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Hypersonic weapons

The electronics design challenges of hypersonic flight. **PAGE 18**

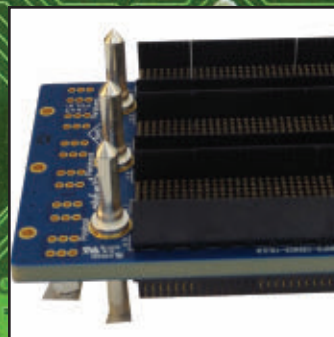
RF and microwave technology

Low SWaP and industry standards dominate today's applications. **PAGE 26**

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*The latest enabling technologies and new products for aerospace and defense design. **PAGE 46***

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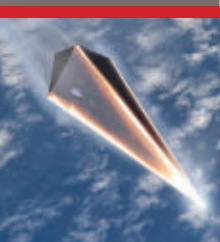
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2 TRENDS

4 NEWS

10 IN BRIEF



COVER STORY

18 SPECIAL REPORT The electronics design challenges of hypersonic flight

Hypersonic munitions present an intimidating set of environmental challenges, raising the bar to an entirely new level of difficulty.



26 TECHNOLOGY FOCUS RF and microwave designers take-on the cluttered spectrum

Systems built for low SWaP and industry standards like SOSA are dominating applications ranging from satellite navigation to next-generation 5G communications.



33 UNMANNED VEHICLES

36 PRODUCT APPLICATIONS

41 NEW PRODUCTS

46 2020 MILITARY & AEROSPACE ELECTRONICS BUYERS GUIDE

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Coronavirus pandemic hits military electronics supply chain with 4-to-12-week lag

FORT WORTH, Texas — Effects of the COVID-19 coronavirus on the U.S. military electronic parts supply chain likely will push-out lead times from four to 12 weeks from order to delivery over what manufacturers had come to expect before the pandemic swept over American shores.

This is the prediction from Don Akery, president of U.S. and international electronics distributor TTI Inc. in Fort Worth, Texas. The market disruption comes at an inopportune period; the defense electronics supply chain had been recovering from disruptions caused by a surge in demand from Trump Administration defense spending increases.

Defense integrators ranging from circuit board manufacturers to finished military platform designers had been complaining about delivery delays of electronic parts since at least 2018 because of a towering wave of demand triggered by Trump defense budget increases, which began shortly after President Trump took office in early 2017.

"Lead times have been extended in the defense space for the past couple of years," Akery told Military & Aerospace Electronics in an early April interview. "We saw it start more than 18 months ago, as demand exceeded capacity. Some had seen lead times push out to 50 weeks, which is unprecedented."

Still, the defense electronics industry has been able to add capacity to make up the supply shortfall, and saw the market start to sort itself out early this year. "They have put more capacity in place, so lead times have been stabilizing," Akery says.

Then the coronavirus pandemic started taking its toll on the global electronics supply chain beginning around late January. "Two to three weeks from now we will see the lead-times push out again," Akery explains. "I would say we will see lead times push out a minimum of four weeks, and for as long as 12 weeks."

Military demand for electronic parts has not slowed, which puts extra temporary pressure on distributors and other parts suppliers. Complicating the picture is surging parts demand from the medical industry for systems like respiratory ventilators to help victims of the coronavirus pandemic.

One market factor with the potential to ease the pressure is a possible temporary dropoff in demand from heavy industrial rugged electronics as non-essential industrial projects take a pause.

"Demand is there, and the defense industry has taken more product in the Americas," Akery says. "The first quarter of 2020 was the highest booking quarter in our history."

Moving forward, TTI officials are doing everything they can to get

parts to the manufacturers that need it most. "Will our customers be able to get everything they need? We will go through a lull, but we don't know exactly for how long. It could ease lead times if rugged industry applications slow down."

Military systems designers also may have to get in line behind the highest-priority electronics manufacturing, which will revolve around medical applications until the coronavirus pandemic begins to subside. When that happens is a matter of conjecture. "There is a priority on medical orders," Akery points out. "Medical orders for us are up 10 or 20X from what they had been."

TTI is putting additional measures in place to deal with the market situation. "The supply chain is pretty critical," Akers explains. "We have an external website we had up here in the Americas since the end of February to communicate to the customers and to the suppliers to help them file for exemptions if they have plants in parts of the world with shelter-at-home orders."

"We also have processes in place where our inventory is not always made available to the general public, but first to our regular customers in case of a constrained supply chain." ←

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The Invisible Headlights project seeks to develop infrared sensors that triangulate background artifacts to create 3D imaging for unmanned vehicle navigation.

Researchers eye 3D infrared sensors for unmanned vehicle navigation

BY John Keller

ARLINGTON, Va. — U.S. military researchers are asking for industry's help in developing computationally intensive 3D infrared sensors that use triangulation and ambient signals in thermal images to create sensors accurate enough for unmanned vehicle navigation.

Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., has issued a broad agency announcement (HR001120S0045) for the Invisible Headlights project.

Invisible Headlines seeks to quantify the measurable information from ambient thermal emissions to create 3D vision. The project seeks to help researchers understand the useful information contained in ambient thermal emissions, and enable passive 3D vision for unmanned vehicle navigation.

Autonomous and semi-autonomous systems require active illumination to navigate at night or underground,

which can make them vulnerable to the enemy because it can be detected by adversaries miles away.

The Invisible Headlights program seeks to eliminate this vulnerability by discovering how to exploit ambient thermal light using a totally passive 3D sensor that is accurate enough and fast enough to support autonomous navigation.

The Invisible Headlights approach is fundamentally different from previous efforts because conventional infrared sensors fail, by design, to collect almost all available information from ambient thermal emissions.

Instead, the Invisible Headlights electro-optical approach seeks to use non-target artifacts in the scene that previously might have been considered clutter to provide the signal necessary to enable 3D vision. It will quantify the available information in ambient ther-

mal emissions, determine how much of that information is useful for building a 3D model of a scene, define the trade space of sensor designs, develop new sensors for increased measurement diversity, and validate all this data in field tests.

The project has two primary goals: understand the useful information in ambient thermal emissions; and enable passive 3D vision for autonomous navigation.

Quantifying the measurable information from ambient thermal emissions is non-trivial and very environment-dependent, DARPA researchers say. It depends on the temperature, chemical composition, geometry, and atmosphere surrounding the objects in a scene.

Moreover, it depends on the aperture, position, measurement modes, and performance of the sensor. In practice, these environments are so com-

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plex that measurement, rather than modeling, is necessary to characterize the actual signal variation.

An ideal sensor might be able to extract many orders of magnitude more data about the environment than is attainable using conventional infrared sensors.

Enabling passive 3D vision for autonomous navigation will require near-zero noise and orders of magnitude greater measurement diversity than conventional sensors — particularly at high speeds. More than likely this will require completely new types of infrared sensors.

The project has two technical areas: near-term passive 3D vision; and sensors for measurement hyperdiversity.

Contractors involved in the project will modify and extend existing sensors to enable passive 3D vision sensors with the potential for low-speed applications to 25 miles per hour.

Contractors also will develop near-zero-noise sensors capable of orders of magnitude more measurements per second than conventional sensors to enable fast, high-spatial-resolution, high-spectral-resolution measurement of an environment and high-speed 3D vision. If successful, these new sensors will enable 3D vision for speeds greater than 25 miles per hour.

The project has three phases: an 18-month effort to determine if thermal emissions contain sufficient information to enable autonomous driving

at night or underground; a 21-month effort to refine models, create experimental designs, and conduct tests to show that real systems can measure the information necessary for 3D vision; and an 18-month effort to build and test passive demonstration systems.

Companies interested were asked to upload abstracts by 8 May 2020, and proposals no later than 17 June 2020, to the DARPA BAA Website at <https://baa.darpa.mil>. ←

Email questions or concerns to Joseph Altepeter, the DARPA Invisible Headlights program manager, at InvisibleHeadlights@darpa.mil. More information is online at <https://beta.sam.gov/opp/8271a213cf88440cbdf14347e2e5e7af/view>.

Army asks industry for open-systems avionics technologies for future helicopters

BY John Keller

FORT EUSTIS, Va. — U.S. Army combat helicopter experts are reaching out to industry for ways to develop open-systems enabling technologies to manage aircraft crew member cognitive workload. Suggested technologies must conform to the Modular Open Systems Approach (MOSA) and Future Airborne Capability Environment (FACE) industry standards.

Officials of the Army Contracting Command at Fort Eustis, Va., have issued a request for information (W911W620RFI0002) for the Revolutionary Technology and Strategies for the Holistic Situational Awareness—Decision Making (HSA-DM) program.

The technologies developed from this program potentially are for integration into avionics for the Future Attack Recon-

naissance Aircraft (FARA) and Future Long Range Assault Aircraft (FLRAA).

Other potential candidate projects for HSA-DM-developed technologies include:

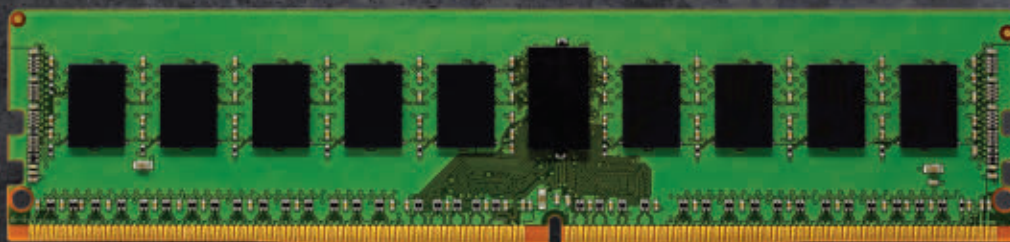
- Degraded Visual Environments-Mitigation (DVE-M);
- Integrated Mission Equipment (IME) for Vertical Lift Systems;



Army helicopter designers are looking to next-generation avionics architectures that follow open-systems standards like MOSA and FACE.

- Joint Common Architecture (JCA);
- Route Optimization for Survivability Against Sensors (ROSAS);
- Survivability Against Integrated and Networked Threats (SAINT);
- Synergistic Unmanned Manned Intelligent Teaming (SUMIT);
- Project Management Office - Command, Control, Communications, Computers, Combat Systems, Intelligence, Surveillance, and Reconnaissance (C5ISR);
- Joint Multi-Role (JMR) Mission Systems Architecture Demonstration (MSAD); and
- Advanced Teaming Demonstration (A-Team).

This request for information for integrated avionics aboard future Army



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helicopters avionics has four separate efforts: information management; data and sensor fusion; autonomous decision aiding and information distillation; and human-machine interfaces. The goal is to eventually create a family of systems that operates in a variety of domestic and combat Army helicopter missions.

Information management seeks to identify information management technologies to receive, process, store, and transmit terabytes of data and knowledge products from several sources simultaneously.

Data and sensor fusion seeks to identify technologies to accept data

from several sensors, databases, and networks, and fuse the data into a comprehensive “own-ship” world model or information manager.

Autonomous decision aiding and information distillation seeks to identify technologies capable of distilling data and information into knowledge products for crew member adjudication and/or autonomous decision making.

Human machine interfaces seeks to identify technologies that facilitate intuitive communication of operational knowledge to and from aircraft crew members.

As aviation technology continues to grow, the number of separate avionics systems and large quantities of data lead to flight crew cognitive overload, Army researchers explain. The crew must search, sort, and synthesize large amounts of information across several systems. This mental load can lead to loss of situational awareness, and reduced mission effectiveness.

To address this problem, the HSA-DM program seeks to define systems that receive several data streams, and present information to the crew members in a timely and effective way. The HSA-DM program should run from 2021 to 2026.

The types of avionics systems that could be part of this program include communications; aircraft status; navigation; augmented flight control; weapons; crew systems; and fused sensor data. Proposed technologies meet standards for cyber security and information assurance. ←

Companies interested were asked to email white papers no longer than 20 pages to the Army's Matthew Shivers by 3 June 2020 at matthew.p.shivers2.civ@mail.mil. Email questions or concerns to Shivers at matthew.p.shivers2.civ@mail.mil. More information is online at <https://beta.sam.gov/opp/661e06e28c6149e9a3eaba0708fbc792/view>.



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Raytheon Technologies to focus on hypersonics, cyber security, avionics, and directed energy

Executives of the Raytheon Co. in Waltham Mass. and United Technologies Corp. in Farmington, Conn., have completed an all-stock merger to form a new company called Raytheon Technologies Corp., one of the largest aerospace and defense companies in the world. The new company, to be headquartered in Waltham, Mass., will have a New York Stock Exchange ticker symbol of RTX. The company has 195,000 employees and \$74 billion in net sales. Raytheon Technologies comprises four businesses: avionics designer Collins Aerospace Systems in Charlotte, N.C.; jet engine designer Pratt & Whitney in East Hartford, Conn.; Raytheon Intelligence & Space in Arlington, Va.; and Raytheon Missiles & Defense in Tucson, Ariz. The new company has expertise in quantum physics, electric propulsion, directed energy, hypersonics, avionics, and cyber security. Collins Aerospace Systems specializes in aerostructures, avionics, interiors, mechanical systems, mission systems, and power controls for commercial, regional, and business aviation, as

well for military applications. Raytheon Intelligence & Space specializes in developing advanced sensors, training, cyber security, and software solutions. Raytheon Missiles & Defense provides technologies to detect, track, and engage aircraft and missile threats. For more information contact Raytheon Technologies online at www.rtx.com.

Raytheon to build AIM-9X advanced air-to-air missiles

U.S. Navy aerial warfare experts are asking Raytheon Technologies Corp. to build several hundred AIM-9X precision short-range infrared-guided air-to-air missiles for jet fighters and other combat aircraft under terms of a \$392.4 million order. Officials of the Naval Air Systems Command at Patuxent River Naval Air Station, Md., are asking the Raytheon Missiles & Defense segment in Tucson, Ariz., to build lot-20 AIM-9X block II and block II+ air-to-air missiles. These air-to-air missiles are for the U.S. Navy, Air Force, and the governments of Australia, Belgium, Denmark, Finland, Indonesia, Israel, Japan, Kuwait, Malaysia, Morocco, Oman, the Netherlands, Norway, Poland, Qatar, Romania, Saudi Arabia, Singapore, Slovakia, South Korea,



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Lockheed Martin to build 48 LRASM subsonic anti-ship missiles

U.S. Air Force airborne weapons experts are asking Lockheed Martin Corp. to build 48 next-generation AGM-158C Long-Range Anti-Ship Missile (LRASM) for use against high-priority enemy targets like aircraft carriers, troop transport ships, and guided-missile cruisers. Officials of the U.S. Air Force Life Cycle Management Center at Eglin Air Force Base, Fla., announced a \$167.5 million contract to the Lockheed Martin Corp. Missiles and Fire Control segment in Orlando, Fla., to build 48 LRASMs. Lockheed Martin won a \$172.1 million contract in late 2017 to build 50 LRASMs as part of Lot 2 production. Before that, Lockheed Martin won an \$86.5 million contract in July 2017 to manufacture the first 23 LRASM munitions in Lot 1 production. That contract marked the first production award for the air-launched variant of the anti-ship missile for the U.S. Navy and Air Force. LRASM is a joint project of the U.S. Defense Advanced Projects Agency (DARPA) in Arlington, Va., the Navy, and the Air Force to design an advanced anti-ship missile that can launch from the Navy F/A-18E/F Super Hornet jet fighter bomber, as well as from the Air Force B-1B Lancer long-range strategic bomber. In the future LRASM also will launch from the F-35 Lighting II joint strike fighter, as well as from the Navy Mark 41 shipboard Vertical Launch System. The missile travels at high subsonic speeds, and likely will give way in the future to expected new generations of hypersonic missiles. Submarine-launched versions are under consideration.

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Air Force and Honeywell switch to full-scale development for aircraft GPS modernization

U.S. Air Force satellite navigation experts are moving to full-scale development of a system that blends the Global Positioning System (GPS) navigation and guidance system with inertial navigation system (INS) technology. Officials of the Air Force Life Cycle Management Center at Robins Air Force Base, Ga., announced a \$99.1 million contract to the Honeywell Inc. Aerospace segment in Clearwater, Fla., for engineering, manufacturing and development (EMD) of the Embedded Global Positioning System/Inertial Navigation System Modernization (EGI-M) system. The EGI-M system supports the rapid insertion of new capabilities into military aircraft like the F-22 jet fighter and E-2D carrier-based radar aircraft to operate in GPS-denied environments. EMD describes where a system is developed and designed before going into production after the formal start of any program. The goal is to complete system development, develop affordable manufacturing processes, and test the system before proceeding to production and deployment. EGI-M technology is designed for compatibility with legacy aircraft, and adds Automatic Dependent Surveillance-Broadcast (ADS-B) Out to comply with the Federal Aviation Administration's NextGen air traffic control requirements. ADS-B Out transmits information about an aircraft's altitude, speed, and location to ground stations and to other equipped aircraft in the vicinity.

Lockheed Martin to build eight F-16 jet fighters for Bulgaria in \$512 million deal

Aerial warfare experts at Lockheed Martin Corp. will provide eight F-16 Block 70 jet fighters to Bulgaria in a

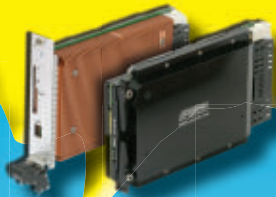
\$512 million contract. The U.S. Air Force is asking the Lockheed Martin Aeronautics segment in Fort Worth, Texas, to build the Block 70 F-16s, which are the newest F-16 configuration. Its avionics have the Northrop Grumman AN/APG-83 active electron-

ically scanned array (AESA) radar. This variant has a center pedestal display, and a modernized mission computer. The Lockheed Martin F-16 Block 70 features the most advanced fourth-generation fighter aircraft capabilities in NATO's inventory.

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Analyzing data from thousands of sensors is goal of DARPA Ocean of Things project

BY John Keller

ARLINGTON, Va. — U.S. military researchers are asking the defense industry to analyze and refine data from thousands of floating sensors in the ocean to create actionable intelligence to help Navy commanders carry out their missions at sea.

