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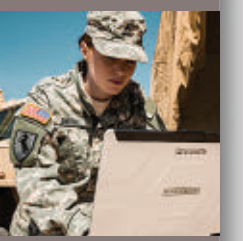
COVER STORY



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BY **JOHN KELLER**, EDITOR IN CHIEF

Mattis faces his biggest challenge yet as secretary of defense

Retired U.S. Marine Corps Gen. James Mattis will have a big job to fill as U.S. secretary of defense. There's no doubt he's a fighter and a staunch advocate for U.S. military forces, yet his deftness in handling an organization as large, diverse, and set-in-its-ways as the U.S. Department of Defense (DOD) remains to be seen.

President-elect Donald Trump nominated Mattis as defense secretary last month. Not only must members of Congress confirm Mattis as defense secretary, but they also must grant a waiver to the National Security Act of 1947, which requires a seven-year wait period before retired military personnel can become secretary of defense. He retired from the Marine Corps in May 2013.

The DOD is one of the biggest and most complex bureaucracies in the U.S. government. With 2.8 million employees, the DOD is the largest employer in the world, and has its share of competing fiefdoms and special-interest groups. DOD has nearly 1.3 million active duty military personnel, more than 801,000 National Guardsmen and Reservists, and more than 740,000 civilians. That's a lot to manage.

Not only would Mattis as defense secretary be responsible for the DOD's internal personnel, but he also must ride herd on a $600 billion defense budget, about one-third of which is for procurement, research, and development. With that, the defense secretary also must form relationships with, and keep a close eye on, the companies in the U.S. defense industry. He also would have to spearhead efforts to revitalize the Department of Defense, which has faced eight years of downsizing, sequestration, and social engineering while at the same time trying to keep international terrorism at bay.

Mattis has a lot of leadership and management experience, yet nothing close to the size of the job that awaits him at the Pentagon. In the Marine Corps, Mattis has commanded everything from a rifle and weapons platoon to U.S. Joint Forces Command. Notably he was in charge of the Marine Corps Combat Development Command where he was in charge of the Marines training and education programs.

A lifelong bachelor, Mattis started in the Marines in 1969 as a second lieutenant, and retired as a four-star general in 2013. Since separating from the military Mattis has been on the board of directors of General Dynamics Corp.; was an Annenberg Distinguished Visiting Fellow at the Hoover Institution, a conservative think-tank and research group at Stanford University in Palo Alto, Calif.; and was an advisory board member of the nonprofit Sprit of America organization to promote the safety and success of American troops and locals they seek to help.

With a personal reputation as a straight-shooter, Mattis is known for his sometimes-blunt comments, which include:

- "Be polite, be professional, but have a plan to kill everybody you meet."
- "I were to sum up what I've learned in 35 years of service, it's improvise, improvise, improvise."
- "Demonstrate to the world there is 'No Better Friend, No Worse Enemy' than a U.S. Marine."

It has been said that Mattis might be too much of a military man to lead the Pentagon. The secretary of defense, after all, is intended to be a civilian appointment, and represents civilian control of U.S. military forces.

Were Congress to grant him the necessary waiver to the National Security Act, Mattis would be only the second U.S. secretary of defense to receive such a waiver. General of the Army George Marshall retired from active service in 1945 and was appointed secretary of defense in 1950.

So assuming that Congress confirms Mattis as President Trump's defense secretary, as presumably its members will, the general will have his work cut out for him.

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Navy taps Metron to develop machine intelligence for UUV surveillance

BY JOHN KELLER

ARLINGTON, Va. — Unmanned underwater vehicle (UUV) experts at Metron Inc. in Reston, Va., are moving forward with efforts to develop machine intelligence for future generations of U.S. Navy UUVs for a wide variety of applications, like long-range surveillance.

Officials of the Office of Naval Research (ONR) in Arlington, Va., announced a $29.8 million contract to Metron for an effort titled "advanced autonomy for unmanned undersea vehicles." This research project seeks to write and test software for advanced UUV autonomy that runs on government-provided hardware. The goal is to demonstrate emerging machine autonomy capabilities in several different kinds of military missions.

Metron is involved in developing autonomy software for the ONR Large Displacement Unmanned Undersea Vehicle (LDUUV) project, which involves autonomy software, computer hardware, and sensors. In 2013, Metron won a $7.3 million ONR contract for in-lab integration and testing of autonomy and mission planning software with bench test hardware selected for deployment on the LDUUV. That 2013 ONR contract to Metron contained two one-year options with the potential to increase the contract's total value to $18.3 million. As that original contract wraps up, this new contract apparently is asking Metron to move forward with machine autonomy development for future Navy UUVs.

ONR's LDUUV project seeks to develop a large unmanned submarine able to operate in the open ocean and in coastal waters and harbors on missions lasting more than 70 days to gather intelligence, surveillance, and reconnaissance (ISR) information. The program is developing UUV autonomy and long-endurance propulsion systems for large UUVs.

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

Other challenges involved with developing LDUUV autonomy software include detecting, locating, and identifying surface vessels; determining the intent of detected surface vessels; and detecting and avoiding fishing nets and fishing gear, including monofilament and twine nets. Once outside the specified areas, human operators may intervene over satellite links, if necessary.

In addition to Metron, other companies are working on autonomy and control for the future LDUUV. UUV designer Hydroid Inc. in Pocasset, Mass., also is developing an autonomy testing system for the LDUUV. Hydroid is a subsidiary of Kongsberg Maritime AS in Kongsberg, Norway.

Navy researchers are overseeing development of machine intelligence technology for a new generation of unmanned underwater vehicles (UUVs).

Hydroid uses the Remote Environmental Measuring Units (REMUS) UUV as an autonomy testing system for LDUUV technology. The vehicle-control architecture is the same in the LDUUV and REMUS underwater vehicles, making it easy to move software from one vehicle to the other.

On the LDUUV program, several companies are developing propulsion and power technologies for the future large unmanned submersible. Among the companies are: Fuelcell Energy Inc. in Danbury, Conn.; Sierra Lobo Inc. in Fremont, Ohio; the Hamilton Sundstrand Corp. Sea Systems segment in Windsor Locks, Conn.; General Atomics in San Diego; Lynntech Inc. in College Station, Texas; and NexTech Materials Ltd. in Lewis Center, Ohio.

The contract awarded to Metron has options that could increase its value to $33.9 million. Metron will do the work in Reston, Va.; San Diego; and Cambridge, Maine, and should be finished by March 2020.

FOR MORE INFORMATION visit **Metron** online at *www.metsci.com*.

Lockheed Martin to provide cybersecurity for Navy C-130T avionics

BY JOHN KELLER

PATUXENT RIVER NAS, Md. — Avionics software experts at Lockheed Martin Corp. are taking measures to provide data integrity and cyber security for the U.S. Navy's fleet of 20 C-130T Hercules cargo, logistics, and utility aircraft.

Officials of the Naval Air Systems Command at Patuxent River Naval Air Station, Md., announced a $16.1 million contract modification to the Lockheed Martin Rotary and Mission Systems segment in Owego, N.Y., for data integrity in the Avionics Obsolescence Upgrade (AOU) effort on the C-130T aircraft.

U.S. military attention to cybersecurity weapons and surveillance platforms is increasing with a data-integrity and cybersecurity project for the Navy's fleet of 20 C-130T Hercules cargo, logistics, and utility aircraft.

Since 2012, Lockheed Martin has been installing, upgrading, and maintaining an avionics and software integration solution to upgrade Navy C-130T aircraft under the AOU program.

The effort includes modernizing the C-130T's communications suite, flight management system, cockpit displays, navigation computers, autopilot, and automatic flight control system with an integrated, modular open systems approach (MOSA), by adhering to the Future Airborne Capability Environment (FACE) standard.

Data integrity, a subset of cybersecurity, involves maintaining and assuring the accuracy and consistency of data over its life cycle as a system stores, processes, or retrieves data. It seeks to prevent the loss or corruption of important data by malicious or accidental means.

The C-130T AOU effort includes government-furnished color weather radar; UHF, VHF, and HF radios; embedded global positioning system (GPS) and inertial navigation systems; protected instrument landing system (P-ILS); and standby instruments for use with Lockheed Martin-furnished avionics hardware and software.

On this order, Lockheed Martin will do the work in Ottawa and Owego, N.Y., and should be finished by March 2018. ←

FOR MORE INFORMATION visit **Lockheed Martin Rotary and Mission Systems** online at *www.lockheedmartin.com/us/rms.html*, or **Naval Air Systems Command** at *www.navair.navy.mil*.

IN BRIEF

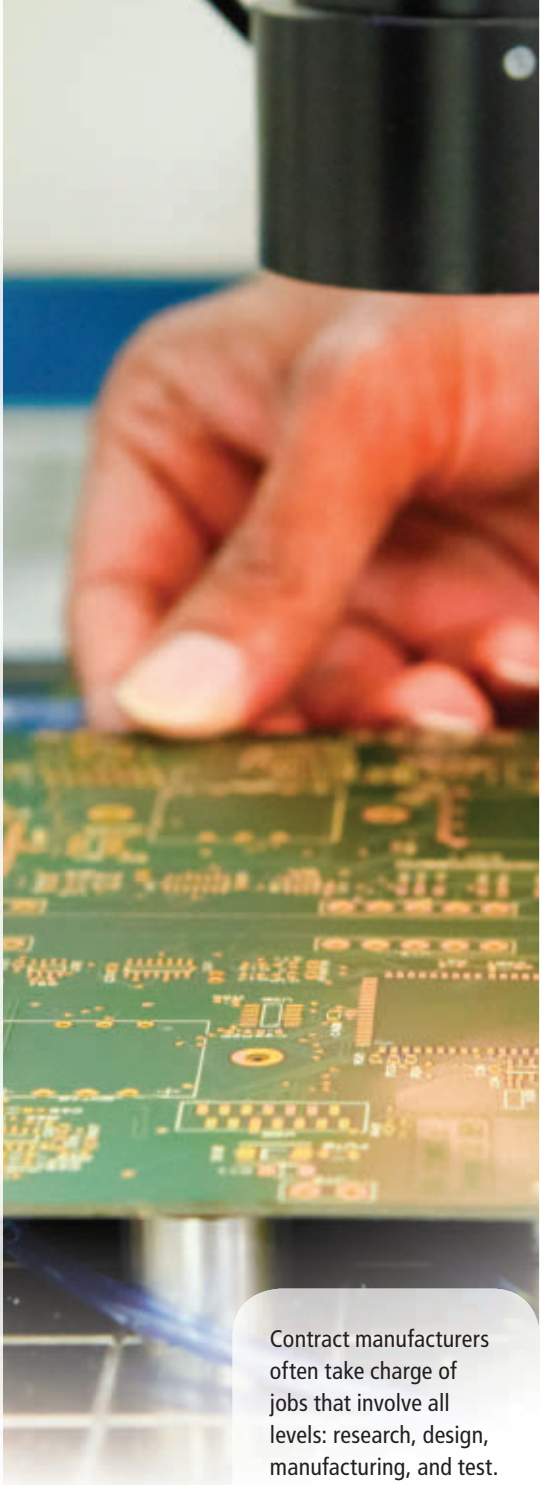
Cybersecurity's next phase could be cyber deterrence

