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Volume 9 | Number 8

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P 20

Q&A with Andrew Teich, President and CEO of FLIR Systems – Page 16

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P 40

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ON THE COVER:

Top photo: As part of the GPS modernization program, the M-code signal will improve security and anti-jamming of military navigation using GPS – by involving civil code and encrypted military code. Photo courtesy of Rockwell Collins.

Bottom photo: Engineers upgrading platforms such as the U.S. Army Bradley Fighting Vehicle like the combination of ruggedization and low cost associated with MicroTCA technology. U.S. Army photo of M2 Bradley Fighting vehicles by Spc. Nevada Smith.

November/December 2013 | Volume 9 | Number 8

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Presented by: Military Embedded Systems
http://ecast.opensystemsmedia.com/426

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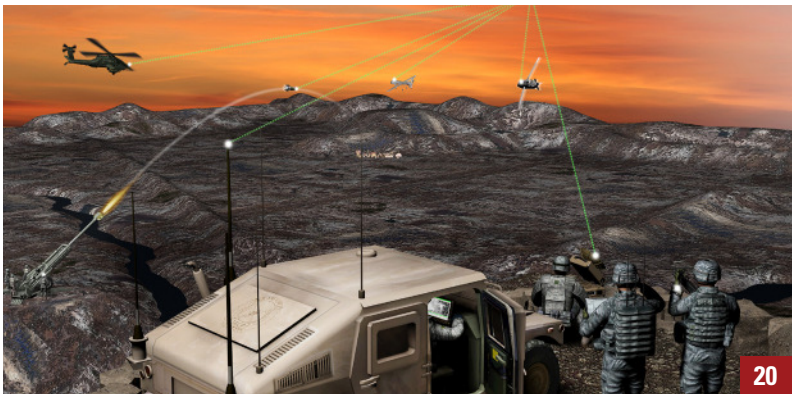

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INDUSTRY SPOTLIGHT | AdvancedTCA/MicroTCA for military applications

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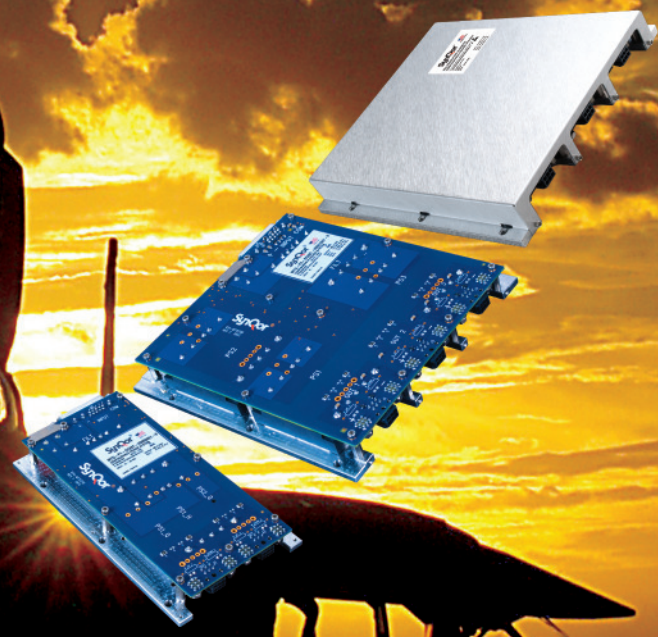

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35	**Excalibur Systems, Inc.** – Dragon – it's not a myth
47	**GE Intelligent Platforms, Inc.** – GE's COTS rugged systems are ready whenever the deployment clock is ticking
19	**General Micro Systems, Inc.** – SWaP this!
39	**IBI Systems, Inc.** – IBI Systems Inc. for full line of rugged systems
21	**Innovative Integration** – Four screaming fast ADCs
3	**Kontron** – Transforming the landscape of military supercomputing
29	**LCR Electronics** – Designed rugged. Tested rugged. Deployed.
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18	**TeleCommunication Systems, Inc. (TCS)** – Toughest SSDs on the planet
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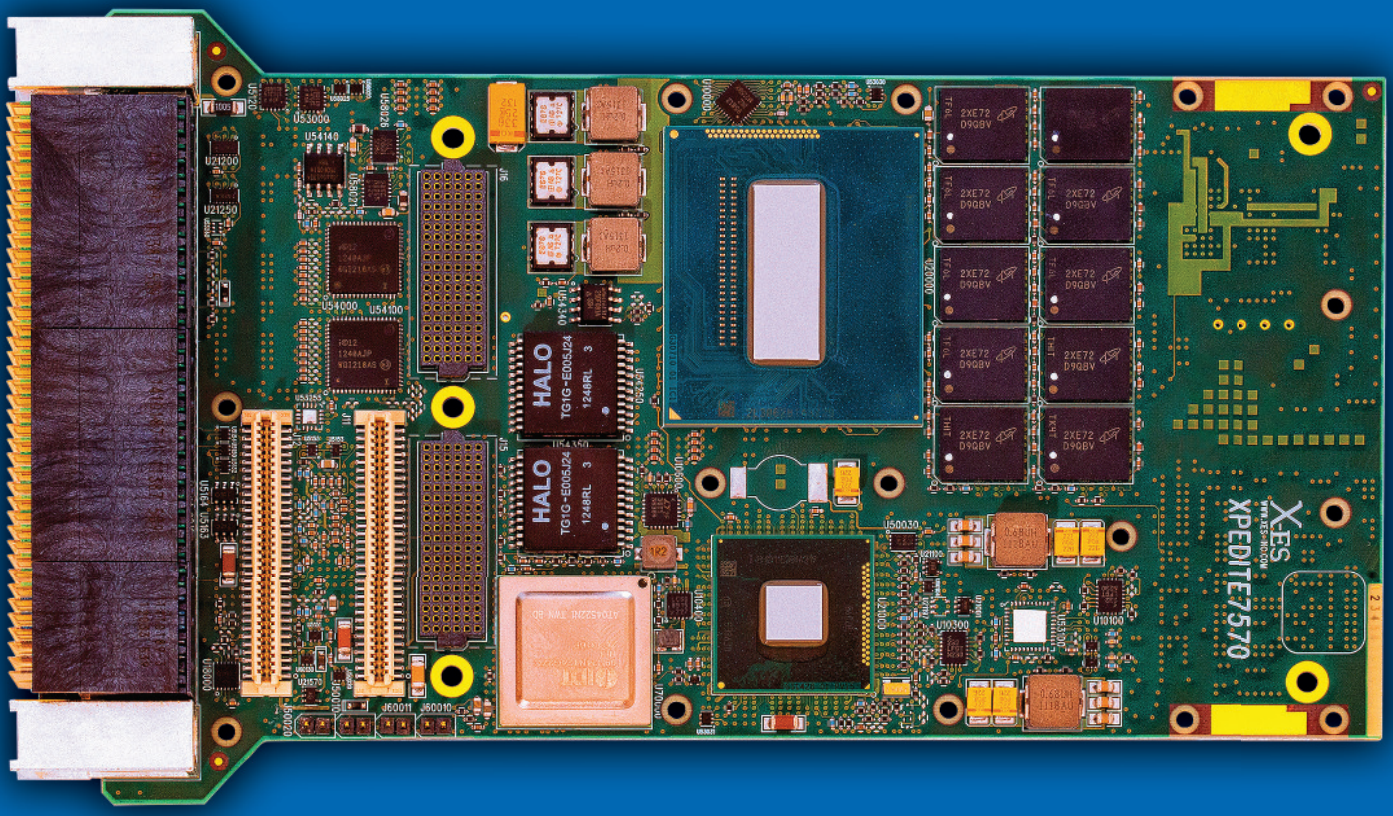

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DNA marking for counterfeit parts: problem solver or money pit?

By John McHale, Editorial Director

Counterfeits – not counterfeit currency, mind you – but counterfeit Integrated Circuits (ICs) in the military supply chain that make their way into a weapon system or the avionics of a jet fighter can cause loss of life. Government and industry spend millions of dollars every year to mitigate against counterfeit components entering their supply lines, but it's still a serious threat. These shady parts are very easy to acquire, you can just go to sites like www.chinaicmart.com and get whatever you like. In most cases they look exactly like legitimate parts, but have not been tested or qualified according to military standards.

While everyone – Department of Defense (DoD) and industry alike – want to stop these parts from making their way into systems, disagreements still exist on how it's done. Controversy is swirling around the Defense Logistics Agency's (DLA's) use of Deoxyribonucleic Acid (DNA) marking from a company called Applied DNA Sciences in Stony Brook, NY. DNA is a special ink for marking Federal Supply Class (FSC) 5962 IC parts as authentic. The DNA ink is a DLA requirement established through the Defense Logistics Acquisition Directive, says DLA spokeswoman Michelle McCaskill.

The DLA claims this initiative increases competition and enables more protection against counterfeits, while some industry players say it is a classic example of wasteful spending by the government. Accusations of wasteful spending in an era of budget cuts are worth a closer look.

The controversy

Aftermarket suppliers Lansdale Semiconductor in Tempe, AZ, and Rochester Electronics in Newburyport, MA, claim that the DNA process doesn't really stop counterfeits, just marks the component as being non-counterfeit – something Original Component Manufacturers (OCMs) already do. The use of DNA equipment is increasing costs to DLA by as much as 40 percent, says Lee Mathiesen, Operations Manager at Lansdale Semiconductor. Millions of taxpayer dollars are being wasted marking parts already authorized as authentic as a way to work with non-authorized brokers of ICs, he adds.

If the government buys from the OCMs they will have no issue with counterfeits so why impose rules on everyone so you can buy form unauthorized sources, says Paul Gerrish, Co-President of Rochester Electronics. Buying from brokers is still risky even if they employ DNA marking "as they do not have to follow the same rules for product storage and manufacturing as do authorized OCMs. It is an unnecessary risk," he adds. Rochester Electronics has decided against using DNA, Gerrish says.

Lansdale will use the ink to continue selling to the DLA, Mathiesen says. Compliance with DNA requires an equipment investment, but the government is paying for it, not the suppliers. The only thing it's really costing Lansdale "is time," he adds. Aside from opening parts up and looking at the process die under close examination the only way to avoid using counterfeit parts is to buy from authorized OCMs like Lansdale and Rochester, Mathiesen says.

DLA responds

DLA officials admit that costs are high with the initial investment in the technology, but over the long run they say costs will go down and create a more competitive marketplace with more players, reducing the expense to taxpayers. The DNA marking would provide a way to work with the independent brokers and still hold them accountable and ensure the use of authentic components, they say.

"DLA believes that costs would rise, especially in the initial phases of adopting the requirement," McCaskill says. "However, DLA believes the costs will decrease over time and be relatively insignificant as greater adoption of the technology and increased competition occurs." DLA also gives a supplier the option to mark in-house, or use a third party to mark on their behalf, she adds. The DLA currently has 27 suppliers that DNA mark – nine are OCMs, three are major defense contractors, and 14 are DLA approved distributors, she continues. "The number of participating suppliers is increasing and resulting in better mitigation of vulnerabilities in the DoD supply chain."

Countering the claim that DNA doesn't prevent counterfeiting, DLA responded by saying that as part of their research and development efforts on this project they engaged a large nonprofit research and development laboratory to attempt to defeat the technology. "Those defeat efforts were not successful," McCaskill says. "To date, DNA marking has proven uncopyable and it allows for multiple levels of in-field screening and forensic authentication." She added that this was part of "an 18-month research and development project also identified 100 percent of DNA-marked product at various nodes in the supply chain and accepted no false positives."

Mathiesen and Lansdale President Dale Lillard are also concerned that using the ink technically alters the part, which they say will require it to be re-qualified and potentially given a different part number – according to the letter of the regulations. Lansdale's executives say all 5962 qualified OCMs on MIL-PRF-38535 disagree with DLA's interpretation in their response below.

In response to this claim the DLA spokeswoman says "the marking does not alter the part and require re-qualification as Lansdale claims. SigNature DNA may be applied in a component substrate or as a marking added post-production. DLA

does not believe the post-production mark necessarily requires re-qualification or that it meets the criteria as a form of remarking or rebranding. Adding an additional mark does not by itself constitute remarking, and such action does not cause all additional testing that may be related to marking to be invoked. Using MIL-PRF-38535 as a basis, a manufacturer which adds a DLA-compliant DNA mark may need, as a consequence of the addition, to conduct certain testing only, such as a Resistance to Solvents test. For example, MIL-PRF-38535, A.3.6, 'Marking of microcircuits' addresses that after the manufacturer marks the part, the marking must be legible, complete, and shall meet the resistance to solvents requirements test method 2015."

Smarter spending

DLA has proof that DNA marking can't be copied, and the initiative will bring more players into the marketplace – all good things – but as with anything it comes back to the money. Specifically the cost to set up companies with DNA marking technology and the cost of the license fee to Applied DNA Sciences, which according to Lansdale, is about $50,000 – or $1,350,000 yearly that the government has to reimburse the suppliers for before they take into ink and labor costs. While the DLA will reimburse companies for this expense, it still doesn't sufficiently explain whether it is necessary or not to fund that equipment for suppliers who already produce authentic products.

Lansdale's Mathiesen has a solution to this problem that makes financial sense. He suggests only requiring the independent brokers to use DNA marking and not the authorized OCMs, which already have competent anti-counterfeit policies in place. That argument seems to make economical sense to me, especially in times when many military programs, bases, and laboratories are cutting costs and reducing personnel wherever they can to deal with sequestration and congressional budget cuts. So I asked the DLA why they are spending so much money in this budget-cutting environment to mark authorized OCM products as non-counterfeit if they are already proven to be authentic?

In response DLA officials made the competition argument again and say it is only fair to apply the rules equally to all suppliers. "DLA acquisition policies encourage competition in the marketplace, while ensuring that conforming product is provided to the warfighter," McCaskill says. "There is a spectrum of product required, and no OCM provides all of it (even if DLA could simply sole-source such procurements). For this reason, the sourcing and qualifications attributes for various types of entities doing business with DLA and being a trusted supplier of FSC 5962, Electronic Microcircuits, are established and consistently applied."

I get the government's argument that increased competition will drive costs down and applying rules equally to each supplier has an element of fairness. However, smart, responsible spending will reduce costs as well while providing fairness to the taxpayer. If you are going to require DNA marking, be smart about how you implement it – mark the parts that need it, not ones that don't.

SWaP changes image processing

By Charlotte Adams

A GE Intelligent Platforms perspective on embedded military electronics trends

Situational awareness is essential for survival on the battlefield. But while satellites and large surveillance resources packed with sensors and signal processing hardware serve the needs of higher echelons, it has traditionally been difficult to get data to small detachments and individual soldiers within tactical timelines.

Demand at all levels, meanwhile, is accelerating for real-time video. A squad leader, soldier, or marine needs to see what's happening over the next hill. They can't wait for the intelligence to trickle down from higher headquarters. But even this localized information flow could swamp a viewer in the heat of battle, making it easy to miss a crucial detail. Thus, there is a premium on real-time image processing to speed detection and tracking so that soldiers can respond to threats in a timely manner.