Officials of the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., have issued a broad agency announcement (HR001120S0042) for the second phase of the Ocean of Things project.

This project, first announced in late

2017, seeks to develop persistent, wide-area sensor surveillance across large ocean areas using large numbers of intelligent floats or buoys.

The solicitation focuses on the analytics portion of the Ocean of Things project. DARPA wants companies to develop analytical techniques to distill insights from an autonomous float field and produce mission products from many concise float data reports. Several contract awards are expected collectively worth as much as \$8 million.

While the Ocean of Things program

aims at affordable ocean sensing at large scales and high resolution, the project's analytics portion seeks to provide detailed understanding of the ocean environment to protect natural resources and enable the military to operate more effectively on the high seas.

The Ocean of Things program provides environmental sensing and operational surveillance missions by composing data from a distribution of heterogeneous floats. Each float characterizes the physical environment through periodic sampling of local ocean properties, while also reporting significant maritime events.

A primary objective is to develop edge-processing methods to identify and report essential information from any events within a float's range to enable mission analysis once the data reaches the cloud. This project also will help choose sensors and sampling rates to make the most of system



DARPA is asking industry to analyze data from thousands of sensors floating in the ocean to create actionable intelligence and help Navy commanders carry out their missions at sea.

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Ultimately DARPA researchers envision a field of smart sensors housed on as many as 50,000 floats to cover vast ocean areas as large as one million square kilometers.

Those participating in the program's data analytics section should apply advanced processing techniques like filtering, clustering, and machine learning to develop vessel tracks, characterize vessel behaviors, identify new signatures, and conduct other mission analytics.

The project also will visualize float sensor coverage, predict float field performance, and control individual floats to maintain a floating sensor field comprising thousands of floats.

The second phase of the Ocean of Things project has two technical areas:

design and production of floats; and developing advanced data analytics to generate mission products. This announcement only involves data analytics.

For Ocean of Things analytics,

During the Ocean of Things first phase, companies developed user interfaces computers to analyze data sets for several small float deployments in Southern California and the Gulf of Mexico. In the second phase, performers will use an existing user interface, advanced algorithms, and analytic techniques to analyze all data.

In the second phase, companies will work closely with existing float designers during software design and testing.

Building the capabilities envisioned in the Ocean of Things project is important because today's naval

and commercial ships typically can use only their onboard sensors for situational awareness. Using remote sensors from aircraft and satellites, moreover, can be limited or impossible because of fog, rain, cloud cover, and other environmental conditions.

The smart float system in the Ocean of Things program will use a cloud-based architecture, find ways to visualize the dynamic capabilities of the system, and find new ways for operators to interact with large numbers of floats. ◀

Companies interested were asked to upload proposals by 15 May 2020 at <https://baa.darpa.mil>. Email questions or concerns to DARPA at HR001120S0042@darpa.mil. More information is online at <https://beta.sam.gov/opp/37991fec08e949db80f9e3185d1a319b/view>.

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The U.S. military is trying to develop a wearable sensor that would act as an alarm to warn warfighters of laser threats.

Military needs a wearable laser detector to provide real-time warning

BY John Keller

ARLINGTON, Va. — U.S. military researchers are asking industry to develop a small, lightweight, wearable laser detector to determine in real time if an adversary

is using lasers for weapons guidance or range finding, or that could damage sensors or human eyes.

Officials of the U.S. Defense

Advanced Research Projects Agency (DARPA) in Arlington, Va., has issued a small-business innovation research (SBIR) solicitation (HR001120S0019-05)



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for the Wearable Laser Detection and Alert System.

DARPA researchers want to understand the feasibility of a wearable laser sensor that can detect laser irradiation rapidly during the day and at night and alert the wearer in real-time of lasing.

DARPA wants a wearable laser-detection system with low size, weight, and power consumption (SWaP) that would act as a stand-alone sensor to detect laser illumination over the 450-to-1600-nanometer visible to shortwave infrared region.

The wearable detection system should weigh no more than 3.53 ounces, and receive power from a rechargeable conformal wearable battery that weighs less than 3.3 pounds. This battery should be able to power laser detector for 72-hours of continuous operations.

The wearable system must provide real-time warning of lasing, be comfortable to wear, and be easily integrated into existing military head gear. Technology developed will fall under guidelines of the International Traffic in Arms Regulation (ITAR).

The system should be able to detect laser irradiation at energies of 500 microwatts per square centimeter and greater to warn personnel of potential ocular damage or damage to electro-optical and infrared sensors in near-real time.

Although DARPA researchers are interested in broadband coverage, they particularly are interested in wavelengths that include 532, 632, 1064, 1300, and 1550 nanometers.

The system should not react to bright non-laser sources such as solar phenomenon, flares, background light, thermal light, headlights, rocket plumes, muzzle flashes, and other sudden bursts of high-intensity light not

related to laser illumination.

Proposers should provide a feasibility study for developing a laser detection system, including modeling and simulation. Proposals should identify commercial off-the-shelf (COTS) sensors or components that can help demonstrate the system. ←

Companies interested should upload proposals to the DOD SBIR/STTR Proposal Submission website at <https://www.dodsbirsttr.mil/submissions/login> no later than 26 May 2020. Email questions or concerns to DARPA at HR001120S0019@darpa.mil. More information is online at <https://beta.sam.gov/opp/f35da0a4ad204bea99b80498b6d2f9a7/view>.

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The DARPA MACH program seeks new materials and designs for cooling the hot leading edges of hypersonic vehicles.

The electronics design challenges of hypersonic flight

Hypersonic munitions present an intimidating set of environmental challenges, raising the bar to an entirely new level of difficulty.

BY J.R. Wilson

Contrary to popular opinion, there is nothing new about hypersonic flight.

Nazi Germany's V-2 rocket achieved speeds of Mach 5, but was not called hypersonic, a term not coined until 1946 by Hsue-shen Tsien, an aerodynamicist at the California Institute of Technology.

In 1949, the two-stage Bumper rocket achieved a speed of Mach 6.7 before burning up on atmospheric reentry. Yuri Gagarin became the first human to travel at hypersonic speed during his historic orbital flight in 1961. The following month, Alan Shepard joined that unique club when his suborbital flight exceeded Mach 5 on reentry. And in November that year, Air Force Maj. Robert White exceeded Mach 6 in the X-15 research plane. Ballistic missiles routinely reach speeds of up to Mach 9 during reentry from space; the Space

Shuttle, dropping out of orbit, entered the atmosphere at roughly Mach 22.

However, these examples were largely short-term and on fixed trajectories, while hypersonic missiles follow unpredictable and adjustable flight paths, placing variable and far greater environmental pressures on electronic components and sensors needed for their successful operation.

Aircraft moving through the atmosphere at speeds exceeding Mach 5 (roughly 3,800 miles per hour, depending on altitude) challenge engineers with extraordinary levels of heat, vibration, and shock.

The need for rugged

The technologies for ruggedization include enhanced circuit board design and component selection; screening

components; and ensuring that electronic parts will survive the vibration, temperature, and pressure extremes of hypersonic flight.

"Matching and overcoming hypersonic threats will demand technology advances across three broad areas: propulsion systems; airframe materials; embedded electronics," wrote Lorne Graves, chief technology officer of rugged computer specialist Abaco Systems in Huntsville, Ala., in a March 2019 white paper. "While most research spending is targeting the first two areas, it is clear that innovative improvements in embedded electronics are key to creating fully functional hypersonic systems."

He identified four primary functions embedded electronics that will need to perform for deployable hypersonic platforms:

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Technician at a Northrop Grumman facility in Charlottesville, Virginia, inspect a 3D printed manifold for one of their navigation systems.

- mission computing, focused on responding to commands, adjusting to changing conditions and ensuring that all subsystems work in concert to accomplish a platform's mission;
- flight computing, controlling the path of the platform, monitoring the outputs of sensors and controlling the operational employment of sensors;
- real-time signal processing for radar, electro-optical sensors, and elec-

tronic warfare (EW); and

- flawless and secure communications with command and control networks.

"The electronics to perform these functions may exist in a single computing enclosure or be spread across several, Abaco's Graves wrote. "The system may even be designed so that a subsystem of electronic components can perform multiple functions, switching between them based on the mission situation. But, regardless of the configuration, hypersonic flight will present the electronics with an intimidating set of environmental challenges, taking conditions already faced by airborne electronics and raising the bar to an entirely new level of difficulty."

Efforts to overcome those difficulties continue to be the focus of numerous research programs in the U.S., Russia, China, France, India, Australia, and Japan. From military labs to academia to private companies, new technologies are being developed, old technologies modified, and revolutionary designs tested to address the issues facing hypersonic missile engineers.

Pressure on circuit boards

"Traveling at those speeds, the vibration profiles will evolve beyond what typical standards currently call for, so you have a lot of work to do on printed circuit boards, all the separable connector failure points and mitigating the effects of those so you don't have failures, either right away or fatigue failures, which are worse," says Ivan Straznicky, chief technology officer for advanced packaging at Curtiss-Wright Defense Solutions in Ashburn, Va.

"Heat is another area," Straznicky continues. "If a missile goes back into the atmosphere at those speeds, it generates a lot of heat, so we need materials to shield against that. But you can't get rid of that heat entirely, so it will be hot inside that missile. You need electronics that can survive above typical temperature ranges, which may require unique solutions, such as vapor chambers or perhaps some type of liquid cooling."

Experts say they will have to design components to withstand environmental conditions as severe as 10 times higher than the maximum allowed under VITA 47 — an American National Standard that defines rugged environmental, design, and construction requirements for rugged commercial-off-the-shelf (COTS) plug-in embedded computing boards. Still, there is no ruggedization "silver bullet" to protect hypersonic electronics and sensors.

"There are potentially flight versus mission computers on the platforms, which may have very different requirements," Straznicky points out. "The flight computer may need be certified to DO-254 DAL A [the most stringent design assurance level for airborne electronics], which is a high bar. Mission computers still need to be ruggedized, to the same level, but the design



Curtiss-Wright's new TTC- MDW-2020, is a miniature double-wide-form-factor data acquisition unit (DAU) designed for use in flight test instrumentation applications such as testing of hypersonic ordnance.

assurance levels impose significant additional restrictions on the hardware, such as recognizing failure modes.”

Manufacturing also can be a challenge. “Components are no longer made specifically for military applications, but predominantly for commercial,” Straznicki explains. “A lot of component manufacturers do have industrial, sometimes military, temperature characteristics, but those are few. When you design those in and assemble them onto a printed circuit board, then put cooling systems on top of that, everything needs to work reliably, such as solders. That’s a fairly esoteric specialty for ruggedization.”

It also is a problem researchers and engineers have been studying for decades. At the end of an October 1967 flight that reached Mach 6.7, the X-15 suffered intense heating from shock waves that partially melted the pylon that attached the aircraft’s ramjet engine to the fuselage. While external heat is a problem for external structures, such as sensors, it also significantly raises the aircraft’s internal temperature, threatening to damage sensitive electronics.

Conformal coatings

Experts say that environmental ruggedization to protect electronics from heat at hypersonic speeds — exterior temperatures rising higher than 4000 degrees Fahrenheit — almost certainly will rely on conformal coatings.

“We have three different types of coating: acrylic, urethane and parylene, a vacuum vapor deposited film up to half a millimeter of thickness that wraps itself around everything on the board. That is the ultimate in protection. That protects against humidity and condensation, which you would have to protect against in cases of very rapid changes in temperature,” Straznicki says.



Hypersonic weapons are subject to many environmental extremes in heat, shock, vibration, and high G forces.

“Whatever the actual shock and vibration levels and the actual environment, once released, we can work to those types of extremely harsh environments, even beyond current ruggedization requirements.”

The specific technologies used to ruggedize against heat and vibration also will vary throughout the vehicle, depending on where the electronics are installed. The nose, for example, will experience harsher temperatures than the tail.

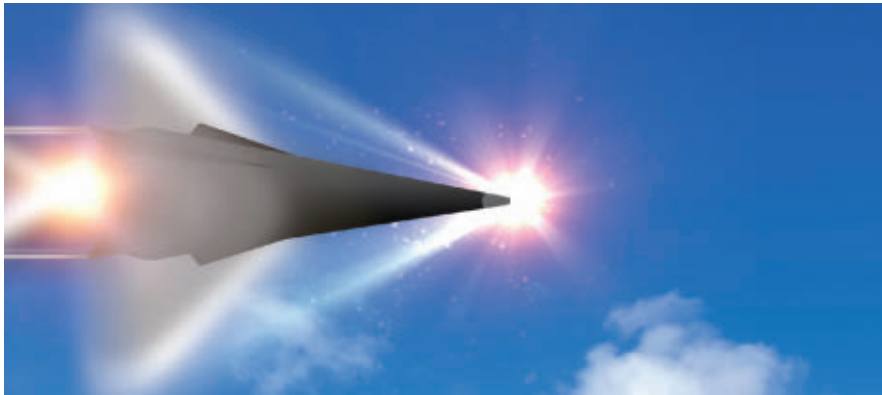
Design engineers basically are using existing technologies and designs developed during the past three decades, modified to increase

the ability to survive in those harsh environments, says Farhad Daghighi, vice president for sales and business development at the Curtiss-Wright Defense Solutions Aerospace Instrumentation Group.

Where sensors are installed also will impact the level of ruggedization required, such as the types of glues and fasteners used to attach them to the skin of the vehicle. The problem is two-fold — finding materials that can withstand both extreme temperatures, including a rapid transition from the cold of altitudes exceeding 100,000 feet to the intense heat of reentry and flight through the lower atmosphere, and



Lockheed Martin is at the forefront of U.S. hypersonic weapons development of enabling technologies like electronics, materials, and testing.



Known electronics cooling methods are insufficient to cool the extreme temperatures of hypersonic flight, which requires new methods to enable components to operate safely in high heat.

intense shock and vibration.

Thus the true difficulty with developing a hypersonic missile is not pushing it to such high speeds, but ensuring the embedded computing systems can endure the extreme range of temperatures, G forces, vibration, humidity, and pyrotechnic shock — and do so without adding weight or bulk to the missile.

“Uncontrolled energies at resonant frequencies can rapidly destroy components and connections throughout an embedded computing system. Some hypersonic platform designs further complicate the mechanical vibration challenge by using an engine that varies its combustion behavior based on altitude,” says Abaco’s Graves.

“This innovative propulsion solution also means that the engine vibration characteristics will vary, further complicating embedded electronics designs,” Graves says. “Other environment considerations are not related to hypersonic speeds, but must still be accounted for, based on a given platform’s mission profile.”

Commercial electronics

In today’s high-tech environment — especially with the limited market of military hypersonics — application-specific developments solely for

military use simply are not practical. Using the latest in rapidly advancing commercial computing and communications silicon to create the kind of powerful, multi-function computing required for hypersonic missions will have to suffice. But systems using commercial chips will have to be ruggedized far beyond civilian requirements to ensure survivability in the harshest environments.

“Continual evaluation of trends and innovations in commercial semiconductor development is a key component. So are continued improvements to already world class ruggedization practices. A third component supporting rapid deployment is a software framework for developing high-performance, real-time embedded applications,” Graves wrote.

“The AXIS Software Tool Suite from Abaco includes modules supporting the accelerated development of algorithm implementation, data movement, inter-process communications, image processing, event analysis and more capabilities. At the platform level, programs need powerful embedded electronics that can support all aspects of a mission, making software development a critical function.”

Yet even collaborative efforts among

the top researchers and facilities can only go so far in the development of workable and, above all, reliable ways to deal with those problems. For high-speed aviation, validating ruggedization falls to the flight test stage of development.

“In the world of flight test, products have to be much more rugged than the design products for the operational stage of an aircraft. So we push the envelope much further than we would on an operational platform,” Curtiss-Wright’s Daghigh says.

“For an aircraft that typically flies at Mach 2, we push the tests to Mach 3,” Daghigh says. “For hypersonics, you have to push that even further; if it is supposed to go to Mach 8, we test it to Mach 9 or 10. In flight test, you’re in experimental mode and anything goes, which you have to be ready for because we are measuring thousands of sensors down to the nanosecond to see what happened across them all if something goes wrong at any one point. In the operational environment, they won’t take the aircraft beyond its design characteristics.”

In addition to the purely engineering problems facing hypersonic development, U.S. Department of Defense (DOD) also must keep a close eye on international developments, primarily from potential adversaries such as China and Russia, both of which have claimed to already have hypersonic capability, with missile ranges as far as 1200 miles.

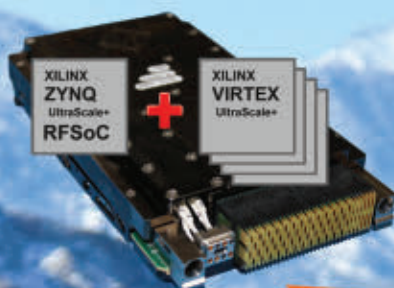
World hypersonic development

Russian President Vladimir Putin has announced the Avangard hypersonic glide vehicle is “operational” and capable of speeds to Mach 27. The Chinese claim to have two hypersonic missiles: The DF-17, unveiled on 1 Octo-

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ber 2019, and the Starry Sky-2, a Mach 6 hypersonic glide platform still under development.

Maintaining U.S. competitiveness in hypersonics involves not only watching Russian and Chinese developments, but also tracking trends in commercial processing and communications technology. That evaluation then leads to adopting the best examples of commercial technology across multiple processor types.

“Today’s processing silicon is segmented into technology types, including multi-core general purpose processors (GPPs), general purpose graphics processing units (GPGPUs), field programmable gate arrays (FPGAs), digital signal processors (DSPs) and communications processors (CPs),” Graves wrote.

“As the name suggests, a GPP is not specialized — and yet, for the purposes of embedded computing, it is. A GPP is the best processor type when decision-making and context-switching is important; for example, when responding to commands.”

Each advance in modern processors, however, increases one of the most pernicious problems with hypersonic

flight — heat. Even as each new generation of processor provides geometric increases in performance, increases in performance, increases vital to the complex requirements of a hypersonic vehicle, the internal heat generated increases, as well. In recent years, however, there has been little change in the maximum operating temperatures of most commercial silicon, typically around 100 degrees Fahrenheit.

