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Military EMBEDDED SYSTEMS

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ON THE COVER:
Top image:
The U.S. military's Joint Light Tactical Vehicle moves through the manufacturing line at Oshkosh Defense. Photo courtesy of Oshkosh Defense.
Bottom image:
An Army UH-60 Black Hawk helicopter prepares to unload airmen during an air assault mission as part of exercise Rail Yard at Warren Grove Gunnery Range, N.J. Air National Guard photo by Tech. Sgt. Matt Hecht.

Autumn acquisitions touch military embedded computing, safety-critical markets

By John McHale, Editorial Director

Two key acquisitions colored the fall season in the embedded world, both of which will affect military embedded computing applications. One was at the component level, the other at the board and subsystem level, as Qualcomm bought NXP, formerly Freescale, for about $47 billion and then soon after Mercury Systems picked up avionics computer supplier Creative Electronic Systems (CES) for about $38 million.

While autumn 2016 is not the shopping spree we saw back when Curtiss-Wright and GE Intelligent Platforms (now Abaco Systems) were buying up companies – and advertisers of ours – each deal has an impact on the military electronics arena.

Qualcomm and NXP

NXP produces mixed-signal semiconductor electronics for defense RF applications – gallium nitride (GaN) and laterally diffused metal oxide semiconductor (LDMOS) products – as well as materials for automotive uses, broad-based microcontrollers, secure identification, and network processing. Via its acquisition of Freescale in 2015, NXP also produces the PowerPC processors that are used in many legacy VME single-board computers. The acquisition news has some concerned that support for those chips may evaporate. PowerPC technology dates back to Freescale's acquisition of Motorola Computer Group in the previous decade.

"Qualcomm buying NXP disturbs me regarding the continued longevity of PowerPC," says Ray Alderman, chairman of the board for VITA, the standards body behind the VME, VPX, and other military embedded computing standards development. "The PowerPC roadmap may be less solid as Qualcomm is unlikely to focus on big processors like the PowerPC Altivec."

It's also true that Qualcomm does not have much military business, as its volumes and profits are generated by the much-larger consumer markets. Yet the RF business that supports many military radar applications is likely to not be affected too much by the change in ownership, as the RF world is lucrative and GaN components are some of the hottest products not only in the military RF world but in other larger commercial markets as well.

Mercury Systems, CES, and avionics safety certification

While the NXP acquisition is hotter news in other markets, Mercury purchasing CES is big news in the military embedded computing world. With this acquisition, Mercury is taking a big step into the safety-critical avionics market. CES has been quite successful in enabling commercial off-the-shelf (COTS) embedded computing elements to be certified up to Design Assurance Level (DAL) A for DO-254 and DO-178.

"The addition of CES adds important and complementary capabilities in mission computing, safety-critical avionics, and platform management that are in demand from our customers," says Mark Aslett, Mercury's president and chief executive officer. "These new capabilities will also substantially expand Mercury's addressable market into commercial aerospace, defense platform management, C4I [command, control, communications, computers, and intelligence] and mission computing – markets that are aligned to Mercury's existing market focus."

While this deal vaults Mercury into the commercial avionics world, it should be noted that Mercury does already play in the commercial aviation world with low-noise amplifiers (LNAs) that are used on commercial aircraft for WiFi access, ground-based air-traffic-control radar amplifiers, and W band pixels used for obscured-landing vision systems.

The CES acquisition also enables Mercury to compete in one more market with long-term rivals Curtiss-Wright and Abaco Systems, as the latter two are already finding success in the safety-critical world with their COTS products.

Certifying COTS to the highest design levels is a growing demand from end users who are squeezing integrators to use more COTS and commercial technology in the more complex avionics systems they are developing – the demand to bring the graphics and computing innovation seen in the commercial world to the cockpit. For more on this topic, read the Q&A with Paul Hart, CTO with Curtiss-Wright Defense Solutions, about certifying COTS for DAL level A on page 26.

So will we see any more mergers before year's end?

While the mergers in this sector of the military market have slowed down for a while, the recent activity shows it may be starting to pick back up, Alderman says. "Military embedded suppliers are swiped up for two main reasons. One, because the acquired company has healthy contracts/design-ins with the military on multiple programs and in the long run can be like buying an annuity – it keeps on giving. Number two is to gain expertise on a technology not currently in your repertoire and to gain entry to another slice of the market, such as safety-critical avionics.

"I think that we will probably see some more mergers and acquisitions in our industry based on these reasons," he continues. "And while I don't know the details, I suspect these were also the reasons behind the Mercury acquisition of CES, which has the contracts and also has strong technology that Mercury does not have in the commercial avionics market."

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FACE conformance program

By Charlotte Adams

An Abaco Systems perspective on embedded military electronics trends

September 2016 marked a major milestone along the long road to avionics software standardization: the last essential component of the system developed by U.S. Navy and Army aviation authorities and their suppliers clicked into place.

This final element, probably the most crucial to the success of the Future Airborne Capability Environment (FACE) consortium's efforts to promote standardization in military software development, is the FACE conformance program.

The complex body of standards that the consortium has developed or incorporated from other sources will continue to evolve within the context of the Open Group, the vendor-neutral sponsor of the effort. More to the point, however, is the question of how software will be assessed against the FACE technical standard. Standards are good, but there must be a mechanism to determine whether software conforms to them. Ultimately, the military program manager needs to have some sort of guarantee that approved modules will actually play together.

According to the consortium, the four-step conformance program includes preparation of the module, verification that the software was developed in accordance with the FACE technical standard, certification of the software's conformance, and registration of the software in the FACE registry, which is a catalog of approved modules. The verification process involves the examination of elements such as data model files and object code. The Open Group FACE consortium also says that its conformance process will reduce the need for buyers to test for conformance, simplify the procurement process, and accelerate fielding, all at lower cost and risk.

FACE and hardware?

The FACE standard promises to bring a host of benefits to the industry. Among other things, it promises to promote software interoperability, portability, and reusability. It also aims to free program managers from vendor lockdown, thereby increasing competition among suppliers. One major question, however: how does the FACE standard play in the world of boards and boxes?

Although the effort grew out of the need to control the costs of application software development, FACE standards attempt to cover everything from the application to the low-level driver code. For board developers – whose software dwells primarily in the FACE's I/O segment – this effort means making components such as drivers for video, Ethernet, MIL-STD-1553, and serial bus outputs conformant with the FACE standard.

The FACE standard provides standard application programming interfaces (APIs) for I/O drivers in order to insulate applications from subsequent changes in lower-level elements. In this area, board developers add "shims" that translate their vendor-specific drivers to the FACE-conformant APIs.

Board designers also use operating system software, which falls under the FACE Operating System segment. The FACE standard recognizes both POSIX (i.e., most Linux distributions) and ARINC 653 operating systems.

An example of hardware with a FACE roadmap is Abaco Systems' FORCE2 Open Reference Computing Environment (Figure 1), a rugged enclosure with a 3U VPX single board computer (with an XMC mezzanine card supplying ARINC 1553 and 429) and graphics card that is designed to host safety-critical, FACE-conformant applications. The system uses the ARINC 653 real-time operating system from Wind River Systems – VxWorks 653 – with a certifiability roadmap to DO-178.

