JUNE 2017

# Military & Aerospace Electronics

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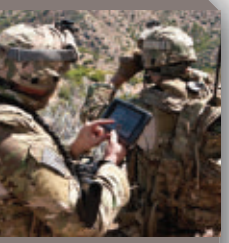



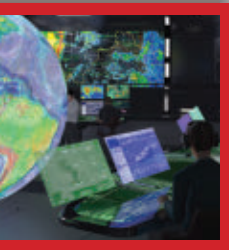

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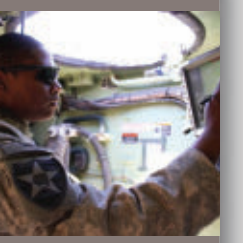





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BY **JOHN KELLER**, EDITOR IN CHIEF

# Is military C-RAM development as efficient as it could be?

The Pentagon is spending substantial time, effort, and money for counter-rocket, artillery, and mortar (C-RAM) technology to protect U.S. warfighters on the front lines and on invasion beaches from enemy airborne threats. It's fitting that military leaders should develop these kinds of technologies in this era where enemy threats to deployed warfighters can take so many forms, from conventional military forces to concealed terrorists wielding weapons ranging from improvised explosive devices to smart munitions.

U.S. military forces have several systems deployed or in development to help form an umbrella of protection over vulnerable U.S. and allied warfighters operating well within the range of most enemy weapons.

In development is the U.S. Air Force Raytheon Three-Dimensional Expeditionary Long-Range Radar (3DELRR) system to detect, identify, and track objects at great distances in conflicts that could involve large numbers of enemy advanced unmanned aerial vehicles (UAVs), fixed-wing aircraft, helicopters, and ballistic and cruise missiles. Also in development is the U.S. Marine Corps Northrop Grumman Ground/Air Task-Oriented Radar (G/ATOR), designed to protect Marines on attack beaches from low-observable targets with low radar cross sections, such as rockets, artillery, mortars, cruise missiles, and UAVs. Northrop Grumman, moreover, is enhancing G/ATOR capability to counter enemy rockets, artillery, and mortars.

Another battlefield radar system in the works is the U.S. Army SRCTec AN/TPQ-49 and AN/TPQ-50 lightweight counter-mortar radar (LCMR) to help defend deployed warfighters from rocket, artillery, and mortar attacks using 360-degree surveillance and 3D rocket, artillery, and mortar location using non-rotating, electronically steered antennas.

Already deployed is the U.S. Army Lockheed Martin AN/TPQ-53 radar system to protect against rockets, mortar rounds, and artillery shells. This radar also is designed to pinpoint the location of enemy launchers to direct counter-battery fire.

In addition to battlefield air-defense and C-RAM radar systems, some Army and Marine Corps programs intend to fuse data from sensors and slave them to weapon systems layered from close-in to long-range distances to destroy or disable enemy airborne threats.

Northrop Grumman, for example, is providing hardware and services for Army C-RAM capabilities to protect brigade combat teams from enemy airborne attack. Northrop Grumman is integrating existing field artillery and air defense sensors, a commercial off-the-shelf (COTS) warning system, and a U.S. Navy-developed interceptor to protect forward-deployed warfighters.

Lockheed Martin is developing Extended Area Protection and Survivability (EAPS) Integrated Demonstration (ID) technology to counter incoming enemy rocket, artillery, and mortar rounds, as well as enemy cruise missiles and UAVs.

Other military research projects seek to fuse battlefield radar systems, other kinds of sensors, and weapons to enhance C-RAM capability. One is the Office of Naval Research's Target Processing Center Sensor Correlation and Fusion project, which seeks not only to detect enemy artillery, rocket, and mortar rounds and reduce false alarms, but also to speed counter fire to destroy enemy projectiles, artillery emplacements, and launchers.

This sounds like a lot of different projects intended to protect military forces from, you guessed it, rockets, artillery, and mortars. I'm not suggesting this is a bad thing, yet I do wonder if U.S. military C-RAM efforts might be duplicative or otherwise potentially wasteful. I have to ask if there's any way that at least some of the enabling technologies of these different programs could combine to enhance efficiencies, while not compromising on capabilities.

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# Army and Oshkosh to revitalize heavy battlefield truck fleet

**BY JOHN KELLER**

**WARREN, Mich.** – U.S. Army logistics authorities are continuing their effort to revitalize the Army's fleet of heavy battlefield trucks with orders collectively worth $170.5 million to Oshkosh Defense LLC in Oshkosh, Wis., to rebuild 423 heavy battlefield trucks, as well as vetronics, trailers, and related heavy transport equipment to like-new condition.

Officials of the Army Contracting Command in Warren, Mich., are asking Oshkosh to rebuild different models of the Heavy Expanded Mobility Tactical Truck (HEMTT), as well as provide rebuilt palletized load system trailers and self-recovery winches.

Oshkosh will recapitalize, or "recap" these heavy trucks and related equipment, which means to rebuild the vehicles to like-new condition for upgrading and extending the service life of these military trucks and transport equipment. Last month, Oshkosh won contracts collectively worth $259.6 million to recapitalize 454 heavy battlefield trucks and related equipment.

The recap process is to extend a vehicle's service life, reduce its operating and support costs, enhance its capabilities, and improve its system reliability, maintainability, safety, and efficiency.

The Oshkosh HEMTT is an eight-wheel-drive, diesel-powered, 10-short-ton tactical truck that's been in the Army inventory since 1982. The HEMTT is designed to provide heavy transport capabilities for supply and re-supply of combat vehicles and weapons systems on the battlefield.

The large battlefield truck has a militarized commercial engine and transmission, and has an optional centrally mounted self-recovery winch. Its two-person cab is armored to protect the occupants from small-arms fire and shrapnel.

The HEMTT truck models involved in these orders are the M1074A1 and M1075A1 palletized load systems (PLS); M985A4 HEMTT trucks; M985E1A4 guided missile transporters; and M984A4 and M983A4 recovery vehicle wreckers. The contract also is for 42 new M1076A0 PLS trailers and 61 M984A4 self-recovery winches.

The U.S. Army is asking Oshkosh Defense to rebuild the nation's HEMTT heavy battlefield truck fleet to like-new condition.

The Army's heavy truck recapitalization orders to Oshkosh in April involved the M1977 HEMTT common bridge transporter; M984 wrecker; M978 water and fuel tanker; M985 cargo truck; M983 tractor unit; and PLS.

The Oshkosh PLS cargo truck and trailer secures as many as 10 supply pallets with a total load capacity of 16.5 tons. The vehicle has a hydraulic arm and cargo hook for loading and unloading. The M985A4 HEMTT truck is designed to support the Multiple Launch Rocket System (MLRS) and Patriot missile.

The Oshkosh M985E1A4 guided missile transporter is for the delivery, recovery, and loading of guided missiles. It removes spent missile canisters from the launcher and replaces them with fresh missiles. The M984A4 and M983A4 recovery vehicle wreckers are designed to recover vehicles bigger than 10 tons, even those mired in mud, sand, water, or snow.

Oshkosh will do the work in Oshkosh, Wis., and should be finished by January 2019.

**FOR MORE INFORMATION** visit **Oshkosh Defense** online at *https://oshkoshdefense.com*, and the **Army Contracting Command-Warren** at *http://acc.army.mil/contractingcenters/acc-wrn*.

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# Electronics-killing EMP weapons are focus of $15 million contract to Raytheon

**BY JOHN KELLER**

**KIRTLAND AIR FORCE BASE, N.M.** – High-power electromagnetics (HPEM) experts at the Raytheon Co. will help the U.S. Air Force determine the feasibility of using electronics-killing electromagnetic pulse (EMP) weapons aboard combat aircraft under terms of a $15 million contract.

Officials of the Air Force Research Laboratory (AFRL) Directed Energy Directorate at Kirtland Air Force Base, N.M., are asking the Raytheon Missile Systems segment in Albuquerque, N.M., to investigate ways to integrate future HPEM technologies into aircraft weapons.

An HPEM weapon, in theory, would emit a short burst of EMP, or a strong electromagnetic disturbance, that would damage or destroy targeted electronic systems, such as radar, communications, power grids, land vehicles, and aircraft.

The effects of an HPEM would be similar to those of a lightning strike or the EMP generated by the detonation of a nuclear weapon. In other words, it could destroy or damage any kind of unshielded modern electronics, ranging from computers, to electric generators, to small appliances.

The contract is part of the AFRL's HPEM Research Program, begun two years ago to advance the state of the art in HPEM technologies for directed-energy weapons and a variety of other aerospace and defense uses.

On this contract, Raytheon experts will look into the feasibility of developing and using HPEM weapons aboard a variety of aircraft. Raytheon will conduct studies develop concepts, and conduct tests for building HPEM systems and components for military aircraft.

Raytheon experts also will use simulation tools to assess the performance and mission operations of future HPEM weapons-equipped aircraft.

Airborne HPEM-based EMP weapons have the potential to knock out enemy sensors, communications, weapons, and other electronic systems without killing people.

The Air Force Research Lab's HPEM Research Program seeks to develop HPEM technology not only for electronics-killing aircraft weapons, but also for directed-energy weapons, cyber warfare, electronic warfare (EW), power electronics, and antennas.

The program has six technical areas: HPEM Transition; HPEM Cyber/Electronic Warfare (EW) Applications; HPEM Effects; Electromagnetics (EM) Weapons Technology; Numerical Simulation; and NextGen HPEM.

Raytheon is handling the HPEM Transition technical area.

In March, Booz Allen Hamilton in McLean, Va., and CSRA LLC

Raytheon is working on electronics-killing EMP weapons for potential deployment on combat aircraft.

## Raytheon to begin production of advanced shipboard radar system for guided missile destroyers

Shipboard radar experts at the Raytheon Co. will begin production of the new AN/SPY-6(V) Air and Missile Defense Radar (AMDR) for late-model Arleigh Burke-class (DDG 51) Aegis destroyers under terms of a $327.1 million U.S. Navy order. Officials of the Naval Sea Systems Command in Washington are asking the Raytheon Integrated Defense Systems segment in Marlborough, Mass., to build the first three AMDR low-rate initial production units. Raytheon prevailed over Northrop Grumman Corp. and Lockheed Martin Corp. to build the AMDR in 2013. The AMDR will supersede the AN/SPY-1 radar that has been standard equipment on Navy Aegis Burke-class destroyers and Ticonderoga-class cruisers. This order includes non-recurring engineering efforts in support of AMDR production. The Raytheon AN/SPY-6(V) AMDR will improve the Burke-class destroyer's ability to detect hostile aircraft, surface ships, and ballistic missiles.

in Chantilly, Va., each won a $10 million contract for the program's HPEM Cyber/Electronic Warfare (EW) Applications technical area, which seeks to identify and develop HPEM technologies for the cyber and electronic warfare communities.

HPEM Effects will investigate the effects of HPEM against a broad range of electronics, and develop predictive models for HPEM battle damage.

Electromagnetics (EM) Weapons Technology will move new HPEM technologies into pulsed-power weapons, including developing compact repetitive pulsed-power topologies; investigating high-energy particle beams; and creating weak and strongly ionized plasmas using ultrashort pulse lasers (USPL).

Numerical Simulation will develop simulation to help develop modern HPEM systems and the Improved Concurrent Electromagnetic Particle-in-Cell (ICEPIC) software.

NextGen HPEM will develop the source and antenna technologies for HPEM weapons, including broadband high-power amplifiers, tunable high-power oscillators, and broadband antennas RF effects weapons that work over a broad range of frequencies, pulse lengths, pulse repetition frequencies, and power densities.

Raytheon will do the work at Kirtland Air Force Base in Albuquerque, N.M., and should be finished by August 2020.