Cooling challenges

One of the most common methods of cooling such systems is blowing forced air over them, which obviously is not possible in hypersonic flight, where external heat also must be extirpated. That leaves two other primary techniques: conduction cooling and heat pipes, sometimes combined within an advanced system design.

Conduction cooling is implemented with a heat frame that encloses a circuit board where the processors are connected, and wedge locks that firmly attach the heat frame/circuit board assembly to a system chassis wall, Graves explains. The wedge locks also help address another problem — vibration — by increasing system rigidity.

Heat pipes are used to move heat directly from a surface with significant heat load, such as a multi-core GPP, to a cooled surface, often inside the finned outer surface of a chassis enclosure. A heat pipe’s effectiveness is dependent on a number of variables, but they are often an efficient way to deal with difficult hot spots in a system.

“Vibration effects, as well as acceleration G forces and pyrotechnic shock, can all be mitigated by using damping materials at physical connection points, both within a system chassis and where the chassis is attached to the airframe,” according to Graves.

But the extremes to which hypersonic flight pushes all environmental requirements — especially at speeds in the Mach 20 to Mach 30 range envisioned for hypersonic missiles — means there must be significant advances in every component and every method used to defeat those challenges. Simulations are used to identify potential weaknesses in COTS components used in the design, then those are strengthened and secured to ensure they can withstand the hypersonic environment before they ever go on a flight test vehicle.

“It’s like a Lego concept where you can stack modules on top of each other, depending on the number of sensors and how big that configured stack is going to get, and ensure it will stay intact for the specific mission or if you will need additional work to hold it in place,” Daghigh says.

DARPA MACH program

The Materials Architectures and Characterization for Hypersonics (MACH) program at the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., comprises two technical areas. According to the agency, “the



Hypersonic munitions are creating huge challenges for electronics designers to survive the rigors of high-MACH operations.

first seeks to develop and mature fully integrated passive thermal management systems to cool leading edges based on scalable net-shape manufacturing and advanced thermal design. The second will focus on next-generation hypersonic materials research, applying modern high-fidelity computation capabilities to develop new passive and active thermal management concepts, coatings and materials for future cooled hypersonic leading edge applications.”

“Hypersonics is a very interconnected design process. Every change you make has to be connected to every other component, unlike building an airplane. With MACH, we’re talking about a leading-edge technology that will improve the capability of the vehicle with very little redesign required,” says MACH Program Manager William Carter. “It’s one thing to have an aeroshell on the leading edge, but you also have to have all the communications and other stuff on the inside protected from the heat of hypersonic flight. Just swapping out one component could leave you vulnerable to a thermal shift.

“Cooling is interesting because you are trying to get heat off a very hot vehicle. SWaP [Size, Weight and Power] is important because these are very constrained platforms. Based on the aerodynamic principles involved and launch capabilities, you have a highly SWaP-constrained platform. So, advances in electronics, fuel and materials in general will be very important.”

Hypersonic weapons research received about \$2 billion in 2020 and the Pentagon is asking to increase that to \$3.2 billion in 2021. Those numbers reflect the status of hypersonics as the DOD’s number-one research priority, with strong bipartisan support in Congress and from the White House.

WHO’S WHO IN ELECTRONICS FOR HYPERSONICS

Abaco Systems
Huntsville, Ala.
www.abaco.com

Aerofjet Rocketdyne
Huntsville, Ala.
www.rocket.com

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

Jacobs Technology Inc.
Fort Walton Beach, Fla.
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Lockheed Martin Corp. Missiles and Fire Control
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China Lake Naval Air Weapons Station, Calif.
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Northrop Grumman Corp.
Falls Church, Va.
www.northropgrumman.com

Raytheon Technologies Corp.
Waltham, Mass.
www.rtx.com

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

In addition to vehicle and propulsion designs, dozens of defense contractors, subcontractors, and research labs are devoting increasing levels of effort to hypersonics, including solving the environmental hazards facing such a missile’s electronics and sensors. For example, John Varley, vice president for hypersonics at the Lockheed Martin Corp. Missiles and Fire Control segment, has said Lockheed alone has about \$3.5 billion in hypersonics work across several divisions.

Keeping up with adversaries

What the Chinese and Russians have done in that area is largely unknown (publicly, at least), but the United States and its allies have decades of experience in shielding such systems against heat, vibration, and shock. Those come largely from the space program, where hypersonic speeds are foundational, as well as military programs, from the X-15 to the Waverider.

While all three nations report testing hypersonics, no one has proven yet to have conquered those environmental challenges sufficiently for reliable and successful maneuverable flight.

That such a capability will be achieved in this decade seems almost

certain, bringing in a new era of warfare as game-changing as the development of intercontinental ballistic missiles — especially when a hypersonic cruise missile carries a nuclear warhead, as Adm. Charles Richard, head of the U.S. Strategic Command, told a Senate Armed Services Committee hearing on 13 February.

“I will offer that it is not our policy or intent right now to nuclearize hypersonics,” he added. “Other nations can choose to do what they wish in that area and, yes, this is the competition.”

Able to strike a target anywhere on Earth in a matter of minutes, a functional long-range hypersonic missile’s speed and maneuverability also would make it virtually impossible for current missile shields to defend against. But the reality of this new “nightmare” weapon is entirely dependent upon radically advanced glues, solders, heat dissipation, anti-shock and anti-vibration protection for its most delicate internal components.

“This has a lot of similarities to the introduction to the intercontinental ballistic missiles back in the late Fifties and early Sixties and we are ready to address it,” Richard assured Congress. ◀

RF and microwave designers take-on the cluttered spectrum

Systems built for low size, weight, and power consumption (SWaP) and industry standards like SOSA are dominating applications ranging from satellite navigation to next-generation 5G communications.

BY **Jamie Whitney**

The presence of dense radio frequency (RF) signal traffic on the battlefield is constant, and radio silence is no longer the norm. Experts in the RF and microwave equipment and component manufacturing world say they are seeing a boost in support for open-system standards while packing more power into smaller spaces using commercial-off-the-shelf (COTS) components.

“Military radio systems were traditionally stovepiped and had a lot of internally designed signal synthesis and baseband-to-RF conversion sections, says Dean Handrinos, co-founder and partner at Triad RF Systems in East Brunswick, N.J. “These subsystems were usually designed around

a limited number of waveforms that would not change over the lifetime of the product. Adapting a legacy radio for a new signal would call for a whole-sale redesign.”

Now, with a boom in software-defined radio (SDR) technology, Handrinos says mil-aero radio manufacturers are afforded a lot more accessibility.

“An engineer now has the ability to design a radio capable of generating many different signal types and modulations, without having to design a system from scratch,” Handrinos says. “When needed, they can change waveforms on the fly programmatically. This accessibility is also apparent on the RF circuit front as well. RF SoCs [systems-on-chip] now exist that can directly synthesize complex signals up to 6 GHz and can handle instantaneous transmit modulation bandwidths hundreds of megahertz wide and beyond.”

Handrinos explains that Triad RF Systems is getting requests from systems integrators to close long-distance unmanned aerial vehicle (UAV) systems radio links, as they have much higher bandwidth and throughput requirements than before.

“These links are now tasked with passing data-intensive HD [electro-optical/infra-red] streams and other data

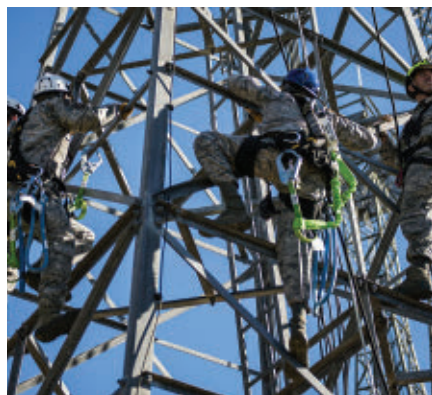
from multiple payloads,” Handrinos says. “Bolting-on an amplifier to boost link distance, as was formerly done, no longer solves data link distance issues because modern radio systems with complex waveforms (like 256QAM) are much more sensitive to the signal distortion an amplifier introduces. Much more advanced amplifier products with control systems to manage this distortion and keep the link reliable are required, and that is where our specific expertise lies.”

Software-defined advantages

He continues, “Triad designs high power RF Systems, so while it is now easier for radios to generate these complex signals at the board level, it is an entirely different challenge to transmit that signal at high output power, with sufficient signal linearity and SNR for the radios to communicate properly.”

Handrinos notes the company’s Triad High Power Radio (THPR) system reflects the trend of enabling high data rates across long wireless links in unmanned systems in air, sea, or on the battle field.

“Our main product line, the THPR-high power radio system, is a radio-agnostic solution for when extended range is needed from modern



U.S. Air Force RF and microwave technicians rappel down a radio antenna tower during an immersion tour at Moody Air Force Base, Ga.

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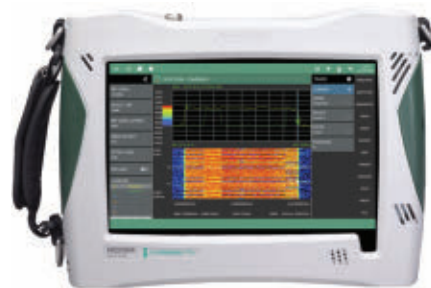
high-bandwidth military radio systems utilizing technologies such as MIMO and mesh networking," Triad's Handrinos says. "Our advanced amplifiers are tailored for the multitude of signals that can be generated out of an SDR. We also qualify our products to ensure that we deliver the promised data rate at much higher RF output powers than the stock radios are capable of. Internal monitoring and auto power control circuitry take nearly all the guesswork

and troubleshooting out of deploying a long range, high bandwidth link. Our current product line spans 400 MHz to 6 GHz, but there are plans to develop for X and Ku bands as well."

Brian Kimball, senior product manager at Mercury Systems in Andover, Mass., says that even as platforms get smaller, performance needs to be maintained.

"We're definitely seeing a trend towards spectral density," Kimball says. "I think this is driven by the need for smaller platforms and the different forces don't want any degradation in performance. They don't want to suffer a limited number of channels, but they're in a more SWaP-constrained envelope. I also think ruggedness is a trend because of, again, the small-form-factor nature of these newer payloads."

Kimball also says that open standards like Sensor Open Systems Architecture (SOSA) and similar initiatives are driving development in the RF and microwave sector for mil-aero



The Anritsu Field Master Pro MS2090A with real-time spectrum analysis.

manufacturers.

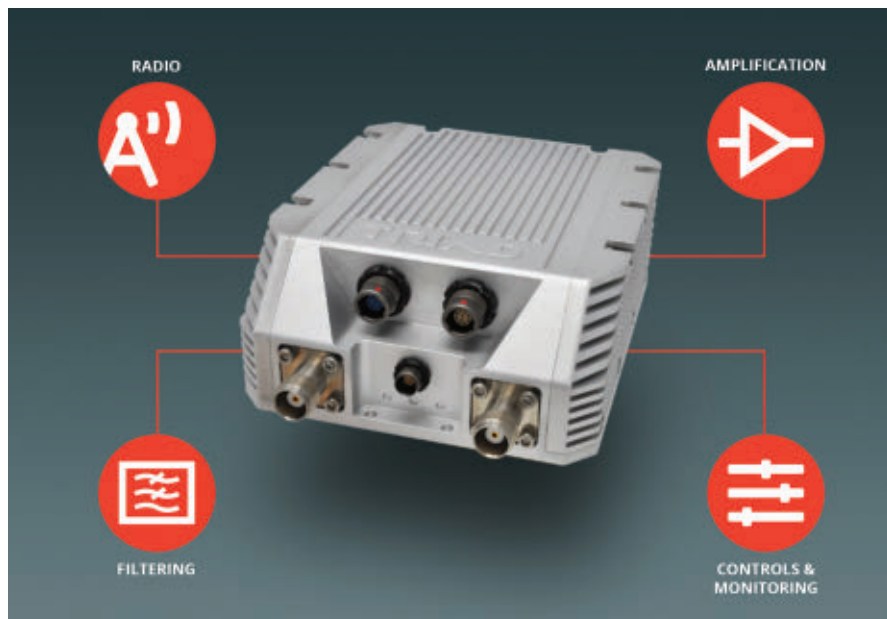
"We have a case now where the RFM 3U transceiver product line was in VITA 65 and we're transitioning to SOSA-aligned. And the way we did it in their modular transceivers and a digital baseboard that they sit on," Kimball says. "So, we just had to do a minor tweak to the digital baseboard to fall in line with SOSA. And we're doing that on multiple fronts with primes for both the Army and the Air Force."

The imperative for SOSA

The Open Group, which oversees SOSA standards, comprises more than 750 companies worldwide. SOSA aims to reduce development cycle time and cost, systems integration cost and risk, and sustainment and modernization cost. In addition, the group aims to increase commonality and reuse, support capability evolution, mitigate obsolescence, and isolate the effects of change.

Mercury's Kimball says that SOSA is now "sticking" in ways that it previously didn't is because of buy-in by military branches.

"It is not a 'maybe' - it is a 'must' for some of these newer platforms that we're seeing," Kimball says. "If the Army and the Navy and the Air Force have programs for it, it's a must. The industry is going to follow along. It's actually being driven from the top. The



The Triad High Power Radio (THPR) system is a radio-agnostic solution for when extended range is needed from modern, high bandwidth military radio systems.

beauty of SOSA is it takes something like other open standards like VITA 65 and it takes away the undefined pins. So, you really can have a payload slot that could be vendor A, vendor B, vendor C, take one out, plug the other one in and things will work."

Kimball continues, "That's wonderful for the forces to have that (so) they don't have vendor lock. They could even take a card out, put another card in and change the function of the mission. So, I think it's is universally starting to stick. And I think it starts at the top."

In addition to spectral density and SOSA-alignment, Kimball notes the trend of operating at higher frequencies.

"I also would say directed activation is encroaching in the RF space. You know, it was just a couple of years



The Mercury Systems Spectrumseries RFT-3200 downconverter and matching RFT-4200 upconverter-broadband frequency conversion products for agile electronic warfare and electronic intelligence systems.

ago ... you couldn't see much above two gigabytes. Now we have products that can see up to eight gigs for analog input bandwidth and there are definitely some on the horizon that can even digitize a K-Band that really shifts the RF problem."

Stop the bounce back

While the military wants robust performance for its RF and microwave systems, it also aims to stop ene-

mies' signals from bouncing back to them. In addition, forces aim to minimize their own signal degradation. Laird Performance Materials, based in Chesterfield, Mo., has its Performance Materials group, which f, based in Santa Clara, California, focuses on mitigation of electromagnetic interference inside of electronic packages and dissipation of heat.

Rick Johnson, president of Laird R&F Products, explains that there are a trio



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of military uses for its performance RF materials.

“The first one is what I’m going to call ‘survivability,’” Johnson says. “So, you put absorbers on things that you don’t want to return energy from. And that’s certainly something that is being used a lot nowadays as things try to become less and less observable to detection radars. So that’s one of our big main areas of focus.”

The second, Johnson says, is in antennas.

“Antenna pattern enhancement, reducing antenna side lobes, reducing backscatter from antennas, improving the isolation of an antenna so it performs better,” says Laird’s Johnson. “That is a big part of our work in both military and commercial.”

Finally, Johnson says is the focus on internal high frequency electromagnetic interference (EMI).

“So, normally, if you’ve got a noisy chip, you can put a board-level shield around it or something else to mitigate it,” Johnson says. “If you start hav-

ing these problems in the microwave and millimeter wave frequencies, the wavelengths are getting so small that traditional EMI shielding doesn’t work properly. So, you have to be augmented by putting absorbers in there, which will then absorb the energy. So, it is not only just keeping the energy inside the box and meeting FCC requirements, but also stopping one component from interfering with another. So, it’s used a lot in automotive radars between the transceiver in the transceiver assembly. It’s used in high frequency EMI applications for datacom and automotive electronics.”

Laird’s Johnson says that microwave absorbing material is made up of two parts - one, a binder, which could be in an epoxy in an elastic or thermal plastic.

“Their function is to provide the external coating or the body of the absorber,” says Johnson. “The other key factor is then the fillers that go inside of it ... What I want to focus a little bit on is the fluorosilicones and

we’re adding different electromagnetic fillers, and those fillers then vary as frequencies vary. What we’re seeing is on the material side, the environmental side, we’re seeing higher temperatures. We’re seeing use and harsher environments that need better fuel resistance. We’re seeing materials that need better corrosion resistance.”

Johnson continues, “Everybody’s familiar with silicones or uses gaskets or uses caulking for your bathtub for a silicone that are similar, but they have this fluorine attached to them, which then gives it a much better temperature capability (but) the most important part is fuel resistance. And so, silicones are traditionally not used on aircraft and other areas because of their susceptibility to swelling by fuel or damaged by fuel. So, what we have done is really focused on using these fluorosilicones in a variety of different ways.”

Noise in the signal

While warfighters and commanders depend on RF and microwave equipment to transfer invaluable data that could make or break mission successes, tracking down sources of interference is also incredibly important.

Just as technology has made transferring data across the frequency faster, what was once relegated to the benchtop is now field deployable.

While the traditional spectrum analyzer continue to be a workhorse for RF engineers, real-time spectrum analyzers (RTSA) offer myriad benefits for industries and agencies looking to glean additional insights into signals across the spectrum.

With real-time analysis, experts can conduct continuous gapless capture and analysis of elusive and transient signals, which is not something conventional spectrum analyzers and vec-

WHO’S WHO IN RF & MICROWAVE

Aitech

Chatsworth, Calif.
www.rugged.com

Anritsu America Test and Measurement

Morgan Hill, Calif. www.anritsu.com

Crystal Group

Hiawatha, Iowa
www.crystalrugged.com

Curtiss-Wright Defense Solutions

Ashburn, Va.
www.curtisswrightds.com

dB Control

Fremont, Calif.
www.dbcontrol.com

Elma Electronic

Fremont, Calif.
www.elma.com

Fairview Microwave Inc.

