Military EMBEDDED SYSTEMS

Nov/Dec 2014
Volume 10 | Number 8
MIL-EMBEDDED.COM

EVOLUTION OF MILITARY NAVIGATION IS WELL UNDERWAY

P 16

P 38

Interoperability key to adoption of VITA and PICMG standards in military, aerospace market – By Lewis Allison, Alpha Data

VITA 75 addresses SWaP-C challenges

P 30

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ON THE COVER:

Top photo: Pictured is an artist rendering of Lockheed Martin's GPS III satellite. Photo courtesy of Lockheed Martin.

Bottom photo: A modular, standards-based approach to subsystems enables powerful computing capability in multiple applications such as unmanned aerial vehicles. Pictured is a RQ-7B Shadow launched by U.S. Marine Unmanned Aerial Squadron 2. Photo by Lance Cpl. S.T. Stewart.

Nov/Dec 2014 | Volume 10 | Number 8

COLUMNS

DEPARTMENTS

EVENTS

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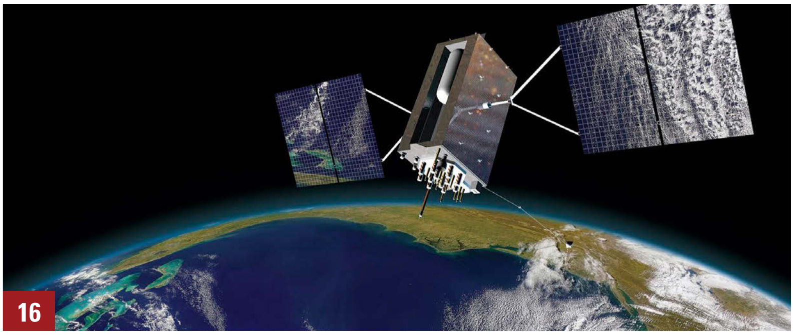

16

20

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ADVERTISER INFORMATION

Military EMBEDDED SYSTEMS

OpenSystems media.

MES Editorial/Production Staff

John McHale, Group Editorial Director
jmchale@opensystemsmedia.com

Lisa Daigle, Assistant Managing Editor
ldaigle@opensystemsmedia.com

Amanda Harvey, Assistant Editor
aharvey@opensystemsmedia.com

Sally Cole, Senior Editor
scole@opensystemsmedia.com

Steph Sweet, Creative Director
ssweet@opensystemsmedia.com

Konrad Witte, Senior Web Developer
kwitte@opensystemsmedia.com

Sales Group

Tom Varcie, Sales Manager
tvarcie@opensystemsmedia.com
(586) 415-6500

Shannon E. Alo-Mendosa
Strategic Account Manager
shannona@opensystemsmedia.com, (978) 501-9116

Rebecca Barker, Strategic Account Manager
rbarker@opensystemsmedia.com, (281) 724-8021

Eric Henry, Strategic Account Manager
ehenry@opensystemsmedia.com, (541) 760-5361

Kathleen Wackowski
Strategic Account Manager
kwackowski@opensystemsmedia.com
(978) 888-7367

Asia-Pacific Sales
Elvi Lee, Account Manager
elvi@aceforum.com.tw

Regional Sales Managers
Barbara Quinlan, Southwest
bquinlan@opensystemsmedia.com
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Denis Seger, Southern California
dseger@opensystemsmedia.com
(760) 518-5222

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sstarr@opensystemsmedia.com
(775) 299-4148

Europe Sales
James Rhoades-Brown
james.rhoadesbrown@husonmedia.com

Reprints and PDFs

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OpenSystems Media Editorial/Creative Staff

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John McHale, Group Editorial Director
Military Embedded Systems
PC/104 and Small Form Factors
PICMG Systems & Technology
VITA Technologies

Lisa Daigle, Assistant Managing Editor
Military Embedded Systems
PC/104 and Small Form Factors

Amanda Harvey, Assistant Editor
Military Embedded Systems
PC/104 and Small Form Factors
VITA Technologies

Sally Cole, Senior Editor
Military Embedded Systems

Jerry Gipper, Editorial Director
VITA Technologies
jgipper@opensystemsmedia.com

Curt Schwaderer, Editorial Director
Embedded Computing Design
cschwaderer@opensystemsmedia.com

Joe Pavlat, Editorial Director
PICMG Systems & Technology
jpavlat@opensystemsmedia.com

Rich Nass
Embedded Computing Brand Director
Embedded Computing Design
rnass@opensystemsmedia.com

Joy Gilmore
Assistant Webcast Manager
jgilmore@opensystemsmedia.com

Monique DeVoe, Managing Editor
Embedded Computing Design, DSP-FPGA.com
mdevoe@opensystemsmedia.com

Brandon Lewis, Assistant Managing Editor
PICMG Systems & Technology
Embedded Computing Design
Industrial Embedded Systems
blewis@opensystemsmedia.com

Rory Dear, Technical Contributor
Embedded Computing Design
rdear@opensystemsmedia.com

Konrad Witte, Senior Web Developer

Steph Sweet, Creative Director

David Diomede, Creative Services Director

Joann Toth, Senior Designer

Corporate

www.opensystemsmedia.com

Patrick Hopper, Publisher
phopper@opensystemsmedia.com

Rosemary Kristoff, President
rkristoff@opensystemsmedia.com

John McHale, Executive Vice President
jmchale@opensystemsmedia.com

Rich Nass, Executive Vice President
jmchale@opensystemsmedia.com

Wayne Kristoff, CTO

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Headquarters – ARIZONA:
16626 E. Avenue of the Fountains, Ste. 201
Fountain Hills, AZ 85268
Tel: (480) 967-5581

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Mercury Systems stirs up RF world with open standard initiative

By John McHale, Editorial Director

They're doing it again. Officials at Mercury Systems in Chelmsford, Mass., fed up with a lack of interoperability standards in the RF world, have decided to create one all by themselves. They have launched an initiative called OpenRFM that will create standard interfaces for RF boxes so that they can essentially be interoperable regardless of who built them. The move is bold and resembles their efforts to forge interoperability in the backplane with OpenVPX in 2009.

Back then they had opposition, but their critics/competitors were all part of the same VITA Standards Organization (VSO). With OpenRFM they are working without a standards group and targeting a market where proprietary architectures – not open ones – have been the rule.

There has been a lack of standardization on the microwave side, which has made upgrading technology challenging, says A. Lorne Graves, Chief Technologist, Embedded Products at Mercury. OpenRFM is looking to change that culture with affordable, modular, and scalable technology that can uplift existing systems, he adds. According to Mercury, OpenRFM essentially standardizes the interfaces of integrated microwave assemblies "to streamline the design and integration of RF and digital capabilities within sensor processing subsystems" in electronic warfare (EW) and signal intelligence (SIGINT) applications.

Mercury's OpenRFM products come in 3U and 6U form factors and can work with any module – VXS, VPX, VME, etc., Graves says. The products are protocol agnostic and also use a common test bed, which reduces development time. Currently Mercury has three main customers for three different missions spaces working on OpenRFM and providing feedback, Graves adds.

The company has strengthened their RF technology through acquisition over the last decade, snapping up key suppliers Echotek in 2005, LNX in 2011, and Micronetics in 2012. They also opened an Advanced Microwave Center earlier this year in Hudson, N.H.

Their RF pedigree gives them credibility, but I believe Mercury's efforts will prevail in the long run, because the company is responding to current procurement trends. Across the Department of Defense (DoD) there is a push toward commonality – using the same equipment, hardware, and software across multiple platforms to reduce operational and training costs. The government doesn't want to invest in proprietary technology and development and they don't want power points. They want tech that works today and that can be interoperable with other current systems, as this not only saves money but also improves efficiency, combats obsolescence, and eases training and maintenance.

Mercury's initiative reminds me of the DoD's efforts to create a common unmanned aircraft system (UAS) control station architecture – the UAS Control Segment (UCS). The DoD was tired of having to pay for a different ground control station for every UAS. The key UAS integrators were not happy at first, but they bought into the concept because their customer demanded it, and the UCS program is now moving forward.

Much like the UAS platform builders, Mercury's RF market competitors make their living off proprietary interfaces and architectures and will be loath to change, which is what makes Mercury's move so daring. However, the end user – the U.S. military – wants commonality and open architectures among all its systems.

Not the first time

Defining standards in the RF world will be a more difficult process than what Mercury experienced when they spurred OpenVPX because with OpenVPX they and the VSO members all had common goals, says Ray Alderman, Chairman of the VITA Board. "There were conflicts, but we sorted them out." That type of harmony doesn't exist in the RF world.

It wasn't harmonious at first when Mercury officials decided to work outside of VITA, after being frustrated with the lack of progress being made in the organization to develop the VITA 46 (VPX) standard. There was conflict among competitors, and at times the discussion got bogged down. As a result Mercury formed the OpenVPX Working Group, made up mostly of customers – primes – and stepped outside of VITA and the VSO's development process. Some members were not happy and felt left out for competitive reasons. However, nearly everyone got to play and eventually they came back to VITA, working together to get VPX ratified.

Alderman, who was initially skeptical of OpenVPX, says today it was an "amazing model." By developing about 50 percent of the standard externally "they saved months or maybe a year or more of development time."

He says he believes the OpenRFM effort will be successful as well. "Standardization is needed for the RF industry and it is what the end users – the government and the major primes such as Boeing and Lockheed Martin – want. It is really intriguing what Mercury has done, but there are 10 or 15 more areas where [standardization in military systems] needs to be done as well and the top primes want to do it," he continues. "This is only the beginning."

Digital image processing

By Charlotte Adams

A GE Intelligent Platforms perspective on embedded military electronics trends

High-definition (HD) digital electro-optic and infrared sensors are shoveling ever-more data into the battle space. How can soldiers get that information quickly enough to act on it in a timely manner? Intel data traditionally has been the preserve of the higher echelons, while trickle-down information has been the lot of the fighters in the field.

Part of the answer is the extension of high-resolution sensors from satellites and large manned aircraft to smaller unmanned platforms – and portable or handheld devices – that can link information to forces on the ground, even to small units looking over the next hill. These sensors and accompanying processors have been scaled down in size so that they can be mounted together in small gimbals, yet they provide more detailed imagery at longer ranges than was possible before.

Even very geo-specific data could confuse rather than clarify a local situation for soldiers in the stress of combat, when there is precious little time to interpret ambiguous imagery. The need for local information but also for clarity in its presentation has driven advances in real-time image processing, so that fighters can obtain the situational awareness they need to protect themselves and to act decisively against threats within tactical timelines.

Image processing gets sophisticated

Although the most modern sensors feature some processing at the point of collection, most images don't come out of the front end of the camera fit to be seen, much less understood. Images may be distorted and vertigo-inducing as a result of the motion of the sensor, as the gimbal swivels, and as the platform moves due to engine vibration, flight maneuvers, and turbulence. The targets may float out of the images if areas of interest are not consistently and accurately tracked.

High-resolution digital sensors are being phased into the inventory; while many analog interface sensors are still being deployed and shipped, they are increasingly being replaced with digital imagers. Digital signals don't have to be converted and can be more easily processed to enhance image quality. The

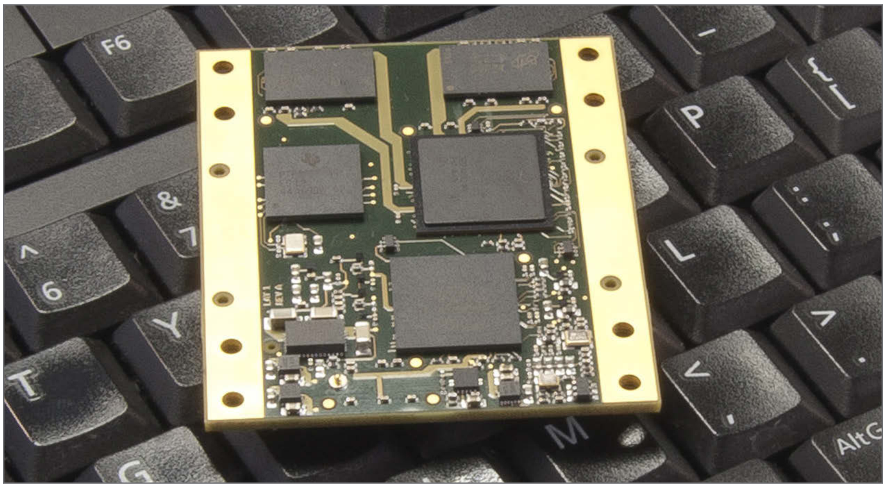

Figure 1 | The ADEPT4000 from GE enables the connected battlefield with one high-def video tracker card.

higher the resolution, for example, the more the user can zoom in on particular details. Sophisticated processing is still necessary to collect, stabilize, track, and compress this digital video imagery so that it can be transmitted to users without overwhelming data links.

Traditionally, real-time video trackers performed two essential tasks: stabilization and tracking. Stabilization removes unwanted movement and vibration in the image produced by the platform and the sensor. Tracking, on the other hand, keeps the target within the center of the sensor's field of view. Tracking algorithms send steering commands to the gimbal, based on target information derived from the sensor data.

The latest generation of automatic video trackers can also eliminate full rotational movement, allowing the image to be controlled in azimuth, elevation, and rotation axes. This advanced stabilization technology makes it easier and faster for users to see what's going on in an image or video. Some processing cards include built-in data compression as well, to minimize transmission bandwidth and give the user the ability to overlay images with other information such as GPS latitude/longitude, map coordinates, and time stamps.

These newer products also minimize latency by providing parallel-processing paths for handling multiple high-resolution targets simultaneously. They combine the latest ruggedized off-the-shelf processing technology together with field programmable gate arrays (FPGAs) for efficient data handling and processing.

One example of the new-generation, high-definition video tracker cards is GE's ADEPT4000, which provides tracking, stabilization, and compression of images up to 1080p30 resolution and frame rate, in a single one-ounce, sub-credit-card-sized, 5 W package with onboard Ethernet connectivity to enable the connected battlefield (see Figure 1).

In addition, the latest technology includes advanced, dynamic power-saving techniques, such as "sleep" modes, which prolong battery life, so that processing takes place only when the sensor is focusing on an area of interest. Size, weight, and power (SWaP) optimization is designed in from the start.

As today's forces engage in asymmetrical conflicts that demand real-time intelligence data at the tactical edge, the need grows for small, rugged, power-efficient computational packages with built-in connectivity at a reasonable cost. Image-processing technology is keeping pace with these tough demands by leveraging off-the-shelf hardware with innovative software and packaging.

defense.ge-ip.com

Convergence comes to GPU processing for C4ISR

By Marc Couture

An industry perspective from Curtiss-Wright Defense Solutions

We've seen it before: the trend towards convergence that adds formerly discrete functions into solutions that used to be vertically distinct. These days, for example, word-processing programs are hard to distinguish from page-layout programs. Or how about: Your phone is now a web browser. The same trend is now starting to affect how embedded systems designers leverage GPU processing for Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance (C4ISR) applications such as signal intelligence (SIGINT) and electronic warfare (EW). Until recently, a designer looking to take advantage of the large matrix of math-friendly single precision floating-point cores that make up a GPU had few options. The most common approach was to go with an appropriate dedicated GPU from NVIDIA, such as their Fermi or Kepler families, or one of AMD's Radeon devices. Times have changed, however; today, GPU options have expanded to include Intel's Core i7 products, whose built-in GPU functionality and AVX math library support continues to grow. On the FPGA front, we're starting to see devices with built-in ARM cores, while discrete GPU devices are delivering expanded functionality as well.

One of the key factors helping to make alternatives to dedicated GPUs more attractive for C4ISR system designers is the huge role that latency plays in SIGINT and EW applications. GPUs come out of the video and gaming markets where they are used to drive millions of pixels. While military system designers have put the massive floating-point throughput and internal pipelining architecture of GPUs to good use, these devices can't deliver the low latency needed for some of the most demanding applications. For many of these sense-and-response applications, dataflow must take place in nanoseconds and can literally be a matter of life and death. For some radar and SIGINT applications the latency performance of dedicated GPUs is acceptable, while for others it's not. The latency experience with GPUs results mostly from their use of multiple lanes of PCI Express (PCIe) to move data off-chip. In contrast, Intel's mobile class quad-core Core i7 processor has added an embedded GPU right next to the CPU. For example, the latest generation Core i7, the 4th generation "Haswell" device, features a GT2 embedded GPU in the silicon. The device's GPU and four processor cores are all interconnected at their last level cache. Because the data doesn't have to go off-chip to be processed, latency is greatly reduced compared to a dedicated GPU device. Even better, one can reasonably assume – based on past history and current Internet scuttlebutt – that the next generation of Core i7s will boast an even larger GPU. If Intel decides to double the GPU and increase the size of the cache, the result could be performance that rivals today's discrete GPU devices.

Convergence is also increasing on the software side. One trend that can help increase the use of general-purpose processors as math engines for C4ISR is the increasing popularity of OpenCL for parallel programming. Today, OpenCL can be used to program the Core i7's CPU and the AVX vector engines in the device's embedded GPU. Increasingly, though, OpenCL support is also found on FPGAs from leading vendors such as Altera and Xilinx, with Texas Instruments supporting OpenCL on its ARM devices. The promise is of a nearly "universal" programming language that can be used for programming the heterogeneous architectures typically found in C4ISR systems.

