sources onto the output video in real-time. The overlay data comes through the serial port. This real-time overlay capability, without the requirement of additional external processing hardware, enables operations in constrained space or remote applications. Examples include, onboard moving and mobile platforms, like UAV or ROV operations and in conventional moving vehicles such as off-road exploration or public safety vehicles. There are static applications also, such as remote dome-mounted cameras used in intelligent traffic system (ITS) applications that require video with overlay. For more information contact dPict Imaging online at <http://dpictimaging.com>.

Optical fiber with different-shaped fiber cores introduced by Armadillo SIA

Armadillo SIA in Riga, Latvia, is introducing two silica, multi-mode optical fiber products for laser and astronomy applications, as well as for applications where the shape and homogeneity of the output beam is critical. The Optran UV NCC ultraviolet non-circular core fibers operate from 190 to 1200 nanometers and the Optran WF NCC water-free non-circular core fibers operate in the 300 to 2400-nanometer spectral range. The company's silica shaped fiber cores are available in rectangular, square, octagonal, hexagonal, and other shapes to offer coupling efficiency. Although the optical fiber cores are various shapes, the Optran UV/WF NCCs' silica cladding is circular to accommodate most standard fiber cable connectors. For improved packing density with multi-fiber bundle assemblies, Armadillo also offers non-circular *Continued on page 43*



The Joint Air-to-Surface Standoff Missile — Extended Range (JASSM-ER) air-to-ground missile uses precision routing and guidance in adverse weather, day or night, using an infrared seeker.

Lockheed Martin to build 97 new JASSM-ER infrared-guided air-to-ground missiles

BY John Keller

EGLIN AIR FORCE BASE, Fla. — Missile designers at Lockheed Martin Corp. will build 94 advanced air-to-ground missiles under terms of a \$97.3 million order.

Officials of the U.S. Air Force Life Cycle Management Center at Eglin Air Force Base, Fla., are asking the Lockheed Martin Missiles and Fire Control segment in Orlando, Fla., to build 97 lot-20 Joint Air-to-Surface Standoff Missile — Extended Range (JASSM-ER) stealthy air-to-ground missiles with containers.

The JASSM-ER is a 2,250-pound cruise missile with a 1,000-pound penetrator and blast-fragmentation warhead. It uses precision routing and guidance in adverse weather, day or night, using an infrared seeker in addition to the anti-jam GPS to find a specific aim point on the target.

JASSM, which has been in service since 2009, is a long-range, conventional, air-to-ground, precision standoff missile for the U.S. and allied forces that is designed to destroy high-value, well-defended, fixed and relocatable targets. The JASSM

has a range of 230 miles, while the JASSM-ER has a range of 620 miles.

The stealthy JASSM missiles have standoff ranges to keep air crews well out of danger from hostile air defense systems, while their stealthy airframes makes the smart munitions extremely difficult to defeat, Lockheed Martin officials say.

JASSM can be fired from several different aircraft, including the B-1, B-2, B-52, F-16, F/A-18E/F, and F-15E. International JASSM users include the Australian, Finnish, and Polish air forces.

Looking to the future, Lockheed Martin is working on the JASSM to enable the missile to fire from U.S. and international versions of the Lockheed Martin F-35 Lightning II joint strike fighter aircraft and other international military aircraft. ◀

On this order Lockheed Martin will do the work in Orlando, Fla. and Troy, Ala., and should be finished by June 2026. For more information contact Lockheed Martin Missiles and Fire Control online at www.lockheedmartin.com, or the Air Force Life Cycle Management Center at www.aflcmc.af.mil.

Industry to develop tunable, controllable obscurants to hide from infrared sensors

BY John Keller

ARLINGTON, Va. — U.S. military researchers are asking industry to develop smoke and other obscurants that degrade an enemy's ability to see the battlefield, but that enable U.S. and allied forces to see the battlefield clearly.

Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., have issued a broad agency announcement (HR001122S0007) for the Coded Visibility project.

Obscurants are for confined urban spaces to hide from an adversary's digital infrared sensors and other night-vision systems. Despite decades of development, current obscurants continue to have three critical limitations: they degrade the visual capability of friendly forces and adversaries; their performance is fixed and cannot be tuned in real time; the serious health risks they pose often require using respirators.

The goal of the DARPA Coded Visibility program is to address these limitations by developing next-generation obscurants that enable U.S. and allied forces to see, while blocking an adversary's ability to see.

The project seeks to develop obscurants that are tailorable, tunable, and safe, which means the light absorption and scattering performance are controllable, and pose no health risks to those nearby.

Coded Visibility likely will require several types of particulates in one obscurant plume, and will look into the limits of light absorption and scattering. Contractors will design of new particulates, and simulation tools to integrate absorption and scattering from several particulates. Active modulation of tunable obscurants could provide U.S. and allied forces with ways to control obscurants for enhanced visibility.

Electromagnetic fields can interact with and manipulate particles to influence their scattering behavior by either modulating the particle's orientation and position using electric or magnetic fields, or changing the particle's conductivity, absorption, or scattering using electromagnetic sources. Coded Visibility is



Obscurants are for confined urban spaces to hide from an adversary's digital infrared sensors and other night-vision systems.

a 4.5-year project that should start next July.