Lewisville, Texas
www.fairviewmicrowave.com

Laird Performance Materials

Chesterfield, Mo.
www.laird.com

Mercury Systems

Andover, Mass.
www.mrcy.com

Micro Lambda Wireless

Fremont, Calif.
www.microlambdawireless.com

Pasternack Enterprises

Irvine, Calif.
www.pasternack.com

Pentek Inc.

Upper Saddle River, N.J.
www.pentek.com

RIGOL

Beaverton, Ore.
www.rigolna.com

Triad RF Systems

East Brunswick, N.J.
www.triadrf.com

VPT

Blacksburg, Va.
www.vptpower.com

W.L. Gore

Newark, Del
www.gore.com

tor signal analyzers can do. This allows for signal-in-signal monitoring for traffic that should not be there or may be causing interference.

Experts at the Anritsu Corp. U.S. Test and Measurement division in Morgan Hill, Calif. explain that RTSA test and measurement instruments give a much broader view compared to traditional technology of what's going on in the spectrum compared to traditional technology.

"It would be used for spectrum clearing to check to see in a base environment if there's any unknown or unwanted transmitters that could affect the security of these operations," says Anritsu Product Manager Kirby Hong. "The second use could be general maintenance of equipment. Is it performing correctly? Are they meeting their specifications? When the radar is turned off, does it unintentionally emit spurious signals? It could be a security problem. Look for illegal listening devices, especially those that have a very transient nature that isn't broadcasting all the time. If there's a bug recording conversations, and periodically it transmits to a receiver station somewhere, that could be missed by a traditional spectrum analyzer."

Scanning the spectrum

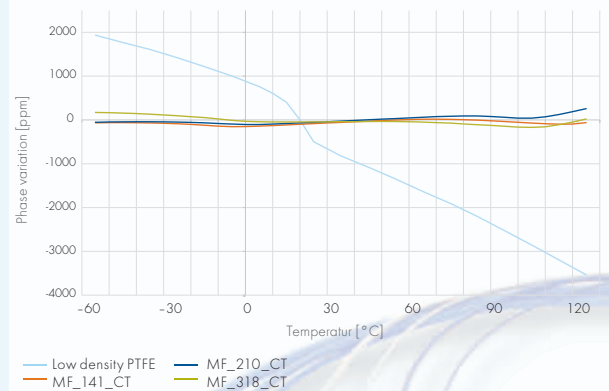
Anritsu's Field Master Pro MS2090A instrument with real-time spectrum analyzer option was selected to locate the interfering signal. According to the manufacturer, in the optional real-time mode, the MS2090A can accurately measure the amplitude of a single spectrum event as short as 2 microseconds and detect a single event as short as 5 nanoseconds. The MS2090A is a ruggedized, size, weight, and power (SWaP) optimized, field-deployable handheld spectrum analyzer that has a 110 MHz analysis bandwidth and an measurement range from DANL to +30 dBm.

Using the MS2090A RTSA, experts were able to find the cause of the interference alarms at the public safety agency: high wind caused a cable to bang up against the tower, causing passive intermodulation.

The MS2090A can help with interference hunting, spectrum clearing, broadcast transmitter analysis, monitoring microwave radio links, satellite system monitoring, pulse radar measurements, 5G NR base station measurement, and 5G coverage mapping.

Hong and Angus Robinson, a marketing manager at Anritsu, notes that due to SWaP optimization, the battery-powered Field Master Pro MS2090A can be mounted into aircraft, vehicles, and deployed nondescriptly in cases

CT assemblies vs conventional PTFE-based assemblies



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to keep an inconspicuous eye on signals across the spectrum in real time.

“One of the government agencies we’ve been talking to is currently mounting into airframes, inside military aircraft, very large lab type instruments for exactly this application,” says Robinson. “And so, you can imagine anything that you’re putting up in an airframe in terms of weight and size is a big issue. They’re very excited about the small form factor and the ability to get that same functionality in a much smaller form factor. There’s also a group of people who want to leave these units in, say, unsuspecting looking Pelican cases...It’s got a big battery in the case as well, and they leave it gathering data somewhere for a day or what have you and then come back home and pick it up.”

Rugged recorder

Pentek Inc. in Upper Saddle River, N.J., recently unveiled its RTX 2684 26 GHz RF Sentinel Intelligent Signal Scanning small-form-factor recorder, which is an addition to its Talon family.

“The RTX 2684 Sentinel recorder is a complete antenna to disk solution with RF signals down converted directly to the A/D converters,” says Rodger Hosking, vice-president of Pentek. “Its 5x reduction in packaging size over the rackmount equivalent, bandwidth performance, and storage capacity all offer huge improvements in addressing challenging SWaP constraints in mobile or space limited platforms.”

The Talon RTX 2684 SFF recorder weighs in at 23 pounds and is designed for extreme operating environments. Optimized for SWaP, the rugged sealed

½ ATR recorder is available with up to 61 terabytes of removable SSD storage. The quarter-ATR chassis makes it suitable for military, security and government intelligence (SIGINT, COMINT and ELINT) applications that are mobile or very space limited.

A Pentek Model 78141A Jade transceiver module serves as the data acquisition engine of the Talon RTX 2684. One of its dual 3.2 GS/sec 12-bit A/D converters operates at a sample rate of 2.8 GS/sec. The Model 78141 is coupled to the 500 MHz bandwidth analog IF output signal of a 26 GHz RF tuner front end, delivering excellent dynamic range across its entire spectrum. A digital downconverter (DDC) in the Model 78141 provides frequency zooming for recording signal bandwidths of 500, 250 or 125 MHz. ←

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The Boeing MQ-25 carrier-launched unmanned aircraft will refuel Navy aircraft to extend their ranges at sea.

Boeing to build three MQ-25 carrier-based unmanned aerial tanker aircraft

BY John Keller

PATUXENT RIVER NAS, Md. — U.S. Navy carrier aviation experts are ordering three unmanned aerial tankers from the Boeing Co. in preparation for future larger orders and eventual carrier deployment of these unmanned tanker aircraft.

Officials of the Naval Air Systems Command at Patuxent River Naval Air Station, Md., announced an \$84.7 million order to the Boeing Co. Defense, Space & Security segment in St. Louis for three new MQ-25 unmanned tanker

aircraft for system demonstration.

These three new MQ-25s and their avionics are called system demonstration test articles, which are to demonstrate the maturity of the MQ-25 manufacturing process, and ensure the readiness of MQ-25 production, systems, facilities, tooling, test equipment, inventory, and supplier management.

The MQ-25 is the U.S. Navy's first operational carrier-based unmanned aircraft and is designed to provide a

much-needed refueling capability, Boeing officials say. Navy officials expect to declare MQ-25 initial operational capability by 2024. The MQ-25 first flew last fall.

The MQ-25 will provide carrier-based refueling capability to extend extending the combat range of deployed F/A-18 Super Hornet, EA-18G Growler, and Lockheed Martin F-35C combat aircraft.

Boeing won a \$805 million development contract to build four MQ-25

carrier-based unmanned aerial tankers in 2018, prevailing over competing designs built by General Atomics in San Diego and the Northrop Grumman Corp. Aeronautics Systems segment in Palmdale, Calif.

The Boeing MQ-25 aircraft has an advanced, customized remote I/O interface controller based from Aitech Defense Systems Inc. in Chatsworth, Calif. The system is based on the Aitech Ai-RIO avionics remote interface.

The Ai-RIO is expandable with as many as eight units networked together. Added capabilities include I/O, power switching, and mass/SD FLASH memory. The remote I/O subsystem includes a Gigabit Ethernet port with precision time sync IEEE-1588 support, 10 RS-422 ports, eight LVDS or RS-422/485 UARTS, four SpaceWire ports with LVDS I/O, two CANbus ports, and 16 GPIO in two blocks of eight.

The Ai-RIO is an high density, low

power rugged subsystem for vehicle platform flight control, attitude and navigation controls, servo-valve and thrust vector control (TVC), robotic motor control, video and image processing and storage, data telemetry, platform stabilization, communications and telematics, high speed data recorders, booster and launch propulsion and thruster control, remote sensor and effector monitoring.

Boeing can use the Ai-RIO as a stand-alone command and data handling platform or networked remote command/response I/O unit. It a radiation-qualified dual-core PowerPC processor with two rad-tolerant FPGAs. All internal electronics are conduction-cooled and mechanically fixed and housed within a sealed, EMI/EMC Faraday cage for maximum thermal transfer.

In addition to Aitech, other subcontractors to Boeing on the MQ-25 project

are; BAE Systems; Collins Aerospace; Cox & Co.; Crane Aerospace & Electronics; Cubic; Curtiss-Wright Defense Solutions; General Electric Corp.; L3Harris Technologies; Héroux-Devtek; Honeywell International; Innovative Power Solutions; Moog Aircraft Group; Parker Hannifin; Raytheon; Rolls-Royce; and Triumph Group.

On this order Boeing will do the work in St. Louis; Indianapolis; Torrance, Goleta, Irvine, Anaheim, San Diego, Irwindale, and City of Industry, Calif.; Longueuil, Quebec; Columbus and Bridgeport Miss.; McKinney, Texas; Monroe, N.C.; Palm Bay and Clearwater, Fla.; Ajax, Ontario; Eatontown, N.J.; and Endicott, N.Y., and should be finished by August 2024. ←

For more information contact Boeing Defense, Space & Security online at www.boeing.com, or Naval Air Systems Command at www.navair.navy.mil.

DARPA Manta Ray project seeks to develop long-range unmanned submarines

In the near future, the U.S. Defense Advanced Research Projects Agency (DARPA) in Arlington, Va., wants to deploy unmanned underwater vehicles (UUVs) that can take-on months-long missions without any in-person human logistical support or maintenance. DARPA awarded contracts in February to three companies that will help develop the unmanned submarines: Lockheed Martin Corp., Northrop Grumman Corp., and Navatek LLC. A fourth company, Metron Inc., is working on solutions specific to undersea energy harvesting techniques that will allow the autonomous subs to operate seamlessly

at great depths. Their work is part of DARPA's Manta Ray program, which will advance technology for future long-range unmanned undersea vehicles. The name relates to an artist's mockup of one of these potential subs, which resembles a Manta Ray. With little human support required, DARPA hopes these vessels will eventually become another arrow in combatant commanders' quivers.

Military forces focus attention on counter-drone attack technologies

Lasers, interceptor missiles and electronic warfare are all fast-growing potential answers to a seemingly unstoppable increase in enemy drone attack technologies. Given the rapid pace of technological advancement,

and the seemingly ubiquitous availability of unmanned aerial vehicle (UAV) technologies, the U.S. military is moving quickly to keep pace — and stay in front of possible drone swarm attacks, close-in drone-fired weapons, and even instances wherein drones themselves become explosives. In an effort to address this, the Army and Raytheon are now accelerating development and deployment of an upgraded counter-drone weapons system designed specifically to address close-in small drone threats. The integrated counter-drone system uses a Ku band mobile, 360-degree ground radar called Ku-band Radio Frequency System (KuRFS) — in conjunction with a suite of specific countermeasures, called effectors. KuRFS can provide

Penn State to develop autonomous underwater navigation sonar for submarines and UUVs

BY John Keller

ARLINGTON, Va. — U.S. Navy researchers needed enabling technologies for sonar-based continuous subsea autonomous navigation for manned and unmanned submarines. They found their solution from the Penn State University Applied Research Laboratory in University Park, Pa.

Officials of the Office of Naval

Research (ONR) in Arlington, Va., announced an \$8.4 million contract to the Penn State Applied Research Lab for the Advanced Broadband Navigation Sonar System Future Naval Capabilities program.

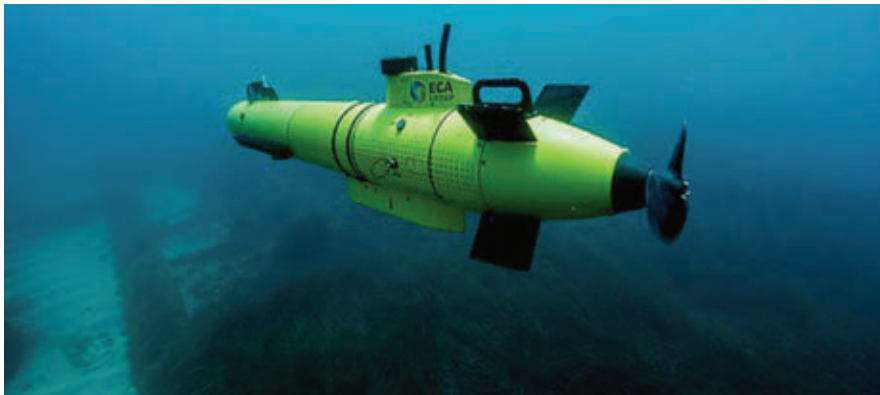
Penn State researchers will develop and demonstrate navigational sonar systems for continuous subsea autonomous

navigation. Sonar, short for sound navigation and ranging, detects undersea objects by transmitting powerful sound waves through the ocean and detecting return signals that bounce off objects.

ONR researchers are asking Penn State experts to improve undersea position and velocity estimation using sonar to give Navy manned submarines and unmanned underwater vehicles (UUVs) with enhanced navigational performance.

Penn State won this contract by participating in the Long Range Broad Agency Announcement for Navy and Marine Corps Science & Technology project. ←

On this contract the Penn State Applied Research Lab will do the work in University Park, Pa., and should be finished by March 2023. For more information contact the Penn State Applied Research Lab at <https://arl.psu.edu>.



Penn State University researchers are develop navigation sonar for new generations of manned and unmanned submarines.

threat information for ground commanders who can then opt to use laser countermeasures, EW, High-Powered Microwave weapons or a kinetic energy interceptor missile-drone called Coyote Block 2. However, before any threat can be destroyed, it must first be identified or “seen.”

UUV designers cite hardware-agnostic systems in explosives detection and disposal

As the U.S. Navy explosive ordnance disposal (EOD) community’s capabil-

ity grows in sophistication and quantity, a community leader says they’re being served well by their creed to remain hardware-agnostic. The EOD force has been set on a path to grow its Expeditionary Mine Countermeasures Company numbers and double the number of unmanned systems platoons that operate under those companies. The service’s investment in the people and in the Mk 18 Mod 1 Swordfish and the Mk 18 Mod 2 Kingfish unmanned underwater vehicles (UUVs) they operate come as

the Navy is also planning to merge the Kingfish program with the Razorback UUV the Littoral Combat Ship community uses. The new Medium UUV program, for which the Navy plans to release a request for proposals by the end of this fiscal year, could end up being the Kingfish or a variation thereof, could look more like the Razorback UUV, or could be sometime brand new, with the open architecture to operate all the sensors and cameras that both the EOD and the LCS communities need.

PRODUCT applications



CYBER SECURITY

Air Force chooses Dark Wolf Solutions for cyber penetration testing

U.S. Air Force cyber security experts needed a company to perform software penetration testing and adversarial assessment. They found their solution from Dark Wolf Solutions LLC in Chantilly, Va.

Officials of the Air Force District of Washington at Joint Base Andrews, Md., announced \$75 million blanket purchase agreement to Dark Wolf for cyber innovation services. The work to be conducted includes software penetration testing and adversarial assessment.

A penetration test attempts to exploit computer and digital networking vulnerabilities to determine if unauthorized access or other malicious activity is possible.

Penetration testing typically includes network penetration testing and application security testing as well as controls and processes around the networks and applications, and should occur from outside the network trying to break in, as well as from inside the network.

An adversarial assessment gauges the ability of a computing or networking system to carry on its mission while withstanding cyber attacks, including protecting the system, detecting cyber threats, reacting attacks, and restoring degraded mission capability degraded or lost because of hackers.

Dark Wolf Solutions specializes in agile software development, information operations, penetration testing, incident response, rapid prototyping, machine learning, and engineering services.

The company's cyber security expertise revolves around malware analysis, vulnerabil-

ity research, vulnerability assessment, network intrusion analysis, internet of things (IoT) security, and incident response.

On this contract Dark Wolf will do the work at Hill Air Force Base, Utah, and should be finished by this October. For more information contact Dark Wolf Solutions online at www.darkwolfsolutions.com, or the Air Force District of Washington at www.afdw.af.mil.

AVIONICS

Saab chooses VuCube from Vu Systems for enhanced flight vision avionics

Avionics designers at aircraft designer Saab AB in Stockholm needed enhanced vision technology to enable airplane pilots to land safely in poor visibility from rain, low clouds, or fog. They found their solution from Vu Systems in Morrisville, N.C.

Vu Systems designed a passive millimeter wave sensor called the Vu Cube. Saab officials announced that their company will manufacture Vu Cubes for Saab's Next Generation Enhanced Flight Vision System, which uses passive millimeter wave imaging technology.

The Vu Cube system can blend these sensors with a terrain database into a synthetic vision system that adds some level of man-made objects. The integrated image shows up on the pilot's head-up display.

Saab has tested the system on a seven-passenger Beechcraft King Air 200 twin-engine aircraft during more than 100 instrument

approaches, company officials say.

The Vu Cube avionics system can image airfields through rain, clouds, and fog at ranges of several miles to help pilots line-up their runway approaches in poor visibility.

Millimeter wave scanning is the basis of full-body imaging devices deployed at airport security checkpoints. The wavelengths of millimeter waves are large enough to pass through most materials, like clothing.

The full-body scanner projects millimeter waves onto the subject and the waves are reflected either by the subject's skin, or by any objects being carried by the person, so the sensor can detect objects under the subject's clothes.

The Vu Cube operates by passive millimeter wave scanning, reading thermal energy in the millimeter wave spectrum. The millimeter wave emissions reflected off a ground object like an airport runway are different from emissions reflecting off particles in the air.

Fog and cloud particles are between 10 and 100 microns in size. The Vu Cube reads thermal energy in 3000-micron wavelengths that cut through fog and cloud particles, thus allowing the sensor to detect runways and other objects even through rain and fog.