The demand for real-time information at the tip of the spear has driven downsizing not only of the surveillance vehicles, sensors, motors, and gimbals, but also of image processing hardware (see sidebar). Instead of the typical trend towards ever more capability at ever increasing weight and cost, this sector has emphasized the opposite – just enough capability in the smallest possible package. As the unmanned tactical surveillance industry says – every ounce counts. Reduced Size, Weight, and Power (SWaP) mean longer dwell times, heightened situational awareness, and greater chance of survival.

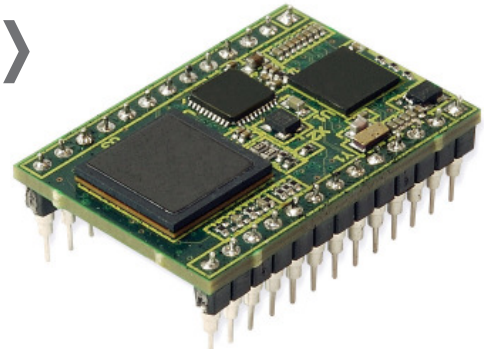

Figure 1 | The GE Intelligent Platforms ADEPT3100 is a rugged, 0.9 inch by 1.3 inch board that uses a standard commercial processor and can simultaneously stabilize video and track a single target.

Stabilization and tracking

In real-time video processing two key tasks are stabilization and tracking. *Stabilization* means removing the motion of the platform and the sensor from the video output, so that the viewer can focus on it without experiencing vertigo. This is important because the smaller the platform, the larger the bounce. *Tracking* means keeping the user-selected target in the center of the sensor's field of view. Tracking requires sending steering commands – expressed in pixels or angles – to the gimbal, based on target positioning information extracted from the raw video data. Conducted in a closed loop between the computing resource and the sensor, the tracking function also filters the data via preprocessing algorithms to detect target edges and size in order to help the sensor stay locked on.

Downsizing

For many years stabilization and tracking functions required separate sets of hardware. Over the past 10 years, that hardware has shrunk dramatically. A typical cycle would be from a pair of 6U VME boards, to a pair of PC/104 boards, to a pair of chip-sized boards, and finally to a single small board or system-on-a-chip.

Even software can be tuned, engineered, and consolidated to maximize efficiency and minimize resources. Thus, the mathematical models on which the code is based, which describe the processes of stabilization and tracking, can be downsized to match the processor. When the models need to run on a smaller device, engineers can switch off expendable parts of them until they run reliably on a smaller chip. One example is the GE Intelligent Platforms ADEPT3100, a rugged, 0.9 inch by 1.3 inch, 1.5 W board using a standard commercial processor, which can simultaneously stabilize video and track a single target (see Figure 1). The 0.2 ounce device digitizes and processes standard-definition PAL or NTSC analog video signals, providing two serial lines for interfacing to external platforms.

Doing more with less

Over the years, military unmanned platforms, sensors, and gimbals have shrunk in size to match the real-time data demands of combatants in asymmetrical warfare. There is often no front line, so even the smallest units need some sort of organic intelligence capability in order to operate effectively. Image processing technology has kept up with this trend and has produced boards that do much more with much less than in the past.

defense.ge-ip.com

Smartphones

Smartphones: Analogy to image processing

The best analogy to the current state of image processing hardware in the small-platform, man-portable sensor domain is the smartphone. Both the military and the commercial applications require embedded, low-power-burning chips, a stripped-down operating system, and the ability to run graphics applications, manipulate and display data, and run for a long time. In fact, some of the commercial general-purpose processors used in cell phones are applicable to military image processing. These chips can combine signal processing as well as traditional CPU functions. There is no need for image processing systems to use special-purpose chips like ASICs or FPGAs that are more difficult to program and require more power.

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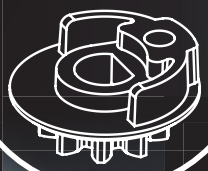

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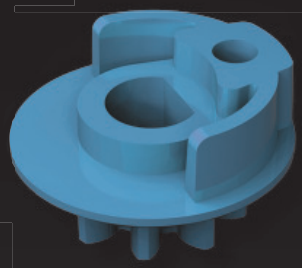

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Pre-validated hardware and software eliminate risks of new system capabilities

By Lee Brown

An industry perspective from Curtiss-Wright Controls Defense Solutions

Adding new critical capabilities such as digital mapping, Human Machine Interface (HMI), and cross domain guard data security solutions into rugged deployed systems for defense and aerospace applications can be a challenge – both to development schedules and program budgets. The most costly and time consuming approach for adding new capabilities is to develop the hardware and software for the desired solution completely in-house. Because that approach requires in-house expertise in a range of disciplines, especially if the design is initiated from the ground-up, it poses a host of potential failure risks.

A better approach is to source the software solution, and the hardware it will be hosted on, from vendors who specialize in the design of the system elements required. While this approach offers a far less risky way forward than attempting to develop the system capability completely in-house, there still remains those risks associated with ensuring that the sourced hardware and software solutions will work together optimally.

Reducing integration risks

One of the constants in the design of rugged embedded systems for defense and aerospace applications is the risk involved, both in terms of time and cost, when attempting to integrate a third party software solution with Commercial Off-The-Shelf (COTS) modules. The time required to develop the needed software components, including BSP, RTOS, and graphics drivers – and then after integration is completed, test and validate the resulting solution, can add numerous unknowns and uncertainty to the process of bringing critical capabilities to deployed systems.

There are more efficient approaches for integrating new capabilities in open architecture-based systems that can eliminate the risk to system development schedules without the additional costs and risks typically associated with integrating and modifying multiple software components (that may come from multiple vendors) on COTS hardware. For many of the most desired critical capabilities, leading COTS hardware board and subsystem vendors have already solved the integration/testing/validation problem in advance for the system designer and can rapidly deliver what Curtiss-Wright terms "System Ready Applications."

Figure 1 | An example of Curtiss-Wright's SRA is a new Cross Domain Solution with pre-tested and validated support for Radiant Mercury on the rugged VPX3-1257 3U OpenVPX single board computer.

System Ready Application approach

The use of pre-qualified and validated System Ready Application (SRA) capabilities based on off-the-shelf hardware modules and third-party software solutions accelerates the integration of critical applications for rugged embedded systems while eliminating the risks associated with getting the hardware and software to work together.

The SRA approach enables system integrators to choose from a list of pre-validated capability solutions, each addressed with a qualified software and hardware set, to identify which COTS module and pre-qualified SRA partner software package has already been verified. Because the test and verification process has already been performed for the desired capability this pre-validation approach allows system designers to increase the integration speed of new capabilities into embedded systems.

By eliminating the design risk associated with adding applications to new and existing systems, pre-verified SRAs will reduce the upfront costs and development schedule.

Pre-validating application solutions

The availability of pre-qualified and validated SRAs (featuring proven capabilities such as HMI, digital maps, and cross domain guard solutions for use with specific COTS modules) can significantly speed the integration of new capabilities into embedded systems designed for demanding deployed applications. This approach effectively addresses the growing demand for critical digital moving maps, situational awareness, and cockpit and vehicle display capabilities.

Examples of SRAs currently available under the Curtiss-Wright's initiative include hardware/software solutions for Radiant Mercury; a UCDMO-listed CDS-T cross domain guard software solution developed by the U.S. Navy and serviced by Lockheed Martin for industry use; Ensco Avionics' IData Tool Suite HMI and digital map capabilities; and General Dynamics UK's SoftMap digital mapping and situational awareness visualization software.

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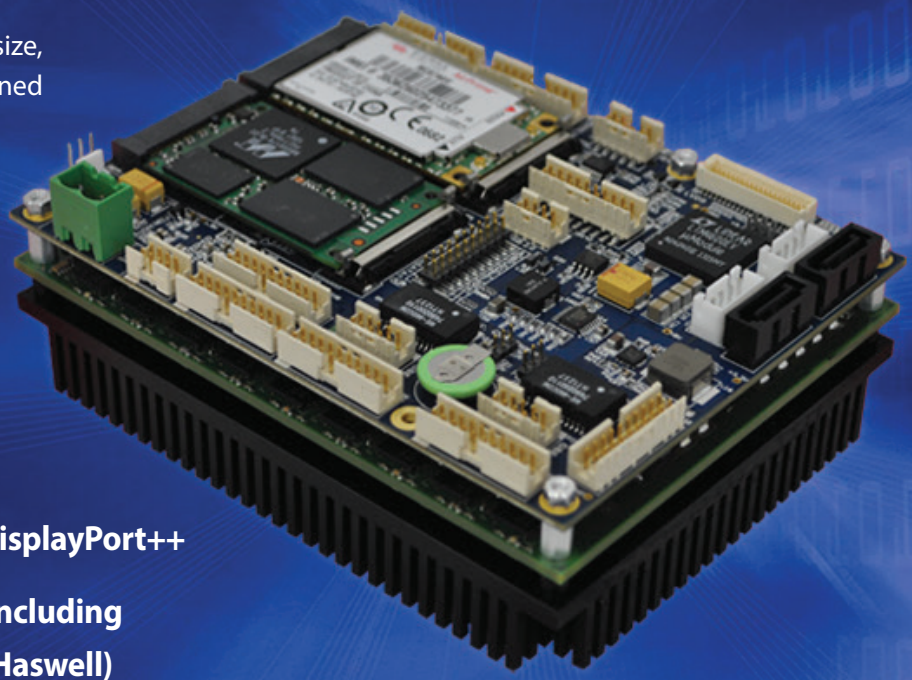

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NEWS

Army Special Operations helicopter pilots to use synthetic vision from Rockwell Collins to navigate degraded environments

Rockwell Collins won the first phase of a three-phase U.S. Army contract to develop the Degraded Visual Environment Pilotage System (DVEPS) for the Army's Special Operations Aviation Regiment (SOAR) helicopters. Rockwell Collins' synthetic vision technology, used in business jet cockpits, will enhance the SOAR pilots' situational awareness in degraded environments. The DVEPS makes use of the Synthetic Vision Avionics Backbone (SVAB) system, which has already been demonstrated with Defense Advanced Research Projects Agency (DARPA) for its Multi-Function Radio Frequency (MFRF) program. The SVAB uses advanced data processing algorithms to fuse 3D synthetic vision-based imagery with lightweight DVE sensors, such as millimeter wave radar or LIDAR. The fused 3D imagery will be used in the DVEPS program, along with enhanced pilotage symbology to deliver a view of the operational environment and flight guidance for the en route, approach, and hover phases of flight. The DVEPS system will enhance visual cues to enable pilots to maintain correct altitude and speeds when landing in degraded visual environments.

Figure 1 | The Degraded Visual Environment Pilotage System (DVEPS) synthetic vision technology enhances situational awareness and visual cues to pilots. Photo courtesy of Rockwell Collins

Kontron's new COM Express modules designed for harsh environments revealed at MILCOM

At the MILCOM 2013 conference in San Diego, Kontron announced its new COM Express Computer-on-Module (COM). Designed for harsh environments, the COMe-bIP6RXT features extended temperature (-40 °C to +85 °C) operations with ECC and rapid shutdown capabilities, and also provides improved power ratios that enable increased processing and graphics performance. Production is to start before the end of 2013.

VITA Hall of Fame introduced, first inductee named

OpenSystems Media's publication *VITA Technologies* announced the VITA Technologies Hall of Fame, as well as its first inductee – John Rynearson, technical director of VITA. The hall of fame is intended to honor those most influential to VITA and to preserve the memory of the people and technologies that have had the greatest impact on the open standards industry since its beginnings. The news was announced during the November VITA Standards Organization (VSO) meeting in Scottsdale, AZ. Rynearson is slated to retire as of January 1, 2014. More will be inducted into the VITA Technologies Hall of Fame each year; the next set of inductees will be announced in January of 2014. To see the current progress of the hall of fame, visit http://opensystemsmedia.com/hall-of-fame/vita-technologies. The nomination process will also be posted on the website in January.

Blighter Surveillance Systems releases lightweight mobile e-scan radar

Blighter Surveillance Systems has announced its Blighter Revolution 360, a lightweight, low-cost e-scan vehicle-mobile radar. The radar is capable of detecting small and slow-moving targets – even in cluttered environments – with its Frequency Modulated Continuous Wave (FMCW) Doppler fast-scan processing. The Blighter Revolution 360 consumes less than 100 W of power and incorporates a 38 kg mast payload. It is capable of detecting a moving person 4.6 miles away, and a large vehicle 13.7 miles away. The radar is deployable on vehicle or trailer masts and provides 360-degree surveillance with its specially designed, maintenance-free cable drive azimuth positioner. At its most optimum, the radar can achieve full 360-degree scan surveillance in 12.5 seconds.

Figure 2 | The Blighter Revolution 360 e-scan radar is capable of detecting figures and vehicles long-range. Photo courtesy of Blighter Surveillance Systems

WHITE PAPER

Tackling thermal design challenges of smaller, lighter, and more efficient avionics

By: Mentor Graphics Corporation

With every Kelvin increase in temperature, the risk of avionics component failure increases. For civil and military applications, the thermal characteristics of avionics components directly influence overall thermal management. They dictate the Size, Weight, and Power (SWaP) of the cooling and therefore the overall system and can decide between function and failure. Commercial Off-The-Shelf (COTS) components for avionics systems may cost less, but the lower price has to be weighed against SWaP and reliability to ensure the whole cooling system is viable. This white paper demonstrates how thermal transient testing combined with Computational Fluid Dynamics (CFD) can help find this balance and ensure that safety critical devices work within their prescribed temperature limits.

Read the white paper: http://opsy.st/1amCZNp

More white papers: whitepapers.opensystemsmedia.com

E-CAST

Enabling open architectures in rugged ISR applications

Presented by: Pentek, RTI, and TE Connectivity

Even though the U.S. Department of Defense (DoD) budget is shrinking and the country's military footprint worldwide is receding, the need for the warfighter to have accurate and actionable intelligence has never been more critical. Data from Intelligence, Surveillance, and Reconnaissance (ISR) systems such as radar, image processing payloads on Unmanned Aerial Vehicles (UAVs), and more will be used to provide commanders with real-time situational awareness. Each system will also need to embrace open architectures and the latest commercial standards to meet the DoD's performance, size, and cost requirements. This webcast will discuss how embedded defense suppliers are meeting these challenges.

View the e-cast: http://ecast.opensystemsmedia.com/435

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E-CAST

Managing ITAR/export compliance reform for defense electronics suppliers

Presented by: Military Embedded Systems *magazine*

Multi-million dollar fines, criminal charges, lost business – all of these are the side effects of non-compliance with the International Traffic in Arms Regulations (ITAR). Ignorance of the law does not guarantee a pass. New reforms coming out of the Obama Administration are gradually loosening these controls, beginning with non-combat related aircraft and commercial satellite related items. The Departments of State and Commerce are continuing to create and publish new rules and changes to the ITAR and Export Administration Regulations (EAR), moving a large set of controlled parts common to the State Department's U.S. Munitions List (USML) Category VIII over to the Commerce Control List (CCL) and authorizing the parts for export to 36 countries. This on-demand webcast with export compliance attorneys from the defense industry discusses how these reforms will affect the military electronics suppliers including new requirements and potential pitfalls.