Cyber attackers pose many threats to a wide range of targets. Russia, for example, was accused of hacking Democratic Party computers throughout the year and interfering with the U.S. presidential election. From 2005 to 2015, federal agencies reported a 1,300 percent jump in cybersecurity incidents. Clearly, we need better ways of addressing this broad category of threats. Some in the cybersecurity field are asking whether cyber deterrence might help. Cyber deterrence focuses on making potential adversaries think twice about attacking, forcing them to consider the costs of doing so, as well as the consequences that might come from a counter-attack. There are two main principles of deterrence. The first, denial, involves convincing would-be attackers that they won't succeed, at least without enormous effort and cost beyond what they are willing to invest. The second is punishment: Making sure the adversaries know there will be a strong response that might inflict more harm than they are willing to bear. ←

Contract manufacturing: there when you need it

The nation's prime defense contractors often find themselves with too many orders to handle with in-house expertise. That's where electronics contract manufacturing comes in.

BY **J.R. Wilson**



Contract manufacturers often take charge of jobs that involve all levels: research, design, manufacturing, and test.

With the rapid expansion of high-tech military equipment and componentry, thousands of small specialty manufacturers have come into being, with the initial big boost during with the Space Race of the 1960s.

That decade also marked the start of an acquisition and merger cycle that saw the majority of those companies — large and small — joined to become 20th Century defense industry giants, such as McDonnell and Douglas, Northrop and Grumman, Lockheed and Martin, as well as those whose names did not continue, as with the McDonnell Douglas acquisition of Hughes Helicopters about a decade before McDonnell Douglas itself vanished into Boeing.

Throughout that period — and with even greater frequency since the turn of the century — contract manufacturing of military electronics grew into a major industry in its own right. Working primarily for systems integrators, contract manufacturers typically focus on specific areas, such as machining; mechanical and electrical assemblies; power systems; lasers; optics; sensors; robotics; vehicular controls; RF systems; satellite instrumentation; environmental stress screening; G-force testing; and electronic circuit card assembly.

"In the last 10 years, if you look at industry consolidation, that tends to support systems integration, which intuitively should mean more contract manufacturing," says Matt Turpin, CEO of contract manufacturer Zentech Manufacturing Inc. in Windsor Mill, Md. "Given the peaks and troughs of the mil-aero business, any company that tried to stay vertically integrated would probably die. Given the rate of technology change, vertical integration would not, in general, be able to keep up."

The role of industry consolidation

This is the primary reason that big systems integrators like Lockheed Martin, Northrop Grumman, and L-3 rely on best-in-breed contract manufacturing," Turpin says. "The economics don't really support them trying to do it all in-house. If you try to bring in that capability for just your stuff, you can't even out the troughs in mil-aero the way an independent contract manufacturer can."

Contract manufacturing of military electronics is significantly different from the model in use in many other industries, where the contract manufacturer produces complete products under the contractor's brand.

In the military market, the contract manufacturer may produce unique components designed by the contractor or provide its own designs, developments, prototyping and modeling, assemblies, fabrication, tooling, manufacturing, qualification testing, procurement, and logistics services to meet the contractor's requirements.

Representative of that is Jabil Circuit Inc. in St. Petersburg, Fla. With $18 billion in annual revenues, Jabil is the third largest contract manufacturer in the world — behind Taiwan's Hon Hai Precision Industry (Foxconn) and Singapore's Flextronics International Ltd.

Trailing closely behind Jabil in size are U.S. contract manufacturers Sanmina Corp. in San Jose, Calif.; Benchmark Electronics Inc. in Angleton, Texas; and Plexus Corp. in Neenah, Wis.

Jabil promotes its second largest division, Defense and Aerospace, as providing a skilled workforce for aerospace and defense manufacturing, design, and supply chain management for high-mix, low- to medium-volume products and electronic and mechanical solutions to complement original equipment manufacturers' core competencies and reduce program costs.

"Systems integrators are still doing a lot of work in-house, but are outsourcing more each year, although the increase is not that great," says Mike Matthes, president of the Jabil Aerospace and Defense division.

Demonstrating value

"We have to provide a value proposition to show it is more advantageous to outsource electronics manufacturing than to keep it in-house, which allows them to focus more on their strategic plans and not worry about the actual manufacturing," Matthes says. "Jabil is moving into a new capability — aerospace machining — and entering into agreements to provide that to defense and civilian companies." Contract

Milwaukee Electronics is a regional contract manufacturer focused on providing North American engineering and manufacturing services, from design support to SMT PCB assembly through box build.

manufacturers also have to grow their capabilities to retain that value, he points out.

"We do electronic manufacturing and systems integration, but not the machining portion," Matthes continues. "At Jabil Green Point, our largest division, we do machining, mostly in China, but not for aerospace. It's not an easy capability to master and we're working with our customers to develop and launch that. Some of that will be based in the U.S., other parts in Asia. Military contracting would have to be done in the U.S., including a new facility. Almost everything we have at this time is commercial aerospace, but we will be working toward that."

Jabil's high volume of non-military contract manufacturing is fairly common among the larger contract manufacturers, much of it for overseas customers, although many of the smaller companies have focused their efforts tightly on items in demand by U.S. military contractors. While the vast majority of such contracts are with industry, some contract manufacturers do have direct contracts with the military services and the U.S. Department of Defense (DOD).

"It's a combination," says Zentech's Turpin. "We have two divisions, one with a long history of direct contracts, primarily with the Navy. The other does fewer direct contacts, but in the last five years contracts with the Army at Aberdeen Proving Ground and a blanket purchase agreement with the Navy have increased. But most are with industry," he says.

"For us, the U.S. government — and certainly DOD — are huge customers with lots of opportunity, predominantly subcontract work for primes, especially as we come out of sequestration, where defense dollars really did shrink a lot," adds Jabil's Matthes. "As we move forward

Contract manufacturers have workforces with deep levels of expertise to handle today's complex manufacturing jobs.

under the new administration, there certainly are possibilities for increased defense spending."

Prime defense contractors are reluctant to surrender their manufacturing capabilities to contract manufacturers.

"The primes have their own manufacturing and to move it out they would have to cut jobs and close factories, which is never palatable for anyone," Matthes says. "And moving jobs and changing the labor landscape is never popular, even if the work remains in the U.S. It does become popular when the benefits outweigh concerns, so our job is to show where that value is."

Industry diversity

U.S. military electronics contract manufacturers come in all sizes, representing the full gamut of needs from systems prime contractors and, to a lesser extent, the military services themselves. By focusing their efforts and investments in specialty technologies and workers, they can make themselves too valuable to the defense industry at large to be taken in-house by individual companies.

Representatives of that diversity include: NEO Tech in Chatsworth, Calif., with a focus on advanced IP protections systems, anti-counterfeit protection, and upgrading or replacing out-of-date legacy systems for its aerospace and defense customers.

"The obsolescence of electronic components is a serious challenge in the aerospace and defense markets. Many of the ICs designed into systems have shorter life cycles than the end products in these markets," according to a company document. "NEO Tech has implemented a supply- chain design for the industry that can support long product life cycles. NEO Tech Obsolescence Mitigation helps customers through the obsolescence process so disruption to ongoing programs is mitigated."

Many contract manufacturers also are prime contractors themselves, typically on smaller systems for the military services.

One such is Sparton Corp. in De Leon Springs, Fla., which focuses on specialized technologies like embedded systems, RF, lasers, optics, sensors, and robotics for uses as varied

as undersea warfare to cockpit controls to satellite communications, as well as aerospace and military printed circuit board assemblies.

Sypris Electronics in Tampa, Fla., a division of Sypris Solutions in Louisville, Ky., offers complete electronic manufacturing services (EMS) from circuit card assemblies to complex box builds and systems integration. Their approach is based on a Lean/Six Sigma, continuous improvement culture cultivated through internal investments.

TeligentEMS LLC in Havana, Fla., another ITAR and ISO 9001 registered contract manufacturer, offers product manufacturing services in a wide range of technologies, including unattended ground sensors, GPS tracking devices, spread spectrum transceivers, and handheld communication devices. The company promotes its capabilities in "technically complex defense projects, combined with strong configuration management capabilities and organizational flexibility."

Specializing in electronic, electro-mechanical, and electro-optical equipment, the engineering group at TRICOR Systems Inc. in Elgin, Ill., develops complete packages for their customers, from concept to operating manuals. That has included a broad array of products, under contract and for sale directly by TRICOR, from extremely complex to simple test equipment, hardware and software simulators, illuminator systems, and airborne black boxes.

Steady work flow

Commercial and non-military government contracts provide the ability to "even-out the troughs" as defense spending changes from year to year and administration to administration. Homeland security, for example, has grown significantly as a market in which contract manufacturers can find customers and is expected to continue to grow for the foreseeable future. That also applies — primarily in the U.S. — to investments in cyber-related hardware and chem/bio-detection equipment. Globally, industry experts say there has been a stated focus on improving commercial air fleets.

Jabil Circuit experts are helping train a new generation of technicians to take on tomorrow's demanding manufacturing jobs.

The resulting increased demand for contract manufacturers has led not only to growing competition but also to closer industry oversight.

"For existing EMS companies, if there is more demand for military equipment, most U.S.-built, there will be an uptick of military assembly work in the U.S., but it also is likely to incentivize people to get into the market, either through acquisitions or expansion," says Zentech's Turpin. "To an outsider looking in, military electronics may seem pretty simple, but hiring and maintaining a skilled workforce, and maintaining a balance through the peaks and troughs is a different story."

