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Active protection for battle tanks

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Mitigating RF interference

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Laser weapons show their stuff

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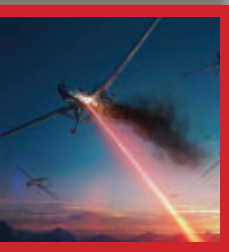

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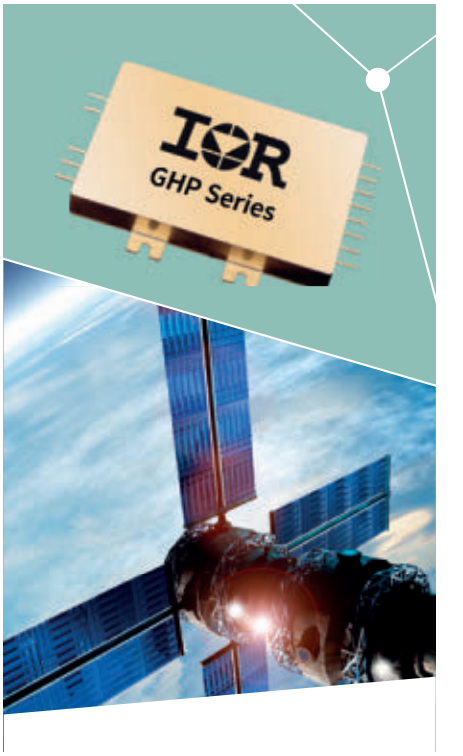

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BY **JOHN KELLER**, EDITOR IN CHIEF

Is the world ready for an undersea missile?

Military forces throughout the world are obsessed with speed. Jet aircraft, the missile, even the lowly bullet typically go faster than the speed of sound. Everywhere is a preoccupation with speed. In fact, today's most advanced militaries are working on so-called hypersonic missiles that eventually could travel through the air at about seven times the speed of sound, or 5,320 miles per hour.

That kind of speed means a hypersonic missile could hit a target 100 miles away in little more than a minute — not much time for countermeasures and evasive maneuvers. It's little wonder that speed is a top priority among military weapons developers.

How is it that the obsession for speed hasn't extended into the realm of undersea warfare? Submarines aren't too fast, but they shouldn't be. Their job is to lurk silently and undetected until that fateful moment when they launch a missile or torpedo.

The torpedo — signature weapon of the submarine — isn't very fast, either. The U.S. MK 48 torpedo achieves a top speed of about 55 knots, or 63 miles per hour. That's about as fast as a minivan full kids in the slow lane of the freeway ... not exactly the best comparison when describing a formidable modern weapon. It certainly pales in comparison to missiles and rockets.

But what if a torpedo could move at 200 knots? That's 230 miles per hour — not even close to supersonic, but still a mind-boggling speed underwater. A 200-knot torpedo essentially would be an underwater missile. Is this even possible, and if so, why don't we hear more about it?

Well, the underwater missile is real. It's called the supercavitating torpedo. The Russians have built one called the VA-111 Shkval, which can reach underwater speeds in excess of 200 knots. Iran reportedly has developed a variant of the Russian Shkval called the Hoot. The German navy is credited with developing the Superkavitierender Unterwasserlaufkörper supercavitating torpedo, but it never went into production. The U.S. Navy is said to be toying with supercavitating torpedo technology.

These undersea missiles achieve their speed essentially by encasing the torpedo inside a bubble to eliminate the water's hydrodynamic drag. Once inside this bubble, and free of the water's drag, a rocket engine shoots the munition through the water faster than a NASCAR racer.

Supercavitation, by the way, refers to phenomenon in which water is forced around an object like a ship's propeller at high speeds. This causes the pressure around the object's trailing edge to below the water's vapor pressure, causing bubbles. This is bad for modern submarine propellers, because it creates noise that can enable an enemy to detect it. It's good, though, when attempting to shoot objects like torpedoes through the water at high speeds.

So why haven't supercavitating torpedoes come to revolutionize war at sea? It seems this technology also causes big problems with torpedo guidance, control, and precise targeting.

Conventional torpedoes steer themselves toward their targets with control surfaces that, in the water, act like an airplane's wings, rudder, and elevator in the air.

One big problem with supercavitating torpedoes is they can't stick control surfaces outside their protective bubble, lest the bubble bursts. No control surface contact with the water means no control of the torpedo; it goes in a straight line, period. This means they're prone to missing their targets.

Modern torpedoes home in on their targets with passive and active sonar. They must be able to hear the sound emitting from their targets, as well as a return signal from a sonar ping.

Supercavitating torpedoes don't have this advantage because they're really, REALLY LOUD — too loud to hear much of anything. From a guidance standpoint, it can't tell the difference between an enemy ship or submarine, and a rock formation.

So, a supercavitating torpedo is fast, but it's also can't steer very well, and can't hear its target. Is it a viable weapon today? That's questionable.

All that could change, though, once someone figures out an efficient way to maneuver them, and enable them to home-in on their targets. Then they will be formidable weapons, and that day may not be too far off. ←

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Navy eyes Tomahawk missile for anti-ship role

Smart munitions experts at the Raytheon Co. are moving forward with a U.S. Navy program to retrofit the venerable Block IV Tactical Tomahawk missile for the anti-ship role with a new sensor system to enable the weapon to attack moving enemy vessels at sea. Officials of the Naval Air Systems Command at Patuxent River Naval Air Station, Md., have announced plans to award a contract to the Raytheon Missile Systems segment in Tucson, Ariz., to upgrade the Tactical Tomahawk guidance test set to support Maritime Strike Tomahawk (MST) integration and test efforts. The value of the upcoming contract has yet to be negotiated. Raytheon will provide updated technical data package (TDP) upgrade test units to the Maritime Strike Tomahawk configuration. Raytheon will integrate seeker technology and processing capabilities into the Tactical Tomahawk Block IV missile to enable it to hit moving targets at sea. The company will provide analysis, modeling, simulation, evaluation, prototyping, final integration, test, and delivery of a seeker and processor for the Tactical Tomahawk missile, and prepare for missile recertification. The Maritime Strike Tomahawk will enable Navy cruisers, destroyers, and attack submarines to attack maneuvering enemy vessels.

Army eyes new lightweight, maneuverable battle tank to transform land warfare

The U.S. Army is evaluating plans to build prototypes of a new highly deployable lightweight mobile protected firepower armored vehicle that is *[PAGE 6]*

DRS Land Systems for active protection aboard M1A2 Abrams main battle tanks

BY **John Keller**

WARREN, Mich. — U.S. Army armored combat vehicle experts needed active protection systems to shield the Army's fleet of M1A2 Abrams main battle tanks from rocket-propelled grenades, anti-tank guided missiles, and similar threats. They found their solution from DRS Land Systems in St. Louis.

DRS Land Systems is adapting Israeli-developed technology to help shield M1A2 Abrams main battle tanks from rocket-propelled grenades and anti-tank guided missiles.

Officials of the Army Contracting Command in Warren, Mich., announced a $192.5 million two-year contract to DRS Land Systems to build Abrams Active Protection Systems for the M1A2 tank.

DRS will provide the active protection systems, sets of countermeasures and calibration and maintenance kits for the Abrams M1A2 system enhancement program (SEP) version 2.

DRS is working together with Rafael Advanced Defense Systems Ltd. in Haifa, Israel, to adapt the Rafael Trophy active protection system to the M1A2 Abrams tank. Rafael developed Trophy together with the Elta Group of Israel Aerospace Industries Ltd. in Ashdod, Israel. The Trophy system intercepts and destroys incoming missiles and rockets with a shotgun-like blast.

Trophy is designed to locate and destroy incoming enemy fire instantly using a 360-degree radar, processor, and on-board computer. It can locate, track, and destroy approaching anti-tank-guided-missiles, rocket-propelled grenades, or similar anti-armor weapons by launching a countermeasure to detonate the incoming munition away from the vehicle.

The interceptor uses small shaped charges attached to a gimbal on top of the vehicle. The small explosives fire to a point in space to intercept and destroy the approaching round. Trophy locates and identifies incoming threats with radar that scans the tank's perimeter out to a known range. The onboard computer determines the optimal kill point for any incoming threat.

Trophy has been used in combat on Israeli Merkava tanks. In addition to locating and destroying incoming missiles and rocket-propelled grenades, the system also can locate and cue weapons to the positions enemy shooters.

The DRS-Rafael Trophy system can defeat all known anti-armor shaped-charge weapons, like missiles, rockets,

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[FROM PAGE 4] expected to change land warfare by bringing new options to help advance infantry as it maneuvers toward enemy attack -- and outmatching Russian equivalents. Long-range precision fire, coordinated air and ground assault, mechanized force-on-force armored vehicle attacks, and drone threats all are changing so quickly that maneuvering U.S. Army infantry needs better firepower from battle tanks to advance on major adversaries in war, Army leaders explain. The Army is evaluating industry proposals in anticipation of awarding developmental deals by next year — with prototypes to follow shortly thereafter. The service's request to industry describes the Mobile Protected Firepower program as providing integrated brigade combat teams with direct-fire, as well as long-range and cyber-resilient capability for forcible early entry operations. The effort intends to find the optimal blend of lethality, mobility and survivability. Senior Army leaders say that the new Mobile Protected Firepower program will be more survivable and superior than its Russian equivalent.

Pentagon has secret artificial intelligence program to find hidden nuclear missiles

The U.S. military is increasing spending on a secret research effort to use artificial intelligence to help anticipate the launch of a nuclear-capable missile, as well as track and target mobile launchers in North Korea and elsewhere. The artificial intelligence (AI) effort has gone largely unreported, and the few publicly available details about it are buried under a layer of near impenetrable jargon in the latest Pentagon budget. But U.S. officials familiar with the research told Reuters there are multiple classified programs now under way to explore how to develop [PAGE 8]

and tank-fired high-explosive anti-tank shells before they strike the tank.

The system enables networked threat awareness by pinpointing and reporting shooter location improves platform protection with low risk of collateral injury, and can ensure freedom of movement and maneuver, DRS officials say.

On this contract DRS Land Systems will do the work in St. Louis, and should be finished by March 2020. ←

For more information contact ***DRS Land Systems*** *online at* www.leonardodrs.com/locations/drs-land-systems-st-louis-mo, *or the* ***Army Contracting Command-Warren*** *at* http://acc.army.mil/contractingcenters/acc-wrn.

Leonardo DRS to provide rugged computers for military networked battle

BY **John Keller**

SCOTT AIR FORCE BASE, Ill. — U.S. military battlefield computing experts needed a modular family of rugged computers that integrates networked battle command information system capabilities onto a common computing platform. They found their solution from Leonardo DRS Network & Imaging Systems LLC in Melbourne, Fla.

Officials of the Defense Information Technology Contracting Organization at Scott Air Force Base, Ill., announced a potential $841.5 million contract to Leonardo DRS for the Mounted Family of Computer Systems (MFoCS) II program.

MFoCS integrates Force XXI Battle Command Brigade-and-Below and Joint Battle Command-Platform (JBC-P) capabilities into a common computing system. The MFoCS II program primarily is in response to U.S. Army battlefield computing requirements.

MFoCS supports situational awareness, command and control, and maneuver capability with next-generation rugged computers and displays that several different configurable levels. Systems include ruggedized tablet computers, processors, keyboards, removable solid-state disks, displays, and cabling.

DRS Network & Imaging Systems a modular family of rugged computers to the military to integrate networked command information onto a common computing platform.

This contract to Leonardo DRS is for computer hardware and services for full-rate production, fielding, and replacement requirements to meet JBC-P program requirements. DRS is the original MFoCS contractor.

JBC-P consists of ultra-rugged computers, software, and Suite B encryption security that enables warfighters to send and receive friendly force position location.

It JBC-P essentially is a follow-on to, or advanced component of, the Army's Force XXI Battle Command Brigade and Below (FBCB2) program, and will be interoperable with the current FBCB2 Blue Force Tracking (BFT) system.

The FBCB2 provides battlefield situational awareness to enable fast, well-informed decisions. The JBC-P is expected to enhance FBCB2 performance, and reduce the risk of fratricide.

For the remainder of this decade and into the 2020s, MFoCS is designed to push the leading edge of technology from inception to retirement in combat computing, whether in compliance with the Army's VICTORY (Vehicular Integration for C4ISR/EW Interoperability) initiative, security, or ruggedization.

The Army awarded the MFoCS contract to DRS in 2013 in a potential $455 million deal. The contract calls for DRS to build a variety of vehicle-mounted command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) equipment.

The foundational element of the MFoCS program is the rugged tablet that warfighters can mount in combat vehicles, as well as disconnect the tablets and continue using them while operating on foot. This enables warfighters in vehicles to share what they are seeing on their screens with warfighters operating on foot.

Battlefield commanders can work on a tablet in a combat vehicle, and then take the computer into a command post and dock it.