**FOR MORE INFORMATION** visit **Raytheon Missile Systems** online at *www.raytheon.com*, and the **Air Force Research Laboratory Directed Energy Directorate** at *www.kirtland.af.mil/Units/AFRL-Directed-Energy-Directorate*.

# EQ-4B UAV to provide battlefield networking and situational awareness

**BY JOHN KELLER**

**HANSCOM AIR FORCE BASE, Mass.** – Battlefield communications experts at Northrop Grumman Corp. are equipping long-endurance unmanned aerial vehicles (UAVs) with military networking equipment to provide situational awareness to frontline warfighters.

Officials of the U.S. Air Force Life Cycle Management Center at Hanscom Air Force Base, Mass., announced a $39.9 million contract to the Northrop Grumman Aerospace Systems segment in San Diego to equip the EQ-4B Global Hawk UAV with the Battle Field Airborne Communications Node (BACN).

The contract calls for Northrop Grumman to provide BACN payload modification, integration, and installation onto the EQ-4B, the BACN-equipped version of the Air Force RQ-4 Global Hawk long-range, long-endurance large UAV.

The BACN payload aboard the Global Hawk provides warfighters round-the-clock with essential information to pursue and defeat the enemy, Northrop Grumman officials say. The BACN airborne executive processor (AEP) enables a persistent gateway in the sky that receives, bridges, and distributes communications among participants in a battle.

BACN's AEP provides translator and gateway interfaces among all supported communications systems, and forwards knowledge-based intelligence information to the Global Information Grid.

BACN can help ground troops overcome the limitations that mountainous terrain places on line-of-sight communications. It acts as an airborne communications node that mimics satellite communications in limited theaters of operations.

BACN bridges the gaps between those systems, enabling situational awareness from small ground units in contact up to the highest command levels, Northrop Grumman officials say. Global Hawk makes BACN available to support the warfighter 24/7.

The Global Hawk UAV can remain on station unrefueled for more than 34 hours. The large UAV also can be refueled in the air from manned refueling aircraft or from other specially outfitted Global Hawk UAVs that act as aerial refueling aircraft.

The EQ-4B Global Hawk UAV will act as a battlefield communications node for frontline networking and situational awareness.

BACN translates among tactical data link networks, enables joint range extension, beyond-line-of-sight connectivity for disadvantaged users, and IP-based data exchange among dissimilar users.

On this contract, Northrop Grumman will do the work in San Diego and Palmdale, Calif., and should be finished by May 2018.

**FOR MORE INFORMATION** visit **Northrop Grumman Aerospace Systems** online at *www.northropgrumman.com*, and the **Air Force Life Cycle Management Center** at *www.wpafb.af.mil/aflcmc*.

# Special Operations forces eye new lightweight SATCOM communications

**BY JOHN KELLER**

**MacDILL AIR FORCE BASE, Fla.** – U.S. Special Operations Command (SOCOM) is kicking off an industry competition to develop a new family of lightweight satellite communications (SATCOM) equipment for covert use on the battlefield.

SOCOM officials, based at MacDill Air Force Base, Fla., have announced plans to issue a solicitation later this year for the SDN Family of Systems (FoS) Sub One-Meter Variant (SDN-Lite) project.

The future SDN-Lite terminal variants will operate in X, Ku, and

U.S. Special Operations Command ready to approach industry for new lightweight satellite communications (SATCOM) equipment for covert use on the battlefield.

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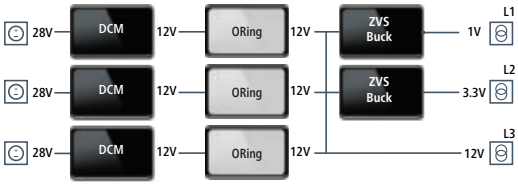


### Communications Equipment Challenges

The DCM's fixed switching frequency (750 kHz) enables a compact EMI filter to meet stringent conducted noise specifications.

Learn more about solving the challenges in Communications Equipment ›


### Airborne Equipment Challenges

Scalable modular DCM based design, enables high power, regulated outputs with up to 200 mF of bulk capacitance.

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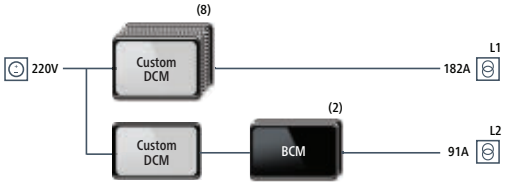
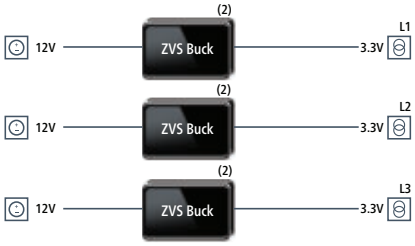



### Jammers and Countermeasure Challenges

High efficiency ZVS regulators (95%) enable high temperature operation with minimal power de-rating.

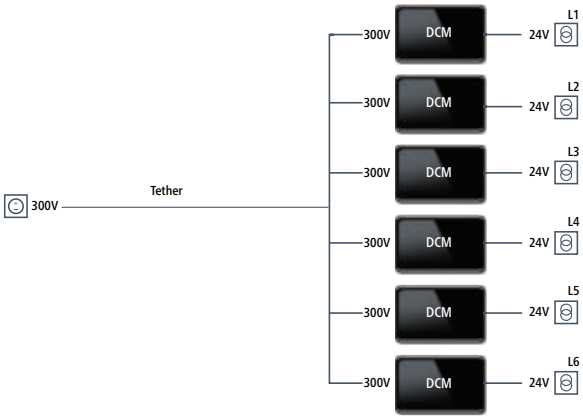
Learn more about solving the challenges in Jammers & Countermeasure Equipment ›




### UAV Challenges

Lightweight DCMs (29.2g) enable a scalable high density power design.

Learn more about solving the challenges in UAV Equipment ›



# Expanding the Family of MIL-COTS Products

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**Output Power:** 3623 ChiP: Up to 320W
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- For use with MIL COTS PI31xx regulators

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**Output Voltages:** 5V, 12V, 15V, 24V, 28V, 48V

**Output Power:** 3414 VIA: Up to 320W
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**Efficiency:** Up to 93%

**Dimensions:** 3414 VIA: 89.5 x 35.6 x 9.4 mm
3714 VIA: 95.3 x 35.6 x 9.4 mm

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**Efficiency:** Up to 96.5%
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LGA SiP: 10 x 10 x 2.56 mm

### Cool-Power® ZVS Buck-Boost Regulators ›

**Input Voltages:** 8 – 60V
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**Output Voltages:** 10 –50V
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12 – 34V

**Output Power:** Up to 240W continuous

**Efficiency:** Up to 98% efficiency at >800 kHz FSW

**Dimensions:** LGA SiP: 10 x 14 x 2.56 mm


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Ka SATCOM bands, and will be part of the SDN family of systems, which will represent an evolutionary follow-on replacement for the legacy Special Operations Deployable Node-Family of Terminals (SDN-FoT).

The SDN-Lite will be a sub one-meter aperture terminal for U.S. Special Operations Forces (SOF) that will consist of modular and portable SATCOM terminal variants that will handle secure and non-secure voice, video, and data communications at several classification levels.

The SDN-Lite will provide multi-user, multi-classification SATCOM transmit and receive capabilities, and provide Special Operations users with worldwide connectivity to the SOF Information Environment (SIE) via separately acquired base-band equipment.

The primary goal of the SDN-Lite is to deliver at least the existing capabilities of legacy Special Operations SATCOM systems while reducing size, weight and power consumption (SWaP).

The SDN family of 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. The FoS ultimately will comprise several terminal 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-to-1.3-meter aperture with automatic satellite acquisition operating in the X, Ku, and Ka bands (SDN-Medium), and a 2-to-2.4-meter aperture with automatic satellite acquisition and tracking, operating in the C, X, Ku, and Ka bands (SDN-Heavy).

SOF historically 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.

The first phase of SDN-Lite production will build and test five each of the X-band SDN-Lite and two each of the Ku and Ka-band SDN-Lite. U.S. Special Operations is pursuing the SDN-Lite project as a non-developmental effort, so system performance for the most part reflects the capabilities of the currently fielded legacy systems.

The contractor ultimately chosen for the SDN-Lite project should be able to deliver the first nine terminals within 90 days of contract award, which is expected in November 2017. The winning SDN-Lite contractor should be able to deliver at least 15 SDN-Lite terminals each month until the five-year program concludes at 809 terminals.

Special Operations Command officials say they anticipate a formal solicitation for the SDN-Lite project sometime this fall. Companies interested should e-mail questions and comments to the Special Operations Command's Jonathan Katz at jonathan.katz@socom.mil and Phillip Sabo at phillip.sabo@socom.mil.

**MORE INFORMATION IS** online at *https://www.fbo.gov/spg/ODA/USSOCOM/SOAL-KB/H92222-17-R-0004-SDN-L/listing.html.*

# What is global persistent surveillance?

*Next-generation persistent ISR will require more signal processing and data fusion on the sensor platform, as well as precision approaching artificial intelligence.*

BY **J.R. Wilson**

Global persistent surveillance conjures images of innumerable National Security Agency (NSA) analysts poring over sensor data covering every square inch of the Earth, 24/7/365. While there is a limited capability for gathering such data, using geosynchronous satellites carrying powerful sensors, there are not enough memory cores, bandwidth, human analysts, or real artificial intelligence products for such an approach to be practical.

This raises the first and — in the minds of many of those involved — perhaps the most important question: What is global persistent surveillance?

There have been several definitions offered, most similar to the Joint Warfighting Center's Joint Doctrine Support Division, which in 2011 issued a *Commander's Handbook for Persistent Surveillance* citing the joint doctrine definition as "a collection strategy that emphasizes the ability of some collection systems to linger on demand in an area to detect, locate, characterize, identify, track, target, and possibly provide battle damage assessment and retargeting in near- or real time. Persistent surveillance facilitates the prediction of an adversary's behavior and the formulation and execution of preemptive activities to deter

**SHOWN ABOVE:** This artist's rending depicts a possible future satellite ground control system in a global persistent surveillance environment. (Photo Credit: Raytheon)

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or forestall anticipated adversary courses of action. An effectively executed persistent surveillance strategy greatly enhances joint military operations."

Today's persistent intelligence, surveillance, and reconnaissance (ISR) overlays all five military domains — air, land, sea, space, and cyber — not as individual activities by separate services, but as joint networked systems using real-time and archival data fusion.

With ever-increasing volumes of data gathered by more and better sensors in an already bandwidth-constrained battlespace, next-generation persistent ISR will require more signal processing and data fusion be done on the sensor platform, but with a precision approaching artificial intelligence.

To expand those definitions to "global" status currently requires a modification of the concept to "globally available persistent surveillance, on demand, whenever, wherever, and for any duration required by the end user." The request may come from a platoon sergeant who needs to know what is over the next hill, in real-time or a four-star geographic combatant commander needing an up-to-date overview of an entire country or region, up to the White House situation room, where the President, Secretary of Defense, and Joint Chiefs of Staff need both as wide a view of an area of concern as possible and a real-time look at who is doing what and where.

Given current technology and other factors like acquisition procedures and inter-service and cross-agency cooperation, some say this definition today is unrealistic.

## Setting the bar high

"So far, that doesn't really exist, although the trends are moving in the right direction to enable it," says Steven Gitlin, vice president of corporate strategy at unmanned aircraft designer AeroVironment Inc. in Monrovia, Calif. "The question is, who is willing to pay for it at what level of persistence. We could deliver a similar capability today, if the customer is willing to pay for it, but it would cost and would have to solve a specific need."

Technologies involving solar power and batteries are coming to bear on prospects for global persistent surveillance, Gitlin says. "Advances in renewable energy, such as solar power, also are benefitting that kind of architecture. So as solar panel efficiencies have increased and costs have come down, the modes of integrating those into aircraft have increased. It's also new integration technologies on the platform and advances in battery technology, driven by the electric car and cell phone industries, which bode well for cycle time and other factors that will be important for high-altitude, long-endurance platforms."