Proposals for Coded Visibility must address the visible and near-infrared light bands, or the midwave and longwave infrared bands. Several contracts will be awarded. ◀

Companies interested should upload proposals no later than 21 Jan. 2022 to the DARPA BAA web-

site at <https://baa.darpa.mil>. More information is online at <https://sam.gov/opp/19dd0193803843a992d2a7ad444739ae/view>.

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Teledyne FLIR to provide maintenance parts for electro-optical sensors

BY John Keller

U.S. Navy electro-optical sensors experts needed spare parts for several land – and sea-based sensors for intelligence, surveillance, and reconnaissance (ISR) applications. They found their solution from Teledyne FLIR LLC, a subsidiary of Teledyne Technologies in Wilsonville, Ore.

Officials of the Naval Surface Warfare Center Crane Division in Crane, Ind., announced a \$43.9 contract to Teledyne FLIR for spare parts for the Teledyne FLIR Sea Star Safire III, Brite Star II, Maritime 380HD, and TacFLIR 380HD electro-optical sensor systems.

The Sea Star Safire III is a rugged ship-mountable system to provide surface ships with a day and night high-resolution infrared and visible-light imaging and range finding capability to augment existing optical and radar sensors to detect and identify asymmetric threats.

The Brite Star II electro-optical system functions as the fire-control system for the Patrol Coastal Griffin missile system. It uses infrared and charge-coupled device (CCD) cameras to detect, identify, and track targets.

▲ **Teledyne Technologies will provide spare parts to the U.S. Navy to keep a variety of electro-optical sensors in working order for intelligence, surveillance, and reconnaissance (ISR) applications.**

Brite Star II uses a laser range finder to determine the distance and position of the target and provides terminal guidance to the launched Griffin Missile seeker head with a laser designator. The sensor also includes a diode-pumped laser rangefinder and designator for long range target designation.

The small Griffin missile is fired from a common launch tube and is for Special Forces operations. It measures 43 inches long, weighs 33 pounds, and packs a 13-pound explosive warhead for low collateral damage.

The Star Safire 380-HD sensor combines color daylight digital camera and medium-wave infrared (MWIR) thermal-imaging camera in a motion-stabilized pod that is hardened for military fixed-wing aircraft, helicopters, aerostats, and other kinds of aircraft.

The Star Safire 380-HD, which has an optional shortwave infrared (SWIR) camera and laser rangefinder, illuminator, and pointer, embeds metadata in its video stream.

The optional SWIR sensor in the Star Safire 380-HD provides expanded multi-spectral day and night imaging with high

definition mega-pixel resolution imagery. SWIR sensors can detect light from just beyond what the human eye can see to where infrared thermal imagers can perceive, and has the ability to see through windows and other kinds of glass, unlike medium – or long-wave infrared thermal imaging sensors.

SWIR light wavelengths are from 0.9 to 1.7 microns, and are reflective light, so its imagery has shadows and contrast. Since SWIR images are not in color, objects are easily to recognize. One big advantage of SWIR imaging sensors is their ability to use night sky radiance, which emits five to seven times more illumination than starlight — nearly all of it in the SWIR wavelengths. As a result, SWIR imaging sensors use this night radiance to reveal objects clearly on moonless nights.

The Teledyne FLIR Systems Star Safire 380 thermal-imaging pod is for applications in surveillance and reconnaissance; search and rescue; maritime patrol; border patrol, unmanned aerial vehicles (UAVs); and force protection.

The thermal imager is an all-digital, full HD system in one line-replaceable unit. It has high-bandwidth HD-SDI video channels with symbology overlays that comply with government HD standards, providing 1080-pixel, 720-pixel, and other formats.

Sensor and geospatial data is embedded within the digital video stream, and the unit offers expanded multi-spectral imaging, with extended color imaging into the dark, and the unit can view, track, and mark ground locations using its embedded inertial measurement unit.

The Star 380 HD can follow moving targets with its multi-mode autotracker, and can illuminate wide areas covertly. It also can point out distant targets to other forces, and determine target distance and location. The thermal imager's all-weather design is qualified to MIL-STD-810 and 461.

The TacFLIR 380-HD is an intelligence, surveillance, target acquisition, and reconnaissance (ISTAR) sensor designed for land vehicle applications. Identical to airborne and maritime versions of the Star Safire 380-HD, TacFLIR 380-HD offers seals and shock mounts for land vehicle environments.

Payloads include a MWIR camera with a native 1280-by-720-pixel resolution, HD CCD cameras, HD SWIR camera, a laser range finder, and a laser pointer. Six-axis stabilization gives the TacFLIR 380-HD geolock and target-tracking capabilities. ◀

On this contract Teledyne FLIR will do the work in Wilsonville, Ore., and should be finished by March 2027. For more information contact Teledyne FLIR online at www.flir.com, or the Naval Surface Warfare Center-Crane at www.navsea.navy.mil/Home/Warfare-Centers/NSWC-Crane.

Continued from page 39 form (NCF) fiber versions. NCF has a fluorinated silica cladding that mimics the shape of the fused silica core, with optical properties identical to NCC. Armadillo's non-circular core fibers operate from ultraviolet to visible out to the near-infrared (NIR) spectrum. Other features include homogeneous power distribution and low numerical aperture (NA) expansion. With image scrambling characteristics and laser damage resistance, the new Optran family of UV and WF NCC fibers eliminates the need for laser beam-shaping optics. For more information contact Armadillo SIA online at www.armadillosia.com.