Register for the pay-per-view e-cast for $99:
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WHITE PAPER

VPX for high-performance avionics computers

By: Creative Electronic Systems

Delivering high-performance data processing outside of the controlled environment of a computing center is a complicated challenge. The set of VPX standards provides an excellent framework to define a modern solution. Filling in the technical content requires the collaboration of many experts in various fields, and while OpenVPX defines the interconnect topology between modules, it does not define either the protocol to be used on these connections, nor the internal allocation of these links. Thus, the system integrator needs to select modules that are compatible with the specific allocation of the interconnect channels. This white paper contains recommendations and configuration advice.

Read the white paper: http://opsy.st/1euA8Ty

More white papers: whitepapers.opensystemsmedia.com

Defense companies funding their own R&D have smoother ride in today's military market

Q&A with Andrew Teich, President and CEO of FLIR Systems

INTERVIEW

Department of Defense (DoD) technology procurement is undergoing significant changes and reforms mostly driven by economical challenges and funding cutbacks. One change is to push the cost burden of research and development onto defense suppliers, often forcing these companies to employ more of a commercial model of development. In this Q&A with Andrew Teich, the new President and CEO of FLIR Systems, a leading designer and manufacturer of thermal imaging infrared sensors, he discusses how FLIR is navigating these procurement challenges and also discusses how thermal imaging technology will move beyond the military and into the commercial space. Edited excerpts follow.

MIL-EMBEDDED: ***Can you tell me a little about FLIR – where it's located, number of employees, and the military applications its technology targets?***

TEICH: FLIR Systems is headquartered in Wilsonville, OR, and has about 3,000 employees worldwide. It has two divisions – Government and Commercial. Each really refers to end use markets we call on, but there are areas where commercial customers procure our government division's technology and vice versa. Fundamentally this division exists to address the diversity of the customers we are calling on. The government customer has a longer purchase cycle and the products themselves go through a rigorous qualification process and have a longer life cycle. On the commercial side the inverse is the case. It is higher volume and product life cycles are much shorter.

Our strategy is akin to four legs of a stool. Two legs are maintaining proficiency in government and commercial markets. The third piece is having good global coverage – we are more than 50 percent international. The last piece is being highly integrated vertically. We are most integrated in the infrared/thermal space and are expanding our product offering beyond thermal to include radar, sonar, and other sensing solutions. Maritime surveillance may be the most promising market going forward as demand for surveillance technology in this area continues to increase. Maritime platforms we are involved in typically use our SeaSTAR III multi-sensor, high resolution, large format 640x480 thermal imaging payload. It has ultra long-range thermal and lowlight TV cameras, multiple laser options, and a spotter scope.

MIL-EMBEDDED: ***Budget cuts, sequestration, and other events have forced Department of Defense (DoD) leaders to rethink how they fund technology. They no longer want to look at power points for future technology development they will need to fund. Program managers today want technology they can test right away and, if needed, deploy immediately. The days of the DoD cutting big Research & Development (R&D) checks are likely a thing of the past. How is FLIR navigating this environment?***

TEICH: FLIR is suited to this environment due to its concept of Commercially-Developed/Military-Qualified (CDMQ) product development for military and government customers. We believe now more than ever that the CDMQ concept is co-linear with the customers' desire to get more bang for their buck. They want to spend the highest percentage possible in procurement dollars on the actual price of the product rather than development – to get better value for their money. In this regard CDMQ is very much aligned with the DoD's current model for procurement reform. CDMQ came from our own internal development where we continue to spend about 10 percent internally on R&D each year. The concept of being able to utilize our own funding to develop solutions deployed on a broad scale from an application and geographic standpoint benefits the customer. By having global deployment the coverage becomes much broader than with a single customer deployment – such as the DoD only. This results in higher volumes, which brings costs down. This also manifests itself in terms of quality as higher volumes of specific solutions enables a more efficient manufacturing process.

CDMQ is based on the principle of producing fully military qualified, mission complaint equipment under a commercial mindset. The military qualification component of this mantra is well understood, as the testing and qualification parameters of military products are typically very well documented. Conversely, the contractual components of most product development programs are where the problems arise. Issues such as cost overruns, recurring unit prices, scope changes, long-term supportability, and soft specification compliance have brought many well-intentioned military

product developments to their ultimate demise. However, by self-funding the major elements of a product development, there is a constant focus on the end commerciality of the item, which includes recurring unit prices, performance, and supportability. These three parameters ultimately define the success of a product in the fielding and sustainment phases of a program.

> "The concept of being able to utilize our own funding to develop solutions deployed on a broad scale from an application and geographic standpoint benefits the customer ... This results in higher volumes, which brings costs down."

MIL-EMBEDDED: ***It has been nearly 20 years since Secretary Perry's memo requiring the use of Commercial Off-The-Shelf (COTS) equipment wherever and whenever possible. CDMQ sounds a lot like COTS. How do you define COTS today?***

TEICH: I think COTS refers to something viable now, in production, and is non-developmental in nature. It refers to the state of the product evolution cycle more so than the funding. A COTS product to me is one that is done and does not require further development. In other words, if we respond to a bid and the product is not available today off the shelf then it is not COTS.

MIL-EMBEDDED: ***If commercial development is always the end goal, where is FLIR's thermal management technology today in terms of commercialization?***

TEICH: Technology developed for the military typically goes through four phases before it becomes a commodity product used by average consumers. GPS is an example of this. In the first phase it was developed for military use. Then dual use surveyors began deploying it for applications such as commercial shipping. The third phase is broad commercialization with the commercial market being the main driver. Eventually volumes tend to explode and then it enters the last phase, which is commoditization. Once a military-only product, GPS can now be bought by anyone for use with their car, their watch, or their smartphone.

Thermal imaging is further back than GPS technology, but is on the cusp of moving from the dual use phase to the broad commercialization phase. What's happening today is that we have emergent applications driving infrared and sensing technology. It is already heavily deployed in Unmanned Aerial Vehicles (UAVs) and thermal weapon sites. It is also likely at some point that every warfighter will have a thermal imager.

There is also a tremendous amount of interest in the commercial space for this technology. In commercial circles we have developed thermal imaging sensors for vehicle vision systems through FLIR's commercial division. It will first be deployed on high-end automobiles and will be able to see five times further than high beam headlights – enabling drivers to see and safely avoid pedestrians or animals. If you look at general situational awareness applications for thermal imaging at the vehicle level there will be opportunities to equip vehicles in any of these environments with an array of cameras for all light weather conditions.

Consumer awareness also must be overcome for thermal imaging to reach commercialization and commoditization phases. Most people in the military know about thermal imaging, but few in consumer markets know about thermal imaging.

MIL-EMBEDDED: ***Are there barriers to entry in the commercial market?***

TEICH: In the commercial business there are two key barriers to non-linear growth: price and awareness. By lowering our cost we can lower our prices. We pass those cost savings on to our customers. If we lowered our cost by 30 percent we believe these prices would be elastic. Prices come down and volumes go up in a non-linear fashion.

Price is the key issue here – if you're taking someone else's money, you have to do exactly what they want. To be able to sell that technology to someone else you must use commercial revenues to fund broad base technology development and feed it to a broad base of customers.

MIL-EMBEDDED: ***Has thermal imaging technology evolved to the point where it can be designed into a modern handheld computer or smartphone?***

TEICH: GPS only needed to answer one question – where am I? Thermals need to answer one simple question too – what's out there? Every soldier wants to know the answer to those two questions all the time. However, right now there does not exist a handheld device with thermal imaging that can provide those answers.

MIL-EMBEDDED: ***How are reduced Size, Weight, and Power (SWaP) requirements affecting your development process for thermal imaging products?***

TEICH: One thing we are good at is managing SWaP. Our products over time have gotten smaller and lighter. For example on our Star SAFIRE HDc we redesigned everything inside to get the performance of a large gimbal at half the weight or better in a 10-inch gimbal. We enhanced the resolution and performance of the system without increasing size or weight. We were able to do this because we make all the

sensor components ourselves, which also enables us to keep cost down and commercialize the product for other applications (see Figure 1).

MIL-EMBEDDED: ***FLIR is involved in military systems and programs worldwide – exporting highly sensitive technology to many different countries for civilian and military use. All of which means U.S. export regulations such as the International Traffic In Arms Regulations (ITAR) need to be closely followed. Currently the Obama administration is reforming export regulations to make it easier for U.S. companies to do business internationally. Will the reforms help or is it just more government bureaucracy?***

TEICH: ITAR is a big issue for us. We tend to develop technology in certain limits to keep it listed as dual use on the Commerce Control List (CCL) rather than on the U.S. Munitions List (USML),

Figure 1 | The Star SAFIRE HDc from FLIR Systems uses completely redesigned components to achieve large-gimbal performance at half the weight in a 10-inch gimbal.

which covers technology strictly developed for U.S. military use and therefore more rigidly controlled for export. What we're hoping from export reform is that the effort underway will stick to its outlined principles and build a higher wall around the high-end military-only technology and put the other technology under Commerce control. The result will be a more robust and more deterministic definition of how U.S. companies can export their technology to the international market. The ITAR has a degree of uncertainty, so if the government follows through, on principle doing business internationally will be more predictable. We'd also like to see policy makers be well aware of what foreign technologies are available because what we want in the end is a level playing field. **MES**

__Andrew Teich__ was named President and Chief Executive Officer of FLIR Systems, Inc., in May 2013 and elected to FLIR's Board of Directors in July 2013. Teich joined FLIR as Senior Vice President, Marketing when FLIR acquired Inframetrics in 1999, where he served as Vice President of Sales and Marketing. He joined Inframetrics in 1984. He holds a B.S. degree in Marketing from Arizona State University and is an alumnus of the Harvard Business School Advanced Management Program.

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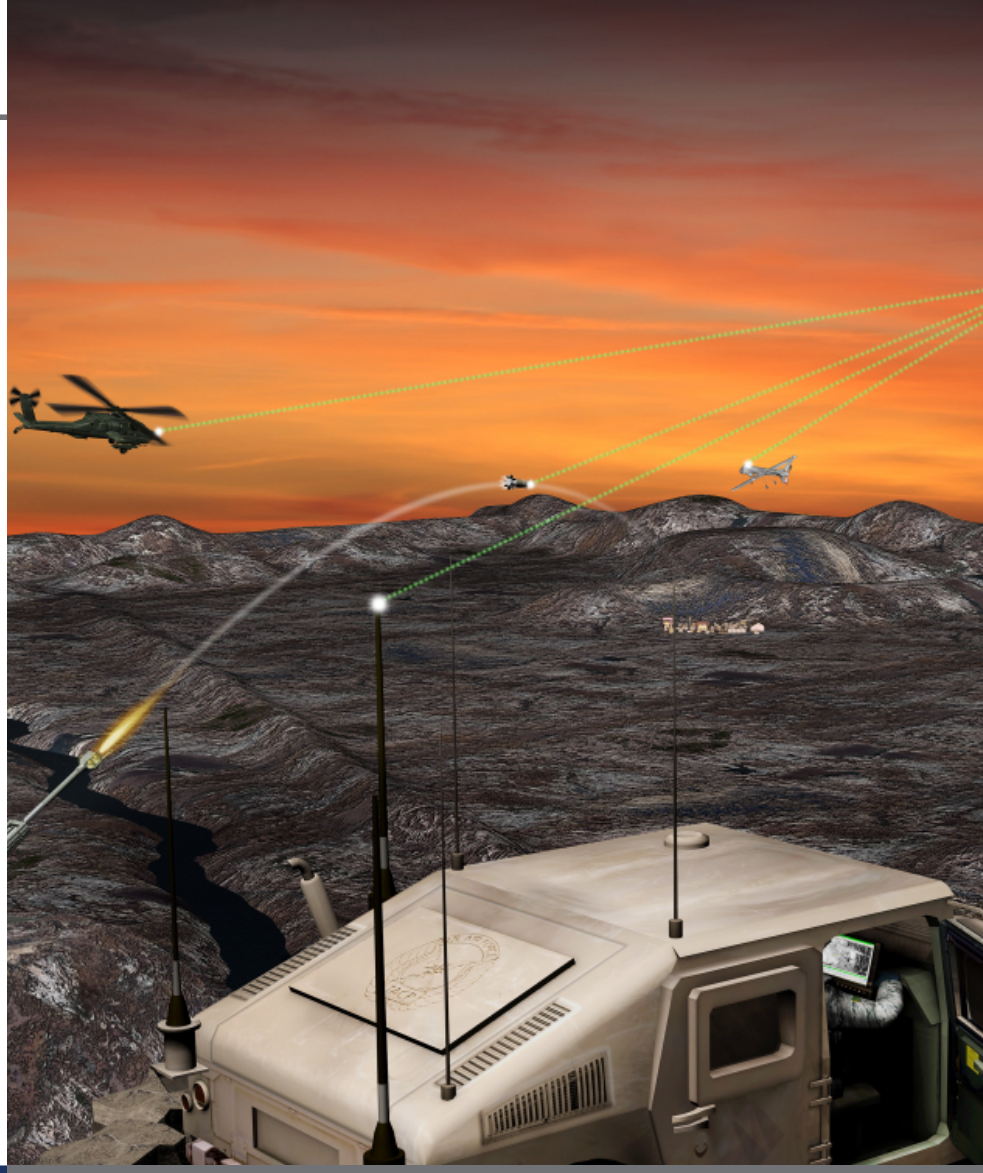
GPS: Smaller, faster, jam-proof, and nearly everywhere

By Sally Cole, Senior Editor

Missile systems, Unmanned Aerial Vehicle (UAV) payloads, soldier radios, and other applications are seeing the benefits of miniaturization and enhanced performance in Global Positioning System (GPS) technology. However, GPS designs also require more elaborate anti-jamming techniques such as combining GPS with Inertial Measurement Units (IMUs) to combat new, sophisticated threats. Meanwhile, DARPA researchers continue to reduce GPS footprints as they combine a tiny IMU and timing capability on one substrate.



As part of the GPS modernization program, the M-code signal will improve security and anti-jamming of military navigation using GPS – by involving civil code and encrypted military code.

The original GPS satellite-based navigation system, operated by the U.S. Department of Defense (DoD) for military and general public use, consists of a network of 24 satellites orbiting 20,350 kilometers above Earth. Now, after years of one main constellation, other countries and consortia around the globe – including the European Union, Russia, China, and India – are launching their own constellations of Global Navigation Satellite Systems (GNSS).

The GNSS proliferation and the increased performance demands in military navigation are driving innovation in GPS designs – reducing size and weight while enhancing precision. With each advance, military navigation designers find new uses for the technology – from Boeing Joint Direct Attack Munition (JDAM) missiles to smartphones to small UAV payloads.

A myriad of new applications for GPS seems to appear each time the technology shrinks in size. Engineers at Rockwell Collins in Cedar Rapids, IA, are working with the Army to take their GPS technology and evolve it for surface ground navigation. "The Army is moving to smartphones, so we're reinventing GPS for that environment, which is where a stamp-sized product fits in because you can embed it into systems ranging from tactical radios to laser range finders – any micro system for UAVs," says Al Simon, marketing manager for Rockwell Collins in Cedar Rapids, IA. The company is also working on a GPS device about the size of a hockey puck that provides warfighters with strategic position, navigation, and timing information capability in one tiny device, he adds.