Another convergence trend seen on the FPGA front is the addition of floating-point units into devices. One could ask whether the resulting device looks more like a GPU than an FPGA. In addition to being programmable with OpenCL, FPGAs add another powerful advantage over GPUs in that FPGAs are extremely flexible when it comes to high speed I/O. Whether you require low-voltage differential signaling, differential signaling, or high-speed serial, FPGAs offer much greater flexibility when compared to discrete GPUs with their multiple lanes of PCIe.

GPU vendors aren't slowing down either: One convergence trend is the addition of ARM cores into discrete GPUs. Formerly, discrete GPUs required an Intel device to function as a proxy for system management. With a built-in ARM processor, however, the GPU can become much more autonomous: It will be able to directly receive sensor data, stand itself up, issue its own context switching and dynamic cache allocation, and the like. This setup can free discrete GPUs from the massive latency hit they now endure while changing modes, for example.

The good news is that all of this convergence, effectively expanding the periodic table of compute elements, will give C4ISR system designers so many more choices. OpenCL becoming virtually ubiquitous across so many platforms will enable system integrators to preserve a lot of their IP from tech refresh to tech refresh or from application to application. The application will then determine whether it is best to use a general-purpose processor, an FPGA, or a discrete GPU.

Marc Couture
Senior Product Manager, Intel, PowerPC, and GPGPU-based DSPs, ISR Solutions Group
Curtiss-Wright Defense Solutions
www.cwcdefense.com

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By Amanda Harvey, Assistant Editor

NEWS

Lockheed Martin ships MUOS-3 to Cape Canaveral

Navy and Lockheed Martin officials shipped the third Mobile User Objective System (MUOS) spacecraft to the Cape Canaveral Air Force Station in Florida, where it will be prepped for liftoff this January on a United Launch Alliance Atlas V rocket. MUOS operates similar to a smart phone cell tower in the sky, enhancing current secure mobile satellite communications for warfighters on the move. MUOS Wideband Code Division Multiple Access technology users will now have beyond-line-of-sight capability for the first time to transmit and receive voice and data via an Internet Protocol-based system.

Prior to the launch, Lockheed Martin engineers will finish post shipment testing, then fuel the satellite's propulsion system and the spacecraft will be encapsulated inside the launch vehicle's payload fairing. The spacecraft will then be integrated onto the top of an Atlas V launch vehicle for final integrated testing and closeout preparations for launch.

Figure 1 | Lockheed Martin engineers prepare to ship the third MUOS satellite to Cape Canaveral Air Force Station in Florida. Photo courtesy of Lockheed Martin.

Sigma Labs awarded Phase II DARPA contract for 3D metal printing

Honeywell Aerospace has granted Sigma Labs a Defense Advanced Research Project Agency (DARPA) Phase II award. Sigma Labs, a developer of advanced, in process, non-destructive quality inspection systems for metal-based additive manufacturing, completed Phase I of the contract earlier this year. DARPA's program goal is to develop an Integrated Computational Material Engineering (ICME) framework to more accurately predict the properties of metal components produced using additive manufacturing. Work on Phase II of the contract is expected to begin in quarter four of 2015 and run through mid-2016, with a total award value of approximately half a million dollars.

General Dynamics Electric Boat receives $84 million Navy contract modification

General Dynamics Electric Boat will continue development of the Common Missile Compartment for the Ohio replacement submarine and the UK's Successor ballistic-missile submarine with an $83.8 million contract modification from the U.S. Navy. The contract modification will provide funding for 17 tactical missile tubes – 12 for the UK Successor ballistic-missile submarine; four for the Ohio replacement submarine; and one for the Strategic Weapons System – Ashore test facility. It is expected that 241 missile tubes will be manufactured over the life of the program. This U.S. Navy five-year, $1.85 billion contract was initially awarded to General Dynamics Electric Boat in December 2012 to perform research and development (R&D) work for the Navy's next-generation ballistic-missile submarine. Construction is scheduled to begin in 2021, and the potential value of the overall contract is $2.3 billion.

Blighter Surveillance announces e-scan coastal radar enhancements

Blighter Surveillance Systems has announced new enhancements to its electronic-scanning (e-scan) radar for coastal and harbor security, including a new sea wave clutter filter. The new features will enable the e-scan radar to protect coastlines from enemy forces including pirates, smugglers, and terrorists arriving at a distance of as far as 6.2 miles (10 kilometers). The new features allow the radar system to detect and locate these small and slow-moving targets during day and night and in almost all weather conditions.

The low-power, solid-state, passive e-scan array radar features sensitive Doppler target detection and frequency modulated continuous wave (FMCW) transmission technology. The sea clutter filter technology enables the Doppler signal processing unit to filter out sea wave clutter returns in both amplitude and velocity. The small radar uses low power, transmitting only 4 W and consuming 100 W. Remote operation over narrowband wireless links or satellite communication systems is available due to the radar's low data bandwidth requirement.

Figure 2 | Blighter Surveillance's electronic-scanning radar can detect small and slow-moving enemy forces up to 10 km away. Photo courtesy of Blighter Surveillance Systems.

Northrop Grumman's MQ-8C Fire Scout UAS completes sloped landing test

Northrop Grumman's MQ-8C Fire Scout has successfully completed precision sloped landing tests at Point Mugu, Naval Base Ventura County. "The autonomous MQ-8C Fire Scout system is able to precisely track and understand the roll and pitch of the surface, which resembles at-sea conditions," said Capt. Patrick Smith, Fire Scout program manager at Naval Air Systems Command. The MQ-8C is the latest Fire Scout unmanned aerial system (UAS), which is designed to perform intelligence, surveillance, and reconnaissance (ISR) missions for the U.S. Navy. These flight tests will culminate in the MQ-8C Fire Scout's actual takeoff and landing at-sea on the deck of a Navy vessel. The MQ-8C Fire Scout has completed 219 flights and accumulated 287 flight hours since its first flight in October 2013. Recently, the MQ-8C has undergone electromagnetic testing and the initial phase of dynamic interface testing. The first ship-based series of flights are scheduled for late 2014.

Figure 3 | The MQ-8C Fire Scout unmanned aerial system (UAS) successfully completed its precision sloped landing test. Photo courtesy of Northrop Grumman.

Raytheon develops wearable computer system for intel operations

Raytheon engineers announced the company's wearable computing Intel-Ops solution at the AUSA 2014 Meeting and Exposition. The new solution merges a wearable computer system with Raytheon's situational awareness capabilities to provide an enhanced real-time view of the battlefield. The new Intelligence and Operations Convergence system integrates tech from existing Programs of Record such as the company's deployed Air Warrior wearable computing technologies and marries it with the DCGS-A Lite capability that enables troops to receive intelligence and generate new intelligence as they perform missions in bandwidth-challenged areas. The new system has been selected for demonstration to U.S. Special Forces in late 2014.

Army's Aerostat enabling airborne surveillance for U.S. borders

Lockheed Martin officials and the U.S. Army have extended the mission of the company's Persistent Threat Detection System (PTDS) aerostat system to be evaluated by the Department of Homeland Security (DHS) Customs and Border Protection (CBP) for operation along the Southern border of the United States. The U.S. Army uses PTDS to help troops identify threats, track insurgents, and enhance overall readiness for warfighters overseas. With the troop drawdown, more of the systems are becoming available for other uses.

PTDS can deliver panoramic day/night surveillance in extremely challenging weather and can remain continuously aloft at high altitudes. It differs from other persistent ground surveillance aerostats used before by CBP in that it can fly at greater altitudes for longer periods of time, thereby providing 24/7 coverage to a larger area. The system can also be equipped with multiple sensors, which may be easily and quickly interchanged in order to support different types of CBP missions.

Acromag announces new rugged SFF mission computer for deployable systems

Acromag has introduced a new rugged small form factor (SFF) mission computer, the ARCX box. It is engineered with size, weight, and power (SWaP) in mind, to address space requirements on vehicle electronics. The mission computer is designed for military and aerospace deployable systems, such as C4ISR, command and control applications, payload management, and vetronics. The cableless, fanless ARCX box is manufactured to IP67 standards and shock and vibration tested to MIL-STD-810G. The SFF mission computers are available as either single PMC/XMC slot or double PMC/XMC slot versions. Features include optional front I/O panel, mini PCIe, mSATA module slots, PMC, secondary connectors, and XMC. The ARCX box comes with a built-in power supply and power filter and equipped with a high-performance Intel 4th gen Core i5/i7 CPU.

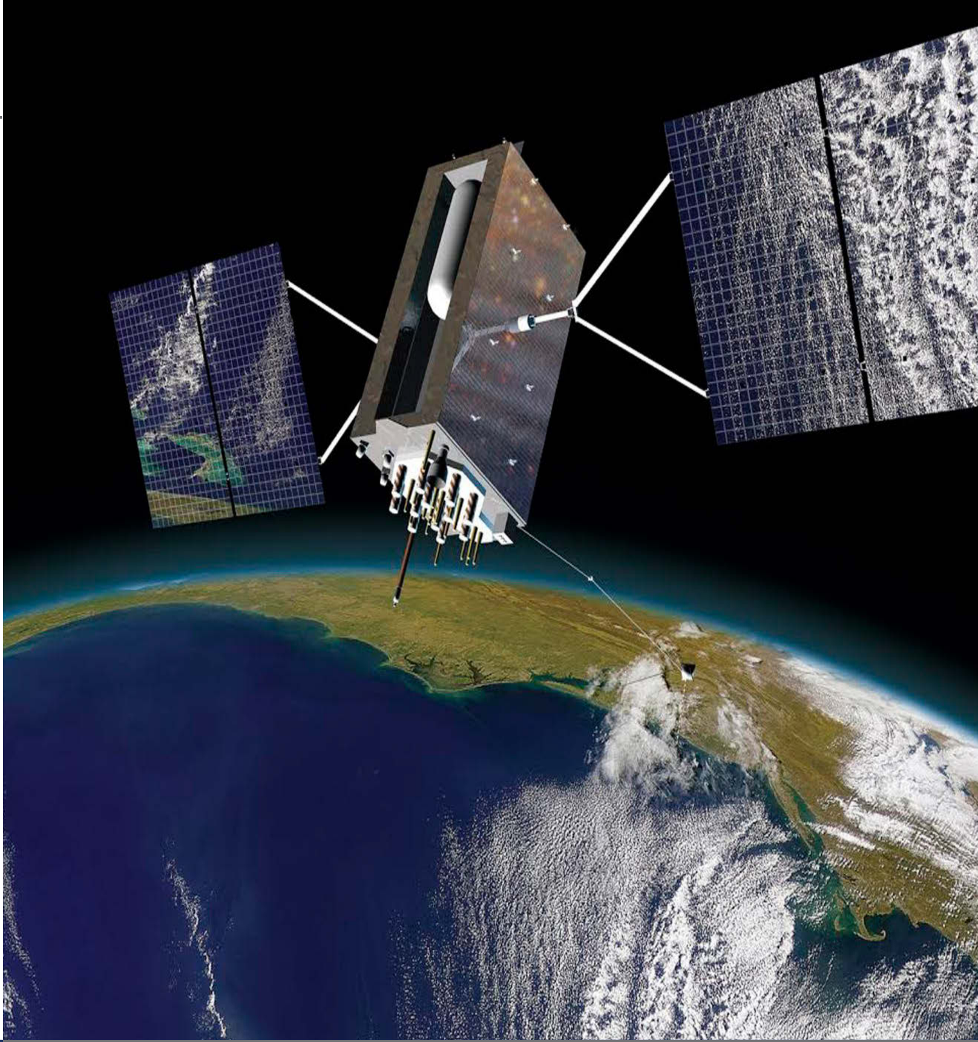
Figure 4 | Acromag's ARCX box is a rugged small form factor (SFF) mission computer for military and aerospace systems. Photo courtesy of Acromag.

NAVIGATION/GPS TECHNOLOGY
FOR MILITARY APPLICATIONS

Evolution of military navigation is well underway

By Sally Cole, Senior Editor

Military navigation is undergoing several significant changes – including the introduction of international satellite constellations, a transition from Selective Availability Anti-Spoofing Module (SAASM) secure GPS to M-code, and an increasing interest in augmenting GPS with other technologies.



Pictured is an artist rendering of Lockheed Martin's GPS III satellite. Photo courtesy of Lockheed Martin.

The combined launch of new international satellite constellations and arrival of modernized GPS, a.k.a. Military code or simply "M-code," means changes are underway on several fronts for the U.S. military and its allies in terms of achieving secure positioning, navigation, and timing (PNT) based on the global navigation satellite system (GNSS).

The GNSS currently encompasses all of the equipment capable of receiving signals from multiple satellite systems – including the U.S. NAVSTAR GPS and Russia's GLONASS, as well as Europe's Galileo and China's Beidou systems, which are in the process of being deployed now. France, Japan, and India also plan to send up regional geostationary satellites, which will become part of GNSS.

Many of the signals sent by the new constellations are extremely robust and contain more complex data than the original GPS system. Notably, signals from the new constellations don't necessarily operate within the same frequency bands as signals in the past, so it's necessary to ensure antennas are capable of receiving multiple satellite signals.

"As a global company serving the U.S. military and other militaries around the world, other countries' constellations will affect us and our markets," says Al Simon, marketing manager for Rockwell Collins (Cedar Rapids, Iowa; www.rockwellcollins.com). "Conversations with customers are evolving into discussions about which markets, constellations, and specific capabilities they'll need now."

Multi-constellation capability is a rapidly evolving requirement, particularly for international militaries, points out Nik Hartney, Honeywell Aerospace's director of Defense Navigation Aircraft (Phoenix, Ariz.; www.aerospace.honeywell.com). "Now that other countries are investing in their own constellations, they want to integrate them into their aircraft and navigation systems."

This entire space "is becoming very interesting, and one in which secure GPS or GNSS will be of value – both in terms of M-code or Galileo's PRS, which is Europe's encrypted equivalent capability," Simon notes.

M-code

The U.S. military is currently transitioning to next-generation GPS M-code, a central element in the modernization of military GPS capabilities.

"Upgrading to modernized or M-code, the follow-on to the current Selective Availability Anti-Spoofing Module (SAASM) military GPS signal in space, is a major priority for the U.S. military right now," says Hartney.

Honeywell is working to complete the first integration of an M-code receiver in its embedded GPS inertial navigation system (EGI) to prepare for the FY2017 mandate. During 2014, the industry made solid progress preparing for the M-code mandate. Rockwell Collins, for example, tested its "GB-GRAM-M" M-code GPS receiver – using live M-code signals – to navigate an AeroVironment RQ-11B

Raven unmanned aerial system. And the U.S. Air Force also demonstrated its M-code signal in a jamming environment using a Raytheon MAGR2K receiver.

In a related effort, backed by a $2 million contract from the U.S. Air Force Research Laboratory and the GPS Directorate, Rockwell Collins is developing a secure software-defined radio (S-SDR) GNSS receiver capability. "This program will help develop the security architecture required for future receiver equipment approvals and certifications," Simon says.

Augmented GPS for GPS-denied or degraded environments

For U.S. military operations within GPS-denied or degraded environments, relying solely on GPS for navigation isn't an option. "Everyone is pursuing a capability set that's robust enough to ensure navigation if GPS experiences a temporary outage, or, in a wild scenario, even a permanent outage," Simon says. "Navigation augmentation needs are different for each customer – it depends on the platform involved."

Inertial measurement units (IMUs) are emerging as one of the hottest topics of "augmented" conversations taking place now, because these sensors don't rely on external signals and can't be jammed. "The performance of IMUs has improved significantly and they've also become smaller and more affordable, so they're being discussed as legitimate navigation aids for specific missions," says Simon.

Honeywell makes high-accuracy embedded GPS/INS (EGI) navigation systems with inertial sensors for military aircraft, and Hartney explains that their high performance "is particularly important for GPS-denied environments – allowing the navigation system to 'coast' through GPS outages without significant degradation of accuracy."

Combining EGI with beam-forming anti-jam systems is another area Honeywell is focusing on. "Tests show this combination is capable of maintaining GPS tracking through the most significant jamming environments – with little to no degradation in accuracy," Hartney says (see Figure 1).

For scenarios in which GPS is truly denied, Honeywell is integrating other inertial aiding sources to provide GPS levels of accuracy. "These include a star tracker capable of geolocation, which provides full position updates to the inertial solution, Precision Terrain Aided Navigation for updating the inertial solution over known ground locations, visual aided navigation, and many more," Hartney explains.

In terms of other alternative technologies for GPS-denied environments, while DARPA and the military labs have all been exploring this realm for many years, we're finally on the front edge of seeing some of those technologies actually entering programs now.

The U.S. Army's Assured PNT program is one of the main ground navigation efforts helping to drive these technologies

Figure 1 | Pictured is Honeywell's EGI FALCN navigation system, launched this year. It is a smaller, lighter version of the company's H-764, for defense aircraft.

DARPA zeros in on next-gen technologies for GPS-denied environments

The U.S. Defense Advanced Research Projects Agency (DARPA) is actively exploring several next-generation technologies for positioning, navigation, and timing (PNT) – ranging from penny-sized inertial sensors, pulsed lasers, and tracked lightning strikes – to provide precise location-based insights within GPS-denied regions.