Fiber optic transceivers for rugged applications introduced by ShowMeCables

ShowMeCables, an Infinite Electronics-brand electronics distributor in Irvine, Calif., is introducing fiber optic transceivers for data communications, information technology, and telecommunications. These fiber optic transceivers are MSA-compliant and compatible with most switches and routers, and come in form factors such as GBIC, SFP, SFP+, and XFP. Distance options range from 220 meters to 120 kilometers and three transmitter wavelengths are available: 850, 1310, and 1550 nanometers. Operating data rates cover 100 megabits per second to 10 gigabits per second. Most of these transceivers were designed to withstand extreme industrial temperatures. For more information contact ShowMeCables online at www.showmecables.com.

Camera for aerial imaging, machine vision, and automation introduced by Teledyne Dalsa

Teledyne DALSA in Waterloo, Ontario, is introducing the Falcon4-CLHS M4480 camera, based on the Teledyne e2v Lince 11.2M monochrome sensor for industrial imaging applications requiring high-speed data transfer. The camera is for aerial imaging, machine vision, industrial automation, flat panel display inspection, semiconductor inspection, circuit board automated optical inspection. The Falcon4-CLHS model delivers an easy-to-use CLHS interface camera that can reach a frame rate as fast as 609 frames per second in 11.2 MP resolution, and several thousands of frames per second in partial scan mode. The sensor's binning mode can reach a pixel full well capacity of more than 160Ke. For more information contact Teledyne Dalsa online at www.teledynedalsa.com. ◀

PRODUCT APPLICATIONS

UNMANNED CONTROLLERS

► Researchers choose handheld unmanned vehicles controller from Auterion

Researchers in the U.S. Defense Innovation Unit (DIU) in Mountain View, Calif., needed commercial technology to enable soldiers to operate several kinds of unmanned vehicles with one handheld controller. They found their solution from Auterion Government Solutions Inc. in Moorpark, Calif.

DIU has chosen Auterion for the Soldier Robotic Controller (SRoC) program, based on an existing commercial handheld controller called Skynav, company officials say.

The SRoC program seeks to develop control systems for small unmanned aerial vehicles (UAVs) and unmanned ground vehicles (UGVs) that today do not integrate with existing fielded equipment.

Designed with the ability to scale, the Auterion Skynav is interoperable and can control many types of quad, multi-rotor, VTOL, and fixed-wing small UAVs.

Under the SRoC Program, Auterion engineers will extend the Skynav's capabilities to accept external and embedded radio integration via an interchangeable module.

This enables air and ground interoperability by communicating via several open protocols and facilitates soldier-wearable solutions. The SRoC controller also will enable users to swap radio modules in the field.

"The ability to control and extract data from multiple types of air and ground systems using a flexible and scalable hardware platform coupled with a standard, government sponsored software platform is a critical element for current and future autonomous system development



and deployment," says David Sharpin, CEO of Auterion Government Solutions. For more information contact Auterion Government Solutions online at www.auterion-gs.com, or the Defense Innovation Unit at www.diu.mil.

NAVIGATION AND GUIDANCE

▼ Boeing to install Raytheon secure GPS aboard tiltrotor Osprey aircraft

U.S. Navy airborne navigation and guidance experts are asking avionics integrators at the Bell Boeing Joint Project Office, Amarillo, Texas, to retrofit an upgraded Global Positioning System (GPS) receiver into the V-22 Osprey tiltrotor aircraft.

Officials of the Naval Air Systems Command have announced a \$15.4 million order to the Bell Boeing JPO for systems engineering, technical, logistics support, and retrofit of the Miniaturized Airborne Global Positioning System Receiver 2000 (MAGR-2000) for integration onto the V-22 Osprey aircraft.

The MAGR-2000 modular GPS receiver is an open-systems architecture form, fit, and function backward-compatible replacement of the MAGR, which provides enhancements like improved acquisition and GPS solution performance, all-in-view GPS satellite tracking, and GPS integrity.

The MAGR provides precision navigation for U.S. military aircraft and smart munitions by accessing special encrypted military positioning signals from GPS satellites, called P/Y-Code. The MAGR-2000 also includes a selective availability anti-spoofing module (SAASM) upgrade.

The Raytheon Intelligence & Space segment in El Segundo, Calif., works together with GPS



receiver specialist Trimble Inc. in Sunnyvale, Calif., on the MAGR-2000 program. Trimble provides militarized P/Y-Code GPS receivers for embedding in the Raytheon MAGR-2000 avionics.

The MAGR-2000 also incorporates the new M-Code for further secure GPS capability to help protect military GPS signals against electronic warfare (EW) jamming and cyber attacks.

The MAGR-2000 GPS navigation avionics is aboard several different kinds of military aircraft, including the F/A-18 Hornet jet fighter-bomber, VH-3D presidential helicopter, and V-22 Osprey tiltrotor. The system is for new and existing military aircraft.

In 2018 Raytheon received an \$11.4 million U.S. Air Force order to add trusted computing capability to the MAGR-2000 through trusted application-specific integrated circuit (ASIC) technology.

Trusted ASICs are high-reliability electronic components designed and manufactured under U.S. Department of Defense (DOD) supervision and certified to military standards to protect sensitive electronics from tampering, cyber attacks, environmental extremes, and other security threats.