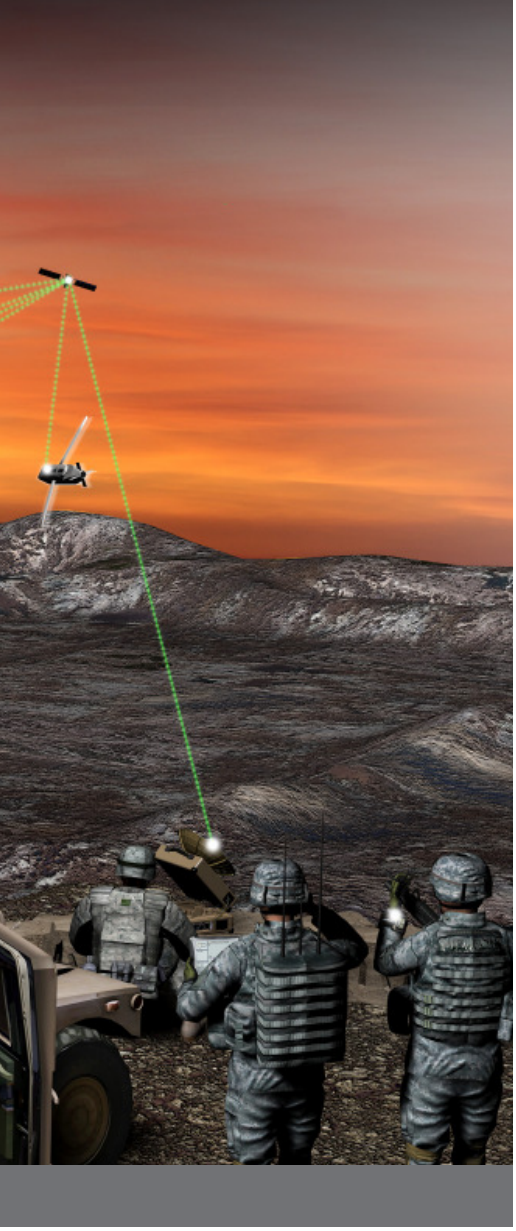
"The drive toward smaller packaging will continue until we reach the size of a pinhead," Simon continues. "We're also adding more functionality onto receivers now. Not only can they do GPS processing, but we can add anti-jam embedded electronics onto the card itself." Rockwell Collins' Micro GPS Receiver Application Module (MicroGRAM), for example, is the size of a postage stamp.

Unfortunately, as GPS devices get more sophisticated so do the attacks, requiring even more elegant security and anti-jam capability with each new breakthrough.

Spoofing and jamming threats are on the rise

The threat to GPS from jamming or spoofing – disorienting or hacking the positioning system – has been steadily rising during the past few years.

"We've seen widely publicized cases of the vulnerabilities of GPS – particularly



for commercial unencrypted GPS. But this is causing concern about total reliance upon GPS, so the industry is exploring alternatives," Simon says.

Rockwell Collins' military GPS receivers are anchored to the encrypted military signal, which can provide some anti-spoofing protection. "The ability to deal with L1 and L2 frequencies gives us inherent anti-jam capability," Simon continues. "Then we also provide some assisted anti-jamming for augmented anti-jamming above and beyond what you'd get from just having multiple frequencies. As military GPS receiver providers, we can protect GPS very well – certainly beyond the vulnerabilities of a civil receiver."

"However, navigation systems of the future are probably going to need multi-sensor capability," in case GPS capability is taken out by enemy forces, Simon notes.

M-code

M-code, part of the GPS modernization program, is a new signal designed to improve security and anti-jamming of military navigation using GPS, but it will require a level of technology updating because the different frequencies and signals involved will require different antennas.

"M-code is important within the U.S., because it's the next-generation military GPS that involves civil code – but also encrypted military code," Simon explains. "Rockwell Collins has been involved in the development of M-code receivers in a prototype sense for several years now, and continues to be involved. M-code is considered to be a big anchoring point for the U.S."

Current congressional mandates and legislation require any military receiver purchased after fiscal year 2018 to be M-code capable. For this reason, "the whole community is keeping an eye on this, since it isn't too far off," Simon says.

It is important to note that M-code is still in the development stage; production

DARPA develops TIMU as aid to GPS navigation

The U.S. military uses space-based GPS to navigate – whether by land, air, or sea. The combination of a simple receiver with processing power enables accurate navigation wherever a signal is available. However, signals from GPS satellites are unavailable in tunnels, underground, or underwater – or worse, when they're intentionally jammed or spoofed.

For situations in which GPS is temporarily unavailable, experts at the U.S. military's Defense Advanced Research Projects Agency (DARPA) in Arlington, VA, are developing a Timing and Inertial Measurement Unit (TIMU) to aid navigation.

The use of IMUs for navigation isn't a new concept. "It actually predates the advent of the GPS system by several decades, although their use has been largely supplanted by GPS in most widely deployed DoD systems. This is principally due to the relatively low Size, Weight, Power, and Cost (SWaP+C) and extraordinary accuracy of GPS," says Dr. Robert Lutwak, DARPA program manager.

DARPA continued its investment in the development of IMUs during the intervening decades, Lutwak notes, particularly "with respect to the development of Micro-Electro-Mechanical Systems (MEMS) and high-performance atomic inertial sensors."

Recent concern about the vulnerability of navigation in GPS-denied environments has renewed DARPA's interest in IMUs, particularly as flywheel navigators for navigating through denied areas.

Three pieces of information are necessary for navigating between two known points with precision: orientation, acceleration, and time. DARPA's TIMU integrates devices capable of measuring all three simultaneously, Lutwak explains. The single-chip TIMU prototype contains a six-axis IMU consisting of three gyroscopes and three accelerometers, and also integrates a highly accurate master clock into a single miniature system smaller than the size of a penny, he adds.

DARPA's main goal is to build a tightly integrated IMU with unprecedented reductions in SWaP+C compared to existing technologies, enabling the devices to be deployed on a wide variety of platforms.

MEMS-based IMUs are already available as commercial products, which are typically constructed of multiple MEMS devices that are assembled into an IMU at the instrument level. "The principal challenge for the TIMU project is the simultaneous co-fabrication of a complete suite of MEMS inertial sensors, along with the control electronics, on a single substrate," Lutwak says.

Could TIMUs potentially replace GPS? DARPA's TIMU is "intended to provide fly-wheeling between GPS fixes, but isn't expected to replace it," he notes.

DARPA's Micro-Technology for Position, Navigation, and Timing Program is currently funding seven organizations to develop a single-chip TIMU device, including: the University of Michigan, Georgia Tech, UC Irvine, NASA's Jet Propulsion Laboratory, Honeywell, HRL Laboratories, and Evigia. The TIMU project is still in the early stages of development, but many of the project's researchers recently demonstrated basic functionality of their initial prototypes. "But don't expect to see this technology transition until fiscal year 2015 at the earliest," Lutwak says.

Figure 1 | The VN-200 from VectorNav Technologies combines calibrated inertial sensors and GPS for better position, velocity, and accurate orientation.

receivers for M-code aren't available yet. "M-code is introducing a whole new layer of security and design complexity. For receivers to become M-code capable, yet remain in the same form factor as the currently used receivers, there's a degree of technical and design maturity that must improve to move forward," Simon explains. "We'll obviously get there, but dealing with M-code and multi-constellation and keeping the same form factor that users have come to appreciate and value is introducing a few technical challenges."

Combining GPS and IMU technologies

Some military designers are combining GPS receivers with IMUs to establish navigational 'backup' for emergency situations and to thwart jamming or spoofing. The general consensus seems to be that GPS and IMUs are simply better together.

In terms of combining GPS and IMU, a hybrid or fused sensor solution really is the best approach, says Jay Napoli, vice president of Fiber Optic Gyros/OEM sales for KVH Industries in Middletown, RI. "Because you can't jam, fool, or otherwise spoof an inertial navigation system." It also works underground or underwater, he adds.

While IMUs can be used as a standalone navigation product, "you get a better solution when you integrate it with GNSS; the two systems are simply better together than either one on their own," Napoli continues.

Inertial Sensing Units (ISU) or GNSS, or a combination of the two, are enabling the use of sensors in a wide variety of applications that couldn't have supported them in the past, says James Doebbler, director of R&D for VectorNav Technologies in Dallas, TX. "Since they've become smaller and lighter, it's amazing what we can stick these sensors onto or into these days," he says.

VectorNav's GPS-aided inertial navigation system, the VN-200, combines calibrated inertial sensors and GPS for better position, velocity, and accurate orientation (see Figure 1).

"These systems are used on different flying UAV platforms – both fixed wing and multi-rotor," Doebbler explains. "We also have guided-munitions projects in development right now, in which the common theme is to get smaller cost, size, weight, and power. Many of these small guided-munitions don't have very large cross sections, but need both positioning and orientation. For smaller unmanned vehicles, weight and power are the big issues. So our VN-200 is in the same footprint and has all the same parameters as the high-end GPS units, but we've managed to pack in a lot of benefits by integrating the ISU into it." **MES**

Complex military systems require efficient power electronics

By John McHale, Editorial Director

High density power electronics with high efficiencies – typically more than 90 percent – are becoming the de-facto requirement for high-end mission critical military platforms such as radar, fighter jets, UAVs, and weapon systems where size, weight, and power are limited. Meanwhile, Gallium Nitride-based RF components are beginning to populate military RF applications.

Unmanned Aerial Vehicle (UAV) platforms require power components with high efficiencies in small footprints. Photo of a U.S. Air Force MQ-1 Predator UAV by Tech. Sgt. Effrain Lopez.

Whether for unmanned or manned platforms in the air or on the ground, innovation in power electronics is driven by reduced requirements for Size, Weight, and Power (SWaP). However, it's the last part of that acronym – power – that really enables the first two or, to be more precise, efficient power through higher density. Signal processing for modern military radars, weapon systems, avionics, Unmanned Aerial Vehicle (UAV) payloads, missile control, etc., use processing power that generates tremendous amounts of heat. Therefore the more efficient the power electronics – 90 percent is the norm today – the less heat that needs to be dissipated and the more performance system integrators can pack into the same footprint each time they upgrade.

"When discussing power electronics design trends there always seems to be variations on the same theme – increased efficiency of power and greater densities," says Kai Johnstad, Product Marketing Manager at Vicor in Andover, MA. "There is also a need for smaller packages for portable applications, which also drives up efficiency demands on the primary power source."

"The key characteristics military customers want from power components are high efficiency, high density, and high reliability over a long life. Very high reliability (high-rel) is needed in power electronics for aviation and military systems where products such as missiles that may sit in storage for as long as 20 years, but then still need to work when placed in mission critical applications," says Martin Schlect, President and CEO of SynQor in Boxborough, MA. "The density of a power supply goes hand-in-hand with its efficiency, but often designers are limited by how much heat can dissipate from a product. For high-rel applications SynQor offers its MilQor series of high-rel DC-DC converters and EMI filters, which come in multiple input voltage ranges, have no opto-isolators, and operate at a fixed frequency. For military applications that do not have demanding high-rel requirements the company has a product family called Mil-COTS that includes DC-DC power converters, EMI filters, and PFC modules."

Reduced size

"We see increased demand for more power in existing industry standard packages as opposed to smaller converters," Schlect says. "Customers do not necessarily want a smaller physical brick, they want more power in the same physical footprint they are working with today. In other words they want more density in the same size and weight they have now. To accomplish this, the efficiency of the converter has to increase since heat removal from the package is the limiting factor.

"The density of a power supply goes hand in hand with its efficiency, but often designers are limited by how much heat can dissipate from a product," he continues. "For customers there is a lot of expense associated with inefficiency, especially when it comes to removing heat from the board or system. Heat removal is a big endeavor as the heat removal system often adds weight. However, if your power supply is more efficient then you will not need that thick cold plate or a fluid/liquid cooled system. Improved efficiency also solves

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weight issues for systems running off batteries. They need to run for a certain amount of time and if you can get 10 percent more efficiency from a power supply your battery can last 10 percent longer. Therefore the need to carry extra batteries decreases, reducing the weight. This also applies to UAVs, which can stay on station longer for persistent surveillance missions if their power electronics are more efficient."

Radar

"Radar, especially airborne radar with its SWaP and high efficiency requirements, is becoming a growing market for power component products, which has not traditionally been the case as power components were not ideal for the demands of dynamic loading common in radar systems," says Tom Curatolo, Director of Global Defense and Aerospace Business for Vicor. "In radar, applications pulling large currents for various duration during the radar's transmit and receive mode places a major demand on power supplies. Typically the transmit mode is short and requires a big burst of current and the power supply has to deliver that from a state of no load to near full load conditions. In the past, power supplies needed a huge amount of capacitance to address the demand for instantaneous current draw.

"Vicor's Factorized Power Architecture leverages the Sine Amplitude Converter's ability to deliver virtually instantaneous current by locating it at the point of load with the ZVS Buck-Boost regulator upstream where its control loop for regulation is not limiting the delivery of current for demanding dynamic loads," Curatolo continues. "This is accomplished with the VI Chip's fixed frequency PRM and VTM chip set. It enables designs to have efficient power components and also take advantage of capacitance multiplication – where less capacitance can be used on the input of VTM for the same impact that large levels of capacitance were previously used at the load, leveraging higher reliability. This means more PCB real estate and lower cost." (See Figure 1.)

The power requirements for the Next Generation Jammer program are very similar to those for radar systems. "An offshoot of the radar market is the

Figure 1 | Vicor's VI Chip PRM and VTM modules are a fixed frequency chip set that enable more power efficiency in smaller footprints.

jammer," Curatolo says. "The Next Generation Jammer program is an airborne jammer that has a variety of parameters that have to be met for the power section such as small size and light weight, which leads to efficiency. More than 90 percent efficiency is the baseline for the program."

VITA 62

The VITA 46 standard – also known as VPX – is driving many signal processing intensive applications in military applications such as radar, sonar, image processing, etc. However, the power supplies for VPX systems lacked a standard to make them work with multiple VPX vendor solutions. Thus VITA 62 was created to enable that interoperability, and products based on this standard are growing in demand just like VPX systems.

"There has been much discussion around VITA 62 and OpenVPX in these circles. Embedded computing companies continue to use bricks in their power supplies for open computing standards," Vicor's Curatolo says. "Embedded designers are putting more and more power on these cards in a fixed form factor and are requiring more power density from their DC-to-DC converter devices."

"We see the most steady demand for VPX, VME, and VXI power supplies," says Gerry Hovdestad, Director of COTS Engineering at Behlman Electronics in Hauppauge, NY. Behlman Electronics offers a VITA 62 and OpenVPX compliant DC-to-DC power supply called the VPXtra 1000CM series. The 6U device is a conduction-cooled, switch mode unit designed for military and industrial applications. It uses SynQor bricks and provides 600 watts of DC power via five outputs, Hovdestad says.