Many of the limitations associated with GPS can be traced directly to "weak signal strength, which prevents it from being used as a reliable standalone navigation system within buildings or canyons, dense foliage, as well as underground and undersea," explains Lin Haas, program manager of DARPA's Strategic Technology Office. DARPA's goal is to provide GPS-quality and better PNT to military users – regardless of the operational environment. To do this, DARPA is operating five separate programs devoted to developing smaller, more cost-effective, and improved inertial sensors for dead reckoning as well as earth-relative positioning sensors to complement GPS that use imagery, signals of opportunity, and yes, really, even lightning strikes.

Adaptable Navigation Systems (ANS)

DARPA's ANS program is creating algorithms and architectures for rapid plug-and-play integration of PNT sensors across multiple platforms. The main goal is to improve inertial measurement devices by using cold atom interferometry, which measures the relative acceleration and rotation of a cloud of atoms within a sensor. By leveraging quantum physical properties, the "Holy Grail of navigation" can be achieved: extremely accurate inertial measurement devices capable of operating for long periods without requiring external data to determine time and position.

Even long-duration inertial measurement units (IMUs) require an occasional position fix, so taking it a step further, DARPA researchers are exploiting non-navigational electromagnetic signals from commercial satellites, radio and television signals, and lightning strikes as additional points of reference for PNT. These sources are not only more abundant and provide stronger signals than GPS, according to DARPA, but in combination can enable position information in GPS-denied and GPS-degraded environments.

Microtechnology for PNT (Micro-PNT)

By leveraging microelectromechanical systems (MEMS) technology, DARPA's Micro-PNT researchers are developing highly stable and precise chip-scale gyroscopes, clocks, and complete integrated timing and inertial measurement devices (see Sidebar Figure 1).

An early prototype device combines three gyroscopes, three accelerometers, and a highly accurate clock-on-a-chip so tiny that it looks small on the face of a penny. It should enable not only dramatic cost reductions, but also size, weight, and power (SWaP) improvements.

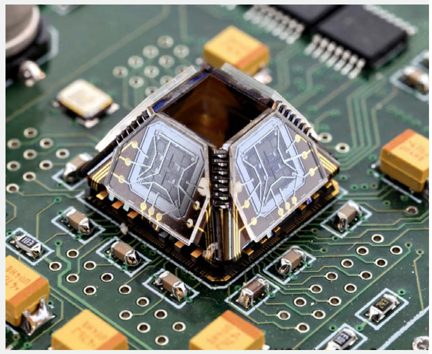
Quantum-Assisted Sensing and Readout (QuASAR)

Optical atomic clocks that are both precise and portable – boasting a timing error of less than 1 second in 5 billion years – could greatly enhance existing military systems such as GPS, according to DARPA, and also potentially enable entirely new radar, LIDAR, and metrology applications.

Program in Ultrafast Laser Science and Engineering (PULSE)

Cutting-edge pulsed laser technology is being applied to significantly reduce the size of and improve the precision of atomic clocks and microwave sources to enable more accurate time and frequency synchronization over large distances.

"PULSE uses the exquisitely stable light flashes emitted by optical frequency comb sources to develop techniques for synchronizing high-accuracy optical clocks embedded on distant, potentially mobile platforms," says



Sidebar Figure 1 | DARPA's Micro-PNT researchers have created a tiny device that combines three gyroscopes and accelerometers with a highly accurate clock-on-a-chip. Photo courtesy of DARPA.

Prem Kumar, program manager in DARPA's Defense Sciences Office.

Spatial, Temporal, and Orientation Information in Contested Environments (STOIC)

To provide GPS-independent PNT with GPS-level timing in contested environments, the STOIC program is combining three elements: long-range robust reference signals, ultra-stable tactical clocks, and multifunctional systems.

While GPS is the world standard in global navigation satellite systems and will likely continue to play a key role in navigation systems for the foreseeable future, DARPA's PNT programs are producing "adaptable navigation algorithms and architectures that can fuse data from any sensor that contains spatial or temporal information with GPS for a robust positioning and timing solution," notes Haas. And, of course, "embedded systems are standard features in most navigation systems – at least those DARPA is working with – from RF processing in software-defined radios to image processing in optoelectronic sensors," Haas adds.

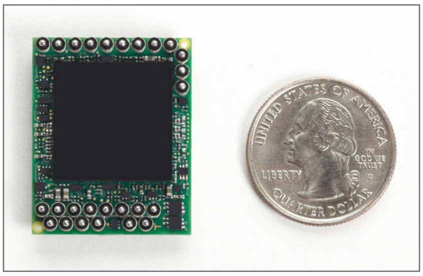


Figure 2 | Pictured is Rockwell Collins' small GPS receiver, the MicroGRAM.

forward, Simon points out. This program's mission is to provide optimal and affordable PNT capabilities with designs, products, and solutions that promote decisive action in all Army operations. To this end, Rockwell Collins has developed a stamp-sized GPS receiver, the MicroGRAM, which can be embedded into systems ranging from tactical radios to laser range finders (see Figure 2).

The Army is also actively pursuing pseudolite technology, which provides GPS-like service in electronically or physically challenging environments by broadcasting a signal similar to a GPS signal that can be used to supplement signals from GPS satellites. "Within a theater or battle region, pseudolites enable more GPS signal availability without requiring more satellites in the sky," Simon explains. "We're seeing strong interest in pseudolites, but also in chip-scale atomic clocks, MEMS IMUs, and star tracking."

Threat environment and security

In a "threat environment" in which there's a possibility of satellites or signals becoming unavailable, two very different philosophies are being discussed: Advocates who support not being completely reliant upon satellite-based navigation vs. satellite and space advocates whose position is that if a satellite goes down – even intentionally – the culprits couldn't get away with taking out more than one. Conversations of this type are likely underway at the most senior levels of the Department of Defense and, in fact, policy guidance is expected to emerge soon.

"During the past six months we've asked for clarity on this issue because it's a complex, confusing environment," Simon notes. "M-code is still in development and the user equipment is still maturing, so we'll likely be talking about this for several years."

Military receivers, from a security standpoint, are either based on SAASM or M-code and use encrypted signals and processing and algorithms, so vulnerabilities to hacking aren't a big concern. "The likelihood of a military receiver being hacked is minimal," Simon explains. "But once we start migrating to other devices or multisensor devices – with open service GNSS or GPS combined with other navigation augmentation – the manner in which it's protected becomes more of an issue. While the SAASM or M-code side of the receiver can be protected, the question becomes: Can the rest of the receiver be protected for users who have migrated to other sensors?"

This is a concern expressed by military users – even at the policy level. They need to be able to trust that receivers won't be vulnerable to attacks, so efforts are underway to develop algorithms to ensure continued receiver security. **MES**

Power supplies: Make them efficient and make them small

By Amanda Harvey, Assistant Editor

Small unmanned aircraft are driving reduced size, weight, and power requirements for electronics suppliers. Pictured is the Triton unmanned aircraft system as it completes its first flight from the Northrop Grumman manufacturing facility in Palmdale, Calif. U.S. Navy photo courtesy of Northrop Grumman by Daniel Perales.

Stringent size, weight, power, and cost (SWaP-C) requirements out of the Department of Defense (DoD) flavor nearly every military platform, but the most challenging letter in that acronym might well be the "P." Achieving highly efficient power supplies and power management schemes in small form factors is not easy, but new developments in VPX, solid-state solutions, and smart power management are meeting and exceeding the DoD's SWaP-C benchmarks.

Everything seems to be getting smaller in the U.S. military arsenal – whether it's an unmanned aerial vehicle (UAV), an intelligence, surveillance, and reconnaissance (ISR) payload, or a handheld GPS device. The electronics driving these systems are also getting more powerful and as a result generate more heat and at times require more power to run – not a perfect marriage for systems that need to perform on the battlefield.

Small systems offer an advantage to airborne applications specifically, in particular UAVs. "If you look at some of the UAV platforms, one pound equals so many miles of range they can get out of that UAV. Every pound makes a big difference to military customers, so a very compact, lightweight management system really helps," explains Steve Goldman, product line manager, SSPC, Data Device Corporation (DDC) in Bohemia, N.Y. (www.ddc-web.com).

Talking SWaP-C

All these conditions help fuel the popularity of the SWaP acronym, with a "C" for cost recently added due to the challenging budget environment. "The SWaP acronym is very key to what Vicor does in our core design strategy," says Tom Curatolo, director of Vicor's global defense and aerospace business in Andover, Mass (www.vicorpower.com). "SWaP is something we typically focus on with our technologies. We've got some proprietary technology that we brought to market recently that play very well for the military designs in regards to smaller size, lighter weight, and much higher power density."

The "C" in "SWaP-C" is also becoming more of an issue; with sequestration and recent budget constraints, a number of military customers now have a growing concern about cost, says Vicor's Curatolo. "We've seen a number of customers have a concern on some level about the cost and we've taken that into consideration with a lot of our new designs," he says. For SWaP-C requirements Vicor offers the VI chip, a PRM regulator sized at just 32.5 mm x 22 mm x 6.73 mm that meets MIL-STD-1275 and MIL-STD-704 requirements for ground vehicle and airborne requirements, respectively. The PRM regulator also provides increased power density over the previous generation, delivering 500 W of output power and a power density of 106 W/cm3 at 97.7 percent efficiency.

Although its first letter is not represented in SWaP-C, most experts feel efficiency is the most important characteristic when it comes to power supplies. "The trends in order of importance are still for higher efficiency, lower cost, lighter weight, and more power," says Jerry Hovdestad, director of COTS engineering for Behlman Electronics in Hauppauge, N.Y. (www.behlman.com).

For reduced SWaP requirements, engineers at SynQor in Boxborough, Mass., designed the military commercial off-the-shelf (M-COTS) EXA Series of isolated and fully regulated DC-DC converters. This product provides as much as 300 W of power in a quarter brick package. The EXA series has a 95 percent efficiency at full load and a 28V nominal input voltage – 16-40Vin range with a 50V transient for 1 second. They are offered in five different output voltages: 5V, 12V, 15V, 28V, and 50V. The quarter bricks meet MIL-HDBK-704, MIL-STD-1275, and MIL-STD-461 requirements when paired with the company's M-COTS EMI filters.

VPX and UPS

High performance computing and SWaP-C requirements often drive system integrators to choose VPX systems – specifically the 3U form factor – especially in UAV and ISR payloads and as a result VPX-based universal power supply (UPS) devices are in demand.

While VME-based UPS products are still healthy, it seems VPX is the most popular right now, presiding over CompactPCI and others. "VME is still being supported but most of the new high-end systems are using VPX for the improved data throughput and system performance," confirms Behlman's Hovdestad.

"Whether the application calls for an advanced payload or just to improve the performance of an existing system, the reduction in weight and improved processing speed offered by VPX offers significant system enhancements," he says. "The weight reduction gives extended flying time and the faster processing allows the same platform to gather more data and to obtain highly detailed information from that data."

Behlman's 3U OpenVPX VITA 62-compliant VPXtra 500M card is a COTS DC-DC power supply. The rugged, conduction cooled card delivers 550 W of DC power via

Smart power management via SSPCs

Solid-state power controllers (SSPCs) are enabling more efficient power management in military platforms.

SSPC "solutions are being used to replace traditional, electro-mechanical distribution components, with a solid-state solution," says Steve Goldman, product line manager, SSPC, Data Device Corporation (DDC) in Bohemia, N.Y. (www.ddc-web.com).

Sidebar Figure 1 | Solid-state power controllers from DDC: 32-channel board (back), lightweight and ruggedized PDUs (front).

This is being driven by a number of things, according to Goldman: customers are looking for better reliability over electro-mechanical implementations; they want reduced size and weight, especially for ground vehicles and aircraft systems; and they are also looking for smart power management.

"Smart power management includes things like load shedding, load sequencing, measuring or recording load diagnostics (like current levels of voltage on the load), and also the ability to be able to reconfigure the power distribution system to match up with different vehicle variants or different vehicle mission profiles," he explains (See Sidebar Figure 1).

SSPC implementations are convenient because they are programmable to serve multiple purposes, unlike traditional electro-mechanical systems, Goldman continues. "The traditional electro-mechanical systems were fixed – you'd have a fixed breaker at 20 amps and you'd have a whole rack of those, and so on. If you had a different variant for the same vehicle, you'd have to reconfigure that whole system from scratch every time. Whereas with SSPC implementations, everything is programmable, so you can use the same part number essentially, or LRU [line replaceable unit], in the system and reprogram it to serve multiple purposes."

Originally only used in high-value military programs, solid-state solutions have become more cost-effective over time, and power density and operating ranges have increased significantly, making them more applicable for use in a wider range of military systems.

"The amount of power dissipated by these solid-state solutions are much lower, they fit into a wider range of applications than they did before, and the form factors are much more dense," Goldman says. "It's becoming a more and more common requirement as you see in systems going forward to use a solid-state solution."

six outputs, and is designed for mission-critical airborne, mobile, shipboard, and vehicle applications (see Figure 1).

SynQor also offers VITA 62-compliant VPX power supplies in the 3U and 6U packages. Each supports a nominal 28V DC input using the company's MilQor Mil-COTS product line. The 3U VPX has six standard VITA 62 outputs with a maximum total output power of 500 W over the full temperature range, while SynQor's 6U VPX device has two available options that have five standard VITA 62 outputs. The 1000 W 6U VPX version has a standard input filter and the 800 W 6U VPX version has an advanced filter that also enables input transient suppression, reverse polarity protection, inrush current limit, and surge protection. All three VPX Power Supplies comply with MIL-STD-461F, MIL-STD-704 (level dependent), and MIL-STD-810G. For more information, visit www.synqor.com.

Figure 1 | Behlman's 3U COTS VPXtra 500M card is designed for use in airborne, shipboard, vehicle, and mobile applications.

Thermal management

These super computing VPX boards with their impressive signal processing chips enable unprecedented capability, but also create thermal headaches – especially in small designs.

"The thermal management aspect is so key," Vicor's Curatolo says. "You can make things smaller and smaller and smaller, but if you can't cool it efficiently enough, then that defeats the purpose of making things smaller and lighter weight, when you have to add large heat sinks and whatnot to keep it cool."

Creative packaging is one solution to increase thermal management, such as "pulling heat out of all sides of the product rather than just having a single aluminum baseplate that a lot of the militarized bricks offer today," he continues. "We're looking at more creative ways of removing heat from the package."

Whether it's advancements in SWaP-C, solid-state solutions, VPX integration, or smart power management, military suppliers continue to focus on the efficiency of military power supplies for a wide range of applications.

"To assist the military through these solutions is key; we get their feedback, we understand their challenges, and then we try and take the technologies we have and make sure they align with the challenges and level of demanding applications that are out there," says Curatolo. **MES**

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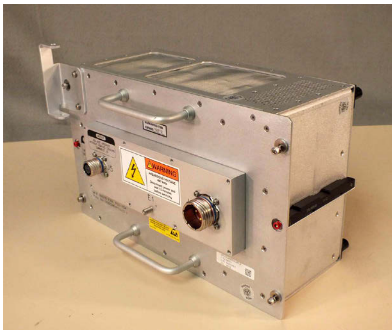

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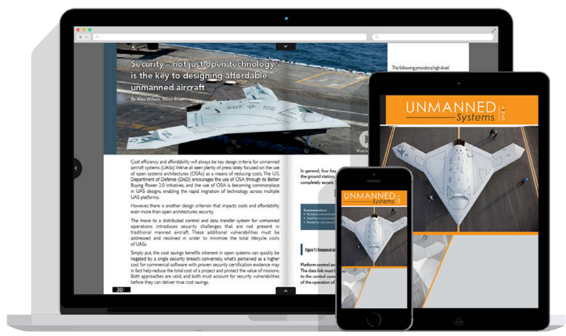

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MicroTCA: A force to be reckoned with for military, aerospace applications

By Justin Moll

Aircraft sit on the flight deck of the aircraft carrier USS Theodore Roosevelt (CVN 71).
U.S. Navy photo by Mass Communication Specialist Seaman Anthony N. Hilkowski.

For applications requiring high performance, versatility, and reliability in a backplane-based system, the three main choices for open-standard computing architectures are OpenVPX, MicroTCA (MTCA), and AdvancedTCA (ATCA). For military and aerospace applications, AdvancedTCA often can't compete on size, weight, and power (SWaP) unless its massive throughput is critical. Of the two remaining primary options, MicroTCA recently has been chosen over VPX in several new military and aerospace applications where VPX once dominated, ranging from airborne and naval settings to ground-vehicle-mount and fixed radar installations.

What has changed?

MicroTCA has been around for eight years now, but in the last 18 months, it has seen increased interest from and adoption by the military and aerospace community. Why is MicroTCA increasingly beating out VPX? To begin with, MicroTCA is a commercial off-the-shelf (COTS)-interoperable architecture, with rugged specifications already ratified and available. Its mature, proven architecture has seen some high-performance advancements, while the vendor base has stabilized and improved. Moreover, low price is now a top tier concern for prime contractors.