On this order the Bell Boeing JPO will do the work in Ridley Park, Pa., and in Amarillo, Texas, and should be finished by November 2024. For more information contact the Bell Boeing Joint Program Office online at www.boeing.com, or Naval Air Systems Command at www.navair.navy.mil.

LASER WEAPONS

▲ Army ready to order eight prototype laser weapons from Kord Technologies for Stryker vehicles

U.S. Army laser weapons experts needed a company to design an enhanced prototype air-defense laser for the Stryker armored combat vehicle. They found their solution from Kord Technologies Inc. in Huntsville, Ala.

Officials of the Army Rapid Capabilities and Critical Technologies Office (RCCTO) at Redstone Arsenal, Ala., has announced plans to issue a sole-source request for

prototype proposal to Kord Technologies for the Directed Energy Maneuver Short Range Air Defense (DE M-SHORAD).

The Army selected Kord Technologies and the Raytheon Technologies Corp. Missiles & Defense segment in McKinney, Texas, last September to supply three 50-kilowatt high-energy laser weapons for three Stryker A1 combat vehicles as part of the DE M-SHORAD project.

The two companies participated in a laser weapons combat shootoff to demonstrate the capabilities of their systems last July at Fort Sill, Okla.

Kord will develop as many as eight enhanced DE M-SHORAD prototypes based on lessons learned during the July shootoff. The DE M-SHORAD prototype will be a 50-kilowatt mobile laser weapon able to shoot down manned and unmanned fixed-wing aircraft and helicopters, as well as missiles, from the Stryker vehicle.

The company will build as many as four DE M-SHORAD

prototypes for delivery in 2023, and as many as four more system prototypes in 2024. Kord engineers will make design changes to DE M-SHORAD prototypes to reduce overall weight and increase maintainability.

Army experts say Kord is the only responsible source able to develop and deliver this prototype within the required schedule, and that

competition of this effort is not practicable and will not meet mission fielding requirements.

Although this notice is not a request for competitive proposals, responsible sources may submit capability statements demonstrating the ability to provide the requested prototypes. Email statements no later than 3 Dec. 2021 to the Army's Simone Brightmon at simone.l.brightmon.civ@army.mil.

Companies interested in subcontracting opportunities should contact Kord Technologies online at <https://kordtechnologies.com/contact-us>.

For more information contact Kord Technologies online at <https://kordtechnologies.com> or the Army Rapid Capabilities and Critical Technologies Office (RCCTO) at <https://rapidcapabilitiesoffice.army.mil>. Additional information is online at <https://sam.gov/opp/3ad5a9cbdba94c6ea2872374bdaefd48/view>.



RADAR

► Raytheon to build 19 advanced AESA radar sets for targeting and mapping

Radar experts at Raytheon Technologies Corp. will provide the 19 AN/APG-79(V)4 active electronically scanned array (AESA) airborne radar systems to upgrade U.S. Marine Corps F/A-18C/D combat jets under terms of a \$63.1 million order.

Officials of the U.S. Naval Air Systems Command at Patuxent River Naval Air Station, Md., are asking the Raytheon Intelligence & Space segment in El Segundo, Calif., for AN/APG-79(V)4 radar systems and software in support of radar retrofit and integration into Marine Corps F/A-18C/D Hornet carrier-based jet fighter-bombers.

The AN/APG-79(V)4 is a scaled version of the AN/APG-79 AESA radar designed originally for the U.S. Navy Boeing F/A-18E/F fighter-bomber and EA-18G Growler carrier-based electronic warfare jet. It provides aircrew situational awareness, near-instantaneous track updates, and multi-target tracking capability.

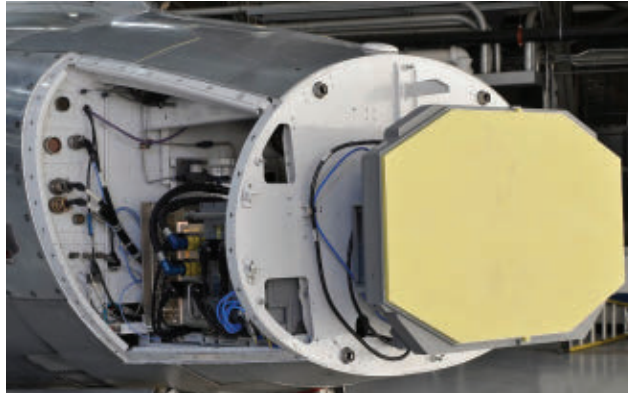
The order includes software, obsolescence management, engineering support, and technical, financial, and administrative data necessary for retrofit integration into the Marine Corps F/A-18C/D combat aircraft.

The AN/APG-79(V)4 radar provides extended detection range, simultaneous air-to-air and air-to-ground targeting capabilities, high resolution synthetic aperture radar (SAR) mapping, and high reliability.

The APG-79 radar has an open-systems architecture and rugged commercial-off-the-shelf (R-COTS) parts. Its array has solid-state transmit and receive modules for enhanced reliability, as well as an advanced receiver/exciter, ruggedized R-COTS processor, and power supplies.

The APG-79 AESA airborne radar uses transmit/receive (TR) modules populated with gallium arsenide (GaAs) monolithic microwave integrated circuits (MMICs). Presumably these are some of the electronic modules that Boeing experts will modify with updated electronics to mitigate obsolescence issues.

The radar's active electronic beam scanning helps steer the radar beam at nearly the speed of light to optimize situational awareness and air-to-air and air-to-surface capability,



Raytheon officials say. The agile beam enables the multimode radar to interleave in near-real time, so that pilot and crew can use both modes simultaneously.