On nearly every aspect of this level of persistent surveillance — from the nature of the target, terrain, weather, and time of day to who is seeking the information and for what purpose — the answer is "it depends" when considering what platforms and sensors are required, the level of detail sought, and even the definition of "real time."

"Looking at the mission, real time is whatever is required to give the decision-maker enough time and information to make the best decision, based on refined information and intelligence. We are definitely targeting our technologies in automated analytics and fusion because we see machines will be required to keep up," says Eric Vogel, program director at BAE Systems ISR Solutions in Nashua, N.H.

"The key challenge is keeping pace and being agile in a rapidly

evolving environment, the ability to put what I need when and where I need it, even if I can't predict that in advance as well as I used to. All the sensing modalities are important, with cross-domain being very important for persistent surveillance," Vogel says.

Another change, which has been in progress for the past few years and now is gaining momentum, is making such systems software-defined — that is, changing various aspects of the system to fit changing mission and environmental requirements using software modifications rather than swapping out fixed-use hardware.

"Sensors that are software-defined and can be responsive to the environment and operations they are put in will be key technologies to fulfill those missions going forward. It needs to be flexible during the mission and over the life cycle to keep pace with a very evolving threat environment," Vogel continues.

## Tailoring to the environment

"Scalable open-architecture systems leveraged from a core common architecture, in both hardware and software, enable you to tailor the sensors to match the platform environment and SWaP-C [size, weight, and power, plus cost] requirements, but you don't have to start from scratch each time. That's another way of being agile because it reduces NRE [Non-Recurring Engineering], cycle time, deployment time — persistent surveillance is all about a proliferation of sensors and this enables that."

While today's persistent-surveillance might not be close to the military's dreams of perfect capability, there still is plenty of embedded computing technology available that offers to move capabilities forward, says Marc Couture, senior product manager-digital signal processing and high performance embedded computing at the Curtiss-Wright Corp. Defense Solutions Division in Ashburn, Va.

"It's basically data that's actionable. There are cases where if it takes 10 minutes to identify a convoy, that might still be considered real time. Others measure it in milliseconds or even microseconds.

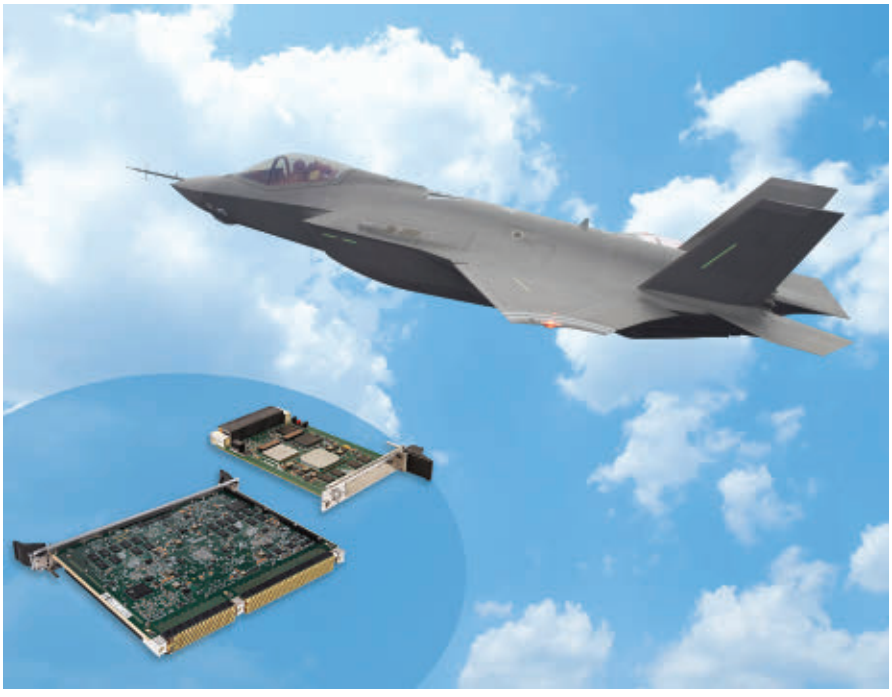
A platoon doesn't want to wait for information, so real-time is mandatory. There is still a need for post-mission analysis, but a lot of what used to be discerned post-mission is more and more being done in real time," Couture says.

"A lot of what this technology is all about is doing what analysts have done for a long time, but more accurately and orders of magnitude faster. For example, Nvidia GPUs [graphics processing units] are trained to look for specific targets based on existing databases, learning while in-theater. With a limited data pipe, the higher the quality of data and more quickly it can be obtained, the better. AI [artificial intelligence] is going to impact all aspects of defense computing, but surveillance is where it is already starting to hit."

Artificial intelligence has a multitude of definitions, influenced by the state-of-the-art in computer technology, the needs of the user community, and the amount and speed of processing. Still, there remains significant concern about the roles of human processing and machine processing in the ISR environment.

"Agile ISR is a centerpiece, a key enabler for future operations. I've been in this business 20 years and have seen it evolve from stovepiped, hardware-driven solutions to COTS-based, software-defined solutions running with open interface standards and business models that drive innovation at multiple levels of the system," notes BAE Systems' Vogel.

"As sensor providers, we are looking at technologies that enable our customers to digest and quickly



generate actionable intel from the wealth of raw data produced by these modern sensors. Advanced analytics and fusion processing are at the top of the list to help solve that problem, automating as much as possible. If you rely on humans to do it all, you won't be able to keep up with the wealth of data coming in or what needs to be disseminated to the right people at the right time."

## Speed of technology

Current and future requirements for persistent surveillance have grown significantly because of major advances elsewhere in military technology, says retired U.S. Air Force Lt. Gen. David A. Deptula, dean of the Mitchell Institute for Aerospace Studies in Arlington, Va.

"As we have achieved greater abilities in accuracy and the delivery of effects, that has driven the need for persistent surveillance," continues Deptula, who from 2006 until his retirement in 2010 was the Air Force's first deputy chief of staff for ISR. "The side that wins in the future is the side that has the greatest situational awareness and acts most quickly."

The speed of decision making, not precision targeting, today is among the most important military capabilities. "The ability to hit a target is no longer an issue — the U.S. can strike any target anywhere on the Earth, all day and night, any weather, rapidly and with precision," Deptula says. "The issue now is what effect to you want to achieve, which is not always kinetic. The challenge is not lethal force, but to define and fix the target. In World War II it took a thousand aircraft dropping 10,000 bombs to destroy a target that today one aircraft can accomplish. The need for accurate information drives persistent surveillance."

What sensor technologies and platforms are necessary, and how

they will be used remains a matter of debate — especially as rapidly evolving technologies influence those requirements.

Visible-light and infrared sensors today often work together with synthetic aperture radar, RF emitter data, and other relevant information. "A lot of the sensor fusion challenges involve overlaying all of those sensor types to get better overall data," says Curtiss-Wright's Couture. "Persistent surveillance is just a waterfall of data coming out of sensors with finer resolution — and we're now finally seeing sensor fusion, which has been talked about for decades. And processing systems that were too big and heavy 10 years ago are now possible."

The sheer volume of surveillance data available today is one of the biggest challenges facing systems designers. "The resolution per unit of surface area is much higher today; megapixel cameras are now gigapixel, SAR images have higher resolution, there are big advances in SIGINT, with far more accuracy than just a decade ago," Couture continues. "All the advancements in those technologies give you greater accuracy, but also mean you have a lot more data coming out of the sensors, so it's a good thing computing capability is keeping up with that deluge. AI at the cognitive level is coming out of its infancy, but still has a lot to be done in the next decade."

These new approaches will require vast use of new technologies, yet legacy systems also will play a role in future persistent ISR efforts.

Legacy systems "were designed to collect a specific type of data for a specific user. As we look at the speed of the threat and how it has evolved, we now realize there is better intel when looking across the entire set of data for context rather than looking at any one type of data for overall situational awareness and context," says Jane Chappell, vice president for global intelligence solutions (GIS) at the Raytheon Co. Intelligence, Information & Services segment in Dulles, Va.

"Any one piece of data by itself is interesting, but putting it in context with the overall environment brings a whole new level of intelligence,"

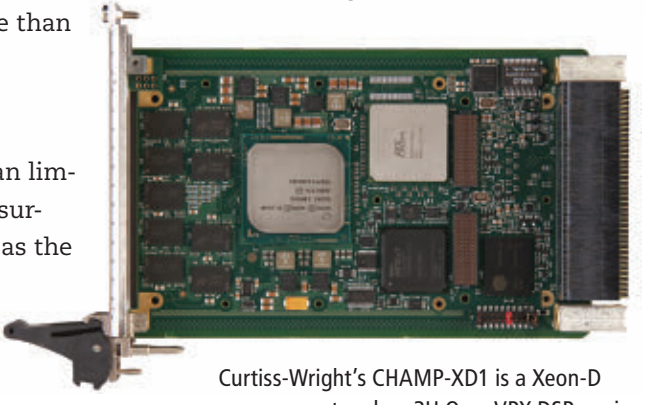
Chappell says. "Persistent surveillance is extremely important if you look at how our adversaries have changed their means and methods since the Cold War. That pace has changed in how they approach issues, how they fight a war, how they disrupt our capabilities, which makes it key for us to predict and automate and move at a faster pace than any adversary."

## Human limitations

There also is a human limitation to persistent surveillance, especially as the volume of data keeps growing. This is one of the chief challenges of the U.S. Army Program Executive Office for Intelligence, Electronic Warfare & Sensors (PEO-IEWS).

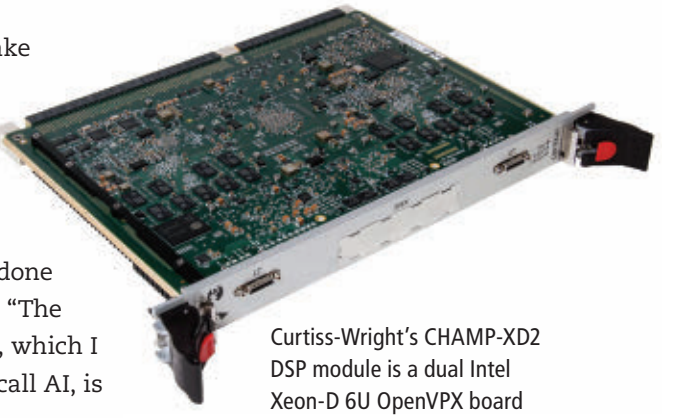
"Apart from fusing data to a single operating environment, which is not a trivial issue, the persistent sensing of one area leads to analyst fatigue — looking at one environment for extended periods of time for what can sometimes be vague details," Mark Kitz, chief engineer at PEO-IEWS at Aberdeen Proving Ground, Md. "We mitigate that through algorithms for change detection and orienting the analyst toward other things to keep them engaged, but, in the end, they do get fatigued quite quickly, no matter the sensor technology."

One challenge is to balance the amount of sensor processing that humans and machines perform so that human analysts can stay focused. "We are trying to keep the analyst engaged in the sensor's area of activity so they can make decisions in a timely manner, maintaining that diligence and balancing how much is done using algorithms and how much is done by the analyst," Kitz says. "The focus of these algorithms, which I would not go so far as to call AI, is to ensure the analyst doesn't miss something. The key is to supplement, not supplant, the analyst."



Curtiss-Wright's CHAMP-XD1 is a Xeon-D supercomputer-class 3U OpenVPX DSP engine for use in SWaP-constrained ISR applications, such as those deployed on UAVs.