Leonardo DRS will receive a minimum of $5 million, and will fulfill task orders collectively worth as much as $841.5 million. On this contract Leonardo DRS will do the work in Melbourne, Fla., and should be finished by May 2024.

For more information contact ***Leonardo DRS*** *online at* www.leonardodrs.com, *or the* ***Defense Information Technology Contracting Organization*** *at* www.disa.mil/Mission-Support/Contracting.

[FROM PAGE 6] AI-driven systems to better protect the United States against a potential nuclear missile strike. If the research is successful, such computer systems would be able to think for themselves, scouring huge amounts of data, including satellite imagery, with a speed and accuracy beyond the capability of humans, to look for signs of preparations for a missile launch, according to more than half a dozen sources, included U.S. officials, who spoke on condition of anonymity because the research is classified.

U.S. Air Force to boost nuke sniffing with modified C-130 turboprop aircraft

When the Air Force dispatches aircraft to the Asia-Pacific to monitor the atmosphere for signs of nuclear activity from North Korea, it relies on its WC-135 Constant Phoenix nuke-sniffing planes. But with only two of those in the service's inventory, it's possible the WC-135s might not be able to respond to every contingency. Enter the ever-versatile C-130 Hercules, which now can be equipped with a modular kit that allows it to detect nuclear particles in the atmosphere. The Air Force spent $10.1 million in 2016 for two "Harvester Particulate Airborne Collection System" kits that can be strapped onto C-130H/Js and collect microscopic nuclear solids if the service can't make its WC-135 aircraft available, said Susan Romano, a spokeswoman for the Air Force Technical Applications Center (AFTAC), which is responsible for conducting nuclear surveillance for the Defense Department. The system operator first would use Harvester's Directional Gamma Radiation Sensor (DGRS) to pinpoint the radioactive plume. This particular component consists of four large sodium iodide radiation detectors and a complex processing algorithm. ←

Raytheon developing ship antennas to handle radar, radio, and EW simultaneously

BY **John Keller**

ARLINGTON, Va.— U.S. Navy shipboard electronics experts are pushing forward with a project to design dynamic multi-mission radar antennas able to carry out functions like surveillance, communications and electronic warfare (EW) simultaneously.

The U.S. Navy is asking Raytheon to develop dynamic multi-mission radar antennas for simultaneous surveillance, communications and electronic warfare.

Officials of the Office of Naval Research (ONR) in Arlington, Va., announced a $9.5 million order to the Raytheon Co. Integrated Defense Systems segment in Tewksbury, Mass., for the Flexible Distributed Array Radar (FlexDAR) effort.

In this order, Raytheon will demonstrate how combining every-element digital beamforming, network coordination, and precise time synchronization can enable multiple-input and multiple-output (MIMO) operation to improve shipboard target detection, tracking, and electronic protection.

MIMO uses several transmit and receive antennas to multiply the capacity of an RF link like radar by exploiting multipath propagation. It sends and receives more than one data signal simultaneously over the same radio channel.

MIMO is one way for systems designers to reduce the number of RF transmit and receive antennas on large platforms like surface warships. Placing many antennas in a relatively small space can cause cross RF interference.

FlexDAR is part of the Navy's Integrated Topside (InTop) program to develop a scalable family of EW, radar, signals intelligence (SIGINT) and communications systems for several classes of Navy surface ships and submarines.

In 2012 ONR researchers asked 18 InTop contractors to work on developing a scalable family of radar antennas as part of the InTop FlexDAR project. The InTop program began in 2009.

The InTop program seeks to dominate the RF spectrum and create affordable, scalable antennas and antenna subsystems on Navy surface ships and submarines not only for radar, but also for EW and RF communications systems.

A growing number of antennas aboard today's surface combatants has led to problems with electro-magnetic interference (EMI), radar cross sections, and the overall performance of shipboard electronic warfare, radar, and communications systems.

In addition to Raytheon, the InTop contractors are:

- ATK Space Systems in Dayton, Ohio;
- Argon ST in Fairfax, Va.;
- BAE Systems in Nashua, N.H.;
- Ball Aerospace & Technologies Corp. in Broomfield, Colo.;
- Boeing Co. in Seattle;
- Cobham Defense Systems in Landsdale, Pa.;
- Colorado Engineering Inc. in Colorado Springs, Colo.;
- DRS Signal Solutions Inc. in Germantown, Md.;
- FTL Systems Inc. in Rochester, Minn.;
- General Dynamics Mission Systems in Fairfax, Va.;
- Harris Corp. Radar Systems in Van Nuys and Thousand Oaks, Calif.;
- HYPRES Inc. in Elmsford, N.Y.;
- Lockheed Martin Corp. in Moorestown, N.J.;
- Northrop Grumman Corp. in Baltimore;
- S2 Corp. in Bozeman, Mont.; and
- Southwest Research Institute in San Antonio, Texas.

The FlexDAR project is developing technology to enhance the capabilities of future radar sensors including software-defined digital re-configurability at the foundational level, Raytheon officials say.

The program demonstrates radar and radar-to-radar communications for bi-static radar exchange and control, which increases detection and firm-track range and improves electronic protection.

Raytheon has designed an InTop FlexDAR radar front-end, and built two identical multi-function array antennas for ONR's Chesapeake Bay Detachment near Chesapeake Beach, Md., to demonstrate network-linked, distributed sensors and explore next-generation radar capabilities.

On this order Raytheon will do the work in Tewksbury, Mass., and should be finished by February 2019. ←

For more information contact ***Raytheon Integrated Defense Systems*** *online at* www.raytheon.com, *or the* ***Office of Naval Research*** *at* www.onr.navy.mil.

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Laser weapons show their stuff in real-world conditions

From surface warships, jet fighter aircraft, military tactical vehicles, and even unmanned systems, laser weapons are demonstrating with increasing frequency that they are ready for the battlefield

BY **J.R. Wilson**

The 21st Century already has seen more "science fiction" become everyday fact than at any other time in history, from smart phones that make Star Trek's communicators appear primitive to the Robonaut — a C3P0-like humanoid robot working on the International Space Station — to perhaps the most iconic of all: laser weapons.

Directed-energy weapons (DEWs) have been a staple of future warfare depictions since H.G. Wells published "War of the Worlds," with its Martian "heat rays," 120 years ago. Hughes Aircraft engineer and physicist Theodore Harold Maimain generally is credited with inventing the laser, firing the world's first coherent light — in-phase rays of the same wavelength — from his solid-state pink ruby laser on 16 May 1960.

Progress from that point moved steadily forward technologically, but lasers found little support from military leaders, who saw them as little more than weak, short-range toys. One of the first large-scale productions of lasers actually was in toys, along with laser pointers. As they became stronger, with longer ranges, the military began using laser beams to illuminate targets; warfighters on the ground or aboard helicopters would focus a beam on a target, and a rocket, typically fired from a second platform, would follow the beam to the target.

Laser-guided weapons improved significantly during the long post-9/11 wars in Iraq and Afghanistan, becoming part of the U.S. military's arsenal of precision guided weapons that greatly reduced collateral damage to property and non-combatants. Experiments continue to expand the way in which lasers are and will be used by the military, such as recharging unmanned aerial vehicles (UAVs) in flight.

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Disabling battle tanks

Weapons that could halt enemy tanks and infantry or bring down hostile UAVs, bomb-carrying balloons, or manned aircraft, disable satellites, or destroy missiles in flight remain a top goal — and one that already has been demonstrated and almost certainly will see widespread military deployment by the 2020s. How soon they will become an integral and significant part of U.S. military capability "is a customer-driven decision," Ron Dauk, a program manager for laser and electro-optical systems at the Boeing Co. Directed Energy Systems segment in Albuquerque, N.M.

"We are starting to see customers purchase multiple laser weapons systems and move toward how to integrate those into standard deployed combat forces. So I would say that time frame is sooner rather than later, perhaps even this year, Dauk says. "The technologies and capabilities are relative enough to demonstrate that, as we have with the Stryker system in Germany in recent months. So I think it's coming pretty soon," he says.

Some of the near-term pushes in deployable laser weapons are in ground and naval applications, which is probably where laser weapons will first cross the threshold to be deployed, Dauk says. "There is more of a challenge in airborne systems that can operate effectively within the constraints of an airborne platform. So the Army and Navy probably will be the first, but with the Air Force not far behind."

With all the services working on laser weapons, he adds, the near term will see several new opportunities to bring unique capabilities to the battlefield, to engage targets very cost-effectively, and meet the need for a mix of various responses and capabilities. "They provide a great solution to shooting down a $600 quad-copter with a dollar-a-shot laser," Dauk says.

The ability to bring lasers to all kinds of high-level applications probably will happen between 2025 and 2035, Dauk says. "We're looking at how to bring lasers to all kinds of higher-level applications, such as ship defense for airborne self-protection," Dauk says. "Lasers can provide solutions to some very hard targets right now — and with the technology increasing and developing, they

Fast-moving laser weapons like this prototype mounted to a light tactical military vehicle depend on reducing component size, weight, and power consumption (SWaP).

really are becoming a viable option, to the point where the military can seriously consider a laser weapons system in their mix of capabilities."

Won't replace kinetic weapons

Rhoan Boucher, directed energy lead for Boeing's Integrated Air and Missile Defense, is quick to note laser weapons, despite rapid technological evolution and unique capabilities, will not replace existing or future kinetic weapons in the foreseeable future.

"We view lasers as complementary to current systems, not competitive. It allows field commanders to dial an effect. They want the option to be able to decide what the best mix is to go after a particular target and lasers will increase those options, today and in the future, while keeping costs low," he says.

The Army Space and Missile Defense Command (SMDC) at Redstone, Arsenal, Ala., is in charge of meeting requirements for lasers in missile defense for Army UAVs and helicopters, and for ground troops and vehicles. The Army is looking at several potential laser weapon systems, platforms and use strategies, including enhancing the maneuver force with adjustable non-lethal-to-lethal lasers mounted on combat vehicles.

One of those efforts demonstrated arming a Stryker combat vehicle with a 5-kilowatt Mobile Expeditionary High-Energy Laser (MEHEL), which completed a hard-kill challenge at White Sands Missile Range, N.M., before going to Fort Sill, Okla., where regular soldiers began testing it, says Lt. Gen. James Dickinson, commander of Army Space and Missile Defense Command.

Significant milestone

The next challenge is to install a 100-kilowatt laser on a Family of Medium Tactical Vehicles (FMTV) truck to provide laser weapons for brigade combat teams. Those programs and others mark a significant milestone in the history of laser weapons.

"These are no longer lab systems. They are being built and taken out into the field or being readied for deployment. We're no longer talking about the art of the possible," says Rob Afzal, senior fellow-laser and sensor systems at Lockheed Martin Rotary and Missions Systems. "We're just at the beginning and these systems will evolve to more power from the laser, more capability from the sensors and

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continuing reduction in SWaP [size, weight and power], so they can be more capable on more platforms."

Laser weapons offer several advantages, Afzal says. "Its importance, is two-fold: great precision with low collateral damage and, second, the cost-exchange ratio. If the operation of the system is very low-cost, once installed, being able to use it in an asymmetric way against other low-cost threats will play a very important role."

Laser weapons are moving out of the laboratory and into the field at a quickening pace. "We're focused on moving laser weapons systems out of the lab and onto the battlefield to give our warfighters a decisive advantage," says Ben Allison, high-energy laser product line director of advanced concepts and technology at Raytheon Space and Airborne Systems in El Segundo, Calif.

"With that goal in mind, we're investing in ready-now capabilities and near-term technologies," he says. "For example, we've put the MTS [Multi-spectral Targeting System] at the center of our solution. With more than 4 million combat hours, it's a proven sensor with unmatched detection and tracking capabilities. We're coupling MTS with mature, fiber-combined lasers and demonstrating our capabilities in real-world scenarios.

Raytheon demonstrated the company's High-Energy Laser Weapon System (HELWS) late last year at the Army's Maneuver Fires Integrated Experiment at Fort Sill, Okla., aboard a Polaris MRZR small all-terrain vehicle. The system identified, tracked, fired on, and destroyed a mix of 12 small- and medium-sized UAVs. Company officials also worked with separate Army organizations to demonstrate the HELWS on the AH-64 Apache attack helicopter.

Parts of a system

Allison notes the laser itself is only one component of a laser weapons system. "The laser is just part of the solution. The beam director, power and thermal systems are equally important components. State-of-the-art for HEL is about the art of the possible. It comes down to how you make the subsystems — beam directing, power, and thermal — work together to create an integrated solution. Optimization is the key," he says, adding creating such an optimized and integrated solution opens the door for lasers in a wide range of applications."

The U.S. Air Force Self-protect High Energy Laser Demonstrator (SHiELD) program seeks to integrate a high-energy laser onto a tactical aircraft for self-protection against incoming threats.

Almost every military platform considered appropriate for laser weapons is under consideration for HELWS, Allison says. Some examples include the Navy and U.S. Marine Corps Humvee, the Army the Stryker and FMTV, and the army and U.S. Special Operations Command (SOCOM) AH-64 attack helicopter and MH-60 utility helicopter.