About three years ago, industry standards group IPC — Association Connecting Electronics Industries in Bannockburn, Ill., came up with a list of trusted sources. "Competition to receive that is brutal," Turpin says.

IPC describes its origin and purpose on its website: "IPC Validation Services was created to answer a recognized need identified in an industry survey — 75 percent of responding engineers and executive management from OEMs, EMS providers, and industry suppliers viewed a supplier qualification program as vital to their business. For EMS providers and industry suppliers, IPC Validation Services provides the opportunity to become part of a network of trusted sources that industry will look to first and foremost when evaluating existing and potential business partners.

"Participating EMS providers and supplier companies will be audited by IPC Validation Services — the authoritative, objective source for quality conformance and data reporting — to earn certification through the Qualified Products List (QPL) and Qualified Manufacturers List (QML) programs. Once certification is achieved, EMS companies and industry suppliers earn the right to a high level of visibility throughout the industry," the IPC description reads.

Disruptive technologies

Industry leaders largely agree that coming disruptive technologies, including further advances in miniaturization and evolution of the Internet of Things, also will change the world of electronics contract manufacturing.

"There are many disruptive technologies being developed right now, but nobody knows which ones will actually displace an existing technology in a way that is efficient and effective in meeting military SWaP [size, weight and power] requirements or commercial requirements for quality. Everything active will be disrupted by such things as nanotech, nanostructures, new fabrication techniques other than 3D printing — which itself is changing so fast, making prototyping faster and less expensive, for example," Zentech's Turpin says.

"Quantum computing is another that will change everything in the future, if and when they get it nailed down — how manufacturing and product development are done," Turpin continues. "As relates to EMS companies, all that further underscores and exacerbates the issues surrounding capital investment. These technologies are not cheap and it doesn't make sense for a prime to invest in such technologies with only relatively small production requirements."

As more new and disruptive technologies come out, it will be incumbent on the primes to determine which EMS companies have the right people and equipment to build their products and properly use those technologies. Those in charge of contracting complex, high-reliability, military and aerospace assemblies will have to place even more emphasis on who is building those components by fully understanding the problems, challenges, and risks involved.

"If you use the wrong electronics contract manufacturer, no matter how good they may be, if they don't have the right people or equipment, you could end up killing your own business," Turpin warns.

Jabil's Matthes agrees, but does not believe such new developments constitute an immediate concern for military electronics contract manufacturing.

"I see disruptive technologies that will take hold, but not in the short term," Turpin says. "When you have a force out there fighting, if you are going to change the equipment they are using, you will have to do a lot of testing before making that move, which could take years. It could be a long time before it finds its way into the field to any large extent," he predicts.

"So in the next few years, I don't think disruptive tech will be a big changer; it will be more policy, funding, and outsourcing strategies from the primes," Turpin says. "The big technology trends are going to make their way in, but will require a lot of time to mature and meet pretty stringent reliability and operating requirements. So while those will slowly become part of it, they will be slower to adoption than on the commercial side."

Zentech Manufacturing maintains close times with major U.S. and international defense contractors for complex electronic subsystems design and test.

Government and industry policies

For the military, then, technology changes will not be as important to contract manufacturing as new government policies, especially given the anticipated changes of the new Trump Administration. That also applies to changes in how the military does business, moving more toward autonomous systems, major improvements in battery technology, and overall energy requirements and technologies, with the commercial sector leading the way. Continuing advances in materials science also will shape that future.

Regardless of how quickly new technologies and new demands on contract manufacturing develop, they are on the horizon and primes and contract manufacturers will have to prepare themselves for them.

"Wherever there is change, there is opportunity; it just depends on how well you are positioned to take advantage of it, especially in areas in which you are investing," says Jabil's Matthes. "The trick is to invest in the right technologies at the right time." Jabil's size will be an advantage that will enable company executives to make strategic decisions rather than betting the company. "The more resources you have, the easier it is to fund that type of research and development.

"We are a Fortune 150 company, about $18 billion in annual revenue and 180,000 employees worldwide," Matthes says. "That can be an advantage in having a breadth of resources and capabilities, but it

Manufacturing technicians like these at Zentech often are long-term employees valued for their deep levels of experience.

can be a disadvantage if a customer fears we're so large, their work might get lost. But divisionalizing our business units and keeping each customer with its own business unit manager makes the connection much more intimate and gives the feel of a smaller, more nimble company."

For the next decade, Zentech's Turpin sees a future depending on increased investment in manufacturing technologies for the military electronics market, in the U.S. and abroad.

"I would love to say increased profitability will mark the decade, but I say that tongue-in-cheek due to the continuing peaks and troughs in mil-aero. Nevertheless, the promise of increased military spending should be good for business," Turpin says. "Other changes for contract manufacturing to stay in business, especially on the mil-aero side, will mean more new investments in capital equipment. When new technology comes out, you need equipment to work it and inspect it in order to compete."

While all military electronics contract manufacturing must be done by U.S. companies at plants in the United States, successful competition for customers — primarily commercial — around the world is important to the ability of contract manufacturers to maintain a steady level of business and invest in the appropriate technologies and expertise.

Domestic manufacturing

In one of the first efforts to support advanced domestic manufacturing technologies, the U.S. Congress approved the Revitalize American Manufacturing and Innovation (RAMI) Act in 2014. It was designed to use federal and private matching funds to create an initial network of as many as 15 institutes around the country, pursuing areas of greatest interest to industry.

The resulting National Network for Manufacturing Innovation, renamed Manufacturing USA in 2016, established nine institutes in its first years of operation, with another six planned for 2017. The long-term goal is for as many as 45 public-private partnerships, each with its own technology focus area, but working toward a common goal, to secure America's technological future through manufacturing innovation, education, and collaboration.

Seen as a major boost for prime and contract manufacturers, the Manufacturing USA network is operated by the inter-agency Advanced Manufacturing National Program Office (AMNPO),

Contract manufacturers like Zentech often must maintain large factory capacities to handle rush jobs and large orders.

headquartered in the National Institute of Standards and Technology at the Department of Commerce. The office is staffed by representatives from federal agencies with manufacturing-related missions, as well as fellows from manufacturing companies and universities, all working with DOD, NASA, the National Science Foundation, and the departments of Energy, Education, and Agriculture.

As it has grown and adjusted to continuing rapid changes in technologies, manufacturing processes, and market demand, but the organization says it has not changed its overarching mission:

- "to convene and enable industry-led, private-public partnerships focused on manufacturing innovation and engaging U.S. universities; and
- "to design and implement an integrated whole-of-government advanced manufacturing initiative to facilitate collaboration and information sharing across federal agencies.

"By coordinating federal resources and programs, the AMNPO enhances technology transfer in U.S. manufacturing industries and helps companies overcome technical obstacles to scale up new technologies and products."

Turpin describes it as the best effort to date to help contract manufacturers, primes, and the military maintain the nation's technological lead.

Manufacturing goals

"At a macro level, the U.S. does a lot of things extremely well, but one thing it has not done well is have a national manufacturing strategy. Other countries have a very defined national strategy to embrace, enhance, and grow advanced manufacturing in their nations," Turpin explains.

"The IPC was very active in lobbying Congress to set up the RAMI Act. The advanced manufacturing centers being created throughout the country to focus on building up the next generation of manufacturing in the U.S. should help the military and commercial worlds."

In a strategic plan for Manufacturing USA issued in February 2016, Commerce Secretary Penny Pritzker noted that manufacturing "innovation is the lifeblood of our economy, supporting one-third of our economic growth," from the largest defense and commercial companies to the smallest contract manufacturers and suppliers. "Having a cutting-edge manufacturing sector that remains a step ahead of the global competition is not simply nice to have, it is a 'must have' for our country to thrive, now and in the future," she wrote. "In today's advanced manufacturing industries — those that make the highest-value goods, pay the highest wages, and export all over the world — product and process innovation are two sides of the same coin. Inventing, designing, making, and improving happen in concert, which requires a collaborative environment that brings together researchers and companies throughout the supply chain.

"America has all the essential ingredients to form innovation ecosystems, including universities and government labs that excel at basic science and technology research, top-flight original equipment manufacturers, capable suppliers, enterprising start-ups, and a new generation of workers," Pritzker wrote. "The NNMI Program assembles our diverse competitive assets — the people, organizations, and resources — necessary for the United States to stay at the head of the pack in the global race to out-innovate — and out-produce — the competition... [laying] the foundation for American manufacturing competitiveness for generations to come."

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Driving demand for rugged mobile computers

Wide-ranging military and aerospace applications demand the use of rugged mobile computers that meet a host of requirements.

BY **Courtney E. Howard**

Aerospace and defense missions, today and for the foreseeable future, rely on the availability of robust and reliable computers — a growing proportion of which must be mobile. Most systems also must be rugged, to withstand the rigors of transport, field use, and exposure to any of a variety of environmental conditions. It isn't enough to be mobile and rugged, however; modern aerospace and defense applications are driving the demand for ever smaller, more robust, and flexible system designs.

Capable, compact computers

Rugged, mobile computers, like virtually all other military and aerospace electronics, must meet demanding size, weight, power consumption, and cost (SWaP-C) specifications — while adhering to a host of other requirements. The pressure is on, now more than ever, to produce computers that are more robust, more capable, and more portable than anything deployed to date in aerospace and defense.

"For several years now, the rugged market has been experiencing demand for smaller-footprint platforms for mobile computing that still need to meet performance and cooling requirements," says Shan Morgan, president of Elma Electronic Inc. in Fremont, Calif. Command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) programs, for example, "have significantly augmented demand for high-performance central processing units (CPUs) and general-purpose graphics processing units (GPGPUs) in these small systems, further challenging SWaP packaging solutions," Morgan says.

"Efforts to embrace open architectures and expanded networked computing increase the need for computers everywhere," Morgan adds. "The market has moved beyond the design phase and into deployed systems across multiple defense disciplines." In fact, a defense customer called on Elma Electronic engineers to deliver a powerful, flexible computing platform compact enough to fit in a suitcase.