Although the U.S. military today has a commanding lead in persistent surveillance technologies, other nations are moving from near-peer to parity. "Other nation-states are just as sophisticated as we are in some areas," points out Curtiss-Wright's Couture. "Cognitive EW, for example, is a cat-and-mouse game. Deep learning and machine learning tie into these cognitive efforts, not just EW but other areas, as well, where you try to get your adversary's sensors to pick up false information. Just the sheer number of assets the U.S. has kept us in the lead for now, but I feel we are in danger of falling behind in some areas; we should never get complacent."



Curtiss-Wright's CHAMP-XD2 DSP module is a dual Intel Xeon-D 6U OpenVPX board qualified to -40 to 85 degrees Celsius operating temperatures and extreme shock-and-vibration levels.

There are several reasons that the U.S. technological lead in persistent surveillance may be diminishing — some of which are self-inflicted, says the Mitchell Institute's Deptula. "We've seen the globalization of technology and we have created fiscal limits on what goes into defense that are not based on national security. Meanwhile, our adversaries, because technology is becoming a commodity and they have been sending students to our schools, are closing the margin of advantage the U.S. used to have. And now it is getting to parity, which will be a challenge for us as we move forward."

## Integrated base defense

While global persistent surveillance or something close to it may be the ultimate goal of major intelligence-gathering organizations, the most pressing need emphasizes the "globally available" concept. That need, providing constant ISR to defend areas of interest like forward operating bases, is a goal of the Army PEO-IEWS.

"Apart from anomalous ID detection, explosive detection,

identification of threats, the technology we're most interested in for integrated base defense is stand-off detection, so we can identify a potential threat prior to engagement," Kitz says. "We're highly invested in video detection capability and the algorithms of change detection and anomalous behavior, challenging industry on how to get more stand-off."

Even such a localized effort is not divorced from a larger ISR capability.

"Aerostats are the primary platform, although we also deliver towers and use UAVs [unmanned aerial vehicles]," Kitz says. "These sensors and platforms are not entirely dedicated to base defense, but are integrated into the force protection system so we have one picture of the area rather than just base protection."

One goal is to put persistent surveillance information in the proper context. "We interface with Army intelligence processing and overall military intelligence so we understand what is happening in the area and the operational environment in context of the security of the base. Those interfaces are critical to providing the base commander with an understanding of what is happening around the base."

As the area grows over which persistent surveillance is necessary, so does the need for consolidating all sources of information into one comprehensive picture. That capability, at least from a source perspective, has grown substantially since the turn of the century.

"The number of sensors and systems out there today is much larger, especially if you bring in commercial data sources," says Bob Canty, vice president for business development at Raytheon Intelligence, Information & Services. "Sharing data across all those systems is another enabling factor in achieving global persistent surveillance. That is where technology really comes into play—the reduction of sensor cost. But if you are bringing in open-source data, how do you track its pedigree throughout the effort so you have confidence in the end result?"

Using computers to put all that data together to free human

The U.S. Army uses the Persistent Ground Surveillance System (PGSS) in deployed applications for persistent surveillance.

analysts to spend more time analyzing is another goal.

"Visualization of data has always been incredibly important — and you want enough data to understand context and make decisions on consequences. We have spent a lot of R&D on understanding the target of interest and defining it in a way that the data finds the user rather than the user trying to find the data. In the past, roughly 80 percent of an analyst's time was spent looking for data. We want to reverse that, so they spend 20 percent looking and 80 percent analyzing," says Raytheon's Chappell.

"That's all about understanding what the target and area of interest are and making sure, through the analytics, that the data are searched in a way that it is reduced to a manageable set," Chappell says. "So, it is all about the analytics and automation — the speed and how we get the right data to the users for better decisions and how you use the results of that and move that data through the system to take the next set of actions."

While providing persistent surveillance for a small area, such as a forward operating base, might seem a lot simpler than doing the same across a wide geographic region, the Army's Kitz says that is not necessarily the case.

"Fifteen years ago, you were looking at a small area. Now, using hyperspectral capabilities, we can see a wider view and much further out to identify a potential threat or anomalous behavior, which make our demands for processing and on the analysts much higher," Kitz explains.

"Persistent surveillance requires infrastructure for a forward operating base — concrete, fiber, an aerostat, and a large ground station. The only other consideration is the investment that enables the integration of all these sensors, a contingency operations cell, analysts, etc. And the more sensors and data you have, typically the more infrastructure you require."

## Rewinding the data

There also is a forensic aspect to persistent surveillance — the ability to rewind the data to track movements and developments leading up to an incident.

"Forensics can be enormously important when you are trying to trace the cause of a particular activity. At the same time, if I'm engaged in a real-time activity, I'm

less concerned with forensics than I am with real-time knowledge of what my adversary is doing and how can I stay a step ahead," says the Mitchell Institute's Deptula. "The real-time aspect gives the edge over an adversary by building situational awareness, but that is not to reduce the importance of forensics, which can help develop options to greater strategic challenges."

BAE Systems' Vogel agrees: "Being agile and allowing customers to do either real-time or forensic analysis with a common sensing solution is the most important thing."

Software-defined systems will satisfy the bulk of requirements going forward, while advances in commercial technologies will enable those systems to have the performance required and the flexibility necessary to adapt to military targets.

"There are domains where MILSPEC sensors are still required, but even there you are seeing much more COTS influence than in the past. The whole chain has to be optimized to achieve an advantage," Vogel says. "If you have the best sensors, but the next step in the cycle isn't equally the best, then that's the limiting factor in the product you're generating. It's really a system-of-systems approach, from the platform through the sensor to the back-end processing, all of which are critical."

The ISR target environment is evolving more rapidly than it ever has. "Traditional technologies and acquisition models need to be updated to keep pace with that, Vogel says. "We're addressing that in two ways, from a technology standpoint — software-defined, open architecture sensors built on standards-based designs and open to technology insertion over their life cycles — and, of equal importance, open business models, giving customers the right positions and data so they can promote competition and innovation to get discriminating technology insertion when its needed."

As to the future, Raytheon's Chappell offers a more definitive look at real-time delivery. "As we continue to evolve our capabilities, it all goes back to the changing nature of the threat and our need to stay ahead of that threat. We have a lot of capability from a sensor standpoint; now it is all about networking those capabilities together, sharing the information across the different organizations at the speed and skill we need to understand patterns of life. And that means a big focus on automation and analytics," she says. "So, the key is delivering at the speed of need."

# Radiation-hardened space electronics enter the multi-core era

*The pace of embedded computing technology development is placing pressure on satellite and spacecraft designers, who must deliver reliable systems at low costs.*

BY **John Keller**

The growing use of space-based electronics for manned spacecraft, satellites, and deep-space probes is putting pressure on the rad-hard community to deliver technology with high performance and low cost.

Space is a dangerous place, especially when it comes to sensitive electronic components like microprocessors, solid-state memory, and network interfaces. The problem is radiation; space has a lot of it, and most modern electronic components were not designed to operate in a radiation environment.

Levels of radiation that occur in space can cause a variety of problems for electronic components, ranging from complete burnout to the occasional bit flip that can corrupt some data and render the reliability of even untouched data open to question.

There are ways to specially design radiation-hardened electronic parts to resist the effects of radiation, but it's expensive to do this. Moreover, overall demand for rad-hard electronic parts is relatively low, which can drive up their costs even more.

Then there's specially shielded packaging of electronic parts to keep radiation at bay. Not only is this approach expensive, but it also can be heavy enough to adversely influence launch costs. There are other ways of dealing with space radiation, ranging from redundant subsystems, selective shielding, and upscreening commercial off-the-shelf (COTS) electronics for enhanced reliability.

Among the challenges of space operations today are balancing electronics costs, capabilities, and reliability such that systems are good enough to operate in specific radiation environments for expected durations to meet mission requirements.

**Space radiation effects**

There are several ways that electronic parts designers can radiation-harden their devices. One of

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the most common is to harden for total-ionizing-dose radiation — or the amount of radiation the device is expected to withstand for its entire life before problems occur. A typical requirement is for 100 kilorads of total-dose radiation hardness.

The evolution of today's advanced electronic components, however, also is changing the total-dose picture. Specifically, the shrinking size of circuits on today's most modern chips is lessening their vulnerability to total-dose radiation.

"As technology nodes decrease in size — from 90 nanometers to 14 nanometers — total ionizing dose performance naturally improves," says Michelle Mundie, business area director of standard products at rad-hard specialist Cobham Semiconductor Solutions in Colorado Springs, Colo.

This phenomenon is a double-edge sword, however, because the steady shrinking of chip geometries also makes these devices even more vulnerable to other kinds of radiation effects, namely single-event upset (SEU) and single-event latchup (SEL). "Single-vent effects like latchup are becoming more of a problem, so we have to design for those effects," Mundie says. "Devices today are more sensitive to radiation at the gate and transistor level."

Curtiss-Wright is providing the company's radiation-tolerant Smart Backplane technology for the European Space Agency's Vega-C expendable space launch rocket.

Single-event upset can corrupt data when a radiation-charged particle flips a data bit from a one to a zero, or vice versa, which corrupts data. SEU typically does not physically damage an electronic device, only the data it contains or that flows through it. Single-event latchup, however, can be damaging if it causes a short circuit that triggers thermal runaway. Device designers must consider these potential threats.

There are several design approaches to mitigating radiation effects, which include radiation hardening by design, selective shielding, redundancy, and error-checking. One of today's most notable rad-hard by design projects is the High Performance Spaceflight Computing (HPSC) Processor Chiplet program.

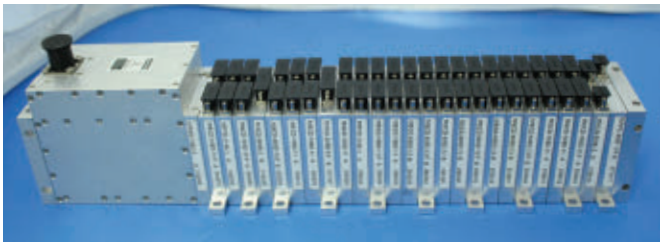
**Rad-hard by design**

Rad-hard by design involves designing an electronic component from the ground up to resist radiation effects. It can be one of the most expensive and time-consuming approaches, but sometimes it's the only solution for electronic components that are crucial for protecting human lives or safeguarding important orbital and deep-space missions.

U.S. government space experts are working with the Boeing Co. to create a new generation of radiation-hardened microprocessors for a wide variety of space applications to provide some of the most advanced processor

technologies with broad industry and software support for future space missions.

Sponsors of the HPSC project are the U.S. National Aeronautics and Space Administration (NASA) and the U.S. Air Force Research Laboratory at Kirtland Air Force Base, N.M. Industry experts from the Boeing Solid-State Electronics Development segment in Seattle are carrying out the program, based on a $25.9 million contract awarded last March by the NASA Goddard Space Flight Center in Greenbelt, Md.



Curtiss-Wright is delivering the company's MnACQ-2000 Miniature Network Data Acquisition System, shown above, for the NASA Orion spacecraft and the Space Launch System (SLS). These data-acquisition systems are hardened against the effects of space radiation.

The HPSC program is intended to develop rad-hard microprocessor technology that will replace or augment previous generations of rad-hard microprocessors, such as the RAD750 from the BAE Systems Electronic Systems segment in Manassas, Va., and the RH-1750A, RH-32, and Advanced Spaceborne Computer Module (ASCM) from the Honeywell Aerospace segment in Clearwater, Fla.

Managing the HPSC project are experts at the NASA Jet Propulsion Laboratory (JPL) in Pasadena, Calif., led by Richard Doyle and Raphael Some. The NASA Goddard Space Flight Center is managing the HPSC contract.

The program is developing technologies for a next-generation, general-purpose, multi-core space processor to meet on-board computing needs of future manned spacecraft and space robots. The four-year project is expected to deliver a next-generation, rad-hard space processor based on the ARM processor architecture to provide optimal power-to-performance for upgradeability, software availability, ease of use, and relatively low costs.