Also under consideration for laser weapons is the MRZR light tactical vehicle for rapid deployment, the F-15 jet fighter for the Air Force Research Laboratory's Self-protect High Energy Laser Demonstrator (SHiELD) program, and the AC-130 utility turboprop aircraft. "Fixed installations for area protection also are important," Allison says.

The U.S. Air Force has long pushed the boundaries of laser and support technologies, seeking ways to integrate a high-energy laser and the power and cooling systems they require into the already densely packed spaces in military aircraft, especially jet fighters.

Air Force aircraft and spacecraft also share responsibility for missile defense. The Air Force directed-energy weapons flight plan systems in development are to deliver effects against adversary systems and not directly against humans.

The Air Force Research Laboratory (AFRL) Directed Energy Directorate at Kirtland Air Force Base, N.M., is overseeing several laser weapon efforts, yet its SHiELD project is the science and technology priority. SHiELD's goal is to integrate a high-energy laser system onto a tactical aircraft to demonstrate self-protection against incoming threats.

Laser systems have been integrated into several ground and sea military platforms like the Army's HEL-MD demonstrator and the Navy's Laser Weapon System (LaWS), as well as large aircraft like the Airborne Laser [ABL] and the Advanced Tactical Laser.

Raytheon is working with U.S. Special Operations Command to fire a directed energy beam onto a ground target from the AH-64 Apache attack helicopter, shown above, as well as from other military helicopters.

Size, weight, and power

"SHiELD will take these advances one step further in reducing size and weight and ruggedizing the system for use on a tactical aircraft," says Michael Jirjis, directed energy experimentation lead at the Air Force Research Lab.

"The Air Force is also pushing money to other efforts not within AFRL, examining options to use some directed energy prototyping funding on an AC-130 gunship and to support the high-value aircraft defensive mission set," Jirjis says.

The Air Force Strategy document — "America's Air Force: A Call to the Future" — calls directed energy a "game-changing" technology offering transformational capabilities to airmen, enabling them to "effectively, affordably and rapidly defeat massed attacks from an adversary and to strike critical targets at the speed of light," according to the Air Force directed-energy weapons flight plan.

"These same weapons can provide the ability to precisely engage targets of interest with little to no collateral impacts or detectable disturbance and provide protection to Air Force assets that must operate in harm's way. directed-energy weapons provide flexibility by offering an increased range of effects when used in conjunction with conventional weapons. The range of effects include destroy, damage, disable or disrupt and the effects can be permanent, temporary or reversible," the Flight Plan states.

While great strides have been made in the past few years, the next generation of laser weapons will need advancements in several areas to make such systems more operationally viable against a larger number of targets, Allison says. Those areas include high-density power systems based on lithium battery technology; sensors and tracking; advanced RF systems; laser power from tens to hundreds of kilowatts,

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depending on the mission; and all laser ranges from base defense near-range to long ranges for advanced capabilities.

"Advanced algorithms and computing contribute to a more capable target track system, providing for quicker, more precise and more efficient engagements, says the Air Force Research Lab's Jirjis. "The power and thermal management system directly impacts the rate at which you can fire and recharge the high-energy laser. Advanced optics provide greater sensor and effector capability in a variety of conditions."

Raytheon is demonstrating a prototype high-energy laser weapon for its suitability for tactical aircraft like the AH-64 Apache attack helicopter, shown above.

Lasers aren't just all about weapons. "Airborne high-energy laser systems will be used as hybrid sensors and effectors for certain target sets in the near future," Jirjis says. "Lasers may ensure aircraft survivability and defend against long-range threats. Ground-based high-energy laser systems will soon become a limited — but key — part of the Air Defense network. Eventually, they may even replace some certain kinetic air defense systems. The Navy has already fielded demonstrators on ships and is aggressively driving development and fielding more advanced systems."

Lockheed Martin has demonstrated the company's Advanced Test High Energy Asset (ATHENA) laser against medium-sized UAVs like the MQM-170C G2 Outlaw, shown above.

Busy laser activity

The past year has seen a significant level of activity and program advancements in laser weapons, says Lockheed Martin's Afzal. The first program that Lockheed Martin won was Laser Advancements for Next-generation Compact Environments (LANCE), an Air Force Research Lab to build a high-power laser.

LANCE is part of a larger program called SHIELD, which is a demonstration to put laser weapon into a pod, Afzal says. The company also won the next phase of the Army High-Energy Laser Tactical Vehicle Demonstrator (HELTVD) program to put a laser on a military truck.

"The biggest award of that period was from the Navy for the High Energy Laser and Integrated Optical-dazzler with Surveillance [HELIOS], to build and deliver a complete laser weapon for integration onto a destroyer. Its function is to engage and destroy UAVs and small boats. It also has a non-lethal optical dazzling capability over long distances to dazzle surveillance sensors," Afzal says.

Where the world is headed with laser weapons is part of discussions within each armed service and collectively across the U.S. Department of Defense, U.S. allies, and potential adversaries. Discussions range across applications, from short-range, low-power, and non-lethal to high-energy lasers capable of destroying a ballistic missile in flight.

"Across all our military services and agencies, everyone has some type of technology demonstration or prototype under development," says Paul Shattuck, director of directed energy systems at Lockheed Martin Space Systems in Sunnyvale, Calif. This has led to major acquisitions and programs of record, he says.

Lockheed Martin's Advanced Test High Energy Asset system, also known as ATHENA, is a prototype laser weapon system designed to defeat close-in, low-value threats like rockets, UAVs, and small boats. It is a transportable, ground-based system that serves as a low-cost test bed for demonstrating military laser weapons technologies. A ruggedized variant of the system would be suitable for military operations.

"ATHENA is a complete, self-contained laser weapon system designed primarily for tactical operations, such as defending forward bases against rockets, artillery, UAVs," Shattuck says. ATHENA has been in operation since 2012, and this past year was 5-for-5 in tests against the MQM-170C G2 Outlaw medium-size UAV from Griffon Aerospace in Madison, Ala.

In the Fall of 2017, the Missile Defense Agency (MDA) in Huntsville, Ala., awarded contracts to Lockheed Martin, General Atomics, and Boeing to develop preliminary designs for the Low Power Laser Demonstrator (LPLD), concluding two years of concept designs. During Phase 3, tentatively scheduled for 2019 through 2023, one or more of those designs will be built and flight-tested to demonstrate the ability to acquire a missile in flight and hold the laser beam steadily on-target.

The role of artificial intelligence

The question of whether artificial intelligence may be relevant for laser weapons hovers over the technology. "As multiple asymmetric threats become more prevalent, AI could play a significant role in detection, targeting and aim point selection and maintenance," says Raytheon's Allison.

Many grades of artificial intelligence exist today for target detection, identification, and tracking, yet in the near future a human always will be involved in the process.

"In next-generation systems, you'll see more intelligence added into the laser weapon, especially as new intelligence and targets come on line," Allison says. "As you add in continuing improvements in targets, laser weapons will be integrated into larger systems of systems and a layered type of defensive system, with various sensors fused together and tasking of weapons depending on who has the highest possibility of prosecuting the mission."

Determining how these weapons will function in the real world will play an important role. "As you get these into the field, it's really learning their capabilities, probably finding things you didn't expect that will open up new avenues for offensive and defensive operations and rules of engagement — and that's when they really come into their own," Allison says.

Lasers won't replace legacy weapons

There is general agreement across the military that laser weapons will not replace legacy nor future new kinetic systems, but will become a significant and integral part of a new offensive and defensive, lethal and non-lethal, increasingly accurate, flexible, multi-platform weapons system-of-systems.

Raytheon is demonstrating the feasibility of designing mobile laser weapons mounted to light tactical vehicles to protect warfighters and equipment on the front line from unmanned aircraft, rockets, mortars, and artillery shells.

Unlike the past four decades, however, the U.S. will not be alone in this evolution and is certain to face peer and near-peer adversaries who are pouring more and more resources into developing and quickly fielding weapons that will change the face of warfare.

"We can no longer rely on superior numbers of weapons and must leverage disruptive technologies to increase the effectiveness of our weapons. Although directed energy weapons cannot replace kinetic capabilities, they have the potential to become powerful new force-multipliers and greatly reduce the overall cost of conducting key U.S. offensive and defensive operations," predicts the Air Force Research Lab's Jirjis.

"In particular, a combination of non-kinetic and kinetic systems could enable U.S. forces to prevail more rapidly over enemies fielding sophisticated anti-access/aerial denial weapons," Jirjis says. "Lasers and High-Power Microwaves are being explored to offer transformational capabilities in combat scenarios to ensure our airmen the highest protection in an ever-increasingly dangerous environment."

Mitigating electromagnetic and radio-frequency interference

Aerospace and defense engineers focus on component- and system-level EMI/RFI protection to help ensure platform effectiveness and mission success.

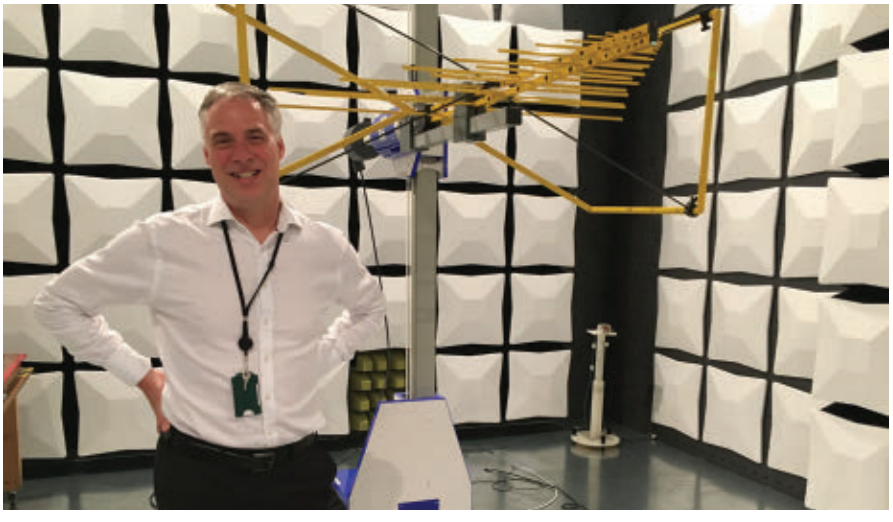
BY **Courtney E. Howard**

Electromagnetic interference (EMI) — noise or disturbances over a very broad frequency spectrum — increasingly is becoming an important factor in modern electrical designs, says Jeremy Ferrell, standard product engineering manager at power electronics specialist VPT Inc. in Blacksburg, Va.

"The complexity of designs is growing at an exponential rate, causing a higher probability of interaction between circuit subsections," Ferrell says. "If the emitted noise from each circuit interacts with one another, unintended results will occur."

Aerospace and defense vehicles employ an ever-increasing amount of electronic and electrical systems, each of which can incorporate a growing number of components — and all are capable of emitting and succumbing to electrical and electronic noise.

"Increased use of digital components in ever-denser assemblies has made EMI protection even more critical in system designs," explains Valerie Andrew, strategic marketing architect at Elma Electronic in Lawrenceville, Ga. "Factors at all levels of a system must be considered. At the PCB [printed circuit board] level, for example, crosstalk and component density play a critical role in the emissions; EMI interference levels are affected by the materials used and the number of apertures in the chassis enclosures and racks. Even cabling must be considered for the deployed platform."



RFI experts at Curtiss-Wright Defense Solutions use an anechoic chamber to determine some of the best ways of mitigating unwanted RF energy.

Two-way street

Aerospace and defense systems designers are integrating components from different manufacturers at the platform level, says Chad Hutchinson, director of engineering at rugged computer specialist Crystal Group Inc. in Hiawatha, Iowa. If one is generating noise and another is susceptible to the noise, there's a problem, he adds. "You'll have issues with susceptible electronics not being able to operate correctly; it could fail during an operation or do the wrong thing at the wrong time, which could result in personnel injuries, damage to the equipment, or a failure of the mission or whatever the application happens to be."

EMI mitigation always has been a critically important factor in embedded computing defense and aerospace systems, says Doug Patterson, vice president of the military and aerospace business sector at Aitech Defense Systems in Chatsworth, Calif. "Today, with lower noise floors and tighter change-of-state voltage margins in high-speed serial systems, spurious EMI can play havoc with any unprotected systems.

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It's not only the susceptibility to incoming radio-frequency (RF) radiation that's a concern. Mitigating the outgoing emissions of a system is of equal importance."

EMI, including the radio-frequency interference (RFI) subset of noise within the RF spectrum from 20 kHz to 300 GHz, generally is a two-way street, explains Paul Pino, principle electrical engineer at Gore Microwave Cable Assemblies in Landenberg, Pa. "If a cable assembly is capable of producing sizable amounts of interference, it also is likely to be susceptible to receiving sizable amounts of the same."