One of Elma's customers needed "a lightweight, yet very rugged, computer housed in a one-person transportable suitcase," Morgan describes. The computer, serving as a portable security device for facial- and other visual-recognition tasks, needed to scale up to five Ethernet ports with the ability to attach up to four cameras; and most importantly, it had to have a special input/output (I/O) panel with connections for specific locations. "Elma's solution resulted in a unique platform that met all the requirements: a rugged, fanless embedded system with a high-performance [Intel] Haswell-class CPU, Ethernet port scalability, and a flexible I/O panel with customer-speci-

fied connections — all housed in a SWaP-compliant, small-form-factor (SFF) enclosure.

"Just like the push in industrial and consumer markets, there will continue to be pressure on defense applications to make computers ubiquitous and ever smaller," Morgan predicts. "Invest in a strong infrastructure and in people with proven expertise in their field, who are knowledgeable and flexible enough to provide low-risk, quality solutions at a fair cost."

SWAP-C is a certainty

"SWaP-C remains in the highest demand today and represents the longest lasting trend I've seen in many years, as evidenced in the more compact and highly functional board-level, commercial off-the-shelf (COTS) single-board computers (SBCs) and GPGPU-based subsystems being developed," says Doug Patterson, vice president of marketing and business development at Aitech Defense Systems Inc. in Chatsworth, Calif.

"In regards to GPGPU, packing one gigaflop (GFLOP) of processing performance for C4ISR applications into a five-inch by five-inch, stand-alone enclosure represents the height of SWaP-C today," Patterson says of Aitech's A176 Cyclone, introduced last September.

"The self-contained, military-grade A176 Cyclone redefines SFF power density by delivering 60 gigaflops per watt (GFLOPs/W) in a compact, low-power, high-performance embedded computer (HPEC)," officials describe. The fanless, rugged GPGPU supercomputer packs 1 teraflop (TFLOP) or parallel processing in a 20 cubic-inch footprint by combining the Nvidia Maxwell architecture, 256 CUDA cores with 4 GB of LPDDR4 RAM, the Quad-core ARM Cortex A57 CPU providing an operating frequency to 1.9 GHz per core, with an overall maximum power consumption of 17 watts.

"GPUs unburden the CPU from heavy computation, enabling better and faster processing of the overall system, a principle taken from

the graphics-intensive gaming industry. A compact, rugged system that delivers these levels of processing truly redefines what an embedded designer can do with an HPEC," adds Aitech GPGPU Product Manager Dan Mor.

The new rugged mobile computer, weighing roughly two pounds and measuring 4.3 by 4.3 by 1.18 inches, is well suited to embedded deep learning, computer vision, graphics, and GPU computing applications in harsh environments, including C4ISR, intelligent video analytics, image capture and processing, unmanned aircraft system (UAS) and unmanned ground vehicle (UGV), and signal processing and persistent video surveillance applications.

AiTech introduces its A176 Cyclone small-form-factor, high-performance embedded computer.

"The main applications for our military and aerospace products are in C4ISR and command and data handling (C&DH) subsystems, where simple platform control is combined with multiple channels of high-speed situational awareness video data, which is all processed at increasingly higher bandwidths and transmitted to ground stations or also stored in locally-accessible Flash storage," Patterson says. The current trend toward "smaller, faster, and lighter with a focus on cost vs. performance benefits" will continue, he predicts, adding that "the defense and aerospace markets may be poised toward a possible market expansion."

Sensors and server-class computing

"Mobile computing is becoming challenged because it is no longer capable of processing at the capabilities necessary. What you really need is a rugged workstation, server, etc. to grow to needs of computational and SWaP requirements," says Scott Kongable, president of Crystal Group Inc. in Hiawatha, Iowa.

The widespread use of sensors, answering the call for real-time actionable information and installed on ever more compact platforms, is helping drive the need for rugged mobile systems capable of delivering robust compute power and high-speed and high-capacity data storage in a small footprint.

Demand, Kongable explains, is increasing for Non-Volatile Memory Express (NVMe), a scalable host controller interface – designed to capitalize on the low latency and internal parallelism of flash-based storage devices, mirroring the parallelism of contemporary CPUs, platforms, and applications – from NVM Express Inc. in Wakefield, Mass. "The move to NVMe is driven by the ever-increasing amount of sensor data being gathered, and the need for faster data capture and processing."

Boeing engineers retrofitting P-8A Poseidon maritime patrol aircraft for the U.S. Navy called on Crystal Group for a modern system to store collected digital data, including digital video.

Boeing selected Crystal Group to provide Video And Data Storage System (VADSS) hardware to retrofit 24 low-rate initial production aircraft that Boeing delivered to the U.S. Navy. VADSS includes Crystal Group's rugged, lightweight computer servers and storage devices that capture and process video data gathered from surveillance sensors onboard the aircraft.

"Sensors are becoming so small and inexpensive, more can be put on a vehicle resulting in more data to be processed in a shorter amount of time," Kongable says. As a result, demand is growing for "higher capacities in smaller devices, more mobility and integration in a smaller SWaP form factor, minimizing power consumption, and using the Internet of Things (IoT) for the collection of sensory input and processing thereof." The future is likely to hold more of the same: systems that are "smarter, faster, smaller, draw less power, and fuse and process higher volumes of data for real-time and predictive use.

"Find an experienced partner you can trust – one that understands unique, advanced requirements, the technology available, and how to engineer new capabilities," Kongable advises. Life-cycle management, total cost of ownership, trust, reliability, mission success, and actual testing vs. built to requirements are among the things to consider, he says. "Budget isn't everything."

SFF on the rise

"Small-form-factor box products are finally growing in demand," says Russell Nieves, director of embedded solutions at Acromag in Wixom, Mich. Military and aerospace organizations use Acromag ARCX SFF mission computers as data-recording devices and display controllers, as well as for weapons fire control.

"MIL-STD-810-level shock-and-vibration survival is critical, as well as full operation in [extreme] temperatures," Nieves says. In fact, he says, "many Marine Corps-based inquires come from the fact that we offer IP67 [dust and water] protection (submersible) in our ARCX" SFF mission computer.

Nieves and his colleagues at Acromag anticipate "continued growth in the market for applications-specific solutions that can live in harsh, extreme environments. Many companies want COTS as part of that offering; although some applications can be simple enough to be done with a COTS solution, most have to be a combination of various technologies, necessitating a custom solution in the end." As such, he recommends involving technology partners early on in the project.

"Understand your application both from a hardware and software standpoint, and involve suppliers up front so they can assist in providing the best solution," Nieves says. For example, "thermal dynamics can be a little confusing to understand so working with the solution supplier will ensure this can be addressed properly in the beginning stages of the project."

COTS and capabilities focus

Like SWaP, another significant rugged mobile computing trend "is not new at all," explains Chris Ciufo, chief technology officer at General Micro Systems (GMS) in Rancho Cucamonga, Calif. "It's what drives the entire civilian industry and it directly affects the defense industry's insatiable appetite for technology. It's doing more — much more — with a whole lot less."

Add to it the complementary trend that the U.S. Department of Defense (DOD) "wants the same technology capabilities that they know are available in the civilian world," Ciufo says. "Think of the connected home, more capabilities in your iPhone or new automobile, and the falling price of consumer tech with each successive generation.

"Put these two together on new programs and what you see is the need for the next system upgrade to add

much more performance or capability, along with the consolidation of several systems into one system or one box — all with a smaller overall footprint and at the same or less cost," Ciufo continues.

An example Ciufo gives is combining a weapons system computer with the mission planning console such that the operator's control console displays targets and friendly forces on a moving map. That same computer also calculates the fire control solution and/or aims a weapons array or computes the most efficient travel route while sending all that data up or down the chain of command on a secured, tactical local area network (LAN) or satellite communications (SATCOM), he says.

General Micro Systems engineers married the latest COTS technology with the DOD's expectation for smaller, better, faster, and cheaper for the U.S. Army's Warfighter Information Network-Tactical (WIN-T) program. "WIN-T is the Army's tactical Internet, and the Increment 2 upgrade provides data-on-the-move capability," Ciufo explains. "That is, the processing and SATCOM modems and line-of-sight, radio-frequency (RF) networks no longer force the connected vehicles and assets to stop to transmit/receive.

"This on-the-move capability is a huge upgrade that required lots more processing performance. You'd expect that this would also require more equipment or bigger equipment," Ciufo adds. "Yet, the Army and General Dynamics, the prime contractor for WIN-T, came to GMS and we leaped over 'incremental COTS upgrades' and instead recommended Intel's new Xeon D 12-core server CPU. Collectively, we created the SB2002-SW 'Blackhawk' Xeon D virtual machine processor/network switch that replaced up to five separate boxes in a WIN-T installation."

The project leveraged GMS and other technologies "to provide the warfighter with 'much more' at a price and size that was actually less than previous systems," Ciufo says. "The resulting improvement was a boon to the Army, and General Dynamics was praised for removing equipment from Increment 1 (predecessor) vehicles while lowering cost. In the Army's Stryker vehicle, for example, two crew seats could be re-installed as extra space was freed up with fewer and smaller GMS boxes."

Military programs, such as WIN-T, that were slowed down due to budget cuts will see renewed funding, Ciufo predicts. With more powerful processors from ARM, Qualcomm (NXP/Freescale), and Intel, he also expects "more emphasis on sensor fusion, machine vision, and processing at the tip of the spear; i.e., more digital signal processing (DSP) and image processing on the actual platform instead of recording data, returning to base, and processing that data using rack-mount servers."

The "Green Series" GMS rugged embedded computer harnesses an Intel Atom processor.

General Micro Systems' RuggedView smart displays include robust embedded computers.

At the same time, Ciufo explains, Intel is adding (Altera) field-programmable gate arrays (FPGAs) to its Xeon server processors and potentially some of its higher-end Core i7 CPUs, which promises to bring even more performance in smaller packages. "This bodes extremely well for GMS as our whole value proposition is loads of performance and I/O in the smallest, lightest package possible."

FPGAs and multi-core computing

The use of high-powered FPGAs in RF rugged systems is a growing mil-aero trend, as is high-core-count processing using virtual machines (VM), says Jason Shields, product manager of 3U VPX solutions at Curtiss-Wright Defense Solutions in San Diego. "These are typically 'headless' systems that have no video output and are used as embedded servers or as a general-purpose processing box."