Although previous generations of rad-hard space processors like the RAD750 have performed well for years, "there are needs now that are well in excess of what that processor can do," explains Wesley Powell, assistant chief for technology in the NASA Goddard electrical engineering division.

Today's radiation-hardened space processors typically are single-processor systems based on existing commercial or military computers. They operate at maximum required throughput, fault tolerance, and power levels. Air Force and NASA space experts, however, say they anticipate future missions that will require an increase in throughput and wider variations in throughput, fault tolerance, and power levels.

**Commercially developed technology**

"We're basing this device on commercially developed, well-supported IP, and making sure there is a wide user base and software support — something that is well-supported by industry," Powell says. Air Force and NASA experts have defined the ARM-based hardware and companion Linaro system software as the HPSC processor baseline architecture.

Boeing embedded computing experts will develop a new space processor design that will provide orders of magnitude improvement in performance and performance-to-power ratio as well as the ability dynamically to set the power-throughput-fault tolerance operating point.

The HPSC project also will use Radiation Hard by Design (RHBD) standard cell libraries, as well as the ARM A53 processor with its internal NEON single instruction, multiple data (SIMD) design. "You really need the ability to do radiation hardening by design, applied to standard cells, etc., that allow you to use a modern semiconductor process," Powell says.

NASA experts are looking at three broad application areas for the next-generation HPSC microprocessor: vision systems, model-based reasoning for on-board autonomy, and high-rate instrument processing, Powell says. Vision systems would involve space applications like obstacle avoidance. "We need to process imagery to determine where you should and should not land, and in real time," Powell says.

Model-based reasoning for on-board autonomy could enable spacecraft designers and space mission managers to migrate much of the mission-planning and resource-management tasking to the spacecraft, rather than rely on ground controllers for those jobs. NASA experts also are thinking ahead to future deep-space missions in which ground controllers may not always be in touch with the spacecraft, so must rely on the spacecraft to make some of its own decisions.

High-rate instrument processing involves demanding digital signal processing for sensors and instruments like synthetic aperture radar and hyperspectral electro-optical sensors. "We want to migrate some on-board data processing on-board the spacecraft so we can downlink data of interest, rather than just the raw data," Powell says.

In addition, NASA experts are looking to Boeing to develop enabling technologies for a space processor that not only is radiation hardened, but also can manage its own electricity demands to preserve power resources — especially on deep-space missions far from Earth.

Aitech offers the E905 three-slot, cold-plate-cooled, space-rated embedded computing enclosure for mission-critical space applications, built on a 3U CompactPCI platform using machined aluminum.

**Smart power usage**

A key goal is the ability to trade dynamically between processing throughput, power consumption, and fault tolerance. "We want to be power-aware in our processor, and be able to ramp-down the processor for just what we need. That is kind of missing today," Powell says. "We are looking for the ability to tailor power, processing, and fault tolerance. Flexibility is one of the key objectives for HPSC."

Fault tolerance management middleware will enable the processor to detect and log errors; remove services likely to experience hard failures; respond to uncorrectable errors; and implement n-modular redundancy, checkpoint/rollback, or other high-level fault tolerance.

Additional applications for the HPSC processor will include military surveillance and weapons systems, human-rated spacecraft, habitats and vehicles, and robotic science and exploration platforms. System applications range from small satellites to large flagship-class missions.

Additional space computing tasks of the HPSC processor will include command and data handling, guidance navigation and control, and communications like

software-defined radio; human assist, data representation, and cloud computing; high-rate real-time sensor data processing; and autonomy and science processing.

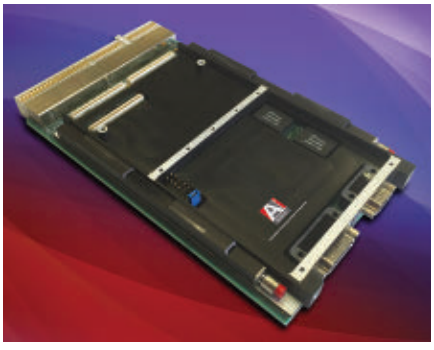
Boeing will provide prototype radiation-hardened, multi-core computing processor Chiplets, system software, and evaluation boards for Chiplet test and characterization. The Chiplets each contain eight general-purpose processing cores in a dual quad-core configuration, and interfaces to memory and peripheral devices.

"The period of performance is 45 months, so by late 2020 we're expecting Boeing to provide a processor chip or chiplets, packaged chiplets and bare die, and evaluations boards populated with chiplets to exercise the silicon," Powell says. "These chiplets will not be space-qualified; the focus of this project is on the silicon."

System software infrastructure will support real-time operating systems and Unix/Linux parallel processing to support hierarchical fault tolerance ranging from single Chiplet deep-space robotic missions to multi-Chiplet -redundant human spaceflight missions. "We also expect system software, including operating system, compilers, debuggers, a Linux operating system, and a real-time operating system," Powell says.

The HPSC processor will include Serial RapidIO (SRIO) for high-bandwidth communications, and several interfaces to high-speed, off-chip memory. The SRIO interfaces also can function as advanced microcontroller bus architecture (AMBA)-bus bridges to tile or cascade several processors to increase bandwidth or improve fault tolerance.

The SRIO interface also can extend the HPSC processor to other SRIO-enabled processing devices such as field-programmable gate arrays (FPGAs), graphics processing units (GPUs), and in the future to other application-specific integrated circuit (ASIC)-based coprocessors.



Embedded computing companies that specialize in rugged COTS technology are adapting design techniques to provide rad-hard computing for space. Shown above is the Aitech SP0-S enhanced space-qualified 3U CompactPCI single-board computer.

Powell says NASA and the Air Force will consider a flight-qualification program when the HPSC program concludes in late 2020 or early 2021. After that, it's reasonable to assume the technology will be ready for deployment. Powell speculates that HPSC technology could be deployed for at least 10 years before designers must look at a new generation of rad-hard microprocessors.

**Looking beyond microprocessors**

Outside the realm of the HPSC program, NASA experts are considering plans for additional radiation-hardened computer components, such as

general-purpose graphics processing units (GPGPUs), field-programmable gate arrays (FPGAs), as well as volatile and non-volatile memory. The problem right now is funding.

For the HPSC program "we looked at a number of processing architectures, and the biggest bang for the buck was a general-purpose, multicore processor," Powell says. For the future, nevertheless, "we have interest in some sort of paring of a general-purpose multicore processor with a rad-hard FPGA or GPGPU. There is interest, but we can't say that we have funding for that, but there's definitely interest.

"We're also interested in advancing volatile and non-volatile memory and networking rad-hard technologies," Powell continues. We have interest in developing a rad-hard ecosystem around that HPSC processor."

Looking to the future, companies with expertise in radiation-hardening GPGPUs, FPGAs, as well as volatile and non-volatile memory are urged to contact Wesley Powell, assistant chief for technology in the NASA Goddard electrical engineering division, at wesley.a.powell@nasa.gov, or Richard Doyle, program manager of information and data science at the NASA Jet Propulsion Laboratory, at Richard.J.Doyle@jpl.nasa.gov.

**COTS electronics for space**

While it's true that some space applications require the most expensive radiation-hardening solutions, the reality is that space systems designers must do the best they can to use commercially available electronic components for space applications.

Often this approach involves taking a hard look at whether the intended application is life- or mission-critical, the expected severity of the radiation environment in which the overall system will operate, and the duration of the planned mission, and then designing a radiation-tolerant system that's good enough.

Low-Earth orbit (LEO), for example, does not experience the same radiation levels that higher orbits or deep-space have. A growing number of LEO satellite applications today, moreover, have

relatively limited life cycles. Some Earth-observation projects, in fact, are expected to last for less than five years.

"There's a push to put a lot more hardware on LEO orbits lasting from three to five years for space observation," says George Romaniuk, director of space product management at Aitech Defense Systems Inc. in Chatsworth, Calif. "The orbit is low, so the requirements are not that stringent. On the other hand, we see groups that will be for lunar or asteroid exploration beyond Earth orbit. They want to stay for a very, very long time (18 years, minimum) so the market is starting to segment."


Cobham is using upscreening technologies and years of knowledge to create a radiation-hardened CAN bus network interface.

Applications in lower-Earth orbits that may be of relatively short durations — and that could tolerate the occasional data upset — are a particularly promising market for COTS electronics suppliers, particularly for cost-sensitive applications like small satellites. "Our lives are basically lives of compromise," Romaniuk says. "We may not have $7 million to create something nice, but we have to piece together things that will provide performance and reliability."

Cobham has specialized for decades in selecting commercially developed electronic parts that are appropriate for some space applications. The company uses upscreening and a variety of other testing. The company started their rad-hard upscreening business about 20 years ago with a focus on solid-state memory, and now is expanding into microcontrollers and mixed-signal analog products.

"With changing market pressures from the small satellite industry, and the drive to smaller device sizes, a lot of the space market is looking at flying at COTS products," says Cobham's Mundie. "We knew the need was there, and our focus is changing to ensure we are offering our right products to the industry. It is a challenge for us to identify COTS products that will work in a variety of applications."

**Multi-core redundancy**

Some technological developments in the COTS computing industry are providing serendipitous advantages for space systems designers. Not only are deeply submicron geometries naturally resistant to total-ionizing-dose radiation, but modern multicore processor architectures also offer opportunities for system redundancy.

Embedded computing designers at the Curtiss-Wright Corp. Defense Solutions Division in Ashburn, Va., are using multi-core processors not to block radiation-induced single-event effects, but to recover gracefully without system disruption when upsets occur.

"Where we are now using multi-core processors to speed up computing, we also can use that to our advantage by running the same code in multiple cores," says Paul Hart, chief technology officer and technical fellow of avionics and electronics at the Curtiss-Wright office in Christchurch, England.

"We run main code in one core, and duplicate code in another core that run in lockstep," Hart explains. Running identical code in three separate processor cores enables the system to detect a malfunction in one core, shut down the offending core, and continue operating based on no detected malfunctions in the other two.

"If a single event does occur, it will cause one of the cores to lose lock," Hart says. "If that happens the higher-level supervisory system that operates above it will reset the device. It will take in the order of seconds to reboot a typical embedded application; while the upset core is rebooting, the other two carry on. You're fully recoverable after a bit flip."

**Radiation creep**

Hardening electronic systems to the effects of radiation isn't just a space problem any longer. Aircraft flying at altitude, at about 30,000 feet and above, also are starting to experience radiation-induced effects. "There are 500 times more neutrons at 30,000 feet than there are on the ground," points out Aitech's Romaniuk.

If commercial avionics systems designers aren't considering radiation hardening today, they soon will be. The shrinking of commercially developed microprocessor architectures and other electronic devices will continue making the problem worse.

## General Dynamics tests military 4G network

General Dynamics Mission Systems streamed video more than 62 miles over ocean between tactical antennas during the Marine Corp-backed Ship-to-Shore Maneuver, Exploration, and Experimentation military exercise, part of a program intended to implement a tactical 4G network. Known as the "Long Shot," it would provide broadband capabilities over the ocean, even with satellite failure and other obstacles. The "Long Shot" doubles the range of existing line-of-sight systems, and provides increased bandwidth for video footage and other data. It will use similar technology as civilian networks and is expected to be adopted by the U.S. Navy and U.S. Marine Corps. Additional demonstrations are expected this year.