Figure 1 | The Abaco Systems FORCE2 Open Reference Computing Environment rugged mission/display computer was designed with a FACE roadmap.

Road ahead

Edition 3.0 of the FACE technical standard is about to move to formal review, for one thing. This version fills some of the gaps in the previous iteration that could have impeded interoperability among conformant modules. Edition 3.0 also adds an optional life cycle management (LCM) element that addresses how units of conformance are initialized and controlled. The new feature will be useful in a system that includes boards from multiple suppliers because it will prevent namespace collision between the FACE-conformant drivers built into the respective boards and standardize how the drivers are initialized, started, and other operations.

Seven years ago, comprehensive software standardization in military avionics programs was still some way away. Interoperability was largely achieved after the fact on a procurement program-level basis.

The FACE standard has changed that because the effort is firmly supported, from the top down, by the U.S. military's Navy and Army aviation branches, in collaboration with their supplier base. The whole process will be a win for both the buyers and the taxpayers if it ensures interoperability and portability, lowers procurement costs, and increases competition.

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New RF tuners drive the design of multichannel signal analyzers for SIGINT

By Marc Couture
An industry perspective from Curtiss-Wright Defense Solutions

Here's the problem: Your unmanned aerial vehicle (UAV) is flying through densely populated geography when one of its signal intelligence (SIGINT) systems' radio-frequency (RF) channels detects an emitter signal of interest on a specific frequency, indicating a potential target. It's not enough to know there's a potential threat out there somewhere. You need to know the threat's exact location, and you need to know it in near-real-time. The challenge is that to geolocate a particular emitter, the SIGINT system needs to reassign three or four of its other RF channels, so they can – along with the original channel – perform the interferometry, using TDOA [Time Difference of Arrival] localization techniques, that's needed to zero in on the potential target.

All of this means that during the geolocation process, those additional channels aren't able to continue their own scanning of the electromagnetic spectrum (EMS) for other threats. For that reason, a SIGINT system needs to pack in as many RF channels, along with the supporting processing and high-speed networking, as the platform's size, weight, and power (SWaP) envelope will permit.

Only a decade ago, a 6U board could typically only carry two RF tuner channels, while a 3U board was limited to a single channel. The good news is that times have changed. On the processing side, designers have recently seen the emergence of Intel's Xeon Processor D devices. These devices enable a 20-time improvement in compute power compared to ten years ago by delivering supercomputing levels of compute power on 3U and 6U VPX boards. (Figure 1.)

Now, a comparable revolution in higher density RF tuner modules has begun. During the recent AUSA 2016 show in October, DRS' Signal Solutions business unit introduced its new Vesper family of multichannel 3U and 6U wideband RF receivers. The 6U Vesper provides an amazing 9 RF tuner channels in a single 6U slot. Their 3U version supports two RF channels. What's more, these RF receivers digitize the incoming analog data right on the tuner before sending it out for processing over 10 Gigabit Ethernet.

Figure 1 | The 6U CHAMP-XD2 board – aimed at use in compute-intensive defense, aerospace, and industrial applications – fields dual Xeon Processor Ds for a total of 24 cores in a single slot.

For SIGINT and ELINT [electronic intelligence] applications, these new open standards-based technologies represent a major breakthrough. Given the same SWaP envelope as they had a decade ago, system designers can now build systems that feature far greater electromagnetic spectrum coverage and the capability to locate many more targets simultaneously.

For example, at the high end it's now possible to build a multichannel 6U VPX system that delivers 144 Intel processing cores and 54 RF channels using six Xeon Processor D-based modules and six of the new Vesper RF receivers. One or more 10/40 GigE Switch/Router cards can be used to share all that data across the system's processing assets. This enables input data from the RF channels to be compared while simultaneously geolocating multiple emitters in space and time, and still provides plenty of remaining channels to handle ongoing scanning of the EMS.

The more channels that can be dedicated to a particular frequency, the better the resulting resolution and accuracy. This type of next generation SIGINT/ELINT system is able to support many different combinations of channel assignments, all of which can be modified dynamically and constantly. One subset of channels might be assigned to scan the entire electromagnetic spectrum while a second subset handles direction finding on a single frequency and another subset does direction finding on an entirely separate frequency.

Because these RF tuner and Xeon Processor D technologies are based on open-standards, they are also scalable. If a UAV has limited available power, or the system is destined for a compact electronic warfare pod whose physical height can't support 6U cards, the existing application software doesn't have to be rewritten. The same application software code and algorithms written for a high-end 6U architecture system can also be used in 3U systems for different programs and platforms with less forgiving SWaP envelopes or less demanding processing requirements.

Intel's Xeon Processor D devices brought supercomputing level multi-core computing into the embedded space. Now, with the emergence of DRS's Vesper RF receivers, system designers have a perfect match for taking advantage of that incredible level of processing. These solutions can deliver an unprecedented multiplier effect because of the number of RF channels that can now be deployed in a COTS system. Solutions based on these technologies will enable the warfighter to see more emitters simultaneously and geolocate those threats in near-real time without compromising the ability to continue scanning the electromagnetic spectrum for other targets.

Marc Couture is the Senior Product Manager for Intel, PowerPC, and GPGPU-based digital signal processors in the ISR Solutions group at Curtiss-Wright.

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By Mariana Iriarte, Associate Editor

NEWS

Fire Scout to carry Osprey AESA radar

U.S. Navy officials selected Leonardo-Finmeccanica's Osprey active electronically scanned array (AESA) radar to be equipped on an unmanned MQ-8C Fire Scout helicopter for testing and evaluation.

Under contract, Leonardo will deliver an initial batch of five radars to Naval Air Systems Command (NAVAIR) representatives. NAVAIR officials will then have the option to buy a larger quantity of the radars for use in real operations.

Naval officials explain that the two-panel version of the Osprey radar will provide remote operators with a 240-degree field of view and a range of digital modes including weather detection, air-to-air targeting, and a ground moving target indicator (GMTI).

Figure 1 | Northrop Grumman's MQ-8C Fire Scout unmanned helicopter landing on a flight deck. Photo courtesy of Northrop Grumman.

DARPA taps Raytheon to provide crew-augmented technology for GXV-T program

Defense Advanced Research Projects Agency (DARPA) officials tasked Raytheon BBN Technologies – a subsidiary of Raytheon Co. – to develop crew-augmenting technology that will provide situational awareness to troops inside windowless armored vehicles. The project comes as part of the agency's Ground X-Vehicle Technologies (GXV-T) program.

The technology uses lidar (light detection and ranging) data to create a 3-D model of the vehicles' environment, employing high-definition video to render a visual representation of the surroundings. Additional sensors provide the location of incoming hostile fire, while blue-force GPS positioning locates friendly forces.