Curtiss-Wright's CHAMP-XDx family of DSP processor modules, based on the Intel Xeon D, addresses these applications, Shields says. "When integrated with one of our MPMC system enclosures, we are able to satisfy the demand for more

processing capability with significant SWaP reduction."

Multi-core processors will continue to replace several slots of boards used today, Shields predicts. He also forecasts: a need to include high-speed interfaces, such as 10G-SR and eventually 40G Ethernet, to the outside of the box; a need for more and more FPGA resources and performance, considering it is a flexible method of controlling I/O and internal data flow; and the increased use of GPGPUs as a main DSP engine.

Performance per watt

Mil-aero customers continue to push for technologies that provide the greatest amount of performance with the least power consumption, says Mike Southworth, product manager of Parvus system products at Curtiss-Wright.

"Customers want the most FLOPS or MIPS (million instructions per second) per watt possible from the latest Intel, Nvidia, ARM, and other multi-core system on chip (SoC) devices that offer CPU and GPU co-processors to eliminate the need for multiple separate processor boxes and reduce system SWaP," Southworth explains.

Defense integrators use rugged COTS solutions, such as Curtiss-Wright's DuraCOR ultra-small-form-factor (USFF) mission processor and DuraNET networking subsystems, to miniaturize line-replaceable unit (LRU) technology with advanced processing and networking architectures, Southworth says. The company's rugged computer systems are used in various mil-aero applications — including armored ground vehicles, ground stations, and unmanned aircraft systems — by Northrop Grumman, Lockheed Martin, Boeing, Sikorsky, and others.

"Engaging with a partner as early in the process as possible, to help support the front-end architecture and requirements, can ultimately save your program several million dollars," Southworth adds.

Tablets taking off

The aerospace and defense sector places the most extreme demands on rugged tablets of any industry, admits Mark Holleran, president and chief operating officer (COO) at Xplore Technologies Corp. in Austin, Texas. In fact, Xplore engineers

designed the company's XC6 ultra-rugged tablet PC — with IP67 water protection and MIL-STD-461F certification for RF interference and radiation protection — for use in the harshest military conditions. Demand is growing for flexible mobile solutions within multiple segments of aerospace and defense, not just extreme field conditions, he says.

Aerospace and defense professionals "are recognizing that off-the-shelf devices such as those manufactured by Samsung and Apple are just not well-suited for their operational environments for one reason or another," Holleran says. "Unlike iPads and Galaxy Notes, rugged tablets provide the proper safeguards against exposure to vibrations, shock, fluid contaminants, humidity, and even salt fog — which can corrode electronics used in maritime operations. And, unlike rugged tablets, commercial-grade devices aren't built to last three to five years. Any device with a frequent rip-and-replace requirement complicates technology management efforts in an already highly complex tech environment.

"Today's off-the-shelf devices are also lacking the ports, security, and physical resilience that come standard with many rugged tablets. That's why the total cost of ownership is lower for rugged tablets than any non-rugged form factor; they last longer and inherently provide overall technology platform stability," Holleran continues. "Given the complexity of global aerospace and defense technology systems and the intense security mandates they must satisfy, there's a growing interest in fully rugged tablet computers (IP65) that offer built-in encryption, smart card/common access card (CAC) readers, biometric scanners, trusted platform module (TPM) 2.0, and multi-factor authentication solutions."

Xplore rugged tablets have been used throughout aerospace and defense over the past decade, by U.S. Army, Air Force, Navy, and Marines and several international forces to control unmanned vehicles on land, sea, and air, as well as underwater. Engineers at Strategic Robotic Systems (SRS) in Redmond, Wash., exclusively selected the Xplore XSLATE D10 rugged tablet to serve as the core of the intuitive human machine interface (HMI) used to control SRS's new FUSION hybrid underwater vehicle. FUSION, which will be available to the mass market in April 2017, combines an autonomous underwater vehicle (AUV), a remotely operated vehicle (ROV), and DIVER navigation/propulsion into one system.

General Micro Systems' RuggedView high-bright, NVIS smart displays with full-featured embedded computers are well suited to avionics applications.

The Intel-powered Xplore D10 Android tablet will provide FUSION operators with a single user interface to drive all three vehicle modes during mine countermeasure (MCM), explosive ordinance disposal (EOD), and other military inspection tasks, as well as search and rescue or body recovery operations. The Xplore rugged tablet will also facilitate the exchange of data between the FUSION vehicle's sensors, the HMI, and servers accessible by all mission participants, whether they're working from the field or the office.

"The Xplore XSLATE D10 tablet PC provided SRS with the perfect integrated solution to our FUSION topside control system," SRS Fusion President Jesse Rodocker explains. "Although our original plan was to repackage an off-the-shelf Android platform for our HMI, we quickly ran into a number of issues during development and testing. This is when I discovered the Xplore ruggedized Android tablet and realized that it answered all our specialized requirements, including the increased reliability and intuitiveness that had led us to favor an Android versus Windows solution at the outset. Since we've been able to perfect the HMI, we've been able to deliver much improved and long demanded underwater technology capabilities to those responsible for critical defense and search-and-rescue operations."

The biggest future trend for military will undoubtedly be increased usage of unmanned technology, Holleran predicts. "We'll see rugged tablets become the PC form factor of

choice for more C4ISR-type defense projects, such as those involving unmanned vehicles, in the near future given how critical rugged tablets are for the control of such technology by field personnel. This trend is also contributing to the increased testing and deployment of Xplore fully rugged and ultra-rugged tablets by the military sector."

Don't compromise, advises Holleran. "There's a reason why you're considering rugged computers in the first place: You need a PC solution that is highly secure, highly flexible, and most importantly highly reliable. But not all rugged computers are created equal — and being 'rugged' is not enough to satisfy the uniquely specialized computing requirements of most aerospace and defense sub-sectors.

"Look beyond the rugged ratings — MIL-STD-810G, ingress protection (IP), etc. — and confirm that your PC selection can support every one of your current and anticipated work flow requirements without issue," Holleran recommends. "Ensure you're considering security, safety requirements (if using in hazardous locations), wired and wireless connectivity capabilities as well as I/O requirements, outdoor viewability, ease of data entry when the user has gloves on or is on the move, and the longevity of the battery. Confirm failure rates for every device, as well. You might be surprised to learn that even some rugged tablets can fail fast; not because they aren't physically durable enough, but because they're lacking the processing power, memory, or storage capacity necessary for the data-intense applications you need to run."

Detachable laptops in demand

The 2-in-1 detachable laptop is one of the hottest trends in the rugged mobile computing space, says James Poole, federal sales director at Panasonic Systems Communication Co. in Washington. "With ergonomics playing a crucial role in the day-to-day activities carried out in the field, this new type of multifaceted device is among the most popular in the industry as it provides the best and most desired features of both a laptop and a tablet. The laptop includes a full-size detachable keyboard that is ideal for data entry and reporting,

while the tablet detaches from the keyboard providing the lightweight portability that users need in the field." Hybrid and multi-use devices will be prevalent in the future as they offer more flexibility for users, Poole predicts.

Another trend, which will only continue to grow, is the need for application-driven solutions, Poole adds. "With more data available than ever before, military officials understand the important role that optimized software applications and wireless connectivity play in carrying out day-to-day duties. Specialized software applications that can effectively organize, list, and track inventory or assign resources help officials more effectively manage a response effort in real-time when every second counts."

The high-performance graphics system from Aitech and CoreAVI uses Aitech's M596 graphics/video XMC and C112 single-slot 6U VPX SBC.

While many companies look at sticker price to determine which product to deploy within their agency, Poole recommends taking into account the amount of testing specifically geared toward military customers and use cases that have taken place. "While it may seem that consumer devices enclosed in a 'rugged' case are good enough and offer a lower initial investment, the cost and performance over the life of the device can be significantly higher than a purpose-built rugged device designed specifically for your agency's needs."

U.S. Air Force officials learned this lesson the hard way; in fact, they needed tactical, easily transportable meteorological systems to support airmen and to replace consumer-grade mobile computers experiencing numerous failures in the U.S. Air Combat Command's (ACC's) Tactical Meteorological Observing System (TMOS) or AN/TMQ-53. It was critical that they find a reliable, rugged device to support the weather systems in combat zones and other locales.

"When TMOS was first engineered, it was designed using standard, off-the-shelf consumer notebooks. While these consumer-grade notebooks had a lower sticker price, they quickly proved unreliable in the Air Force's challenging environment, ultimately costing more money in the end," says AN/TMQ-53 Program Manager Barbara Moore. "TMOS weather systems are deployed around the world, transported in boxes loaded into the back of a Humvee to deployment out of a helicopter. It is critical that all their technology components can function correctly during all types of deployments."

TMOS now uses fully rugged Panasonic Toughbook 30 mobile computers to operate their weather systems in all types of environments around the world to capture critical information on weather conditions. Decreased failure rates have reduced maintenance costs and repair times and extended the life cycle of the weather systems, officials say.

"Our airmen are now more combat-ready because they know when they test their Toughbook computers at the shop before they get on a plane to deploy, that the computer is also going to work in the deployed location," Moore says.

"The Toughbook laptops reduced the amount of inventory we had to keep on hand and decreased our shipping costs," says Alli Bey, a contractor who helped to prepare the TMOS deployable weather systems. "We are no longer shipping computers all around the world because they are constantly failing. We went from a failure rate of about 25 percent of the entire fleet to down to less than 2 percent; that reduced our shipping costs by thousands. We were shipping an average of 50 computers a year, just to support computers that had failed and now we ship an average of two per year. Panasonic's rugged laptops have made us more efficient and combat-ready, ensuring our airmen get the critical data they need when they need it."

Military embedded dominated by Intel microprocessors; NXP, ARM, Nvidia also in mix

BY **John Keller**

Microprocessor suppliers for aerospace and defense embedded computing systems generally fall into three camps: Intel, Qualcomm NXP, and Nvidia, experts say. Of these three, Intel clearly is dominant, Qualcomm NXP (formerly Freescale) occupies application niches, and Nvidia is an up-and-coming supplier — particularly where massively parallel processing is involved for high-performance embedded computing (HPEC).

One up-and-comer for military embedded computing might be the ARM architecture, which microprocessor designers license from ARM Holdings plc in Cambridge, England.

