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COTS satellite design

DARPA Blackjack program to develop small, secure military satellites for low-Earth orbit. PAGE 4

Rad-hard space electronics

Electronics industry is developing high-reliability, radiation-hardened integrated circuits to suit a variety of space applications. PAGE 20

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Persistent surveillance

Electro-optical sensors and digital signal processing create persistent-surveillance capabilities. PAGE 10

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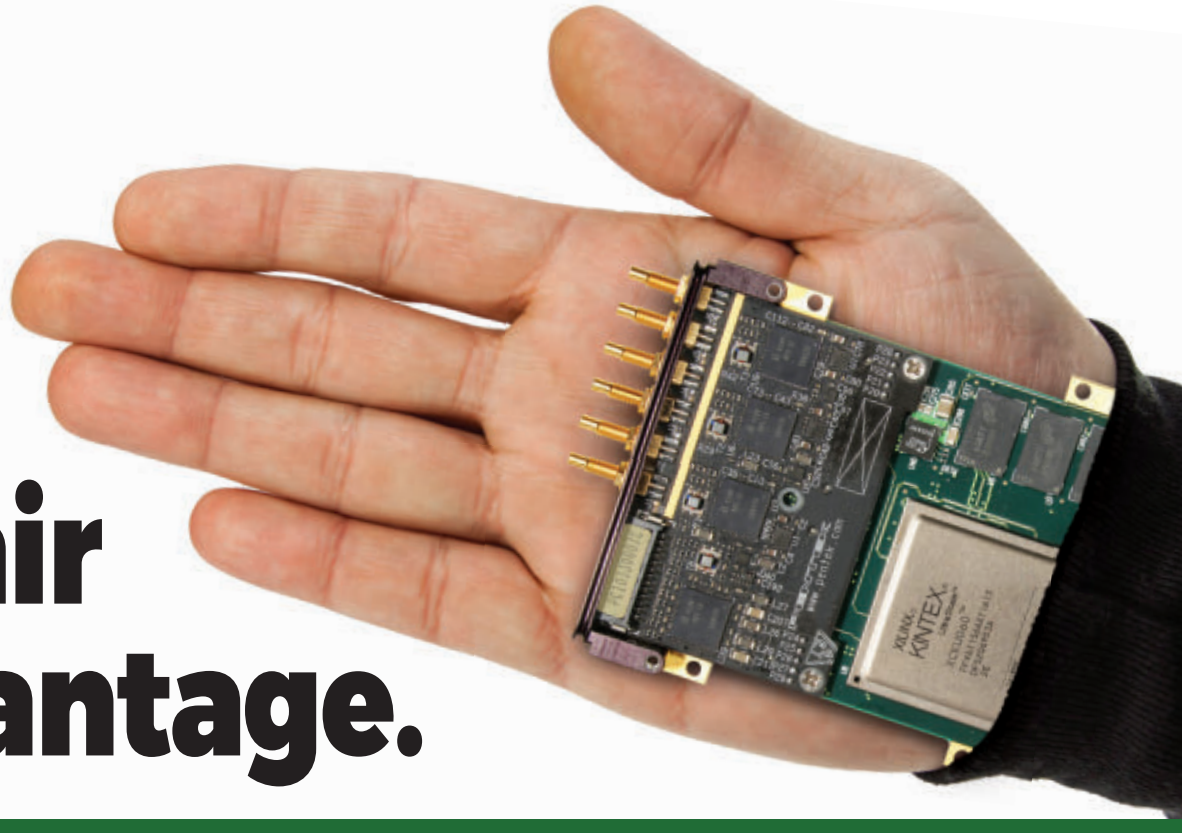

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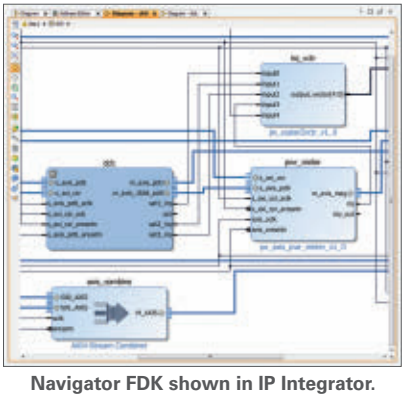

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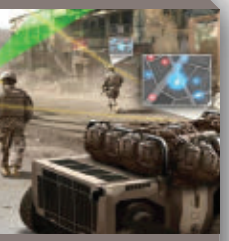
JUNE 2018
VOL. 29, NO. 6

Military & Aerospace Electronics



COVER STORY

Military & Aerospace Electronics® (ISSN 1046-9079), Volume 29, No. 6. Military & Aerospace Electronics is published 12 times a year, monthly by PennWell® Corporation, 1421 S. Sheridan, Tulsa, OK 74112. Periodicals postage paid at Tulsa, OK 74112 and at additional mailing offices. SUBSCRIPTION PRICES: USA $185 1yr., $327 2 yr., $466 3 yr.; Canada $280 1 yr., $479 2 yr., $618 3 yr.; International $335 1 yr., $638 2 yr., $834 3 yr. POSTMASTER: Send address corrections to Military & Aerospace Electronics, P.O. Box 47570, Plymouth, MN 55447. Military & Aerospace Electronics is a registered trademark.

BY **JOHN KELLER**, EDITOR IN CHIEF

The dark underside of defense industry prosperity

It's almost impossible to talk to people in the military and aerospace industry these days without side discussions about how great the defense business is today. We've seen record defense budgets during the Trump Administration, the market uncertainty of sequestration is but a distant memory, and defense electronic suppliers can't seem to fill orders fast enough.

I haven't seen the defense industry this giddy in a long time. People are ready, once again, to spend company money on internal research and development in realistic hopes of landing some lucrative defense contracts. Some are kicking themselves for not anticipating the magnitude and pace of the defense industry turnaround. The biggest challenge these days seems to be simply keeping up, after having spent so long in recent years sweating over where the next contract is coming from.

Yet as with any industry in the throes of substantial growing pains, there's a downside to our industry's newfound prosperity: a steady stretching out of the supply chain as systems integrators scramble to fill orders, and suppliers try to deal with higher levels in demand than they've seen in years.

Today's there more demand for electronics parts than suppliers can fill — and the problem seems to be getting worse, as the defense industry continues to ramp-up.

Need to order electronics parts from suppliers you haven't done a lot of business with lately? Good luck. As demand changes, so do rules of the supply chain. When supplies get tight, electronics parts distributors will take care of their best customers first. What, you're not one of your distributor's best customers? Then get in line. Your order will be filled... when and if they can get to it. And don't hold your breath, either. The wait probably won't be just days; it'll most likely be weeks or even months.

While you're waiting for parts, moreover, your customers will be less than patient. In the midst of plenty, you'll be worried about losing contracts because you can't get the parts fast enough to fill orders. The problem for your customers, however, is the parts squeeze hits across the industry; it's not likely that other systems designers can fill orders any faster than you.

There's a second problem in such a tight market: rising costs. Not only are parts suppliers serving their best customers first, but they also are serving their highest bidders. If you're willing to pay more, then it's more likely you'll have your parts orders filled more quickly than those who aren't.

How are electronics companies supposed to plan for this kind of thing? Growing demand, tight parts inventories, and rising costs can put a crimp in the best-laid plans. It's a mess brought on by good times that we've just got to deal with as best we can.

The good news is this won't go on forever. The market will sort itself out... eventually. It just has to take its toll in headaches and sleepless nights first.

Here's another nagging thought: today's good times in the defense business won't last forever, either. The big question is how long will the wave last before it crashes ashore. I've seen some estimates that U.S. defense budgets will peak sometime between 2020 and 2022. After that it's expected to taper off as an overheated market cools off.

I worry that the defense economy will start to slow just as the parts supply chain catches up with peak demand. Then we'll have a surplus parts market and the problems that will bring. And so it goes.

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news

Army wants wearable electronics sensors to detect medical ailments

U.S. Army medical researchers are ready to approach industry for high-reliability wearable electronics sensors able to quantify thermal work strain, changes in electromyography that indicate muscular injury, neurocognitive changes that suggest compromised brain function, and early signs of illness. Officials of the U.S. Army Medical Research Acquisition Activity in Frederick, Md., issued a presolicitation (MTEC-18-07-HRAPS) for the Health Readiness and Performance System (HRAPS) Wearable Physiological Sensor Development (HRAPS) project. The upcoming request for project proposals (RPP) seeks to modify a pre-existing wearable sensor into a prototype device in the lab and in the field to help determine design for manufacturing, manufacturing setup costs, and a first-article manufacturing run. E-mail technical questions to Dr. Lauren Palestrini, MTEC director of research, at lauren.palestrini@officer.mtec-sc.org.

Raytheon to produce Rolling Airframe Missiles for shipboard defense

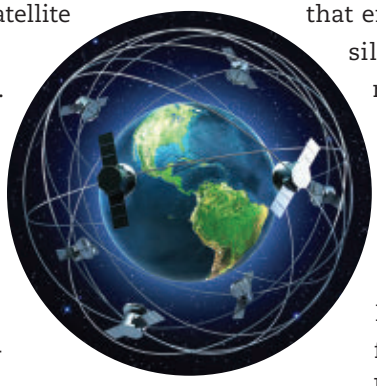
Shipboard missile-defense experts at the Raytheon Co. will provide the U.S. Navy and U.S. allies with the Rolling Airframe Missile (RAM) Block 2 to protect ships from incoming missiles under terms of a $242.1 million contract. RAM is a ship self-defense weapon designed to provide protection for ships of all sizes, ranging from 500-ton fast attack craft to 95,000-ton aircraft carriers. The contract is for the RAM Block 2 guided missile round pack, missile ordnance alterations, and spare parts. A supersonic, lightweight, quick-reaction, fire-and-forget weapon, the RAM

DARPA Blackjack to develop small, secure military satellites for low-Earth orbit

BY **John Keller**

ARLINGTON, Va. — U.S. military researchers are asking for industry's help in developing a constellation of small, secure, and affordable military satellites that are able not only to operate in low-Earth orbit (LEO), but also that capitalize on modern commercial satellite technologies.

Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., issued a broad agency announcement (HR001118S0032) in April for the Blackjack program to develop SWaP-optimized military communications and surveillance satellites designed to operate in LEO.



The DARPA Blackjack program seeks to orbit a constellation of small, secure, and affordable military satellites that capitalize on modern commercial satellite technologies.

Blackjack seeks to develop low-cost space payloads and commoditized satellite buses with low size, weight, power, and cost (SWaP-C) with similar capabilities to today's military communications that operate at geosynchronous orbit (GEO), but at a fraction of the cost.

Military satellites are critical to U.S. warfighting capabilities. Traditionally they are placed in GEO to deliver persistent overhead access to any point on the globe.

Yet in the increasingly contested space environment, these costly and monolithic systems are vulnerable targets that would take years to replace if degraded or destroyed. Moreover, their long development schedules make it difficult or impossible to respond quickly to new threats.

The Blackjack program seeks to develop enabling technologies for a global high-speed network backbone in LEO that enables networked, resilient, and persistent military payloads that provide infinite over-the-horizon sensing, signals, and communications capabilities.

Historically, U.S. Department of Defense (DOD) satellites have been custom-designed, with lengthy and expensive design and upgrade cycles. The evolution of commercial space, however, has led to LEO broadband Internet communications satellites that could offer attractive economies of scale.

The Blackjack program will emphasize a commoditized bus and low-cost interchangeable payloads with short design cycles and frequent technology upgrades, based on a 'good enough' payloads optimized for more than one type of bus.

For more on commercially developed space electronics technologies see The evolving world of radiation-hardened electronics on page 20.

Commoditized satellite buses based on open-architecture electrical, software, and mesh network interface control could provide a way for dozens or hundreds of different types of military satellite payloads to operate in low-Earth orbit, DARPA officials say.

The Blackjack program has three primary objectives:

- develop payload and mission-level autonomy software with on-orbit distributed decision processors that can operate autonomously with on-orbit data processing, and perform shared tasks on-orbit;
- use advanced commercial manufacturing for military payloads and the spacecraft bus, including high-rate manufacturing using commercial off-the-shelf (COTS)-like parts, reduced screening and acceptance testing for individual spacecraft, and reduced expectations for spacecraft life; and
- demonstrating satellite payloads in LEO that operate on par with current GEO systems with the spacecraft at costs of less than $6 million per satellite.

To reduce integration risk, Blackjack will develop an avionics unit called Pit Boss for each spacecraft with high-speed processor and encryption devices that will function as a common network and electrical interface.

Not only will Pit Boss provide a common electrical interface to each payload, but it also will provide mission level autonomy functions, enable on-orbit edge computing, manage communication between Blackjack satellites and ground users, provide a command and telemetry link to the bus, and encrypt payload data.

Every Blackjack satellite will consist of one commoditized bus capable of broadband rate global communications to other nodes, one Pit Boss control unit, and one or more military payloads that can operate autonomously for more than 24 hours.

The goal is to develop a 60-to-200-satellite constellation operating at altitudes of between 310.7 miles and 807.8

system is designed to attack enemy helicopters, aircraft, and surface craft. It uses passive RF and infrared guidance for engaging several threats simultaneously. RAM Block 2 has a large rocket motor, advanced control section, and an enhanced RF receiver able to detect quiet threat emitters. It is more maneuverable and longer range than its predecessors. The MK 44 guided missile round pack and the MK 49 guided missile launching system together hold 21 missiles. Existing shipboard sensors can provide the system with target and pointing information. The MK 44 missile also part of the SeaRAM anti-ship missile defense system, replacing the M601A1 Gatling gun in the Phalanx close-in weapon system with an 11-round launcher.