GXV-T aims to improve mobility and survivability of armored vehicles without adding more armor and weight. DARPA is focusing on advanced technology development in four vehicle-related areas: mobility enhancement, agility for survivability, crew augmentation, and signature management.

Laser-guided rockets contract won by BAE Systems

BAE Systems will supply the U.S. Navy with its Advanced Precision Kill Weapon System (APKWS) laser-guided rockets. The initial contract is worth an estimated $130 million; if all options are exercised the value of the contract could reach as much as to $600 million.

The three-year indefinite delivery/indefinite quantity (IDIQ) contract is expected to help meet the needs of the U.S. Navy, Marine Corps, Army, and Air Force, as well as the forces of a growing number of allied nations.

Engineers designed the APKWS around BAE Systems' proprietary Distributed Aperture Semi-Active Laser Seeker technology. Company officials state that they designed the technology to transform a standard unguided 2.75-inch (70 mm) munition into a precision laser-guided rocket, with no modifications needed.

Lockheed Martin receives full-rate production contract for SEWIP Block 2 systems

U.S. Navy officials awarded Lockheed Martin an initial $148.9 million contract for full-rate production of Surface Electronic Warfare Improvement Program (SEWIP) Block 2 systems, which are aimed at improving the naval fleet's electronic warfare (EW) capability.

Under contract, Lockheed Martin will provide additional systems to upgrade the AN/SLQ-32 systems on U.S. aircraft carriers, cruisers, and destroyers, as well as systems on other warships. Block 2 provides an upgraded antenna and receiver and offers an improved interface with existing ship combat systems.

The contract includes four additional option years; work will be performed at the company's Syracuse, New York facility. Officials note that the system is compliant with the Navy's Product Line Architecture strategy, which facilitates the rapid introduction of new technology into the fleet.

Figure 2 | USS Carney (shown here) has already been deployed with the SEWIP Block 2 system. Photo courtesy of the U.S. Navy.

MQ-4C Triton receives milestone C approval

Navy officials recently announced that the MQ-4C Triton unmanned aircraft system (UAS) has received milestone C approval from the government, which will enable the program to enter into Low Rate Initial Production (LRIP).

Frank Kendall III, the Under Secretary of Defense for Acquisition, Technology and Logistics (AT&L), made the decision in September. The Triton – scheduled to deploy in fiscal year 2018 – will be a forward-deployed, land-based, autonomously operated system that provides persistent, intelligence, surveillance, and reconnaissance (ISR) within a range of 2,000 nautical miles using a multisensor mission payload including maritime radar, electro-optical/infrared (EO/IR), electronic support measures (ESM), Automatic Identification System (AIS), and basic communications relay.

"This milestone brings us closer to delivering a new capability to the fleet," says Sean Burke, Triton program manager. "Teamed with manned counterparts, Triton's highly capable sensor package will provide persistent maritime intelligence, surveillance, and reconnaissance data collection and dissemination capabilities to the fleet."

Figure 3 | An MQ-4C Triton prepares for flight. Photo courtesy of the U.S. Navy.

NAVAIR selects MacAulay-Brown systems to provide cyber warfighting capabilities

U.S. Navy officials selected MacAulay-Brown, Inc. (MacB) to support the Naval Air Systems Command (NAVAIR) Cyber Warfare Detachment (CWD) initiative and provide cyber warfighting capabilities for Navy aircraft, weapons, and related aviation systems and subsystems including ashore and afloat enterprise systems.

The multiyear basic ordering agreement (BOA) will cover five areas: penetration testing and penetration tool development, full-spectrum operational cyberwarfare support, protection solutions and systems-integration services, risk assessments and assessment methods, and system definition and architecture development.

NAVAIR CWD develops and assesses cyberwarfare capabilities for mission assurance; it also handles those systems that defend weapons and support equipment including aircraft, unmanned vehicles, sensors, and corresponding maintenance, communications, and logistic systems.

Interoperable tech opportunities growing in U.S. UAS market, analysts say

The U.S. military, as it seeks to minimize training requirements, is channeling funding toward platform upgrades and autonomy, especially in unmanned aircraft systems (UASs), say analysts at Frost & Sullivan. The analysts say that the U.S. Air Force wants to upgrade its UAS programs by deploying an open architecture, thereby ensuring standards-based modularity to enable plug-and-play sensors and implementing quick hardware and software upgrades.

According to the Frost & Sullivan report, titled "U.S. Military Unmanned Aircraft Market," UAS market revenues that stood at $4.18 billion in 2015 are expected to grow to $6.25 billion in 2021, at a compound annual growth rate (CAGR) of 6.9 percent. U.S. Air Force officials have made a case for a new MQ-X to replace the MQ-1/9 fleet, but the budget will not allow for a new-start MALE [medium altitude/long endurance] UAS program. Therefore, the Air Force is focusing on the less-expensive sensors and platforms, such as those in the MQ-9 extended range (ER) aircraft.

This reality is creating opportunities in technology areas such as automated processing, exploitation and dissemination of sensor data, platform endurance, battery-energy densities and link security, according to Frost & Sullivan.

U.S. Army AH-64E Apache helicopter to receive sensor upgrades

Lockheed Martin engineers are slated to upgrade the Modernized Target Acquisition Designation Sight/Pilot Night Vision Sensor (M-TADS/PNVS) on the AH-64E Apache helicopter, under a U.S. Army contract worth an estimated $49.3 million.

Under the contract, Lockheed Martin will produce an additional 42 Modernized Day Sensor Assembly (M-DSA) upgrade kits and spares for the U.S. Army as part of Lot 1 production. Manufacture and assembly will take place at Lockheed Martin's facilities in Orlando and Ocala, Florida, through March 2019.

The upgrades will enable pilots to identify targets at farther distances through an additional field of view and will allow for extended-range picture-in-picture capability. Company officials say that operators will also gain the ability to view high-resolution, near-infrared, and color imagery on cockpit displays.

Figure 4 | The M-TADS/PNVS sensors fielded on the Apache helicopter. Photo courtesy of Lockheed Martin.

Turbine trainer aircraft valued at $32 billion over next decade

Analysts at the Teal Group are forecasting a world market for 2,737 turbine trainer aircraft, worth about $32.3 billion, over the next 10 years, an increase of more than 50 percent over the 1,876 aircraft worth $19.9 billion delivered between 2006 and 2015 (all in constant 2016 dollars).

The world trainer market is valued at about $3 billion per year, compared with about $20 billion for the world fighter-aircraft market, according to Teal. Trainers grew at a CAGR of 3.8 percent between 2005 and 2015 (in value of deliveries).

The U. S. Air Force's T-X advanced trainer program aims to procure 350 jets to replace the Air Force T-38 fleet, with the possibility of hundreds more for other customers and applications, according to Teal. Finding the money for turbine trainer aircraft may be a hurdle, however: "Funding T-X is the biggest apparent impossibility," says Richard Aboulafia, Teal Group vice president for analysis. "The Air Force has made its top objectives clear: F-35 A, B-21, and Boeing's KC-46 tanker are the three highest priorities, presenting huge challenges on their own, even before lower priorities such as T-X or the new Combat Rescue Helicopter are funded."