Mitigating EMI and radio frequency interference (RFI) is comprehensive and typically involves ensuring components neither are emitting nor susceptible to electrical noise. "Integrating a complex communications system on a vehicle platform has to account for every potential RF noise source on that platform, and mitigate or suppress them all, not just some," says Aitech's Patterson.

COTS complications

In more and more cases, engineers are using militarized or rugged commercial off-the-shelf (COTS), Crystal Group's Hutchinson says. COTS components bring several benefits, such as a high technology refresh rate and lower costs compared to full military standard or MIL-SPEC counterparts, but "commercially available items not designed for the electromagnetic spectrum present some very unique challenges from susceptibility standpoint."

COTS parts sometimes require special handling when operating in an EMI and RFI environment. "When it comes to militarizing or ruggedizing electronics, in many cases you can take existing COTS electronics and provide shielding, such as encasing the entire piece of electronics inside a Faraday cage that shunts radiated emissions to ground and creates boundary layer between the outside environment and electronics itself."

Sometimes designing with COTS parts requires special attention to cables and connectors, Hutchinson explains. "You also can do filtering on signal lines and power cables to protect against equipment generating noise or noise in outside world," Hutchinson adds. "You can use a filter at the interface point that will contain those emissions, and prevent them getting from one component to the other. That will only get you so far, especially when talking about trying to [apply a bandage to] an existing piece of electronics."

Aitech power supplies, including the company's new rugged 3U VITA 62 P233 PSU, have added EMI/RFI L-C power filters built into the unit to help suppress RFI noise generated by the internal switching regulators within the unit.

Sometimes the solution involves keeping surrounding components as electronically quiet as possible. "Military standards are so high for knocking down emissions; you need to not generate the noise to begin with," Hutchinson says. "In such situations, militarized COTS is not a viable solution; instead, it's advantageous to use a true MIL-SPEC solution designed from the ground up to comply with EMI requirements, such as RTCA DO-160 and MIL-STD-461, and apply filtering and shielding on that, as well."

Chassis contemplations

"Interference from external equipment or mechanical parts can cause noise and influence on analog/digital signaling of operational system," says Dan Mor, general-purpose graphics processing unit (GPGPU) product manager at Aitech.

"Emissions from the operational system itself on external equipment, which can be mission-critical, also can disturb the proper operation of peripheral systems," Mor says. "The system should be immune from external noise and not produce noise to the outside word. These are two main reasons why EMI/EMC is so important. Almost every new project we have — in avionics, ground fixed, ground mobile vehicles, etc. — requires EMI mitigation or EMC. Sometimes we need to prove that our products are designed and manufactured to meet these requirements and specifications."

Incorporating EMI/RFI mitigation — and EMC — at the system chassis will help filter a majority of the energy from the power or input/output lines in question, Aitech's Patterson says. "Tuned, low-pass filters shunt that excess energy to ground from the incoming power lines as well as susceptible signal lines, greatly reducing the potential of spurious effects."

Each sealed ATR chassis Aitech has delivered over the past 35-plus years has an EMI/RFI filter on the power input lines to filter out incoming — and outgoing — RF radiation, Patterson says. The company's power supplies also have added EMI/RFI L-C power filters built into the unit to help suppress RFI noise generated by the internal switching regulators within the unit. "It's always best to suppress any potential RFI noise at the source, whenever possible," he adds.

Problematic power supplies

"As data rates become faster due to the use of Ethernet and CAN-based networks on aircraft, at the same time composites are replacing the Faraday-cage protection afforded by aluminum aerostructures, EMI/RFI mitigation is becoming increasingly important," says Paul Hart, chief technology officer and technical fellow at Curtiss-Wright Defense Solutions in Christchurch, England.

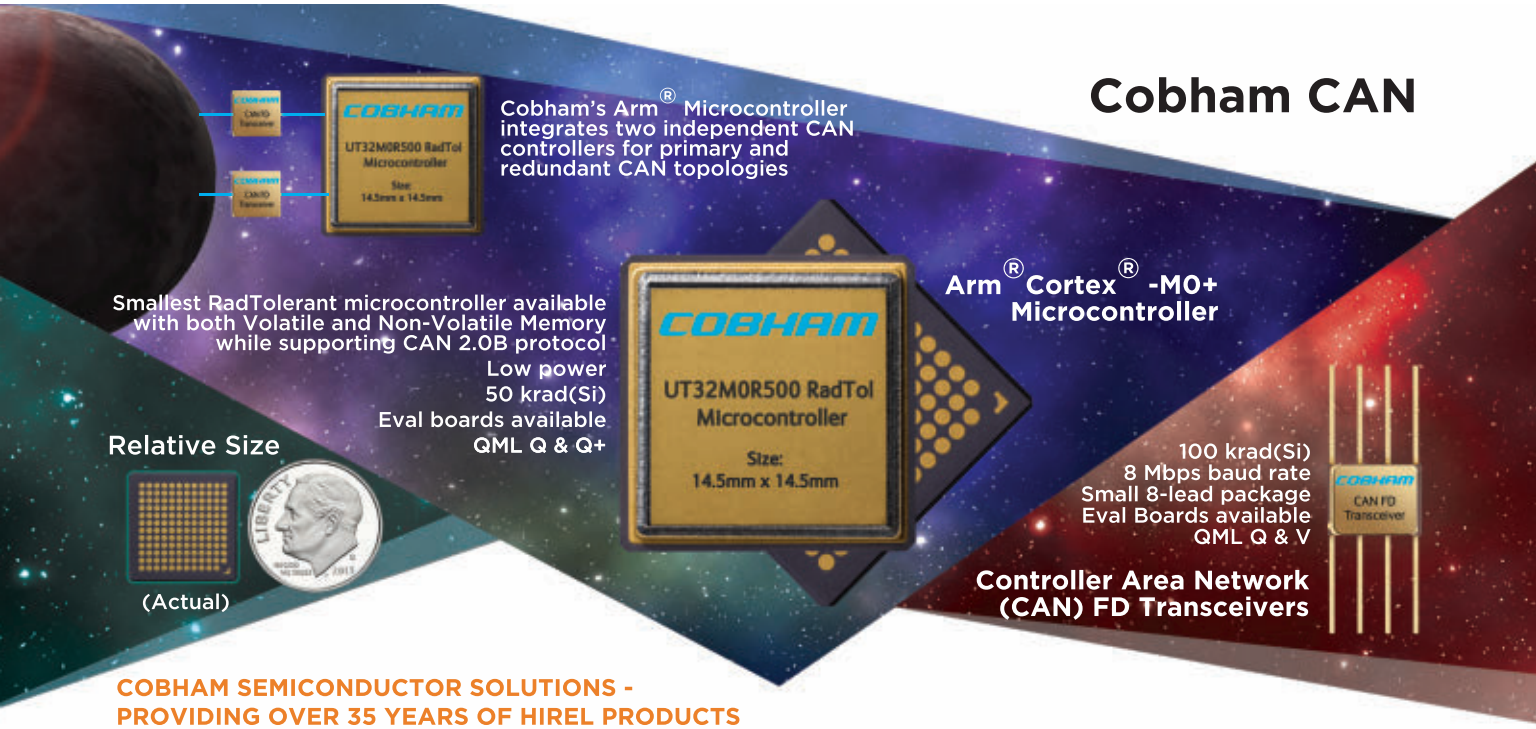
Several EMI/RFI mitigation strategies are implemented on avionics and mission systems to guarantee reliable operation in a high electrical noise environment, Hart says. "In addition to screening of signal wires to prevent crosstalk and using separate connectors for different signal types, design of the electrical power scheme is crucial," Hart says. "For example, conducted and radiated noise emissions from the power supply need to be minimized using filter networks. These prevent interference with other equipment in close proximity."

Other design approaches also can come into play. "Metalwork screening and RFI gaskets around the power supply reduce stray emissions and provide further immunity from external interference," Hart continues. "In addition, power supplies will generally isolate the input and output voltages — using isolation transformers and/or isolated DC-DC converters. These minimize stray currents by preventing multiple return paths back to ground."

A honeycomb filter sits on the exterior of an Elma Electronics system and helps reduce EMI/RFI through the individual cells, which reflect and absorb noise.

One of the main noise generators in circuits is the switching power supply, which has very fast switching transients with possibly high voltage, VPT's Ferrell explains.

"The switching power supply chops up input voltage to give what you need on the output side," Crystal Group's Hutchinson says. "To get those voltages, most power supplies in the server world are switching on and off fast;



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every switching transient looks to the outside world like noise."

It causes a conducted noise on the input voltage bus and a radiated noise that can couple to surrounding circuits, Ferrell says. Engineers focus on many different ways to reduce both the radiated and conducted emissions from switching power supplies.

"The testing limits are governed by a couple of different specifications. For military and aerospace applications, most customers look to MIL-STD-461 for limits on both conducted emissions and radiated emissions. VPT uses this standard along with others to ensure parts meet the noise requirements," Ferrell says. "This is accomplished in most cases by adding an additional EMI filter that is matched to our switching power supply design. The filter in combination with proper system layout ensures the requirements are met."

Power supplies can be one of the main noise generators in circuits, and should be examined closely to determine the best EMI and RFI mitigation techniques.

Rugged remedies

Crystal Group engineers militarize existing COTS electronics to ensure they can operate in the electromagnetic spectrum for which they were not originally designed — and power supplies present a particular challenge, Hutchinson says. "Most commercial power supplies are not inherently quiet, so we developed a team here to design power supplies from the ground up to be truly MIL-SPEC. We develop and use a custom filter targeted at the noise range you are generating."

No matter the remedies, it seems, some nagging challenges can remain. "Given the challenges with power supplies and very tight emission restrictions, such as the more stringent RTCA DO-160 requirement for flight-based defense aviation, you just can't [apply a bandage] and get the level of emissions required," Hutchinson says. "We needed to have the talent here to design from ground up to not generate noise in the first place; and where you have to generate noise, like when switching frequencies, you design input filters to prevent it from getting to the outside world. When you do all that together, you end up with a total solution for the best possible performance."

Adding an EMI filter is an excellent start to reducing conducted and radiated emissions from a switching power supply, but it also is critical that the switching power supply and EMI system layout is done properly, Ferrell says. "This includes keeping the EMI filter and power supply very close together, ensure the output of the switching power supply does not cross the input of the EMI filter, choosing an EMI filter and power supply that is enclosed in a six-sided metalization, and shielding any wires or traces going to switching loads."

To achieve true electromagnetic compatibility (EMC), engineers and systems integrators need to look at spectrum management, Hutchinson says. "At the platform level, you need to be managing the full spectrum of your individual component suites. The best way is for every device to be compliant with MIL-STD-461. It is important to look at the total system-level impact of noise and determine if you can live with that outage or whether that frequency is something you need to go after and eliminate."

Cabling concerns

"You can have the best-designed enclosure in the world, but if it is connected to a cable or interface that is not properly bonded or shielded, the system will radiate or be susceptible to noise throughout the environment," Crystal Group's Hutchinson cautions. "Other equipment can't differentiate whether the noise is coming from your box or a cable connecting it to the vehicle — and frankly, it doesn't matter; it's still noise. Proper bonding and shielding of cables properly terminated at both ends are needed."

The objective of cable shielding is essentially to keep out noise and signals external to the cable and to keep in the signal of interest, Gore's Pino says. When a cable assembly is sensitive to EMI/RFI, the signal of interest — i.e., the signal being conveyed through the cable — can be compromised or even rendered unintelligible by interference.

"Take a full-wave antenna that's only 9.2 centimeters at PCI Express speeds, or even less at higher PCI Express rates, for example," Aitech's Patterson says. "A short piece of unshielded or unprotected wire 9.2 centimeters long will resonate at 3.25 GHz, transferring all the available radiated energy of the incoming signal directly onto that I/O line. A 30 GHz high-energy radar pulse only needs an antenna approximately 1 centimeter long to create a full-wave resonant antenna.

"As the internal processor frequencies get higher, and the change-of-state margins decrease, to keep up with the demand for higher performance and throughput, dealing with EMI/EMC will continue to be a challenge," Patterson adds. "In many cases today, systems designers will need to carefully consider the use of overbraid shielding on all the I/O cabling that runs through the

platform to reduce the susceptibility to induced EMF [electromagnetic flux] from RFI and lightning strikes, both near-field and direct strikes."

Capable cables and connectors

EMI and RFI mitigation is a growing concern for several reasons, Gore's Pino says. "Today's military electronic warfare (EW) and radar systems are operating at higher frequencies and higher power levels. Regarding cable assemblies in microwave applications (300 MHz to 300 GHz), as frequency increases, it becomes more challenging to effectively shield the cable assembly.

A variety of products are available, such as flanges and gasketing, to help reduce the influence of stray RF energy.

"Higher-frequency signals coupled with an increase in transmitted power can result in an increase in radiated power due to shield leakage," Pino continues. "This combination can place electronic equipment or even other cable runs adjacent to the radiating component at greater risk for interference." Troubleshooting a signal interference problem, especially in an aircraft, can be daunting. Effective shielding of cable assemblies and electronic components is critical to system performance, he says.