Three decisions Cyber Command's new leader will have to make

Army Lt. Gen. Paul Nakasone is taking the reins at the National Security Agency and Cyber Command, where he will head the 10th, and newest, combatant command. As the organization takes on greater responsibilities, Nakasone will receive broad authorities as the global coordinator for cyber and trusted computing operations in the Department of Defense and as the joint force trainer for cyber. Here are three key decisions Nakasone will face and that will shape Cyber Command in the long term: does he need to change the cyber warrior force; what new tools does Cyber Command need; and how does he evolve cyber operations? Currently cyber capabilities – namely strategic level effects that require work over fiber across the globe – are supervised at the highest level of government. Nakasone, as head of Army Cyber Command, has overseen several rotations of a pilot program to game how tactical cyber and electronic warfare effects can be integrated into local brigade combat teams. ←

miles above the Earth's surface. One operations center will cover all government satellites and payloads, and the constellation will be able to operate without the operations center for 30 days. Blackjack payload data processing will be performed on-orbit without the assistance of ground data processing.

The program has three phases: defining bus and payload requirements; developing bus and payloads for a two satellite on-orbit demonstration; and demonstrating a two-plane system in low-Earth orbit for six months. A future Blackjack demonstration constellation will involve 20 spacecraft in two planes with one or more payloads on each satellite. Companies interested were to submit full proposals by early this month. ←

More information is online at https://www.fbo.gov/spg/ODA/DARPA/CMO/HR001118S0032/listing.html.

Army wants artificial intelligence technology for cyber and electronic warfare

BY **John Keller**

ABERDEEN PROVING GROUND, Md. — U.S. Army researchers are surveying industry to determine the state of the art in artificial intelligence technologies for electronic warfare, cyber warfare, signals intelligence, and big-data analytics.

The Army is looking for artificial intelligence in electronic warfare, cyber warfare, signals intelligence, and big-data analytics.

Officials of the Army Contracting Command at Aberdeen Proving Ground, Md., issued a request for information (W56KGU-18-X-A515) for the Artificial Intelligence and Machine Learning Techniques, Algorithms, and Capabilities project.

The RFI is to obtain market research from academia, industry, and government agencies on internally- and externally funded independent research in artificial intelligence (AI), machine learning (ML), cognitive computing (CC) and data analytics (DA) techniques, algorithms, and capabilities that have application to Army research. The Army contracting command issued this notice on behalf of the Intelligence and Information Warfare Directorate of the Army Communications-Electronics Research, Development and Engineering Center at Aberdeen Proving Ground, Md.

The Army wants to know how these enabling technologies could improve military applications in electronic warfare (EW); intelligence, surveillance, and reconnaissance (ISR); reconnaissance, surveillance, and target acquisition (RSTA); offensive cyber operations (OCO); signals intelligence (SIGINT); processing, exploitation and dissemination (PED); and big data analytics.

Army researchers established a cognitive-computing and machine-learning team in March 2017 to help identify artificial intelligence technologies that could enhance Army operations, in EW, ISR, RSTA, OCO, SIGINT, PED, and data analytics. Army researchers seek greater insight into artificial intelligence techniques, algorithms and capabilities to determine areas of AI research suitable for investment and eventual integration into next-generation Army SIGINT/Cyber/EW/ISR systems.

For these purposes, electronic warfare includes survivability EW, offensive EW, electronic support, reconnaissance and surveillance, electronic attack, and battle damage assessment. Offensive cyber operations include cyber electromagnetic activities, ISR, situational understanding, operational preparation of the environment, and battle damage assessment.

Army researchers also are interested in industry research into big-data artificial intelligence frameworks; autonomous decision making for manned and unmanned operations; and foundational tools, techniques, algorithms and capabilities. Experts want to identify accessible data sources and repositories, and whether these data sources contain labeled or unlabeled data or both.

Researchers also want information on how artificial intelligence could benefit big data volume, velocity, variety and veracity, as well as multi-spectral processing. In addition, researchers want to speed the ability to convert data information understanding to decision action in multi-domain battle and joint, multi-national, and multi-echelon operations. This includes the ability to understand and operate in contested and congested imperfect information environments; automated decision making and autonomous processes; cognitive modeling of the opposing force to determine adversary intent; and synchronous distributed systems operating together for precision EW, cyber operations, SIGINT, or ISR/RSTA.

Companies interested should respond by post, UPS, or FedEx to 6565 Surveillance Loop, Building 6001, Aberdeen Proving Ground, MD 21005-1846.

More information is online at https://www.fbo.gov/notices/3d789a5bc86b9657d683cec6119d28e2.

Navy wants shipboard electronics repair of CSGA cabling and connectors

BY **John Keller**

DAHLGREN, Va. — U.S. Navy shipboard electronics experts are reaching out to industry for new repair concepts for cable shield ground adapter (CSGA) cabling and connector technology for use aboard surface warships. Officials of the Naval Surface Warfare Center Dahlgren Division (NSWCDD) in Dahlgren, Va., issued a source-sought notice (N0017818Q9000) seeking cooperative research and development agreement partners with expertise in CSGA repair aboard Navy ships. Navy experts are looking for companies to provide a CSGA for cable and connector repair that meets military standards and guidelines.

Navy experts are looking for new repair concepts for cable shield ground adapter (CSGA) cabling and connector technology for use aboard surface warships.

The Navy has developed and patented a CSGA that is easy to use, robust, and inexpensive to accommodate a broad range of cable and conduit sizes with a minimal number of adapters. Any size cable from 1/8- to 1-inch can be grounded and secured in a K-sized tube using the Navy's device.The Navy CSGA uses an internal seal as its primary protection against environmental conditions, and can seal questionably reliable heat shrink boots as secondary protection. These connectors protect shipboard equipment from electromagnetic interference (EMI) and electromagnetic pulse (EMP).

The Navy's CSGA meets MIL-STD-1310H, yet still is expected to cost about one-tenth that of current products. The design also can enable repair and retrofitting of previous installations without expensive repair kits and the time-consuming process of pulling cables. The Navy's solution weighs about 50 percent less than other products and offers solid pull-out resistance.

Companies with a CSGA that can meet MIL-STD-2105, MIL-STD-1310, MIL-PRF-24758 and MIL-Spec MIL-DTL-38999L may submit the information to NSWCDD. Include a capabilities statement, management chart, breakdown of personnel, and relevant past work in similar areas. Companies interested should submit CSGA information to the NSWCDD, Topside Engineering Branch, Code B53, 5493 Marple Road, Building 185, Dahlgren, VA 22448-5153. ←

More information is online at https://bit.ly/2LLDVCo.

Army seeks ability to detect explosive chemicals at standoff ranges

BY **John Keller**

FORT BELVOIR, Va. — U.S. Army force-protection experts are reaching out to industry for quick-turnaround technologies to detect abnormal behaviors, chemicals, and vapors that could indicate the presence of vehicle-borne improvised explosive devices (VBIEDs) at standoff distances.

Army Contracting Command officials, on behalf of the Army product manager for force protection systems (PdM-FPS) at Fort Belvoir, Va., issued a sources-sought notice (W909MY-18-R-C009) for the Countering Vehicle Borne Improvised Explosive Devices (CVIED) project.

Army experts are looking for mature non-developmental capabilities that could be delivered within one year to detect abnormal or suspicious vehicle and personnel characteristics, as well as chemicals and vapors from standoff distances. Suspicious characteristics include excessive weight; off-centered loading; erratic maneuvering; uncharacteristic electronic devices; electronic emissions; uncharacteristic heat, density, or other unlisted signatures; and modifications from original equipment design. Officials want non-proprietary interoperability with currently fielded force protection systems that could be used as mobile fixed-site solutions for standoff detection and relaying detection data to operations centers or entry-control points.

Army leaders want to identify suspicious vehicles and personnel characteristics automatically from safe distances.

Companies interested should e-mail sabin.a.joseph.civ@mail.mil and christian.y.digbeu.civ@mail.mil.

More information is online at https://bit.ly/2snpzQz.

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MAINTAINING A CONSTANT RECONNAISSANCE EYE

Electro-optical sensor payloads combine with sophisticated digital signal processing to create persistent-surveillance capabilities able to look backwards and forwards through time.

BY **J.R. Wilson**

Maintaining constant surveillance of the airspace around important military and intelligence sites has been a priority for since World War II, when the only persistent capability was radar, still in its infancy.

Radar, significantly improved in range and detection capability since then, remains a mainstay of persistent surveillance, but in the 21st Century is only one part of a growing number of technologies covering not only airspace but providing surveillance of surrounding land and seascapes, as well.

"The key element for [airborne] persistent surveillance is there are different sizes of UAVs [unmanned aerial vehicles] with different payloads and CONOPs, the data they collect, analyzing real-time, storing, and available cooling," says Marc Couture, director of engineering for intelligence, surveillance, and reconnaissance (ISR) at Curtiss-Wright Defense Solutions Division in Ashburn, Va.

High-performance embedded computing (HPEC) aspects of today's persistent-surveillance and electronic warfare (EW) systems are taking over several jobs from human intelligence analysts, Couture points out.

"With cognitive EW, you are replacing some of the things once performed by an analyst who would pick out targets, but now these cognitive systems are getting better at identifying items of interest — tanks under trees, and civilian vs. mil convoys," he says. "It not only aids faster detection, it can identify and assess different targets, provide certain parameters and help guide decisions much,

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much faster as actual encounters occur. It puts a tighter loop on the kill chain, better solutions and fewer mistakes."

Of growing importance — especially given the volume of data from multiple sensors involved in persistent surveillance — are the quality, capabilities, and in-field upgradeability of the system's onboard software.

Sensor operators for persistent-surveillance systems use multi-window graphics systems to keep a close eye on broad areas for suspicious activity or other movements of interest.

"Depending on how you pass around data, you may have tens of thousands of lines of pre-written code by the primes, so our job is to provide deployable field replaceable units that provide choices," Couture says. "The networking and fabricing are absolutely critical, in terms of speed, but also software reliability; there are a lot of correlated data in time and space that have to be accounted for so you don't want to miss the right thing."

High-performance embedded computing

Curtiss-Wright is pursuing Open HPEC, which combines multi-core Xeon general-purpose processors, general-purpose graphics processing units (GPGPUs), and in the future will tie in field-programmable gate arrays," Couture explains. "The days of some programmer being able to optimize all this data traffic are over, so the software has to be just as good as the hardware."

Multi-core Intel Xeons and GPGPUs are tightly associated with deep and machine learning, which are necessary for demanding applications like cognitive EW, Couture says. "You need different elements for different functions. And you have SWaP [size, weight and power] considerations, as well."

One expert has discussed the technologies and sensors required by UAVs, manned aircraft, and spacecraft essential to activity-based persistent surveillance of tactical targets.

Those include passive detection, radar detection, antenna monopulse, active electronic scanned antennas (AESA), moving target detection (MTD) and moving target tracking (MTT), motion compensation, tactical target spectral characteristics, space/time adaptive processing (STAP), synthetic aperture radar (SAR) imaging, change detection (CCD) and synthetic monopulse, veteran design engineer and consultant David Lynch Jr., president of DL Sciences Inc. in El Segundo, Calif., wrote in his 2018 book, *Tactical Persistent Surveillance Radar with Applications*.

As technological evolution continues to shrink those components in size and power, while increasing range, capability, and interoperability, more elements can be packed into the tight confines of UAVs, helicopters, satellites, and other platforms — or enable relatively small aircraft to carry systems that traditionally have been outside their capabilities. That is expected to be a major asset to developing swarm procedures for tactical, operational, and strategic ISR.

The BAE Systems 2-Color Advanced Warning System (2C-AWS) will provide aircraft with missile warning and hostile-fire protection to improve survivability and mission effectiveness in contested environments.

Aerostats a preferred platform

While persistent surveillance is still seen largely as the province of UAVs, ground-based radars, and other sensors, an increasingly common solution involves aerostats — lighter-than-air, typically tethered unmanned platforms, often resembling blimps, of various sizes, payload capacities, and altitude limits.

Markets & Markets, a global research and analysis firm, projects the worldwide aerostat market will reach nearly $11 billion by 2021, up from about $6 billion today. Another market research firm — Inkwood Research — projects the U.S. and Canadian aerostat market alone will reach nearly $8.7 billion by 2026, China and India nearly $6.5 billion, and Europe $4.4 billion. The majority of new aerostats will be for military and homeland security applications, as is the case today.

Mixing cutting-edge technologies with more than 165 years of design evolution, aerostats are produced for military and homeland security persistent surveillance applications by a wide range of contractors worldwide, including potential adversaries:

- Aero Surveillance in Avignon, France;
- Aeros in Montebello, Calif.;
- Airborne Industries in Southend-On-Sea, England;
- Allsopp Helikites Ltd. in Fordingbridge, England;
- Auger RosAeroSystems in Moscow;
- Drone Aviation Corp. in Jacksonville, Fla.;
- Elbit Systems in Haifa, Israel;
- ILC Dover LP in Frederica, Del.;
- Israel Aerospace Industries (IAI) in Tel Aviv;
- Lockheed Martin Aeronautics in Fort Worth, Texas;
- Raven Aerostar in Sioux Falls, S.D.;
- Raytheon Co. in Waltham, Mass.;
- Rheinmetall Canada in Quebec City;
- RT LTA Systems Ltd. in Yavne, Israel;
- SES in Betzdorf, Luxembourg; and
- TCOM in Columbia, Md.