Figure 5 | T-X Trainer for the U.S. Air Force. Photo courtesy of Northrop Grumman.

U.S. Army's UH-60 display units scheduled to be serviced

U.S. Army officials have selected Rockwell Collins to service the MFD-268C4 multi-function display (MFD) units for the UH-60M Black Hawk helicopter fleet. The follow-on IDIQ contract spans over five years and will service up to 2,160 units.

The firm-fixed-price contract covers repairs and service bulletins for MFD-268C4 displays in all of the Army's UH-60M Black Hawks, including those used by UH-60M foreign military sales customers.

The MFD-268C4 displays provide graphic engines, safety-critical processing, and active-matrix LCD technologies, as well as multiple video interfaces. Officials say that the displays will be repaired in the Rockwell Collins Atlanta Service Center.

HackerOne & Synack partner with DoD to follow up on "Hack the Pentagon" initiative

HackerOne and Synack have partnered with the Department of Defense (DoD) to create a new contract vehicle for DoD components and services to launch "bug bounty" challenges. The DoD's goal is to normalize the crowdsourced approach to digital defenses.

In the spring of this year, DoD hosted the first bug bounty program – called Hack the Pentagon – and now defense officials are prepared to launch a second, two-pronged effort with HackerOne and Synack as partners. Initiatives such as bug bounties are designed to identify and resolve security vulnerabilities within DoD websites. The results of the pilot program brought to light 138 unique vulnerabilities; these were remediated in near-real-time by the DoD's Defense Media department.

Officials explain that this contract vehicle for a crowdsourced security solution can also serve as a road map for other departments and agencies. Defense Digital Service (DDS) will work with DoD components and external government agencies in a consultative role to advise on the execution of future programs.

Electronic warfare systems sustainment contract won by Harris

U.S. Air Force officials selected Harris Corp. to perform sustainment work on the B-52 and C-130 electronic warfare (EW) systems.

Under contract, engineers will redesign one of the ALQ-172's Line Replaceable Units (LRU-1) as part of a wider effort to increase the EW suite's reliability, supportability, and availability. In addition to an LRU-1 design, Harris will develop software, support customer testing, and handle other solutions for the U.S. Air Force.

Ed Zoiss, president of Harris Electronic Systems, says, "With the B-52 set to remain a key component of U.S. strategic airpower for the next two decades, it is essential that it be equipped with innovative electronic warfare technology capable of defeating future threats."

Figure 6 | A U.S. Air Force B-52 conducting a low-level flight. Photo courtesy of the U.S. Air Force/Staff Sgt. Benjamin Sutton.

Special Report

NAVIGATION/GPS TECHNOLOGY
FOR MILITARY APPLICATIONS

Backup PNT methods are essential for GPS-denied environments

By Sally Cole, Senior Editor

Air Force Senior Airman Nathan Dupler uses the portable Defense Advanced GPS Receiver while participating in urban operations training during Northern Strike 15 on Camp Grayling Joint Maneuver Training Center, Michigan. Photo courtesy of U.S. Air Force

Backup methods of position, navigation, and timing (PNT) are essential for warfighters operating within GPS-denied environments. Warfighters rely on the U.S. NAVSTAR global positioning system (GPS) and global navigation satellite system (GNSS) for military operations, but are encountering an intense escalation of jamming and spoofing attacks.

For years, the military community has been on a quest to find backup methods to supplement GPS and enable operations to continue uninterrupted within GPS-denied environments. Many methods are being explored to provide assured PNT, and several options are emerging as quite promising.

GPS technology continues to evolve on other fronts, such as the push to M-Code (a restricted military signal) to improve security and antijamming of military navigation using GPS by 2018; the drive to reduce size, weight, power, and cost (SWaP-C); and combining GPS receivers with inertial measurement units (IMUs).

GPS-denied environments

The inability to receive GNSS signals can be caused by many factors – including inaccessible signals based on terrain, jamming, spoofing, or the not-so-likely event of catastrophic GNSS failure.

GPS jamming "involves interrupting the GNSS receiver with power, possibly intentionally or via vicarious interference, from other systems on the platform," explains Peter Soar, business development manager for military and defense for NovAtel in Calgary, Alberta. "We know that jamming is being used aggressively in Ukraine and on the Korean peninsula on a daily basis. It's also become a widespread nuisance through the use of cheap, openly available 'personal protection jammers' that are being misused."

So how bad is the problem? For a little perspective, South Korea's Ministry of Land, Infrastructure, and Transport reports that since 2010, GPS jamming believed to be the handiwork of North Korea has affected more than 2,100 planes. These malicious attacks cause cellphones to malfunction and can disrupt air traffic and ships that rely on GPS for navigation.

NATO is currently moving troops to the Baltic, and "undoubtedly anticipates being hit with high-power GPS jamming," Soar notes. "Typical military jammers are able to affect your GPS receiver for many tens of kilometers by line of sight."

NovAtel's antijam technology, for example, is a null-forming system that preserves the antenna's view of GPS satellites while ignoring jammers to ensure that the satellite signals to compute its precise position and time remain available. Significantly, it offers 40 dB of interference suppression, independent of the antijam performance of the rest of the system (receiver, etc.), which means that you can safely operate 100 times closer to a jammer than without it.

Beyond jamming, spoofing is another method to disrupt GPS. Spoofing involves deceiving a GNSS receiver with false signals, either rebroadcasting or

generating them. "Clearly, the consequences of spoofing can be serious. But many technical barriers must be overcome to successful spoof a properly protected PNT system," Soar says. "If you're worried about being spoofed, at a minimum, use a keyed military receiver."

Another way to make a spoofer's job more difficult is to "combine more than one frequency with possibly more than one constellation, and SAASM [selective-availability anti-spoofing module] or M-Code," Soar advises. "Or you can add a tightly coupled inertial navigation system, which can't be spoofed."

Unfortunately, it's not always feasible to encrypt all systems. "Many military UAVs [unmanned aerial vehicles], for example, are flying hybrid systems to cut down on SWaP-C. They may use an SAASM receiver for general work and protection, but have other unencrypted receivers within the system," Soar explains. "In this case, SAASM receivers are too expensive to be used throughout. And, until recently, you could only get six-meter resolution from a SAASM receiver, so they couldn't provide the accuracy that you get from real-time kinematics."

Now, NovAtel, Rockwell Collins, Geodetics, and TAG – all in their own unique ways – are making hybrid receivers with SAASM onboard that are capable of doing real-time kinematics, which is a technique used to enhance the precision of position data derived from satellite-based positioning systems.

"It's interesting to note that we've had our product on the market for some years now, and uptake was steady until this year," Soar says. "It now appears that someone within the DoD [Department of Defense] has put their foot down and said 'You must stop flying with open signal receivers and get an SAASM.' We're seeing a huge upsurge of interest in SAASM and antijam."

As far as catastrophic GNSS failure, while the likelihood is low, Soar points out that it can't be ruled out. Thankfully, "the growth in GNSS constellations and their growing robustness is significant mitigation of total failure," he adds.