"The resolution of the Vu Cube camera design is such that it resolves runways, taxiways, roads, and other features," says Stedman Stevens, CEO of Vu Systems. "For example, you can easily see people and vehicles when close by, and at distances on approach see the runway and taxiways and in some cases the mechanical structures that hold the approach lighting systems in front of the runway."

The Vu Cube weighs less than 30 pounds, measures 17.75 by 9.5 by 10 inches, and mounts in the aircraft's nose for a clear forward view. Vu Systems has been developing the technology since 2013.

For more information contact Vu Systems online at www.vusystems.com, or Saab AB at <https://saab.com>.



COMMUNICATIONS

Marine Corps picks HF radio systems from L3Harris with NSA Type-1 encryption

U.S. Marine Corps communications experts needed HF manpack and vehicular radios with National Security Agency (NSA)-certified Type-1 encryption. They found their solution from the L3Harris Technologies Inc. Communications Systems segment in Rochester, N.Y.

Officials of the Marine Corps Systems Command at Quantico Marine Base, Va., announced a \$383.2 million five-year contract to L3Harris for RF-300H-MP manpack radios; RF-300H-MP vehicle-mount radios; and RF-300H-MP radio transit cases.

The RF-300H-MP, part of the L3Harris Falcon III radio family, operates in the high-frequency band between 2 and 30 MHz. It can achieve worldwide radio coverage when propagation conditions are right by bouncing RF signals off



the ionosphere.

NSA Type-1 encryption, one of the most stringent information security standards in the U.S., is for cryptographically securing classified U.S. Government information. It encrypts and decrypts classified and sensitive national security information when appropriately keyed, and is for the most stringent protection requirements. It also is among the difficult and costly encryption certifications to obtain for U.S. defense contractors.

This contract includes radio ancillaries, provisioning kits, documentation for HF radio systems, and instructor training.

L3Harris introduced the RF-300H wideband manpack radio system in early 2017 to enable warfighters to use wideband HF to transmit data files beyond-line-of-sight.

The HF radio offers a tenfold increase in data rates and reduced size and weight over then-current manpack radios, and is compatible with more than 100,000 L3Harris Falcon II legacy HF radio units deployed worldwide, company officials say.

The RF-300H is a small, lightweight, and fast wideband manpack radio designed to improve HF tactical communications by transmitting high-level security images, maps, and other large data files from beyond-line-of-sight environments.

On this contract L3Harris will do the work in Rochester, N.Y., and should be finished by March 2025. For more information contact L3Harris Communications Systems online at www.l3harris.com, or Marine Corps Systems Command at www.marcorsyscom.marines.mil.

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Fast. Advancements in technology should never take you by surprise. In the military and aerospace industry, if you're not on top of things, they're on top of you. To stay out front, you need a partner who's plugged into the industry – one who can react quickly to your needs, sometimes before even you know what those needs are.

Focused. It's Falcon's focus on the military and aerospace industry that has allowed us to forge long-term relationships with suppliers who are equally dedicated. Falcon's line card showcases superior, high-reliability product lines from the industry's top manufacturers – all with long-term Mil-Aero strategies – reducing the possibility of obsolescence.

It's Falcon's focus on our customer that enables us to become a dedicated partner. Whether managing individual inventory requirements, providing sophisticated levels of support, or supplying leading-edge technologies to meet rugged environmental demands, Falcon is committed to your success.

Falcon. Falcon Electronics is a Certified Small Disadvantaged Distributor of state-of-the-art semiconductor components, dedicated to the military and aerospace industry. Our suppliers have confidence in us. Our customers trust us. And Falcon is proud to be considered an ally of both.



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SENSORS

RadiaBeam to develop transportable gamma ray generator to detect illegal material

U.S. military researchers needed a transportable gamma ray radiation generator for test and measurement test and measurement to detect nuclear materials, conventional explosives, and illegal drugs. They found their solution from RadiaBeam Technologies LLC in Santa Monica, Calif.

Officials of the U.S. Defense Advanced Research Projects Agency in Arlington, Va., announced a \$10.2 million contract to RadiaBeam for the Gamma Ray Inspection Technology (GRIT) program.

A transportable gamma ray radiation generator also would be useful for detection applications like elemental imaging, non-destructive inspection of additive manufactured components, medical diagnostics, to help scientists understand detailed nuclear structures.

GRIT will develop the critical subsystem and component technologies, support system integration, and perform the testing necessary to demonstrate these new capabilities.

In the DARPA GRIT program's first phase, RadiaBeam engineers will develop a Laser-Compton approach for meeting GRIT program objectives and carrying out relevant system demonstrations.

DARPA is asking the company to develop a prototype gamma ray generator able to produce intense, tunable, and narrow-bandwidth gamma rays using techniques and emerging component technologies small enough for transportable systems.

Gamma rays are penetrating electromagnetic radiation caused by the radioactive decay of atomic nuclei. Gamma rays are the shortest wavelength of electromagnetic waves, and

impart the highest photon energy.

DARPA wants the ability to produce tunable gamma rays from ten of kilo electron-volts (keV) to more than 10 mega electron-volts (MeV) of energy intensities as high as 1012/second with sub 1 percent bandwidth.

Such a technology provides the ability to characterize objects non-destructively not only for their elemental content, but also for their nuclear composition.

On this contract RadiaBeam will do the work in Santa Monica, Menlo Park, and Los Angeles, Calif.; as well as in Paris, and will be finished by March 2021. For more information contact RadiaBeam Technologies online at <https://radiabeam.com>, or DARPA at www.darpa.mil.

COMMUNICATIONS

Lockheed Martin picks SEAKR Engineering for secure anti-jam SATCOM payload

Satellite communications payload experts at Lockheed Martin Corp. needed secure jam-resistant RF and microwave capability for the U.S. Space Force Protected Tactical Satellite Communications (PTS) project. They found their solution from SEAKR Engineering Inc. in Centennial, Colo.

Officials of the Lockheed Martin Space Systems segment in Sunnyvale, Calif, have selected SEAKR to help design and build a prototype payload for the U.S. Space Force's PTS program — a next-generation capability connecting warfighters with more agile and jam-resistant satellite communications (SATCOM).

SEAKR Engineering will support Lockheed Martin in achieving significant developments in the PTS anti-jamming capabilities through collaboration

on the system's advanced space digital processor.

By leveraging its strength in RF communications, SEAKR will help demonstrate PTS anti-jam capabilities by building on advanced RF processing technologies employed in its Wolverine RF processing platform.

The Wolverine reconfigurable processor uses 20-nanometer Ultrascale field-programmable gate arrays (FPGAs), as well as A/D and D/A converters. The company introduced the Wolverine processor last year.

Wolverine production units provide 3.2-to-4.5 gigasample-per-second performance, and SEAKR engineers are targeting a 10x increase for direct RF sampling, company officials say.

The Wolverine features full redundancy, two PowerPC single-board computers, three reconfigurable processor boards, two power modules, and scalability to eight RF processor modules. Each RF processor includes three UltraScale FPGAs and provides four RF I/O ports per module as well as primary and redundant reference oscillator inputs.

The processor uses Xilinx Kintex FPGAs that interconnect with 12-gigasample-per-second SERDES links to enable high-throughput, flexible and reconfigurable modulation, demodulation, channelization, and routing capability.

The complete PTS system will deploy a constellation of dedicated geostationary satellites, commercially hosted payloads, and coalition partner satellites integrated through a ground-control network to provide U.S. and allies with protected communications.

Lockheed Martin, Northrop Grumman Corp., and the Boeing Co. won U.S. Space Force contracts in February and March to develop jam-resistant communications payloads for the PTS program.

The three companies are developing jam-resistant SATCOM payloads for a military or commercial satellite. The U.S. Air Force started the PTS program in 2018 to make military forces less dependent on the Advanced Extremely High Frequency (AEHF) satellites.

For more information contact SEAKR Engineering online at www.seakr.com, or Lockheed Martin Space Systems at www.lockheedmartin.com.



AVIONICS

Navy taps BAE Systems to provide electronic warfare (EW) avionics for F-35 combat jet

U.S. Navy aerial warfare experts needed multifunction electronic warfare (EW) systems for F-35 fighter-bomber combat jets of the U.S. Air Force, Navy, Marine Corps, and allied foreign military forces. They found their solution from the BAE Systems Electronic Systems segment in Nashua, N.H.

Officials of the Naval Air Systems Command at Patuxent River Naval Air Station, Md., announced a \$77.5 million order to BAE Systems to provide 1,464 radio frequency (RF) countermeasures systems, as well as maintain and repair multi-function test stations for the F-35.

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

The system makes the most of detection ranges and gives the F-35 pilot evasion, engagement, countermeasure, and jamming options. The AN/ASQ-239 provides broadband protection to help the F-35 reach well-defended targets and suppress enemy radars.

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

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

On this order BAE Systems will do the work in Nashua, Dover, and Londonderry, N.H.; Landenberg, Pa.; Topsfield and Chartley, Mass.; City of Industry and Carson, Calif; Hamilton, N.J.; and other U.S. locations, and should be finished by September 2023.

For more information contact BAE Systems Electronic Systems online at www.baesystems.com, or Naval Air Systems Command at www.navair.navy.mil.



BATTLEFIELD NETWORKING

Persistent Systems to upgrade tactical battlefield communications

U.S. Air Force communications experts needed a company to upgrade an adaptable networking system that enables military forces on the move to stay in touch in austere environments. They found their solution from Persistent Systems LLC in New York City.

Officials of the Air Force Sustainment Center (AFSC) at Hill Air Force Base, Utah, have announced a \$25 million contract to Persistent Systems to upgrade the Wave Relay Tactical Assault Kit (WaRTAK) using the Persistent Systems Wave Relay Mobile Ad hoc Network (MANET).

The WaRTAK program, which the Air Force launched in 2016, provides Air Force convoys driving close to the front lines of the battlefield with multi-domain communications and situational awareness.

The self-healing adaptable MANET component from Persistent Systems helps infantry warfighters, land vehicles, and helicopters maintain RF communications even when satellite communications (SATCOM) links fail, or land features mask line-of-sight RF communications.

"WaRTAK provides situational awareness with a multi-domain architecture — a combination of MANET, SATCOM, cellular, and land mobile radio," explains Adrien Robenhymer, VP of business development at

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Persistent Systems. "As those communications channels become available, it provides communications between the convoy, helicopters, and command authorities. The system ties radio, GPS, cellular, and satellite internet connections into our self-healing Wave Relay MANET.

Persistent Systems has been involved in the WaRTAK tactical networking program for the past four years. The company won a contract in 2016 to provide MANET capability for the

system. Now it's time to upgrade the system to increase data throughput, as well as reduce its size, weight, and power consumption (SWaP).

The upgraded system that Persistent will provide over the next four years will increase data throughput from about 20 megabits per second to 120 megabits per second, and reduce the system's More capability, more capacity, and faster speeds than 802.11. From 20 to 120 megabits per second, and reduce SWaP by about 60 percent.

Such improvements may help enable the Air Force to incorporate new features like artificial intelligence (AI), automatic roadside bomb detection, and augmented reality for turn-by-turn directions over roadless terrain, Robenhymer says.

"WaRTAK uses our legacy MPU3 and Gen4 equipment," Robenhymer says. "This hardware has been the backbone of the program, operating in extreme conditions and temperatures, but it's time to introduce WaRTAK to the newest generation of gear."

Persistent will provide Android-loaded MPU5 smart networking devices and the Dual Push-to-Talk (PTT) system, which will enable users to talk on two radio talk groups simultaneously and as an intercom system.

For more information contact Persistent Systems online at www.persistentsystems.com, or the Air Force Sustainment Center at www.afsc.af.mil. ←

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new PRODUCTS



BOARD PRODUCTS

3U embedded computing card for general-purpose processing introduced by Abaco

Abaco Systems in Huntsville, Ala., is introducing the rugged high-bandwidth NVP2102A XMC graphics and general-purpose graphics processing unit (GPGPU) embedded computing card for applications that require high-end graphics or CUDA support for general-purpose processing, and raw video capture and display. Based on the NVIDIA Quadro Pascal (GP107) P2000 graphics processing unit (GPU) architecture and providing as much as 2.3 TeraFLOPS of peak performance, the board has four 3G-SDI inputs, provides two NTSC/PAL video inputs, and supports two audio inputs. Video output is via two 3G-SDI and two DVI or DisplayPort interfaces. The board supports direct video capture to GPU memory to reduce latency and minimize glass-to-glass time. The card automatically detects the input resolution of incoming video, and transfers raw video frames to GPU or host memory. It also can encode the captured data using the GPU-native H.265 (HEVC) or H.264 encoders in GPU memory. Windows or Linux drivers and API are available for x86 systems. The NVP2102A supports Abaco's AXIS ImageFlex — an image processing and visualization toolkit that helps users develop high-performance image processing, visualization and autonomy applications for size-, weight-, and power-constrained uses. For more information contact Abaco Systems online at www.abaco.com.



POWER ELECTRONICS

Power buck-boost regulator for military applications introduced by Vicor

Power electronics specialist Vicor Corp. in Andover, Mass., is introducing the PI3740 ZVS buck-boost regulator for military-grade commercial off-the-shelf (MIL-COTS) applications. The power electronics device has an extended operating temperature range of -55 to 115 degrees Celsius and optional tin-lead BGA packaging. The PI3740 DC-DC converter is a high-density and high-efficiency buck-boost regulator with an 8-to-60-volt input voltage range and support for output voltages from 10 to 50 volts. The power supply device offers as much as 140 Watts in a 10-by-14-millimeter SiP package. Higher power delivery is possible with additional devices in parallel. The ZVS switching topology also enables power efficiency as high as 96 percent. For more information contact Vicor Corp. online at www.vicorpower.com.

RUGGED COMPUTERS

Rugged 3U OpenVPX embedded computing system introduced by North Atlantic

North Atlantic Industries (NAI) in Bohemia, N.Y., is introducing the SIU36 configurable rugged embedded computing system to support military and aerospace applications that require high-density I/O, communications, Ethernet switching, and processing. The SIU36 leverages NAI's 3U boards to deliver off-the-shelf solutions that accelerate deployment of size, weight, and power consumption (SWaP)-optimized systems in military air, land, and sea applications. The SIU36 features six 3U OpenVPX card slots; support for as many as 18 I/O and communication smart functions; more than 70 modules to choose from; local or external single-board computer host I/F capability; micro-processor support for Freescale PowerPC QorIQ T2080, Intel Core i7, or ARM Cortex -A9 and -A53; and single board computer-less remote



interface supported via Ethernet connection to the mission computer. NAI's Configurable Open System Architecture (COSA) offers a choice of more than 70 smart I/O, communications, Ethernet switch and single-board computer options. For more information contact North Atlantic Industries online at www.naii.com.

RF AND MICROWAVE

Millimeter-wave waveguide antennas for 5G introduced by Pasternack

Pasternack Enterprises in Irvine, Calif., is introducing millimeter-wave waveguide antennas for 5G and other high-frequency RF and microwave applications. Pasternack has added 54 new models and now covers operating frequency ranges from 1.7 to 220 GHz, nominal gain ranging from 0 dBi to 40 dBi, and different waveguide sizes. Five new categories of high-frequency millimeter-wave waveguide antennas are available to address point-to-point and point-to-multi-point wireless applications. Potential applications include probe waveguide antennas to 170 GHz with 6.5 dBi of gain; dual polarized waveguide antennas to 110 GHz with 13-20 dBi of gain; cor-

ner reflector antennas with .02 m²-16,000 m² radar cross sections; sector waveguide antennas to 40 GHz with 6dBi of gain; and a series of waveguide antenna mounting fixtures designed to work with UG383/U, UG385/U, UG387/U, UG595/U, UG599/U, and UG1530/U flanges. Pasternack also has added 19 models to the company's existing categories of scalar feed horn and omni-directional waveguide antennas. All of Pasternack's waveguide antennas are REACH and RoHS compliant and constructed with high-quality materials and workmanship. For more information contact Pasternack online at www.pasternack.com.

EMBEDDED COMPUTING

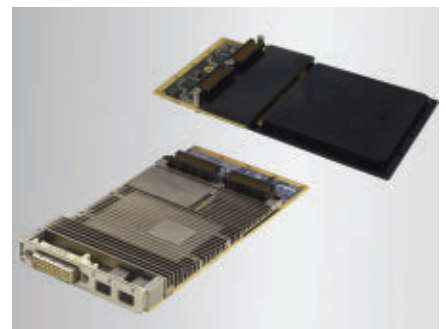
Rugged embedded computer for military applications introduced by Crystal

Crystal Group Inc. in Hiawatha, Iowa, is introducing the RCS7850-32Q rugged switch; RSS116F 12GB DSU rugged secure data storage system; and RE1711 rugged embedded computer for military, aerospace, and industrial applications. The RCS7850-32Q rugged switch is for Navy platforms and forward-deployed weapons systems applications. This MIL-SPEC switch offers network speed with as many as 32 ports of 100 gigabit bandwidth, switching, and forwarding and routing capacities, as well as redundant, hot-swappable power supply and real-time, accurate, secure data processing and transmission. The RSS116F 12GB DSU rugged secure storage system features multi-level security for military and industrial applications, and is used onboard the UK's Airborne Early Warning and Control aircraft. The RE1711 rugged embedded computer is for space-constrained environments on submarines and surface ships. This 8-inch-deep 2U embedded computer also is for unmanned undersea vehicles. For more information contact Crystal Group online at www.crystalrugged.com.

BOARD PRODUCTS

Rugged video-processing mezzanine module offered by Curtiss-Wright

The Curtiss-Wright Corp. Defense Solutions division in Ashburn, Va., is introducing the XMC-4740 rugged video-processing mezzanine module for high-performance video processing and display applications. The product is for aerospace and defense graphics applications with significant video data processing requirements, such as video stabilization, image processing & enhancement, terrain and object tracking or 3D visualization of geospatial data. Curtiss-Wright is introducing it through its reseller agreement with WOLF Advanced Technology in Stouffville, Ontario. The XMC-4740 has a 1.2 TFLOPS AMD Radeon E9171 graphics processing unit (GPU) that provides twice the performance, at similar power levels, compared to the previous E8860 generation GPU. The XMC (VITA 42/61) mezzanine module supports as many as five simultaneous display outputs to DisplayPort and DVI output interfaces. The module's GPU has 4 gigabytes of high-speed GDDR5 128-bit graphics memory. The XMC-4740, available in air- and conduction-cooled configurations. Software support for the XMC-4740 includes AMD software drivers that support Linux and Windows applications with OpenGL and Vulkan graphics APIs, as well as OpenCL to accelerate data processing algorithms. RTOS drivers are available for the Wind River VxWorks and Green Hills INTEGRITY-178 tuMP operating environments. For more information contact Curtiss-Wright Defense Solutions online at www.curtisswrightds.com, or WOLF Advanced Technology at <https://wolfadvancedtechnology.com>.