A variation on the theme is Aero Surveillance's new Tethered Quad and Octocopter ASV 30 400 and 800 series, some of which can be used in tethered and free-flying modes, controlled by the same ground station. Offered in four- and eight-rotor configurations, the company says it can remain aloft for as long as 12 hours at 328 feet in tethered mode or one hour with a range of six miles in free flight. With a payload capacity to 13.23 pounds, it can carry a high-performance electro-optical sensor able to detect mobile objects from as far away as six miles.

Operations planning

All approaches to persistent surveillance — especially of a non-domestic or foreign locale or asset — are subject to unexpected or largely unavoidable problems, from man-made countermeasures to natural events like earthquakes, volcanic eruptions, floods, and storms. One goal of persistent surveillance providers is a quick-response capability to reduce or even counter the impact of such events.

Experts proposed a strategy to simplify updates and reduce surveillance gaps in multi-agent, persistent surveillance missions in a January 2017 paper on "Cloud-Supported Coverage Control for Persistent Surveillance Missions." Authors were from the University of California-Santa Barbara and one from the United Technologies Research Center in East Hartford, Conn.

The SkEye WAPS from Elbit Systems in Haifa, Israel, provides situational awareness of on-the- ground intelligence data, and enables a large number of users to receive real-time, high-resolution imagery and even go back in time.

"This approach decouples assignment from motion planning operations in a modular framework," the paper's abstract says. "Coverage assignments and surveillance parameters are managed on the cloud and transmitted to mobile agents via unplanned and asynchronous exchanges. These updates promote load-balancing, while also allowing effective pairing with typical path planners.

"Namely, when paired with a planner satisfying mild assumptions, the scheme ensures that (1) coverage regions remain connected and collectively cover the environment, (2) regions may go uncovered only over bounded intervals, (3) collisions (sensing overlaps) are avoided and (4) for time-invariant event likelihoods, a Pareto optimal configuration is produced in finite time."

Pareto optimality is a state in which it is impossible to reallocate resources to make any one individual or preference criterion better off without making at least one other individual or preference criterion worse off.

Using several different sensor platforms, such as unmanned aircraft swarms or combined air-, ground-, sea-, and even space-based systems, also can improve surveillance continuity and effectiveness, although both are significantly more difficult if the surveillance target is in unfriendly territory.

The Kestrel wide-area electro-optical surveillance system from Logos Technologies is for deployment on aerostats and airships operating in Afghanistan at altitudes between 1,000 and 5,000 feet off the ground.

That is a major consideration pushing the development of new sensor and platform technologies with greater range and system defenses (passive in the short-term) with higher SWaP characteristics.

These issues are prominent in persistent surveillance schemes of the U.S. and its allies, but also those of potential adversaries or nations that may market such systems to unfriendly actors, including non-state, terrorist and even criminal enterprises.

State of the art

While much of the research and current state of the art of various surveillance systems and technologies are classified, even the Chinese have published papers investigating the problem and potential solutions. One such, published in January 2018 in the *International Journal of Distributed Sensor Networks* by scientists primarily from the School of Aeronautics & Astronautics at Sichuan University in Chengdu, China, looked at ways to control several UAVs over a region of interest (ROI}, obstacle and collision avoidance and group coordination on-station to reduce unobserved areas as much as possible.

"Due to the fact that the loss or damage of individual UAV does not affect the performance of the system, multiple UAVs are highly reliable and more scalable than single complicated UAV. Moreover, multiple UAVs can provide multi-angle observations, which is very important in the surveillance task. Consequently, multiple UAVs are advantageous over single UAV for executing persistent surveillance task," they wrote in "Potential Field Method for Persistent Surveillance of Multiple UAV Sensors."

Addressing swarms of small UAVs and "flocking" micro-UAVs, the paper concludes with a call for future studies to determine the optimal number of platforms to provide uninterrupted persistent surveillance of various types and sizes of targets and returns on investment. Such efforts already are underway at U.S. military facilities, looking into future sensor and platform development; remote control versus increased autonomy; networking multiple sensors on multiple platforms; fusing data for transmission back to surveillance command and control centers.

That is not limited to small or micro-UAVs, however. Curtiss-Wright, for example, is working many of those same issues on large high altitude/long endurance (HALE) and medium altitude/long endurance (MALE) platforms, such as the RQ-4 Global Hawk, MQ-4C Triton, and MQ-9 Reaper. That includes sensor processing – SAR, fire control, E/O-IR focal plane arrays, searching for RF emitters associated with SIGINT, and EW.

The role of SWaP-C

"We are always asked to do a lot of processing in a small, constrained SWaP-C envelope, which usually means having a tightly coupled, high-speed interface to the sensor

Wide-area motion imagery (WAMI) can monitor an area of many square miles in great detail, and uses smart algorithms to extract relevant information automatically.

processor so the data being collected in real-time can be processed as quickly as possible — not just one type or processor but several," Curtiss-Wright's Couture explains.

"The most common is two or three FPGAs [field-programmable gate arrays], using processing technology that is right behind some form of Ethernet from the radar phased array; then behind that Xeon-D processor, which is very popular in defense, because they give a lot of processing power but don't require a lot of power, so you can embed them."

That leads to what Couture calls the heterogeneous processing technology triple play — FPGAs, Xeon-D, and GPGPUs — which he describes as a massive math accelerator, with terafloating point operations per second. As such technologies continue to grow in power and capability, so will the need for greater autonomy to produce real-time information for decision-makers.

"Deep learning and machine learning, often used synonymously, get into concepts that stem from AI theory," Couture says. "GPGPUs have hundreds or thousands of cores and can do a lot of what a human analyst did in the past. In persistent surveillance, you have multiple waterfalls of data — SAR imaging of ground topology, emitter data, RF, microwave — you may be looking to process or even superimpose with other data and hyperspectral imaging.

Heterogeneous processing

"That takes a lot of horsepower, especially in real time, so a lot of what we build are geared toward ingesting massive amounts of data and being able to pass it between these processing elements. So it's not just about putting powerful processing technology on printed circuit boards, but all the plumbing and infrastructure, the physical hardware, along with the middleware and fabric software and all that being able to function properly in adverse environment."

Hyperspectral is a wider swath of the electromagnetic spectrum, while multispectral is different types of cameras, he explains.

"So you don't just have a set of eyes on a target, but different types of eyes. They can see through things at different wavelengths that other sensors can't. Being able to have that data plus SAR imagery and EO — the more information you can gather, the better decision you will make."

As the long wars in Iraq and Afghanistan demonstrated, U.S. military aircraft of all types — helicopters, fighters, bombers, cargo, and transport — are airborne around the clock and, in some cases, fly to theater from U.S. bases, returning once their mission is accomplished. For nearly four decades, the U.S. has had nearly unchallenged air superiority, with little danger to the higher-flying platforms and a record high mission success rate at all levels.

If any future conflict involves Russia, China, or one of their military clients, that will no longer be the case. And while persistent surveillance always has been associated with defending the air, ground, and sea spaces around U.S. and allied installations and formations or keeping a constant eye on unfriendly sites and military movements, future conflicts will require a higher level of persistence in a moving bubble around U.S. aircraft, as well.

General Atomics Aeronautical Systems MQ-9B SkyGuardian version of its Predator UAV can provide persistent surveillance by flying in excess of 35 hours with air speeds to 210 knots at altitudes of more than 40,000 feet.

Influential applications

In the early days of Operation Iraqi Freedom, the Army fielded the Common Missile Warning Solution to protect helicopters from shoulder-fired missiles. Developed by BAE Systems, it later was updated to provide hostile fire protection. In December 2017, BAE Systems Information and Electronic Systems in Nashua, N.H., won the contract for the Limited Interim Missile Warning System (LIMWS) Quick Reaction

Capability, designed to fill a gap between the current AN/AAR-57 common missile warning system (CMWS) and the Army's next threat warning system program of record, the Advanced Threat Detection System (ATDS).

Designed to detect and track man-portable air defense system threats for missile warning, as well as various forms of fire to provide hostile fire indication (HFI), the LIMWS is based on BAE's 2-Color Advanced Warning System (2C-AWS), developed in concert with Leonardo DRS (Dallas, TX), which is providing the 2-color infrared sensor — the eyes of the system.

"The CMWS was fielded across the Army fleet — more than 2000 aircraft — and saved hundreds of aircraft and lives. With the LIMWS, the Army wants to add an IR sensing capability,

Lighter-than-air aerostats are among the most promising and widely used air platforms for persistent surveillance sensor payloads.

which we looked at as an upgrade to our CMWS legacy, making what we had learned in fielding that program part of our 2C-AWS bid," says Chris Austin, director of advanced warning systems at BAE Systems.

"A combination of hardware and software improvements and advanced missile warning and hostile fire algorithms, it brings an enhanced threat protection capability to address new and emerging threats. Initially, it will be installed on the Army's UH-60M Black Hawk helicopters. It is limited to 360-degree protection of an individual aircraft. It does have a reactive capability, with the 2C-AWS coupled with flare and directable IR countermeasures."

The biggest difference between the CMWS and LIMWS, he added, is the new system incorporates E/O-IR sensors, where CMWS uses the ultraviolet spectrum. While the current design does not include multispectral or hyperspectral sensors, he says those are advanced capabilities being looked at for future upgrades.

The first units are scheduled for fielding in 2020. Competition for the ATDS is not expected to begin until later in the decade, giving the LIMWS about a decade to enhance persistent surveillance for Army — and possibly other military — rotorcraft.

The next generation

"We're looking at future capabilities, at the next generation leads for aircraft survivability. This pr ogram is for the Army, but we're looking at opportunities with the Navy and Air Force, as well, primarily rotorcraft," Austin adds. "We're always looking at where the Army may go, focused primarily on rotor wing aircraft and how the services plan to utilize those and making sure we stay up with their needs.

"On the Air Force side, CMWS was selected as the missile warning system for their new Combat Rescue Helicopter. There is no active solicitation for something like 2C-AWS, but the Army is fielding it on their Black Hawks and CRH is a Black Hawk variant, so it could be expanded to that platform. We have developed this system for future advanced capabilities the Army may require — future sensors and countermeasures, so it has the ability to grow and adapt to future new technologies."

BAE also provides a form of persistent surveillance for the Navy with its Lock-on Naval Electro-optic/infrared Sensor System (LockNESS), a fully automated shipboard defense system designed to protect carriers and other surface ships and crews against current and evolving surface threats.

Homeland and border security

Persistent surveillance also has expanded into homeland security border protection capabilities.

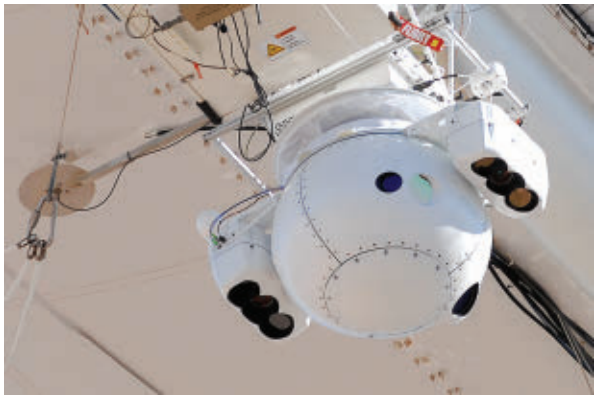
Elbit Systems in Haifa, Israel, has developed the Border Surveillance System (BSS) to provide real-time regional surveillance, early warning, targeting and border-patrol mission management and improve terrestrial and maritime security, regional control and border protection by enabling complete real-time connectivity across the entire border-security array. According to Elbit, "these solutions enable optimum coordination of ISR efforts throughout all operational zones and along the country's borders, supporting stationary control centers, deployed command posts and tactical patrol agents."

In the U.S. Navy's proposed 2019 budget, the Marine Corps is seeking to improve its ground-based persistent surveillance capabilities, citing the need to "facilitate strategic planning for resources and technology and enable the migration of discrete functional capabilities into integrated capabilities that are in alignment with the strategic vision for the Marine Corps Intelligence, Surveillance, and

The Harris Corp. CorvusEye intelligent wide-area motion imagery (WAMI) sensor system is a down-sized SWaP-compliant offshoot of the military Gorgon Stare program for use on small aircraft.

Reconnaissance Enterprise. Ground Based Operational Surveillance was absorbed into the new family of systems, Terrestrial Collection.

"[Requested budget increases for] Battlespace Awareness Information Technology Services supports non-labor information technology requirements reportable under the provisions of the Clinger Cohen Act of 1996. Increase comes from combining GBOSS, MAGTF Secondary Imagery Dissemination System and Tactical Remote Sensor system to become Terrestrial Collection, [along with increases for] Distributed Common Ground System (DCGS)–Marine Corps (DCGS-MC), Technical Control and Analysis (TCAC), Communications Emitter Sensing Attack System (CESAS), [and] Counter Intel Human Intel Equipment (CIHEP)."



Persistent-surveillance sensor payloads can blend a wide variety of electro-optical, radar, and even sound sensors to create a complex picture of activity down below.

Other systems being offered in this arena include: Airborne Industries' Persistent Ground Surveillance Systems (PGSS Aerostats) for wide area surveillance. According to the company, "Due to the increased security threat in many regions, persistent surveillance has become critical in most military operations. With a flight duration of 7 days, the Aerostat systems' ability to detect potential threats and provide intelligence to decision-makers over long periods of time are unrivaled."

The Harris Corp. CorvusEye intelligent wide-area motion imagery (WAMI) sensor system is a down-sized, SWaP-compliant offshoot of the Department of Defense's Gorgon Stare program for use on smaller aircraft. According to Harris, "CorvusEye provides an overview of and automatically detects movement within its coverage area. The dual-mode electro-optic/infrared sensor means surveillance operations can continue uninterrupted from day-to-night and night-to-day."