About MicroTCA

MicroTCA originally stems from AdvancedTCA, which has been around for more than 10 years. The MicroTCA advanced mezzanine card (AMC) was a mezzanine approach that plugged into ATCA carrier blades. Subsequently, the PICMG group proposed a solution for these AMCs to plug directly into a backplane, called MicroTCA. Most importantly, the specification adopted the shelf-management/intelligent platform-management interface (IPMI) features of AdvancedTCA.

The key characteristics of MicroTCA are its modularity and scalability. The open-standard architecture is also fully redundant (meaning no single point of failure exists in the architecture). It boasts a 99.99999 percent uptime, has hot-swappable modules, and can handle high-speed serial as fast as 10 Gbps per lane (40 GbE is in draft specification). Its clock distribution has redundant clocking options, while its truly open COTS architecture is applicable to multiple markets (military/aerospace, communications, physics, etc.). The MicroTCA architecture is also available in commercial and rugged versions.

Comparing VPX

VPX is also a high-speed serial, modular, open standard architecture, offering considerable flexibility and I/O pins in a rugged form factor. However, VPX does not have the inherent system management, e-keying, clocking, or inherent interoperability of MicroTCA. MicroTCA is also smaller, at 75 mm x 180 mm – compared with 133.25 mm x 160 mm for VPX – providing an advantage in the "S"

Figure 1 | An example of MicroTCA.3 modules in conduction-cooled clamshells and an ATR chassis. Standard AMCs can easily be ruggedized with the clamshells to meet MIL-STD shock and vibration levels.

and "W" portions of SWaP (the typical card pitch is the same).

Vendor base

In poker, the weak hands will often fold when the bets get bigger. In the embedded industry, the less serious vendors will pack their bags when they realize that they can't continue to invest in or support the product line to remain competitive. When MicroTCA first arrived, dozens of vendors entered the market without fully understanding the specification and what was required to succeed. At the same time, the specification seemed overhyped, promising to be everything to everyone. The result was a bubble of vendors who introduced, in too many cases, products that did not meet the specification. This misstep left a bad taste in the mouths of many frustrated customers. In contrast, the vendors developing today's MicroTCA products are experienced in the architecture and are able to provide a quality ecosystem of interoperable products. Dozens of interoperability workshops have been presented over the years to ensure that various vendors' products work well together.

MicroTCA.2 and MicroTCA.3

MicroTCA has been used in benign-environment military applications for many years. In 2011, MicroTCA.3 was introduced, providing hardened conduction-cooled options for standard AMCs (see Figure 1). The rugged clamshells provide stability for the connector. MicroTCA.3 has gone through the same testing as VPX – in fact, it underwent extra testing in some areas – at the same lab. Table 1 shows a chart of some of the testing.

The MicroTCA.2 standard – ratified in early 2013 – is similar to MicroTCA.3, except that it has air channels for a hybrid conduction/convection approach. One advantage of MicroTCA is that it is easy to ruggedize standard AMC modules to hardened versions with clamshells. The MTCA.2/.3 designs also provide the ability for Level 2 maintenance, giving at least the same level of ESD protection as VPX.

	MTCA.0	MTCA.1	MTCA.2/MTCA.3
MicroTCA specification-ruggedization level	Telco-centric spec for AMCs plugging into the backplane without modifications.	Industrial/semi-rugged spec for exterior and mobilized communications applications.	Hardened MTCA spec for rugged and military/aerospace wedge-lock design with airflow (MTCA.2) and no airflow (MTCA.3) over the modules.
Maximum operating shock	15 g	25 g	40 g
Maximum operating vibration	1 g sinusoidal	8 g random	12 g random
Operating temperature	-5 °C to +55 °C	Up to -40 °C to +55 °C	Up to -40 °C to +85 °C
Required retention mechanism	Hot-swap handle	Enhanced retention screw	Wedge locks

Table 1 | The MTCA connector passed the same testing (in some cases more extensive) for shock/vibration that the VPX connector went through, at the same lab.

Price is now a key factor

Sequestration and budget cuts have changed the equation for the technology choices for military and aerospace embedded systems. Price used to be a secondary concern for many applications; today, however, price at a comparable level of performance can push a design decision over the top. From a hardware perspective, MicroTCA systems are typically one-half of the cost (approximately) of comparable VPX systems.

A true COTS-interoperable architecture

MicroTCA is a true COTS architecture, used in applications from military and aerospace to communications to test and measurement and high-energy physics. VPX could basically be called MOTS (military off-the-shelf), primarily serving one market. COTS architectures have several benefits, including economies of scale, more versatile product offerings, and a position on the leading edge of performance, pushed there by the communications and physics communities.

As many of the modules and infrastructure products can be used across multiple markets, the same item that may be sold in volume to another market can be sold in small quantities to the military market at a competitive price. For example, a multichannel, high-speed A/D converter for a physics application can be tweaked for use in a military/aerospace sensor or in a radar/sonar application.

Throughout VPX's history, there has been frustration that the specification had interoperability issues. When VPX was started (primarily a concept by one vendor, later broadened to the wider VITA community), it had a very open pinout structure. If designers are dealing with only one vendor, this situation is fine, in that the single vendor will make sure that its boards and backplane are all interoperable. As use widened, however, it didn't take long for issues to emerge where one vendor's boards didn't work with other vendors'. In reaction, OpenVPX was created to define pinout configurations to be interoperable; the problem with this setup was that it was done after the fact. A vendor comes up with a configuration and says to the committee, "This is how you can be interoperable with this board." Another vendor then has to be willing to design a board to a pinout that works with their competitors'. A few "standard-ish" pinout types have emerged, but OpenVPX is far from a truly open interoperable ecosystem.

With MicroTCA, pinout definitions and rules were implemented upfront when the specification was formed, so that the full ecosystem of vendors' designs work together. In addition, MicroTCA holds regular interoperability workshops to ensure that next-generation products work with other products. Even though the specification is clear, when dealing with system-management features and high speeds, this effort is still beneficial and prudent.

Tech advancements gaining momentum

The MicroTCA architecture is also a key architecture of many communications

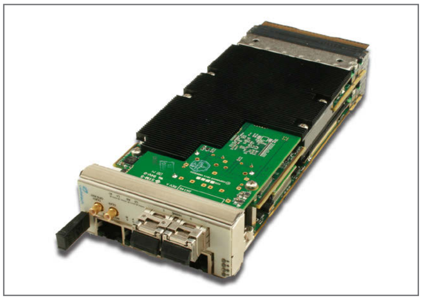


Figure 2 | The 40 G MCH provides GPS/IEEE1588/SyncE for precision timing and time-stamping, a prominent feature in many radar and target-acquisition applications.

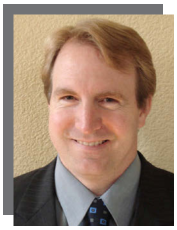
and high-energy physics applications, which means that the push for cutting-edge design is ongoing. For example, there are currently solutions in the market for 40 GbE (the specification is in draft). The industry's first 100 G line cards (via the front panel) were introduced in the MicroTCA form factor. Texas Instruments has also used MicroTCA as the architecture for its EVMK2Hx reference design card.

The architecture has also seen many design wins in military and aerospace projects. One project in particular found a prime military contractor choosing MicroTCA for a shipboard system to handle signal processing of sonar data from towed arrays or other sensors on the board. VadaTech developed a 1U solution for vibration and shock resistance in an isolated rack. The application uses a customized FPGA for beamforming.

We have also seen MicroTCA being chosen for a major European radar platform project; a prime contractor using MTCA on many platforms and several that are planned, including hardened versions; a prime contractor announcing that it chose MTCA over VPX on a rugged vehicle platform; MicroTCA being selected in a satellite system by a national lab; NASA selecting it for ground terminals in SGSS project; and the U.S. military choosing it for helicopter radar applications.

Many of the most cutting-edge digitizers/converters, processing solutions, GPGPUs, and storage are being made available in MicroTCA. Figure 2 shows a 40 G MCH with IEEE1588/SyncE/GPS for precision timing.

Designers looking for a high-performance open standard architecture will find MicroTCA to be an attractive solution. When it comes to SWaP-C, lower costs, higher reliability, cutting-edge designs, and a versatile COTS ecosystem, military and aerospace designers are increasingly moving from VPX to MicroTCA. **MES**



***Justin Moll** is Director of Marketing for VadaTech. With more than 15 years of embedded computing experience, Justin has previously worked in director- and management-level positions for electronics-packaging companies. He has a BS in Business Administration from the University of California, Riverside. Justin is active in the embedded industry and is currently the Chair of the 40 GbE over MicroTCA committee in PICMG. Readers may contact him at Justin@vadatech.com.*

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VITA AND PICMG STANDARDS FOR EMBEDDED MILITARY SYSTEMS

Using VITA 75 and standards-based modular design to address SWaP-C challenges

By David Pepper

A modular, standards-based approach to subsystems enables powerful computing capability in multiple applications such as unmanned aerial vehicles. Pictured is a RQ-7B Shadow launched by U.S. Marine Unmanned Aerial Squadron 2. Photo by Lance Cpl. S.T. Stewart.

As the world's armed forces look to deploy computing capability and unmanned vehicles ever closer to the battlefield edge, size, weight, and power (SWaP) are at a premium. The use of modular building blocks such as COM Express (PICMG COM.0) and/or XMC (VITA 42) – and, for packaging, the rugged small form factor (VITA 75) – represent an excellent means to address the requirements of minimizing size, weight, power, and cost (SWaP-C).

COM Express is an industry standard for computer-on-module that has been around for more than five years and has been widely adopted within the embedded computing industry. A COM Express module provides all the components necessary for a bootable host computer, with a standard set of I/O including Ethernet, PCIe, SATA, USB, and video that is then connected (via predefined connectors and I/O scheme) to a carrier. The carrier is required to break out the signals needed for a complete subsystem. Several sizes have been defined for the modules, enabling good scalability to a large set of applications. The COM Express basic module is defined to be 95 mm x 125 mm.

Although it's well suited to embedded applications, COM Express is not inherently suited to very extreme applications, such as the shock and vibration often found in airborne and ground vehicle applications. Historically, the technology has largely been deployed in benign industrial environments.

> … WITH THE CORRECT USE OF STANDARDS-BASED MODULAR BUILDING BLOCKS, STRICTER COST TARGETS CAN BE MET, ENABLING A VARIETY OF APPLICATIONS SUCH AS SMALL UNMANNED VEHICLES, LARGE AIRFRAMES, AND EVEN LARGER GROUND VEHICLE APPLICATIONS.

This shortcoming on the basic module can, however, be overcome by adding mounting holes. The base specification defines five mounting holes around the edge of the module for mounting, a configuration that leaves the middle of the board (especially in the area of the connector on a Type 6 module) somewhat subject to movement when stressed by vibration. Adding three holes (as seen in Figure 1) to relieve that movement provides for a very rugged module that can be readily used in harsh environments.

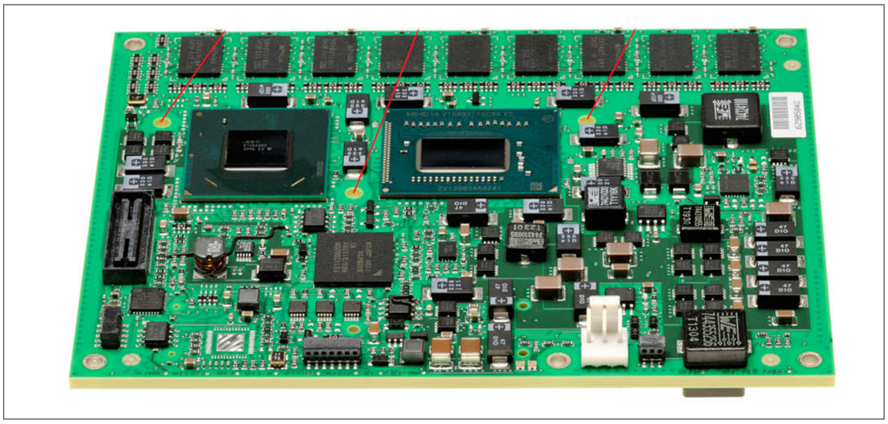


Figure 1 | Providing additional mounting holes significantly increases the ability of COM Express technology to be deployed in harsh environments.

In deployed environments where SWaP is constrained, the additional issue of cooling requires innovative techniques to ensure excellent thermal contact to the CPU die of the module and eliminate the issues posed by height and tolerance mismatches of the CPU die. These techniques are particularly important when working with today's higher-power quad-core processors such as the 3rd and 4th generation i7 CPUs from Intel or multicore Power Architecture CPUs available from Freescale.

COM Express can also provide a good technology migration path, as consideration has been given to the latest high-speed protocols such as PCIe Gen 3. While some special design considerations – such as PCIe re-drivers – may be required, the standard can handle the task of supporting the high-speed protocols that the latest generation processors provide.

Moreover, the modular approach provides excellent risk mitigation in terms of technology obsolescence and the opportunity for cost-effective technology insertion. As technology evolves, modules can be replaced and/or updated as needed, allowing support for long life cycle programs. While module replacement would not be done in the field, the actual update could be performed with minimal effect and could well have no impact on the cooling or power considerations of the platform.

XMC mezzanine standard

XMC is a mezzanine standard that supports switched high-speed interconnect protocols (such as PCIe Gen 1/2/3). Use of XMC as an expansion mezzanine within a subsystem is an excellent choice, as it provides the ability to bring in application-specific capability such as communications (1553 and/or ARINC, for example), graphics, storage, and many others. Moreover, it defines a robust connector system for the fabric and I/O, allowing support for a wide range of applications.

A somewhat recent update to the XMC standard (XMC 2.0) is the addition of an alternative connector (VITA 61) that has been electrically characterized to support 7.5 Gbps, allowing support for PCIe Gen 2 (with good margin) and the possibility of supporting Gen 3 (simulation recommended). As XMC is defined to support both air- and conduction-cooled applications, it is readily applicable to harsh environments.

VITA 75 rugged small form factor

VITA 75 is the response to the accelerating customer demand for increasingly small, lightweight, embedded computing subsystems. It defines the envelope within which the subsystem must fit, the external power and signal interfaces, the mechanical mounting interfaces, and any cooling interfaces. VITA 75 also addresses what's inside the box.

Currently, VITA 75 is a rugged small form factor (SFF) trial use standard that has been available for about two years. The intent is for the trial to extend to about 36 months; at that point, input will be collected and revisions made as needed and it will likely move forward for submission to ANSI.

Several elements of VITA 75 make it particularly compelling in applications where SWaP-C needs to be minimized. First, it allows for a range of front-panel profiles, so that connector and I/O needs can be addressed as needed. Next, it defines a wide range of envelopes, with the smallest occupying a volume of less than 0.05 cubic feet. One of the most compelling elements of VITA 75 is that it defines various types of modules (printed wire assemblies) supporting both bladed – with a module plugged into a backplane – and stacked, featuring modules plugged into each other with no backplane required. As the specification evolves, other module types may be envisioned and defined as needed.

Three types of cooling are currently defined to enable a range of applications: free convection, forced air, and conduct to cold plate. Generally, most applications of the standard will involve either forced air or conduct to cold plate cooling.

Figure 2 | GE's MAGIC1 rugged display computer can deliver over 900 GFLOPS of performance from a small, lightweight subsystem.

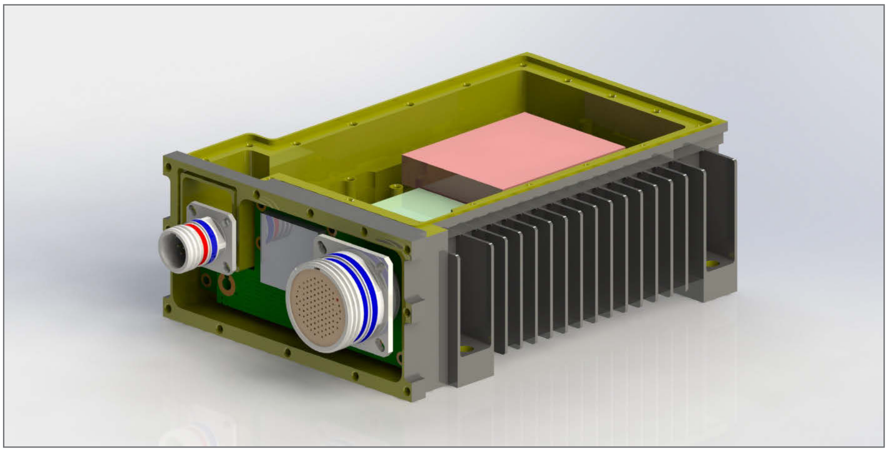


Figure 3 | VITA 75/COM Express could be combined to deliver excellent compute performance from a subsystem with minimal size and weight requirements.

Combining COM Express and XMC within VITA 75 for a complete SFF subsystem

Embedded system design involves, inevitably, a series of tradeoffs in which the designer allocates appropriate priority to key characteristics – which include, at the top level, a trade-off between raw computing performance on the one hand, and SWaP on the other. The goal is typically to maximize available throughput while minimizing SWaP.

Representative of what's possible today is GE's MAGIC1 (see Figure 2). Based on the VITA OpenVPX standard in its 3U form, this rugged SFF system delivers a lower SWaP profile with its size of less than 0.1 cubic feet, weight of less than 12 pounds, and power consumption of less than 120 W. By combining a single-board computer (SBC) and a graphics processing unit (GPU), it allows a relatively small, lightweight subsystem to deliver >900 GFLOPS of peak performance.