The first flight of a C/D Hornet fitted with this AESA radar was in January 2015, and the Marine Corps chose the AN/APG-79(V)4 radar in January 2019 to upgrade

its legacy F/A-18C/D aircraft fleet. The radar enables the Hornet jet to fire several missiles at once and guide them to different targets that are widely spaced in azimuth, elevation, or range.

On this order Raytheon will do the work in Forest, Miss.; El Segundo, Calif.; Andover, Mass.; and Dallas, and should be finished by March 2023. For more information contact Raytheon Intelligence & Space online at www.rtx.com/Our-Company/Our-Businesses/RIS, or Naval Air Systems Command at www.navair.navy.mil.

AIR-LAUNCHED MUNITIONS

▼ Air Force asks Lockheed Martin to build 42 LRASM subsonic anti-ship cruise missiles

U.S. Air Force airborne weapons experts are asking Lockheed Martin Corp. to build 42 next-generation AGM-158C Long-Range Anti-Ship Missile (LRASM) for use against high-priority enemy targets like aircraft carriers, troop transport ships, and guided-missile cruisers.

Officials of the U.S. Air Force Life Cycle Management Center at Eglin Air Force Base, Fla., announced a \$124.9 million order to the Lockheed Martin Corp. Missiles and Fire Control segment in Orlando, Fla., to build 42 LRASMs.

LRASM is a joint project of the U.S. Defense Advanced



Projects Agency (DARPA) in Arlington, Va., the Navy, and the Air Force to design an advanced anti-ship missile that can launch from the Navy F/A-18E/F Super Hornet jet fighter bomber, as well as from the Air Force B-1B Lancer long-range strategic bomber.

In the future LRASM also will launch from the F-35 Lighting II joint strike fighter, the P-8A Poseidon maritime patrol jet, as well as from the Navy Mark 41 shipboard Vertical Launch System. The missile travels at high subsonic speeds, and likely will give way in the future to expected new generations of hypersonic missiles. Submarine-launched versions are under consideration.

LRASM is designed to detect and destroy high-priority targets within groups of ships from extended ranges in electronic warfare jamming environments. It is a precision-guided, anti-ship standoff missile based on the Lockheed Martin Joint Air-to-Surface Standoff Missile-Extended Range (JASSM-ER).

Lockheed Martin has been designing LRASM for the last 12 years, primarily under DARPA supervision. The advanced anti-ship missile is intended to replace the ageing Harpoon anti-ship missile. It has a multi-mode radio frequency sensor, a new weapon data-link and altimeter, and an updated power system.

The LRASM can be guided toward enemy ships from as far away as 200 nautical miles by its launch aircraft, can receive updates via its datalink, or can use onboard sensors to find its target. LRASM will fly towards its target at medium altitude then drop to low altitude for a sea skimming approach to counter shipboard anti-missile defenses.

The LRASM uses on-board targeting systems to acquire the target independently without the presence of intelligence or supporting services like Global Positioning System (GPS) satellite navigation and data links. Lockheed Martin is designing the missile with advanced counter-countermeasures to evade hostile active defense systems.

The Lockheed Martin LRASM has a 1,000-pound penetrator and blast-fragmentation warhead, multi-mode sensor, weapon data link, and enhanced digital anti-jam global positioning system to detect and destroy selected surface targets within groups of ships.

Lockheed Martin is in charge of LRASM overall development, and the BAE Systems Electronic Systems segment in Nashua, N.H., is developing the LRASM onboard sensor systems.

LRASM development is in response to a gap in Navy anti-ship missile technology identified in 2008. The standard Navy anti-ship missile is the subsonic Harpoon, which has been in the inventory since 1977.

Since LRASM started development more than a decade ago, however, hypersonic cruise missiles able to fly faster than five times the speed of sound have become one of the Pentagon's top priorities. This has the potential to limit overall LRASM production numbers.

On this order Lockheed Martin will do its work in Orlando, Fla., and Troy, Ala., and should be finished by September 2025. For more information contact Lockheed Martin Missiles and Fire Control online at www.lockheedmartin.com, or the Air Force Life Cycle Management Center at www.afllcm.af.mil. ◀

Continued from page 34

RF & MICROWAVE

Fixed-chip attenuators for increased power handling introduced by Smiths

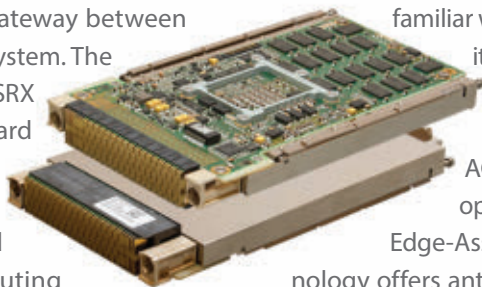
Smiths Interconnect in London is introducing the TSX series of fixed-chip attenuators for harsh-environment space and defense applications. The TSX series is optimized to combine high frequency and power in a small package. The TSX series is designed to offer broadband performance to 50 GHz, while delivering increased power handling in a small 0604 surface-mount package. It offers wider coverage than traditional components while providing optimized return loss for several frequency ranges. This enables RF and microwave systems designers to use one chip in several applications, reducing

the bill of material (BOM) item count and cost of ownership. The rugged chip attenuator design, available for surface mounting, offers 1 to 3 Watts of power handling performance and several attenuation values. The use of an all thin film process on an alumina substrate provides a product suitable for harsh environments. Each product is engineered using 3D electromagnetic simulation software to provide performance in a total thin film process. Features include small form factor; surface mountability; broad frequency range; low voltage standing wave ratio (VSWR); wide range of attenuation values; and tight attenuation tolerance. For more information contact Smiths Interconnect online at www.smithsinterconnect.com. ◀