Logos Technologies maintains a major position in WAMI with the aerostat-mounted Kestrel, Kestrel Block II, Simera and Serenity; aircraft-mounted Redkite, Hermes and LEAPS, and maritime Skua systems. According to the company, "WAMI allows operators and analysts to detect and track multiple geographically dispersed targets of interest at once [and] uncover hidden relationships between locations and events within the sensor's vast field of view. The newest generation of WAMI sensors are miniaturized and more affordable and are available for a range of platforms, including various sized aerostats and multiple classes of unmanned aircraft."

Thus persistent surveillance, in one form or another, is growing as a key element for all four U.S. military services and the Department of Homeland Security in protecting critical infrastructure and assets and is likely to see increased technology advances and applications with each year going forward.

The evolving world of radiation-hardened electronics

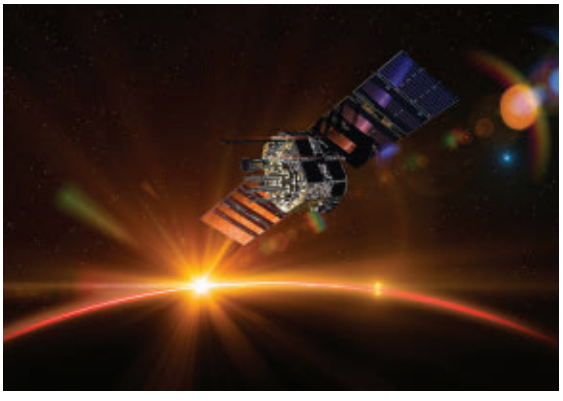
The electronics industry is developing high-reliability integrated circuits to suit a variety of space applications, and is tailoring different levels of reliability for specific missions where SWaP, cost, and performance are top considerations.

BY **John Keller**

Among the most destructive forces known for deployed aerospace and defense electronics systems is radiation. This force can occur naturally in space and at high altitudes on Earth, or can come in massive doses from the detonation of nuclear weapons. Either way, it's crucial for engineers designing for radiation environments to use radiation-hardened electronic components.

One of the biggest questions today, however, is how much radiation hardening is necessary? Money was no object decades ago when it was the norm for designers to harden military electronics to meet anticipated Cold War nuclear weapons threats. It's different now — particularly with the boom in commercial and government satellites, as well as traditional space applications the involve long-term satellite missions in high-Earth orbits.

To be sure, radiation threats to electronics from potential nuclear weapons detonations, on Earth and in space, still exist. In fact, industry experts say demand is increasing in a relatively small market niche for electronics and components able to withstand the effects of nuclear explosions.



New generations of high-performance communications and reconnaissance orbiting satellites are using some of the most advanced radiation-hardened and radiation-tolerant integrated circuits for mission reliability.

Still, today's biggest market driver for radiation-hardened electronics is low-Earth-orbit space applications in communications and Earth observation, where missions might last only for a few years — or even just months — and where threats from space radiation are relatively low.

Adding vastly to demand for electronics able to deal with radiation is an emerging market called "NewSpace," which consists of small short-duration spacecraft sometimes called cubesats, as well as massive future constellations of small communications satellites intended to blanket the Earth with Internet connectivity, which will use rapidly replaceable satellites, and networks with built-in redundancy to cope with occasional spacecraft failures.

NewSpace is driving technology innovation radiation hardened electronics that strives for the smallest, most capable, and most affordable radiation-hardened technology possible that adequate to meet the needs of relatively benign radiation and short mission durations.

NewSpace rad-hard

NewSpace describes a globally emerging private spaceflight industry seeking to develop quick and affordable access to space, driven primarily by commercial considerations. It involves commercial off-the-shelf (COTS) electronic technologies, open-systems architectures, standards-driven approaches, and design approaches that once would be considered unthinkable for space. In short, NewSpace is the domain of "good enough" for the target environment to make the most of performance, affordability, and size, weight, and power consumption (SWaP).

"Many kinds of satellite operators are trying to deploy more quickly and cheaply, and are looking at components of lower screening levels than

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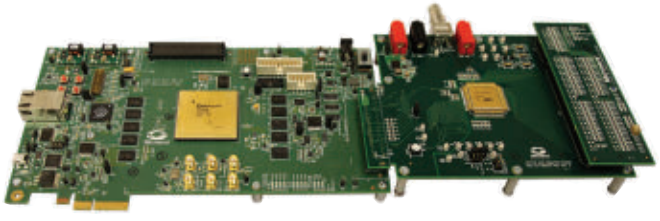
traditional QML [Qualified Manufacturing List]," explains Ken O'Neill, director of marketing for space and aviation at Microsemi Corp. in Aliso Viejo, Calif.

This involves anything "from pure plastic-packaged COTS parts, all the way to screening just below QML, or 'sub-QML'," O'Neill says. "We are exploring ways of offering radiation-tolerant parts with less screening than a traditional QML flow to save lead time and component costs."

This approach has the potential for dramatic reductions in space electronic components, which is significant in a market where low-Earth-orbit satellites typically cost several thousand dollars per pound to launch. "You can cut the price of a computer board in half," says Doug Patterson, vice president of the military and aerospace business sector at Aitech Defense Systems Inc. in Chatsworth, Calif.

Reducing costs, however, requires a compromise in quality, radiation hardness, reliability, or mission duration. It all depends on the mission and if these kinds of compromises are worth it. "There is a slight relaxation from the space community, compared to traditional manned and unmanned vehicles, of the components with strict conformance to NASA specs," Patterson says. "Our customers are allowing us to buy the parts with some traceability, but in plastic parts instead of ceramic parts, and with a minimum lot size. This has allowed us to use mil-grade or automotive-grade parts that we upscreen, and it has had a huge impact on the price of the space market."

Several factors are at work that make compromised reliability pay off in the long run; it all boils down to the target mission, its expected operating environment, and the projected risks. NASA, for example, is asking for satellite constellations in which failed satellites can hand off functionality to nearby satellites, and then automatically deorbit themselves to cut down on space junk and reduce program risks. "Rad-hard scares people in the NewSpace market," Aitech's Patterson says. "The prices are way too high; single parts can cost $40,000 or $50,000.



Microsemi integrates the company's radiation-tolerant RTG4 field-programmable gate array on a variety of embedded computing boards for on-orbit space uses.

Cost sensitivities

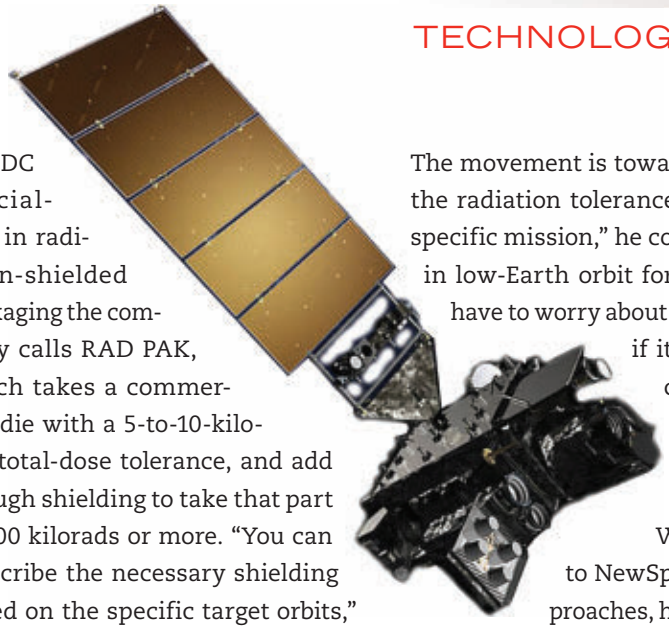
Some companies are finding themselves in the NewSpace market almost by surprise. "Periodically we get a customer who needs a rad-tolerant data drive [SSD]," says Bob Lazaravich, director of secure storage at the Mercury Systems Advanced Microelectronics Solutions group in Phoenix. "Out terrestrial solid-state drive expertise is what we are bringing to the rad-hard world."

Sometime last year, Mercury officials found a customer asking for a rad-tolerant SSD. "The timing was perfect," Lazaravich says. "Demand has amazed us. There is more interest in this than we have had in our secure SSDs previously. We have a first-generation device, and are working on a second-generation device." On hindsight, strong demand shouldn't have been such a surprise. "If you're in space, you're collecting imaging or sensor data, and you need storage for that," he says. "It's a perfect match for us to build a rad-hard SSD."

Mercury starts with commercial-grade Flash memory, and upscreen the parts to withstand the effects of 100 kilorads of total-dose radiation. The company also uses the RTG4 field-programmable gate array from Microsemi. "There is screening that goes on for each device that goes into the product," says Mercury's Lazaravich. "They are all SLC devices with as large of geometries as we can find — the older ones. We have them tested for different kinds of radiation effects, and then we build-in radiation mitigations to account for the kinds of failures we might expect."

Just as Mercury experts were surprised to find themselves in the NewSpace market, they also might be surprised to find themselves part of the traditional space market. The company's first-generation 440-gigabyte space SSD should be able to hold up for a three-year mission in space, but the second-generation 1-terabyte device might be able to operate in space for 10 years or longer, Lazaravich says.

Cobham is offering the RadTolerant Arm Cortex -M0+ microcontroller for space applications with an integrated analog front end and on-board volatile and non-volatile memory.



"For the first generation we kept everything simple," Lazaravich says. "We used no microprocessors, and used a whole new design approach to building a drive. The second generation looks more like our normal hard drive, and in the future third generation we expect to be indistinguishable from a SSD you build buy in the store — but far more reliable."

So what's the secret to screening parts to be just good enough for space applications? "You model the orbit, and use collected radiation data from space," explains Mark Tiddens, product sales manager at Data Device Corp. (DDC) in Poway, Calif. "You look at the thickness of the spacecraft shell, the electronics box aluminum, and at what is the rad-tolerance of the die to determine how thick the shielding needs to be."

DDC specializes in radiation-shielded packaging the company calls RAD PAK, which takes a commercial die with a 5-to-10-kilorad total-dose tolerance, and add enough shielding to take that part to 100 kilorads or more. "You can prescribe the necessary shielding based on the specific target orbits," Tiddens says. "We have parts that are rad-tolerant enough, or we can add our RAD PAK shielding for even more hardness."

It all comes down to where the spacecraft must operate. "NewSpace looks at old space as being over-designed and over-tested," Tiddens says. The movement is towards optimizing the radiation tolerance and cost to a specific mission," he continues. "If it's in low-Earth orbit for 10 years, you have to worry about 50 kilorads, but if it's five years it could be down to 40 kilorads for these parts."

When it comes to NewSpace design approaches, however, it's difficult to avoid program risk, experts admit. "This is an exciting and disruptive movement," says Tiddens. "Nobody really knows why these parts fail in space. You can do the modeling and say this is the radiation requirement, but some NewSpace people are just doing trial and error. Some parts

work fine, but some don't; it's a tough situation to optimize."

Test and qualification

It's easy to talk about radiation testing and qualification to upscreen commercially available parts for use in space, but quite another actually to carry out these procedures. It takes expertise, time, and specialized test and measurement equipment to come up with accurate characterizations of how commercial parts will behave in space.

"In the NewSpace market now, small satellite startups are not looking to implement rad-hard components, but to get any data they can to see if commercial parts are rad-tolerant," says Aridio Sanchez, executive director of rad-hard test and measurement specialist VPT Rad Inc. in Chelmsford, Mass. "We do radiation-effects testing to qualify the devices, and to see if they are rad-hard or rad-tolerant. Typically, parts that are screened to be much lower than rad-hard are more cost-effective."

It's up to VPT Rad, and test houses like it, to document if commercial-grade parts can stand-up to the space radiation environment. "We have a suite of test equipment that can support technologies from discretes up to complicated memory products," Sanchez says. "Customers drop off their parts, and we take care of everything else. A company may have a project where they want us to qualify parts to be radiation-hardened, and we have to prove that."

The space electronics market is hot, as VPT Rad's business would attest. "NewSpace is pretty heavy, and the market is getting very competitive with a lot of folks trying to get into the same market," Sanchez says. "That is pretty much the major switch in the business we have been seeing over the past 10 years in radiation testing."

Sanchez says the majority of his customers are from the commercial world who are trying to get into the space market and find more cost-effective ways to get rad-tolerant parts into their systems. The company also serves government customers who are trying to characterize just the right parts for long-term programs.

The TRRUST-Stor secure solid-state drive (SSD) for trusted computing applications comes in a radiation-hardened version for orbiting satellites and manned space missions.

The Microsemi RTG4 rad-hard FPGA is going aboard a wide variety of orbiting satellites that must operate in radiation environments.

Traditional space electronics

Several companies specializing in radiation-hardened electronics have been in business for years, if not decades, and were veterans of the market long before NewSpace ever got its name. Microsemi's O'Neill describes traditional space as high-end systems for national defense, long-term NASA space missions, and high-revenue telecommunications "where there is lots of money or very high states resting on those systems."

Microsemi provides the LX7720 rad-tolerant position sensing and motor controller and LX7730 telemetry controller. The 7730 is qualified to MIL-PRF-38535 QML Class Q and Class V — the government's highest quality standards for space — and the 7720 is on a path to QML qualification, O'Neill says.

Microsemi also provides the RTG4 radiation-tolerant field-programmable gate array (FPGA) that has been qualified to QML Class Q, and is on a path to QML Class V sometime this summer.