Engineers at Advanced Avionic Technologies Corp. (AATC) in Medford, NY, are also developing a line of 3U and 6U VPX power supply products, says Russel Kittel, Business Development Manager at AATC. The 3U device will target reduced SWaP applications, he adds. "We can produce five to six variants on the same power supply by employing a toolbox approach, allowing the customer to pull from various subcomponents to meet his design requirements," Kittel says.

SynQor, which already provides its Mil-COTS bricks to many embedded computing companies for their VITA 62-based power supply modules, is developing their own VPX power supply assembly, using their Mil-COTS devices. "We already have a VME-based power assembly, but are focused on VPX going forward as it is in demand for many military applications," SynQor's Schlect says. "We are releasing a 3U VPX assembly that will be standard, with six outputs running at 500 watts and a 6U VPX assembly running at 1,000 watts." **MES**

Gallium Nitride driving RF power designs

Designers of RF power components for military applications say the development of Gallium Nitride (GaN) material has enabled major performance improvements.

"Gallium Nitride is the disruptive technology in this space, allowing for the creation of discrete and Monolithic Microwave Integrated Circuit (MMIC) solutions that boast higher power density, higher bandwidth, and higher efficiency than what's been achievable in the past," says Dr. Douglas Carlson, Director of Strategy at MACOM in Lowell, MA. "These attributes are providing customers with high power solutions that are smaller in size, more highly integrated, and easier to implement in their end systems. MACOM is providing customers with solutions from very low to very high frequency and from moderate power levels to over 1 kW per device."

Freescale is also making a significant push into the military and aerospace arena with their new line of GaN RF power transistor products and a team dedicated to this market. GaN technology also benefits military radio communications system designs, says John Powell, Marketing & Business Development for Military RF at Freescale in Tempe, AZ. As the military moves toward more broadband solutions they want power components they can tailor to a specific frequency and LDMOS; Gallium Arsenide (GaAs) and GaN enable that flexibility in the design process, he says. The company also has a large range of LDMOS RF power transistors and GaAs MMIC products they are now tailoring to military requirements.

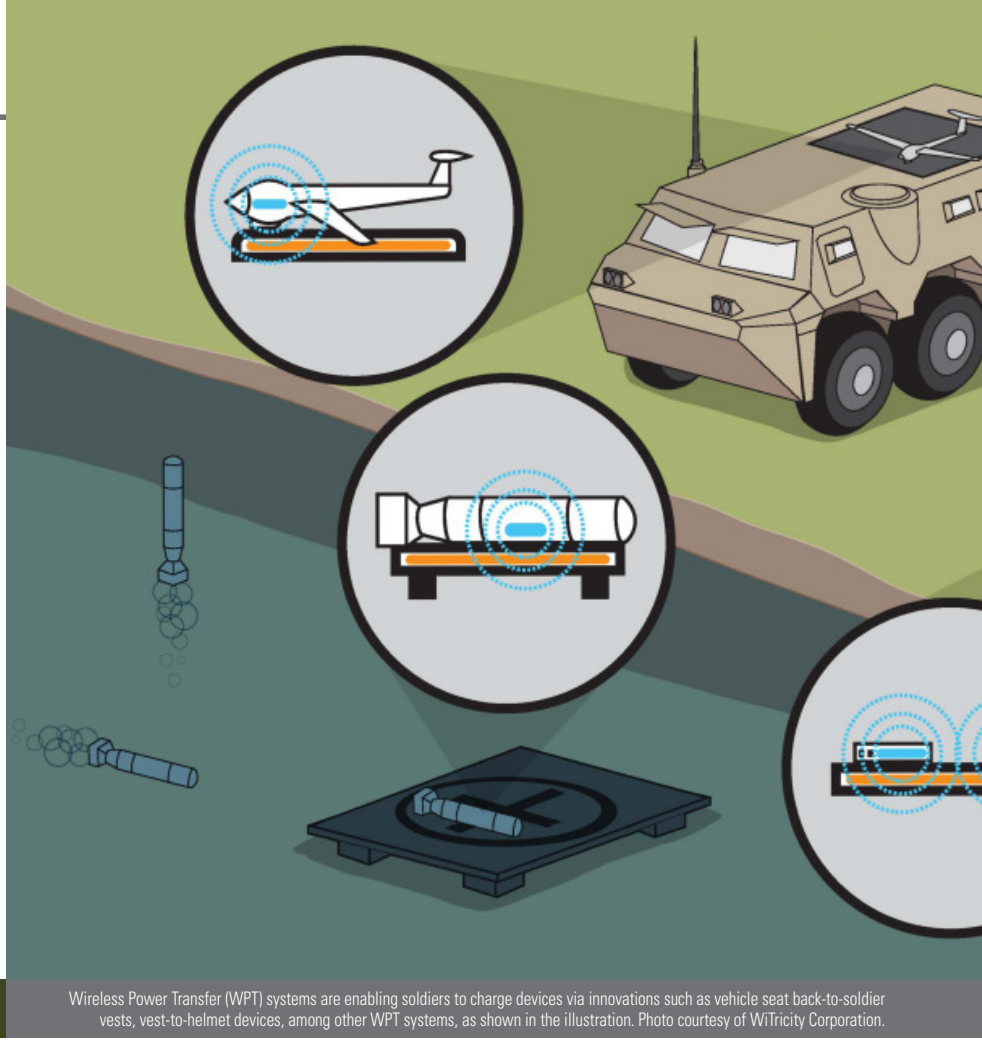
"We continue to see demand for power density and higher efficiency solutions," says Paul Quintana, Director of Vertical Marketing, Defense, Security & Computing at Microsemi in San Jose, CA. "From a technology standpoint there is strong interest in Silicon Carbide (SiC) solutions and the associated benefits they provide, including higher voltage capabilities and higher temperature operation. GaN on SiC is also gaining traction for high-power applications such as secondary surveillance radar and collision avoidance air traffic control equipment. From an applications standpoint, we're seeing increasing interest in wireless charging. We recently announced a new family of 1200 and 650 V SiC Schottky barrier diodes for high power defense, aerospace, and industrial applications. These devices help drive better levels of performance, efficiency, and reliability."

GaN technology also helps improve life cycle costs as system integrators are outsourcing more of their RF functions. "Budgetary constraints on the global defense industry are creating an inflection point in the business environment," Carlson says. "System OEMs, facing significant cost pressure and threats of program cancellations, have re-examined their sourcing models for critical RF components. MACOM is finding that system integrators, in an effort to lower cost and program risk, are outsourcing many RF functions, which were previously held for internal manufacturing. The budgetary environment is also driving the close consideration of service life extensions to major system platforms. The implementation of Gallium Nitride can provide significant efficiency for these improvements, leading to the lower life cycle costs, which drives the justification for these system upgrades."

MACOM offers the MAGX-001090-600L00 high power transistor, which is a gold-metalized, matched GaN on SiC, RF power transistor optimized for pulsed avionics applications such as secondary surveillance radar in air traffic control systems. The device delivers 600 W of output power with a typical 21.4 dB of gain and 63 percent efficiency. It has a low thermal resistance of 0.05 °C/W and a load mismatch tolerance of 5:1. The product also has a low pulse droop of 0.2 dB and can be used under more demanding Mode-S ELM operating conditions.

Alleviating the battlefield battery burden with wireless power

By Jeff Muhs



Wireless Power Transfer (WPT) systems are enabling soldiers to charge devices via innovations such as vehicle seat back-to-soldier vests, vest-to-helmet devices, among other WPT systems, as shown in the illustration. Photo courtesy of WiTricity Corporation.

Wireless power, a new technology already poised to change the way we recharge everything from smart phones to electric vehicles, has the unique potential to transform war fighting of the future and alleviate the battlefield battery burden for both soldiers and manned and unmanned vehicles on land, in the air, and undersea. The U.S. military goals of digitizing dismounted soldiers, sensing their environment, and sharing information could require as much as twice the power as is required by warfighters today; the already burdensome tasks of carrying, operating, and maintaining multiple batteries, cords, and connectors will only be exacerbated unless dramatic changes in power management are implemented using highly resonant Wireless Power Transfer (WPT) systems.

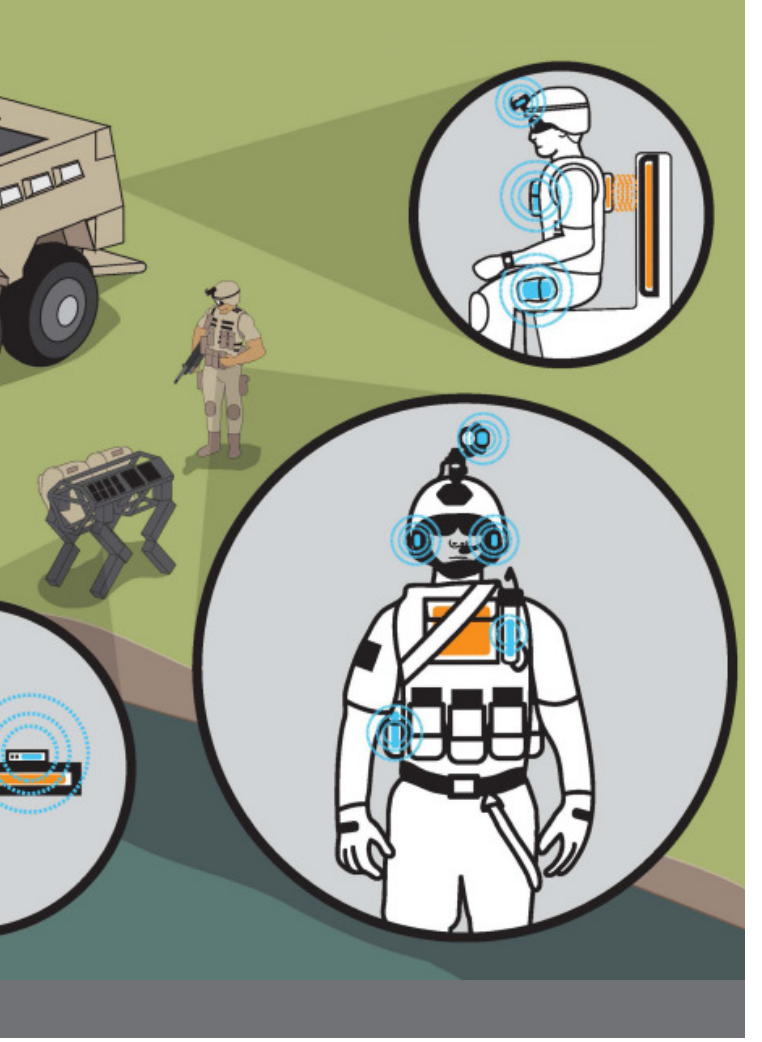
In a typical 72-hour mission, warfighters carry as many as 70 primary cells, and seven types of batteries weighing over 20 pounds[1]. In addition to the physical burden of carrying backup batteries, relying on an array of individual cells introduces dependence on a complex supply chain, user error, wasted time, and device failure. Today's military-battery burden extends well beyond soldier-based systems to manned and unmanned aerial, ground, and underwater vehicles and systems that use extensive amounts of electric power, are often range-limited by battery life, and rely on manual battery recharging and/or replacement techniques.

Together, these challenges point to a fundamental need to rethink, automate, and future-proof battlefield power distribution through the implementation of new technologies that dramatically reduce the battery burden. Wireless power offers the unique potential to quickly, safely, cost-effectively, and automatically recharge virtually any mobile military device or system that relies on batteries.

First applications and next steps

The first use of wireless power by the U.S. military will likely be to automatically recharge batteries embedded in Unmanned Ground Vehicles (UGV) used on the battlefield. In addition to the obvious benefits of improving and automating the battery-recharging process, a primary motivation for using WPT in this application is to eliminate exposure when soldiers leave the safety of armored vehicles to manually replace UGV batteries. Initial prototypes embedded in QinetiQ Talon robots are being deployed to Afghanistan for field testing this year to recharge batteries when a robot is docked to an armored vehicle.

Building upon this initial success, the next step is to focus on enabling other high-use, high-power, and high-availability devices and systems. For example, wireless power – combined with intelligent power management – has the potential to more than halve the battery weight and number of primary cells carried by dismounted warfighters and reduce the energy storage



requirements on unmanned vehicles. Cutting dependence on primary cells will ensure device availability and allow warfighters to focus on a single power source, eliminating potential errors in high-stress situations.

The basics of highly resonant wireless power transfer

Highly resonant WPT can occur when two high-quality-factor electromagnetic resonators are tuned to the same frequency and are within range to couple magnetically.

The power sources and capture devices include specially designed magnetic resonators that efficiently transfer power over mid-range distances via the magnetic near-field. These proprietary source and device designs and the electronic systems that control them support efficient energy transfer over distances that are multiples of the size of the sources/devices themselves.

This highly resonant WPT technology provides advantages over traditional magnetic induction that requires source and capture devices to be very close to one another – within millimeters – to transfer power efficiently.

Energy transfer via magnetic near-field can penetrate and wrap around obstacles, and can provide for safe, non-radiative energy transfer. Scalable designs enable solutions from milliwatts to kilowatts, while flexible geometries allow WPT systems to be embedded in vests, helmets, weapons, cameras, sensors, and other gear.

The efficiency of WPT systems is limited by the relative size, orientation, alignment, and distance between source and device resonators, as well as by the operating frequency and efficiency of the power electronics. In applications such as electric-vehicle charging, end-to-end efficiencies in excess of 90 percent are achievable over gaps of 20 cm or more.

Toward the wireless warfighter

WPT is a maturing technology already applicable to a host of today's military applications. To reach its maximum potential and meet the demands of tomorrow's wireless warfighter, however, the technology must continue to evolve, develop, and grow in sophistication and intelligence. Next-generation components, systems, and devices must also be designed and developed with WPT in mind to optimize form, fit, and function and also to ensure that the systems are efficient, safe, and accurate Over the course of the past year, a large number of potential defense-related use cases for WPT have emerged, such as:

- Soldier vest-to-helmet WPT to power helmet-mounted devices
- Soldier helmet-to-goggle WPT to power devices and defog optics
- Vehicle seat back-to-soldier vest WPT to recharge central batteries

Figure 1 | Prototypes of vest-pocket batteries to power helmet lights and other soldier-worn electric devices have been successfully demonstrated.

- Operating base rack-to-soldier vest WPT to recharge central batteries
- Simple, smart, and wireless power managers
- In-vehicle, drop-in, multi-device WPT recharging boxes
- Operating base, drop-in, multi-device WPT recharging boxes
- Vehicle-to-Unmanned Aerial Vehicle (UAV) WPT systems
- Other vehicle-to-UGV WPT systems beyond the Talon robot
- Vehicle-to-Unmanned Underwater Vehicles (UUVs) WPT systems
- Wireless rechargeable batteries and multi-battery recharging boxes
- Soldier vest-to-affixed device WPT to recharge batteries
- Soldier vest-to-handheld device WPT to recharge batteries

Recent progress and ongoing activities

In addition to the ruggedized systems wirelessly recharging Talon robots from armored vehicles, proof-of-concept prototypes are being developed to move energy wirelessly between vest-embedded batteries and small helmet-mounted batteries used to power mounted electronics such as night vision and radio devices. This reduces the size and weight of helmet-mounted batteries and eliminates the need for a power cord connecting the helmet to the vest-mounted battery pack.