As with any technical problem, Pino says the first step toward resolution lies in understanding; and, understanding grows naturally through testing and characterization. It's important to understand that shielding effectiveness is not strictly a cable-related phenomenon, he adds; rather, connectors and cable termination play into the equation, as well.

"For military aircraft applications, EMI/RFI challenges can be addressed through a number of tactics," Pino says. With electronic components, use application-appropriate shielding enclosure designs," Pino says. "In applications where cable installation or aircraft servicing can potentially damage cables, use ruggedized microwave cables with proven shield designs capable of withstanding the rigors of installation and servicing."

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Common-sense procedures can make a lot of difference, Pino says. "Ensure all coaxial connections are clean and tightened to the proper torque settings. In high-vibration environments, be sure cables are properly secured and use locking connector coupling nuts or coupling nuts drilled for lock wire holes. In microwave cable airframe installations, don't try to stretch a cable to make a connection. Be sure to use properly sized P-clamps when securing cables. Cable placement is critical: if possible, don't position cables in close proximity to high-power emitting antennas."

Good advice also can go a long way, Pino says. "In commercial applications, instruct technical personnel on the finer points of proper microwave cable assembly care and handling. It is particularly important when using non-ruggedized or general-purpose cables as they are considerably more fragile than their ruggedized counterparts. Cable assembly shielding problems are often the result of damage due to improper handling. Discourage the practice of repeatedly bending cables just behind the connector or coiling cables in tight loops for storage — doing so exposes the assemblies to unnecessary wear and tear. Lastly, proper microwave connector care and maintenance is key to preserving their mechanical and electrical integrity to maintain performance."

Cables, especially microwave cables, often are the last component to be considered when a system is under design; yet, it cannot be over-emphasized how impactful cable performance can be on overall system performance, Pino says. "Customers often treat cables as ideal or near-ideal functioning components, thinking there's not much difference from one product to another. The common thinking is that cables simply link one critical system to another. In reality, a microwave cable is a critical system unto itself, capable of imparting unintended results in system performance. Customers rarely consider how a cable's performance can degrade with improper handling, damage inflicted during installation, or degradation over time due to poor design or construction."

Mitigation for military and aerospace

System complexity is only going up, which increases the need for designers

to become more familiar with proper EMI reduction and shielding techniques, VPT's Ferrell says. "EMI requirements need to be thought of at the beginning of the design to ensure compliance at the end. Failure to do so can result in long schedule delays that stem from design changes that are required due to EMI testing."

Working with the customer in the early stages makes it much easier to consider all the factors that will affect EMI protection, Elma's Andrew says. "We examine it from the functional board set (masking) to the backplane (crosstalk), to box (material type), to cabinet and cabling (EMC attenuation protocols). The best advice we can give is to make sure you work with the platform and component suppliers as early as possible in the development process; it's much easier to design a system that successfully meets specs and delivers the protection required."

Systems designers should look for every opportunity to attack EMI and RFI. "Digital frequency and component density are likely to increase, so EMI attenuation will always be a factor in system designs," Andrew says. "There are mitigation techniques at all levels of design, from the inside out."

EMI/RFI mitigation schemes rapidly will evolve as the energies of radiated and conducted emissions increase, Aitech's Patterson predicts; but so far, this has been handled by a relatively simple inductor-capacitor resonant, low pass filter. "Combining inductors and capacitors has been around since the early days of heterodyne tube radios. It's just that the Ls and Cs are getting smaller, as the frequencies and bandwidths increase."

The RF environment, which is already filled with a variety of noise sources and interference, will only become even more crowded, Pino says. "In the future, EMI/RFI-resistant systems and components will play an even greater role in overall system reliability." ←

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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, however, 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. In the latest issue of Nature, 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. "The most promising thing about this work is that you can optimize your photonics independently from your electronics," says Amir Atabaki, a research scientist at MIT's Research Laboratory of Electronics. "We have different silicon electronic technologies, and if we can just add photonics to them, it'd be a great capability for future communications and computing chips."

Marvin to provide guided missile launchers for Air Force and Navy planes

Aircraft weapons experts at Marvin Engineering Co. in Inglewood, Calif., will provide the U.S. Air Force with 1,450 guided missile launchers for combat aircraft under terms of a $126.6 million five-year contract. Officials of the Air Force

Lockheed Martin to extend shipboard EW with on-board helicopters

BY **Edward J. Walsh**

NATIONAL HARBOR, Md. — Lockheed Martin Corp. is extending the reach of Navy shipboard electronic warfare (EW) systems to SH-60S and SH-60R helicopters by means of its Advanced Offboard Electronic Warfare (AOEW) system.

That's the word from Joe Ottaviano, Lockheed Martin's director for electronic warfare, who made his comments at the Navy League Sea-Air-Space conference and trade show earlier this spring in National Harbor, Md.

The Lockheed Martin Mission Systems and Training segment in Syracuse, N.Y., is integrating the AOEW active mission payload in a pod designated ALQ-248. The SH-60S and SH-60R are variants of the Navy's SH-60 Seahawk.

The "S" is designated primarily for mine countermeasures, the "R" is fitted out for anti-submarine warfare operations, although both conduct combat search and rescue, surveillance, and other missions.

Lockheed Martin is prime contractor for Block 2 of the Navy's long-term surface warfare improvement program (SEWIP), which started in 2002 to upgrade the Raytheon-developed passive SLQ-32(v) electronic warfare system aboard surface ships. General Dynamics Advanced Information Systems won a 2003 contract for Block 1 SEWIP to address SLQ-32(v) obsolescence.

Lockheed Martin won the Block 2 work in 2009 to modernize electronic support antennas, receivers, and interface to the SLQ-32(v). (The currently fielded system, incorporating upgrades to date, is SLQ-32(v)6.)

The U.S. Navy is using helicopters to extend the electronic warfare reach of surface warships.

In early 2015 the Navy awarded Block 3 work to Northrop Grumman, which will add an electronic attack capability. The Navy also plans to pursue a Block 4 effort to incorporate electro-optic and infrared sensors to the '32(v) system.

The AOEW pod aboard the SH-60S and SH-60R helicopters can be integrated with the SLQ-32(v)6 system aboard Ticonderoga-class (CG 47) cruisers and Arleigh Burke (DDG 51) destroyers, through the ships' Aegis combat system, to detect approaching threat missiles and generate electronic countermeasures. The pod also will be able to operate independent of the ship.

Lockheed Martin won the Navy contract in early 2017 to develop the AOEW pods system, and to build 18 units if all options are exercised.

The company also is upgrading the ALQ-217 passive electronic support measures system now fielded to the E-2C and E-2D Hawkeye maritime surveillance aircraft. The system consists of four antennas, four active front ends, and a receiver/processor. The upgrade increases system power and replaces older analog components with digital technology. ←.

Northrop Grumman to upgrade U.S. early warning military radar

BY **John Keller**

PETERSON AIR FORCE Base, Colo. — Military radar experts at Northrop Grumman Corp. will modernize and upgrade three ageing ground-based warning radar systems to help protect the U.S. and its allies from enemy ballistic missile attack.

Officials of the Air Force Life Cycle Management Center at Peterson Air Force Base, Colo., announced a maximum $866 million five-year contract to the Northrop Grumman Mission Systems segment in Chantilly, Va., to modify and sustain the Precision Acquisition Vehicle Entry Phased Array Warning System (PAVE PAWS); the Ballistic Missile Early Warning System (BMEWS); and the Perimeter Acquisition Radar Attack Characterization System (PARCS).

Northrop Grumman is upgrading three ageing ground-based early warning radar systems to help protect the U.S. and its allies from enemy ballistic missile attack.

PAVE PAWS is a ground-based radar system that provides U.S. Strategic Command (USSTRATCOM) at Offutt Air Force Base near Omaha, Neb., with warning and attack-assessment information on all intercontinental ballistic missiles (ICBMs) launched throughout the world that might be headed for U.S. territory.

BMEWS, meanwhile, is a ground-based radar system that helps warn USSTRATCOM and NATO authorities of submarine- and sea-launched ballistic missile (SLBM) attacks and provides data to help evaluate the severity of ballistic missile attacks.

PARCS is a large radar installation in North Dakota that provides ballistic missile warning and attack assessment, as well as space surveillance data to the North American Aerospace Defense Command (NORAD) at Peterson Air Force Base, Colo., as well as to USSTRATCOM and regional combatant commanders. PARCS monitors and tracks more than half of all Earth-orbiting objects with its AN/FPQ-16 phased-array radar system pointed northward over Hudson Bay, and analyzes more than 20,000 tracks per day, from giant satellites to space debris.

The PAVE PAWS and BMEWS beam steering unit (BSU), receiver exciter (REX), receiver beam former (RBF), array group driver (AGD), radio frequency monitor (RFM), frequency time standard (FTS), and the corporate feed (CFD) were built for these five radars in the late 1970s and were upgraded in the 1980s, Air Force officials say.

The REX and FTS already have been redesigned and upgraded at Beale Air Force Base, Calif., Fylingdales, England, and Thule, Greenland sites as part of the Upgraded Early Warning Radar (UEWR) programs. They were to be upgraded at the Clear, Alaska, and Cape Cod, Mass., sites by 2016 or 2017, officials say. ←

Life Cycle Management Center at Robins Air Force Base, Ga., are asking Marvin to provide the LAU-129/128 guided missile launcher and launcher subassemblies for Air Force F-15 and F-16 jet fighters, we well as for the U.S. Navy F/A-18 Hornet fighter bomber. The Marvin LAU-129/128 aircraft missile rail launcher is for firing the AIM-12 Advanced Medium-Range Air-to-Air Missile (AMRAAM), AIM-9 Sidewinder missile, and similar weapons. It attaches to the aircraft wingtip or under wing pylons. The launcher has a self-contained power supply, converts analog to digital signals, and comes with nitrogen bottle or self-contained compressor for seeker cooling. The LAU-129/128 fits F-15, F-16, and F-22 jet fighters, the F/A-18 jet fighter-bomber, and the military Humvee ground vehicle when fitted as a ground anti-aircraft missile launcher. Internationally, the launcher also can fire the Derby and Python missiles. For more information contact **Margin Engineering** http://marvineng.com, or the **Air Force Life Cycle Management Center-Robins** at www.robins.af.mil.

BAE Systems to provide radar-controlled deck guns for Coast Guard cutters

U.S. Navy surface warfare experts are ordering two computer- and radar-equipped deck guns for large U.S. Coast Guard offshore cutters under terms of a $16.4 million order. Officials of the Naval Sea Systems Command in Washington are asking the BAE Systems Platforms & Services segment in Minneapolis to build two 57-millimeter MK 110 Mod 0 gun mounts and related hardware. The MK 110 GM consists of a 57-millimeter gun, muzzle velocity radar, power distribution panel, barrel-mounted television camera, and ruggedized laptop computer gun control. ←

Navy eyes UUV weapons payloads to stop or disable 160-foot ships at sea

BY **John Keller**

The U.S. Navy wants to develop an unmanned underwater vehicle fast enough to run down 160-foot ocean vessels.

NEWPORT, R.I. — U.S. Navy unmanned underwater vehicle (UUV) experts are surveying industry for enabling technologies for future UUVs to stop or disable large ocean-going vessels as long as 160 feet. Experts are interested in lethal or non-lethal UUV weapons payloads, as well as ways to speed UUVs accurately to their targets.

Officials of the Naval Undersea Warfare Center Division Newport (NUWCDIVNPT) in Newport, R.I., have issued a request for information (N66604-18-R-2397) for explosive or non-explosive technologies that could enable a UUV to stop or disable boats and ships shorter than 50 meters long (164 feet).

For reference, a 50-meter vessel is roughly as long as a medium-sized luxury yacht, or a U.S. Coast Guard Sentinel-class fast-response cutter. This RFI is to gather information on best practices, technology solutions, and cost estimates for UUV modular lethal or non-lethal weapons payloads and enhancements.

The Navy's request for information is to help experts understand market availability, technical characteristics, cost, and functionality of information technology (IT) tools, applications, or products for enabling UUVs to stop or disable 50-meter vessels, and to provide the Navy with an asymmetrical warfare advantage during UUV operations in complex, shallow-water, and cluttered littoral environments.

The idea is to detect, understand, and react to threats in this environment that pose significant risk to the warfighter and other military assets. Officials of the Naval Surface Warfare Center Indian Head EOD Technology Division (NSWCIHEODTD) in Indian Head, Md., also will use information provided from industry.

The project has two objectives: to investigate UUV effector payloads for UUVs can stop or disable maritime vessels of less than 50 meters in length; and investigate technologies to give UUVs the speed and navigational precision to deliver effector payloads to stop or disable ocean vessels.

The first objective is to investigate UUV effector payloads that can be integrated into, deployed from or attached to a UUV to help it stop or disable maritime vessels shorter than 50 meters. The means of disablement may be kinetic or non-kinetic and the effect may be lethal or non-lethal.