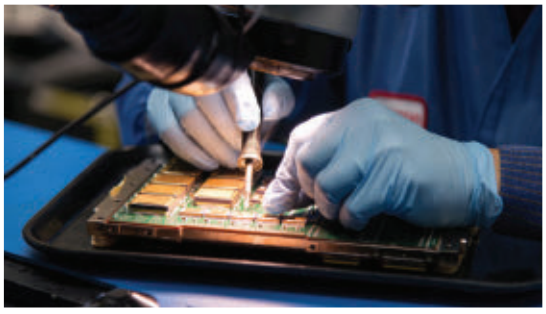
VPT Inc. in Blacksburg, Va., for example, specializes in rad-hard power electronics like DC-DC converters. "We are spending a lot of effort on point-of-load converters, which needs to support high-performance digital electronics for space, like single-board converters, FPGAs, and peripherals," says Brandon Witcher, senior design engineer at VPT Inc.

One issue driving VPT's designs is the need to develop power electronics for a wide range of input voltages — some even for 12-volt input voltages. "Once a lot of digital electronics was using a 5-volt distribution bus, but then as voltages continue to shrink, a lot of that went to 3.3 volts. The 3.3-volt device can directly power I/O and peripherals, and can use the point-of-load converter to power-down to a lower voltage."

At higher voltages, the current starts to increase, and puts a lot more current through the distribution bus, Witcher says. "If you can increase the distribution bus, you can increase the voltage and lose less power along the line. Some people are distributing at 5 volts, some at 3.3 volts, and some at 12, and we want to hit all those targets."

For traditional and NewSpace electronics applications, one thing is clear: the increasing need for ever-smaller

and more power-efficient electronics. "Small size is extremely important, so we try to shrink the size as much as we physically can," Witcher says. "The need for lower voltage and higher current on spacecraft is driving us to a trend in higher-voltage input buses."



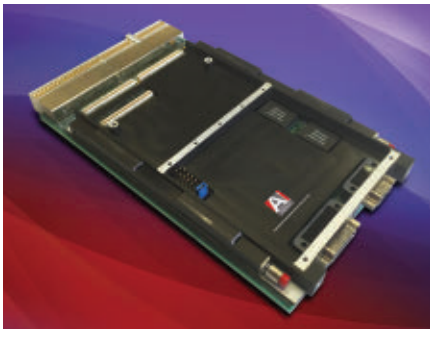
BAE Systems uses radiation-hardening by design to produce the RAD 5545 system-on-chip rad-hard microprocessor, which company officials say is one of the most reliable radiation-hardened processors available.

Cobham Semiconductor Solutions in Colorado Springs, Colo., has been involved in the space electronics market for at least three decades. A veteran of the traditional space market, Cobham officials are capitalizing on their experience to expand into the NewSpace market.

QML standards

One of Cobham's recent achievements is helping the U.S. Defense Logistics Agency define the new Class Y requirements for non-hermetic rad-hard space parts, according to MIL-PRF-38535 — the U.S. military specification that establishes performance and verification requirements of single-die integrated circuit devices.

"We were the first company awarded a Class Y certification in 2014," says Michelle Mundie, business area director for standard products at Cobham. "We offer a qualified ceramic flip-chip column grid array package, which reduces overall size, footprint, and costs for rad-hard performance, while enhancing performance."



The Aitech SP0-S 3U CompactPCI radiation-tolerant single-board computer based on the PowerPC microprocessor, is for NewSpace applications for deployment in low-Earth orbit.

Cobham also is adapting a volatile- and non-volatile memory in a ceramic hermetic package to an organic non-hermetic package that meets Class Y guidelines. "We are working with DLA on implementing to standards around organic packaging, which we are hoping to be in 2019," Mundie says.

Traditionally, Cobham has provided rad-hard electronics parts for national security programs like geosynchronous military satellites, navigation satellites, tracking and data satellites, as well as weather satellites. The company has long-term expertise in rad-hard computing and processing; imaging, sensing, and distributed command and control; telemetry; RF phased arrays; and distributed power architectures.

From there, Cobham experts are evolving their designs toward integrated and differentiated system-on-chip solutions that are reliable and affordable enough even for NewSpace applications. "Addressing SWaP-C also drives down our costs to make our products more affordable," Mundie says.

The company is developing a radiation-tolerant, 32-bit ARM Cortex-M0 processor plus microcontroller, which took a discrete solution and integrated its design onto a one-chip solution. "We integrated a complete front-end analog signal chain, which includes a 12-bit ADC [analog-to-digital converter] with a programmable gain amplifier, 16-channel multiplexer, two 12-bit DACs [digital-to-analog converters], and comparators and timers," Mundie says.

For the future, Cobham officials are focusing on their company's core military, commercial, and civil space markets and are expanding into NewSpace applications in small satellites, mega-constellations, as well as sensing, imaging, and energy harvesting for spacecraft on-board power.

"These new markets do have a different structure, so they are not 15-to-20-year missions," Mundie says. "They are 2-to-5-year missions, with some level of radiation hardening. That also is putting pressure on Cobham to reduce flows and become more innovative." Meeting those requirements involves developing subsets of traditional space requirements to provide systems designers with the size, performance, and costs they want.

"Our customers say we need cheaper products, so how do we perform a subset of the qualification requirements that will meet their needs," Mundie says. "It provides a lower level of reliability and some radiation assurance, and is looking for the 'good-enough' solution for the LEO orbit that is going up there for two to five years."

Rad-hard by design

Although demand is relatively light, applications still exist for the most radiation-hardened electronics parts, despite their high costs, lag in technology, and long wait times. Among the providers of these parts, which are designed from the ground-up to be radiation hardened are the BAE Systems Electronic Systems segment in Manassas, Va., and the Honeywell Inc. Radiation Effects Center of Excellence in Clearwater, Fla.

Cobham helped craft the government's Class-Y radiation-hardened standards to accommodate non-hermetic electronic parts for use in space.

"The government still needs systems that are hardened for weapons effects, such as the SBIRS [Space-Based Infrared Surveillance] system to monitor for weapons launches," says Paris Wiley, senior technical manager at Honeywell. The upcoming global positioning system (GPS) program to update the nation's navigation satellites also will electronic components able to survive and operate through nuclear events.

Honeywell operates an integrated circuit fab in Plymouth, Minn., that produces electronic parts designed especially for radiation hardness. Among the military systems that require radiation hardness of this magnitude also are the next-generation land-based intercontinental ballistic missile (ICBM) — also known as the Ground-Based Strategic Deterrent (GBSD), Trident submarine-launched ballistic missile, and upgrades to the Minuteman ICBM. "There has been a lot of recent activity in modernizing our strategic missiles," Wiley points out.

"For these applications, the requirements haven't been relaxed; for our strategic capabilities, they have remained roughly the same," Wiley says. "That's where the Plymouth foundry comes in, and why it is such a critical national asset."

In the future, it's likely that rad-hard chip designers will combine techniques in rad-hard by design with radiation-mitigation techniques to ensure the highest possible reliability, yet provide strategic weapons systems designers with the latest electronic technologies. "For strategic applications, we could combine a rad-hard-by-design part where we can get them, with radiation mitigation with analog and digital filtering, shielding, and running computations at different times and comparing them to enable the system to respond to potential corruption," Wiley says.

Still, there remains a need for rad-hard by design to the highest standards, even though the market for these parts is shrinking. "The foundry is a national asset," Wiley says. "It is the only place that makes digital parts like processors and memories that can tolerate radiation to these levels."

Weapons-grade rad-hard

Recent global tensions illustrate the need to maintain this kind of rad-hard capability. "One of the biggest challenges we have seen is that space is no longer a sanctuary," says Ricardo Gonzalez, product line director for space systems at the BAE Systems Electronic Systems sector in Manassas, Va. "We must be

able to deploy space systems and have the ability to defend them, and DOD [the U.S. Department of Defense] is putting in significant funding for that."

At BAE Systems, pure rad-hard by design work has gone away over the past 10 years, but the company still is in the business of providing the most advanced rad-hard processors and general-purpose computers for government space and military programs.

"Rad-hard by design is no longer necessary," Gonzales says. "We can leverage commercial foundries to have the wafers fabbed, and bring the wafers back into BAE Systems in Manassas. We operate fabless, but all our rad-hard capabilities are still here."

BAE Systems provides the RH45 45-nanometer semiconductor technology that enable the next generation of rad-hard electronic parts that make the most of SWaP. Using this we can build anything from ASICs [application-specific integrated circuits], to a next-generation processor on a chip," Gonzalez says. He calls the BAE Systems RAD 5545 system on chip, which uses RH45 technology, "the most advanced microprocessor available for space today."

It's a rad-hard quad-core processor that delivers 5.6 billion instructions per second, and can withstand radiation levels to 1 megarad of total-dose radiation. The RAD 5545 is the basis of a radiation-hardened single-board computer that meets open-systems VPX standards, that will go into several national defense systems.

Looking to the future, Gonzalez says it's no longer adequate to build rad-hard electronics that can survive tremendous levels of radiation. Today it's necessary to design rad-hard electronics with the ability to support fast-changing threats from U.S. adversaries.

"Smaller platforms will be in high demand, and reprogrammability is a necessity. Higher levels of integration

The SCS750 radiation-hardened single-board computer from Data Device Corp. is for mid- and high-performance space embedded computing, and on-board data processing on the spacecraft.

afford bigger missions with smaller footprints," Gonzalez says. Future rad-hard electronics also must be able to support cyber resiliency, autonomous operation, and other advanced capabilities.

Toward this goal, BAE Systems experts are working on future technology nodes able to yield 28-, 22-, 14-, and sub-10-nanometer chip technologies. "This aggressive reduction in size, weight, and power will afford much smaller systems that can handle more threats autonomously and drive more missions for the hardware on orbit," Gonzalez says. ←

COMPANY LIST

Aitech
Chatsworth, Calif.
http://www.rugged.com

BAE Systems
Manassas, Va.
https://www.baesystems.com/en-us/our-company/inc-businesses/electronic-systems/product-sites/space-products-and-processing

Cobham Semiconductor Solutions
Colorado Springs, Colo.
https://ams.aeroflex.com/aboutus/au-cos.cfm

Data Device Corp. (DDC)
Bohemia, N.Y.
http://www.ddc-web.com

Honeywell Aerospace
Clearwater, Fla.
https://aerospace.honeywell.com/en/markets/space

Infineon Technologies
El Segundo, Calif.
https://www.infineon.com

Intersil
Milpitas, Calif
https://www.intersil.com/en.html

Maxwell Technologies
San Diego
http://www.maxwell.com

Mercury Systems
Andover, Mass.
https://www.mrcy.com

Microelectronics Research Development Corp.
Colorado Springs, Colo.
http://www.micro-rdc.com/index.htm

Micropac Industries Inc.
Garland, Texas
http://www.micropac.com/MII-Home.html

Microsemi
Aliso Viejo, Calif
https://www.microsemi.com

Northrop Grumman Corp.
Manhattan Beach, Calif.
http://www.northropgrumman.com/Pages/default.aspx

pSemi Corp.
San Diego
http://www.psemi.com

Space Micro
San Diego
http://www.spacemicro.com/index.html

Triad Semiconductor Inc.
Winston-Salem, N.C.
https://www.triadsemi.com

VPT Inc.
Blacksburg, Va.
http://www.vptpower.com

VPT Rad
Chelmsford, Mass.
http://www.vptrad.com

DRS Laurel to build clutter-rejecting missile-defense radar to protect Navy ships

BY **John Keller**

DRS Laurel Technologies is providing the U.S. Navy with the AN/SPQ-9B anti-ship missile defense (ASMD) radar systems to protect vessels from enemy anti-ship missiles.

WASHINGTON — U.S. Navy missile-defense experts are asking the DRS Laurel Technologies segment of Leonardo DRS in Johnstown, Pa., to provide AN/SPQ-9B anti-ship missile defense (ASMD) radar systems to help protect U.S. Navy surface warships from enemy anti-ship missiles.

Officials of the Naval Sea Systems Command in Washington announced a $64.3 million contract to DRS Laurel to build as many as 59 AN/SPQ-9B ASMD radar systems and related equipment. With this contract, DRS Laurel displaces the AN/SPQ-9B incumbent contractor Northrop Grumman Corp.

This contract includes options that could bring its cumulative value to $263 million. This contract combines purchases for the U.S. Navy and the government of Japan.

The AN/SPQ-9B is an X-Band pulse-Doppler frequency-agile radar that scans out to the horizon and performs simultaneous and automatic air and surface target detection and tracking of low-flying, anti-ship cruise missiles, surface threats, low-and-slow-flying aircraft, unmanned aerial vehicles (UAVs), and helicopters.

The system is connected to shipboard missiles and machine guns for engaging incoming threats.

The radar is designed for the littoral environment in harbors and along coastlines, and has high clutter improvement factor supporting a very low false track rate in the littorals and in high-clutter environments. Its design makes the most of commercial off-the-shelf (COTS) and non-developmental item (NDI) equipment.

The unattended radar consists of four air-cooled, below-deck cabinets, a motor generator, and one above-deck antenna unit designed for low-radar-cross-section reflectivity appropriate for stealth ship design.

The AN/SPQ-9B is aircraft carriers, amphibious assault ships, cruisers, Coast Guard maritime security cutters, Arleigh Burke-class destroyers, and allied cruisers and destroyers.