## Israel orders on-the-go satellite communications

Israel's Ministry of Defense has contracted with Elbit Systems Ltd. to provide satellite-on-the-move (SOTM) systems for land vehicles. The vehicle satellite communications (SATCOM) contract is for two years, and puts the number of systems to be supplied in the "dozens." Elbit's ELSAT 2100 SOTM family of systems enables fast broadband data networking capabilities for a variety of military vehicles and features advanced tracking capabilities. ←

# Rockwell Collins to mitigate interference from ocean wave action in Navy radio

BY **John Keller**

**PATUXENT RIVER NAS, Md.** — U.S. Navy airborne radio communications experts needed the ability for low-flying aircraft to receive and network data amid radio interference caused by ocean wave action. They found their solution from Rockwell Collins in Cedar Rapids, Iowa.

Officials of the Naval Air Systems Command at Patuxent River Naval Air Station, Md., announced their intention to contract with Rockwell Collins to enable the company's AN/ARC-210 airborne radio's Ethernet interface to accept data for transport over line-of-sight UHF radio signals in a sea-scattering multipath environment.

Breaking ocean waves can scatter and otherwise interfere with the radio signals of low-flying aircraft. This can complicate the ability of Navy fixed-wing planes and helicopters to send and receive important voice and data communications while flying near the ocean's surface.

The Navy Rockwell Collins AN/ARC-210 airborne radio has Ethernet I/O functionality to send and receive data to and from on-board networked displays, communications, weapons, and other systems. The RF interference from breaking ocean waves can impede on-board communications and networking.

The value of the upcoming Navy contract to Rockwell Collins to improve the AN/ARC-210 radio's ability to communicate and network in the presence of wave-induced RF interference has yet to be negotiated.

Ocean waves can cause radio interference for low-flying aircraft. Rockwell Collins is trying to change all that.

The upcoming contract will have options to include beyond-line-of-site, 25-kilohertz, dedicated, demand-assigned multiple access (DAMA), and integrated waveform (IW) communications in AN/ARC-210 radio capabilities.

Additional information about this upcoming Navy contract to Rockwell Collins is online at https://www.fbo.gov/spg/DON/NAVAIR/N00421/N00019-19-RFPREQ-PMA-209-0007/listing.html. ←

**FOR MORE INFORMATION** visit **Rockwell Collins** online at *www.rockwellcollins.com*, or **Naval Air Systems Command** at *www.navair.navy.mil*.

# Raytheon moves forward with 3DELRR counter-UAV radar

BY **John Keller**

**HANSCOM AIR FORCE BASE, Mass. —** Radar experts at Raytheon are moving forward with full-scale development of a portable air-defense radar system intended to detect, identify, and track enemy missiles as well as manned and unmanned aircraft.

Officials of the U.S. Air Force Life Cycle Management Center at Hanscom Air Force Base, Mass., announced a $52.7 million contract to the Raytheon Integrated Defense Systems segment in Woburn, Mass., to build three advanced-development versions of the Three-Dimensional Expeditionary Long-Range Radar (3DELRR) System.

The 3DELRR radar, pronounced "three-dealer," is to replace the Air Force's Northrop Grumman AN/TPS-75 transportable, 3D, passive electronically scanned array air search radar for enabling U.S. and allied invasion forces for protection from airborne threats after establishing beachheads.

Raytheon won a potential $71.8 million contract in October 2014 to begin 3DELRR engineering and manufacturing development (EMD).

This contract covers EMD of three production-representative units, but allows the ability to exercise options for low-rate production, interim contractor support, and full-rate production when appropriate.

Raytheon's 3DELRR system is a C-band gallium nitride (GaN)-based radar. GaN technology helps increase the radar's range, sensitivity, and search capabilities, while operating in C-band offers increased flexibility because that portion of the spectrum is relatively uncongested. 3DELRR will be the principal Air Force long-range, ground-based sensor for detecting, identifying, tracking, and reporting aerial targets for the Joint Force Air Component Commander through the Theater Air Control System.

The 3DELRR system is designed to deal with regional and near-peer conflicts of the future that could involve large numbers of enemy advanced unmanned aerial vehicles (UAVs), fixed-wing aircraft, helicopters, and ballistic and cruise missiles. 3DELRR is designed to detect, identify and track a wide variety of objects accurately at great distances. C-band, moreover, is a relatively uncongested portion of the electromagnetic spectrum. The radar is interoperable with coalition systems and meet the requirements of many foreign militaries.

The 3DELRR system is similar to the Ground/Air Task-Oriented Radar (G/ATOR) that Northrop Grumman is building the for U.S. Marine Corps. G/ATOR is being developed to protect Marine Corps expeditionary forces from rockets, artillery, mortars, cruise missiles, UAVs, and other low observables. It is a deployable short-to-medium-range multi-role radar system. 3DELRR, on the other hand, is designed to detect and track threats at longer ranges.

Like 3DELRR, the G/ATOR is based on GaN technology, yet the G/ATOR system is designed to handle air surveillance, weapon cueing, counter-fire target acquisition, and air traffic control for Marine Corps warfighters operating in invasion beaches.

Missile designers at Raytheon are developing a next-generation battlefield radar to protect warfighters from UAVs and other airborne threats.

The Raytheon 3DELRR initial $19.5 million contract awarded two years ago involved system EMD, low-rate initial production (LRIP), and interim contractor support (ICS). The contract was for purchase of three radar systems, and has options worth about $71.8 million for three additional radar systems.

The 3DELRR will provide the Air Force control and reporting center with real-time data to display air activity, and will provide warning and target information. The system also will provide operators with a precise, real-time air picture to provide air traffic control services to individual aircraft across a wide range of environmental and operational conditions.

Raytheon will do the work in Andover, Mass., and should be finished by November 2020.

**FOR MORE INFORMATION** visit **Raytheon Integrated Defense Systems** online at *www.raytheon.com*.

## L-3 boosts UUV technologies with OceanServer acquisition

Executives of L-3 Technologies in New York are boosting their capabilities in naval unmanned underwater vehicles (UUVs) with their acquisition of OceanServer Technology Inc. in Fall River, Mass. Terms of the deal were not released. OceanServer develops and manufactures autonomous, lightweight UUVs for military and commercial applications that involve intelligence, surveillance, and reconnaissance (ISR); anti-submarine warfare (ASW); and mine countermeasures. The newly formed L-3 OceanServer and will be integrated into the L-3 Sensor Systems segment. The acquisition, which closed on 17 March 2017, is one of the first L-3 moves into the unmanned vehicles market. L-3 OceanServer perhaps is best-known for its Iver commercially developed low-cost UUV for coastal applications, such as sensor development, general survey work, subsurface security, research, and environmental monitoring. One person can carry the UUV, which features point-and-click mission planning. "OceanServer Technology positions L-3 to support the U.S. Navy's vision for the tactical employment of UUVs," says L-3 CEO Michael Strianese. "OceanServer Technology provides L-3 with a new growth platform that is aligned with the U.S. Navy's priorities." ←

# General Atomics to build four more Gray Eagle long-endurance attack drones

BY **John Keller**

**REDSTONE ARSENAL, Ala.** — U.S. Army aviation experts are ordering four MQ-1C Gray Eagle reconnaissance and attack drones, as well as four unmanned aerial vehicle (UAV) satellite control stations.

Officials of the Army Contracting Command at Redstone Arsenal, Ala., announced a $25.3 million contract modification to General Atomics Aeronautical Systems Inc. in Poway, Calif., for the Gray Eagle attack drones and satellite communications air data terminals.

The General Atomics MQ-1C Gray Eagle attack drone is a medium-altitude, long-endurance (MALE) unmanned aircraft that is an upgraded MQ-1 Predator as an extended-range, multi-purpose UAV. 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 (HFE) able to 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/ground moving target indicator (SAR-GMTI) system, and targeting capability from an AN/AAS-52 multi-spectral targeting system (MTS) under the nose. The aircraft can carry a payload as heavy as 800 pounds.

The U.S. Army is ordering four more MQ-1C Gray Eagle UAVs for long-range surveillance and attack missions.

Army commanders deploy the Gray Eagle UAV in platoons, each with four aircraft, support equipment, and payloads like electro-optical/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 satellite communication 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.

General Atomics will build the Gray Eagle UAVs in Poway, Calif., and should be finished by December 2017. ←

**FOR MORE INFORMATION** visit **General Atomics Aeronautical Systems** online at *www.ga-asi.com*.

# Navy orders three MQ-4C Triton long-range maritime surveillance UAVs

BY **John Keller**

**PATUXENT RIVER NAS, Md.** — U.S. Navy aviation surveillance experts are ordering three MQ-4C Triton long-range and long-endurance unmanned aerial vehicles (UAVs) for global maritime surveillance for surface ships and submarines.

Officials of the Naval Air Systems Command at Patuxent River Naval Air Station, Md., announced a $303.9 million order to the Northrop Grumman Aerospace Systems sector in San Diego for the three Triton low-rate initial production UAVs as part of the second lot of Triton production. This order includes one Triton main operation control station, one forward operation control station, trade studies, and tooling.

Northrop Grumman is developing the MQ-4C Triton, also called the Broad Area Maritime Surveillance (BAMS) UAV, to fly maritime surveillance missions as long as 24 hours at altitudes of more than 10 miles to enable coverage out to 2,000 nautical miles. The UAV's sensors can detect and classify different types of ships automatically.

The Triton is to be a crucial component of the Navy's 21st century strategy for conducting surveillance of surface ship and submarine traffic in the vast Pacific and other oceans around the globe. The Triton UAV will work together with the Navy's P-8A Poseidon manned maritime patrol aircraft.

The Triton's maritime search radar is called the Multi-Function Active Sensor (MFAS), and will provide the UAV and its operators with a 360-degree view of a large geographic area while providing all-weather coverage for detecting, classifying, tracking, and identifying points of interest. MFAS is separate from the Triton's air-to-air radar. The MFAS radar first flew on the Triton during testing in April 2015.

Along with the air-to-air and MFAS radar systems, the MQ-4C will carry an electro-optical/infrared (EO/IR) sensor that will provide still imagery and full-motion video of potential threats; an electronic support measures package to identify and geolocate radar threat signals; and an Automatic Identification System (AIS) that will detect and track vessels equipped with AIS responders.

The MQ-4C Triton is designed to provide combat information to military authorities like the expeditionary strike group, carrier strike group, and the joint forces maritime component commander. The Triton air vehicle is based on the U.S. Air Force RQ-4B Global Hawk, while its sensors are based on components and systems already fielded in the U.S. military. The large unmanned aircraft provides intelligence for large ocean areas to maintain the common operational and tactical picture of the maritime battle space. The Triton feeds intelligence, surveillance, and reconnaissance (ISR) data to the Global Information Grid, and can work alone or together with other aircraft and surface ships.

The Navy's growing MQ-4C Triton unmanned aircraft fleet will handle long-range maritime surveillance for surface ships, submarines, and other threats.

The MQ-4C Triton's ability to perform persistent ISR within a practical range of 2,000 nautical miles enables the P-8A aircraft to focus on anti-surface ship warfare, anti-submarine warfare (ASW), and multi-intelligence. It can fly as far as 8,200 nautical miles without refueling.

Triton aircraft and support facilities are being based domestically at Point Mugu Naval Air Station near Ventura, Calif., and at Jacksonville Naval Air Station, Fla. Triton UAVs also will be forward-deployed to Kadena Air Base, Japan; Andersen Air Force Base, Guam; Sigonella Naval Air Station, Italy; as well as at installations on the islands of Hawaii and Diego Garcia.

On this contract Northrop Grumman will do the work in San Diego, Palmdale, and Santa Clarita, Calif.; Red Oak, Texas; Baltimore; Salt Lake City; Bridgeport, W.Va.; Indianapolis; Moss Point, Miss.; Montreal; Vandalia, Ohio; Medford, New York; and other U.S. locations, and should be finished by April 2021.

**FOR MORE INFORMATION** visit **Northrop Grumman Aerospace Systems** online at *www.northropgrumman.com*.

# Northrop Grumman to provide aircraft laser-based missile defense

BY **John Keller**

**PATUXENT RIVER NAS, Md.** — Missile-defense experts at Northrop Grumman Corp. will provide electro-optical equipment for laser-based missile-defense systems aboard large military aircraft under terms of a $99.5 million U.S. Navy order.