Proof-of-concept prototypes developed for the Defense Advanced Research Projects Agency (DARPA) that transfer power wirelessly from military vests to handheld devices contained in vest pockets have also been demonstrated successfully. A new project funded by the U.S. Army will explore the feasibility of transferring power between a vehicle seat back to a soldier-worn vest so that as warfighters sit in vehicles, their central battery can be recharging.

WiTricity engineers recently demonstrated the ability to wirelessly transfer several hundred watts of power through seawater. In the future, WPT systems will likely be encased in sealed

enclosures to allow several kilowatts of power to be transferred through water with a high degree of spatial freedom. WiTricity envisions UUVs being recharged simply by floating alongside a dock, larger vessel, or other power source, eliminating the need for tight mechanical coupling and allowing power to be transferred underwater safely, reliably, and efficiently.

In the years to come, expect developers of defense systems to utilize wireless charging systems in a wide variety of systems and devices to improve operational efficiency and convenience. In doing so, they will be leveraging a disruptive technology capable of dramatically reducing the battery burden, supporting an overhaul of power management in military systems, and significantly augmenting mission effectiveness for the warfighters of tomorrow. **MES**

Reference:

1 Dr. Ed Shaffer, U.S. Army Research Laboratory (ARL) Battery Technology Industry Day, McLean, Va.; February 16, 2011; http://www.arl.army.mil/www/?article=564.

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ADVANCEDTCA/MICROTCA FOR MILITARY APPLICATIONS

Making the case for using ATCA in military signal processing

By Rob Persons

Data in the modern battlefield has become as essential as munitions. Detection, target tracking, and the decisions that must be made – based on data acquired from sensors and cameras mounted to Unmanned Aerial Vehicles (UAVs) or a myriad of radar and sonar devices on a cruiser – all require sophisticated algorithms executing on powerful computing equipment. Traditional methods of Digital Signal Processing (DSP) have used specialized FPGA equipment, multiprocessor VME, and OpenVPX solutions, but a new class of computing has the potential to replace some of those expensive and highly specialized processing elements.

U.S. Air Force photo by Master Sgt. Stanley Thompson

Advanced Telecom Computing Architecture (AdvancedTCA or ATCA) is an open computing standard that is very valuable to military applications requiring a huge amount of processing. Advances in microprocessor technology and accompanying software will make ATCA a very powerful technology for complex signal-processing applications of the future.

ATCA's new DSP applications include subfields such as audio/speech signal processing, sonar and radar signal processing, sensor array processing, spectral estimation, statistical signal processing, digital image processing, signal processing for communications, control of systems, biomedical signal processing, and seismic data processing.

New technologies are emerging that will enable ATCA to address DSP applications, especially those in defense and aerospace.

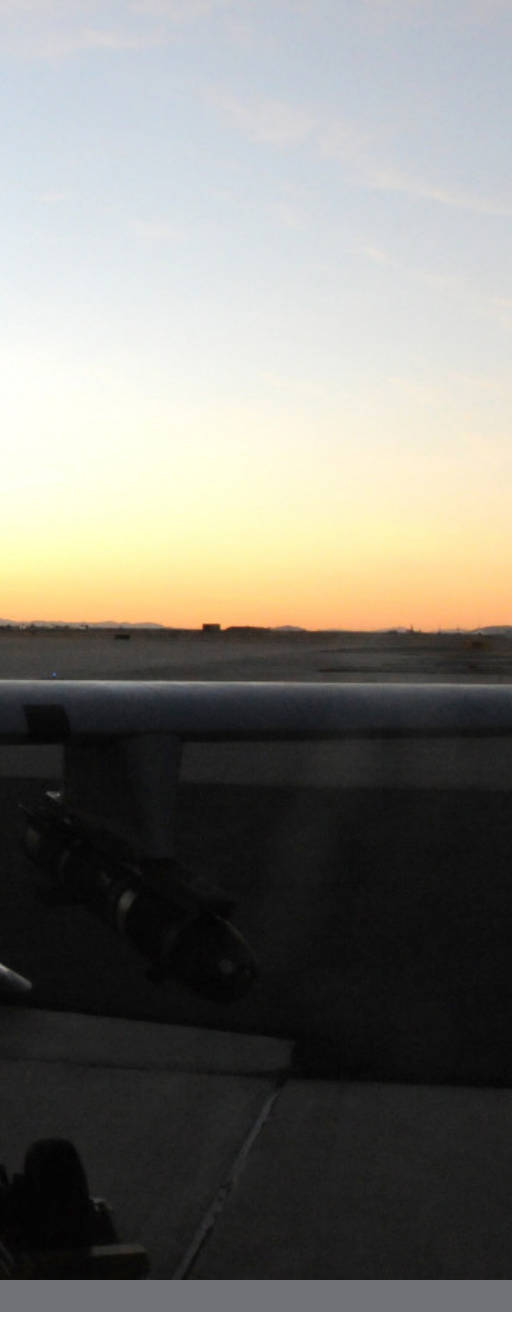
These technologies include:

- High-performance multicore processors
- Updated vector processing units in cores
- High-speed fabrics in the ATCA backplane
- Advanced flow-control software on ATCA switches and blades
- Repurposing packet-processing software to target DSP applications

The trends driving the opportunity for defense contractors include the cadence of Intel Xeon processor performance and functionality, and underlying fabric interfaces moving from 10 G to 40 G with the release of PICMG3.1R2.

The inherent ruggedness of ATCA, having been designed for the telecom industry's NEBS standards, lends itself to semi-rugged deployments such as shipboard manned, airborne, and transit-case applications. There is now an opportunity for defense contractors to leverage packet processing blades and software originally developed for telecom networks for very dense computing and signal processing.

This new category of ATCA blades, based on general-purpose processors but applied to DSP applications, can be termed algorithm processing blades.



Digital signal processing

In this instance, DSP can be defined as the mathematical manipulation of an information signal to modify or improve it in some way. The basic concept in a defense application can be characterized that:

1. Some kind of sensor device detects objects
2. A high-speed interface transfers this data to a rack with computing equipment
3. Analog data is either:
   a. Converted to digital at the sensor, or
   b. Converted to digital at the signal processing unit

Traditionally, DSP subsystems have been based on VME technology; there is a push for high-speed serial interfaces to replace the VME parallel bus, which is an ideal opportunity to evaluate technologies such as OpenVPX and ATCA. These computing architectures offer multiprocessor boards that support high-level DSP libraries and a host processor to manage data flows, as well as a range of ruggedization levels depending on the requirements of the application.

High-performance processing core

The latest generation of Intel Xeon processors, such as the Intel Xeon E5-E2600 v2 processor family (formerly code named *Ivy Bridge*), feature many high-speed interfaces into the processors. Beyond the 10 multithreaded cores running at up to 2.4 GHz clock speed, these processors also offer a large 25 MB Level 3 (L3) cache. Thanks to four integrated memory controllers, the memory interfaces provide a very fast method for moving data that is sent to the blade into the processor itself. A dual-processor ATCA blade offers very high-speed dual Intel QuickPath Interconnect (QPI) connections between the processors should the application need to move data between processors. These new processors feature 40 lanes per socket of 3rd generation PCI Express connectivity directly to the processors, whereas earlier generation devices offered PCI Express connectivity in a host bridge. This direct connectivity can be leveraged for high-speed fabric interfaces in ATCA. Along with the processors, Intel is developing hardware acceleration functionality that more traditionally may be seen in a dedicated packet processor.

Intel Advanced Vector Extensions

Introduced in the 2nd generation Intel Xeon family processors, Intel Advanced Vector Extensions (AVX) is a set of instructions for doing Single Instruction Multiple Data (SIMD) operations on Intel architecture CPUs. The 128-bit SIMD registers of Intel Streaming SIMD Extensions (SSE) have been expanded to 256 bits. This expansion potentially doubles floating-point operation performance when using single precision floating-point numbers. Intel AVX also offers specific instructions that support signal-processing applications and optimized libraries for AVX. Optimized VSIPL libraries are also available from third parties.

For applications such as radar detection, signal processing frequently requires multiple processors, which are often distributed across multiple blades. The performance boost provided by Intel AVX implemented in an ATCA system helps developers reduce processor and blade counts, thereby lowering BOM and design complexity. The reduced processor count and inherent efficiency of the ATCA bladed architecture can significantly lower power consumption.

The first is a 4x 10GBASE-KR Fabric configuration, defined in the ATCA specification as PICMG 3.1R2 "Option 3-KR," with 10 Gigabit Ethernet (GbE) links through separate MACs and data running over four individual Fabric lanes. The second option is a single 40GBASE-KR4 Fabric configuration, defined in the ATCA specification as PICMG 3.1R2 "Option 9-KR," with a single 40 Gbps link to a single 40 G MAC. Both options provide total bandwidth at 41.25 Gbps baud rate of 40 Gbps bit rate.

Figure 1 on the following page shows the architecture of a 40 G ATCA switch blade, such as Emerson's ATCA-F140. The new 40 G interfaces allow for inbound and outbound traffic at 40 G while still supporting the older 1 G and 10 G standards. How, exactly, does such a setup effectively get the data coming into the system to the correct processor payload blades? Advanced flow-management software has been developed to take individual IP streams, classify them, and then direct them to specific boards in the system. Furthermore, the software optimizes the return flow of the data as it exits the system.

Flow management

Software such as Emerson's FlowPilot add-on package performs just these functions, using software and hardware capabilities of the 40 G switch on the ATCA-F140. This software ensures fast

packet handling inside the system, with multiple configuration options to tailor the function of FlowPilot to the feature set that is actually required. More importantly, FlowPilot will distribute flows across a number of configured blades according to configured parameters, ensuring that they remain constant over time and that the same inspection device receives the entire flow. Additional functions include health check on an application level along with link transparency, connecting left-side and right-side cables to a virtual connection.

Figure 2 shows the architecture of Emerson's ATCA-7475 as an example 40 G ATCA packet processing blade based on dual 10-core Intel Xeon E5-2600 v2 family processors. Each CPU is connected to one 40 G Mellanox ConnectX3 Ethernet controller using 3rd generation PCI Express, allowing maximum throughput between controller and memory together with direct connection to a processing unit. Additional 10 G ports to the external world to add preprocessing capabilities can be added using a Rear Transition Module (RTM, a plug-in card that is connected to the rear of a blade inside the chassis to add interfaces and features) with four to six 10 G ports.

The blade is designed to take advantage of the packet-processing capabilities of the Intel Communications Chipset 89x0. This device provides offloaded hardware acceleration to improve the cryptographic and compression performance of the processors. The ATCA-7475 also allows the mounting of a mezzanine module featuring two more Intel Communications Chipset 8920 devices to take further advantage of the offload capabilities.

Figure 1 | 40 G ATCA switch blade architecture (Emerson ATCA-F140).

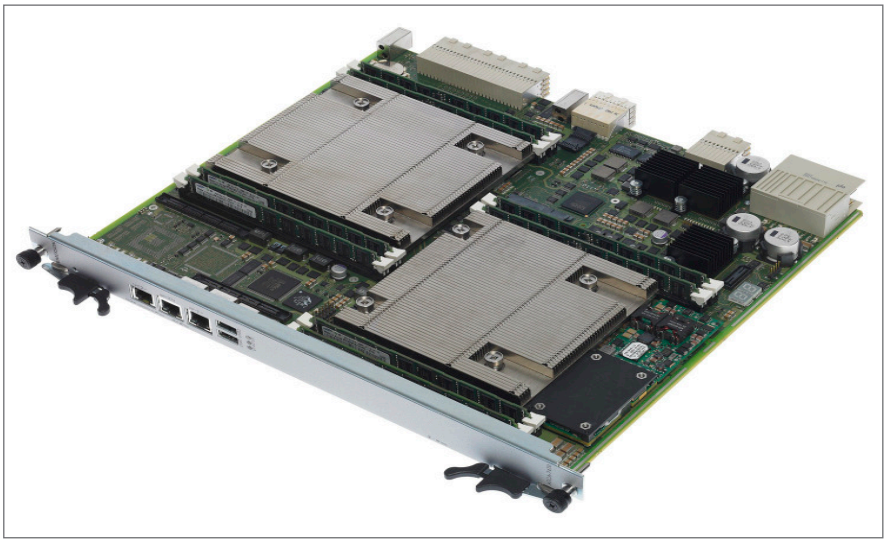


Figure 2 | 40 G ATCA packet processing blade based on dual 10-core Intel Xeon E5-2600 family processors (Emerson ATCA-7475).

Intel Data Plane Development Kit

Intel has made available a lightweight runtime environment for Intel architecture processors, offering low overhead and run-to-completion mode to maximize packet processing performance: the Intel Data Plane Development Kit (Intel DPDK).The Intel DPDK focuses on how the individual processor cores can be more tightly managed outside of any encumbrance of the operating system activity and allows those cores to act in quite a deterministic fashion. Additional libraries around memory, queue, and buffer management help manage the flow of how the data moves to individual cores, between cores, or another core outside the system.

It provides a selection of optimized and efficient libraries, also known as the Environment Abstraction Layer (EAL), which are responsible for initializing and allocating low-level resources, hiding the environment specifics from the applications and libraries, and gaining access to the low-level resources, such as memory space, PCI devices, timers, and consoles.

The EAL provides an optimized Poll Mode Driver (PMD); memory and buffer management; and timer, debug, and packet-handling APIs, some of which may also be provided by the Linux OS.

To facilitate interaction with application layers, the EAL, together with the standard GNU C Library (GLIBC), provide full APIs for integration with higher-level applications.

The 40 G ATCA blade based on dual Intel Xeon E5-E2600 v2 processors, such as

Emerson Network Power's ATCA-7475 packet processing blade, is tailored for digital signal processing to create an algorithm processing blade. One physical core on each device is dedicated to control plane applications based on Linux. This core works in tandem with the 40 G network interface controller to move the data in and out of the other processor cores at optimal speed. The rest of the cores, meanwhile, are available to run individual DSP algorithms. A section of data would be distributed to each core and processed to completion without interruption. The combination of high-performance processors with Intel AVX and 40 G blade interfaces creates a set of DSP engines from general-purpose processors that can run at a very high speed.

System architecture

1. Packetized sensor data enters into the ATCA switch as 10 G or 40 G data
2. Flow control software on the switch load balances and distributes the data to the appropriate processor board
3. Flow control software on the blade then load balances and distributes the data to the specific algorithm running in a specific thread of a specific core
4. With the assistance of the AVX coprocessor, the DSP algorithm is completed without interruption
5. Flow control on the board and switch then directs the results to another payload board either for further processing or out of the system

ATCA right platform for defense, aero

ATCA is an ideal computing platform to address digital signal processing applications, especially those in defense and aerospace. The other benefits of ATCA for defense and aerospace contractors, such as being a truly open architecture, with inherent ruggedness and power efficiency, mean that the time is right to leverage the packet processing blades and software originally developed for telecom networks for very dense computing and future complex signal-processing applications. **MES**

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ADVANCEDTCA/MICROTCA FOR MILITARY APPLICATIONS

ATCA, a competitive alternative to 6U VPX

By John Long and Donald Germany

Hardware-platform decisions have always been challenging in the aerospace and defense market, as applications in these markets typically require cutting-edge technology and a deployment life cycle that could extend for decades. Developing hardware from the ground up is costly and can lengthen development schedules; however, the advent of open standards such as VITA and PICMG means that many engineering teams have started using these standards to reduce development cost and time to market.