HIGH-PERFORMANCE COMPUTING

High-performance VME single-board computer introduced by GMS

General Micro Systems (GMS) Inc. in Rancho Cucamonga, Calif., is introducing the VME120 single-board computer family to enable quick and easy systems upgrades to naval platforms and other legacy systems. The VME120 is form, fit, and functionally compatible with several generations of currently deployed VME boards. The Aegis combat system and other Navy programs have relied on GMS VME computer boards for critical applications such as fire control, engine control, machinery control, and operator console displays. The Navy's evolving software requirements and program enhancements mandate performance higher than that provided by the original VME boards, which in turn requires the market's newest processors and features. The versions of the VME120 embedded computing boards maintain backward compatibility with legacy systems and add latest-generation Intel Kaby Lake Core i7 processors and modern graphics features. GMS VME computer boards are designed for technology refresh and technology insertion and pre-planned product improvement using the same backplane, signal positions, and front panel connections. For more information contact General Micro Systems online at www.gms4sbc.com.

POWER ELECTRONICS

Rugged small-form-factor high-power amplifier introduced by Fairview

Fairview Microwave Inc. in Irvine, Calif., is introducing a series of Class AB broadband high-power amplifier modules for applications that need a high power, small-form-factor RF amplifier. The power electronics devices incorporate gallium nitride (GaN), laterally-diffused met-

al-oxide semiconductor (LDMOS), or vertical double-diffused metal oxide semiconductor field effect transistor (VDMOS) semiconductor technology. These devices consist of 18 new models spanning frequency bands from 20 MHz to 18 GHz. These designs are stable and operate in a 50 Ohm environment. These small-form-factor power electronics devices offer power gain to 53 decibels and saturated output power levels from 10 Watts to 200 Watts. This line includes two heatsink modules with DC controlled cooling fans to maintain baseplate temperature. These compact coaxial packages use N-type or SMA connectors and have integrated D-sub control connectors for DC bias, enabled with TTL logic control and temperature and current sense functions. The rugged assemblies can withstand relative humidity exposure to 95 percent maximum and operate over a wide temperature range from -20 to 60 degrees Celsius. For more information contact Fairview Microwave online at www.fairviewmicrowave.com.



CABLING AND CONNECTORS

Flexible cable assemblies for GPS modules and LAN routers introduced by Cinch

Cinch Connectivity Solutions in Wesaca, Minn., is introducing RG-174 based Johnson cable assemblies for transmitting data signals for GPS modules, LAN routers, and WAN system equipment. The cable assemblies come using an SMA bulkhead jack to SMA plug, reverse polarity SMA bulkhead





jack to reverse polarity SMA Plug, and SMA bulk-head jack to MMCX plug connector interfaces. The Johnson cable assemblies from Cinch come in flexible, conformable, and semi-rigid cable types. With 30 new interface configurations in standard and metric lengths, these RG-174 cable assemblies are more economical than RG-316 cable assemblies. These cable assemblies are available through distributors Digi-Key, Mouser and Newark. For more information contact Cinch Connectivity Solutions online at <https://belfuse.com/cinch>.

DATA STORAGE

Rugged FIPS 140-2-certified solid-state drive introduced by Phoenix

Phoenix International Systems in Orange, Calif., is introducing the VP1-250-eSSDC FIPS 140-2-certified encryption Open VPX NVM Express (NVMe)



solid-state disk data storage module for military and airborne applications. The VP1-250-eSSDC helps remove legacy layers of hard drive interfaces such as SATA and SAS by using the speed and parallelism of solid state nonvolatile memory. The rugged data-storage system has a streamlined efficient queuing protocol combined with an optimized command set register interface enables low latency and high performance. Data moves quickly and efficiently with minimal burden on the host CPU. The VP1-250-eSSDC supports TCG compliant AES-256 and FIPS 140-2-certified encryption

as well as military-grade data elimination. NVMe is an industry-standard interface to accelerate the performance of the nonvolatile PCI Express solid-state drive. The NVMe protocol was established in collaboration by the server industry to standardize a scalable PCI Express interface. NVMe provides opportunities for increased data throughput and reduced latency while reducing the number of drives necessary. For more information contact Phoenix International Systems online at www.phenixint.com.

AVIONICS

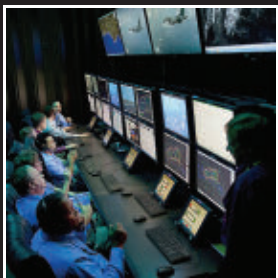
Rugged military-temperature MIL-STD-1553 avionics databus transceiver for FPGA designs introduced by Holt

Holt Integrated Circuits in Mission Viejo, Calif., is introducing the HI-15850 3.3-volt MIL-STD-1553 dual transceiver for commercial and military avi-

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onics databus applications. The HI-15850 offers 1.8-, 2.5-, and 3.3-volt compatible digital I/O to provide systems designers with flexibility to interface with a broad range of field-programmable gate arrays (FPGAs) and avoid use of level shifters and other additional circuitry. This device is based on Holt's HI-1585 and provides the same

features of bus tail-off compensation and receiver output pulse extension. Tail-off compensation compensates for bus tail-off, which is an undesirable temporary DC offset on the terminal's bus stub. The avionics databus receiver output pulse extension ensures receiver output pulse widths remain above 180 nanoseconds, improving receiver sensitivity for designs operating close to the minimum receiver input response amplitude and ensuring proper decoding. "This device will enable customers to use their existing FPGA digital I/O without the need for voltage conversion or other logic," explains George Noh, director of sales and marketing at Holt. For more information contact Holt Integrated Circuits online at www.holtic.com.

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THE 2020 MILITARY ELECTRONICS BUYERS GUIDE

Board Products 49

Communications/network controllers	49
Data-acquisition boards	49
DSP boards	49
FPGA boards	49
Graphics/imaging boards	49
I/O boards	49
Memory boards	49
Mezzanine/daughter boards	49
Peripheral/device controllers	50
Single-board computers	50

Communications and Peripherals 50

Audio equipment	50
Communications equipment - Laser communications	50
Communications equipment - Microwave communications	50
Communications equipment - Military telecommunications	50
Communications equipment - Radio	50
Communications equipment - Satellite equipment and telemetry	50
Data buses and networking - High-speed switched fabrics	50
Data buses and networking - Network interface controllers	51
Data buses and networking - Tactical networks	51
Data buses and networking - Wired networks	51
Data buses and networking - Wireless networks	51
Data storage - Data recorders	51
Data storage - Optical memory	52
Data storage - RAID/computer farms	52
Data storage - Solid-state memory	52
Data storage - Tape memory	52
Frequency management systems	52

Components/Power Electronics/ Sensors 52

Adhesives, encapsulants and bondings	52
Components - Altimeters	52
Components - Backplanes	52
Components - Circuit breakers	52
Components - Connectors	52
Components - Control heads	52
Components - Enclosures and chassis	52
Components - Fasteners	52
Components - Fiber optics	52
Components - Filters/gasketing	54

Components - Flight instruments	54
Components - Gyroscopes	54
Components - Hold-downs	54
Components - Human-machine interfaces	54
Components - Latches and hinges	54
Components - MEMS and nanotechnology	54
Components - Radiation-hardened components	54
Components - Relays	54
Components - Switches	54
Components - Wire and cable	54
Displays - Cockpit displays	54
Displays - Electroluminescent (EL) displays	54
Displays - Enhanced/synthetic vision systems	54
Displays - Heads-up displays	54
Displays - Helmet-mounted displays (HMD)	54
Displays - In-flight entertainment system displays	54
Displays - Liquid crystal displays	54
Displays - Organic light-emitting diode (OLED) displays	54
Displays - Plasma displays	54
Integrated circuits, analog - Bipolar transistors	54
Integrated circuits, analog - IGBTs	55
Integrated circuits, analog - MOSFETs	55
Integrated circuits, analog - Passive components	55
Integrated circuits, analog - Power discrete devices	55
Integrated circuits, analog - Power integrated circuits	55
Integrated circuits, analog - Rectifiers	55
Integrated circuits, analog - Thyristors	55
Integrated circuits, digital - A-D converters	55
Integrated circuits, digital - ASICs	55
Integrated circuits, digital - Communications/networking ICs	55
Integrated circuits, digital - D-A converters	55
Integrated circuits, digital - Digital signal processors	55
Integrated circuits, digital - FPGAs	56
Integrated circuits, digital - General-purpose ICs	56
Integrated circuits, digital - Graphics ICs	56
Integrated circuits, digital - IP cores	56
Integrated circuits, digital - Memory ICs	56
Integrated circuits, digital - Microprocessors/microcontrollers	56
Integrated circuits, digital - Mixed-signal ICs	56
Integrated circuits, digital - Network interface ICs	56
Integrated circuits, digital - Peripheral/support ICs	56
Integrated circuits, digital - Solid-state memory	56
Power electronics - Actuators	56
Power electronics - Auxiliary power units (APUs)	56
Power electronics - Batteries	56
Power electronics - Circuit breakers	56
Power electronics - Emergency power units	56
Power electronics - Generators	56

Power electronics - Inverters/converters	56
Power electronics - Motor controllers	56
Power electronics - Motors	56
Power electronics - Power distribution systems and equipment	56
Power electronics - Power supplies	56
Power electronics - Transducers	58
Power electronics - Transient voltage suppressors	58
Sensors - Chemical analyzers	58
Sensors - Inertial	58
Sensors - Infrared/ultraviolet	58
Sensors - Ladar/lidar	58
Sensors - Radar	58
Sensors - Sonar	58
Sensors - Tactile	58
Sensors - Visible-light cameras	58

Computers 58

Air data computers	58
Desktop computers	58
Electronic flight bags (EFBs)	58
Embedded computers	58
Flight directors	58
Laptops/notebooks/handheld computers	58
Multicomputer systems	58
Rack-mount computers	59
Servers	59
Specialized computers - TEMPEST	59
Wearable computers	59

Diagnostics and Control 59

Avionics health management	59
Clocks/timers	59
Engine controls	59
Engine monitoring	59
Fuel management systems	59
Health and usage monitoring (HUMS)	59
Ice detection	59
Overheat detection	59

Electro-Optics 59

Bonding and adhesives	59
Cameras	59

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Electro-optic materials and substrates	59
Equipment manufacturing	59
Forward-looking infrared systems	59
Laser components	59
Lasers	59
LEDs	59
Lighting	60
Night vision	60
Optical amplifiers	60
Optical coatings/treatments	60
Optical detectors	60
Optical fiber	60
Optical filters	60
Optical imaging	60
Optical switches	60
Optical transceivers	60
Optics	60
Thermal imaging	61
Ultraviolet light sources	61

Navigation..... 61

Automatic dependent surveillance-broadcast (ADS-B) equipment	61
GPS systems	61
Terrain	61

Platform Systems/Subsystems... 61

Autopilots	61
Avionics	61
Cabin management systems	62
Countermeasures	62
Electronic flight instrument systems (EFIS)	62
Landing systems	62
Light management systems	62
Lighting	62
Navigation equipment	62
Satellite systems	62
Security systems	62
Shipboard/maritime electronics	62
Training and simulation	62
Unmanned vehicles	62
Vetronics	62
Weather systems	62

RF and Microwave..... 62

Amplifiers	62
Antennas	63
Bonding and adhesives	63
Diplexers/multiplexers	63
Discrete components	63
Filters	63
Frequency synthesizers	63
Hybrids	63
Microwave subassemblies	63
Mixed-signal devices	63
MMICs	63
Oscillators/synthesizers	63
RF attenuators	63
RF packaging	63
RF switches	63
Signal generators	63
Transmit/receive modules	63
Up/down converters	64

Safety Equipment and Components..... 64

Alarm systems	64
Altitude alerts	64
Anti-icing equipment	64
Anti-static equipment	64
Collision avoidance systems	64
Emergency locator transmitters (ELTs)	64
EMI/RFI	64
Fire detection	64
Stall warning	64
Terrain awareness warning systems (TAWS)	64
Windshear warning systems	64

Services 64

Assembly/subcontract services	64
Calibration services	64
Consultants	64
Design engineering	64
Distributors	65

Software 65

Applications	65
Communications/networking	65
Data security	65
Database management	65
Databases	65
Design and development tools	65
Document management systems	65
Electronic design automaton (EDA)	65
Graphics and simulation	65
Information security	65
Moving maps	65
Operating systems	65
Product life cycle management (PLM)	65
Programming languages	65
Real-time operating systems (RTOS) and kernels	65
Software code design, test, and verification	65

Test and Measurement 65

Calibration equipment	65
COTS upscreening	65
EMC compliance	65
HALT/HASS	65
Meters	66
Network analyzers	66
Network/data bus analyzers	66
Optical test and measurement	66
Oscilloscopes	66
Portable test systems	66
Software-driven instrumentation	66
Spectrum analyzers	66

Thermal management/cooling systems..... 66

Conduction cooling	66
Convection cooling	66
Liquid cooling	66

BOARD PRODUCTS

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NETWORK CONTROLLERS**Abaco Systems**

See ad page 11

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ADL Embedded Solutions Inc
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See ad pages 3, 47
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See ad page 53

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See ad page 53

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See ad page 8

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See ad pages 3, 47

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See ad inside front cover

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See ad page 44

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See ad page 11

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See ad page 8
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See ad pages 3, 47

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See ad inside front cover

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See ad back cover

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See ad page 45

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See ad page 11

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See ad page 23

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See ad pages 3, 47

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See ad inside front cover

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See ad page 45

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See ad page 7

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See ad page 11

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See ad page 8
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See ad pages 3, 47

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See ad inside front cover

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See ad page 8

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See ad pages 3, 47



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See ad page 15

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See ad page 11

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See ad page 23

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Diamond-MT

Dynatem

See ad page 53

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See ad page 8

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See ad pages 3, 47

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See ad inside front cover

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See ad back cover

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See ad page 13



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See ad page 51
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See ad page 15

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See ad page 31

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See ad page 32

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See ad page 57

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See ad page 51

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See ad page 31

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See ad page 31

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See ad back cover

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See ad page 57

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See ad page 13

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See ad page 53

Elma Electronic Inc

See ad page 8

Extreme Engineering Solutions (X-ES)

See ad pages 3, 47

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See ad back cover

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See ad page 11

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See ad page 8

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See ad pages 3, 47



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See ad page 15

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See ad page 11

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See ad page 53

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See ad pages 3, 47

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See ad page 53

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See ad pages 3, 47

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See ad page 53

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See ad pages 3, 47

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See ad page 45

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See ad page 31

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See ad page 12

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See ad page 29

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See ad page 39

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See ad page 13



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See ad page 8

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See ad pages 3, 47

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See ad inside front cover

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See ad page 31

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See ad page 12

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See ad page 16

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See ad page 61

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See ad page 10
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See ad page 53
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See ad page 61

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See ad page 37

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See ad page 55

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See ad page 17

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See ad page 37
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See ad page 12

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See ad page 11

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See ad page 10

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Custom MMIC
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Delphi Automotive LLP

Dynatemp
See ad page 53
ECRIN Systems
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Essex Industries

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See ad pages 3, 47

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See ad page 19

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See ad page 12

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See ad page 16

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See ad page 51

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See ad page 19

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See ad page 31

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See ad page 12

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See ad page 55

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See ad page 37

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See ad page 37



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See ad page 15

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See ad page 55

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See ad page 15



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See ad page 15

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See ad page 17

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See ad page 37
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See ad page 37

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See ad page 15

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See ad page 37

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See ad page 7
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See ad page 51

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See ad page 57

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See ad page 51
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Renesas Electronics Corp
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See ad page 32

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See ad page 57

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See ad page 32

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See ad page 57

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See ad page 17

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See ad page 51

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See ad page 37

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See ad page 17

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See ad page 12

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See ad page 61

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See ad page 37

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See ad page 12

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See ad page 51

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See ad page 12

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See ad page 51

Fibercore Ltd

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See ad page 31

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Interstate Connecting Components

See ad page 12

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See ad page 32

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See ad back cover

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See ad page 51

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See ad page 12

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See ad back cover

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See ad pages 3, 47

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See ad back cover

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See ad page 8

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 See ad page 23
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 See ad page 53
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 See ad page 8
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 See ad pages 3, 47
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 See ad page 8
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 See ad pages 3, 47
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 See ad inside front cover
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 See ad page 8
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 See ad page 10
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 See ad page 51
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 OPCO Laboratory
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 Ibis Electro-Products Corp
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 Knight Optical
 Krell Technologies Inc
 Kugler of America Ltd
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 LaserOptec
 Lasertec Inc
 Micro Laser Systems Inc
 MOK Optics Co Ltd
 NextGen Adhesives
 OFS
 OPCO Laboratory
 Quantum Composers
 Reynard Corp
 RPMC Lasers Inc
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 Avo Photonics
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 DRS Daylight Solutions
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 Inc (EOC)
 Electron Test Equipment
 Excelitas Canada
 Fibercore Ltd
 FISBA
 General Atomics Aeronautical
 Systems Inc
 Gooch & Housego PLC
 Guernsey Coating Laboratories Inc
 Konica Minolta Sensing
 Americas Inc
 Krell Technologies Inc
 LAS-CAD GmbH
 Lasertec Inc
 Micro Laser Systems Inc
 Newport Corp
 NextGen Adhesives
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 Quantum Composers
 RPMC Lasers Inc
 SPI Lasers UK Ltd
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 Timbercon Inc
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 Diverse Optics Inc
 Dynatron
 Electro Optical Components
 Inc (EOC)
 Electrolube
 Embassy Global