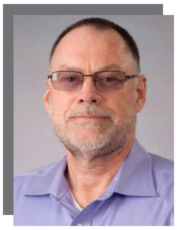
While such a system has many applications, it might not be suitable for applications where such significant processing power is unnecessary but minimal SWaP is a high priority.

Using the modular building blocks discussed above, together with VITA 75, it's possible to envisage a SFF subsystem (see Figure 3) with the characteristics required of a system with substantially superior SWaP to the 3U VPX system described previously. With the use of a quad-core Intel architecture COM Express basic module, along with other I/O as needed (1553 via an XMC, for example), a subsystem can be built that provides about 75 GFLOPS of peak compute performance. In this configuration, however, the size is much smaller at about 0.05 cubic feet, the weight is less than five pounds, and power consumption is less than 50 W. Of course, performance can be scaled back if very low power is a prerequisite (to maximize mission length, for example) to less than 25 W if needed.

One potentially significant advantage of taking this type of building-block approach is that higher-cost connectors and backplane systems can be avoided by stacking the building blocks (a COM Express module connected to a common carrier with the additional ability to host an XMC mezzanine for expansion). Such a stacked approach can also avoid some of the signal-integrity challenges that a traditional daughtercard/backplane approach may have. Special consideration is still required in the design, as connector-insertion loss, printed circuit board dielectric, and signal trace lengths must all be carefully managed to support high-speed protocols such as PCIe Gen 3.

Standards-based modular approach

A modular approach, along with the correct subsystem standard such as COM Express, can enable excellent SWaP-C conditions. In the harsh environment of the battlefield, the combination of rugged COM Express, together with VITA 75, enables the development and deployment of subsystems that can be scaled across a range of envelopes and use a wide range of cooling and mounting techniques. Additionally, with the correct use of standards-based modular building blocks, stricter cost targets can be met, enabling a variety of applications such as small unmanned vehicles, large airframes, and even larger ground vehicle applications. The combination of COM Express and VITA 75 holds great promise for the challenges inherent in bringing increasingly powerful computing closer to the battlefield edge. **MES**



David Pepper *is Product Manager/Technologist, Military/Aerospace Products for GE Intelligent Platforms. Over the past 16 years, he has primarily focused on standard form factors (CompactPCI, VME, and VPX) using ARM, Freescale, Intel, and NVIDIA technologies. David's current efforts are towards achieving the highest compute densities possible in these form factors while continuing to recognize the need to address SWaP-C concerns. Prior to GE, David spent 19 years at NASA's Marshall Space Flight Center. He has a BS from Athens State University and an MS from Southeastern Institute of Technology.*

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SpaceVPX extends the embedded computing standard to meet the special demands of space

By Gregory Powers

Image courtesy of NASA.

Space vehicles, whether manned or unmanned, have traditionally relied on custom embedded computing systems. Since standard systems were not designed with space applications in mind, they did not address the critical issues of space flight, such as outgassing, "tin whiskers," redundancy, and ruggedness. Designers and engineers, however, recognize the benefits of using well-established, standardized, open-architecture platforms to create a diverse ecosystem offering more choices, lower costs, and reduced risk. The availability of space-centric standardized platforms brings the advantages of a competitive environment, lower development costs, and higher reliability.

Using open standards means not having to repeatedly climb the learning curve for new designs. Reuse of hardware, firmware, and software shortens design cycles and lowers life cycle costs. It can also allow designers to focus on pressing issues like reduced size, weight, and power consumption (SWaP), which is always a leading priority in space applications.

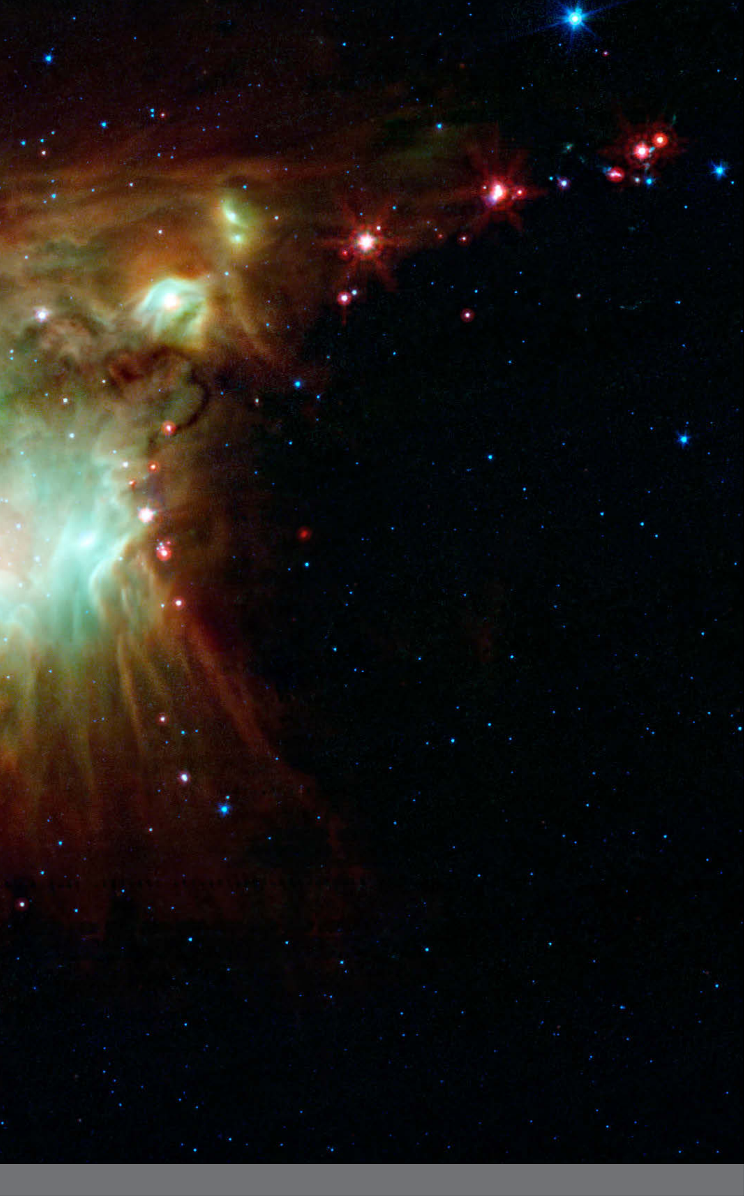
Designing for reliability

SpaceVPX, also known as VITA 78, uses the VITA 65 OpenVPX backplane standard as the basis for space-capable systems. Developed by the VITA 78 working group as part of the Next Generation Space Interconnection Standard (NGSIS), SpaceVPX enhances the VPX standard with features required for space. Thus, SpaceVPX addresses a number of issues critical to spaceflight not covered by VPX (see Figure 1):

- Single-point failure tolerance through redundant power distribution and fault detection on critical configuration signals
- Spare modules that can be powered on and off as needed
- System management with support for new features
- Robust system diagnostics

SpaceVPX adds a dual-redundant utility-management module and plane to manage the new features. Similar to the profiles created in OpenVPX, SpaceVPX also defines profiles for payload, control, memory, and switching.

The U.S. Air Force Research Laboratory (AFRL), which launched NGSIS in 2011, was searching for a standards committee to host their NGSIS and came to VITA. They determined that



VPX would be an acceptable architecture and initiated a Study Group in March 2012 that became VITA 78.

A strawman was developed outside the public realm of the VITA Standards Organization (VSO) until International Traffic in Arms Regulations (ITAR) clearance was achieved. VITA 78 then transitioned to a functioning VITA 78 Working Group in early fall of 2013.

VITA 78 is now in the latter stages of development, having recently gone through a Working Group ballot. From there it will proceed to a VSO ballot, then be submitted for ANSI approval. Time frames on this process are not highly regimented, as the ballots are really tools to solicit comments; the time frame for release can vary depending on the number of comments and the time needed to resolve the comments. The AFRL has led the initiative, assisted by multiple OEMs.

SpaceVPX connectivity: Ultra-rugged

Designing an embedded computing system for space requires a solution that not only withstands the extreme vibrations of liftoff, but also handles the extreme temperatures, background radiation, and other harsh conditions of extraterrestrial travel.

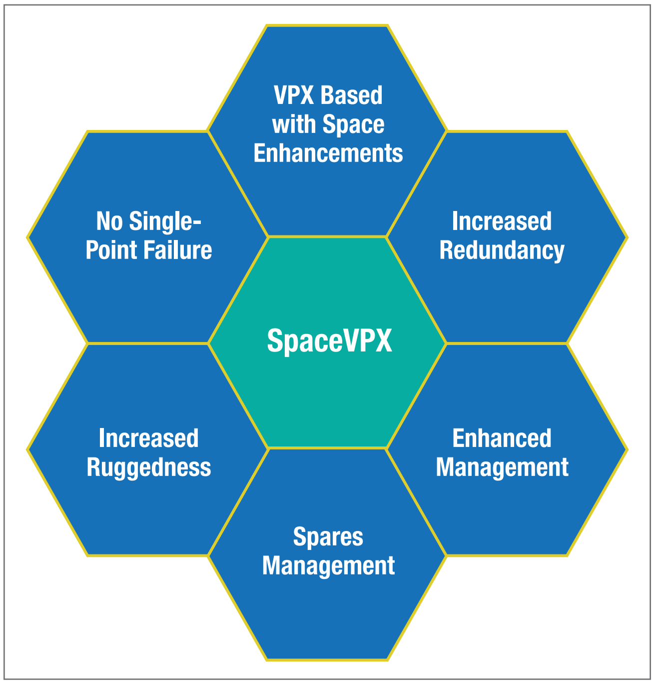


Figure 1 | SpaceVPX builds on VPX with enhancements for space-related issues.

The TE Connectivity backplane connector chosen for SpaceVPX, the MULTIGIG RT 2-R connector, is a backwards-compatible variant of the VITA 46 VPX connector, the MULTIGIG RT 2 connector. The MULTIGIG RT 2 connector, the standard for VITA 46 VPX, represented a huge step forward in the world of rugged embedded computing and is deployed globally in applications ranging from armored vehicle vetronics and helicopter radar avionics to space applications. The modular connector system features a protected backplane connector and uses a pinless wafer design in place of pin contacts, an approach well-established in commercial applications. Wafers – available for differential, single-ended, and power needs – can be easily modified to support specific customer needs for characteristic impedance, propagation delay, and other electrical parameters. Even though the wafers can be "tuned" to specific electrical needs, standard wafers, for instance, 100-ohm wafers for differential signals, suffice in most cases.

The VITA 46 MULTIGIG RT 2 connector is qualified to VITA 47 environments. For optimal design factors of safety, SpaceVPX looks beyond VITA 47 to incorporate both enhanced environmental performance and design redundancy, together with consistent space-design paradigms. Relative to environmental concerns, new testing levels have been explored to characterize the interconnects beyond the severest-anticipated exposure levels. One such public initiative has been the VITA 72 study group. The VITA 72 group devised the vibration "torture test," exposing a 6U VPX test unit to random vibration levels of 0.2 g2/Hz for 12 hours. To meet the requirements of VITA 72, TE engineers modified the contact system of the VITA 46 connector to provide quad-redundant contact rather than the two points of the existing system. Increasing the points of redundancy increases reliability in a high vibration environment. The new MULTIGIG RT 2-R connector doubles the points of contact between the receptacle contact and the wafer, thereby providing SpaceVPX designers with both access to a massive and time-tested VPX ecosystem and the redundancy desired for space flight applications.

Beyond its ultra-rugged design, the MULTIGIG RT 2-R connector has several other features that make it attractive for space applications.

- The MULTIGIG RT 2-R version is a very light VPX backplane connector. In traditional backplane connector designs, the plug-in module connector is often the heavy half, but the MULTIGIG connector's minimalistic design takes advantage of significant air gap rather than heavy polymer.
- It meets NASA outgassing requirements total mass loss (TML) of 1.0 percent and collected volatile condensable materials (CVCM) of less than 0.01 percent. Outgassing, which is the release of gases trapped in a solid, is an issue since the gases can degrade performance of charge-coupled device (CCD) sensors in satellites, thermal radiators, or solar cells. Outgassing is a challenge to creating and maintaining clean, high-vacuum environments. Moreover, the closed environment of spacecraft can make outgassing an even greater concern.
- Because the connector avoids use of pure tin, it therefore does not promote growth of so-called tin whiskers that can be a source of shorting between contacts, between printed circuit board pads, and between contacts and pads. Tin whiskers can also lead to metal vapor arcs, which occurs when the solid metal whisker is vaporized into a plasma of highly conductive metal ions that can form an arc capable of carrying hundreds of amperes. Tin whiskers have been demonstrated as a significant potential failure mode for on-orbit satellite failure.

VPX is the prevalent standard for embedded high-performance computing, with a data rate demonstrated above 10 Gbps. Benefiting from several years of evolution, the VPX ecosystem is highly diverse, providing designers with an array of choices for single-ended and differential signals, mezzanine, power, optical, and RF connectivity. As VPX has evolved, new standards have been created to deliver a comprehensive range of interconnection needs. Figure 2 shows a notional configuration of signal, RF, and optical possibilities on a single card edge.

The additional connectors available for the ecosystem have not been fully evaluated for SpaceVPX applications, but initial examination has not identified any insurmountable issues. As designers look for additional connectivity solutions, those already part of the VPX ecosystem are leading candidates.

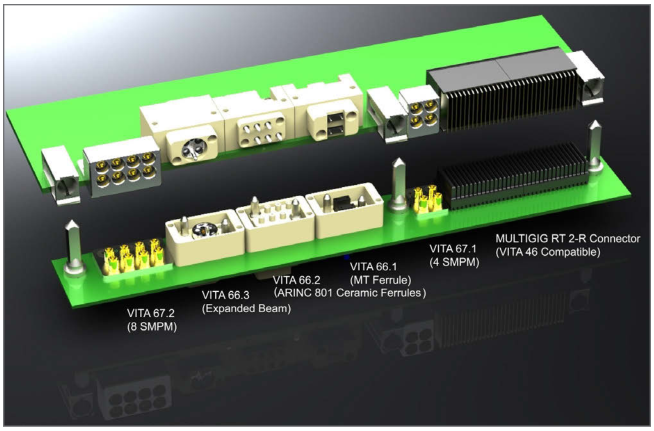
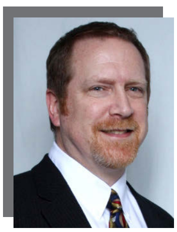


Figure 2 | The evolution of the VPX system means that new standards have been created to serve a range of interconnect needs. (Source: TE Connectivity.)

VPX takes to space

SpaceVPX builds on the well-established philosophy of combining open architectures and commercial off-the-shelf (COTS) products for high-performance embedded computing (HPEC). Not only does it enjoy the advantages of a robust competitive environment, it can also tap into the rich availability of products already introduced. At the same time, SpaceVPX extends the VPX standard to accommodate the unique needs of space flight to create a system that puts a top priority on redundancy and reliability in hostile environments. SpaceVPX can be seen as a prime example of dual-use technology, using the same connector deployed in countless VITA 46 VPX programs in development and putting it to work in space flight hardware.