The effector payload must be able to be transported and deployed from an UUV or be part of the UUV itself. Navy researchers want the maximum effect from the smallest possible UUV.

The second objective is to investigate commercial or developmental UUV capability enhancements that will result in increased UUV speed and positional and placement accuracy to deliver the effector payload. Industry white papers may address one or both objectives.

Companies interested should email responses no later than 31 Aug. 2018 to the Navy's Christopher Patty at christopher.patty@navy.mil. Email questions or concerns to the Navy's Gregory Harris at gregory.s.harris@navy.mil. ←

More information is online at https://www.fbo.gov/spg/DON/NAVSEA/N66604/N66604-18-R-2397/listing.html.

Navy asks Metron to develop advanced modular payloads for unmanned undersea vehicles

BY **John Keller**

ARLINGTON, Va. — Machine autonomy experts at Metron Inc. in Reston, Va., are developing advanced modular payloads for unmanned undersea vehicles (UUVs) under terms of an $8 million contract.

Officials of the U.S. Office of Naval Research (ONR) in Arlington, Va., are asking Metron UUV experts to undertake this research as part of a 2017 long-range broad agency announcement for Navy and Marine Corps science and technology research. This contract to Metron has options that could increase its value to $21.1 million.

The ONR solicitation that pertains to this contract to Metron encompasses technology research in expeditionary maneuver warfare and combating terrorism; command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR); ocean battlespace sensing; sea warfare and weapons; warfighter performance; naval air warfare and weapons.

Metron has years of experience in machine autonomy to enable long-endurance UUVs to operate autonomously in many different kinds of challenging ocean environments.

In late 2015 ONR awarded a $29.8 million contract to Metron to develop machine intelligence for future generations of U.S. Navy UUVs for a wide variety of applications like long-range surveillance.

In this project Metron produced software for advanced UUV autonomy that runs on government-provided hardware to demonstrate emerging machine autonomy capabilities in several different kinds of military missions.

Metron Inc. id developing experimental modular payloads for unmanned undersea vehicles (UUVs) for the U.S. Office of Naval Research.

The company also is involved in developing autonomy software for the ONR Large Displacement Unmanned Undersea Vehicle (LDUUV) project, which includes autonomy for the LDUUV involves autonomy software, computer hardware, and sensors.

In 2013 Metron won a $7.3 million ONR contract for in-lab integration and testing of autonomy and mission planning software with bench test hardware selected for deployment on the LDUUV.

Metron developed autonomy software to enable the future LDUUV to avoid all vessels in its area of operations, including fishing boats. Company experts tackled autonomy challenges such as detecting and avoiding undersea stationary and moving obstacles, as well as path planning algorithms to minimize energy consumption while avoiding obstacles.

Metron has dealt with detecting, locating, and identifying surface vessels; determining the intent of detected surface vessels; and detecting and avoiding all kinds of fishing nets and fishing gear, including mono-filament and twine nets which are difficult to detect. ←

Army orders mini-helicopter drones, considers issuing to infantry

Infantry soldiers one day may be using pocket-size helicopter drones in combat to help them find their enemies. The Black Hornet Personal Reconnaissance System — a miniature unmanned helicopter with video cameras — enables infantry squads to see enemy units from the air. The Army has awarded a $2.6 million contract to FLIR Systems Inc. of Wilsonville, Ore., for an undisclosed number of the devices, the company said in a recent statement. Each hand-launched Black Hornet helicopter is about the size and weight of a parakeet. It can shoot live video with either a daylight imager or infrared, has a range of a little less than a mile and can fly for 25 minutes at a speed of 13 miles per hour. The Army bought several Black Hornet drones for testing with Special Forces units in 2016 and 2017, FLIR said. The Army will continue testing the Black Hornet while it considers issuing the device to troops in the field.

Navy begins Triton maritime-patrol flight operations at Point Mugu, Calif.

The U.S. Navy hosted a ceremony last week at Naval Base Ventura County at Point Mugu, Calif., to mark the start of flight operations for the Northrop Grumman-built MQ-4C Triton long-range maritime patrol unmanned aerial vehicle (UAV). Northrop Grumman officials say the Unmanned Patrol Squadron 19 maintenance detachment will test and conduct maritime patrol training on two MQ-4C UAVs before the service branch deploys the UAVs to Guam in late 2018. A newly refurbished hangar at the Point Mugu facility can house as many as four Triton UAVs. The MQ-4C Triton can operate for as long as 24 hours. ←

Headwall integrates hyperspectral and lidar aboard unmanned aircraft

Headwall Photonics Inc. in Fitchburg, Mass., is introducing advanced sensor payloads consisting of hyperspectral sensors and laser radar for deployment on unmanned aerial vehicles (UAVs). Through the fusion of hyperspectral imaging data and 3D light detection and ranging (lidar) output, Headwall is using unmanned vehicles to address remote-sensing applications ranging from civil and military infrastructure inspection to crop science applications requiring discrete solutions for crop monitoring. The Headwall payload consists of a Hyperspec spectral imager, a lidar unit, a UAV, a high-performance Global Position System (GPS), inertial measurement unit (IMU), and software for data acquisition and work flow processing for exploitation. The combination of hyperspectral and lidar is especially powerful because the entire data set can be acquired on inexpensive UAV platforms with both sensor instruments operating simultaneously. For more information contact **Headwall Photonics** online at www.headwallphotonics.com.

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BAE Systems to rebuild 164 Bradley armored combat vehicles and vetronics

BY **John Keller**

WARREN, Mich. — Armored combat vehicles designers at BAE Systems will rebuild and upgrade as many as 164 U.S. Army M2 Bradley Fighting Vehicles with revamped vetronics electrical systems, smart power management software, heavyweight torsion bars, track upgrades, improved suspension, and new shock absorbers.

The latest versions of the Bradley Fighting Vehicle have the electro-optical Improved Bradley Acquisition Subsystem (IBAS) to help keep the vehicle's 25-millimeter chain gun on target.

Officials of the Army Contracting Command in Warren, Mich., announced a $348 million contract to the BAE Systems Platforms & Services segment in York, Pa., to build as many as 164 Bradley M2A4 and M7A4 vehicles.

The M2 Bradley is an infantry fighting vehicle for reconnaissance and to transport a squad of infantry. The armored vehicle protects warfighters inside from small arms fire, while its 25-millimeter chain gun provides firepower to many battlefield threats. The Bradley is maneuverable and fast enough to keep up with heavy armor during an advance.

The M7A4 Bradley, meanwhile, us an upgraded fire-support vehicle with integrated target location equipment to help direct artillery fire and airborne munitions. It has equipment for use by dismounted observers.

Among the electro-optical systems on the Bradley Fighting Vehicle is the Improved Bradley Acquisition Subsystem (IBAS) from Leonardo DRS Electro-Optical Infrared Systems in Melbourne, Fla. IBAS helps Bradley crews identify and fire on targets from long distances to help keep warfighters out of danger.

IBAS helps Bradley gunners to recognize, detect and identify targets with day and forward-looking infrared (FLIR) sensors in all types of weather and battlefield conditions.

The IBAS is equipped with either a HD day color camera or monochrome, FLIR sensor, laser range finder and a built-in TOW missile tracker. A dual axis stabilized head mirror handles line-of-sight stabilization to enable Bradley gunners to track targets while on the move.

The first M2A4 Bradley Fighting Vehicles came off the manufacturing line in 2012 with heavyweight torsion bars and track upgrades, improved suspension, and new shock absorbers.

Now BAE Systems is rebuilding legacy Bradley vehicles with upgraded electrical systems and power train to accommodate today's high-power demands from a variety of systems upgrades such as networked vetronics, software-defined radios, air conditioning systems, and even mobile battery chargers.

On this contract BAE Systems will do the work in York, Pa., and should be finished by June 2019. ←

For more information contact ***BAE Systems Platforms & Services*** *online at* www.baesystems.com, *or the A****rmy Contracting Command-Warren*** *at* http://acc.army.mil/contractingcenters/acc-wrn.

NASA taps Teledyne for space-qualified electro-optical sensor for WFIRST space telescope

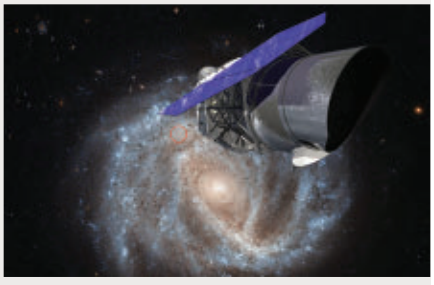
Space observation experts at the NASA Goddard Space Flight Center in Greenbelt, Md., needed space-qualified shortwave infrared (SWIR) electro-optical sensor chip assemblies for the Wide-Field Infrared Survey Telescope (WFIRST). They found their solution from Teledyne Scientific & Imaging LLC in Camarillo, Calif.

NASA has announced a $23 million contract to Teledyne to provide 72 SWIR sensor chip assemblies for the WFIRST space flight focal plane assembly.

Teledyne also will perform a warm functional test and cold functional screen test for final space flight sensor chip assembly testing and performance requirements verification.

Teledyne is the only company able to manufacture the SWIR sensor chip assemblies to WFIRST mission requirements, NASA officials say, adding that Teledyne is providing other hardware and infrastructure to the WFIRST project NASA previously has awarded several contracts to Teledyne for similar sensor chip assemblies on the WFIRST.

Teledyne is providing 18 of the company's H4RG-10 arrays in the focal plane assembly of the WFIRST spacecraft, which is scheduled to launch in the mid-2020s. The H4RG-10 offers more than 300 million pixels, and will be the largest infrared focal plane operating in space when it launches, Teledyne officials say. Teledyne also is building the visible light detectors for the WFIRST coronograph instrument.



Teledyne Scientific & Imaging is providing space-qualified shortwave infrared (SWIR) electro-optical sensor chip assemblies for the Wide-Field Infrared Survey Telescope (WFIRST)

Miniaturization of EW Microelectronics for Self-Protecting Weapons

The miniaturization of microelectronics for electronic warfare presents a new opportunity for the defense community. By embedding this advanced capability within a missile or guided munition, a new generation of smart weapons is emerging. This new class of weapons features self-protection capability to mitigate adversarial electronic attack.

On this 29-month contract for WFIRST SWIR sensor chip assemblies, Teledyne will be finished by October 2020. ←

For more information contact ***Teledyne Scientific & Imaging*** *online at* www.teledyne-si.com, *or the* ***NASA Goddard Space Flight Center*** *at* www.nasa.gov/goddard.

can shoot live video with either a daylight imager or infrared, has a range of a little less than a mile and can fly for 25 minutes at a speed of 13 miles per hour. The Army bought several Black Hornet drones for testing with Special Forces units in 2016 and 2017, FLIR said. The Army will continue testing the Black Hornet while it considers issuing the device to troops in the field. For more information contact **FLIR Systems** online at www.flir.com/products/black-hornet-prs.

Electro-optical gas imaging camera for unmanned aircraft offered by Sierra Olympic

Sierra-Olympic Technologies Inc. in Hood River, Ore., is introducing the Ventus OGI electro-optical gas imaging camera core for fixed-mounted and continuous-monitoring systems or in gimbals and enclosures for unmanned aerial vehicles (UAVs). The camera's midwave infrared (MWIR) detector array offers 640-by-512-pixel resolution at 15-micron pixel-pitch to detect and visualize leaks of gases such as methane, propane, and butane. With a weight of 580 grams with lens, the Ventus OGI is a lightweight, low-power camera core with a special narrow bandpass cold filter in the miniature, long-life, closed-cycle Stirling cooler with an f/1.5 cold shield and an optimized lens. Its detector, cooler, and lens combine with a selection of digital and analog I/O like Camera Link, Gigabit Ethernet, H.264, NTSC/PAL video, and RS-232/RS-422 serial camera control. The camera is an optical gas imaging solution for inspection of fuel and gas lines, storage tanks, generators, drilling and production wells, above- and below-ground gas pipelines, terminals, railway tank cars, flare stack monitoring, as well as booster and pump stations. For more information contact **Sierra Olympic** online at www.sierraolympic.com. ←

PRODUCT applications

TEST AND MEASUREMENT

Navy chooses circuit card test and measurement from Teradyne for MK41 Vertical Launch System (VLS)

U.S. Navy surface warfare experts needed automated test and measurement system hardware and software to test circuit card assemblies for the MK41 Vertical Launch System (VLS). They found their solution from Teradyne Inc., in North Reading, Mass.

Officials of the Naval Surface Warfare Center Dahlgren Division in Dahlgren, Va., announced an $8.5 million contract to Teradyne for test hardware and software that can use legacy test program sets to read the circuit cards for the MK41 VLS.

The Navy is awarding the contract to Teradyne sole-source to produce timely and compatible test results for the Vertical Launch System without the need for costly redevelopment, Navy officials say. Teradyne is the only source capable of delivering these items, officials say.