Excelitas Canada
FiberTech Optica
FoxFury Lighting Solutions
GS PLASTIC OPTICS
Konica Minolta Sensing Americas Inc
Lambda Research Corp
Marktech Optoelectronics Inc
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Nicomatic
OPCO Laboratory
Opto Diode Corp
OSI OptoElectronics Inc
StacoSystems
Thorlabs Inc
Wilbrecht LEDCO Inc
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Aero Dynamix Inc
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See ad page 10
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GS PLASTIC OPTICS
Guernsey Coating Laboratories Inc
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Diverse Optics Inc
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Eureka Dry Tech
FISBA
Gooch & Housego Plc
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Guernsey Coating Laboratories Inc
Incertec
Infinite Optics Inc
JML Optical Industries LLC
Knight Optical
Lacroix Precision Optics
LaserOptec
Lasertec Inc
Lensel Optics Pvt Ltd
Master Bond
MOK Optics Co Ltd
NextGen Adhesives
OPCO Laboratory
OSI OptoElectronics Inc
PG&O - Precision Glass & Optics
Reynard Corp
Rudolph Bros & Co
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Excelitas Canada
Falcon Electronics
See ad page 37
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Gigahertz-Optik Inc
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Guernsey Coating Laboratories Inc
JML Optical Industries LLC
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OSI OptoElectronics Inc
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UTC Aerospace Systems (Sensors Unlimited Products)

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Go4Fiber Ltd
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See ad page 12

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See ad inside back cover

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Lensel Optics Pvt Ltd
MOK Optics Co Ltd
Newport Corp
PG&O - Precision Glass & Optics
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Comar Optics Ltd
FiberTech Optica
FISBA
GEVICAM Inc
GS PLASTIC OPTICS
Guernsey Coating Laboratories Inc
H&L Instruments LLC
Headwall Photonics Inc
Infinite Graphics Inc
Infinite Optics Inc
IRnova AB
Iscon Inc
ISP Optics Corp
ISVI Corp
JML Optical Industries LLC
KEYENCE Corp of America
Lacroix Precision Optics
Lambda Research Corp
LaserOptec
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Navitar Inc
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OPCO Laboratory
Optikos Corp
Pentek Inc
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Radiant Vision Systems
Reynard Corp
Shoghi Communications
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Specialised Imaging Ltd
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See ad page 10
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See ad page 8
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See ad page 37
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See ad page 31
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See ad back cover
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See ad page 8
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See ad page 31

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See ad page 12

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See ad back cover

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ISP Optics Corp
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See ad page 10

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See ad inside front cover

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See ad page 31

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See ad back cover

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See ad page 61

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See ad page 10

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See ad page 8

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See ad page 61

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See ad page 51

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See ad page 14

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See ad page 57

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See ad page 13

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See ad page 8

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See ad back cover

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See ad page 61

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See ad page 23

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See ad page 51

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See ad page 11

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See ad page 10

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See ad page 13

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See ad page 8

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See ad pages 3, 47

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See ad page 31

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See ad back cover

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See ad page 14

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See ad page 57

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See ad page 11

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See ad page 14

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See ad page 44

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See ad pages 3, 47

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See ad page 51

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See ad page 15

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See ad page 31

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See ad page 14

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See ad page 61

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See ad page 37

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See ad back cover

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See ad page 51

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See ad page 19

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See ad pages 5, 27

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See ad back cover

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See ad page 19

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See ad page 14

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See ad page 39

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See ad page 31

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See ad back cover

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See ad pages 5, 27

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See ad page 9

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See ad page 10

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See ad page 8

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See ad page 51

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See ad page 19

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Nicomatic

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See ad back cover

Quell Corp
SynQor Inc
See ad page 57

Techsil Ltd
ZARGES Inc

FIRE DETECTION

Applied Avionics
See ad page 10

Brook One Corp
Pentek Inc
See ad back cover

SSP Manufacturing Inc
Stat-X Fire Suppression

STALL WARNING

Applied Avionics
See ad page 10

Pentek Inc
See ad back cover

TERRAIN AWARENESS WARNING SYSTEMS (TAWS)

Applied Avionics
See ad page 10

Pentek Inc
See ad back cover

WINDSHEAR WARNING SYSTEMS

Applied Avionics
See ad page 10

Pentek Inc
See ad back cover

SERVICES

ASSEMBLY/SUBCONTRACT SERVICES

AbelConn LLC
Adaptive Innovations Corp
ADCO Circuits
Advanced Component Testing
Advanced Precision Engineering Inc
AGDisplays
Alfa International
Altron
aPeak Inc
Atrenne Computing Solutions
Avo Photonics
Berliner Glas KGaA Herbert
Kubatz GmbH & Co
Carolina Microwave Associates Inc
Cobham RAD Solutions
Cobham Semiconductor Solutions
ConductRF
CTT Inc
Custom Manufacturing & Engineering Inc
Diverse Optics Inc
Elan Technical Corp
Electro-Mech Components Inc
EMCCons Dr Rasek GmbH & Co KG
EMS Industrial & Service Co
ESAM Inc
Essex Industries
Fischer Connectors Inc
Gemstar Custom Hard Cases
GS PLASTIC OPTICS

HUBER+SUHNER Inc
See ad page 31
Integra Technologies LLC
Interstate Connecting Components
See ad page 12
Jewell Instruments
John Evans' Sons
Kensington Electronics Inc
Knight Optical
L-com Global Connectivity
See ad inside back cover
Lensel Optics Pvt Ltd
March Electronics Inc
Master Bond
Micross
Nelson Design Services Inc
Nicomatic
Nova Electric
NTS Technical Systems
NuWaves Engineering
Optikos Corp

Pentek Inc
See ad back cover

PIC Wire & Cable
Polarity Inc
Reynard Corp
Sealcon LLC
Secord Solutions
Specialty Coating Systems

SRCTec LLC
SwissOptic AG
Teledyne e2v
Tianjin Anson International Co Ltd
United Electronic Industries Inc
Visotek Inc

CALIBRATION SERVICES

aPeak Inc
Custom Manufacturing & Engineering Inc
Eastern Applied Research Inc
EMCCons Dr Rasek GmbH & Co KG
ESPEC North America | Qualmark
Keysight Technologies Inc
Mahr Inc
Monocle Industries
Optikos Corp
OptoTest
Palmer Wahl Instruments Inc
Pentek Inc
See ad back cover
Radiant Vision Systems
Sofradir EC Inc
SRCTec LLC
SSP Manufacturing Inc

CONSULTANTS

Adaptive Innovations Corp
Alfa International
Altron
Americon
Annapolis Micro Systems Inc
See ad page 23
Archer OptX
Asine Ltd
Concurrent Technologies
Dayton T Brown Inc
Diamond-MT
DLS Electronic Systems Inc
ECRIN Systems
Embassy Global
EMCCons Dr Rasek GmbH & Co KG
Forefronts Defense Systems
GL Communications Inc
Green Hills Software Inc
Industrial Training Consultants Inc
Infinite Graphics Inc
Integra Technologies LLC
The Light Brigade Inc
Nelson Design Services Inc
NTS Technical Systems
NuWaves Engineering
PALMARII Dynamics AB
Pelorus Naval Systems Inc
Pentek Inc
See ad back cover
Puleo Electronics Inc
R Blaine Industries Inc
Secord Solutions
Sofradir EC Inc
Specialised Imaging Inc
Specialised Imaging Ltd
Sunrez Corp
TeamEDA Inc
Tianjin Anson International Co Ltd
Triad RF Systems Inc
TXO Systems Ltd
Viking Equipment Finance
Visotek Inc
VORAGO Technologies

DESIGN ENGINEERING

Active Silicon Inc
ADCO Circuits
ADL Embedded Solutions Inc
Aero Dynamix Inc
AGDisplays
Alfa International
Allied Motion Technologies Inc
Altron
Americon
AMOTronics
Annapolis Micro Systems Inc
See ad page 23
aPeak Inc
Archer OptX
Asine Ltd
Avo Photonics
Birk Manufacturing Inc
Carolina Microwave Associates Inc
Clark Testing
Concurrent Technologies
Critical Link LLC
Custom Manufacturing & Engineering Inc
D6 Industries Inc
Dawn VME Products
See ad page 13
Dayton T Brown Inc
Digital Systems Engineering Inc (DSE)
Diverse Optics Inc
DLS Electronic Systems Inc
Dynatem
See ad page 53
ECRIN Systems
EDT | Engineering Design Team Inc
EMS Industrial & Service Co
Epec Engineered Technologies
Extreme Engineering Solutions (X-ES)
See ad pages 3, 47
First Sensor Inc
Gemstar Custom Hard Cases
Hermetic Solutions Group
Infinite Optics Inc
InfoSight Corp
Integra Technologies LLC
Interface Concept
Jewell Instruments
John Evans' Sons
Lensel Optics Pvt Ltd
Micross
Navitar Inc
Nicomatic
NorComp
NTS Technical Systems
NuWaves Engineering
Optikos Corp
OptoTest
Orion Systems Inc
Orion Technologies LLC
PALMARII Dynamics AB
Pelorus Naval Systems Inc
Pentek Inc
See ad back cover
Per Vices Corp
PIC Wire & Cable
Pixus Technologies
See ad page 14
Polarity Inc
Positronic
Puleo Electronics Inc
Quantum Composers

R Blaine Industries Inc
 Renesas Electronics Corp
 Reynard Corp
 Scalys
 Secord Solutions
 Sofradir EC Inc
 Southwest Antennas
 SRCTec LLC
 StingRay Optics LLC
 TeamEDA Inc
 Teledyne e2v
 Tianjin Anson International Co Ltd
 Vadatech Inc
 Vision Components GmbH
 VORAGO Technologies

VPT Inc

See ad page 17

WOLF Advanced Technology
 ZARGES Inc

DISTRIBUTORS

A&A Coatings - Aerospace
 Thermal Spray Coating
 Acromag Inc
 Aerospace Aces
 Buy NSN
 CNC Center
 Eagle PLC

EMS Industrial & Service Co

Falcon Electronics
 See ad page 37

Interstate Connecting Components

See ad page 12

Kensington Electronics Inc
 LaserOptec
 Lintech Components
 Mahr Inc
 Micross
 Modicon PLC
 MRO Electric
 MRO Stock
 Nelco Products

Pentek Inc

See ad back cover

Saelig Co Inc
 Sealcon LLC
 SSP Manufacturing Inc
 STI Electronics Inc
 Unlimited Purchasing
 Weschler Instruments

SOFTWARE**APPLICATIONS**

AdaCore
 AIM-USA
Annapolis Micro Systems Inc
 See ad page 23
 Computer2100 LLC
 Cuelogic Technologies
 Dspnor AS
 Dynamic Systems Inc
 esd electronics Inc
 HD Barcode
 Infinite Graphics Inc
 Ironwood Electronics
Pentek Inc
 See ad back cover
 Photron USA Inc

Puleo Electronics Inc
 Secord Solutions
 TeamEDA Inc
 United Electronic Industries Inc
 Vision Components GmbH

**COMMUNICATIONS/
NETWORKING****Abaco Systems**

See ad page 11

Acroamatics Telemetry Systems
 Critical Link LLC
 Cuelogic Technologies

Dynatemp

See ad page 53

esd electronics Inc
 GDP Space Systems
 GL Communications Inc
 Graphic Products
 Green Hills Software Inc
 H&L Instruments LLC
 HD Barcode
 Interface Concept

Pentek Inc

See ad back cover

Pleora Technologies Inc
 Puleo Electronics Inc
 SYSGO
 Vector Informatik GmbH
 Vocal Technologies
 Zebra Technologies Corp

DATA SECURITY

Ampex Data Systems
 Cuelogic Technologies

Dynatemp

See ad page 53

Green Hills Software Inc
 Harmonic Software Systems Ltd

Pentek Inc

See ad back cover

Shoghi Communications
 Sital Technology
 Vocal Technologies
 Zebra Technologies Corp

DATABASE MANAGEMENT

Cuelogic Technologies
 Great River Technology

Pentek Inc

See ad back cover

Secord Solutions
 TeamEDA Inc
 UTC Aerospace Systems

DATABASES

Cuelogic Technologies
Pentek Inc

See ad back cover

Secord Solutions
 TeamEDA Inc

**DESIGN AND
DEVELOPMENT TOOLS****Abaco Systems**

See ad page 11

AdaCore

Annapolis Micro Systems Inc

See ad page 23

Cuelogic Technologies
 Data Device Corp (DDC)

Dynatemp

See ad page 53

Graphic Products
 Green Hills Software Inc
 Hitex GmbH
 Infinite Graphics Inc
 Keysight Technologies Inc
 Lambda Research Corp
 LAS-CAD GmbH
 Marvin Test Solutions Inc
 MilesTek

Pentek Inc

See ad back cover

Praxis Optics
 Radiant Vision Systems
 TeamEDA Inc
 Unified Infotech
 Vector Informatik GmbH
 Vision Components GmbH

**DOCUMENT
MANAGEMENT SYSTEMS**

Cuelogic Technologies

Pentek Inc

See ad back cover

TeamEDA Inc

**ELECTRONIC DESIGN
AUTOMATON (EDA)**

Eagle PLC
 Infinite Graphics Inc

Pentek Inc

See ad back cover

TeamEDA Inc
 UTC Aerospace Systems

**GRAPHICS AND
SIMULATION****Abaco Systems**

See ad page 11

Active Silicon Ltd
 AIM-USA
 Industrial Training Consultants Inc
 Infinite Graphics Inc

Pentek Inc

See ad back cover

Vector Informatik GmbH

INFORMATION SECURITY

Computer2100 LLC
 Cuelogic Technologies
 Green Hills Software Inc
 Harmonic Software Systems Ltd
 HD Barcode

Pentek Inc

See ad back cover

Shoghi Communications
 SYSGO
 Vocal Technologies
 Zebra Technologies Corp

MOVING MAPS**Pentek Inc**

See ad back cover

OPERATING SYSTEMS**Abaco Systems**

See ad page 11

Concurrent Technologies

Elma Electronic Inc

See ad page 8

Green Hills Software Inc
 Interface Concept
 SYSGO
 United Electronic Industries Inc
 VersaLogic Corp
 Zebra Technologies Corp

**PRODUCT LIFE CYCLE
MANAGEMENT (PLM)**

Cuelogic Technologies
 Green Hills Software Inc

Pentek Inc

See ad back cover

SRCTec LLC
 TeamEDA Inc
 Teledyne e2v
 UTC Aerospace Systems

**PROGRAMMING
LANGUAGES**

AdaCore
 Critical Link LLC
 Cuelogic Technologies
 Green Hills Software Inc

Pentek Inc

See ad back cover

Secord Solutions

**REAL-TIME OPERATING
SYSTEMS (RTOS)
AND KERNELS****Abaco Systems**

See ad page 11

esd electronics Inc
 Green Hills Software Inc
 Hitex GmbH
 Interface Concept
 Sital Technology
 SYSGO
 Vision Components GmbH

**SOFTWARE CODE DESIGN,
TEST, AND VERIFICATION**

AdaCore
 AIM-USA
 Concurrent Technologies
 Critical Link LLC
 Cuelogic Technologies
 Green Hills Software Inc
 Hitex GmbH
 Infinite Graphics Inc
 MRO Electric

Pentek Inc

See ad back cover

Puleo Electronics Inc
 QA Systems Ltd
 Secord Solutions
 Unified Infotech
 Vision Components GmbH

**TEST AND
MEASUREMENT****CALIBRATION EQUIPMENT**

Chroma Systems Solutions Inc
 CIC Research
 Cobham Antenna Systems
 ConductRF
 Custom Manufacturing &
 Engineering Inc
 DataRay Inc
 Electro Optical Components
 Inc (EOC)

Fairview Microwave Inc
 See ad page 19

Gamma Scientific
 Gemstar Custom Hard Cases
 Gigahertz-Optik Inc
 Gooch & Housego PLC
 Keysight Technologies Inc
 Konica Minolta Sensing
 Americas Inc
 Martin, Froeschner & Associates
 Marvin Test Solutions Inc
 OptoTest
 Palmer Wahl Instruments Inc
 PCE Instruments UK Ltd

Pentek Inc

See ad back cover

Plane Parts 360
 Radiant Vision Systems
 Reynard Corp
 Topac Inc
 Versatile Power
 Weschler Instruments

COTS UPSCREENING

Advanced Component Testing
 DLS Electronic Systems Inc
 Micross
 NTS Technical Systems
 NuWaves Engineering

Pentek Inc

See ad back cover

Silicon Designs Inc
 United Electronic Industries Inc

EMC COMPLIANCE

Advanced Test Equipment Rentals
 CIC Research
 Clark Testing
 Dayton T Brown Inc
 DLS Electronic Systems Inc
 EMCCons Dr Rasek GmbH & Co KG

Fair-Rite Products Corp
 See ad page 51

Ibis Electro-Products Corp
 Keysight Technologies Inc
 NTS Technical Systems

Pentek Inc

See ad back cover

Saelig Co Inc
 Transient Specialists

HALT/HASS

Adaptive Innovations Corp
 Advanced Test Equipment Rentals
 Aries Electronics Inc

Clark Testing
DLS Electronic Systems Inc
EMCCons Dr Rasek GmbH & Co KG
Epec Engineered Technologies
ESPEC North America | Qualmark
NTS Technical Systems
Screening Systems Inc
SRCTec LLC

METERS

Advanced Test Equipment Rentals
Apex Waves
Chroma Systems Solutions Inc
CIC Research
Gamma Scientific
Gemstar Custom Hard Cases
Gigahertz-Optik Inc
Gooch & Housego Plc
Jewell Instruments
Keysight Technologies Inc
Konica Minolta Sensing Americas Inc
OptoTest
Palmer Wahl Instruments Inc
PCE Instruments
PCE Instruments UK Ltd
Per Vices Corp
Plane Parts 360
Radiant Vision Systems
RWC Testing & Lab Supplies
Saelig Co Inc
Topac Inc
Weschler Instruments