The interconnect as offered by TE is already in production and has already flown, with VITA 78 SpaceVPX higher-level products currently in development. Release and flight or fielding of those products has not been announced; the public nature of those announcements may vary depending on whether it is a military or civilian mission. It is likely that integrators offering SpaceVPX-compliant product will make press announcements of product availability/fielding without naming specific missions. **MES**



Gregory Powers *serves as Market Development Manager for the Electronic Systems and Space segments within the Global Aerospace, Defense & Marine business unit of TE Connectivity. He received a B.S. in mechanical engineering from Syracuse University, has completed numerous graduate-level studies, and holds two patents relative to optical datacom devices. Readers can connect with Greg at www.DesignSmarterFaster.com.*

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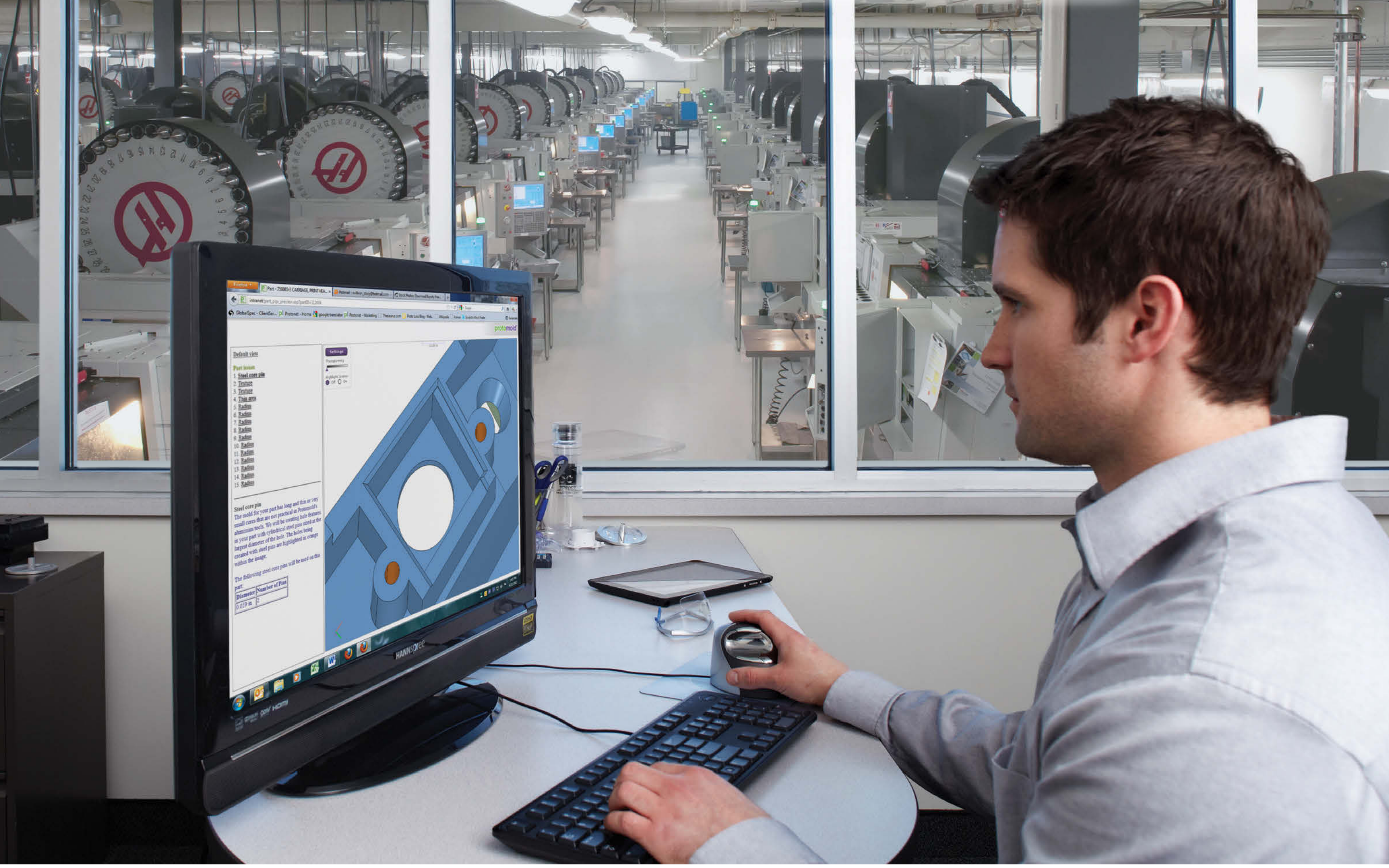

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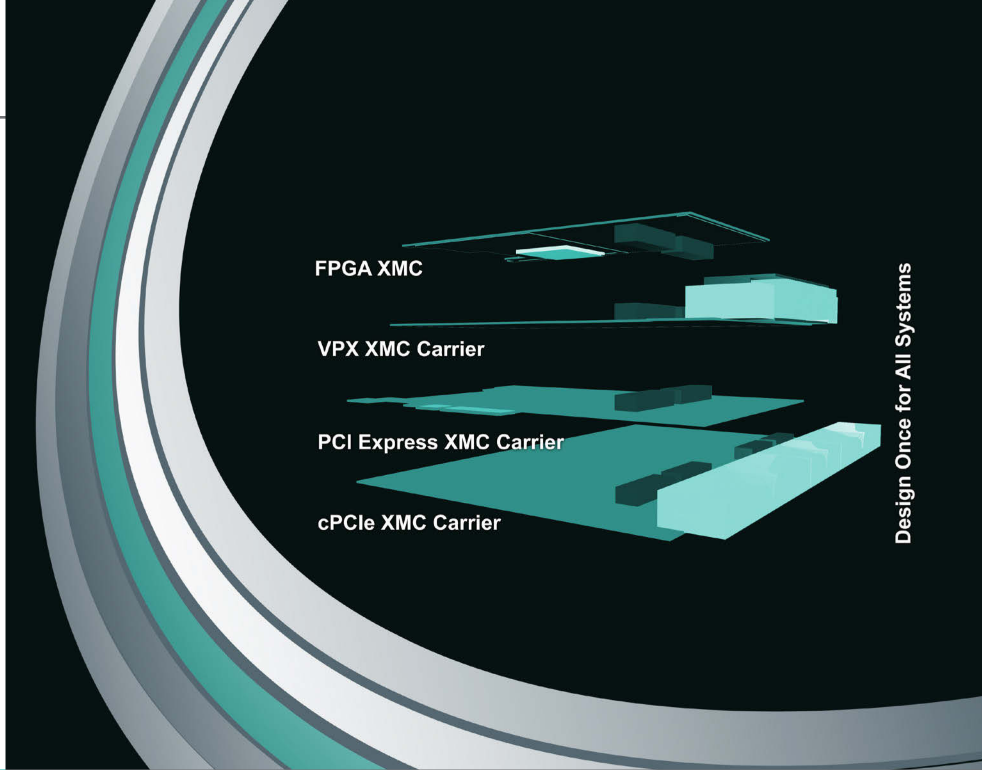
Interoperability key to adoption of VITA and PICMG standards in military, aerospace market

By Lewis Allison



Open standards mean that XMCs and FMCs can be plugged in and out of different systems like Lego bricks ("Design once for all systems"). Engineers can spend less time worrying about interoperability between subsystem components and more time working on application development. (Figure courtesy of Alpha Data.)

VITA and PICMG are the open standards bodies that define the specifications underpinning embedded form factors such as VPX and CompactPCI. Both groups continue to provide a vital service to commercial off-the-shelf (COTS) component manufacturers and customers alike, enabling engineers to spend less time worrying about interoperability between subsystem components and more time working on application development.

Let us consider a defense company embarking on a new radar design. Here are three common scenarios faced by the system integrator:

Assembling the first prototype of a new product
The budget and timeline have been agreed upon and VPX has been selected as the form factor. Subsystem blocks are to include multiple A/D and D/A converter modules, FPGAs for heavy-duty processing of the incoming data, and a single-board computer (SBC) to control the system as a whole.

Along with power-supply units, storage elements, and the chassis itself, all of these components are available as COTS products. With a wide range of vendors for each component, however, how can the engineers responsible for integrating the system be confident that each of these boards will be mechanically and electrically compatible, operate within a power budget, and be able to communicate with each other?

The answer, of course, is that each of these COTS products is compliant with VITA 46 and shares a common slot profile from the OpenVPX standard. Based around a high-speed switched interconnect, the VITA 46 (VPX) and the complementary VITA 65 (OpenVPX) standards provide a framework on which to design a new product, enabling designers to focus more of their energy on the real value of their product. For example, without worrying about interoperability, manufacturers of FPGA boards can concentrate less on the trivial aspects of the board such as pinouts and the polarity of reset signals and more on the intricacies of FPGA configuration, memory interfacing, and implementing DMA engines. An SBC manufacturer can worry less about the mechanical profile of its board and more on exposing the latest features of the chosen processor. The system integrator can be confident that I/O voltages will be compatible, transmit and receive channels will align, and that the boards will be able to communicate.

Inherent to this interoperability is reduced time to market and lowered costs in comparison with custom solutions.

THROUGHOUT THE WHOLE PRODUCT LIFE CYCLE, OPEN STANDARDS ENCOURAGE COMPETITION AND PROVIDE OPPORTUNITIES FOR LARGE AND SMALL MANUFACTURERS ALIKE.

Upgrading the product
The first prototype has been a wide success, but silicon developments mean that the chipset is now inferior to what's offered on the current commercial market and an upgrade is required. In a custom system, this would necessitate a complete redesign due to ingrained device footprints and arbitrary I/O allocation. Having designed to the VPX standard, however, the system integrator is

able to simply swap out boards containing outdated FPGAs, CPUs, or A/D devices and replace with the latest offerings from the various VPX vendors. Open standards bring flexibility and the ability to take advantage of technology improvements.

Changing the form factor

A potential new customer has emerged but with tighter size, weight, and power (SWaP) requirements. Thanks to open standards, much of the original system can be reused. With many vendors producing variations of their boards in different form factors, the system components and key algorithms can remain the same; once again the mechanics, electrical characteristics, and pinouts are guaranteed to work together.

Throughout the whole product life cycle, open standards encourage competition and provide opportunities for large and small manufacturers alike (see Figure 1).

Use of mezzanines in open standards

One of VITA's moves was the development of VITA 42, the XMC standard. XMC – the acronym for switched mezzanine card – inherits the physical sizing of the common mezzanine card (CMC) but adds support for switched interconnect standards such as PCI Express and RapidIO.

Measuring just 149 mm x 74 mm, XMCs can be plugged into PCI Express, CompactPCI, and VPX carriers. This ability to span a number of different architectures is advantageous during the early phases of defense projects. Before the final system is assembled, firmware and software engineers can begin development in a familiar desktop setup using XMCs plugged into a PCI Express carrier. This practice is particularly prevalent where FPGAs are involved, enabling engineers to gain a foothold in the use of the FPGA manufacturer's tools. Importantly, the same XMC can now be deployed in the final chassis-based system, whether that is VPX, CompactPCI, or another embedded architecture.

A number of vendors offer SBCs and FPGA cards in the XMC form factor. Alpha Data offers a range of XMCs featuring Xilinx Virtex 5, Virtex 6, and

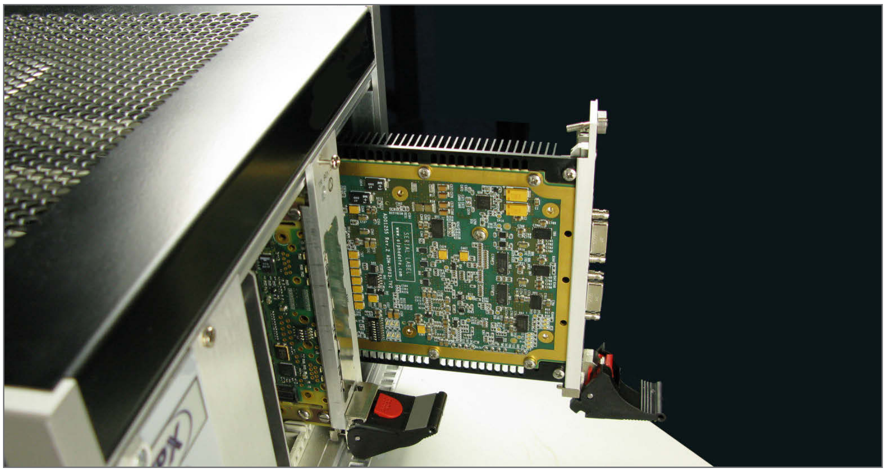


Figure 1 | Thanks to open standards such as VPX, COTS products from various manufacturers can easily be combined in a final system. (Image courtesy of Alpha Data.)

7-series FPGAs, which can be ordered as individual units or preassembled on a 3U VPX carrier (see Figure 2).

VITA 57, the specification for FMC (FPGA mezzanine card) is similar to XMC in that it can be plugged into larger form factors. The key difference with the FMC standard is that the focus is on adapting the I/O of the carrier module's FPGA, whereas the FPGA or CPU, whichever it is, is found on the XMC itself.

Both of these standards share that key ingredient to success in the military/aerospace market – interoperability. Due to the effort of the contributors to the VITA 42 and VITA 57 specification and their various sub-specifications, XMCs and FMCs can be plugged in and out of different systems like Lego bricks, changing the function of the system entirely. Such interoperability means that x86 processors can be swapped out for hybrid FPGA-ARM "system-on-chip" (SoC) devices, DSPs can be replaced by mass storage devices, and upgrades to denser silicon devices is straightforward.

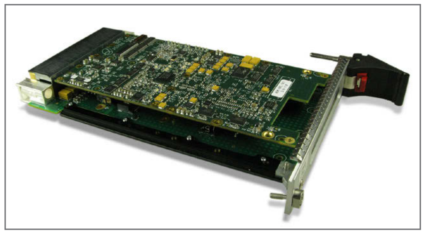


Figure 2 | Alpha Data's ADA-VPX3-7K1 is a Xilinx Kintex-7 based XMC pre-assembled on a 3U VPX carrier.

Looking ahead

While the likes of VPX, XMC, CompactPCI, and MicroTCA have gained a strong foothold in the military market, work on a trio of competing rugged small form factors is in full swing. VITA 73, 74, and 75 are all in the "Draft Standard for Trial Use" phase of development. While which of these the market will adopt remains to be seen, one thing we can be sure of is that interoperability between modules from numerous vendors will be vital to their success.

It's clear that the open-standards movement has made a sizable dent in the historically inflexible defense market. VITA and PICMG standards provide opportunities for board vendors to capitalize on their individual strengths, whether in processors, FPGAs, or any other common component in modern embedded systems. The bonus for system integrators: flexibility throughout the whole life cycle of their product. **MES**

Lewis Allison is a design engineer at Alpha Data Parallel Systems Ltd, a provider of high-end FPGA COTS products. He received a Masters of Engineering in Electronics and a Bachelors of Electrical Engineering degree from the University of Edinburgh. Readers may contact him at lewis.allison@alpha-data.com.

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VITA AND PICMG STANDARDS FOR EMBEDDED MILITARY SYSTEMS

The shift to standards-based hardware for military communications: What role will COTS systems play?

By Thomas J. Kelly

U.S. Army Cpt. Troy Peterson directs an AH-64 Apache attack helicopter strike on a target at the Close Combat Attack lane during the U.S. Army Europe Best Junior Officer Competition at the U.S. Army Garrison Grafenwoehr in Germany. DoD photo by Master Sgt. Robert Hyatt, U.S. Army.

A paradigm shift has taken place within the Department of Defense (DoD) when it comes to deciding which military hardware to use in the field. Traditional purpose-built platforms, with development cycles of five to seven years, have given way to commercial off-the-shelf (COTS) systems, which feature development cycles of just a few months. This shorter development time facilitates a much quicker response to emerging threats. COTS systems also have inherent cost savings that make them an attractive option. These systems are also much more complex than traditional proprietary systems, as they handle exponentially growing sources of information that require near-real-time analytical processing and a rich media experience for the end user. Given all this, the shift toward higher utilization of COTS hardware is a powerful tool for efficiently and effectively managing military threats.

There are many advantages for using standards-based equipment as the basis for designing a new system. Chief among these is the ability to leverage the research and development resources of outside organizations, enabling internal resources to focus on core competencies. Additionally, the DoD can access best-of-breed platforms from a multivendor ecosystem, thereby avoiding vendor lock-in. These factors also translate to greater parts availability, competitive pricing, and interoperability. Another advantage to leveraging standards-based hardware is that it has been validated by a community of users that develop and document best practices that can later be sourced. Finally, the fact that core compute, storage, and switching components will continue to evolve creates an ongoing need for the standardization, economies of scale, and proven technology provided by a COTS system (see Figure 1).

COTS systems based on industry-leading specifications from PICMG and VITA

COTS systems used in the aerospace and defense industry for battlespace communications networks are based on standards from PICMG and VITA, and provide access to the improved reliability, availability, and information processing of standardized equipment.

PICMG is the organization responsible for the development of the AdvancedTCA (ATCA) and computer-on-module (COM) Express specifications. ATCA- and COM Express-based form factors are beginning to be used extensively in the deployment of LTE networks for battlespace communications. PICMG currently focuses on developing and implementing specifications and guidelines for open standards-based computer architectures from a wide variety of interconnects.

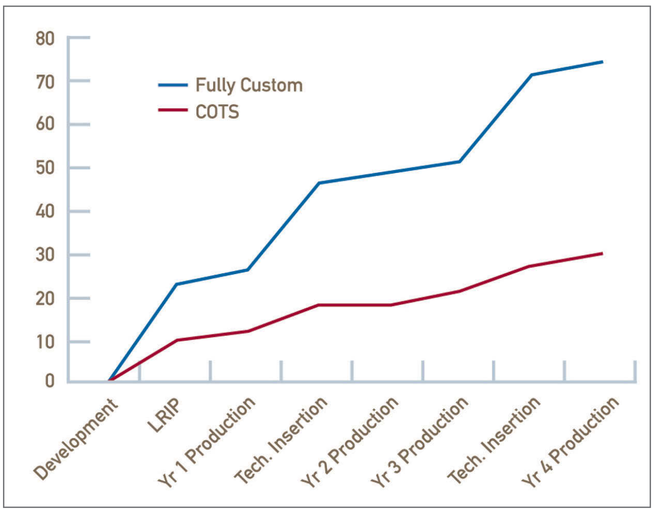

Figure 1 | Proprietary systems development cycles vs. COTS systems development cycles.

Members of the VITA Standards Organization (VSO) have worked together to define and develop key computer bus, board, and system specifications such as VMEbus, PCI Mezzanine Card (PMC), VXS, VPX, FMC, and others. In particular, VPX technologies are targeted at defense and aerospace.

PICMG and VITA specifications were developed to deliver critical infrastructure in embedded systems, with the resulting standards-based hardware meeting NEBS requirements. By taking the incremental step to adapt this hardware for MIL-STD, the systems can be leveraged in military applications that require ruggedized equipment.