Officials of the Naval Air Systems Command at Patuxent River Naval Air Station, Md., are asking the Northrop Grumman Mission Systems segment in Rolling Meadows, Ill., to provide the Large Aircraft Infrared Counter Measures (LAIRCM) for a variety of U.S. Navy and Air Force aircraft. Northrop Grumman will provide weapon replaceable assemblies and support equipment; 302 advanced threat warning sensors; 41 control indicator units; 41 to 2103 signal processors; 82 guardian laser transmitter assemblies (GLTA); 82 GLTA shipping containers; 16 multi-role, electro-optical, end-to-end test sets; and 14 smart connector assemblies.

LAIRCM automatically detects a missile launch, determines if it is a threat, and activates a high-intensity, laser-based countermeasure system to track and defeat the missile. LAIRCM is for Air Force C-5, C-17, C-37, and C-40 cargo and utility jets; Air Force C-130H and MC-130W four-engine utility turboprop aircraft; the CV-22 tiltrotor aircraft, the KC-46 aerial refueling jet, as well as the U.S. Navy P-8A maritime patrol jet. LAIRCM also can fit on some large military helicopters.

The LAIRCM system uses lasers to confuse electro-optical seekers on incoming anti-air missiles.

LAIRCM focuses high-intensity laser energy at the infrared seeker head of incoming missiles to blind the missile and force it off its target. The system is designed to protect large aircraft from shoulder-fired, vehicle-launched, and other infrared-guided missiles when the planes are operating close to the ground, such as on takeoff and landing, as well as during low-level operations and aerial refueling. Later-model

Military leaders are trying to develop aircraft-protection infrared countermeasures able to detect and classify incoming missiles, then emit a custom jamming energy to defeat them.

Work will be performed in Rolling Meadows, Ill.; Goleta, Calif.; Longmont, Colo.; Colombia, Md.; and other locations within and outside the U.S., and should be finished in April 2019.

**FOR MORE INFORMATION** visit **Northrop Grumman** online at *www.northropgrumman.com.*

## Elbit to provide electro-optics helmet-mounted displays for Navy helicopters

Elbit Systems of America in Fort Worth, Texas, will provide the U.S. Navy with helmet-mounted displays for pilots of MH-60R anti-submarine warfare (ASW) helicopters and MH-60S multimission helicopters under terms of a $49.9 million contract. Officials of the U.S. Naval Surface Warfare Center Crane Division in Crane, Ind., are asking Elbit to provide 126 helmet display tracker systems (HDTS) for MH-60R and MH-60S helicopter pilots. The HDTS provides MH-60 situational awareness and targeting enhancements via pilot/copilot line-of-sight capability; continuously computed impact point for the 20-millimeter automatic gun helicopter armament subsystem; LAU-61C/A 2.75-inch unguided rockets; and LAU-61G/A precision guided digital rocket launcher. The MH-60R is an ASW and anti-surface warfare helicopter that can operate from aircraft carriers and from other surface warships equipped with helipads. The MH-60S, meanwhile, is for search-and-rescue, MEDEVAC, utility, and vertical replenishment. The magnetic HDTS helps reduce the MH-60 helicopter pilot's workload and improve crew coordination. The HDTS represents a relatively simple upgrade to the predecessor HUD on the MH-60 rotorcraft.

**FOR MORE INFORMATION** visit **Elbit Systems of America** online at *www.elbitsystems-us.com.*

# Three defense companies to develop ballistic missile defense multi-warhead killer

BY **John Keller**

**HUNTSVILLE, Ala.** — U.S. missile defense experts are moving forward with three U.S. prime defense contractors to develop a future ballistic missile defense multi-warhead killer intended to detect, track, and kill several different incoming enemy missile warheads and decoys with only one counter-missile launch.

Officials of the U.S. Missile Defense Agency (MDA) in Huntsville, Ala., are asking systems designers at the Boeing Co., Raytheon Co., and Lockheed Martin Corp. for technology work related to the Multi-Object Kill Vehicle (MOKV) technology risk reduction effort.

The MOKV is to engage several incoming objects simultaneously with kill vehicles that communicate with one another and destroy several incoming warheads and decoys using advanced sensor, divert and attitude control, and communications technologies.

MDA officials announced a $58.6 million contract to the Boeing Defense, Space & Security segment in Huntsville, Ala., for the MOKV technology risk reduction effort. The Raytheon Missile Systems segment in Tucson, Ariz., won a $59.6 million contract, and the Lockheed Martin Space Systems segment in Sunnyvale, Calif., won a $53.1 million contract for MOKV technology risk reduction.

Now the three companies proceed to the next stage of MOKV development, which attempts to improve performance and reduce risk for MOKV advanced communications, engagement management, and the system's discriminating seeker.

Raytheon, Lockheed Martin, and Boeing also won MDA contracts in 2015 to define MOKV proof-of-concept prototypes, demonstrate risk mitigation steps, assess the technical maturity of their concepts, and rank enabling technologies to minimize design risks.

MDA officials ultimately are expected to narrow the field to one contractor for advanced development and manufacturing for the MOKV program.

The MDA's ground-based interceptor missile today carries one kill warhead that detects, tracks, and attacks an incoming enemy ballistic missile warhead and attempts to destroy it kinetically by force of impact. The MOKV, instead, is expected to launch on one air-defense missile, and deploy several kill vehicles that could engage several incoming enemy warheads. MOKV warheads will be designed to communicate with one another to coordinate their attacks.

As many as six MOKVs will launch on one booster rocket, deploy at the edge of space, steer toward, and destroy several incoming ballistic missile warheads and decoys using separate kinetic hit-to-kill weapons.

The MOKV would function similarly to the MDA's Multiple Kill Vehicle (MKV) program, which was cancelled in 2009. The MOKV is likely to launch on rockets like the U.S. Navy Raytheon SM-3 standard shipboard missile. When put to use, military forces will load several MOKVs on one missile-defense rocket, such as the three-stage Ground-Based Interceptor (GBI). After launch, each MOKV will steer toward an incoming ballistic missile warhead or decoy to destroy it.

Some of the nation's top defense contractors are finding ways to kill several incoming ballistic warheads with just one anti-missile launch.

Each interceptor rocket will have an advanced sensor and divert, attitude-control, and communications technologies, to enable each MOKV to home-in on its target. Each MOKV will have its own sensor and diverting thrusters.

If MDA officials and other senior military leaders decide to proceed with MOKV development, production of these sophisticated missile-defense warheads could begin in 2022.

On the MOKV contract, Boeing will do the work in Huntsville, Ala. On the two previous MOKV technology risk-reduction contracts, Raytheon will do the work in Tucson, Ariz., and Lockheed Martin will do the work in Sunnyvale and Goleta, Calif., and in Bethesda, Md. The three companies should be finished with this phase of MOKV development by spring 2020.

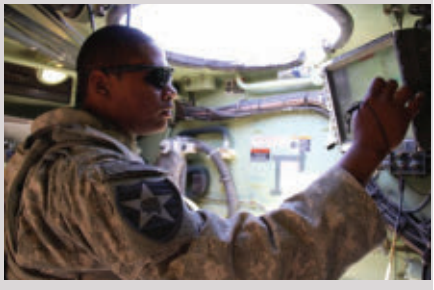
**FOR MORE INFORMATION** visit **Boeing Defense, Space & Security** online at *www.boeing.com/defense*, **Raytheon Missile Systems** at *www.raytheon.com*, and **Lockheed Martin Space Systems** at *www.lockheedmartin.com/us/ssc.html*.

# PRODUCT applications

TRANSCEIVERS

## ViaSat to provide additional situational-awareness transceivers for Blue Force Tracker

U.S. military communications experts needed ground transceivers for a ground-based situational-awareness system that provides location information on friendly and hostile military forces. They found their solution from ViaSat Inc. in Carlsbad, Calif.



Officials of the Defense Information Systems Agency (DISA) at Scott Air Force Base, Ill., announced a $13.7 million contract to ViaSat for ground transceivers for the Blue Force Tracker 2 (BFT-2) program. ViaSat is upgrading the U.S. Army and Marine Corps Blue Force Tracking network with BFT-2 for real-time situational awareness and networking capabilities to the warfighter.

Blue Force Tracking describes a U.S. military GPS-enabled system that provides military forces with the locations of friendly and hostile forces: blue denotes friendly forces, and red denotes hostile forces. Blue Force Tracking systems consist of a computer that displays location information; a satellite terminal and satellite antenna to transmit location and other military data; a global positioning system receiver to determine its own position; command-and-control software to send and receive orders; and mapping software that plots the BFT device on a map.

The BFT-2 network and transceivers improve situational awareness through fast position location information refresh rates and communications across the battlefield. The system also can send and receive text and imagery, as well as display battlefield conditions like the locations of mine fields, battlefield obstacles, and damaged bridges. Some BFT systems also have route-planning tools.

ViaSat provides the BFT-2 network with air and ground transceivers, satellite ground stations, and network control centers, as well as satellite and terrestrial communications services.

ViaSat will do the work in Carlsbad, Calif., and should be finished by April 2018. ←

**FOR MORE INFORMATION** visit **ViaSat** online at *www.viasat.com*.

SPACE ELECTRONICS

## Curtiss-Wright radiation-tolerant space telemetry chosen for European Vega-C rocket

Spacecraft rocket designers at ELV SpA in Rome needed a radiation-tolerant COTS-based telemetry data system for the European Space Agency's Vega-C expendable space launch rocket. They found their solution from the Curtiss-Wright Corp. Defense Solutions segment in Ashburn, Va.

ELV SpA is the prime contractor on the Vega-C rocket and GPM Development and Qualification Program for the European Space Agency (ESA). The telemetry system is based on the Curtiss-Wright radiation tolerant Smart Backplane technology.

The mid-sized Vega-C is designed to deliver cost-sensitive government, commercial, and science payloads weighing three tons or less, such as small satellite constellations to low-Earth orbit. ESA officials want the next-generation Vega-C launcher to support the same or greater mission objectives as the original Vega launcher, but at reduced cost.

Curtiss-Wright will provide ELV SpA with a full telemetry system, including data acquisition, data handling, and RF transmission. Curtiss-Wright will develop and manufacture the telemetry system for Vega-C at its facilities in Dublin, Ireland.

The Vega-C development contract runs from January 2017 until first launch in June 2019, with a value estimated at $5 million. The value of the subsequent production phase could be worth as much as $10 million over the lifetime of the program.

ESA's requirement for Vega-C flights include a minimum of three launches per year, with expected demand for at least four per year, Curtiss-Wright officials say.

**FOR MORE INFORMATION** visit **Curtiss-Wright Defense Solutions** online at *www.curtisswrightds.com/space*.

**FLIGHT LINE TEST**

## Indonesian Air Force selects Marvin Test for Maverick missile testing

Indonesian air force officials have selected the MTS-206A Maverick Field Test Set and MTS-916-3 Modular Target Simulator from Marvin Test Solutions Inc. in Irvine, Calif., to support the testing of AGM-65 Maverick missile and launcher systems.

The MTS-206A and MTS-916, part of Marvin Test Solutions' suite of test tools for legacy and new precision-guided "smart" weapon systems, provide advanced testing capabilities to maintainers at the intermediate and depot levels. The MTS-206A is designed to test all current versions of the Maverick missile system, and is compatible with legacy target simulators, including the AN/DSM-787 (IR), AN/DSM-129 (TV/CCD), and SMU-127 (laser) as well as with the new MTS-916 modular target simulator, which replaces legacy simulators (EO/TV/CCD/IR/Laser).