Above decks, the radar uses a mechanically rotating, electronically stabilized antenna. The 1,500-pound antenna consists of dual planar arrays

Army increases number of RPG-killing tank-defense systems headed to Europe

The U.S. Army is revving up deployment of rocket propelled grenade (RPG)-killing active protection systems weapons on Abrams battle tanks to Europe as part of an effort to better arm its armored brigade combat teams and counter Russian threats in the region. Active protection systems (APS) for military armored combat vehicles use sensors and radar, computer processing, fire control technology, and interceptors to find, target and knock down or intercept incoming enemy fire. The APS system now on Abrams tanks, called Trophy, is engineered to track and destroy approaching enemy fire through 360-degree radar and computer-enabled fire control technology designed to fire out an interceptor projectile to hit and explode attacking RPGs. The interceptor consists of small, shaped charges attached to a gimbal on top of the vehicle. The small explosives are sent to a precise point in space to intercept and destroy the approaching round.

Navy gives littoral-combat ship soft-kill weapon to fend off torpedoes

The U.S. Navy's littoral combat ship is now armed with an emerging ship defense soft-kill countermeasure able to identify, track, and destroy incoming enemy torpedo fire. Navy leaders plan to outfit the entire littoral combat ship (LCS) fleet with the AN/SLQ-61 Lightweight Tow Torpedo Defense Mission Module (TDMM) to fortify the ship's ability to succeed in both shallow- and open-water warfare. The new TDMM has completed two days of at-sea testing to prepare for operational service on LCS ships. The technology uses an underwater acoustic projector, attached to a cable dropped from the ship's stern to identify acoustic homing and wire-guided enemy torpedoes.

mounted back-to-back, each connected to independent transmitters and receivers.

Below decks, the radar consists of processor, receiver/exciter, and transmitter cabinets; radar set control; and motor generator.

The processor cabinet performs signal processing, tracking, and interface functions. The receiver/exciter has three receivers, and generates system frequencies and clocks. The transmitter cabinet receives the RF pulses from the receiver/exciter and amplifies them for output to the antenna. The radar set control provides remote control and monitoring of radar operation in the ship's combat information center. The output of each receiver is converted to digital baseband I-Q data for Doppler processing in the processor cabinet. The system has an auxiliary antenna for electronic counter-countermeasures.

The AN/SPQ-9B radar has digital interfaces to the Aegis combat systems, the MK 34 gun weapon system (GWS), the MK 48 GWS, the Cooperative Engagement Capability, and ship self-defense system. On this contract, DRS Laurel will do the work in Largo, Fla., and Johnstown, Pa., and should be finished by June 2022.

For more information, contact ***DRS Laurel Technologies*** *online at* www.leonardodrs.com/locations/drs-laurel-technologies-johnstown-pa, *or* ***Naval Sea Systems Command*** *at* www.navsea.navy.mil.

Black River eyes enabling technologies in software-defined radio and signals intelligence

BY **John Keller**

ROME, N.Y. — U.S. Air Force researchers needed enabling technologies for software-defined-radio (SDR) signals intelligence for low-power applications in moderate to dense co-channel environments. They found their solution from Black River Systems Co. Inc. in Utica, N.Y.

Officials of the Air Force Research Laboratory Information Directorate, in Rome, N.Y., have announced a $9.3 million contract to Black River for the Signals Intelligence (SIGINT) Software Defined Radio (SDR) project.

Black River experts will help improve Air Force knowledge in the cyber domain by advancing the state of the art in software-defined radio to sustain signals intelligence capabilities, including real-time collection, geolocation, and signal exploitation.

The SIGINT SDR project is to provide game-changing technologies for critical warfighter needs in command, control, communications, cyber, and intelligence (C4I) capabilities with a focus on intelligence and cybersecurity.

Air Force researchers are looking to Black River Systems Co. for low-power, software-defined-radio (SDR) signals intelligence in dense co-channel environments.

The project has two primary thrusts: techniques and algorithms that help identify, collect, process, exploit, and manipulate electronic communication signals in a moderate to dense co-channel environment with potentially significant Doppler effects; and develop capabilities in digital signal processing (DSP) and cyber operations by capitalizing on existing technology.

Black River experts will find ways to detect, identify, characterize, and gelocate emerging communications and low-power signals of interest; develop DSP software for new systems and waveforms; develop software and hardware architectures for standoff collection systems; integrate these capabilities into information operations and collection systems; and characterize cognitive software-defined radios from airborne or ground-based platforms operating in dense-signal environments.

Company experts also will capitalize on existing technologies for DSP and cyber operations to make the most of information from data and signals for warfighters.

The project will involve modifying existing fielded systems with new cyber capabilities, as well as developing an automated signal-processing framework for rapid signal processing and cyber capabilities.

On this contract, Black River will do the work in Utica, N.Y., and should be finished by May 2022.

For more information, contact ***Black River Co.*** *online at* www.blackriversystems.com, *or the* ***Air Force Research Lab's Information Directorate*** *at* www.wpafb.af.mil/afrl/ri.

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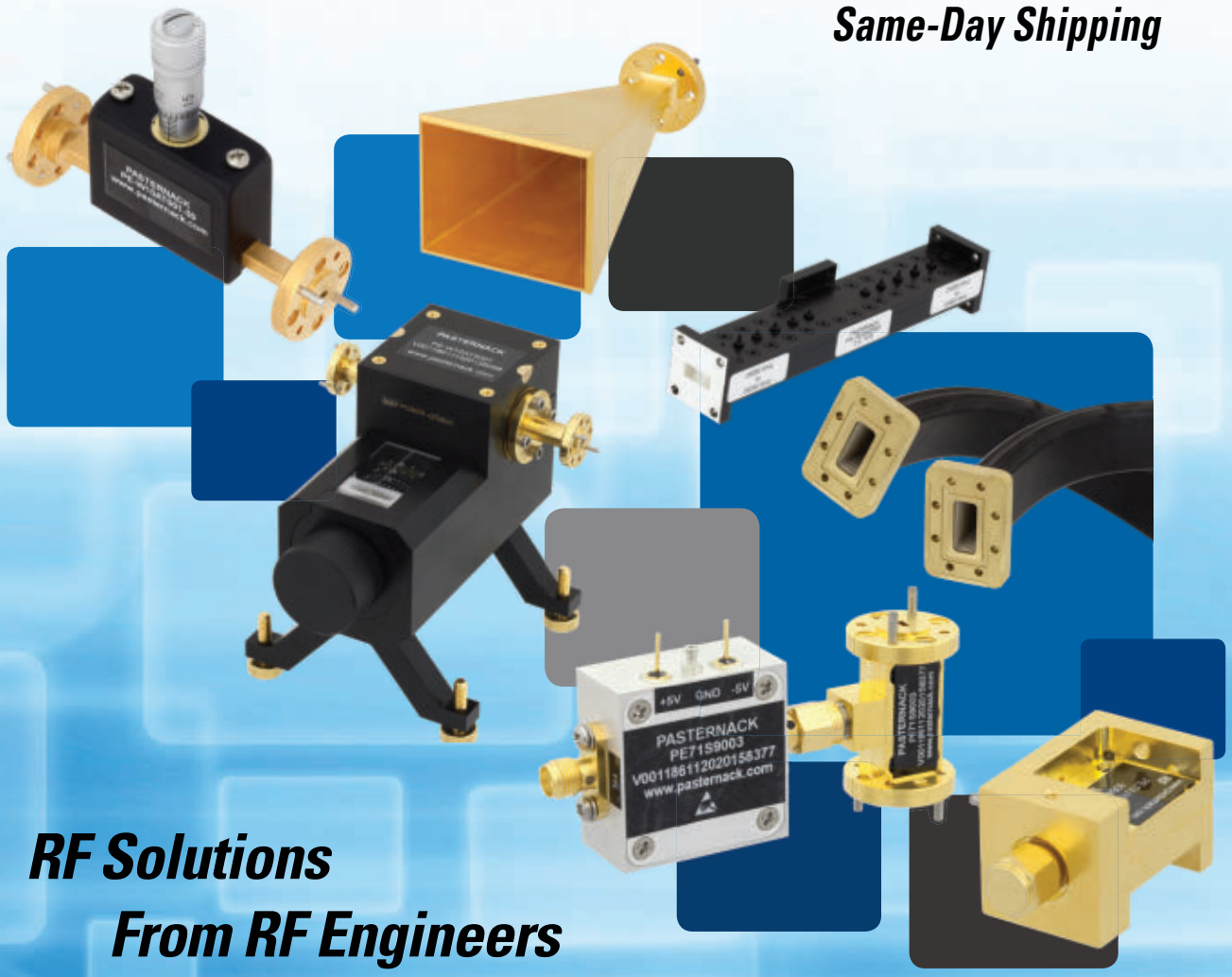

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General Atomics to upgrade 122 MQ-9 Block 5 Reaper unmanned attack drones

BY **John Keller**

General Atomics is upgrading 122 Reaper attack drones with improved range and communications capabilities.

WRIGHT-PATTERSON AFB, Ohio — Military unmanned aerial vehicle (UAV) designers at General Atomics are improving the range and communications capabilities of 122 U.S. Air Force MQ-9 Block 5 Reaper attack drones.

Officials of the U.S. Air Force Life Cycle Management Center at Wright-Patterson Air Force Base, Ohio, announced a $206 million contract to the General Atomics Aeronautical Systems segment in Poway, Calif., to retrofit 122 MQ-9 Block 5 armed UAVs.

General Atomics will retrofit the 122 late-model Reaper drones with extended-range, beyond-line-of-sight, and Barrett asymmetrical digital datalink computer (BADDC) router modification kits. These modified aircraft will fly with the Block 30 Ground Control Station (GCS).

These upgrades will enable the upgraded Reaper Block 5 unmanned aircraft to carry external fuel pods to extend their mission range; add a Ku-band beyond line-of-sight and satellite communications data link control; and the BADDC data routers. General Atomics won a $14.2 million Air Force order last January to develop the upgrade kits.

The BADDC routers act as payload data multiplexers to increase the amount of data that the Reaper Block 5 can send over tactical networks within the UAV's time and bandwidth limitations.

The BADDC data routers select one of several analog or digital input signals from Reaper Block 5 onboard sensors and forwards the selected input into a single line. This makes it possible for several signals to share one device or resource like an A/D converter or one communication line, instead of having one device per input signal.

The Reaper is a variation of the General Atomics MQ-1 Predator UAV that is designed for surveillance and attack missions using a suite of airborne sensors and the AGM-114 Hellfire air-to-ground missile.

The turboprop-powered, multi-mission Reaper armed drone can fly for more than 27 hours between refueling at speeds to 240 knots at altitudes to 50,000 feet. The medium-endurance UAV can carry payloads as heavy as 3,850 pounds, including 3,000 pounds of external stores like Hellfire missiles.

The Reaper can carry as many as four Hellfire missiles, two GBU-12 Paveway II laser-guided bombs, or two 500-pound GBU-38 Joint Direct Attack Munitions (JDAMs). Twice as fast as Predator, the Reaper carries 500 percent more payload and has nine times the horsepower, General Atomics officials say.

The Reaper has a fault-tolerant flight control system, triple-redundant avionics system, and is powered by the Honeywell TPE331-10 turboprop engine, integrated with digital electronic engine control (DEEC) to improve engine performance and fuel efficiency at low altitudes.

The Reaper can carry electro-optical and infrared (EO/IR) sensors, Lynx multi-mode radar, multi-mode maritime surveillance radar, electronic support measures (ESM), laser designators, and a variety of weapons.

The sophisticated drone has redundant flight-control surfaces; can fly remotely piloted or autonomously; has a MIL-STD-1760 stores management system; seven external payload stations; C-band line-of-sight data link control; Ku-band beyond line-of-sight and satellite communications data link control; more than 90 percent system operational availability; and can self-deploy or fly aboard C-130 utility aircraft.

This aircraft has been acquired by the U.S. Air Force, U.S. Navy, U.S. Department of Homeland Security (DHS), NASA, the United Kingdom Royal Air Force, the Italian Air Force, and soon others, company officials say.

On this contract, General Atomics will do the work in Poway, Calif., and should be finished by June 2024. ←

For more information, contact ***General Atomics Aeronautical Systems*** *online at* www.ga-asi.com, *or the* ***Air Force Life Cycle Management Center*** *at* www.wpafb.af.mil/aflcmc.

Lockheed Martin hypersonic missile may achieve speeds of one mile per second

BY **John Keller**

EGLIN AIR FORCE BASE, Fla. — U.S. Air Force airborne weapons experts are looking to Lockheed Martin Corp. to develop and test a hypersonic missile able to achieve speeds of about five times the speed of sound after launch from jet fighters and bombers. Officials of the Air Force Life Cycle Management Center (AFLCMC) Armament Directorate at Eglin Air Force Base, Fla., announced a $928 million contract to the Lockheed Martin Space Systems segment in Huntsville, Ala., for the Hypersonic Conventional Air-Launched Strike Weapon program.

The Air Force is asking Lockheed Martin to develop and integrate an air-launched hypersonic conventional stand-off strike weapon for fighter and bomber aircraft. The hypersonic conventional strike weapon will provide a prompt precision-strike capability against high-value, time-critical fixed and relocatable surface targets. The hypersonic weapon, which is expected to reach speeds of about 3,800 miles per hour, will use global positioning system (GPS) and inertial guidance system (INS) navigation and terminal guidance with a government-furnished warhead.

The contract covers development, integration, and test through full-scale development, which military leaders call engineering and manufacturing development (EMD). For this contract, Lockheed Martin prevailed over other U.S. defense contractors that included the Boeing Co.; Northrop Grumman Corp., Raytheon Co., and Orbital ATK.

Lockheed Martin is developing a hypersonic missile able to achieve speeds of about five times the speed of sound after launch from jet fighters and bombers.

Three of these five companies submitted formal proposals.

Air force officials particularly are interested in rapid development and fielding of the Hypersonic Conventional Air-Launched Strike Weapon. This project began in June 2017 with a sources-sought notice from the Air Force to a limited number of defense prime systems integrators.