IMUs as GPS backup

IMUs are receiving plenty of attention from the DoD as a solid backup solution for GPS-denied environments.

Honeywell Aerospace (Phoenix, Arizona) and Northrop Grumman are currently working with the U.S. Defense Advanced Research Projects Agency (DARPA) on its Precise Robust Inertial Guidance for Munitions (PRIGM): Navigation-Grade Inertial Measurement Unit (NGIMU) program to further develop advanced IMUs.

The goal of the PRIGM/NGIMU project is to "develop a MEMS [microelectromechanical system]-based navigation-grade IMU that has a mechanical/electronic interface compatible with a drop-in replacement for existing tactical-grade IMUs on legacy DoD platforms," explains Dr. Robert Lutwak, program manager for DARPA's Microsystems Technology Office.

The PRIGM program also entails "basic research efforts for advanced inertial micro sensors (AIMS)," Lutwak continues. "PRIGM/AIMS explores alternative technologies and modalities for inertial sensing – including photonic and MEMS-photonic integration, as well as novel architectures and materials systems."

Ultimately, PRIGM/NGIMU is expected to "identify promising candidate technologies for further development as high-performance inertial sensors for long-duration missions and deployment in extreme environments," Lutwak says.

As part of this effort, Honeywell is working to improve the performance of its MEMS HG1930 IMU by three orders of magnitude while maintaining its size, weight, and power consumption (Figure 1).

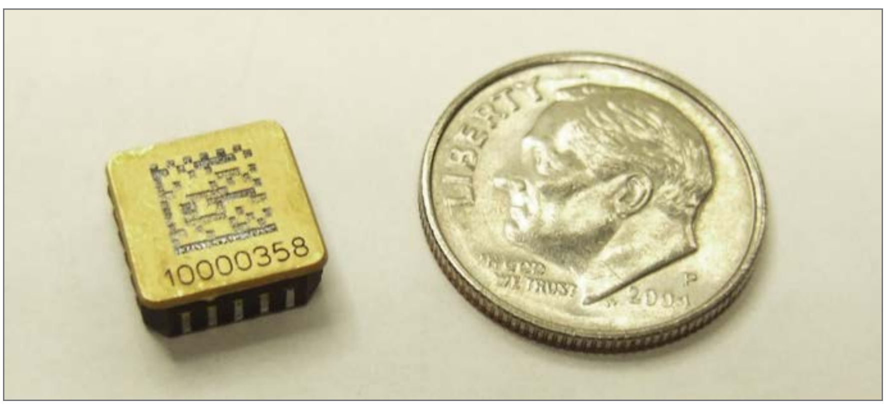


Figure 1 | Pictured here is a Honeywell packaged MEMS gyro sensor.

"GNSS is an outstanding aiding source when it's available, but it's vulnerable to very-low-power signals," says Chris Lund, director of product marketing for Honeywell Aerospace. "The more a platform relies on external signals, the more vulnerable it is to interruption. This is unacceptable for use cases that must always work, such as critical missions on the battlefield."

That's why solutions that don't rely on GNSS signals, such as inertial sensors and non-GNSS aiding sources, are necessary to ensure continuous operation. "One of the primary benefits of inertial sensors is that they can't be jammed or spoofed because they don't rely on external information," Lund adds. "Further, if a platform can leverage the hardware that's already on board, such as altimeters and cameras, alternative navigation techniques can be used with only a software update."

Other GPS backup alternatives

Many GPS-denied backups are currently being explored, including but not limited to TIMUs, eLoran, EPLRS, non-GPS-based positioning, and quantum IMUs.

Honeywell, for its part, is "working on numerous alternatives to GNSS aiding, including vision aiding, collaborative aiding, celestial aiding, terrain-aided navigation, and using signals of opportunity," Lund says. "All of this is aimed at allowing our customers to continue to operate without any degradation in performance – even if GNSS signals aren't available."

› TIMUs

DARPA is working on tiny timing and inertial measurement units (TIMUs) for backup to GPS in applications including personnel tracking, handheld navigation, small-diameter munitions, and small airborne platforms.

"Our goal for TIMUs is to develop a tactical-grade IMU based on MEMS technology, including simultaneous cofabrication of three gyroscopes and three accelerometers with unprecedented SWaP-C gains," Lutwak says. "As our TIMU efforts wind down, DARPA is working with other DoD entities to transition the technology."

› eLoran

Congress recently passed a bill to explore building an alternative to GPS, which might involve reinstating the eLoran network. The original Loran-C navigation system was decommissioned in North America in 2010, so an enhanced system such as eLoran would be an intriguing advance because its signals, unlike GPS, can reach underground, underwater, and inside buildings.

"Although it doesn't provide altitude measurements of anything like the accuracy of GPS, eLoran would be a good complement capability for GPS because it's very difficult to jam," Soar notes.

› EPLRS

The U.S. and Canadian armies are using the Enhanced Position Locating & Recording System (EPLRS), a secure, jam-resistant computer-controlled communications network.

"It's essentially a data radio hooked up to GPS receivers," Soar explains. "These systems constantly send status messages back and forth with position data. If you get jammed, you can use the time-distance-arrival technique on the communications signal between EPLRS stations … and if you've got two, three, or more, you can triangulate. But this method is fairly coarse and intended for backup."

› Non-GPS-based positioning

Australia-based Locata Corp. engineers developed a non-GPS-based positioning system that has been installed at the U.S. Air Force's White Sands Missile Range in New Mexico. It's proven capable of providing "reference truth" positioning across the vast area of White Sands when GPS is being completely jammed.

How does it work? Locata's completely autonomous positioning technology creates terrestrial networks that function as a "local ground-based replica" of GPS-style positioning. It's important to note that this technology isn't intended as a GPS replacement, but rather to provide a local extension and expansion of GPS. It works with GPS but can also operate independently when GPS isn't robust or is completely unavailable.

Instead of relying upon orbiting satellites, LocataNet taps a network of small, ground-based transmitters that blanket a chosen area with strong radio-positioning signals. Since it's terrestrially based and provides powerful signals, Locata's technology works in any internal or external environment.

› Quantum IMUs

Atomic or "quantum" IMUs are probably on the horizon, though likely still years out and classified.

Honeywell is working on "atomic inertial sensors" that are in early stages. "This class of devices uses atoms as the inertial sensor and has the potential to provide amazingly high performance within an extremely small package," Lund notes.

NovAtel builds and designs GPS and GNSS receivers, and uses the best-of-breed IMUs from across the industry. "I can tell you that we put a lot of work into researching IMUs, but we're not working on quantum IMUs yet," Soar says. "If they were ready, we'd know."

Back to basics

At this point, we may also see a return to the basic navigation methods. "Soldiers tend not to know how to map-read as well as they used to," Soar says. "Now, many countries are addressing this problem. The U.S. Navy announced last year that it's reintroducing teaching on sextants. So … right back to old-fashioned ship navigation – you can't jam it."