High availability important for military applications

Being NEBS-compliant, these COTS systems are designed to provide 99.999 percent reliability, a level known as "five nines." A system designed with five nines as a basis will experience less than 5.26 minutes of downtime per year of operation. This level of high availability is gained through a combination of the inherent board designs along with the structured redundancy, monitoring, and reporting capabilities defined in the PICMG and VITA standards. The reduction and/or elimination of single points of failure, along with pre-emptive notification of events indicating excursion for defined operating characteristics, provides a robust foundation for mission-critical systems.

LTE technologies support failover, automatically switching to a redundant or standby hardware component upon the failure of one or more components. In addition, users can swap out failed system components with readily available and inexpensive COTS hardware in the field. Similarly, military users can quickly and easily scale the LTE communications infrastructure, adding COTS system building blocks and expanding capacity on demand and as needed.

COM Express and ATCA: Ultra-portable and ruggedized small form factors

Equipment manufacturers can develop military communications solutions using standards-based products offered in a variety of platform architectures and form factors that include COM Express and ATCA (see Figure 2). Since Intel processors are used across the board, developers can leverage a common code base.

COM Express modules are increasingly being used for military applications. Designed for the latest sets of chips and serial signaling protocols, COM Express modules deliver powerful processing in a small form factor. As military budgets shrink and battlespace needs evolve, more defense communications networks – from the base station through the core – are being consolidated into small, ruggedized communications platforms based on these COM Express modules. Platforms based on COM Express are small enough to allow an entire network to be picked up and moved, or even carried in a soldier's pack.

The standards-based COM Express form factor also enables future upgrades to the latest processor technology to continue to support demanding Command and Control (C2) applications. Radisys was the first to announce COM Express modules with Intel quad-core processing technology, along with ruggedized, extended temperature variants that equip defense customers with the processing power required for embedded technology applications.

COTS SYSTEMS USED IN THE AEROSPACE AND DEFENSE INDUSTRY FOR BATTLESPACE COMMUNICATIONS NETWORKS ARE BASED ON STANDARDS FROM PICMG AND VITA ...

ATCA specifications are designed to provide an open architecture that meets the next-generation requirements of carrier-grade communications equipment. ATCA is also ideally suited for challenging defense applications; LTE communications networks based on ATCA can support thousands of users, as ATCA delivers increased density and scalable performance.

VITA specifications gaining traction in the defense industry

According to a 2013 report by industry research firm IHS, 80 percent of the world market for VME and VPX components is in the defense industry (see Figure 3).

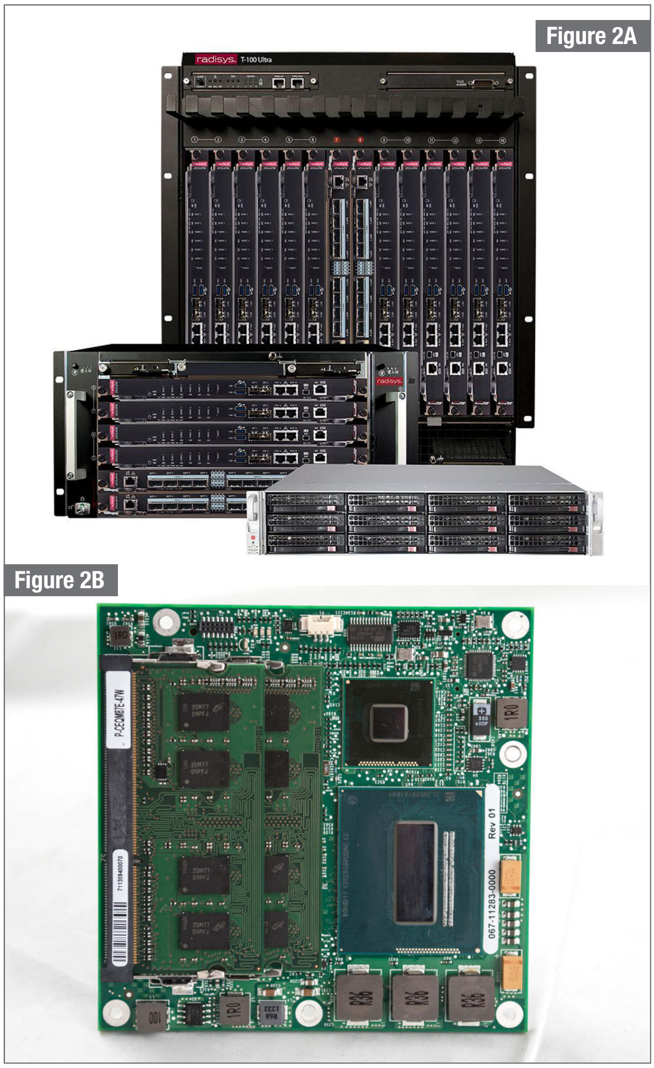

Figure 2 | COM Express modules and ATCA platforms are commonly used in the defense industry. Photos courtesy of Radisys.

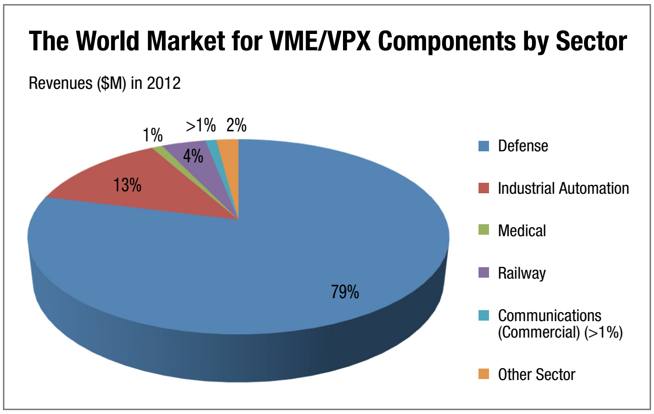

Figure 3 | VME and VPX components are primarily used for military applications. (Source: IHS.)

VPX is an ANSI/VITA 46.0-2007 standard that offers VMEbus-based systems support for switched fabrics over a high-speed connector. It was designed specifically for military applications, as the defense sector is the primary market for VPX technology today. VPX is used almost exclusively for military applications that require high performance and rugged computing platforms. In contrast, VMEbus technology was initially used primarily for industrial applications before gaining a foothold in defense. Products that support the VPX standard, available in 3U and 6U form factors, include single-board computers, multiprocessors, graphics processors, and FPGA-based processing modules.

What's ahead for standards-based hardware

Given the DoD's increased push for cost efficiency, better connectivity in the battlespace, reliability, and portability, the increasing role of standards-based COTS platforms in the future of military operations is inevitable. Equipment manufacturers can take advantage of COTS reference designs for base stations and core networks that can reduce development time and speed up time to market. Whether developers use COM Express, ATCA, or VITA, COTS-based platforms deliver the performance needed in a compact environment. **MES**

Thomas J. Kelly, P.E., *is a senior field application engineer, Aerospace & Defense, at Radisys. Tom supports the product development and integration of COTS equipment to create custom solutions to meet customer-driven requirements with a focus on size, weight, and power (SWaP) to create sustainable product lines. Prior to Radisys, he held several positions with General Dynamics. Readers may contact him at info@radisys.com.*

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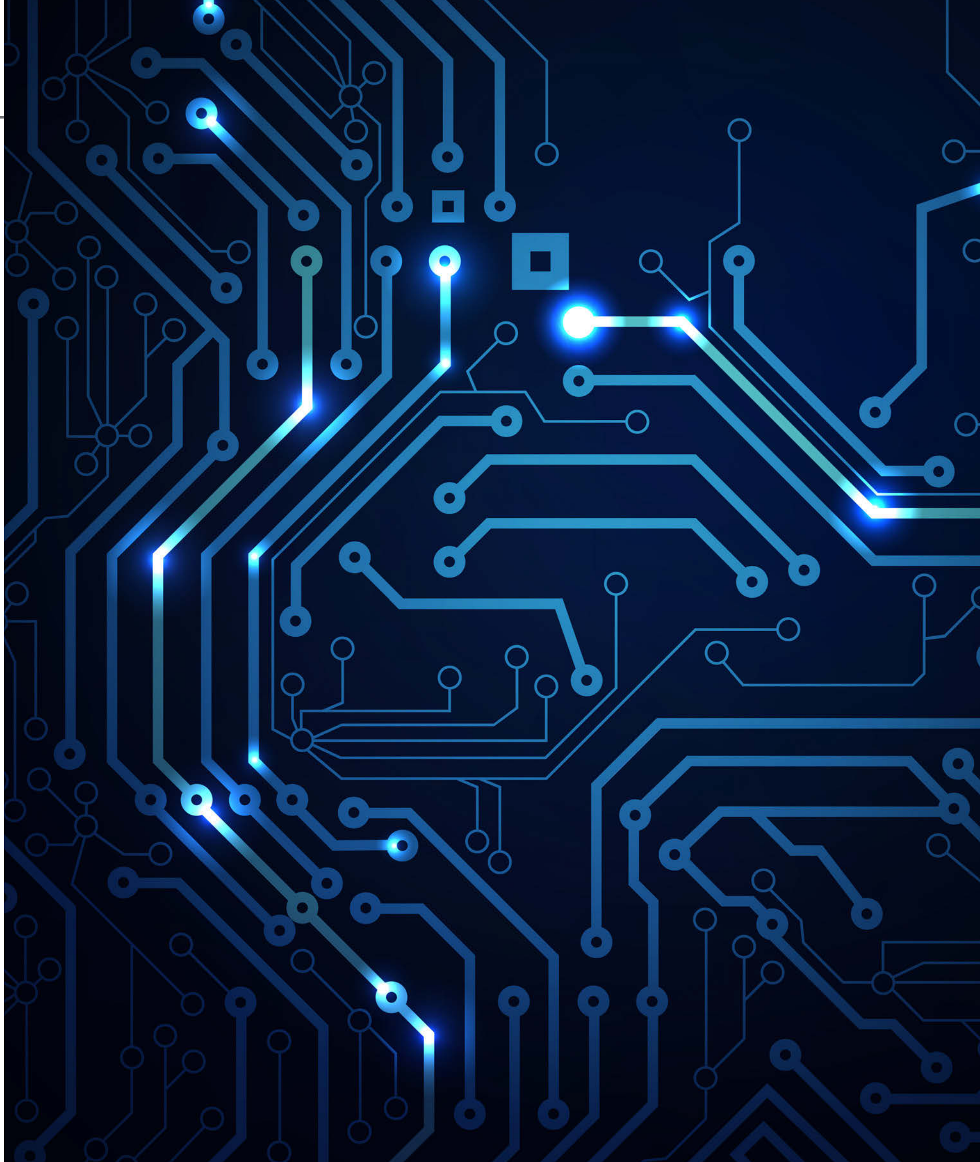

Mainstream IT-based HPEC technologies come of age

By Vincent Chuffart

High-performance embedded computing (HPEC) is moving from the data center into the field of combat. Mainstream HPEC building blocks can reduce costs for these applications while providing ultrafast backplane speeds in a much smaller footprint and easily accommodating new proof-of-concept requirements.

High-performance embedded computing (HPEC) systems are seen as huge rack systems that are deployed to handle the most compute-intensive processing – such as command-and-control systems – that enable military personnel to see or detect ever-smaller objects in larger and larger fields. It seems that the increasingly advanced defense capabilities that can be achieved from the processing of multi-sense data show no signs of slowing down and seem to be limitless. Defense developers have typically gone the route of selecting specialized silicon for HPEC systems, primarily using FPGAs as the solution to deliver quick performance that can handle advanced electronic warfare algorithms and co-processing functions.

However, new HPEC solutions are evolving that are much smaller standards-based platforms – not the mega-computing platforms that we see deployed at present. Many new HPEC requirements that once called for highly sophisticated architecture can actually be satisfied with more compactly packaged mainstream IT technology. For instance, 3U VPX-based systems are available that balance I/O and CPU power with high-speed I/O backplanes and advanced multicore x86 processing architectures. These well-known platforms enable defense contractors to better control resources and costs while saving their most experienced engineering teams for large-scale, more complex systems or specific proprietary solutions that still require a higher level of design expertise.

The advantage of mainstream IT

Defense-system developers can realize many advantages by using mainstream IT HPEC solutions. First, developers can save on engineering resources because mainstream platforms don't use specialty hardware, I/O, and switch fabric to qualify as an HPEC system. With extensive engineering experience with mainstream IT technologies such as x86 processors, TCP-IP, and the PCIe interface, this broader knowledge base can implement HPEC systems in end uses as disparate as laptops and high-end servers all the way up to conduction-cooled, ruggedized HPECs for ground control or even a UAV program. Developers can now tackle larger HPEC requirements that used to require specific proprietary solutions with well-understood architectures that are easier to program and deploy.

Proven technologies such as Intel multicore processors and PCIe 10/40 Gigabit Ethernet (GbE) permit a complete HPEC compute engine constructed of only standards-based components. For example, enabling specific-function FFTs for 3-D radar applications can be achieved through the co-processing capabilities with a GPU that the Intel architecture provides. Using such integrated standard-architecture technologies allows developers to eliminate extra design steps in order to offload certain functions.

DEVELOPERS CAN NOW TACKLE LARGER HPEC REQUIREMENTS THAT USED TO REQUIRE SPECIFIC PROPRIETARY SOLUTIONS WITH WELL-UNDERSTOOD ARCHITECTURES THAT ARE EASIER TO PROGRAM AND DEPLOY.

The escalating data-processing demands from defense OEMs who request "all the performance you can give us" are now running up against the certainty of tightening budgets and the realization that new technology is not created or needed every year. Defense OEMs have learned to stay competitive by developing technology templates that can be used for multiple programs that work for three- to five-year life cycles. Without huge budgets and unlimited user support, defense contractors find that they are more profitable by not constantly supporting specialized silicon, language, and fabrics solutions. Adding to the problem: technology advancements are launched at an accelerated rate, preventing designers from continuously reimaging new architectures from scratch.

Commercial off-the-shelf (COTS)-based computing is the answer for proven building blocks and system solutions, with the algorithms needed already mapped onto the computing architecture. In addition, fewer OEM specialists are needed when HPEC suppliers can meet defense-program metrics by delivering the ultra-fast speeds they need on the backplane in a much smaller footprint. It also helps that COTS suppliers have the experience to accommodate new proof-of-concept requirements.

Leveraging cost-effective, accessible HPEC solutions

Modular and application-ready mainstream HPEC solutions help reduce costs by providing an accessible, easy-to-use, standards-based platform methodology. This proven approach supports a full range of military applications that include the gigabyte per second (GBps) performance needed for radar systems, all the way up to camera interfaces that require tens of GBps or five-plus teraflops, demanded by today's 3-D radar.

Defense contractors can handle programs from the data center to field deployments by using smaller COTS multicore HPEC systems that can deliver a tenfold increase in I/O performance with no porting effort. Taking this simplified standards-based approach enables basic-skill-level engineers to meet high-connectivity and low-latency interconnect requirements with modular processor interconnect fabrics that implement the TCP/IP protocol over the PCI Express infrastructure. Going a step further, experienced HPEC suppliers give customers the option of building the computing portion of the application or supplying the right tools to facilitate a considerable system-size replacement. This can all be done with a couple of 3U VPX boards housed in a rugged, small chassis.

Mainstream HPEC system suppliers also have the knowledge to help with new proof-of-concept requirements. Contractors are able to rely on the suppliers' valuable knowledge to speed complex application evaluation, benchmarking, and development to ensure the system will meet specifications including input rates, processing rates, and output.

Value-added HPEC tools

Value-added tools – such as those that enable users to easily access system-health status – have become a necessity due to continued technology advancements. One example of where this capability would be essential is the need to change clock speed to match battery demand in systems with x86 processor architectures. Varying clock speeds are unacceptable in military embedded systems that depend upon multiple computers and boards in which each board has a different clock cycle; differing clocks can result in an unstable power system. Health-management software tools that control speed and computing power are available today in 3U VPX box-level systems that integrate a computer-management board (CMB) (see Figure 1). These platforms give extensive system-health information at the board and sub-rack level such as controlling airflow temperature for each slot, and holding payload boards in standby mode to accommodate low-energy surveillance mode.

Today's HPEC tools can also be used to implement more realistic lab testing that simulates the stresses and environmental conditions under which a system will be deployed. Proving a simplified methodology for testing new ideas is important, and mainstream TCP/IP streamlines the process from the lab to deployment with the same technology. No one wants to get to the last stage of development and integration, only to find out through actual environment testing that the algorithm doesn't perform to mission standards. Integrated software tools are also invaluable when designing the power-management portion, considering a typical users' guide for a current chipset dedicates 12 pages to defining power-management guidelines (see Figure 2).

A new age of mainstream HPEC is here

Satisfying application requirements for HPEC no longer requires complex, huge platforms. Rather, new HPEC solutions have been evolving steadily that can handle most high-performance computing tasks in much smaller 3U VPX standards-based platforms.

Today's 3U VPX systems employ high-speed switched PCIe and 10 GbE on the backplane, making it far less appealing to use proprietary architectures when these multiprocessor and highly integrated HPEC systems are available to meet defense-program performance and bandwidth specifications. In addition, using modular pre-integrated HPEC solutions ensures design flexibility and longevity. HPEC platforms also feature customization options so system designers can satisfy multiple program-specific requirements. This modular approach more easily accommodates future system upgrades, eliminating the need for a total system redesign.