"ARM architectures are starting to be talked about in embedded applications," says Mike Slonosky, senior product manager for ARM and Power architectures at Curtiss-Wright's Defense Solutions division in Ashburn, Va. "We will see more of that, although we aren't seeing it yet."

Intel dominance

Intel today is the most dominant microprocessor producer for aerospace and defense embedded computing. The company makes a range of processors for a variety of applications, ranging from high-performance processing to power-efficient processors for mobile or wearable applications.

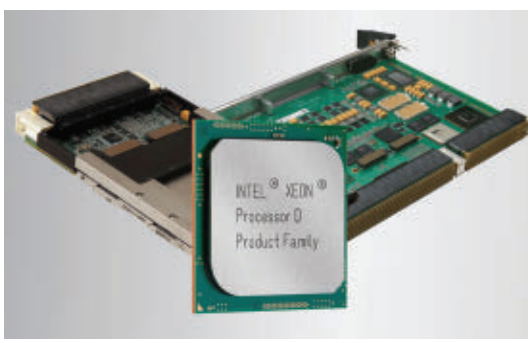
The Intel Core i7 combines general-purpose processing with a general-purpose graphics processor (GPGPU) to help with parallel processing for applications like digital signal processing in radar, electronic warfare, and signals intelligence.

For applications that require power efficiency over the highest possible performance, Intel offers versions of the Atom, which is optimized for mobile applications that must be able to run for as long as possible on battery power. Atom is one solution from Intel that may stave-off competition from the ARM processor.

Niche applications

Qualcomm NXP, with headquarters in Eindhoven, The Netherlands, and U.S. operations in Austin, Texas, manufactures the venerable Power Architecture microprocessor family.

"NXP processors essentially are for control-type systems," Slonosky says, as well as for mission computers that require more determinism and control loops than other microprocessors. Legacy VME single-board computers still make broad use of the Power architecture.



The Intel Xeon D microprocessor is becoming a favorite for high-performance embedded computing (HPEC).

Nvidia GPGPUs typically are considered specialty processors like ASICs and FPGAs, but increasingly are considered to be general-purpose processors, says Marc Couture, product manager at Curtiss-Wright Defense Solutions. "In the past, and even in the present, the GPU has been this sidecar super accelerator, yet the internal architecture and GPGPU software are becoming more suitable to go after general-purpose processing."

COMPANY INFO

Advanced Micro Devices Inc. (AMD)
Sunnyvale, Calif.
www.amd.com

ARM Holdings plc
Cambridge, England
www.arm.com

Intel Corp.
Santa Clara, Calif.
www.intel.com

Microsemi
Aliso Viejo, Calif.
www.microsemi.com

Nvidia Corp.
Santa Clara, Calif.
www.nvidia.com

Qualcomm NXP
Eindhoven, the Netherlands
www.nxp.com/

Texas Instruments Inc.
Dallas
www.ti.com

Software algorithms for radar detection introduced by Cambridge Pixel

Cambridge Pixel in Cambridge, England, is introducing software modeling algorithms to support the radar detection and tracking of small targets in naval, air traffic control, vessel traffic, commercial shipping, security, surveillance, and airborne radar applications. The model-based tracking extensions enable the operator to create several models that match the signature of likely small and weak targets, such as a swimmer or crawler, rigid inflatable boat, Jet Ski, helicopter, small unmanned aerial vehicle (UAV), or a motorcycle. Users also can configure the tracker to look for scenarios like targets moving toward a sensitive location or on a specific heading. The tracking software enables users to acquire several types of targets from the same data set. Cambridge Pixel's SPx radar tracking software is designed to operate with many different radar types and already is widely deployed in command and control, maritime navigation, security, airports, and vessel traffic applications.

FOR MORE INFORMATION visit **Cambridge Pixel** online at *www.cambridgepixel.com*.

Boeing to upgrade radar on Air Force F-15C/D and F-15E combat jets

BY **John Keller**

The U.S. Air Force F-15 jet fighter is about to receive a new radar system. The plane has been in the inventory since the mid-1970s.

WRIGHT-PATTERSON AFB, Ohio — Jet fighter experts at the Boeing Co. will upgrade 71 U.S. Air Force F-15 combat jets with new radar under terms of a half-billion-dollar order.

Officials of the Air Force Life Cycle Management Center at Wright-Patterson Air Force Base in Ohio awarded a $558.5 million contract modification to the Boeing Defense, Space & Security segment in St. Louis to install the upgraded radar systems on Air Force F-15C/D jet fighters and F-15E fighter-bombers.

Boeing, the original manufacturer of the F-15C/D and F-15E combat jets, will install the Raytheon APG-63(V)3 radar on 42 F-15C/D, and Raytheon AN/APG-82 radar systems on 28 F-15E under terms of the contract.

The F-15, designed by McDonnell Douglas, is a twin-engine, all-weather tactical air-superiority jet fighter. It was designed in the late 1960s and entered service in 1976. The F-15E is a ground-attack version that entered service in 1989. The first Air Force F-15E to receive the AN/APG-82 radar upgrade made its inaugural flight in June 2014.

The Raytheon APG-63(V)3 and AN/APG-82 radar systems use active electronically scanned array (AESA) technology, which can steer the radar beam without mechanically moving the radar transceiver antenna. AESA radar uses many solid-state transceivers in an antenna array. It steers the radar beam by emitting separate radio signals from each module. This kind of radar is difficult to detect over background noise and enables F-15 combat jets to broadcast powerful radar signals while still remaining somewhat stealthy.

The Raytheon APG-63(V)3, in service since 2006, is a more modern variant of the company's APG-63(V)2, and applies the same kind of AESA technology that Raytheon uses in the APG-79 designed for the Navy's Boeing F/A-18 Hornet fighter-bomber.

The Raytheon AN/APG-83 radar for the F-15E combines the processor of the APG-79 radar with the antenna of the APG-63(V)3 AESA being on the F-15C/D. This radar upgrade, part of the F-15E Radar Modernization Program, includes a wideband radome for operation on more radar frequencies and improvements to environmental control and electronic warfare (EW) systems.

On this contract Boeing will do the work in St. Louis and should be finished by early 2019.

FOR MORE INFORMATION visit **Boeing Defense, Space & Security** online at *www.boeing.com/defense*.

Raytheon to enhance gallium nitride technologies for radar and RF

Microelectronics experts at the Raytheon Co. are enhancing the company's process for producing gallium nitride (GaN)-based semiconductors for advanced military radar systems, electronic warfare (EW), and other RF and microwave technologies. Officials of the U.S. Air Force Research Laboratory and the Office of the Secretary of Defense have awarded a $14.9 million contract to the Raytheon Integrated Defense Systems segment in Tewksbury, Mass., to enhance GaN semiconductor manufacturing. The pact follows a previous GaN Title III contract, which Raytheon completed in 2013, to increase the performance, yield, and reliability of Raytheon GaN-based, wideband, monolithic, microwave-integrated circuits (MMICs) and circulator components. GaN is a semiconductor material that can amplify high-power, radio-frequency signals efficiently at microwave frequencies to enhance a system's range. GaN technology takes part in military radars and defense systems, including the U.S. Navy's Air and Missile Defense Radar and Next Generation Jammer.

FOR MORE INFORMATION
visit **Raytheon Integrated Defense Systems** online at *www.raytheon.com*, or the **Air Force Research Laboratory** at *www.wpafb.af.mil/afrl*.

FLIR buys Prox Dynamics for expertise in electro-optical UAV sensor platforms

BY **John Keller**

Electro-optical sensors maker FLIR Systems has acquired Prox Dynamics, maker of the pocket-sized PD-100 Black Hornet micro UAV.

WILSONVILLE, Ore. — Executives of electro-optical sensors expert FLIR Systems Inc. in Wilsonville, Ore., are boosting the company's expertise in small unmanned aerial vehicle (UAV) sensor platforms with the acquisition of Prox Dynamics AS in Hvalstad, Norway.

FLIR officials announced that the company has acquired Prox Dynamics for $134 million in cash. Prox Dynamics is a developer and manufacturer of nano-class UAVs for military and paramilitary intelligence, surveillance, and reconnaissance (ISR) applications. Prox Dynamics develops, manufactures, and distributes aerial sensors that are small, light, and covert surveillance systems, FLIR officials say.

U.S. Army researchers are supervising development of the Prox Dynamics Black Hornet Personal Reconnaissance System (PRS), designed to provide infantry soldiers with immediate ISR capability.

The Black Hornet PRS combines a hand controller and a one-pound, force-protection micro UAV, the Prox Dynamics PD-100 unmanned helicopter, for soldiers and small infantry units. The Black Hornet aerial sensor is pocket-sized and hand-launched by a soldier in the field for situational awareness and mission planning.

The Black Hornet aerial sensor uses FLIR's Lepton micro thermal camera, visible spectrum cameras, advanced low-power rotor technology, and proprietary software for flight control, stabilization, and communications.

The Black Hornet helicopter is one of the lightest, stealthiest, and safest drones in the market, offering surveillance solutions for traditional military and special operations forces. It weighs less than one ounce and can fly for as long as 25 minutes at line-of-sight distances to one mile.

The addition of the Prox Dynamics business will augment FLIR's Surveillance segment by extending FLIR's airborne sensor product line and leveraging Lepton technology, FLIR officials say. Prox Dynamics will become FLIR's Unmanned Aerial Systems (UAS) line of business operating within the company's Surveillance segment.

FOR MORE INFORMATION visit **FLIR Systems** online at *www.flir.com* or **Prox Dynamics** at *www.proxdynamics.com*.

Navy to develop unmanned amphibious vehicle for sea, surf, and land operations

BY **John Keller**

Researchers will demonstrate unmanned amphibious vehicle technologies on a Gibbs Quadski from Gibbs Sports Amphibians, shown above.

ARLINGTON, Va. — U.S. Navy researchers are asking industry to develop an amphibious unmanned vehicle able to swim through the ocean and move over land to evaluate coastal areas as invasion beaches, special forces maneuvers, or other military operations.

The unmanned amphibious vehicles must be able to swim through the ocean from at least two miles offshore, negotiate ocean swells and surf safely, and overcome obstacles such as mud flats, rocks, urban development, and vegetation such as mangroves. The idea is to develop an unmanned vehicle able to conduct surveillance and reconnaissance, clear mines, and secure terrain to enable follow-on forces such as Marines and Special Forces to move ashore safely.