The bottom line, as Soar is quick to point out, is that "currently there's nothing quite like GPS/GNSS for accuracy, persistence, and worldwide availability. If alternatives were up to it, we'd use them … but they're not ready." **MES**

Power distribution from the ground up

By Mariana Iriarte, Associate Editor

Military ground vehicles today are carrying more complicated payloads that often include command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) systems. No longer only used for transportation, these platforms have become mobile command centers – like the U.S. Army's Joint Tactical Light Vehicle (JLTV) – meaning power management no longer can be an afterthought or an add-on, but a key consideration at the beginning of the design process.

The U.S. military's Joint Light Tactical Vehicle moves through the manufacturing line at Oshkosh Defense. Photo courtesy of Oshkosh Defense.

Power management for C4ISR on modern military ground vehicles are tackling more than the headlights.

"Vehicles today have more and more sensors, jammers, communications, and other electronics on them (what the military calls 'eyes and ears') that they want to operate with the vehicle engine off," says Jim Sember, sales representative at Korean firm Kokam Co. Ltd.

In the past, operators would have to physically shut systems off all around the vehicle, says Steve Goldman, product line manager at Data Device Corp. (DDC) in Bohemia, New York. Today, however, power is no longer an added component; instead "power management on the JLTV [for example] was designed from the ground up, rather than making low-cost, entry-level models where power was added on later."

The reason: Engineers understand that "as vehicles and the occupants become more connected to the military networks, and as they take advantage of integrated communications and sensors to shooter capability, the requirement for electrical power is increasing," says Richard Coomber, vice president of Integrated Systems at Revision Military in Montreal.

These advances mean that vehicles have become mobile combat stations that continually demand up-to-date technologies that enable soldiers to perform missions ranging from conducting a silent watch to taking the vehicle off-road for a reconnaissance mission.

For certain missions the new technologies mean that "vehicles having high-energy requirements, such as reconnaissance platforms, emit a substantial thermal and acoustic signature that reduces their ability to operate stealthily and therefore reduces their survivability on the battlefield," Coomber adds. "Military customers are looking for ways to manage their signature and maintain or improve survivability while at the same time running high-energy loads. The requirements to deliver high-energy loads while maintaining survivability will only increase as directed-energy weapons and electric armors mature."

Vehicles like the JLTV will replace legacy HMMWVs (commonly called Humvees) in the military. The JLTV addresses size, weight, and power (SWaP) requirements, as well as the flexibility that the warfighter is asking for. Balancing the performance and ensuring the warfighter's survivability were key aspects of designing the vehicle, "We don't make weapons systems, we make trucks," says Dave Diersen, vice president and general manager defense

program – JLTV at Oshkosh Defense in Oshkosh, Wisconsin.

The interesting point about the JLTV is that it was "built on a common set of requirements that meet the needs of the Army and Marine Corps. Differentiation occurs on how the services configure the JLTV based on mission requirements. The platform is designed for that plug-and-play configuration and not just for the Army or Marine use, but for multiple configurations," says John Bryant, President, Defense Programs, at Oshkosh Defense in Oshkosh, Wisconsin.

In terms of power, "The JLTV will provide ten kilowatts of power to handle a wide variety of C4ISR configurations; we provide growth capacity as our onboard digital architecture allows integration of a wide variety of C4ISR suites tailored to commanders needs," Bryant continues.

To help power all those plug-and-play requirements, DDC's solid-state power control (SSPC) power distribution units (PDUs) will "generate six and half kilowatts of power," Goldman says. "There are add-on kits based on the vehicle configuration's function, which may mean more or less C4ISR, depending on the mission. Our device handles all the C4ISR in the vehicle, but not the primary power that controls items such as the windshield wipers. Most of the JLTV configurations use two of our PDUs and as many as four." (Figure 1.)

Figure 1 | DDC SSPCs enable network control, programmability, and autonomous operation. Photo courtesy of DDC.

Power-supply market demands more attention than commercial market

The power-supply market continues to remain steady, but the design and development phase makes the military sector ultimately more costly than the commercial side of the market. "The combination of high performance requirements at environmental extremes and low volumes (compared to commercial applications) results in military batteries generally having build costs five to ten times higher than their commercial counterparts. This is unlikely to improve, as consumer-grade battery research tends to focus on capacity and cost, while military needs are diverging with the main focus on new systems being ballistic (bullet penetration) safety and low/high thermal performance at temperatures that no consumer will ever see," says Richard Coomber, vice president of Integrated Systems at Revision Military in Montreal, Canada.

The reason for this: "In the military sector, a detailed knowledge of the operational requirements and desired effect is needed so that industry can engineer solutions to meet the battlefield need," Coomber notes.

Legacy military systems are getting first dibs in the budget. "We still see a lot of upgrades to older platforms," says DDC's Steve Goldman. "Much like last year, we are only seeing an uptick in a handful of new programs, more so in Europe."

Overall, says Jerry Hovdestad, director of COTS engineering at Behlman Electronics in Hauppauge, New York, "We see a need across the whole spectrum of different systems. We see a need for drone platforms, ship platforms, and vehicle platforms. The vehicle market seems to be as it always has been, always asking for larger quantities.

"With the VPX standard, there's at least the basis to have a design that everyone can use. If people stick with the standard, everybody can use the same power supply. That's encouraging because we don't have to do specialized designs."

The DDC solution for the JLTV is a standard product that evolved from applications for Bradley Fighting Vehicles and other U.S. military ground vehicles, Goldman says. "Oshkosh was looking for a COTS [commercial off-the-shelf] solution, so as not to incur the high cost of customization and even more importantly, to enable flexibility for use across the many variants the JLTV will have. Having one controller for so many configurations solves a lot of problems from interoperability and procurement perspectives.

"The SSPC is essentially an off-the-shelf product, with tweaks coming from connector configurations and ruggedization depending on customer requirements," Goldman adds.

Addressing challenges with today's technology

Updated technology is helping to meet military vehicle power challenges such as this: The battery lasts for 30 minutes. "The vehicle has to be started to recharge the battery, causing the vehicle to produce a thermal image and an audio signal while the battery is being charged. If there was a higher-energy battery that could provide hours or even a day of silent watch, then that could change the tactical capability in a conflict situation," Sember explains.

The need to constantly decrease power consumption and to have longer lasting power supplies will always exist. DDC's solution: "When compared to mechanical technology, solid-state devices such as this solution reduces power dissipation by up to 70 percent, weight consumed by up to 80 percent, and space consumed by up to 86 percent, which is crucial in ground vehicle applications where increased power as well as size and weight means increased fuel, which means increased cost as fuel is very expensive," Goldman says.

Battery-pack systems like Revision Military's help to bring the type of flexibility needed to update systems. The Revision system "uses mission-specific cells, tight integration to the vehicle platform, a modular redundant design approach that allows upgrades, and an engineered solution focused on the mission," Sember states.