ATCA technology is being looked at for a variety of military shipboard applications.
U.S. Navy USS Abraham Lincoln (CVN 72) photo by Mass Communication Specialist 3rd Class Jerine Lee.

Open standards enable engineers to start abstracting software from the hardware, and most development teams use the same basic framework for hardware decisions as they look at the application requirements to determine the processor and I/O requirements. Knowledge of a deployment environment gives designers an understanding of the ruggedization required, while system Size, Weight, and Power (SWaP) requirements provide the final information to allow them to make decisions on hardware.

The deployment environment is one of the major factors in determining which standards can be used. In many cases environmental conditions are not friendly to electronics, requiring conductively cooled solutions, so typical choices have been 3U VME, sometimes 3U cPCI, or 6U VME. In applications where the environment is benign and air-cooled solutions can be used, platforms are typically based on 6U VME or cPCI. With the release of the VPX standard, most developers assumed that the majority of applications would transition to either 3U or 6U VPX. The transition to 3U VPX has begun with 3U VPX offering new features to help kick-start the transition, but the 6U transition seems to be stuck in neutral.

Advanced Telecom Computing Architecture (ATCA), now seeing increased adoption in the air-cooled aerospace and defense market, has the potential to be the successor to 6U VME. This shift is driven by two major factors: To begin with, the application I/O requirements are changing due to the network-centric warfare concept, while sequestration with defense-budget cuts has taken the concept of "affordability" and made it a reality, where performance and price are key factors in funding decisions.

While ATCA and VPX have many aspects in common, their backgrounds are very different. ATCA was brought about by a completely new architecture driven by network equipment to provide a high-performance, high-bandwidth solution for wireless commercial networks. In contrast, VPX was a significant improvement to VME, which is mainly focused on the aerospace and defense markets. The biggest difference between these standards is the physical board size (see Table 1), in which ATCA's larger board size and bigger pitch allows more real estate on the front panels, a larger board area for components, and better cooling.

Changing I/O requirements

Several years ago the Department of Defense (DoD) started pushing the concept of network-centric warfare. The general idea was to get different systems to easily communicate with each other in order to provide the warfighter with better situational awareness. However, many system architects have taken this to the next level, where a network now means that every device is connected to switched Ethernet. This shift is driving two different types of requirements – one consisting of many small pipes and another using a few fat pipes.

The "many small pipes" concept is starting to be widely adopted where every end device is connected via Ethernet, and all devices need redundant connections via two separate switches. The end device could be a user, sensor, or control point. This requires the endpoint to do some front-end processing of the data to convert it to Ethernet. This architecture can drive a significant amount of 1 GbE connections to the system. In some cases the requirement is as high as 48 1 GbE redundant (a total of 96) 1 GbE connections. A more typical architecture is 10 redundant (a total of 20) 1 GbE connections. Many of the new ATCA boards will have 14 10 GbE/1 GbE connections, and can handle this requirement with as few as two to four switches per system. However, as VPX switches are a smaller form factor and typically have six to eight 10 GbE/1 GbE connections, you would need four to six switches per system. This setup would significantly decrease the payload capacity of the systems in the long term and would also have a detrimental effect on SWaP.

The second use case is "big pipes" between systems. In this case, the connections between chassis are either difficult to upgrade, or (in cases where they need to be connected in the field), there is the desire to make as few connections as possible. In both scenarios there exists the desire to overprovide the connections between chassis to either provide bandwidth for future upgrades or to limit the number of physical connections between systems. Most new ATCA switches support Quad Small Form Factor Pluggable (QSFP) 40 GbE links via the Rear Transition Module (RTM), while VPX deploys only a 10 GbE connection.

Key Considerations	VPX	ATCA
Board Size	6U: 233 x 160 mm Area: 373 cm²	8U: 355.6 cm x 280 cm Area: 996 cm²
Backplane Technology	1 Gbps and 10 Gbps, plans for 40 GbE	10 Gbps, moving up to 40 Gbps
Pitch	Typically 1 inch	1.2 inches
Adoption of Standard	2009	2004

Table 1 | A comparison of VPX vs. ATCA chassis specifications.

Affordability is key to defense budgets

For the last few years the DoD has been pushing the concept of affordability, in response to the reduction in defense budgets.

Performance is one of the key parameters when looking at affordability, and every process architecture and application has a unique profile. However, for generic performance the Standard Performance Evaluation Corporation (SPEC) focuses on x86

standards and provides a widely adopted set of tests for performance and allows users to post results.

Most 6U VPX boards that support the x86 architecture use Intel Core i7 processors (mobile processors). The newer blades are typically single-socket and are based on the i7-4770TE, which is a long-life, low-power processor. These blades typically have an XMC or PMC site. From the results posted on the SPEC website, the estimated performance for integer-processing performance is around 180, with the floating-point performance around 130. Typical ATCA blades are dual-socket, based on Xeon server processors, and use the E5-2648LV, which is also a low-voltage, long-life processor. The integer performance of these is around 420 with a floating-point of 360. The typical performance for an ATCA board is roughly twice that of a VPX board. While this case is based on an x86 example, the scaling of a large board size will generally apply to other types of processors.

From a system perspective, for the typical system that is air-cooled and fits in a 19-inch rack, a 5U ATCA system can support six boards while a VPX system can support seven boards. If you assume that two switches are required, the total performance of an ATCA system provides a benchmark of 1,540 on integer performance, as opposed to 900 for a VPX system; the ATCA system's performance is roughly 70 percent higher.

Cost is the other key parameter of affordability. A typical VPX board based on the i7-4770TE processor has a list price of approximately $9,000. ATCA has been widely adopted by the network-equipment providers, which has driven a high unit volume and a lower price point, thereby driving down the price of the typical ATCA board based on the E5-2648L to the $7,500 price range.

If you look at the total price of the typical system – assuming that a chassis with two 10 GbE switches costs around $20,000 – the ATCA system with four computing blades would be $50,000, while a 5U VPX system with five computing blades would cost closer to $75,000. If you compare the performance per dollar, ATCA provides roughly two-and-a-half times the affordability of a 6U air-cooled solution.

Of course, several other soft factors go into hardware selection, some of which favor ATCA, while others lean towards 6U VPX. One factor is that the physical size of an ATCA is larger than a 6U VPX. For ATCA boards in a horizontal alignment, you need roughly a standard 19-inch rack, while for vertical alignment you need roughly 13 inches. In contrast, 6U VPX can fit in much smaller spaces.

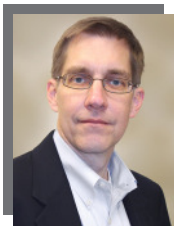
Another component is the perception that ATCA is not as rugged as 6U VPX. However, air-cooled blades are typically only deployed in benign environments. ATCA was designed to handle ambient temperatures of -5 °C to +55 °C, but these ranges can be extended. Moreover, the shock and vibration profiles for

Figure 1 | LCR Electronics 6U ATCA chassis.

the aerospace and defense markets are unique but can usually be handled by a more rugged chassis. LCR has shipped more than 450 ATCA chassis currently deployed in ground mobile and airborne applications, while other vendors are currently shipping volume for naval deployments (see Figure 1).

One other misconception about ATCA is that it is not a long-life-cycle product. The key driver for product End of Life (EOL) is the silicon used on the board, and because both VPX and ATCA use the same type of processor, it is possible to get 10 years of production life out of a payload blade.

A critical factor for all aerospace and defense applications is the use of the latest available technologies. ATCA has an advantage over VPX in this area as well, as the majority of ATCA users are network-equipment providers. Selling communication equipment to the carriers is a very competitive environment, with customers demanding the very latest technology. Major ATCA blade providers are driven by time to market with the silicon, launching their new products when the silicon vendor announces the availability of the silicon. Most board vendors have had 40 GbE switches available for a year, and are using the latest Intel and packet-processing silicon. **MES**



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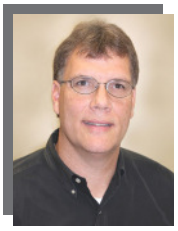

Donald Germany *is the product/engineering manager for LCR's Integrated Systems group. He joined LCR in 2012; Donald has 20 years of embedded computing experience in the military, commercial, and industrial markets. He oversees the development, testing, and support of integrated systems in a variety of form factors from small ATR enclosures to 12U/13U rack-mount systems. Readers can reach Donald at dgermany@lcr-inc.com.*

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ADVANCEDTCA/MICROTCA FOR MILITARY APPLICATIONS

MicroTCA matures to meet rugged requirements at sub-VPX price point

By Brandon Lewis, Associate Editor

Despite early skepticism from the defense electronics community, the MicroTCA (µTCA) standard, which spawned from the telecommunications industry, is gaining fans among military system designers due to its rugged nature and low price point – especially when compared to VPX.

Engineers upgrading platforms such as the U.S. Army Bradley Fighting Vehicle like the combination of ruggedization and low cost associated with MicroTCA technology. Photo courtesy BAE Systems.

Budget cuts and the drive toward commonality often represent opportunities for designers of Commercial Off-The-Shelf (COTS) electronics that advance a Modular Open Systems Approach (MOSA) to defense spending and acquisition. As a result, suppliers of low-price point products based on standards that evolved from the high-volume telecommunications (telecom) industry – such as AdvancedTCA (ATCA) and its smaller form factor companion MicroTCA (µTCA) – are winning more contracts every year.

Aside from cost, these products also need to meet military specifications, and rugged variants of the µTCA specification now meet or exceed the shock, vibration, and thermal qualifications of VPX platforms, doing so at roughly half the cost. Telecom applications often have similar ruggedization requirements to military applications, and that industry's economies of scale enable platforms like µTCA to realize deeper price reductions than traditional military COTS technology. Defense primes such as BAE Systems in Wayne, NJ, are now collaborating with industry to drive rugged versions of µTCA into the military marketplace.

"Several military programs will soon be leaving their present architecture and moving over to µTCA," says Mark Leibowitz, Chief Systems Engineer, Mission Computing, BAE Systems (www.baesystems.com). "If we compare µTCA to VPX, which happens to be the competing standard, they are very similar. However, in this economy, where contracts are dwindling and competition is fierce, cost is the driving factor. Using µTCA offers a cost benefit of approximately 50 percent over a VPX solution. In the µTCA world, the target platform drives cost, not a specific program. With AdvancedMC (AMC) modules for telecom as their target, µTCA vendors look at what is needed and build the product. They can then adapt that product to a µTCA.2 or .3 solution by virtue of putting a clamshell on the module. Remember, they are developing that AMC for clientele looking at large-scale quantities supported by a larger ecosystem. VPX solutions target a specific program and design a product by contract.

"Multiple companies that are designing AMCs will look at what the telecom industry needs and lay out a roadmap that includes processor modules, µTCA Carrier Hubs (MCHs), 10 GbE/40 GbE switches, and so on," he continues. "In developing that product, they are targeting a price that is not driven by a military program. VPX, on the other hand, comes from the VME world, with modules priced at different economies of scale. Once [VPX vendors] add Hardware Platform Management (HPM) the price goes up even higher, even though VPX platforms have basically leveraged design details from the µTCA infrastructure in that regard (see sidebar on page 42)."

MicroTCA meets VITA 47 and innovates on thermal dissipation

To date, critics of µTCA in military applications have charged that the specification family does not provide the shock, vibration, and thermal benchmarks necessary for harsh environments. In response, the µTCA.2/.3 specifications were engineered to rugged requirements and incorporate unique cooling concepts to realize gains in heat dissipation.

Environmental Category and Range		µTCA.2 (Hybrid Air/ Conduction Cooled)	µTCA.3 (Conduction Cooled)
Operating Temperature	–5 °C to +55 °C	MIL-FC1	TEL-1
	–40 °C to +55 °C	MIL-FC2	MIL-CC2
	–40 °C to +70 °C	MIL-FC3	MIL-CC3
	–40 °C to +85 °C	MIL-FC4	TEL-2, MIL-CC4
Non-Operating Temperature	–40 °C to +70 °C		TEL-1
	–40 °C to +85 °C	MIL-FC1, MIL-FC2	MIL-CC2
	–45 °C to +85 °C		TEL-2
	–50 °C to +100 °C	MIL-FC3	MIL-CC3
	–55 °C to +105 °C	MIL-FC4	MIL-CC4
Operating Vibration	1 G (Sine)		TEL-1
	8 G (Random)		TEL-2
	12 G (Random)	(All Classes)	MIL-CC2, MIL-CC3, MIL-CC4
Operating Shock	15 G		TEL-1
	25 G		TEL-2
	40 G/11 ms	(All Classes)	MIL-CC2, MIL-CC3, MIL-CC4
Altitude	–460 m to 18300 m	(All Classes)	(All Classes)

Table 1 | MicroTCA.2 (µTCA.2) and µTCA.3 modules are able to realize ruggedization levels that meet or exceed MIL-SPEC requirements.

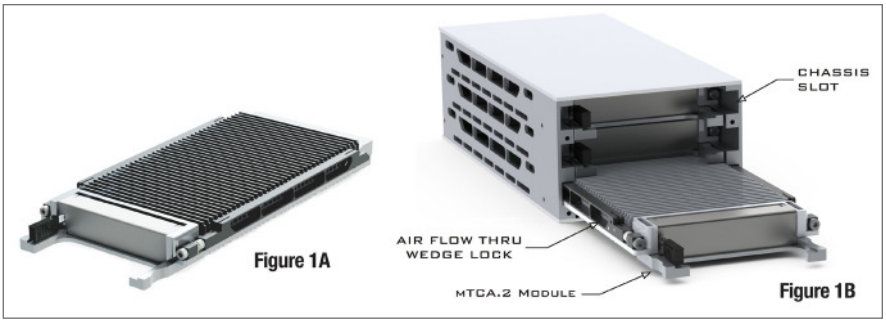

Figure 1 | Pictured are a µTCA.2 module (left) and system (right). In a µTCA.2 solution, when a module is inserted into the chassis its wedgelocks facilitate thermal dissipation through hybrid air/conduction cooling. Photos courtesy of WaveTherm Corporation in Morrisville, NC.

"As far as thermals, shock, and temperature range, µTCA.2 and .3 are modeled around VITA 47 (Table 1)," Leibowitz says. "We had an independent test lab conduct vibration and shock testing at levels beyond the extremes – about 10 percent higher than VITA 47 requirements – up to 50 Gs of shock. We had superb test results, and not only did we do military testing, we did telecom testing on top of that, like mixed-flow gas, a very stringent test that the military does not even test to." (*Editor's note: µTCA.2 Thermal and µTCA.3 Connector Test Reports by Contech Research are available in the resources section at www.picmg.org.)*

In order to achieve high levels of ruggedization, µTCA.3 employs rugged conduction-cooled modules that surpass MIL-STD-810 and RTCA/DO-160 environmental testing, Leibowitz continues. As the µTCA.3 specification was completed first, many of its mechanical features were inherited by µTCA.2, which was originally intended as an air-cooled-only module standard, he notes. However, wedgelock design innovations led to a hybrid cooling approach in µTCA.2 that yields thermal dissipation improvements of as much as 32 percent over standard conduction-cooled modules, Leibowitz explains.