Officials of the Office of Naval Research (ONR) in Arlington, Va., issued a solicitation (N00014-17-S-B004) for Autonomy and Unmanned Vehicle Technologies to Support Amphibious Operations. This initiative seeks to capitalize on technologies of unmanned underwater vehicles (UUVs), unmanned surface vessels (USVs), and unmanned ground vehicles (UGVs). Such technologies include domain-agnostic machine autonomy, sensors, robotics, and kinematics.

By blending these technologies, ONR experts hope to develop autonomous amphibians able to maneuver individually and collectively through the surf zone and emerge to navigate ashore, and then return to the sea after collecting important information.

These unmanned amphibious vehicles must be able to maneuver, sense, and communicate autonomously in the challenging sea-land interface in varied shore environments. These vehicles would take part in the first wave into contested landing zones.

The Autonomy and Unmanned Vehicle Technologies to Support Amphibious Operations program has two technology thrusts: shallow-water and land autonomy for vehicles to operate independently and in teams, and vehicle prototypes for test and evaluation.

Technology area 1 centers on autonomy and manned-unmanned teaming, including sensing, perception, navigation, coordination, and decision-making necessary for amphibious vehicles to swim through the ocean, negotiate the surf zone, and operate on land individually and in teams. This includes swell and breaking wave measurement, dynamic object segmentation and tracking, terrain classification, and methods for mitigating adverse environments, including fog, rain, dust, and salt spray.

Participating companies will use a Gibbs Quadski from Gibbs Sports Amphibians in Nuneaton, England, to demonstrate unmanned amphibian technologies. The four-year program will award contracts worth $250,000 and $4 million per year.

Companies interested should e-mail white papers to troy.hendricks@navy.mil. Send full proposals no later than 31 March 2017 to the Office of Naval Research, Attn: Troy Hendricks, ONR Department Code: 30, 875 North Randolph Street – Suite 645, Arlington, VA 22203-1995.

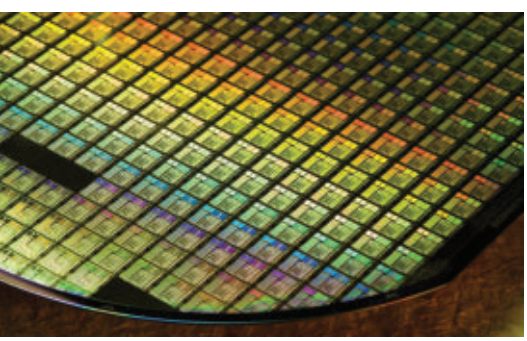
E-mail questions to Darnell.griffin@navy.mil; vera.carroll@navy.mil; or troy.hendricks@navy.mil.

MORE INFORMATION IS ONLINE at *http://bit.ly/2jgy9h5*.

Varioscale to develop process verification of tiny integrated circuits

BY **John Keller**

WRIGHT-PATTERSON AFB, Ohio — Microelectronics experts at Varioscale Inc. in San Marcos, Calif., are helping U.S. intelligence experts find ways of imaging tiny features on silicon integrated circuits for process verification and failure analysis.



Varioscale experts are finding ways of imaging tiny features on silicon integrated circuits for process verification and failure analysis.

Officials of the U.S. Air Force Research Laboratory at Wright-Patterson Air Force Base in Ohio announced a $23.8 million contract to Varioscale for the Rapid Analysis of Various Emerging Nanoelectronics (RAVEN) project. RAVEN focuses on developing an analysis tool capable of imaging minimum-size circuit features on a silicon integrated circuit chip for process verification and failure analysis.

The Air Force Research Lab awarded the contract on behalf of the U.S. Intelligence Advanced Research Projects Activity (IARPA), the research arm of the U.S. Office of the Director of National Intelligence, in Washington.

The RAVEN program encompasses four major areas for tool development: rapid acquisition of images from a bare die; real-time image analysis with in-situ feedback to minimize or eliminate rework due to image anomalies; innovative algorithms for reconstructing the images of individual device layers and the overall device; and computational resources for acquiring, moving, storing, and analyzing petabyte-size data files.

The project involves destructive and non-destructive image acquisition techniques.

Between 2011 and 2015, the semiconductor industry saw significant advances in the scaling of integrated circuits and 3D integration of several wafers, monolithically grown stacked circuits, and non-CMOS structures, officials say. Microprocessors of 14-nanometer size have been in production since July 2014 and 7-nanometer circuits were demonstrated at Albany Nanotech in early 2015.

Samsung, Taiwan Semiconductor Manufacturing Co. (TSMC), and GlobalFoundries have announced plans to ship production-quality 10-nanometer integrated circuits in late 2016. Intel plans to ship 10-nanometer integrated circuits in 2017, and TSMC plans to offer 7-nanometer chips in 2017.

Manufacturing at these technology nodes will require high-speed and high-resolution image acquisition for process verification and failure analysis.

L-3 Warrior Systems to provide Special Forces night vision devices

Electro-optics experts at L-3 Warrior Systems in Londonderry, N.H., will provide U.S. Special Forces warfighters with binocular night vision devices for a variety of nighttime combat and surveillance applications. Officials of the Naval Surface Warfare Center in Crane, Ind., announced a $49.5 million five-year contract to L-3 Warrior Systems for the company's AN/PVS-31 binocular night vision devices (BNVD) with small size, weight, and power consumption (SWaP) white phosphor tubes. The L-3 AN/PVS-31 is a compact, lightweight, Gen III dual-tube night-vision goggle with ergonomic low-profile design and offers superior situational awareness compared to a single-tube goggle, L-3 officials say. The BNVD will enable Special Operations Forces to operate with an enhanced visual acuity in low-light conditions to increase their lethality and survivability while achieving their mission objectives. The contract is for the next-generation BNVD goggles with white phosphor tubes that focus on weight, size, and power reductions, Navy officials say.

FOR MORE INFORMATION contact **L-3 Warrior Systems** online at *www.insighttechnology.com*, or the **Naval Surface Warfare Center-Crane** at *www.navsea.navy.mil/Home/Warfare-Centers/NSWC-Crane*.

The RAVEN program involves imaging metal, polysilicon, vias, contacts, shallow trench isolation (STI) regions, and dielectrics. The project may involve X-ray-based microscopes, high-brightness scanning electron systems, multi-beam scanning electron microscopes, non-scanned projected image electron systems, ion beam imaging systems, ultra-high-resolution interference optical microscopes, and several array AFM systems.

IARPA officials expect several companies to be involved in the RAVEN program.

The five-year RAVEN program has three phases. The two-year first phase will develop a laboratory benchtop or demonstration test tool. The two-year second phase will develop an alpha prototype tool and application demonstration. The one-year third phase will refine the initial prototype into a beta tool suitable for use in a research environment.

FOR MORE INFORMATION visit **Varioscale** online at *www.varioscale.com*, and **IARPA** at *www.iarpa.gov*.

Lockheed Martin to build electro-optical surveillance systems for Navy submarines

BY **John Keller**

Lockheed Martin is building electro-optical surveillance systems for several classes of Navy submarines.

WASHINGTON — Officials of the Naval Sea Systems Command (NAVSEA) in Washington are asking Lockheed Martin Rotary and Mission Systems in Manassas, Va., to build six AN/BVY-1 Integrated Submarine Imaging Systems (ISIS) for the Navy's submarine fleet under terms of a $13.2 million order.

ISIS provides mission-critical, all-weather, visual, and electronic search, digital image management, indication, warning, and platform architecture interface capabilities for Los Angeles-, Seawolf-, and Virginia-class fast-attack submarines, as well as Ohio-class ballistic missile and cruise-missile submarines.

ISIS is part of the Navy's submarine Photonics Imaging System, a non-hull-penetrating replacement for existing optical periscopes. The Photonics Imaging System uses a wide portion of the electro-magnetic spectrum. The ISIS program seeks to replace the optical light path of existing submarine periscopes with high-definition cameras and fiber-optic digital imagery; use infrared cameras for image enhancements; provide active and passive range finding control; install image enhancement capabilities and analysis tools for real-time and recorded imagery; provide image recording, storage, and recall capabilities; and provide the ability to transmit imagery off the submarine to other naval and joint forces.

ISIS provides digital image enhancement of data from a submarine's photonics mast, which uses optical fiber to move imaging data from a raised mast aboard a submerged submarine through tiny openings in the submarine's hull to tactical displays around the interior of the vessel. The photonics mast replaces or augments the traditional periscope aboard U.S. submarines. The photonics mast not only replaces the large opening in the submarine pressure hull necessary for the optics and hydraulics of a traditional periscope, but also can blend image data from several kinds of electro-optical sensors, including visible-light and infrared cameras.

The ISIS system enables a submarine operator to manipulate a photonics mast with a joystick, while looking at digital video on a computer monitor, and share that video in real time with the submarine's combat team on various displays aboard the vessel.

In-Depth Engineering Corp. in Fairfax, Va., under subcontract to Lockheed Martin, serves as the software development lead for AN/BVY-1 ISIS.

On this order, Lockheed Martin will do the work in Manassas, Va.; Northampton and Marion, Mass.; and Chantilly, Va., and should be finished by October 2018.

FOR MORE INFORMATION visit **Lockheed Martin Rotary and Mission Systems** at *www.lockheedmartin.com*.

PRODUCT applications

AVIONICS

Astronautics to supply navigation flight instrument for Boeing commercial jet

Commercial aircraft designers sought a supplemental tactical air navigation tool for the Boeing Special Purpose 777-300ER airplane. They found their solution at Astronautics Corp. of America in Milwaukee.

Boeing experts opted for the Astronautics AFI 3300 three-inch flight instrument with a bearing distance heading indicator (BDHI).

The AFI 3300, a low-power, low-heat, passively cooled display has a mean time between failure (MTBF) rate of more than 10,000 hours, officials say. It also features a 300-by-300-pixel liquid crystal display (LCD) that is dimmable and sunlight-readable, and will include an ARINC 429 digital information transfer system.

Astronautics' AFI 3300 family of displays offers embedded processing, graphics generation, and interface circuitry, and is certified to DO-160G.

Astronautics, given its extensive display product history and BDHI systems experience, will be able to deliver a Federal Aviation Administration (FAA) Technical Standard Order (TSO)-authorized product to Boeing in less than 12 months, company officials say.