Power with a twist of intelligence

VPX power supplies are also in demand for military vehicles: "A lot of people are using VPX and we're seeing some ground-vehicle programs that are going that way; that seems to be the biggest interest at the moment," says Jerry Hovdestad, director of COTS engineering for Behlman Electronics in Hauppauge, New York.

The next step will be to increase the intelligence in power supplies. "What I see is intelligent power supplies used more and more, power supplies that can tell you all about themselves and

Figure 2 | Behlman's VPXtra IQ VPX 1000CD-IQ power supply supports communication, measurement, and control. Photo courtesy of Behlman Electronics.

all about the systems that they are in. Intelligent power supplies can tell you about input power, its output power, and its temperature. It can tell you a lot of information that can be used to tell the health of the system. If you know what you're doing, and then something changes, you know is something going on," Hovdestad explains.

Behlman's VPXtra IQ VPX 1000CD-IQ power supply (Figure 2) is VITA 62 compliant and supports VITA 46.11. This power supply "puts out all the information available including current, voltages, temperature," Hovdestad adds.

Engineers at North Atlantic Industries (NAI) in Bohemia, New York, also offer VPX power supplies for military ground vehicles with their VPX55H-3, a high-power DC/DC converter that plugs directly into a standard 3U VPX chassis with a VITA 62 0.8-inch power supply slot. This solution for VITA 46.0 and VITA 65 systems is compatible with VPX specifications; supports all VITA standard I/O, signals, and features; and conforms to the VITA 62 mechanical and electrical requirements for modular power supplies. The switching power supply is conduction-cooled through the card edge/wedgelock. It accepts +28 VDC input voltage and provides six outputs at as much as 500 watts.

Power supplies are also becoming more efficient. As mentioned earlier, traditionally in a large ground vehicle, the operator or commander will have a control system, such as the DDC solid-state device, which is much easier to operate and much more efficient than past methods where the operator had to physically shut things off all around the vehicle, Goldman says. "Now the system can monitor all these power levels and manage the levels without help from a human operator."

Power supplies that not only monitor the health of the system, but also alert the user that something is amiss, will take the burden off the soldier. Further maturing this technology will only help the U.S. Army's goal to reduce the soldier's monitoring burden.

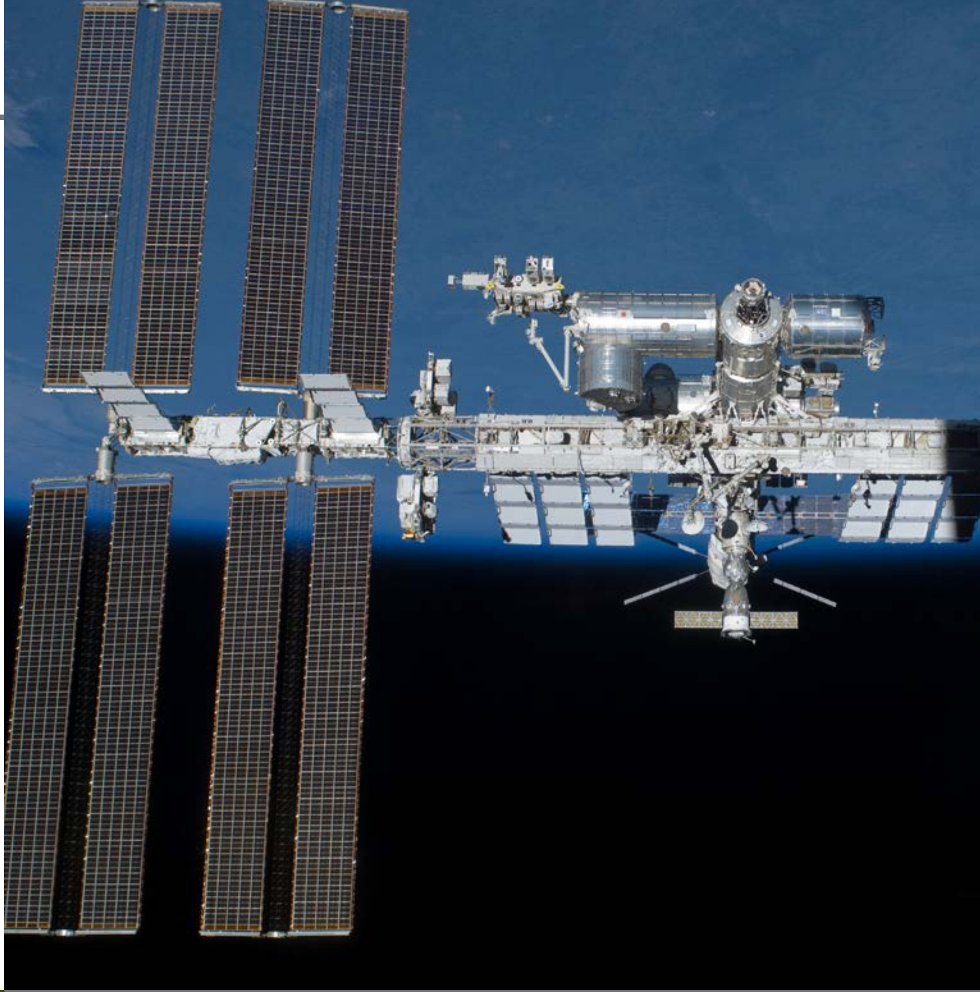
The JLTV is no exception, as it was designed to lessen the soldier's monitoring burden, increase the operational time, reduce maintenance, and essentially reduce the consumption of man-hours, Diersen says.

Yet there is no question that "there's much benefit in troubleshooting your own system," Hovdestad notes. "There is a lot of knowledge that could be learned by looking at the power supply, but actually using the information coming from intelligent power supply is important. Right now it takes a lot of programming and a lot of places are not quite set up to take advantage of it, but when they start getting these systems up and running and they start getting the software established, I think that we'll see very smart systems that can pretty much take care of themselves." **MES**

ARMed and ready

By Ross Bannatyne

While the rest of the engineering world has been developing embedded systems using the ARM microcontroller unit (MCU) architecture for many years, the high-reliability (hi-rel) market has been slow to adopt it. That is a pity because the biggest benefit of using an ARM-based microcontroller is the ease of development that ARM offers, by virtue of the large supporting ecosystem of tools.



High-reliability integrated circuits must be guaranteed to work in extreme environments, like those found in space. Photo of the International Space Station courtesy of NASA.

One reason for this slow adoption of ARM-based microcontrollers is that suppliers of these MCUs have been even slower to embrace the requirements of the military and aerospace design community. High-reliability (hi-rel) integrated circuits (ICs) need to be guaranteed to operate in extreme environments such as extreme radiation or temperature. It consumes considerable resources and budget to develop and qualify chips that are guaranteed to operate in such environments – frankly, it is easier for the semiconductor suppliers to play it safe by developing chips that will sell in higher volume in consumer applications.

Engineers are trained to solve problems: The lack of availability of hi-rel ARM microcontrollers has not stopped these engineers from doing their jobs and creating hi-rel military embedded systems anyway. Today there is a limited pool of components, often very mature products, that will get the job done, although it may not always be pretty. Field-programmable gate arrays (FPGAs), digital signal processors (DSPs), and legacy microprocessors are often used in embedded systems for the simple reason that they have already been qualified to military spec and that they are trusted and proven.