COMMUNICATIONS

► **Rugged 3U VPX embedded computing router introduced by Abaco Systems**

Abaco Systems Inc. in Huntsville, Ala. is introducing the VSR347D rugged 3U VPX secure data router for aerospace and defense applications as a secure gateway between multiple WANs and LANs of any 3U VPX system. The router has the Juniper Network's Junos vSRX virtual firewall and an Abaco single-board computer. This router's security capabilities include a Stateful Firewall, brute force attack mitigation, and malformed packet protect. The embedded computing board comes with 1000Base-T and 10GBASE-KR ports and the ability to expand by connecting external network interface cards using the PCI Express expansion plane. The router is featured in Abaco's upcoming VSR8000 rugged, secure COTS system, and integrates with Abaco's SWE440A single-board computer and FPGA products. For more information contact Abaco Systems online at www.abaco.com.



provides A-PNT information in GPS-threatened environments, and is designed for military vehicles that use Leonardo DRS hardware. The A-PNT technology enables warfighters in combat vehicles to manage A-PNT functions. Operators use one screen through a graphical user interface they are already familiar with. AC2ES blends A-PNT capabilities with cyber-hardened computing, including A-PNT distribution and sharing with other vehicles. AC2ES provides modular upgrade options and integrates Leonardo DRS Edge-Assured cyber protection. The technology offers anti-jam and anti-spoofing, M-Code receivers, image-based terminal, and inertial measurement units. AC2ES provides U.S. Army and Marine Corps users to modernize vehicle navigation with options that accelerate A-PNT capability insertion. For more information contact Leonardo DRS online at www.leonardodrs.com.

NAVIGATION AND GUIDANCE

▼ **Assured position navigation and timing (A-PNT) introduced by Leonardo DRS**

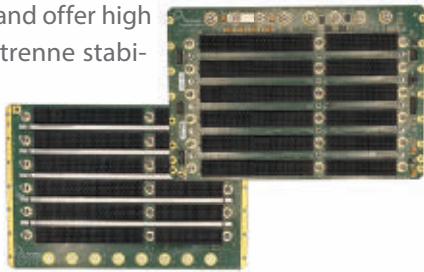
Leonardo DRS Inc. in Arlington, Va., is introducing the AC2ES assured position navigation and timing (A-PNT) system to counter anti-Global Positioning System (GPS) threats while improving the functionality of combat networking. The A-PNT Converged Computing – Embedded and Scalable (AC2ES)



BACKPLANES AND CHASSIS

► **OpenVPX backplanes for fast and high-throughput introduced by Atrenne**

Atrenne, a Celestica company in Brockton, Mass., is introducing Gen-4/5 OpenVPX backplanes for fast high-throughput embedded computing applications. Atrenne's Gen-4/5 OpenVPX backplanes are designed to the demanding signal integrity requirements of PCI Express Gen4 and 100 Gigabit Ethernet, and offer high signal integrity. Atrenne stabilizes return loss, dielectric loss, skin effect loss, and crosstalk in the backplanes by using 3D electron microscopy field modeling in high-frequency structure simulator to develop accurate signal integrity models. "As sensor inputs and signal processing demands increase, so do the data rates of serial switched fabric protocols used for OpenVPX slot-to-slot interconnect planes," says Jim Tierney, the Atrenne vice president of defense and aerospace systems. Atrenne's Gen-4/5 OpenVPX systems operate on high performance VITA 46.30 MULTIGIG RT 3 connectors. Several backplane profiles are available, including pass-thru backplanes. Atrenne also designs application-specific configurations to meet custom requirements. For more information contact Atrenne online at www.atrenne.com.



EMBEDDED COMPUTING

► **GPGPU 6U OpenVPX embedded computing card for EW introduced by EIZO**

EIZO Rugged Solutions Inc. in Altamonte, Springs, Fla., is introducing the Condor XR1 6U VPX series 6U OpenVPX 6U embedded computing card for unmanned systems, airborne radar, signals intelligence (SIGINT), electronic warfare (EW), and digital signal processing (DSP). The Condor XR1 combines single-board computer and general-purpose graphics processing unit (GPGPU) card based on the NVIDIA Turing architecture using either the NVIDIA RTX5000 or NVIDIA RTX3000 GPGPUs. The embedded computing card offers as many as 6150 CUDA cores, 768 Tensor cores, 96 RT cores, and performance of 18.98 trillion floating-point operations per second with CUDA and OpenCL software support. The Condor XR1 supports as many as eight DisplayPort++ video outputs and has dedicated H.264/H.265 (HEVC) encoding/decoding engines. Each GPU can be configured individually to route to various endpoint configurations, as each PCI Express switch also enables mating I/O modules to communicate to the CPU or directly to the GPUs themselves via NVIDIA RDMA. The NVIDIA RTX platform has increased performance in AI and deep learning, and double the parallel processing capabilities from the previous generation. This product is available in conduction – or air-cooled formats and supports PCI Express Gen 3.0. This card is tested to MIL-STD-810 standards and is comes in VITA 65 or SOSA-aligned configurations. For more information contact EIZO Rugged solutions online at www.eizorugged.com.