NETWORK ANALYZERS

Advanced Test Equipment Rentals
Anritsu
Apex Waves
Axtrinet
ConductRF
Continental Resources
Data Device Corp (DDC)
GL Communications Inc
Go4Fiber Ltd
Keysight Technologies Inc
NextComputing
OptoTest
PCE Instruments
PCE Instruments UK Ltd
Pentek Inc
See ad back cover
Timbercon Inc
TXO Systems Ltd
Unlimited Purchasing
Vector Informatik GmbH

NETWORK/DATA BUS ANALYZERS

Abaco Systems
See ad page 11

AIM-USA
Anritsu
Axtrinet
CAEN Spa
Data Device Corp (DDC)
Marvin Test Solutions Inc
NextComputing

Pentek Inc
See ad back cover

Saelig Co Inc
Vector Informatik GmbH

VIAVI Solutions (formerly Cobham AvComm)

OPTICAL TEST AND MEASUREMENT

4D Technology Corp
Advanced Optics Inc
AMOTronics
Anritsu
Archer Optix
Aries Electronics Inc
Axtrinet
Berkeley Nucleonics Corp
Boston Electronics Corp
Canon Medical Systems USA Inc
Comar Optics Ltd
Continental Resources
DataRay Inc
Diverse Optics Inc
Electro Optical Components Inc (EOC)
Embassy Global
FiberTech Optica
Gamma Scientific
Gemstar Custom Hard Cases
GEVICAM Inc
Gigahertz-Optik Inc
GL Communications Inc
Go4Fiber Ltd
Gooch & Housego Plc
GS PLASTIC OPTICS
H&L Instruments LLC
Ibis Electro-Products Corp
Infinite Graphics Inc
Infinite Optics Inc
Integra Technologies LLC
ISVI Corp
KEYENCE Corp of America
Keysight Technologies Inc
Knight Optical
Konica Minolta Sensing Americas Inc
Krell Technologies Inc
kSARIA Corp
Lacroix Precision Optics
Lambda Research Corp
The Light Brigade Inc
Lightel
Mahr Inc
Martin, Froeschner & Associates
Marvin Test Solutions Inc
Micro Laser Systems Inc
Momentum FPD Services Corp
Monocle Industries
Navitar Inc
Newport Corp
OPCO Laboratory
Optikos Corp
OptoTest
PCE Instruments
PCE Instruments UK Ltd

Embassy Global
FiberTech Optica
Gamma Scientific
Gemstar Custom Hard Cases
GEVICAM Inc
Gigahertz-Optik Inc
GL Communications Inc
Go4Fiber Ltd
Gooch & Housego Plc
GS PLASTIC OPTICS
H&L Instruments LLC
Ibis Electro-Products Corp
Infinite Graphics Inc
Infinite Optics Inc
Integra Technologies LLC
ISVI Corp
KEYENCE Corp of America
Keysight Technologies Inc
Knight Optical
Konica Minolta Sensing Americas Inc
Krell Technologies Inc
kSARIA Corp
Lacroix Precision Optics
Lambda Research Corp
The Light Brigade Inc
Lightel
Mahr Inc
Martin, Froeschner & Associates
Marvin Test Solutions Inc
Micro Laser Systems Inc
Momentum FPD Services Corp
Monocle Industries
Navitar Inc
Newport Corp
OPCO Laboratory
Optikos Corp
OptoTest
PCE Instruments
PCE Instruments UK Ltd

Embassy Global
FiberTech Optica
Gamma Scientific
Gemstar Custom Hard Cases
GEVICAM Inc
Gigahertz-Optik Inc
GL Communications Inc
Go4Fiber Ltd
Gooch & Housego Plc
GS PLASTIC OPTICS
H&L Instruments LLC
Ibis Electro-Products Corp
Infinite Graphics Inc
Infinite Optics Inc
Integra Technologies LLC
ISVI Corp
KEYENCE Corp of America
Keysight Technologies Inc
Knight Optical
Konica Minolta Sensing Americas Inc
Krell Technologies Inc
kSARIA Corp
Lacroix Precision Optics
Lambda Research Corp
The Light Brigade Inc
Lightel
Mahr Inc
Martin, Froeschner & Associates
Marvin Test Solutions Inc
Micro Laser Systems Inc
Momentum FPD Services Corp
Monocle Industries
Navitar Inc
Newport Corp
OPCO Laboratory
Optikos Corp
OptoTest
PCE Instruments
PCE Instruments UK Ltd

Pentek Inc
See ad back cover

Photon USA Inc
Prior Scientific Inc
Quantum Composers
Radiant Vision Systems
RAM Optical Instrumentation
Reynard Corp
RFOptic
RWC Testing & Lab Supplies
Sofradir EC Inc
Specialised Imaging Inc
Specialised Imaging Ltd

StingRay Optics LLC
SwissOptic AG
Thorlabs Inc
Timbercon Inc
UTC Aerospace Systems (Sensors Unlimited Products)
Versatile Power
Vision Components GmbH

OSCILLOSCOPES

Advanced Test Equipment Rentals
AMOTronics
Anritsu
Apex Waves
CAEN Spa
CIC Research
Continental Resources
Keysight Technologies Inc
PCE Instruments
PCE Instruments UK Ltd

Pentek Inc
See ad back cover

Saelig Co Inc
VIAVI Solutions (formerly Cobham AvComm)

PORTABLE TEST SYSTEMS

4D Technology Corp
AIM-USA
AMOTronics
Anritsu
Apex Waves
Axtrinet
Berkeley Nucleonics Corp
Cadex Electronics Inc
CAEN Spa
Cepoint Networks LLC
Chroma Systems Solutions Inc
CIC Research
Continental Resources
Custom Manufacturing & Engineering Inc
Data Device Corp (DDC)
DataRay Inc
esd electronics Inc
ESPEC North America | Qualmark
Fair-Rite Products Corp
See ad page 51
Gamma Scientific
Gemstar Custom Hard Cases
GEVICAM Inc
Gigahertz-Optik Inc
GL Communications Inc
Go4Fiber Ltd
GPS Networking
IO Industries Inc
Keysight Technologies Inc
Konica Minolta Sensing Americas Inc
Mahr Inc
Martin, Froeschner & Associates
Marvin Test Solutions Inc
Mega Speed Corp
Monocle Industries
NextComputing
NTS Technical Systems
OptoTest
PCE Instruments
PCE Instruments UK Ltd

4D Technology Corp
AIM-USA
AMOTronics
Anritsu
Apex Waves
Axtrinet
Berkeley Nucleonics Corp
Cadex Electronics Inc
CAEN Spa
Cepoint Networks LLC
Chroma Systems Solutions Inc
CIC Research
Continental Resources
Custom Manufacturing & Engineering Inc
Data Device Corp (DDC)
DataRay Inc
esd electronics Inc
ESPEC North America | Qualmark
Fair-Rite Products Corp
See ad page 51
Gamma Scientific
Gemstar Custom Hard Cases
GEVICAM Inc
Gigahertz-Optik Inc
GL Communications Inc
Go4Fiber Ltd
GPS Networking
IO Industries Inc
Keysight Technologies Inc
Konica Minolta Sensing Americas Inc
Mahr Inc
Martin, Froeschner & Associates
Marvin Test Solutions Inc
Mega Speed Corp
Monocle Industries
NextComputing
NTS Technical Systems
OptoTest
PCE Instruments
PCE Instruments UK Ltd

Pentek Inc
See ad back cover

Pixus Technologies
See ad page 14

Prior Scientific Inc
Radiant Vision Systems
RWC Testing & Lab Supplies
Saelig Co Inc
Silicon Designs Inc
Transient Specialists
United Electronic Industries Inc
Vector Informatik GmbH
Versatile Power
VIAVI Solutions (formerly Cobham AvComm)
Weschler Instruments

SOFTWARE-DRIVEN INSTRUMENTATION

Abaco Systems
See ad page 11

AIM-USA
AMOTronics
Apex Waves
Chroma Systems Solutions Inc
DataRay Inc
Gamma Scientific
Keysight Technologies Inc
Konica Minolta Sensing Americas Inc
Marvin Test Solutions Inc
OptoTest
PCE Instruments UK Ltd

Pentek Inc
See ad back cover

Prior Scientific Inc
Radiant Vision Systems
Red Rapids
Versatile Power
VIAVI Solutions (formerly Cobham AvComm)
Vision Components GmbH

SPECTRUM ANALYZERS

Advanced Test Equipment Rentals
Anritsu
Apex Waves
Computer2100 LLC
Continental Resources
DRS Daylight Solutions
Eastern Applied Research Inc
FiberTech Optica
Gamma Scientific
Keysight Technologies Inc
LP Technologies
Newport Corp
PCE Instruments
PCE Instruments UK Ltd

Pentek Inc
See ad back cover

Per Vices Corp
Saelig Co Inc
Thorlabs Inc
VIAVI Solutions (formerly Cobham AvComm)

THERMAL MANAGEMENT/ COOLING SYSTEMS

CONDUCTION COOLING

ADL Embedded Solutions Inc
Annapolis Micro Systems Inc
See ad page 23

Atrenne Computing Solutions
BV Thermal Systems
Casey Machine Co
D6 Industries Inc

Dawn VME Products
See ad page 13

Electronic Interconnect

Elma Electronic Inc
See ad page 8

Extreme Engineering Solutions (X-ES)
See ad pages 3, 47

Interface Concept
Minoru Co Ltd
Orion Technologies LLC

Pentek Inc
See ad back cover

Pixus Technologies
See ad page 14

Systel Rugged Computers

CONVECTION COOLING

ADL Embedded Solutions Inc
Annapolis Micro Systems Inc
See ad page 23

Atrenne Computing Solutions
BV Thermal Systems
Casey Machine Co
D6 Industries Inc

Dawn VME Products
See ad page 13

Electronic Interconnect

Elma Electronic Inc
See ad page 8

Extreme Engineering Solutions (X-ES)
See ad pages 3, 47

Interface Concept
Minoru Co Ltd

Pentek Inc
See ad back cover

Pixus Technologies
See ad page 14

Systel Rugged Computers

LIQUID COOLING

Alfa International
Annapolis Micro Systems Inc
See ad page 23

Atrenne Computing Solutions
BV Thermal Systems
Casey Machine Co
D6 Industries Inc

Elma Electronic Inc
See ad page 8

Minoru Co Ltd
Orion Technologies LLC

Pentek Inc
See ad back cover

Pixus Technologies
See ad page 14

SSP Manufacturing Inc
Systel Rugged Computers

4D Technology Corp; Tucson, AZ, USA, www.4dtechnology.com

4Lasers; Vilnius, Lithuania, www.4lasers.com

4SProducts - Telecom & Energy Cables; Coral Gables, FL, USA, www.4sproducts.com

A&A Coatings - Aerospace Thermal Spray Coating; South Plainfield, NJ, USA, www.thermalspray.com/industries/aerospace-rotorcraft

Abaco Systems; 8800 Redstone Gateway SW, Suite 200, Huntsville, AL 35808, USA, TEL: 866-652-2226, www.abaco.com
See ad page 11

With over 30 years' experience, the company is a leader in open architecture rugged embedded systems. According to IHS, the company is also the world leader in VITA technology boards. Delivers state-of-the-art commercial off-the-shelf products and support programs that reduce time to deployment, cost and risk.

AbelConn LLC; New Hope, MN, USA, www.abelconn.com

Accusy Photontech Ltd; Fuzhou, Fujian, China, www.accusy.com

Acroamatics Telemetry Systems; Goleta, CA, USA, www.acroamatics.com

Acromag Inc; Wixom, MI, USA, www.acromag.com

Active Silicon Inc; Severna Park, MD, USA, www.activesilicon.com

Active Silicon Ltd; Iwer, Buckinghamshire, UK, www.activesilicon.com

AdaCore; New York, NY, USA, www.adacore.com

Adaptive Innovations Corp; Lakewood, CO, USA, www.a-i-corp.com

ADCO Circuits; Rochester Hills, MI, USA, www.adcocircuits.com

Adimec; Woburn, MA, USA, www.adimec.com

ADL Embedded Solutions Inc; San Diego, CA, USA, www.adl-usa.com

AdTech Ceramics; Chattanooga, TN, USA, www.adtechceramics.com

Advance Circuit Technology Inc; Rochester, NY, USA, www.advcircuit.com

Advanced Component Testing; Ronkonkoma, NY, USA, www.actestlab.com

Advanced Interconnections Corp; West Warwick, RI, USA, www.advanced.com

Advanced Optics Inc; Pewaukee, WI, USA, www.advancedoptics.com

Advanced Precision Engineering Inc; Ipswich, MA, USA, www.apel0.com

Advanced Test Equipment Rentals; San Diego, CA, USA, www.atecorp.com

Advantech; Milpitas, CA, USA, www.advantech.com

Aero Dynamix Inc; Euless, TX, USA, www.aerodynamix.com

Aerospace Aces; Malden, MA, USA, www.aerospaceaces.com

Aerospace Simplified; Spokane, WA, USA, www.aerospacesimplified.com

Aerotech Inc; Pittsburgh, PA, USA, www.aerotech.com

AGDisplays; Greensburg, PA, USA, www.agdisplays.com

Aiconics; Lewisville, TX, USA, www.aiconics.com

AIM-USA; Treviso, PA, USA, www.aim-online.com

AirBorn Inc; 3500 Airborn Circle, Georgetown, TX 78626, USA, TEL: 512-863-5585, abinfo@airborn.com, www.airborn.com
See ad page 16

AirBorn is an employee-owned company whose core business is engineering and manufacturing specialized connectors and electronic components for OEMs worldwide. We serve companies in industries including military/defense, commercial air, medical, industrial, and space. Our all-inclusive "Model-to-Market®" service shepherds your product from the barest of concepts through to mass production.

Aitech; Chatsworth, CA, USA, www.rugged.com

Alfa International; Woonsocket, RI, USA, www.alfaadhesives.com

Allied Motion Technologies Inc; Amherst, NY, USA, www.alliedmotion.com

Altron; Minneapolis, MN, USA, www.altronmfg.com

American; Camarillo, CA, USA, www.controlroomsusa.com

AMOtronics; Aachen, Germany, www.amotronics.de

Ampex Data Systems; Hayward, CA, USA, www.ampex.com

Amphenol Aerospace; Sidney, NY, USA, www.amphenol-aerospace.com

Amphenol Industrial Products Group; Sidney, NY, USA, www.amphenol-industrial.com

AMWEI Thermistor Sensor; Shenzhen, Guangdong, China, www.amwei.com

Analog Modules Inc; Longwood, FL, USA, www.analogmodules.com

ANEXIO; Raleigh, NC, USA, www.anexio.com

Annapolis Micro Systems Inc; 190 Admiral Cochrane Dr, Suite 130, Annapolis, MD 21401, USA, TEL: 410-841-2514, winfo@annapmicro.com, www.annapmicro.com
See ad page 23

Annapolis Micro Systems designs, manufactures and programs powerful COTS FPGA-based boards and systems for challenging data digitization, digital signal processing, and data recording applications. Products are designed for advanced HPC, ISR, and multi-function EW, including phased array radar, cybersecurity network processing, DRFM, beamforming, wireless communication, and radar signal processing.

Anritsu; Allen, TX, USA, www.anritsu.com

aPeak Inc; Newton, MA, USA, www.apeakinc.com

Apex Waves; Cary, NC, USA, www.apexwaves.com

Applied Avionics; 3201 Sandy Ln, Ft Worth, TX 76112, USA, TEL: 817-451-1141, sales@appliedavionics.com, www.appliedavionics.com
See ad page 10

Applied Avionics is the manufacturer of the VIVISUN® line of ruggedized, lighted pushbutton switches and NEXSYS® system-to-system integration avionics. Using NEXSYS® Component Technology, tailored avionics solutions are possible directly inside of the switch offering faster delivery, a simpler certification process and a reduced bill of materials.

Applied Ceramics; Fremont, CA, USA, www.appliedceramics.net

Applied Optoelectronics Inc; Sugar Land, TX, USA, www.ao-inc.com

AR Modular RF; Bothell, WA, USA, www.arww-modularrf.com

Archer Optix; Rockwall, TX, USA, www.archeroptix.com

Aries Electronics inc; Bristol, PA, USA, www.arieselec.com

Arkema Inc; King of Prussia, PA, USA, www.arkema-americas.com

ASAP 3Sixty; White Plains, NY, USA, www.asap3sixty.com

ASAP Aerospace Hub; De Pere, WI, USA, www.asapaerospacehub.com

ASAP Axis; De Pere, WI, USA, www.asapaxis.com

ASAP Buying; Spokane, WA, USA, www.asapbuying.com

ASAP Components; Raleigh, NC, USA, www.asap-components.com

Asine Ltd; Hod Hasharon, Israel, www.asinegroup.com

Atrenne Computing Solutions; Brockton, MA, USA, www.atrenne.com

Avo Photonics; Horsham, PA, USA, www.avophotonics.com

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See ad page 57

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See ad page 7
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ADVERTISERS INDEX

ADVERTISER	PAGE	ADVERTISER	PAGE
Abaco Systems.....	11	L-Com	C3
Airborn Inc.	16	Linear Systems	55
Annapolis Micro Systems Inc.....	23	Milpower Source.....	32
Applied Avionics, Inc.	10	Omnetics Connector Corp.....	29
Dawn VME Products.....	13	Pasternack Enterprises	5, 27
Dynatem	53	Pentek	C4
Elma Electronic Inc.....	8	Phoenix International.....	45
Extreme Engineering Solutions.....	3, 47	Pico Electronics Inc	9
Fair-Rite Products Corp.	51	Pixus Technologies	14
Fairview Microwave.....	19	Radiall AEP Inc.....	39
Falcon Electronics	37	RGB Spectrum.....	44
General Micro Systems Inc.	C2	Synqor.....	57
Holt Integrated Circuits	15	VectorNav	61
Huber + Suhner Inc.....	31	Viking Technology	7
Interstate Connecting Components	12	VPT Inc.	17

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