Teradyne also will deliver software downloads and replacement boards, training, hardware, and software services to ensure that new test fixtures and test program sets will interface seamlessly with the automated test system.

Teradyne will provide the company's Spectrum 9100 automated test system (ATS) unit and additional system hardware, software, and services to implement a seven-unit ATS system to screen MK41 electronic circuit card assemblies.

The Teradyne Spectrum-9100 is an integrated functional test system for high-performance digital, analog, mixed-signal, and serial bus testing in factory, depot, and intermediate test applications that require custom hardware and software integration.

The Spectrum-9100 provides a documented set of core building blocks for interface to computer workstations and integration with application-specific instruments and software tools.

The Spectrum-9100 combines advanced functionality, switching, software, self-test and calibration capabilities. It incorporates industry standards that support multiple application development environments, test program set development processes, and adapters.

Running under the Windows operating system it uses standard test system bus protocols including GPIB, LXI, PXI, and VXI, and employs programming languages and specialized in-house programming tools.

The MK41 VLS is a shipborne missile canister launching system that provides a rapid-fire missile launch capability against hostile threats. Designed by Lockheed Martin Corp., the MK41 VLS is aboard U.S. Navy Ticonderoga-class cruisers and Arleigh Burke-class destroyers.

The MK41 system can store and fire a mix of missiles, including the RIM-66 Standard, RIM-67 Standard, RIM-161 Standard Missile 3, RIM-174 Standard ERAM, Tomahawk missile, RUM-139 VL-ASROC, RIM-7 Sea Sparrow, and RIM-162 ESSM. ←

RF DATA LINKS

Air Force chooses Harris to build HH-VDL video data link radios for situational awareness

U.S. Air Force battlefield airmen experts needed video data link handheld radios to help special forces personnel receive, transmit, and display full-motion video for situational awareness. They found their solution from the Harris Corp. RF Communications segment in Rochester, N.Y.

Officials of the Air Force Life Cycle Management Center at Wright-Patterson Air Force Base, Ohio, announced a $130 million contract to Harris to develop and build the Handheld Video Data Link (HH-VDL) radio.

The HH-VDL radio will help Air Force battlefield airmen exchange secure and unsecure full-motion video and annotated images with command authorities via a small, lightweight, ruggedized, and reliable transceiver.

Battlefield airmen will carry the HH-VDL system for long durations on limited battery power in a variety of difficult environmental and combat conditions. Battlefield airmen include combat air controllers, pararescuemen, special operations weather teams, and tactical air controllers.

Video data link capability improves intelligence, surveillance, and reconnaissance (ISR) that is essential to close air support, command and control (C2), air superiority, target identification, and situational awareness (SA), Air Force officials say.

The HH-VDL system must have Type 1 encryption capability through the use of National Security Agency (NSA) cryptocore modernization and government-approved encryption.

The system must be depot-level repairable, and interoperable with 466ER, Tactical, VNW, FM analog, DDL, STD-CDL and BE-CDL waveforms. It will support UHF, L-band, S-band, C-band, and KU-band, and support new S-band frequencies of 2025 to 2110 MHz. The HH-VDL radio will be water-resistant and ruggedized.

Air Force experts particularly are interested in evolutionary increases in capability, as well as reductions in size, weight, and power consumption (SWaP).

Harris already offers the RF-7800T-HH situational awareness video receiver (SAVR) lightweight, multiband radio for full-motion video and sensor data feeds from aircraft or unmanned aerial vehicles (UAVs).

This handheld radio is for warfighters operating on foot, and also can be used for vehicular and tactical operations center applications. The Harris SAVR can be integrated with the Harris RF-3590 ruggedized tablet and Harris Falcon III radios to share video access throughout mission networks.

The SAVR includes an embedded GPS, and a software-defined architecture to keep pace with emerging digital data link standards through software upgrades.

On this contract Harris will do the work in Rochester, N.Y., and should be finished by April 2023. For more information contact **Harris RF Communications** online at *www.harris.com*, or the **Air Force Life Cycle Management Center** at *www.wpafb.af.mil/aflcmc*.

TRUSTED COMPUTING

Design Knowledge eyes avionics trusted computing and cyber security test and measurement research

U.S. Air Force researchers needed trusted computing and cyber security test and measurement capability for military mission-critical systems. They found their solution from The Design Knowledge Company in Fairborn, Ohio.

Officials of the Air Force Research Laboratory at Wright-Patterson Air Force Base, Ohio, announced a $24.9 million 7-year Small Business Innovation Research (SBIR) phase II contract to Design Knowledge for the Innovative Cyber/Infrastructure Threat Assessment Environment (INCITE) Mission Assurance program.

Design Knowledge experts will carry out advanced research to advance microelectronic components assurance and assessment; assurance test and verification methodologies; situational awareness for mission assurance; decision support for cyber security vulnerability assessments; advanced malware protections research for mission-critical systems; and cyber threat situational awareness for insider threats.

Design Knowledge has been involved SBIR phase 1 and phase II of the INCITE program.

The company has developed an integrated agile work environment to ingest, organize, and visualize unstructured and structured data.

This work environment enables users to identify, analyze, and reveal first-, second-, and third-order cyber effects and perform vulnerability analysis on avionics systems and military networks, and cyber infrastructure.

The work environment capitalizes on existing and proven simulation, analysis, data management, and visualization tools from Design Knowledge, as well as from Edaptive Computing Inc. in Dayton, Ohio, and from DMM Ventures Inc. in Yorktown, Va.

In the INCITE SBIR phase II project, Design Knowledge experts developed a multi-use, adaptable, user-friendly prototype demonstrator to measure the susceptibility or vulnerability of avionics and infrastructure to trusted computing threats like cyber attack, electronic parts tampering, and counterfeit components.

The work environment is designed to interface easily with infrastructure and avionics modeling tools, computer-aided design tools, circuit and system design tools, and other third-party

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simulation, design, and analysis tools, from system to component-level.

The program's second phase was to develop, test, assess, document, and demonstrate the INCITE work environment's capabilities using real-world data in an embedded avionics application and in an infrastructure scenario.

Now the company's phase II work environment is ready for the INCITE program's third phase, in which Design Knowledge experts will integrate the work environment into the Air Force Research Laboratory's Avionics Vulnerability Assessment, Mitigation, and Protection (AVAMP) test bed.

On this contract Design Knowledge will do the work at Wright-Patterson Air Force Base, and should be finished by June 2025. For more information contact **The Design Knowledge Company** online at *www.tdkc.com*, or the **Air Force Research Lab** at *www.wpafb.af.mil/AFRL*.

SOFTWARE-DEFINED RADIO

Black River to pursue SIGINT enabling technologies in software-defined radio

U.S. Air Force researchers needed enabling technologies for software-defined-radio (SDR) signals intelligence (SIGINT) for low-power military 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., 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 cyber security.

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*.

ELECTRO-OPTICS

L-3 to provide night-vision binoculars for U.S. Army

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 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 longwave infrared sensors for combat at night, in bad weather, and in smoke and dust.

Image intensification amplifies available light from stars or other low-light sources, and while long-wave infrared detects temperature differences in objects to make humans, vehicles, and machinery stand out from their cooler backgrounds. Blending the two technologies in a multispectral imaging approach helps each sensor compensate for the weaknesses of the other.

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. ←

TEST AND MEASUREMENT

Four-channel PXI power electronics test unit introduced by Marvin

Marvin Test Solutions Inc. in Irvine, Calif., is introducing the GX3104 four-channel PXI source measure unit (SMU) for power electronics test and measurement that forces and senses voltage and current over a range of ± 20 volts to ± 1 amp. The module's flex-power architecture offers users the option to configure the SMU as a 4-channel, 250-milliamp channel SMU or as a

single-channel 1-amp SMU. This can enable test engineers to support high-current or multi-channel SMU applications with one module. The four channels are electrically isolated from the PXI power supply and share a common, isolated ground. In addition, all module power is provided by the PXI bus, eliminating the need for bulky, external DC power supplies. The GX3104 comes with an API and UI, as well as documentation, online help files, and GtLinux, a software package that supports Linux 32/64 operating systems. For more information contact **Marvin Test Solutions** online at *www.marvintest.com.*

CHASSIS AND ENCLOSURES

Pixus OpenVPX chassis tests air- and conduction-cooled boards

Pixus Technologies in Waterloo, Ontario, is introducing the Pixus OpenVPX development chassis for embedded computing design, with a mix of card guides that enable users to test IEEE 1101.10 air-cooled and IEEE 1101.2 conduction-cooled boards in the same enclosure. The chassis enables the use of rear transition modules (RTMs) and as many as eight backplane slots at a 1-inch pitch. The open-frame design provides a way to attach probes and access the plug-in boards. Pixus offers various slot sizes and profiles

of 3U and 6U OpenVPX backplanes compliant to the VITA 65 specification. A modular power supply enables designers to assemble various modules for 3.3-, 5-, and plus-or-minus 12-volt auxiliary voltages, and other options for the ideal power output for each configuration. Pixus has developed specialty card guides, threaded inserts, and front and filler panels for the half-HP offset spacing of the architecture for a precision fit and alignment. The company has also developed an ultra-rugged rail to prevent bowing or cracking due to high-insertion forces of 6U OpenVPX designs. For more information contact **Pixus Technologies** online at *www.pixustechnologies.com.*

RACKMOUNT SERVERS

Rugged embedded computing processing blades and rackmount server introduced by Mercury

Mercury Systems Inc. in Andover, Mass., is introducing the HDS6603 and LDS6527 3U and 6U

OpenVPX and AdvancedTCA embedded computing processing blades and the HDS9624 rugged ATX rackmount server for trusted computing applications in secure command, control, intelligence, and artificial intelligence. These embedded computers with Intel and NVIDIA processing are for deployment in harsh environments. Each processing solution may include proven BuiltSECURE and modified off-the-shelf (MOTS) technologies. These systems are for on-board processing for unmanned aerial vehicles (UAVs) and other smart platforms designed to gather increasing amounts of intelligence, surveillance, and reconnaissance (ISR) data. These embedded computers use Mercury's BuiltSECURE technology for trusted computing. Mercury's HDS6603 OpenVPX module can deliver 256 gigabytes of memory and Xeon E5 server class processors. The U.S.-made HDS6603, LDS6527, and HDS9624 are manufactured in DMEA-certified facilities using devices from a DMSMS managed supply chain. For more information contact **Mercury Systems** online at *www.mrcy.com/C2I.*

COMPUTER BOARDS

6U VPX FPGA board for electronic warfare (EW), radar, and sonar introduced by Abaco

Abaco Systems in Huntsville, Ala., is introducing the VP869 high-performance 6U OpenVPX

field-programmable gate array (FPGA) embedded computing board for mission-critical applications like electronic warfare (EW), radar and sonar processing, software-defined radio,

advanced digital beamforming, multi-channel digital receivers and transmitters, and satellite communications (SATCOM) systems. The embedded computing board has two Xilinx UltraScale+ FPGAs and a Zynq 7000 series multiprocessor system-on-chip (MPSoC) to provide a form, fit, and function upgrade for the Abaco VP868. It can deliver nearly four times more digital signal processing (DSP) resources and memory than its predecessor. Two industry-standard (VITA 57) FPGA Mezzanine Card-Plus (FMC+) sites come on the VP869 for high-performance analog I/O, digital communications, or video input. The board has more than 72 high-speed serial lanes routed to the backplane delivering 594 gigabits per second of data throughput for advanced processing and offload applications. For more information contact **Abaco Systems** online at *www.abaco.com*.

MOTION CONTROL

High-reliability motor controller for unmanned vehicle and military uses introduced by DDC

Data Device Corp. (DDC) in Bohemia, N.Y., is introducing the high-power-density 80-volt, 30-amp MC-5000 series BLDC high-reliability motor controller for single axis, point-of-load unmanned vehicle and other military applications. The digital-signal-processing family of programmable, turnkey motor controllers designed to precisely control the position, torque, and speed of 3-phase BLDC motors. Applications

include unmanned vehicle electric drives and thrusters, autonomous guided vehicles, pump control, electric actuators, electric valve control, fuel pumps, industrial robotics, antenna and camera position control, and medical diagnostics control. The devices operate in temperatures from -40 to 105 degrees Celsius, and is available in configurations to support motors that use a Hall sensor for torque and speed control, or absolute PWM and incremental encoder feedback for position control. For more information contact **DDC** online at *www.ddc-web.com*.