Military leaders have a strong sense of urgency in developing hypersonic weapons to counter promising developments in hypersonic technology in China and Russia. Some experts content the U.S. military lags behind Russia and China in hypersonic weapons development. The U.S. Navy's most advanced anti-ship missile program — the Lockheed Martin Long Range Anti-Ship Missile (LRASM) — for example, is being designed as a subsonic munition.

On this hypersonic weapons contract, Lockheed Martin will do the work in Huntsville, Ala. The duration of the contract was not specified. ←

For more information, contact ***Lockheed Martin Space Systems*** *online at* www.lockheedmartin.com/en-us/capabilities/space.html.

Navy wants undersea gas stations underwater drones

A California company is working on an underwater refueling station that can top off the fuel cells of undersea surveillance drones, allowing the vehicles to venture farther and work longer. Teledyne, based in Thousand Oaks, California, showed off its undersea power station alongside Gavia, the company's popular underwater surveillance drone, at the Sea-Air-Space Exposition in Maryland in April. The underwater fuel-cell station stores 200 kilowatts of power and works down to a depth of nearly two miles. An undersea drone could hook up to the station and charge its own fuel cells. A Gavia can operate for up to five hours on one 1.2-kilowatt charge. Teledyne is proposing the seven-inch-diameter Gavia for the Navy's oceanographic fleet, which maps the sea floor. But the drone, which travels at speeds up to four miles per hour down to a maximum depth of around 10,000 feet, can also help with search-and-rescue and mine hunting missions.

The day of the unmanned surface ship is dawning

Advances in sensor technology, data analytics, and bandwidth-to-shore are fundamentally changing the way maritime shipping works. As operations are digitized, they become more automated, Dr. Pierre C. Sames, director of Group Technology & Research at class society DNV GL, has stated. Governments around the world are looking into unmanned maritime shipping as a way to move more cargo to sea to contain the spiraling costs of road maintenance caused by heavy truck traffic, not to mention air pollution. Norway is taking a lead in exploring this issue to help bridge the country's many fjords and sea passages to ease transit. The government has turned Trondheim Fjord into a test bed for autonomous ship trials. Other nations, most notably Finland and Singapore, are pursuing similar goals. ←

ELECTRO OPTICS watch

Rugged color cameras introduced by JAI

JAI A/S in Copenhagen is introducing two rugged interface types in the company's line of 3.2 megapixel 3-CMOS prism-based area scan cameras for challenging color imaging applications. The models are the AP-3200T-PGE with GigE Vision interface delivering an output of 3 by 3.2-megapixels at 12 frames per second, and the AP-3200T-PMCL with a dual Mini Camera Link interface delivering an output of 3 by 3.2-megapixels at 55 frames per second. The two feature 3 by CMOS Pregius IMX265 1/1.8-inch sensors with 2048 by 1544 pixels and pixel sizes of 3.45 by 3.45 microns. The camera has a 50G shock rating and 3G vibration rating, as well as operating temperature range of -5 to 45 degrees Celsius.

Integrating optical components into existing chip designs

Two and a half years ago, a team of researchers led by groups at MIT, the University of California at Berkeley, and Boston University announced a milestone: the fabrication of a working microprocessor, built using only existing manufacturing processes, that integrated electronic and optical components on the same chip. The electro-optical researchers' approach required that the chip's electrical components be built from the same layer of silicon as its optical components. That meant relying on an older chip technology in which the silicon layers for the electronics were thick enough for optics. A team of 18 researchers, led by the same MIT, Berkeley, and BU groups, reports another breakthrough: a technique for assembling on-chip optics and electronic separately, which enables the use of more modern transistor technologies. Again, the technique requires only existing manufacturing processes. ←

Leidos to enhance semiconductor lasers for infrared countermeasures

BY **John Keller**

Air Force researchers are considering high-brightness semiconductor lasers for future applications in infrared countermeasures.

KIRTLAND AIR FORCE BASE, N.M. — U.S. Air Force electro-optics experts needed new ways to enhance technology for high-brightness semiconductor lasers for future applications in infrared countermeasures. They found their solution from Leidos Inc. in Reston, Va.

Officials of the Air Force Research Laboratory's directed energy directorate at Kirtland Air Force Base, N.M., have announced a $13.9 million contract to Leidos for the COmpact Semiconductor Mid- and long-wave Opto-electronic (COSMO) research project.

The COSMO program seeks to advance semiconductor lasers for current and future infrared countermeasures systems to deny enemies the use of infrared sensors like missile guidance, night-vision devices, and nighttime targeting systems. The COSMO project is part of the Air Force's Semiconductor Laser (SCL) program to advance the state-of-the-art in compact high-brightness semiconductor laser devices emitting at the mid- and long-wave infrared wavelengths. Mid-wave infrared emits in the 3-to-5-micron bands, and long-wave infrared emits in the 8-to-12-micron bands.

Leidos will concentrate on developing and packaging mid- and long-wave infrared semiconductor laser devices, including development and testing of individual and multi-device format quantum cascade laser (QCL) and diode laser (DL) component technology.

Leidos engineers will use their expertise in exercising beam-combining strategy to strengthen output power, and switching high brightness QCL and DL modules for test, evaluation, prototyping, and use in infrared countermeasures systems. Leidos engineers will work primarily at Kirtland Air Force Base, which has specialized equipment like molecular beam epitaxial system; focused ion beam and scanning electron microscope system; X-ray diffractometer; Fourier transform infrared spectroscopy system; reactive ion etching system; inductively coupled plasma reactive ion etching system; mask aligner; plasma-enhanced chemical vapor deposition system; and evaporative metal deposition system.

Leidos should be finished with this contract by April 2023. ←

For more information, contact ***Leidos*** *online at* www.leidos.com, *or the* ***Air Force Research Lab*** *at* www.kirtland.af.mil/Units/AFRL-Directed-Energy-Directorate.

Army awards $391.8 million contract to L-3 for ENVG-B night-vision binoculars

BY **John Keller**

ABERDEEN PROVING GROUND, Md. — U.S. Army night vision experts needed advanced binocular infrared and image-intensification electro-optical binoculars to enable U.S. and allied warfighters to operate effectively at night. They found their solution from L-3 Insight in Londonderry, N.H.

Officials of the Army Contracting Command at Aberdeen Proving Ground, Md., announced a $391.8 million, three-year contract to L-3 Insight in May for the Enhanced Night Vision Goggle-Binocular (ENVG-B). The ENVG-B project has been a somewhat secretive initiative with few details publicly released about its technologies and specifications because of the program's sensitive nature.

L-3 Insight is one of four U.S. electro-optics companies building versions of the ENVG. The others are Harris Corp. (formerly Exelis) in Roanoke, Va.; BAE Systems Electronic Systems segment in Nashua, N.H.; and the DRS Technologies Imaging and Targeting Solutions (ITS) segment in Dallas. Army officials say L-3 Insight was the only bidder for the ENVG-B program.

The ENVG family represents helmet-mounted night-vision goggles that blend image intensification and long-wave infrared sensors for combat at night, in bad weather, and in smoke and dust.

Harris and L-3 Insight are building ENVG II, while BAE Systems and DRS are building ENVG III. Compared with previous versions of the ENVG, the ENVG III weapon sights also has improved resolution and a wider field of view. The ENVG III is a follow-on contract to previous ENVG I and ENVG II procurements.

L-3 Insight in Londonderry, N.H., will provide the U.S. Army with the new Enhanced Night Vision Goggle-Binocular (ENVG-B) to enhance military operations at night.

The distinction of ENVG III from previous ENVGs is the added rapid target acquisition technology when used with the FWS-I, which is to be a weapon-mounted long-wave infrared sensor used for surveillance and aiming weapons during daylight, darkness, adverse weather, and dirty battlefield conditions, Army officials say.

L-3 Insight provides the AN/PSQ-20B ENVG helmet-mounted dual waveband monocular, which enables the user to view images through one eye, but not through two eyes as a binocular device can. The AN/PSQ-20B ENVG provided improved targeting and identification by fusing image intensification technology with thermal imagery to bring out the best in both sensors.

The system provides has standard 18-millimeter MX-11769 image-intensification tubes; objective focus adjustment from 18 inches to infinity; diopter adjustment from +1 to -2 diopters; meets MIL-STD-810G; has an internal shutter for auto or user initiated single point correction; and offers user-adjustable image-intensification gain and thermal brightness.

The AN/PSQ-20B ENVG is based on the L-3 Insight AN/PVS-31 Binocular Night Vision Device (BNVD) Fusion Goggle System (FGS), which offers green and white phosphor versions.

The AN/PVS-31 BNVD is a compact, lightweight, Gen III dual-tube goggle with an ergonomic low-profile design to provide better situational awareness than a single-tube goggle. Its twin-tube design provides protection in the field against failure or damage versus a single-tube device. It can be used as a monocular when necessary to allow for the dominant and non-dominant eye by rotating either the left or right optic into the stowed position. L-3 Insight designed the AN/PVS-31 BNVD to increase system resolution, reduce head-borne weight, improve system center of gravity, and improve situational awareness.

The AN/PVS-31 BNVD offers manual system gain and focus adjustments; a rotating binocular design for use with a low-profile against helmet when in stowed position; auto off when stowed; LED battery indicator in left and right monocular; replaceable image-intensification tubes; and availability for BNVIS or Aviator's Night Vision Imaging System (ANVIS) mounts.

On the ENVG-B program, L-3 Insight should be finished by May 2021. ←

For more information, contact ***L-3 Insight*** *online at* www.insighttechnology.com.

PRODUCT applications

AIRBORNE RADAR

Telephonics to provide radar for Coast Guard HC-27J surveillance aircraft

U.S. Coast Guard airborne radar experts needed multi-mode radar systems for the new Alenia Aermacchi HC-27J Spartan medium-range, fixed-wing surveillance aircraft. They found their solution from Telephonics Corp. in Farmingdale, N.Y.

Officials of the U.S. Naval Air Warfare Center Aircraft Division in Lakehurst, N.J., on behalf of the Coast Guard, have announced

a $31.8 million contract to Telephonics for as many as 19 multi-mode radar systems for the HC-27J aircraft in support of the Coast Guard.

The Coast Guard plans to commission a fleet of 14 HC-27J Spartan turboprop surveillance aircraft by 2022 for maritime patrol, drug and migrant interdiction, disaster response, and search and rescue missions. The HC-27J is a modified surveillance variant of the C-27J. Monday's contract includes related engineering services and logistics support.

The HC-27J aircraft particularly is suited to detect, classify, and identify maritime targets. These aircraft are refurbished versions of retired U.S. Air Force C-27J Spartan tactical transport aircraft. Regeneration of all 14 aircraft is scheduled for this year 2018.

Telephonics provides the APS-143G and AN/APS-508 multi-mission intelligence, surveillance, and reconnaissance (ISR) radar systems for medium to large fixed-wing aircraft on long-range surveillance missions over sea, land, or air.

The radar systems are designed for maritime, littoral, and land surveillance applications, and has an integrated identification friend or foe (IFF) interrogator. The AN/APS-508 is deployed aboard the Royal Canadian Air Force CP-140 Aurora aircraft.

The AN/APS-508 radar is built together by Telephonics and MacDonald, Dettwiler and Associates (MDA) in Richmond, British Columbia, and manufactured by Lockheed Martin Canada (LMC) in Ottawa. It provides an advanced multi-mode surveillance and imaging capability including ground moving target indicator mode.

The HC-27J aircraft has night vision goggle-compatible cockpit seats, and accommodates two pilots and one loadmaster. In addition to the multi-mode radar, the plan also has the fixed-wing Minotaur mission system suite and avionics for mission performance and safety. It also has military communications, surveillance systems, integrated surface search radar, and electro-optical and infrared sensors.

The HC-27J has two Rolls-Royce turboprop engines and two six-blade composite propellers. It can fly at a cruise speed of 290 knots, and has a maximum speed of 317 knots. It has a range of 2,675 nautical miles and an endurance of 12 hours.

On this contract, Telephonics will do the work in Farmingdale, N.Y., and should be finished in May 2023. For more information contact **Telephonics** online at *www.telephonics.com.* ←

EMBEDDED COMPUTING

HAMAR chooses Kontron computer board to qualify secure information gateway

Trusted computing experts at RECAB Embedded Computers AB in Hamar, Norway, needed a single-board computer to qualify the company's secure information gateway using VPX technology. They found their solution from Kontron in Augsburg, Germany.

HAMAR designers chose the Kontron VX3052 single-board computer to qualify the data gateway. The Kontron VX3052 computer board, designed on a multilayer computer architecture of three-slot single board computers interfaced to each other by an independent data link.

The 3U VPX architecture supporting 10-Gigabit Ethernet brings performance to the gateway, and supports the maintenance capability that RECAB needs for the integrated secure information gateway.

RECAB has been in charge of the 3U VPX secure information gateway system architecture, and overall system design, including the 3U VPX backplane and of the integration of the computer boards and removable drives.

The VX3052 is a two-core and four-thread Intel D-1508 single-board computer with on-board soldered DDR4 SDRAM which features two 10-Gigabit Ethernet Base-KR as well as two 1-Gigabit Ethernet Base T interfaces.

Kontron answers digital security requirements at board level with hardware-enforced root of trust with a dual secure elements, and software-only techniques such as secure boot.

"The certification of secure information gateway systems using Kontron 3U VPX has motivated our customers to adopt such a versatile technology," says Bjørn Espen Aase, managing

director at RECAB. "The Kontron VX3052 features the right balance of processing and communication for secure embedded systems." For more information, contact **Kontron** online at *www.kontron.com*, or **RECAB Embedded Computers** at *http://recab.com*.