"Astronautics' proven certification and display experience allows us to deliver a superior product quickly and at a significant cost savings," says Astronautics Program Manager Matt Frei.

FOR MORE INFORMATION visit **Astronautics Corp. of America** online at *http://astronautics.com*.

Physical Optics to develop miniature military weather-monitoring sensors

U.S. Air Force researchers needed miniature sensors to measure weather conditions covertly anywhere in the world for Special Forces and other military operations. They found their solution at Physical Optics Corp. in Torrance, Calif.

Officials of the Air Force Life Cycle Management Center at Wright-Patterson Air Force Base, Ohio, announced a potential $24.5 million contract to Physical Optics for continued development of small hand-laced or air-droppable weather stations. Physical Optics will finalize development and begin producing the Micro Weather Sensors (MWS) and Advanced Micro Weather Sensors for this follow-on contract to a previous Small Business Innovation Research (SBIR) grant.

The Physical Optics MWS lightweight, ruggedized weather station can be deployed globally in remote locations. It supports continuous, near-real-time weather reporting for air and parachute operations, and includes incident meteorology for wildfire or disaster support.

Using 22 integrated sensors, the MWS collects local weather data and transmits it via the Iridium satellite network to command and control elements or aircraft. The MWS system combines a micro light direction and ranging system, multi-imaging system, GPS, and imaging sensors to measure temperature, pressure, humidity, wind speed, cloud ceiling, visibility, orientation, global position, precipitation, and lightning activity.

Physical Optics engineers will build two MWS test units and two Advanced Micro Weather Sensors, doing the work in Torrance, Calif., and finishing by November 2021.

FOR MORE INFORMATION visit **Physical Optics** online at *www.poc.com*.

new PRODUCTS

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

BACKPLANES

High-speed 3U VPX backplane for mixed payload modules introduced by Elma

Elma Electronic in Fremont, Calif., is introducing a high-speed embedded computing 3U VPX backplane that supports integration of mixed payload modules, including commercial off-the-shelf (COTS) single-board computers, switches, and RF payloads for computer architectures used by the U.S. Department of Defense's (DOD's) Hardware/Software Convergence Initiative. This backplane supports high-speed signals on data paths as well as VITA 67.3 connectors compatible with legacy VITA 67.1 and VITA 66.4 RF and optical I/O connectors. This 3U 12-slot VPX backplane has a radial slot card for timing and synchronization, and includes seven slots that receive radial clock signals (Aux Clk and Ref Clk) driven independently from a radial clock timing card. The remaining five slots receive standard VPX bused Aux_Clk and Ref_Clk signals. The timing card slot also supports a VITA 67.3c connector with 10 SMPM cavities. The backplane can handle VPX connector data rates through its multiple data plane UTP connections at 10 GBASE-KR data rates and 10 GBase-KR UTP control plane connections. The backplane also has four payload slots, each equipped with a combination VITA 67.3c optical and RF connector in the J2 position.

FOR MORE INFORMATION visit **Elma Electronic** online at *www.elma.com*.

INTERCONNECT PRODUCTS

Power connectors and cable assemblies for tight spaces introduced by TE Connectivity

TE Connectivity (TE) in Harrisburg, Pa., is introducing the ELCON Mini power connectors and cable assemblies for aerospace and defense applications that must operate in tight spaces. The ELCON Mini family enables engineers to address increasing power demands, delivering a 400-volt rating to 40 amps per contact in a 2-position, 8-millimeter-high form factor that is roughly the size of a popular HDMI connector. Power engineers and designers often need to be able to make power connections with limited available space and budget along with increasing power demands that can pose quite a challenge. ELCON Mini

power connectors and cable assemblies come in 2-, 3-, 4- and 6-position configurations. The power connectors and cable assemblies have positive metal latch connections, low resistance, and a reliable interface. Cable assembly solutions from TE also offer high-flex and customizable break-out options for routing and installation.

FOR MORE INFORMATION visit **TE Connectivity** online at *www.te.com*.

SINGLE-BOARD COMPUTERS

Rugged 6U VME rugged single-board computer introduced by Abaco

Abaco Systems in Huntsville, Ala., is introducing the PowerXtreme PPC11A 6U VME rugged single-board computer designed for use in harsh-environment applications that require low power consump-

tion. Based on Power Architecture, the new offering is form-, fit-, and function-compatible with its PowerXtreme PPC4A, PPC7A, PPC9A, and PPC10A predecessors. Many thousands of PowerXtreme family single-board computers have been installed, including by the U.S. Navy's MK-48 ADCAP/ACOT heavyweight torpedo program, officials say. The PPC11A is available in two versions. The high-performance option is based on the NXP (formerly Freescale) QorIQ T2081 processor, operating at speeds to 1.8 GHz, which brings the benefits of AltiVec co-processing to a 4-core platform, each of which is dual threaded, offering eight virtual e6500 cores. Customers can expect to see a 2x improvement in performance compared with the predecessor board. The version designed for applications that need low power consumption is based on the NXP QoriQ T1042 processor,

operating at speeds to 1.4 GHz, offering four single-threaded e5500 cores and consuming less than 7.5 watts of power. This enables the PPC11A to consume better than half the power of the PPC10A. Designed for harsh environments and available in five ruggedization levels for optimum price/performance, the PPC11A is for applications like command and control that require high reliability and survivability.

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

SENSORS

High-temperature pressure sensor for jet aircraft introduced by Meggitt

Meggitt Sensing Systems in Irvine, Calif., is introducing the Endevco model 8523 high-temperature pressure sensor for inlet distortion pressures in turbine engines, transmission pressures in automobiles, and rocket motor analysis applications. The sensor uses silicon

strain gages to enable gage and differential measurements, and is designed for static or dynamic pressures. Compared to a similar sensor on the market, the 8523 provides twice the output for improved signal-to-noise ratio and tighter linearity specifications combined with minimum 2X over-range capability, Meggitt officials say. Additional performance benefits include ruggedness to withstand harsh environments, stability over a wide temperature range, and miniature size to fit easily into tight spaces. The sensor has 15, 50, 100, 200, and 500 pounds per square inch gauge pressure (psig) ranges; 300 millivolts full-scale output for signal-to-noise ratio; temperature to 260 degrees Celsius continuous; accuracy with 1 percent linearity at two times full-scale range; and high resonance frequency for dynamic response. The MEMS sensing element is designed for maximum sensitivity and wide frequency response. Internal temperature compensation provides accuracy over

its -54 to 260 degrees C operating temperature range.

FOR MORE INFORMATION
visit **Meggitt** online at *www.meggittsensingsystems.com*.

EMBEDDED POWER

SWaP-optimized power supplies for military VME embedded computing introduced by Aegis

Aegis Power Systems Inc. in Murphy, N.C., is introducing the VME 650 and VME 650A size, weight, and power (SWaP)-optimized embedded power supplies for military VME bus embedded computing applications. The VME high-density power supplies are designed for devices employing the standard 6U form factor, and offer improvements over previous models. Both units are pluggable commercial off-the-shelf (COTS) military power supply solutions with four outputs for 650 watts. The VME650 and VME650A

have keyed connectors to provide keying options when using several power supplies in one VME bus chassis. The primary differences between the two power supplies are cooling method, slot size, and weight. The VME650 is single-slot and conduction-cooled via wedgelocks, while the VME650A is two-slot and air-cooled. The VME650 and VME 650A are drop-in replacements for the existing VME550 and VME 550A power cards, allowing customers to replace older units with the power-packed modules conveniently and for the same price. "Various size, weight, and power (SWaP) initiatives across many markets drove the decision to offer more advanced VME power cards for our customers," says Van Steen, senior engineer at Aegis Power.

FOR MORE INFORMATION visit **Aegis Power Systems** online at *www.aegispower.com*.

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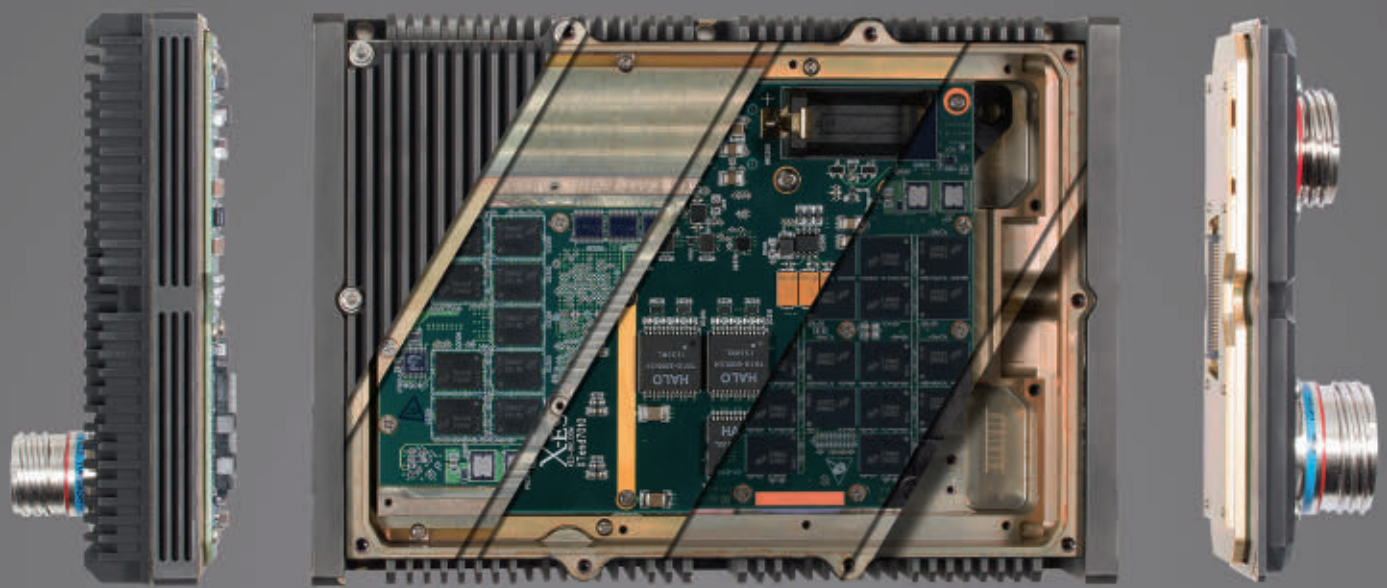

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