The use of standard communication protocols enables developers to protect their application software investments. Mainstream VPX-based HPEC platforms have already been proven to meet size, weight, and power (SWaP) demands while also satisfying the need for higher performance and bandwidth.

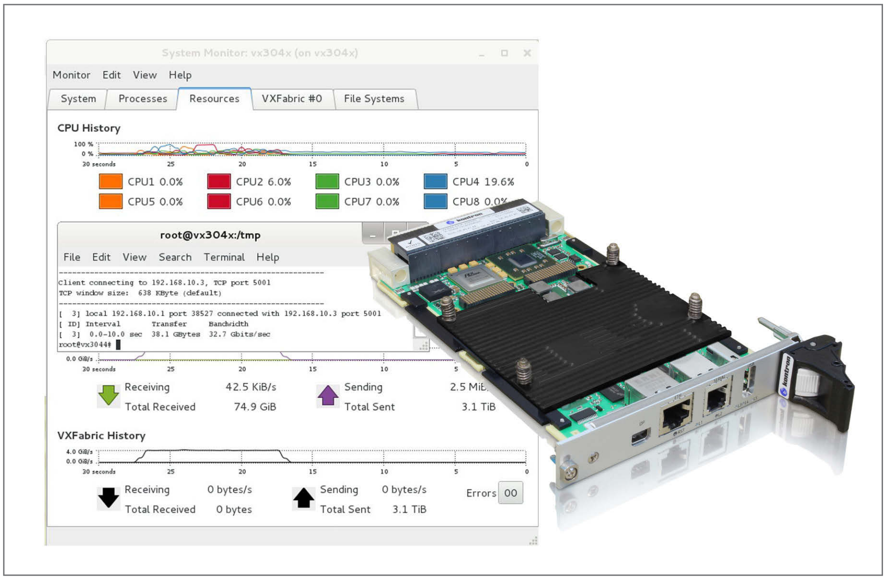

Figure 1 | Kontron VXFabric supplies the needed software between the PCIe Gen 3 switch and the bottom of the standard TCP/IP stack to enable boards to run any existing TCP/IP-based application without having to be modified. This interconnect fabric resource simplifies and helps propel application development of inter-CPU communication in VPX system architectures, enabling military OEMs to reduce development costs.

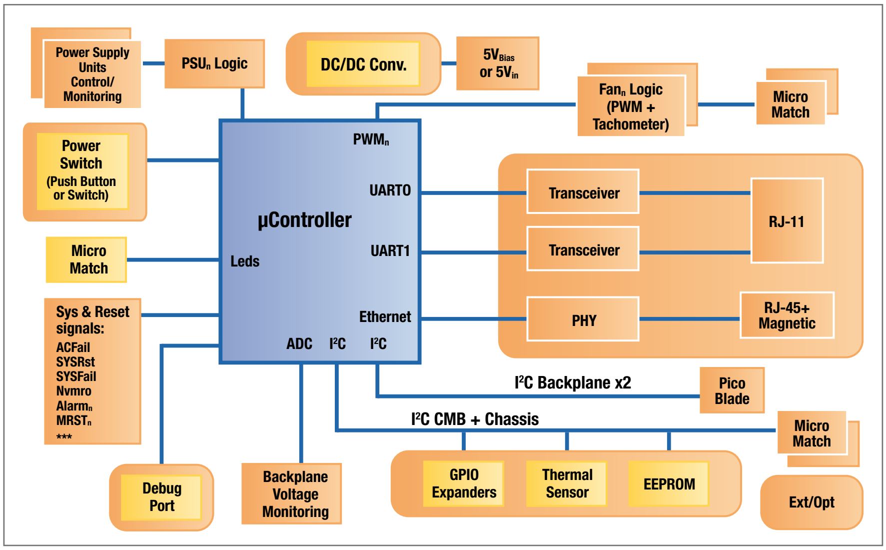

Figure 2 | Kontron's VXControl permits detailed out-of-band system monitoring and control of critical signals at the computer level. It handles computer control and health management for a full range of functions that extend from the serial line interface to SNMP networking connections.

Incremental defense program improvements can now bring new opportunities for smaller HPEC machines that can definitely handle almost any high-performance computing task put before them. **MES**

__Vincent Chuffart__ is Senior Portfolio Manager for Kontron's Military, Avionics, and Rail business unit. He has more than 25 years of experience in computer software and hardware development, encompassing several generations of embedded computers and parallel-signal-processing architectures. Before the Thales Group was acquired by Kontron, Vincent led the Thales embedded computing group before moving into product management. He holds an engineering degree from the Institut superior d'electronique du Nord in Lille, France.

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Enhanced DC/DC converters aim at defense, aerospace applications

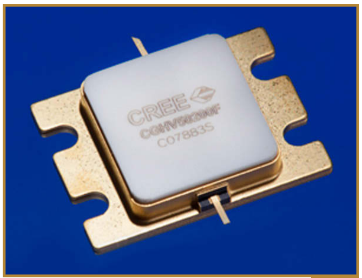
Crane Aerospace & Electronics has announced a series of enhancements to its Interpoint MTR Series of 30-W DC/DC converters for use in demanding environments. The latest version now meets the input voltage transient requirements of MIL-STD-704A, DO-160, and other international standards.

The MTR 50 provides as much as 30 W in single or dual outputs, has an input range of 16 to 50 V, and withstands transients up to 80 V. Magnetic feedback, inhibit, and synchronization functions – coupled with operation over the full military temperature range of -55 °C to +125 °C – enables it to perform in extreme environments including avionics, electronic countermeasures, missiles, radar, navigation, guidance, and utility systems.

The MTR Series singles and duals operate in a hermetically sealed case measuring 2.1" x 1.1" x 0.4" (with a slightly larger size for the flanged version). The product is available on defense, land, and maritime (DLA) standard microcircuit drawings (SMDs).

Crane Aerospace & Electronics | www.interpoint.com | www.mil-embedded.com/p372444

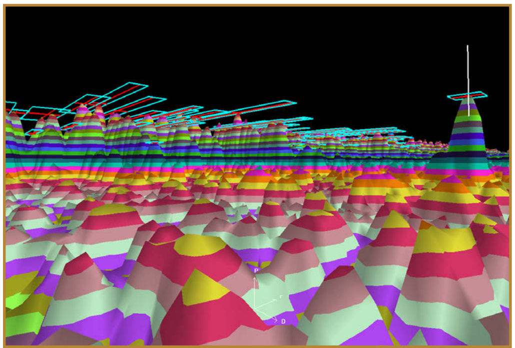
GaN transistor steps up for troposcatter communications applications



With the recently announced CGHV50200F gallium nitride (GaN) high electron mobility transistor (HEMT), Cree is aiming at C-Band applications, used frequently in satellite communications. The HEMT is a GaN transistor for tropospheric scatter (troposcatter) communications applications rated for 200-W continuous wave and 4.4- to 5.0-GHz operation.

The new 50-ohm, internally matched 200-W GaN HEMTs exhibit 180-W typical PSAT and 11.5-dB typical power gain, with 48 percent typical power efficiency. The transistors enable solid-state power amplifiers (SSPAs) to effectively replace traveling wave tube (TWT) amplifiers in satellite broadcasting systems. With their smaller footprint and lifespan over TWTs, GaN-enabled SSPAs can reduce overall system weight and mitigate both operational and replacement costs. The 200-W HEMTs are supplied in a ceramic/metal flange package measuring 23.75-24.26 mm (0.935-0.955") by 23.01 mm (0.906") including the gain and drain, or 17.25-17.55 mm (0.679-0.691") without.

Cree, Inc. | www.cree.com | www.mil-embedded.com/p372445



Sea wave clutter filter boosts e-scan radar's capabilities

New features added to Blighter's electronic-scanning (e-scan) radar now enable the radar to protect complex coastlines from intruders such as smugglers, pirates, illegal entrants, and terrorists who may be using jet skis, kayaks, or rigid inflatable boats. The Blighter radar is now able to detect and locate, at ranges of as far as 10 km away, such small and slow-moving targets day or night and in almost all weather conditions, whether rough seas, heavy rain, or dense fog. Blighter's low-power, solid-state, zero-maintenance passive electronically scanned array (PESA) radar with Doppler signal-processing filters out sea wave clutter returns in both velocity and amplitude to detect very small and slow-moving targets that traditional vessel-traffic systems and maritime radar are not designed to pick up. The enhanced radar is small – about the size of a large briefcase – and low power, transmitting 4 W of power and consuming 100 W during operation. The radar's low data-bandwidth requirement also enables remote operation over narrowband wireless links or satellite communication systems. The Blighter radar integrates with a range of electro-optic camera systems and other situational-awareness sensors, all controlled through the BlighterView HMI command and control software platform.

Blighter radar systems are used at multiple international airports, for force protection by the British army, and in many other asset-protection and border-security applications, including monitoring of the Korean Demilitarized Zone, a 250-km buffer zone that separates North and South Korea.

Blighter Surveillance Systems | www.blighter.com | www.mil-embedded.com/p372448

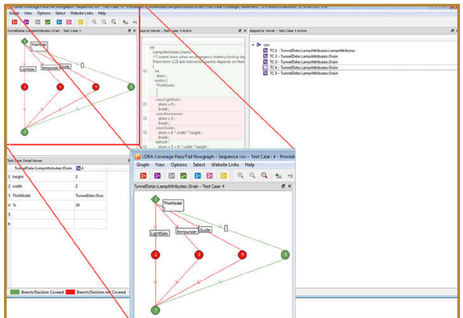
DC/DC power product intended for harsh air/land/sea environments

North Atlantic Industries engineers designed a 3U rugged cPCI power supply, the 75PS4, designed to handle harsh air, land, and sea military and aerospace applications in sense-and-response missions. The PICMG-compliant power converter provides as much as 150 W of power at up to 90 percent efficiency, and features four outputs: +5 V, +12 V, -12 V, and +3.3 V.

The converter – compliant with both MIL-STD-704A-F and MIL-STD-1275 specifications – sports a single-slot, 0.8-inch, 3U package; reverse-polarity protection; built-in holdup time to 50 msec at 150 W; integrated EMI filtering; and a user-programmable interface for power sequencing, output voltage, and current limits. The power product supports continuous background Built-in-Test and the I2C bus for attaching low-speed peripherals.

North Atlantic Industries | www.naii.com | www.mil-embedded.com/p372446

Tool suite automates software verification, standards compliance



Designers of safety-critical systems continue to look for ways to achieve full verification and even certification of multicore systems in a cost-effective manner as they are driven more and more by requirements to reduce size, weight, and power. LDRA experts are helping in this area with their suite of analysis and testing tools that provide system developers with the option to aggregate the coverage data across the various processors in the multicore system without the typical overhead of mutual exclusion. This approach enables developers to avoid deadlocks and delays.

The need for greater processing power with reduced power consumption is driving the developers of safety-critical applications toward multicore systems, but verification of such systems for rigorous safety-critical certifications such as DO-178C poses specific challenges: When multiple processes run on different cores, collecting structural coverage data and creating and executing tests efficiently can be hampered by concurrency, reliability, and robustness roadblocks.

LDRA's verification tool suite integrates with RTOS and compiler vendors such as Wind River and Green Hills Software, which enables users to execute all capabilities across the set of cores. The user – as needed – can introduce capabilities for coding-standard compliance, structural coverage, data and control coupling, and low-level testing as needed on the host, simulator, or actual target hardware.

LDRA | www.ldra.com | www.mil-embedded.com/p372449

Flat-panel rugged touchscreen computer intended for harsh, hazardous environments

The SeaPAC R9-8.4 from Sealevel Systems combines a RISC-based embedded computer with a bright LED-backlit thin-film-transistor LCD touchscreen to create a ruggedized, flat-panel computer intended for use in a variety of human-machine interface applications. The R9-8.4 operates in an extended temperature range – between -30 °C and +70 °C with no heaters or cooling fans required – making it suitable for harsh or hazardous environments. Driven by a 400-MHz ARM9 microprocessor, the touchscreen computer is available with 128 MB RAM and 256 MB of flash memory, with standard I/O including Ethernet, serial, USB, and digital interfaces. Local or remote I/O expansion is available using Sealevel SeaI/O modules, with the ability to choose a variety of I/O configurations including optically isolated inputs, Reed and Form C relay outputs, TTL interfaces, A/D, and D/A. The SeaPAC R9-8.4 connects to SeaI/O modules via the system's RS-485 expansion port, with Modbus RTU handling the communications. The SeaPAC R9-8.4 flat-panel bezel also provides NEMA 4/IP65-compliant protection against particles and sprayed liquids.

The SeaPAC R9-8.4's software package is equipped with the Sealevel Talos I/O Framework, which offers a high-level object-oriented .NET Compact Framework (CF) device interface. This interface provides an I/O point abstraction layer with built-in support for easily interfacing the system's I/O. Linux support is also available

Sealevel Systems | www.sealevel.com | www.mil-embedded.com/p372447

E-CAST

Managing SWaP in ISR systems

Presented by Advanced Cooling Technologies, Curtiss-Wright, GE Intelligent Platforms, and TE Connectivity

Even in today's budget-constrained environment the Department of Defense (DoD) is still funding Intelligence, Surveillance, and Reconnaissance (ISR) missions from payloads in unmanned aerial vehicles (UAVs) to radar and maritime surveillance. All of these applications are driven by requirements for more and more signal processing performance and reduced size, weight, and power (SWaP). Innovation in these systems is happening at the embedded electronics level where designers are overcoming thermal and power dissipation challenges in small system footprints through unique solutions and open architectures. This e-cast of industry experts will discuss the reduced SWaP challenges in ISR systems and more.

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Improving software development efficiency via model-based system engineering

By Esterel Technologies

Keeping Interface Control Documents (ICDs) consistent with architecture design drawn with Visio-like tools is not easy, thus hindering the development process of complex software. While the SysML tools have good arguments in their favor, they are not yet widely deployed for large industrial projects and do not support management of ICDs in a straightforward way. Model-based technology make things much more efficient. This paper proposes more reliance on model-based technologies to manage all required information in a consistent model and generate the ICDs from the model.

Link: http://mil-embedded.com/white-papers/white-engineering-icds-management-sysml/

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CONNECTING WITH MIL EMBEDDED

By Mil-Embedded.com Editorial Staff

CHARITY

House of Heroes

Each month in this section the editorial staff of *Military Embedded Systems* will highlight a different charity that benefits military veterans and their families. We are honored to cover the technology that protects those who protect us every day and to back that up, our parent company – OpenSystems Media – will make a donation to each charity we showcase on this page.

This month we're featuring House of Heroes, a nonprofit organization founded in 2000 that strives to assist veterans and their families by improving their living spaces. The foundation's motto is "On behalf of the Congress of the United States, and a grateful nation, this gift for you, for your gift to us."

Groups of volunteers perform necessary repairs and upgrades on veterans' homes free of charge, including cleaning, installing access ramps, installing or repairing screen doors and windows, painting, repairing or replacing appliances, and yard maintenance. These home repairs are supervised by a licensed contractor to ensure all work is accurate and up to code. House of Heroes provides a great opportunity for members of the community to band together and give back to a veteran in need by improving their living conditions. Volunteers need to be at least 18 years of age but do not need any previous construction or building experience.

House of Heroes' main hub is in Georgia, and they also currently have affiliate sectors in Iowa, Connecticut, and Arizona. The charity set a goal to assist 60 veterans and their families in 2014. Members of the community may nominate a veteran in need; to be eligible for nomination, one must be a military or public safety veteran (or their spouse), have financial or physical needs, and must own the home that needs repair.

For more information on the House of Heroes charity and to find out what volunteer opportunities may be available in your area, visit www.houseofheroes.org. Monetary donations can also be submitted on the website, and a guide with prices of common building materials needed is also included.

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WHITE PAPER

Performance comparison between Intel mobile-class and server-class processors for embedded defense applications

By Mercury Systems

In this white paper, Mercury Systems has highlighted the results from recent tests comparing Intel mobile-class vs. server-class processors, including these findings: server-class processors provide a 2-3x performance gain; leveraging SMP delivers performance benefits; and these combined performance gains can also provide SWaP advantages, as one server-based board can replace up to three mobile-class boards.

These results point to the Intel server-class processor being a viable device for embedded applications that require high performance. Mercury has designed products based on both server- and mobile-class processors to best meet the specific needs of customers.

Read the white paper:
http://embedded-computing.com/white-papers/white-processors-embedded-defense-applications/

More white papers:
http://whitepapers.opensystemsmedia.com/

GE
Intelligent Platforms

GE's COTS Rugged Systems are ready whenever the deployment clock is ticking.

Time is a precious commodity, because there's never enough of it. And time is money.

GE's line of integrated COTS Rugged Systems – which now includes an advanced HPEC capability – provides the quick delivery time most developers need for their unmanned and manned ground and airborne systems. These fully integrated computing platforms can be built around Freescale™ or Intel® processors with a variety of slot configurations to provide enough options to handle most applications. The CRS series takes the risk out of rugged system development with a fully tested computing platform that integrates with our own wide range of COTS products to provide a TRL 6 solution.

Finally, a rugged system that puts "off-the-shelf" back into COTS.

For white papers and application details, visit:
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