**FOR MORE INFORMATION** visit **Marvin Test Solutions** online at *www.marvintest.com*.

**TACTICAL DATA LINKS**

## Navy chooses video data link from Cubic for viewing front-line UAV surveillance

U.S. Navy communications experts needed a rugged portable data link system to enable warfighters at the leading edge of the battlefield to view real-time video from surveillance aircraft securely. They found their solution from Cubic Corp. in San Diego.

Officials of the Space and Naval Warfare Systems Command (SPAWAR) in San Diego announced a $20.9 million contract to Cubic for Portable Common Data Link (PCDL) systems. The contract calls for Cubic to build and deliver 25 TacMobile Person PCDL systems and spare parts for tactical operation centers and mobile tactical operation centers.

The Cubic Team-Portable Common Data Link provides intelligence, surveillance, and reconnaissance for battle groups at the tactical edge. It has small, lightweight components that can be hand carried and assembled by the warfighter at any location. The Cubic Team-Portable CDL can stream video from airborne sensors to enable the warfighter to obtain sufficient real-time information to locate and identify the enemy via a PC or ruggedized laptop computer, mini directional antenna, and TP CDL.

The system can operate with Tactical Common Data Link (TCDL)-based platforms, including ships, unmanned aerial vehicles (UAVs), manned fixed-wing combat aircraft, and helicopters. The Team-Portable CDL also provides UAV level 3 command and control. The system: provides a tactical common data link that complies with the Joint Interoperability Test Command (JITC) specification; offers full-duplex communications; complies with the TCDL interoperability profile; enables reception of ISR data

to include streaming video; boasts modular ruggedized packaging; performs AV command and control targeting and text messaging; acquires and tracks ISR aircraft automatically; is battery operated with minimal power requirements; and is available as a receive-only remote viewing terminal.

The contract has an 18-month base period for buying the PCDL systems and four one-year options for production and engineering services. Cubic will do the work in San Diego, and should be finished in September 2018. If SPAWAR exercises all options the job will continue through September 2022.

**FOR MORE INFORMATION** visit **Cubic Corp.** online at *www.cubic.com*.

# new PRODUCTS

*To submit new products for consideration, contact John Keller at jkeller@pennwell.com.*

BOARD PRODUCTS

## 3U OpenVPX Intel Xeon single-board computer introduced by Abaco

Abaco Systems in Huntsville, Ala., is introducing the rugged SBC367D 3U OpenVPX single-board computer for demanding military and aerospace embedded computing applications, such as electronic

warfare (EW) and intelligence, surveillance, and reconnaissance (ISR). The board uses the Intel Xeon D-1500 processor family with as many as 16 cores, as much as 32 gigabytes of DDR4 SDRAM memory, and support for 10/40 Gigabyte Ethernet across the backplane. The SBC367D provides a 40 Gigabit Ethernet alternative to the PCI Express-based SBC347D, and includes a range of security for support user-defined anti-tamper, information assurance, and other cybersecurity strategies. The board includes the secure Microsemi SmartFusion2 FPGA, and support for Intel Trusted Execution Technology. The SBC367D also includes Abaco's advanced thermal technologies to operate at the maximum rated speed of its components, and is available in air- and conduction-cooled versions with extended temperature capability.

**FOR MORE INFORMATION** visit **Abaco Systems** online at *www.abaco.com.*

CHASSIS AND ENCLOSURES

## Rugged chassis for data recording in space introduced by Curtiss-Wright

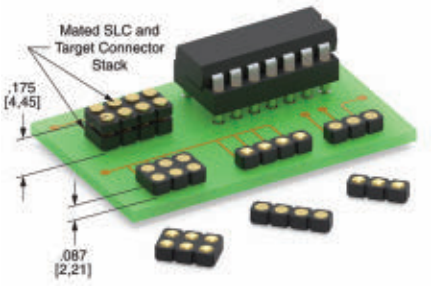
The Curtiss-Wright Corp. Defense Solutions Division in Ashburn, Va., is introducing a rugged multi-slot embedded computing chassis called the KAM/CSB/12U Smart Backplane subsystem for data acquisition, data processing, and recording in radiation-intensive space environments. The rugged Smart Backplane is designed for use in demanding space-based, mission-critical data handling applications on launch vehicles, re-entry vehicles, and low Earth orbit (LEO) satellites. Curtiss-Wright's Smart Backplane technology provides system designers with an intelligent multi-slot backplane that protects critical data acquisition electronics with a radiation-tolerant architecture. A fundamental threat for electronics systems deployed in radiation-intensive environments is the destructive power of single event latch-ups (SEL). Until now, this threat has required radiation-hardened electronics hardware.

**FOR MORE INFORMATION** visit **Curtiss-Wright Defense Solutions** *online at www.curtisswrightds.com/products/space.*

INTERCONNECT PRODUCTS

## Target connectors for circuit boards introduced by Mill-Max

Mill-Max Manufacturing Co. in Oyster Bay, N.Y., is introducing four target connectors with above-board heights of .087 inches for low-profile circuit board applications that require several connections. Target




connectors are for use in place of SMT pads on a printed circuit board as the mating surface for spring-loaded pins. They provide increased durability and are useful in achieving specific distances between boards. These connectors are all surface-mount, available in single- or double-row packages, and come with flat or concave target faces. Concave face targets provide additional surface area for mating and can aid in centering/alignment of components and boards fitted with spring-loaded connectors. Precision-machined pins with an overall length tolerance of plus-or-minus 0.0015 inches help to achieve a co-planarity of 0.005 inches or better for connectors as long as 1 inch. Advanced machining techniques ensure no burr protrusion on either the target face or the surface-mount termination end.

**FOR MORE INFORMATION** visit **Mill-Max** online at *www.mill-max.com.*

SECURE MEMORY

## Secure high-density digital DDR4 SDRAM memory introduced by Mercury

Mercury Systems Inc. in Andover, Mass, is introducing a high-density secure memory product line that integrates double-data-rate fourth-generation synchronous dynamic random-access memory (DDR4 SDRAM) with -SWaP-efficient packaging technology. Replacing as many as 18 industrial or commercial DDR4 devices with one military-hardened component, Mercury delivers 75 percent space savings in a ball grid array (BGA) package with data transfer speeds as high as 3200 megabits per second. Mercury's Advanced Microelectronics Center (AMC) in Phoenix will produce 8-gigabyte DDR4 devices later this year, 2- and 16-gigabyte devices after that. Mercury's 3-D packaging technology transforms a two-dimensional array of discrete memory devices into one vertically stacked dense BGA package without sacrificing the benefits of DDR4 adoption, company officials say.


**FOR MORE INFORMATION** contact **Mercury Systems** online at *www.mrcy.com/DDR4*.

EMBEDDED I/O

## Half-size PCI Express I/O for positioning and communications introduced by NAI

North Atlantic Industries Inc. (NAI) in Bohemia, N.Y., is introducing the 79G5 single-slot, half-size PCI Express multifunction embedded computing I/O board for digital and analog I/O; position control, measurement, and simulation; and communication interface applications. The off-the-shelf solution is built on NAI's Custom-On-Standard-Architecture (COSA), which supports more than 40 different intelligent I/O, communication, measurement and simulation functions. These preexisting tested functions can be combined quickly. Each I/O function has dedicated processing, unburdening the system processor from unnecessary data management overhead. "The 79G5 PCI Express multifunction I/O and communication board meets the needs of commercial, military and aerospace applications that require measurements, simulation and communications," says Lino Massafra, vice president of sales and marketing at NAI.

**FOR MORE INFORMATION** contact **North Atlantic Industries** online at *www.naii.com*.

RF AND MICROWAVE

## RF amplifiers for radar, test, and communications introduced by Pasternack

Pasternack Enterprises Inc. in Irvine, Calif., is introducing five low phase noise RF and microwave amplifiers for sensitive test and measurement, radar, and communications receiver systems. The RF amplifiers incorporate gallium arsenide (GaAs) heterojunction bipolar transistor (HBT) monolithic microwave integrated circuit (MMIC) technology to deliver phase noise performance over a wide dynamic range. These amplifiers can help optimize the sensitivity and dynamic range of high-performance test, radar and communication receiver designs where performance depends on how effectively the smallest and largest signal levels can be processed. For systems that must be able to amplify weak signals close to the noise floor, the low phase noise performance of these amplifiers can help reduce unwanted noise and distortion that can inhibit the quality of the transmitted signal.


**FOR MORE INFORMATION** contact **Pasternack** online at *www.pasternack.com*.

FPGAS

## Secure FPGA with cryptographic microprocessor introduced by Microsemi

Microsemi Corp. in Aliso Viejo, Calif., is introducing TeraFire cryptographic microprocessor capability for the Microsemi PolarFire field programmable gate array

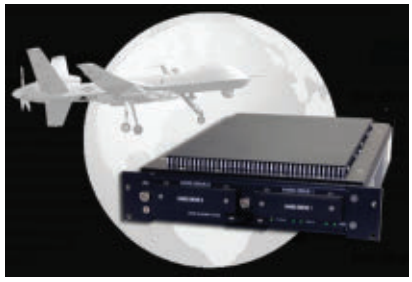

(FPGA) for embedded computing applications that require cybersecurity. The TeraFire hard core provides Microsemi customers access to advanced security capabilities with high performance and low power consumption. Athena's secure TeraFire cryptographic microprocessor technology offers some of the most commonly used cryptographic algorithms. Among the algorithms available are those allowed for military and government use by the U.S. National Institute of Standards and Technology's (NIST's) Suite B, up to the top-secret level, as well as those recommended in the U.S. Commercial National Security Algorithm (CNSA) Suite. The TeraFire cryptographic microprocessor also supports algorithms commonly used in commercial Internet communications protocols such as TLS, IPSec, Makes, and Keyset.

**FOR MORE INFORMATION** visit **Microsemi** online at *www.microsemi.com*.

EMBEDDED COMPUTING

## Computer and data storage for encrypted data streaming introduced by LCR

LCR Embedded Systems Inc. in Norristown, Pa., is introducing the Featherweight COM Express embedded computing and data storage solution for demanding applications that require lightweight, rugged, compact compute and storage, such as harvesting and streaming sensor and video data in the field. Weighing in at 7.5 pounds and featuring COM Express technology, the convection-cooled, customizable, featherweight COM Express single-board computer system features a 6th generation Intel Xeon Core i7 (Skylake)



mobile server and embedded processor with as much as 32 gigabytes of DDR4 memory, and dual DisplayPort outputs. An optional graphics processing unit (GPU) provides additional DisplayPort and HDMI options and HD video processing support. The system also includes as much as 32 terabytes of removable and expandable data storage. The system offers a choice of operating systems such as Red Hat Linux, Ubuntu, and others depending on licensing. Wireless/Wi-Fi communications can be supported, as well as customizable I/O to support a variety of inputs, connections, or displays.

**FOR MORE INFORMATION** visit **LCR** at *www.lcrembeddedsystems.com*.

SAFETY-CRITICAL SOFTWARE

## Software tools for safety-critical applications introduced by LDRA

LDRA in Wirral, England, is integrating the company's LDRA software tools suite with the IBM Rational DOORS Next Generation requirements-management tool for security- and safety-critical aerospace and defense applications. DOORS Next Generation provides requirements definition and management capabilities, a work item system for task management and planning, and a reporting system.

The LDRA tool suite integration brings software analysis and verification into this open collaboration platform. The integrated LDRA tool suite and IBM Rational DOORS Next Generation can reduce the design time and development costs of safety- and security-critical systems for the Internet of Things (IoT), including aerospace and defense applications. This solution enables embedded software and Internet of Things systems developers to achieve life-cycle traceability in an open services for life-cycle collaboration (OSLC) environment. For those environments requiring software qualification or certification, this integration provides the transparency and audit trail required for quality and regulatory review.

**FOR MORE INFORMATION** visit **LDRA** online at *www.ldra.com*.

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