and several components to decode, store, and encode the signal prior to retransmission. The HI-3585 for commercial aviation applications can operate autonomously without a modular concept unit (MCU) or software, and can reproduce ARINC 429 signals transmitted over long cable runs or noisy environments. The device provides alternate input and output resistance values on the line receiver and line driver. External digital input control pins set the receiver and transmitter data rates and speed data received from a low speed ARINC 429 bus. An option to flip the bit order of the received 8-bit ARINC 429 label prior to re-transmission is also provided. The device also features ARINC 429 digital outputs to use an external line driver. An additional digital output sets the data rate on the external line driver. An external HI-8597 line driver can help provide lightning protection on the inputs and outputs that comply with RTCA/DO160G Section 22 Level 3 Pin Injection Test Waveforms. For more information contact Holt Integrated Circuits online at www.holtic.com.

SENSORS

◀ **Triaxial variable-capacitance accelerometer for flight test introduced by Endevco**

Endevco, an Amphenol company in Depew, N.Y., is introducing the model 7298A triaxial variable-capacitance accelerometer to provide high thermal stability and accuracy to measure low-frequency accelerations in aerospace and automotive applications. Typical applications require the measurement of whole body motion in three mutually orthogonal directions immediately following shock motion or in the presence of severe vibrational inputs. Damping prevents resonating and flat frequency response down to DC ensures faithful low frequency accuracy and wide bandwidth. The 7298A offers guaranteed performance over temperature and near-instantaneous recovery after shock for aircraft flight test and other high-accuracy triaxial motion measurement, including trajectory monitoring, modal analysis, flutter

AVIONICS

► **ARINC 420 avionics databus for commercial aviation introduced by Holt**

Holt Integrated Circuits in Mission Viejo, Calif., is introducing the HI-35851 ARINC 429 avionics databus repeater integrated circuit to replace solutions that require software



testing, vehicle dynamics testing, and flight testing of electric vertical take-off (eVTOL) aircraft. The 7298A comes in 2-, 5-, 10-, 30-, 50-, 100-, and 200-G ranges. Each axis of the triaxial accelerometer uses a variable-capacitance MEMS sensing element. Gas damping and internal over-range stops help withstand high shock and acceleration loads. The triaxial sensor is housed in a hermetic screw-mount package with integral hermetic receptacle. An eight-conductor model 3911 cable that accompanies the 7298A features PFA conductor insulation and jacket with a mating nine-socket plug on one end, and tinned pig-tails on the other. For more information contact Endevco online at www.endevco.com.

INTERCONNECT PRODUCTS

► **Fieldbus coupler to help protect data networks introduced by Wago**

Wago Corp. in Germantown, Wis., is introducing the 750-366 fieldbus coupler to help protect the data network in case of problems or failures. The 750-366 supports device-level ring (DLR), and uses the DLR's protocol setup with an Ethernet/IP network. Adding this coupler to a device-level ring network topology ensures that I/O communications remain online in case of a single point of failure. The dual device-level ring Ethernet ports form an integrated switch to eliminate the need for additional devices such as Ethernet switches. Its fast boot-up time also enables systems to get online quickly. Onboard web-based network management enables for parameterization of the device along with seamless firmware updates. The 750-366 also supports additional protocols such as HTTP(S), DHCP, DNS, SNMP, and FTP(S). For more information contact Wago Corp. online at www.wago.com.

BOARD PRODUCTS

▼ **Carrier card that connects PC to XMC over PCI Express introduced by Acromag**

Acromag in Wixom, Mich., is introducing the APCe8775 carrier card that enables a PC to communicate with a Switched Mezzanine Card (XMC) over a PCI Express bus in small embedded computers and servers with reduced-depth expansion slots. These carriers are suitable for high-performance military and scientific research computing systems. Systems

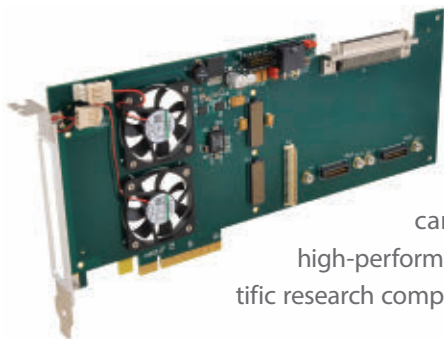
developers can insert an Acromag field-programmable gate array (FPGA) module or other XMC on the carrier card to perform signal processing functions. The APCe8775 three-quarter-length PCI Express card supports as many as eight serial lanes for rapid data transfer between the plug-in XMC and the host computer. These cards also can help test advanced defense and aerospace systems for later deployment on rugged computing platforms such as VME, VPX, or CompactPCI. Several rear I/O connectors enable high-speed serial interfaces between neighboring carrier boards using XAUI or Aurora protocols. An MD68 port and two Samtec QPairs connectors simplify board-to-board connections with a SCSI-3 or Twinax cables to left and right adjacent carrier cards.

Software development tools for this carrier card are available for VxWorks, Linux, and Windows environments. These function libraries provide example routines or DLL driver support with C source code to save time. For more information contact Acromag online at www.acromag.com.