MILITARY AVIONICS

Navy picks open-systems avionics flight computers from General Dynamics for combat jets

U.S. Navy avionics experts needed replacement and repair of flight computers for the Navy's F/A-18E/F Super Hornet, EA-18G Growler, and AV-8B Harrier strike fighter and electronic warfare combat jets. They found their solution from the General Dynamics Corp. Mission Systems segment in Bloomington, Minn.

The Naval Supply Weapon Systems Support activity in Philadelphia is awarding General Dynamics a five-year $17.3 million contract to repair, replace, and support Advanced Mission Computer (AMC) systems, which are considered mission critical to operations of these aircraft.

The Navy awarded the contract sole-source to General Dynamics. This is an urgent requirement and only General Dynamics was asked to bid on the contract, as the company is the manufacturer of the AMC flight computers for these aircraft. This contract includes a five-year base period and one five-year optional period, which if exercised, will bring the contract value to $36.3 million.

General Dynamics designs and builds the Type 3 AMC for the Super Hornet and Growler aircraft, as well as The Mission Systems Computer (MSC) for the AV-8B Harrier jump jet. The AMC is a rugged embedded computer that performs general-purpose, I/O, video, voice, and graphics processing. Communication is over several buses, including 1553, Fiber Optic Fibre Channel, and Local PCI.

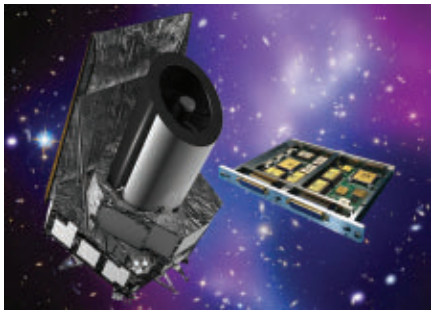
On the flight computer upgrade contract, General Dynamics will do the work in Bloomington, Minn., and should be finished by April 2023. For more information contact **General Dynamics Mission Systems** online at *https://gdmissionsystems.com*, or the **Naval Supply Weapon Systems Support** activity at *www.navsup.navy.mil*.

SPACE ELECTRONICS

OHB Italia chooses rad-hard embedded computing from DDC for ESA Euclid space telescope

Space electronics designers at OHB Italia SpA in Milan, Italy, needed radiation-hardened embedded computing to support instruments aboard the European Space Agency (ESA) Euclid visible to near-infrared space telescope. They found their solution from Data Device Corp. (DDC) in Bohemia, N.Y.

Officials of OHB Italia will deploy the DDC SCS750 single-board computers for space for the ESA Euclid satellite, which is scheduled for launch in 2021. They chose the DDC SCS750 for its high reliability design, high-performance processing capability and TRL-9 space proven experience.



"DDC's SCS750 space computers were selected for their high performance, triple-redundant high reliability, and space-proven computing capabilities, combined with DDC's demonstrated commitment to providing the highest levels of quality and dependability, with zero failures in space," says Elio Mangraviti, OHB's head of electronic units and scientific payloads.

OHB is developing the main electronic units of the two instruments of the Euclid satellite: the visible imager (VIS) and near infrared spectrometer and photometer (NISP). The DDC SCS750 space computers will be used on the NISP and VIS. The ESA Euclid spacecraft includes a near-infrared space telescope designed to map the dark universe.

The VIS images in the visible spectrum to derive dark matter content and properties by studying the tiny deformation of galaxy shapes due to weak gravitational lensing. Its focal plane array is made of 36 large area, back-illuminated, red-enhanced charge-coupled device (CCD) detectors.

The NISP operates between 900 and 2000 nanometers, and provides near-infrared photometry of all galaxies observed, along with VIS and near-infrared low-resolution spectra and redshifts of millions of galaxies.

The SCS750 is part of the Euclid satellite's control and data processing unit (CDPU), which controls the instruments, switches between the different instrument modes, and sequences the operations within each exposure.

The processor executes the real-time lossless compression of data from the 36 CCDs, including their buffering and packetization. An overall daily production of about 120 gigabytes is expected.

OHB is working under a contract with the Italian Space Agency with the scientific contribution of INAF OABO1 (Bologna Astronomical Observatory), INFN2 (Istituto Nazionale di Fisica Nucleare) and IAPS3 (Istituto di Astrofisica e Planetologia Spaziali) for the ESA4 EUCLID mission.

DDC's SCS750 single-board computers use silicon-on-insulator PowerPC processors and radiation-hardened parts, including DDC's RAD-PAK memories, with triple-redundant processing algorithms that provide error detection and correction.

These boards have single-event-upset (SEE) performance of less than one error in 80 years. They can resist 100 kilorads of total-dose space radiation, and are immune to single-event latchup (SEL). For more information, contact **DDC** online at *www.ddc-web.com*. ←

new PRODUCTS

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

CONNECTORS

Enhancements to rugged connectors for military applications introduced by Fischer

Fischer Connectors in Alpharetta, Ga., is introducing extensions to the company's ultra-dense Fischer MiniMax rugged connector series for aerospace and defense applications like unmanned vehicles. The new connectors offer high-speed AWG24 Ethernet data transfer; enhanced IP68 sealing down to 20m/24h; hexagonal body style; and anthracite coating. A new contact block configuration of eight AWG24 pins in a receptacle of 12 millimeters diameter enables fast Ethernet data transmission over long distances. The new configuration can help move Ethernet connectivity into more rugged environments, protected from the elements with enhanced IP68 ratings. Fischer is increasing the depth that the Fischer MiniMax

series connectors can achieve safely, providing enhanced reliability for extreme environments. Sealing ensures the connectors can be submerged as deeply as 20 meters for 24 hours. The Fischer MiniMax series receptacles also come in a hexagonal body style. For more information, contact **Fisher Connectors** online at *www.fischerconnectors.com*.

EMBEDDED COMPUTING

3U VPX Xeon-based board with improved cooling introduced by Abaco

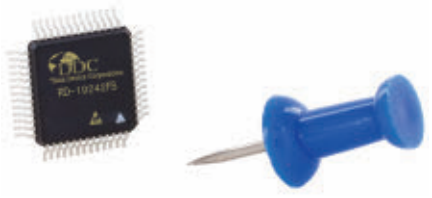
Abaco Systems in Huntsville, Ala., is introducing the SBC347D 3U VPX single-board computer with improved electronics cooling for demanding high-performance embedded computing (HPEC) military and aerospace applications such as command and control; intelligence, surveillance, and reconnaissance (ISR); signal processing; radar and sonar; and electronic warfare (EW). Abaco uses a space-grade thermal-management technology to enable the board's 12-core Intel Xeon D-1500 processor to operate at 100 percent of its capability at temperatures to 75 degrees Celsius in a

conduction-cooled environment. Traditional solutions throttle the CPU by as much as 50 percent of its core frequency to maintain the processor within its rated temperature range to avoid failure. Abaco's thermal-management technology in the computer board heat frame removes and spreads heat while maintaining 500-volt electrical isolation. Not only is the SBC347D able to perform at relatively high temperatures, but also is lighter weight than traditional solid metal heat sinks. For more information, contact **Abaco** online at *www.abaco.com*.

MOTION CONTROL

Rugged resolver-to-digital converter for motion-control introduced by DDC

Data Device Corp. (DDC) in Bohemia, N.Y., is introducing the RD-19242 compact and reliable resolver-to-digital converter for today's rugged, high-reliability, motion-control applications. The converter is a flexible motion-control solution with user-programmable resolution, bandwidth, and tracking rate, enabling it to interface with a wide range of synchro, resolver, inductosyn, LVDT, RVDT, MR, and Halls sensor applications. The

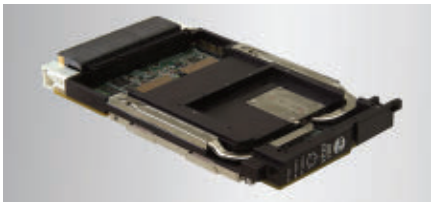


converter has an integrated reference oscillator that reduces cost and external component count, and a serial output (SPI) that uses relatively little processor I/O, freeing up I/O resources for other requirements. The DDC RD-19242 offers a standard off-the-shelf solution that enables fast time to market; RD-19242EX-3L0 development kit that offers a way to evaluate DDC's RD-19242 resolver-to-digital converters; programmable resolution, bandwidth, and tracking rate; encoder emulation that enables replacement of an encoder with a rugged resolver; -55 to 125 degrees Celsius operating temperature range; and serial output. For more information, contact **DDC** online at *www.ddc-web.com*.

BOARD PRODUCTS

Xeon-based 3U OpenVPX computer board for defense introduced by Curtiss-Wright

The Curtiss-Wright Corp. Defense Solutions division in Ashburn, Va., is introducing the high-performance VPX3-1260 3U OpenVPX single-board computer based on the Intel Xeon E-2176M Coffee Lake processor for aerospace and defense embedded computing applications. The VPX3-1260 is for general-purpose mission computing applications that require high processing performance and low power consumption in demand-



ing deployed applications like mission computing, image and display processing, virtualization, and small multi-computer board intelligence, surveillance, and reconnaissance (ISR) systems. The Xeon E-2176M's six-core (12-thread) architecture delivers 2.7 GHz performance that increases

to 4.4 GHz with the processor's Turbo Mode. It offers a performance improvement over previous generations of Intel Core i7 and Xeon processors, and is a processing engine for system designers seeking the maximum amount of performance-per-watt. For more information, contact **Curtiss-Wright Defense Solutions** online at *www.curtisswrightds.com.*

RF AND MICROWAVE

RF loads for quick mating in base stations and antennas introduced by Pasternack

Pasternack Enterprises in Irvine, Calif., is introducing a line of RF loads with 10 different types of connectors for quick mating in military base stations, antennas, and test instrumentation. Pasternack's 24 connect terminations are available with QMA, QN, 4.3-10, SMP, SMP-M, and

BMA connectors for quick snap-on or push-on mating. These RF loads support operating frequency ranges from DC to 40 GHz. The RF and microwave loads deliver a voltage standing wave ratio (VSWR) as low as 1.1:1 and maximum input power as strong as 2 watts. Some models are available with chains. These quick-connect RF loads improve flexibility of installation and eliminate the need for wrench or torque for thread coupling. The QMA model is made of tri-metal-plated brass, the SMP model is gold-plated brass, the SMP-M is made with gold-plated beryllium copper, and the 4.3-10 model is nickel-plated brass. These terminations are for the defense, aerospace, industrial, and telecommunications industries. For more information, contact **Pasternack** online at *www.pasternack.com.*

COMPUTER BOARDS

Rugged XMC card for VPX defense embedded computing introduced by Kontron

Kontron in Augsburg, Germany, is introducing the rugged XMC-GPU91 switched mezzanine card (XMC) in the 1-inch pitch standard VITA VPX form factor for defense programs that span several years. The XMC-GPU91 features the AMD Embedded Radeon E9171 power-efficient graphics processing unit (GPU), and supports the PCI Express 3.0 interface for high data throughput. It features 12-millimeter stacking height for thermal management and cooling. The XMC-GPU91 can combine with an off-the-shelf single-board computer to form a high-performance computer board and GPGPU combination. It takes advantage of the PCI Express 3.0 architecture 16-core Intel Xeon D processors. The AMD E9170 series general-purpose graphics processing unit (GPGPU), based on the Polaris architecture, leverages an optimized 14-nanometer FinFET manufacturing process to provide as much as three times the performance per watt over previous generations of AMD embedded GPUs. For more information, contact **Kontron** online at *www.kontron.com.*

RADIO COMMUNICATIONS

Secure military and civil airborne software-defined radio introduced by Rohde & Schwarz

Rohde & Schwarz in Munich is introducing the R&S SDAR airborne software-defined radio with secure, high-rate data communications that can be certified for military and civil use. The R&S SDAR is an IP-based radio that supports the porting of waveforms independently of the manufacturer. The radio is designed as an open platform based on the international Software Communications Architecture

standard, with a strict separation between the radio's hardware and waveforms. That makes it possible to port SCA-based waveforms, including those from other manufacturers, as well as legacy waveforms to the radio. It enables users to create and modify embedded encryption along with the waveforms to set up secure communications channels that provide interoperability between different branches of a country's armed forces. The radio protects data, and promotes information superiority in joint operations and combined missions. For more information, contact **Rohde & Schwarz** online at *www.rohde-schwarz.com.*

SWITCHED FABRICS

OpenVPX embedded computing switch with health management introduced by VadaTech

VadaTech in Henderson, Nev., is introducing the VPX004 OpenVPX embedded computing switch with integrated health management. Its device manages power, cooling, and as many as 12 payload modules within the chassis. It also manages the PCI Express Gen3 switch and the standard

Gigabit Ethernet with 10 Gigabit Ethernet uplink base channel switch, with support from an enterprise grade Layer 2 or 3 switching/routing stack with Synchronous Ethernet capability. The VPX004 is redundant when used with a second instance of the module, and firmware is HPM.2 compliant. The unit has optional advanced clocking features, including grand master clock and clock distribution and synthesis to enable GPS, IEEE 1588, SyncE, ad NTP. For more information, contact **VadaTech** online at *www.vadatech.com.* ←

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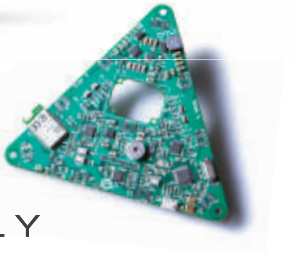

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