"When the .2 specification originally kicked off, the charter was to develop a rugged air-cooled module," says Michael Borthwick, Chief Mechanical Engineer, Mission Computing, BAE Systems. "In initial discussions, what we wanted to really accomplish was to leverage a lot of the work that went into the .3 specification. For example, much of the testing done by independent test labs on the interconnect system for .3 also applied to .2.

"Early on we decided upon a .2 form factor that preserved the wedgelocks mounted on the edges of the module [from .3]. That approach evolved into a wedgelock that would allow air to pass through while still providing the mechanical retention needed to leverage those earlier test results," he explains. "From there, the committee members recognized that not only would we have air passing through the wedgelocks, but we would have an additional opportunity to conduct heat out through those wedgelocks and spread the heat load through the sidewall. That was the birth of the 'hybrid' concept and where the efficiencies can potentially be realized – not only do you have air flowing directly over the module and removing heat through convection, you also have air conducted from the clamshell into the wedgelock and into the chassis sidewall (Figure 1).

"The other thing we were looking to leverage besides the mechanical retention was a module that would permit Two-Level Maintenance (TLM)," Borthwick continues. "We conducted Electrostatic Discharge (ESD) testing for .3, and to accomplish TLM for .2 we retained the clamshell approach. After the charter evolved into the hybrid approach, we performed independent thermal testing to characterize the exact efficiencies we could achieve.

"The clamshell wraps around a standard AMC.0 board; any .0 board can be used in the clamshell," Borthwick says. "It's important to note that the same clamshell form factor is used for both µTCA.2 and µTCA.3, which – similar to VITA 47 – are module-level specifications. In terms of board pitch, the .2 and .3 rugged solutions share the standard AMC module sizes – Compact .6 mm, Mid-size .8 mm, and Full-size 1.2 mm – so you are able to maintain the standard pitch sizes for the module space in your backplane. So if you are developing a solution in the lab and you have X number of cards in an air-cooled bench-top development chassis and now want to leverage everything you did in a µTCA.0 chassis into your MIL system, the pitching remains the same."

"µTCA.0, .1, .2, .3, and .4 all have a fully defined architecture. When you develop a chassis today and deploy your system, you know that you can change that system later on without changing your backplane," Leibowitz says. "In a VPX solution, the implementation varies. Consider the detailed design of a VPX chassis. If you want to change it, you will basically have to go to a vendor and ask, 'Can you build me that same card?' This is because the pitches vary so much and various types of backplane connectors are not interchangeable from vendor to vendor. In the VPX world, functionality affects the solution, and because you can put just about anything on the pinout, the result is a very customized solution."

COTS, interoperability drive down defense costs

As the Department of Defense (DoD) looks to extend the longevity of system designs through open architecture hardware platforms, interoperability has become a key tenet of subsystem acquisition. Because µTCA is defined at the module level, different variants can be achieved within a µTCA chassis by swapping out AMC cards and accompanying hardware. Combined with a non-military COTS price point, this ensures maximum value from deployed µTCA systems.

"µTCA.2 and µTCA.3 are interchangeable," Leibowitz says. "All you have to do is interchange µTCA.3's standard wedgelock and µTCA.2's open airflow wedgelock to interchange the modules. One of the things industry was asking for was the ability to move from a conduction-cooled module to an air-cooled solution. They can do that with the same clamshell design, which actually keeps the cost of the final solution down.

"Whether on large-scale platforms or the smaller UAV-type platforms, defense programs today are demanding MOSA for computer architecture designs," Leibowitz continues. "This allows the government to get the best bang for their dollar. Technology insertions over time become easier because there are no proprietary, sole-source items. A MOSA solution leverages more of the COTS market, which opens up the vendors able to support the technology needed for that architecture.

"Rugged µTCA systems are starting to be delivered – we are on the verge of seeing widespread use of the architecture, he adds. "It takes two to five years after new specifications are released before you start seeing products being deployed." **MES**

A legacy of platform management

A critical component of MicroTCA (µTCA) systems is platform management technology inherited from the AdvancedTCA (ATCA) architecture, says Mark Leibowitz, Chief Systems Engineer, BAE Systems in Wayne, NJ. Platform management enables communication with all of the modules in a system to measure their health, including temperature, voltage, and network control, he continues. It also allows for remote firmware upgrades so that new images can be quickly loaded into multiple or inaccessible slot cards, Leibowitz adds.

"One key thing when you look at the origin of µTCA is that it derived from ATCA, which had an Intelligent Platform Management Interface (IPMI)," Leibowitz says. "As a part of the health management system, IPMI gives you a robust solution."

"The key is that it is inherent in the system," says Michael Borthwick, Chief Mechanical Engineer, Mission Computing, BAE Systems. "From the outset of the ATCA specification, many of the health management and features were built in from the bottom up. Now you see trends in VPX where they are trying to add some of those features. However, they are trying to integrate those features into the established specification, which presents some challenges."

"µTCA.2 and µTCA.3 add another level of platform management, which includes Field Replaceable Unit (FRU) information that gives you the ruggedization level of the module," Leibowitz says. "The MicroTCA Carrier Hub (MCH) reads each AdvancedMC (AMC) and logs the ruggedization level of the card against the ruggedization level defined for the chassis. It then tells the system integrator if they have the right module in there or if someone put in a lower grade module than the system is rated for."

Another advantage of the MCH is that it allows 1 Gigabit Ethernet (GbE), 10 GbE, or Serial RapidIO to be brought through copper or fiber optics to the µTCA backplane, which can support multiple fabrics simultaneously, Leibowitz continues. Whereas VPX allows for only one backplane fabric, this feature enables a different technology to be used for communications with the processor and I/O, easing implementation of distributed solutions, he adds.

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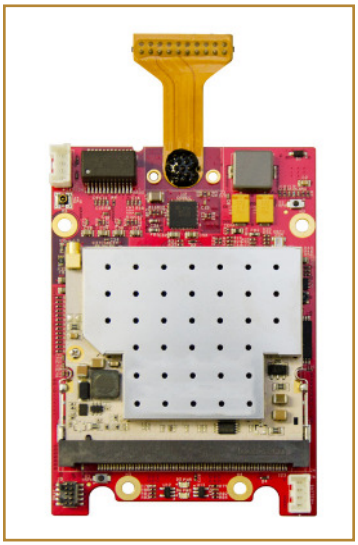


Mobile ad hoc networking in a small form factor

The Mobile Ad Hoc Networking System (MANET), Wave Relay, from Persistent Systems in New York, NY, is designed to maintain wireless connectivity on the go, in a variety of environments. It is a scalable, wireless network that provides data, video, and voice from peer-to-peer, and provides user throughput of 37 Mbps User Datagram Protocol (UDP) and 27 Mbps Transmission Control Protocol (TCP).

Measuring 2.7 x 3.9 x .7 inches and weighing only 3.4 ounces, the Wave Relay Datalink embedded module is designed for integration with portable ground controllers, robotics, Unmanned Aerial Vehicles/Systems (UAVs/UASs), and other integrated systems. As part of the Gen 4 Integration Unit, the Wave Relay Datalink has a flexible board design in a small form factor. The embedded module includes Layer 2 Ethernet connectivity for the plug-and-play operation of cameras, IP sensors, video encoders, and more. Serial-to-Ethernet capability enables the wireless control of serial devices over the network. It has an operating temperature range of -40 °C to +85 °C; low latency, with a bandwidth as fast as 37 Mbps; an average power consumption of 4.2 W; and has an aircraft range of over 130 miles.

Persistent Systems | www.persistentsystems.com | www.mil-embedded.com/p9916712

16-channel LRM SSPC continuously monitors 250 amps

Data Device Corporation (DDC) in Bohemia, NY, has released a new 16-channel Line Replaceable Module (LRM) Solid-State Power Controller (SSPC) capable of a continuous current output of 250 amps. The RP-26231000N1 is packaged in a VITA 48/Ruggedized Enhanced Design Implementation (REDI)-compatible form factor that enables Two Level Maintenance (2LM) operations and also quicker field replacement in deployed vehicles, which reduces downtime and service costs.

The RP-26231000N1 SSPC product family supports real-time digital status reporting and computer control, and is equipped with instant trip, and I^2T wire protection. Included in the SSPC product line are 270 Vdc units with current ratings of 2 through 15 amps, 28 Vdc units from 1 through 80 amps, and 115 Vac units. Custom SSPC modules are also available that are capable of a continuous current output of 300 amps. The RP-26231000N1 SSPC product family feature reduced Size, Weight, and Power (SWaP) when compared to electromechanical breakers and relays, and have a 5x improvement in power/weight density, 7x improvement in power/volume density, and a 70 percent reduction in dissipated power. The SSPC product family is used in applications such as commercial trucks, industrial controls, military land vehicles, ships, weapons systems, and unmanned vehicles.

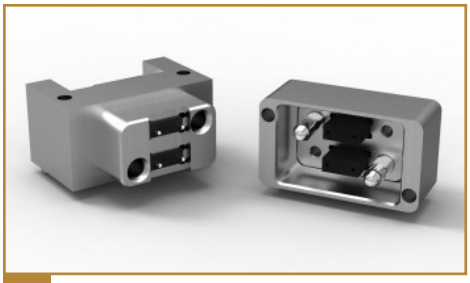
Data Device Corporation | www.ddc-web.com | www.mil-embedded.com/p9916713

Rugged image processing system generates 360° views for optimal situational awareness

Enhanced situational awareness is the goal of the rugged 360° image processing system – the IPS511 – from GE Intelligent Platforms in Huntsville, AL. It enables views with as many as 12 analog inputs while protecting the observer. The subsystem of the IPS511 is a DC-powered video processing unit that is able to process multiple analog video inputs simultaneously to generate video display configurations for two simultaneous video outputs.

The display configurations range from a single switched input display, to stitched or tiled panoramas from multiple video inputs, with an optional overlaid picture-in-picture feature and a symbology display. Additional configurations can provide a ribbon display of all the video inputs at the same time. The subsystem has support for two independent operator displays, enabling each operator to adjust view direction and magnification within the panorama via a touch screen or other interface device. The GE device can process as many as 12 video signals chosen from as many as 16 analog video inputs. It may come with two NTSC/PAL video outputs or two DVI0D video outputs. Control, calibration, and configuration is all done through a remote computer's Ethernet interface.

GE Intelligent Platforms, Inc. | www.defense.ge-ip.com | www.mil-embedded.com/p9916714



Rugged, VITA 66.1-supported optical backplane interconnect targets high-bandwidth applications

Engineers at TE Connectivity in Harrisburg, PA, designed a new ruggedized optical backplane interconnect system that is VITA 66.1 (VPX: optical interconnect on VPX – MT variant) supported and American National Standards Institute (ANSI) ratified. The ruggedized optical interconnect systems are designed to meet the needs of high-bandwidth applications, such as high-definition video and images, and for computing applications that require optical infrastructure.

The ruggedized optical interconnect system is also designed to maximize optical performance and is offered in both receptacle (backplane) and mating plug (daughtercard) connectors. The backplane connector includes two robust guide pins for efficient blind mating; the daughtercard connector housing contains a slot feature to facilitate cleaning the MT interfaces. The fiber optic (ribbon) cable interconnect is fed through the backplane to removable system modules using the two MT ferrules, which each accommodate as many as 24 fiber paths. Locating post features on the interconnect systems ensure proper position on the backplane and module boards. The devices are used in applications such as avionics, vetronics, imaging, targeting, processing, radar, secure communications, and more.

TE Connectivity | www.te.com | www.mil-embedded.com/p9916715

Rugged 12 Gb SAS RAID storage arrays

RAID storage at 12 Gb highlights the RPC 4004 series from Phoenix International Systems, Inc. in Orange, CA. The RPC 4004 series was announced at the MILCOM 2013 conference in San Diego, CA. The RPC 4004 series is available in various configurations for 2.5 inch Hard Disk Drives (HDDs) and 2.5 inch Solid State Disks (SSDs). Each RPC24 converged interface storage array includes two four-port controllers and can be configured in the field with eight 16 Gb Fibre Channel ports, eight 10 Gb iSCSI ports, or a combination of four 16 Gb Fibre Channel and four 10 Gb iSCSI ports. These storage arrays are backward-compatible with 8 Gb/4 Gb Fibre Channel and 1 Gb iSCSI networking solutions, such as switches and host bus adapters. All of the 4004 models are also fully compatible with previous versions of the RPC24 arrays.

The RPC24 4004 series includes 24 drives and two magazines containing as many as 12 HDDs or SSDs, each housed in rugged 2U (3.5 inch) panel height, 19.5 inch deep enclosure. Weighing only 51 lbs with a full complement of 24 SSDs, it is less than 20 inches deep and is certified to military specifications MIL-STD-810G and MIL-STD-461E.

Phoenix International Systems, Inc. | www.phenxint.com | www.mil-embedded.com/p9916716

USB serial radio adapter works with any tactical using MIL-STD-188-184 port

Enhancements have been made to the ACC-188 USB synchronous tactical data communications adapter, developed by Sealevel Systems in Liberty, SC, to integrate a quick disconnect radio cable that enables the adapter to be easily configured for the end user's target radio. Essentially radio agnostic, the cable uses a standard type-A USB connector fitted for any USB-enabled computer, and the other end connects to the user's tactical radio via the quick disconnect cable. When merged with the Defense Information Systems Agency's (DISA's) free PDA-184 software it enables tactical radios to send and receive IP data including e-mail, text messages, and images. This software has a Graphical User Interface (GUI) that enables radio users to transmit and receive a range of different data types at high speeds.

The ACC-188 is compatible with any tactical radio that has a synchronous communication port using MIL-STD-188-184, which allows interoperability between various types of radio brands and models used in the defense industry. Radios the ACC-188 works with include the AN/PRC-117G, AN/PRC-117F, AN/PRC-152, AN/PRC-150, AN/PRC-148, AN/PSC-5D, and the AN/ARC-231. Sealevel's radio adapter is able to perform in -40 °C to +85 °C temperatures.

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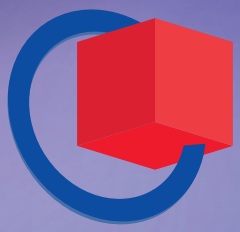

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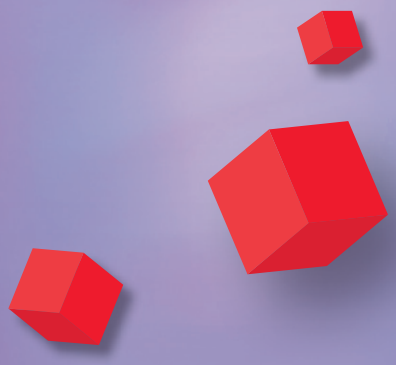

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