TEST AND MEASUREMENT

▼ **SOSA-aligned 3U VPX development platform to accelerate testing introduced by Elma**

Elma Electronic Inc. in Fremont, Calif., is introducing the 3U VPX mid-range CompacFrame development platform to accelerate testing and development of plug-in cards based on The Open Group Sensor Open Systems Architecture (SOSA) 1.0 or OpenVPX. The CompacFrame features as many as eight slots, comes with either a 6 – or an 8-slot backplane, and is tilted upwards by 5 degrees for viewing and card access. The user front-panel interface of



this embedded computing development and test system includes voltage LEDs, monitoring and test points, and reset and power switches. An integrated carrying handle makes it portable. The midrange CompacFrame features a 1,400-Watt ATX-style power supply to power as many as the OpenVPX cards or SOSA cards and an SMA connector for a precision navigation and timing (PNT) card. The unit accommodates VITA 48.1 convection, VITA 48.2 conduction, and VITA 48.8 air flow-through (AFT) cooling methods. An optional rear-accessible VITA 46.11-compliant chassis manager is available for board diagnostics. For more information contact Elma Electronic online at www.elma.com.



RUGGED COMPUTERS

▲ **Mission computer for defense applications introduced by Kontron**

Kontron AG in Ismaning, Germany, is introducing the COBALT S1901 integrated mission computer for harsh-environment aerospace and defense applications. The COBALT S1901 offers high-performance processing and I/O in a small rugged package. It measures 13 by 7 by 4 inches, and operates in temperatures from –40 to 71 degrees Celsius. The rugged computer offers an expandable carrier card for rugged versions of Kontron's COM Express Type 6 or 7 modules, an on-board Ethernet switch supporting 1G, 2.5G and 10G ports, two mini-PCI Express slots, three M.2 slots, and two MXM slots for high-performance GPU modules or custom FPGA modules. When coupled with a COM Express module and optional GPUs enables the COBALT S1901 offers potentially several GPUs and flexible I/O, the COBALT S1901 enables defense systems integrators to host their challenging sensor-based applications without resorting to expensive blade-based chassis systems. The embedded computing system is a rugged, environmentally qualified package for hosting a wide range of defense applications. For more information contact Kontron online at www.kontron.com.

SOFTWARE

▼ **Real-time operating system (RTOS) for safety-critical avionics introduced by SYSGO**

SYSGO GmbH in Klein-Winternheim, Germany, is introducing the PikeOS for MPU separation-kernel-based real-time operating system (RTOS) for microcontrollers (MCU) to help users develop safety-critical space, avionics, industrial, automotive, and medical applications. PikeOS for MPU is especially suitable for avionics and space applications with radiation-hardened controllers that can mitigate single-event upsets. The PikeOS for MPU software also serves together with PikeOS Classic for big system-on-chip (SoC) hybrid solutions with a heterogeneous processor with cores with and without memory management unit (MMU). PikeOS for MPU especially is suitable for safety-critical applications in industry requiring assessable deterministic behavior. It comes only with one address space per resource partition, bringing PikeOS for MPU very close to the original ARINC 653 specification. PikeOS helps manage software stacks of complex big SoCs within one CODEO workspace. CODEO is SYSGO's Eclipse-based integrated development environment (IDE). PikeOS for MPU is based on a separation kernel and offers the performance of traditional real-time software. Separated partitions enable several applications to operate in parallel, and eliminates the risk of application failures propagating to other partitions and applications. For more information contact SYSGO online at www.sysgo.com.



NEW PRODUCTS

POWER ELECTRONICS

► Silicon carbide 1200-volt power modules for avionics introduced by Solitron

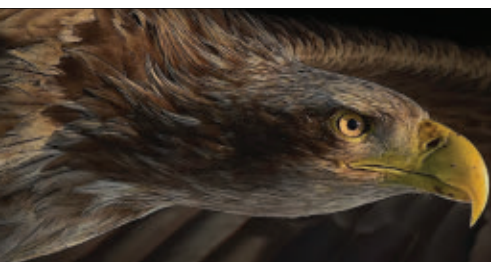
Solitron Devices Inc. in West Palm Beach, Fla., is introducing the SD11900 series 1200-volt 50-amp power electronics modules for demanding applications like avionics-based electromechanical actuators and power converters. The SD11900 has a 37-by 25-millimeter outline, and makes the most of power density while minimizing loop inductance with a pin configuration to allow simple power busing. The SD11902/3/4/5 are half-bridge configurations with two 1200-volt 32-milliohm silicon carbide (SiC) metal oxide silicon field effect transistors (MOSFETs). The SD11902 and SD11904 feature freewheeling 1200-volt silicon carbide Schottky diodes in parallel with the MOSFETs inside



the module. Continuous drain current is specified at 50-amps. The SD11900 series operates in temperatures from - 55 to 175 degrees Celsius. Its construction includes copper baseplates and alumina nitride insulators ensuring TCE matching and high thermal transfer. Isolated integrated temperature sensing enables

high temperature protection. Silicon carbide provides excellent power electronics switching performance versus silicon MOSFETs and insulated-gate bipolar transistors (IGBTs) with minimal variation versus temperature. Higher efficiency levels than silicon due to significantly lower energy loss and reverse charge results in more switching power and less energy required in the switch-on and switch-off phase. For more information contact Solitron Devices online at <https://solitrondevices.com>. ◀

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