MEZZANINE CARDS

Embedded video and graphics XMC for avionics and ground vehicles introduced by Aitech

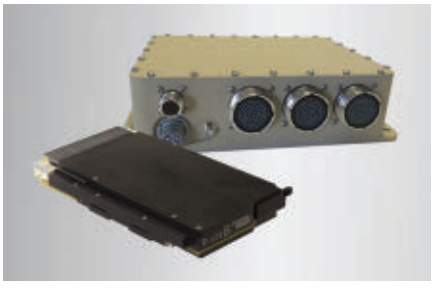
Aitech Defense Systems Inc. in Chatsworth, Calif., is introducing the rugged M596 embedded computing video and graphics switched mezzanine card (XMC) for use in harsh environments that have versatile video overlay and capture requirements, such as advanced civil or military avionics or ground vehicle systems. The XMC uses the powerful Radeon E8860 graphics processing unit (GPU) to capture several video inputs and drive as many as six independent video outputs simultaneously with video switching capabilities. By pairing the E8860 GPU with additional on-board resources like an optional field-programmable gate array (FPGA), the M596 delivers a much

wider variety of video I/O interfaces than many other E8860-based products. These interfaces include DVI output channels as well as S-Video and STANAG 3350 inputs and outputs. For legacy systems with older display technology, the M596 drives composite (RS-170A [NTSC]/PAL) displays. The optional FPGA also provides signal conditioning, compression, and additional graphics overlay and underlay functionality. For more information contact **Aitech** online at *www.rugged.com*.

VETRONICS

Vetronics position, navigation, and timing (PNT) introduced by Curtiss-Wright

Curtiss-Wright Defense Solutions in Ashburn, Va., is introducing the VPX3-673 assured position, navigation, and timing (PNT) high-performance single-board computer to provide PNT services on military ground vehicles and related vetronics. These commercial-off-the-shelf (COTS)-based modules and line-replaceable unit (LRU) solutions are for system integrators seeking to deploy PNT services to ground vehicles operating in GPS-denied environments rapidly and cost-effectively. The rugged VPX3-673 will deliver a GPS receiver (SAASM GB-GRAM Type II, upgradeable to M-Code), chip scale atomic clock (CSAC), and an on-board inertial measurement unit (IMU) to eliminate the need for several in-platform boxes or bolt-on technologies to field navigation warfare capabilities. Curtiss-



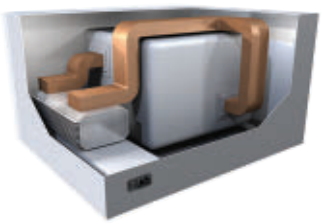
Wright also announced an enhanced version of the company's DBH-672 Digital Beachhead integrated rugged LRU to add support for a GPS receiver (SAASM GB-GRAM Type II, upgradeable to M-Code), CSAC, and IMU to the earlier model's built-in VICTORY infrastructure switch and shared processor unit features. For more information contact **Curtiss-Wright Defense Solutions** online at *www.curtisswrightds.com*.

RF AND MICROWAVE

RF and microwave connector for power handling introduced by HUBER+SUHNER

RF and microwave specialist HUBER+SUHNER in Pfäffikon, Switzerland, is introducing the RFEX RF-energy connector for power handling and

performance in low-cost solution for high-volume RF-energy applications. Designed to handle the mandatory high-power levels in peak demand applications and avoid unnecessary heat generation, the RFEX features an antenna mounted to the topside of the amplifier housing for connecting rectangular waveguides, dielectric filled waveguides, and cooking cavities. While a significant number of components previously were needed to support RF-Energy related building blocks in applications like RF-Ovens and microwaves, the RFEX is directly integrated into the amplifier housing, significantly reducing size and the number of parts required. For more information contact **HUBER+SUHNER** online at *www.hubersuhner.com*.



RUGGED COMPUTERS

Small-form-factor embedded computing systems for military applications introduced by X-ES

Extreme Engineering Solutions Inc. (X-ES) in Middleton, Wis., is introducing two small-form-factor (SFF) commercial off-the-shelf (COTS) rugged embedded computing systems for a range of industrial and military applications. The XPand6212 and XPand6211 offer high-performance networking and communications capabilities and lightweight size, weight, and power (SWaP)-optimized design for deployed applications where connectivity is key to mission success. XPand6212 is designed to make the most of processing performance and signals intelligence with its XPedite7670 Intel Xeon D single-board computer. XPand6211 is configured for high-performance networking with a 24-port Gigabit Ethernet switch, an integrated XPedite5205 XMC/PMC Embedded Services Router (ESR) running Cisco IOS software to support secure, mission-critical communications. Both systems are qualified to MIL-STD-810 and DO-160 standards and purpose-built to withstand punishing environmental conditions. For more information contact **X-ES** online at *www.xes-inc.com*.

MOTOR CONTROL

Power modules for aerospace and defense motor control introduced by Microsemi

Microsemi Corp. in Aliso Viejo, Calif., is introducing the SP6LI silicon carbide (SiC) metal oxide silicon field-effect transistor (MOSFET) power modules for switch mode power supplies and motor control in aerospace

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and defense, industrial, automotive, and medical applications. The power modules come in extremely low-inductance packages dedicated to high current low specific on-resistance

(RDSon). The package, developed for the company's SP6LI product family, is designed to offer 2.9 nanohenry (nH) stray inductance suitable for SiC MOSFET technology and enable high current, high switching frequency as well as high efficiency. Microsemi's SP6LI product family has five standard modules, offering phase leg topology ranking from 1200 volts at 210 to 586 amps at a case temperature of 80 degrees Celsius to 1700 volts at 207 amps at a case temperature of 80 degrees Celsius. For more information contact **Microsemi** online at *www.microsemi.com*.

DATA RADIO

Low-power narrowband embedded radio modem for data telemetry offered by Saelig

Electronics distributor Saelig Co. Inc. in Fairport, N.Y., is introducing the Circuit Design SLR-434M compact, low-power, narrowband embedded radio modem operating in the 434 MHz ISM band for data transmission, telemetry, control in buildings, water level and dam monitoring, and tunnel and bridge condition monitoring. The modem incorporates LoRa technology to achieve extremely long range

for low bit-rate data with low power. The SLR-434M's receiving sensitivity enables communication into areas once considered difficult for RF to penetrate, and making it possible to transmit 1,800 feet or more. The SLR-434M is also switchable to accommodate conventional FSK communication. The SLR-434M can transmit data or operate in simple control systems using Circuit Design's dedicated command protocol from an external CPU or PC via an RS232 or COMport interface. The SLR-434M can process eight I/O switching signals. For more information contact **Saelig** online at *www.saelig.com*.

ANTENNAS

Wireless network antennas for point-to-multi-point Internet introduced by KP

KP Performance Antennas in Edmonton, Alberta, is introducing a line of seven high-gain, dual-band sector antennas for use in wireless network point-to-multi-point applications using many of the popular radios in the wireless Internet service provider (WISP) market. Each of KP's line of seven dual sector antennas each

consists of two or more sector antennas inside a rugged radome. The single mounting point of these antennas reduces inches on the tower, halves the tower rental costs, and lowers wind resistance. They also provide a rapid upgrade path to add frequency bands without installing more infrastructure. These antennas come with four or eight ports and support 2x2, 4x4 and 8x8 multiple-input and multiple-output (MIMO), depending on the model.

The straight-on models provide two forward-facing, high-gain, 65- or 90-degree sector antennas in one radome, one for each frequency band and come in frequency combinations of 2 to 3 GHz, 2 to 5 GHz, 3 to 5 GHz, or 5 to 5 GHz. For more information contact **KP Performance Antennas** online at *www.kpperformance.com*.

ENCLOSURES AND CHASSIS

6U and 3U modular enclosures for rackmount applications introduced by Pixus

Pixus Technologies in Waterloo, Ontario, is introducing modular subrack and enclosure configurations for rackmount embedded computing applications that require a mix of 6U and

3U circuit boards in the same enclosure. The Pixus modular 19-inch rackmount enclosures have been used to enable designers to stack a second set of 3U boards above another row of 3U boards. The segmentation also allows the use of dual 3U segments. The designs include versions in OpenVPX, CompactPCI, and custom backplane architectures. Pixus also offers specialized rugged rails for the high insertion forces of 6U OpenVPX. The company also has applied the hybrid 3U/6U approach for horizontal-mount designs. For example, a 1U chassis can facilitate one each of the two board sizes. Pixus provides subracks and electronics enclosures for various applications, including military and aerospace, industrial, energy, communications, medical, transportation, and research. For more information contact **Pixus Technologies** online at *www.pixustechnologies.com*.

RF POWER

GaN power amplifier for electronic warfare and radar offered by Comtech PST

Comtech PST in Melville, N.Y., is introducing the BME69189-100 gallium nitride (GaN) small-form-factor (SFF) solid-state power amplifier module for electronic warfare (EW), communications, and radar transmitters where space, cooling, and power are limited. The GaN-based 6-to-18 GHz RF amplifier is for replacing traveling wave tube (TWT) and microwave power module (MPM) applications. The power module is for ultra-wideband operation; offers full power across the entire bandwidth; is rugged, reliable, compact, and lightweight; has low harmonic distortion; operates at low voltages; offers soft failure and graceful degradation; and operates from a 28- or 270-volt DC input. It operates from 6 to 18 GHz; has typical RF power output (Psat) of 100 Watts; typical gain at 100 Watts of more than 46 dB; maximum RF input overdrive of +10 dBm; typical gain flatness at 5 dBm Input of ±2.0dB; AB linear class of operation; and maximum input and output voltage standing wave ratio of 2.0:1. For more information contact **Comtech PST** online at *www.comtechpst.com.* ←

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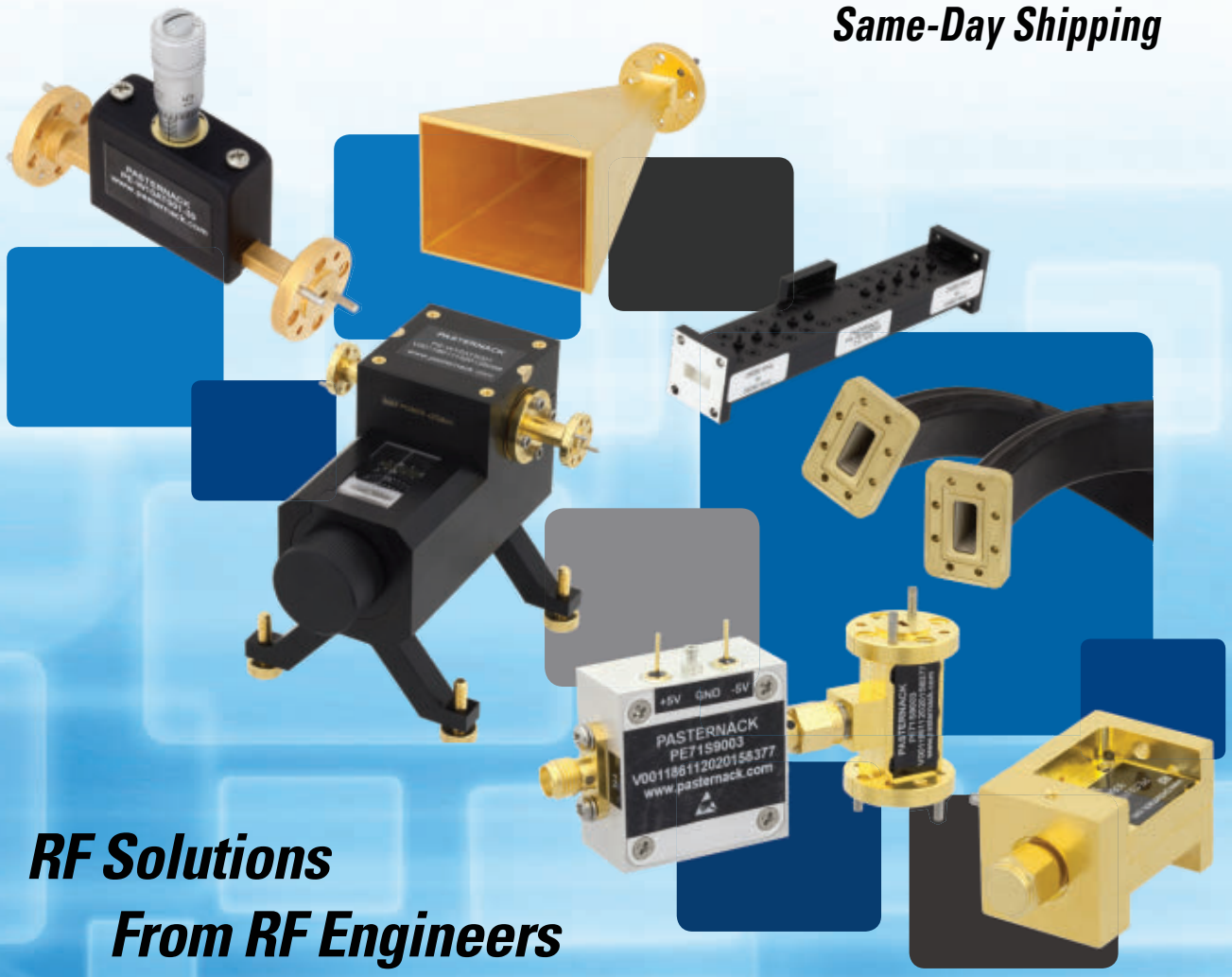

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