What do MCUs bring to the party?

Now that there are options available for rad-hard and extreme temperature ARM Cortex-M based microcontrollers, embedded systems designers can choose the most efficient solution to the problem. There are quite a few benefits of adopting an ARM-based microcontroller, the biggest one being the supporting ecosystem.

The ecosystem for a microcontroller covers many aspects, the most obvious being hardware and software development tools. There exist lots of options from freeware, from cheap and cheerful all the way up to professional-grade tools that cost real money. The ecosystem also encompasses the community – the places to go for help to ask a question, find a software driver or a communications stack that is already available, or get technical support. Training is also included in the ecosystem – either bringing a professional trainer into your facility for a day or two, or going to YouTube to watch a video.

The ARM CPU and instruction set were designed for embedded-control applications. The core is efficient for monitoring incoming data, processing it with math-intensive routines (such as digital filtering on noisy data from sensors), and managing on-chip peripherals that interface to external chips, sensors, and actuators. Most embedded designers that are starting a new design with a blank sheet of paper would probably be expected to start with an ARM microcontroller. The benefit is not just realized in the initial design, but it actually greater in subsequent designs, because the code is reusable. Often a few tweaks to the known good code and some additional routines are all that is required for spin-off or development of next-generation systems. Contrast that ease of use with FPGAs, which are more expensive, are more difficult to design with,

have a smaller existing ecosystem than the MCU, and do not offer the same level of reusability as the MCU.

Power consumption is another major benefit of using microcontrollers, particularly ARM. Because battery-powered systems have been a big driver in the embedded market for many years now, microcontroller architectures have evolved in response to the low-power requirement. Operating current consumption with ARM is typically less than a tenth of that of an FPGA, DSP, or application processor. Moreover, standby current (when the CPU is not executing but non-volatile memory contents are maintained and the core will wake up instantaneously in response to an interrupt) is significantly lower.

Hundreds of different ARM-based microcontrollers are available today, covering almost every conceivable combination of on-chip peripherals, pin count, and memory size option. There are also now many different ARM CPUs in the Cortex-M class (the range that are optimized for embedded applications) to choose from. Fortunately, these CPUs have the same look and feel as well as a high degree of compatibility. The higher performance cores typically have more functionality but retain backward compatibility. Not all of these products are a great fit for military embedded systems; in fact, not many of them are. The good news: A growing number of MCUs have been designed for hi-rel applications and it is now possible to take advantage of the ARM ecosystem.

What makes a hi-rel ARM MCU?

Figure 1 is a block diagram of a hi-rel microcontroller based on ARM Cortex-M0. The IC has a combination of "standard" ARM peripherals such as serial communication interfaces (SPIs, UARTs, I[2]Cs) and counter/timers (for PWMs, etc.) as well as "hi-rel application"-type features.

The hi-rel features that are now available on this class of chip start with enhanced wafer fabrication processing to immunize against latch-up in the presence of radiation or extreme temperature. In addition, all internal registers have been implemented with triple modular redundancy (TMR). Both of these attributes are invisible to the firmware programmer but are critical to the system design.

On-chip peripheral hardware enhancements include an on-chip error detection and correction system with a scrub engine that can automatically correct flipped memory bits. This feature has been included to ensure that the memory operates reliably in the presence of ionizing radiation particles. Note that while the TMR also protects

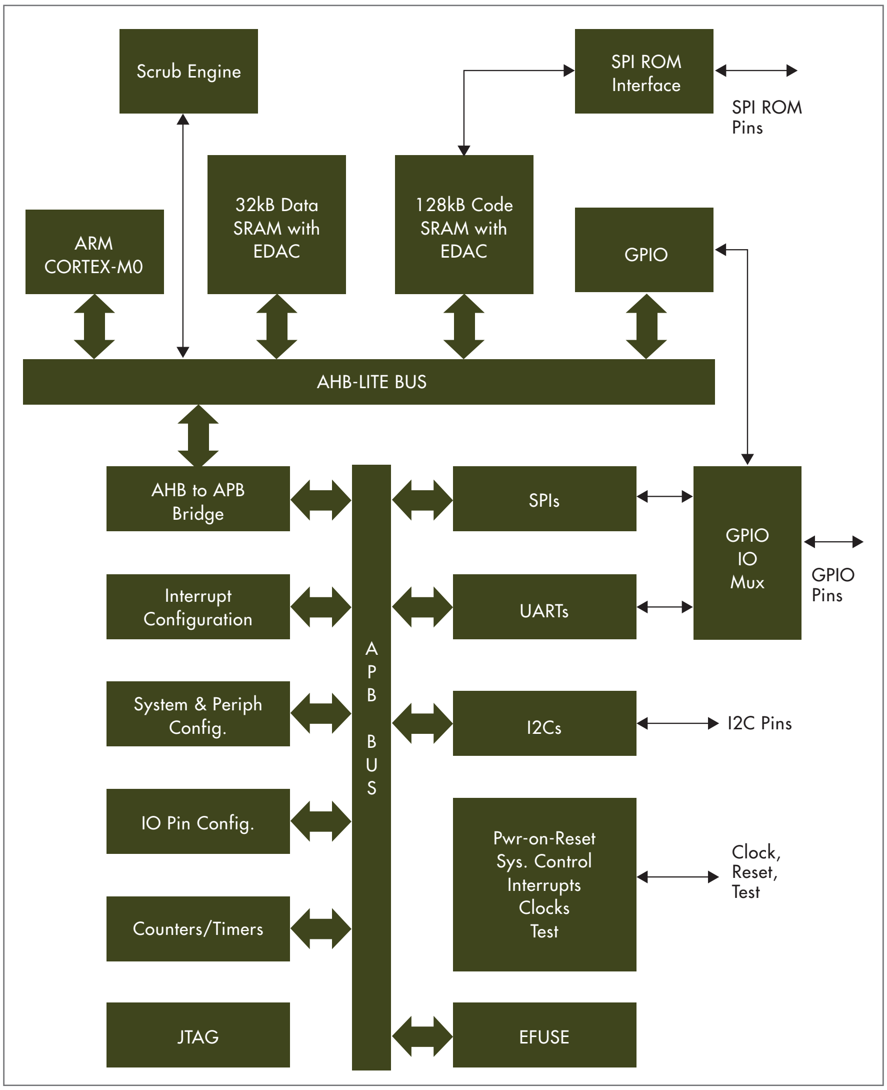


Figure 1 | Block diagram of ARM microcontroller intended for hi-rel embedded applications.

the chip against ionizing radiation, the chip is designed to protect the logic and circuit routing rather than the memory cells.

Along with integrating processing enhancements and hi-rel type peripherals, the packaging options are optimized for extreme environments. Figure 2 shows a PCB that has been developed for a space application – the PCB is located on the International Space Station. Right in the center of the board is an ARM Cortex-M0 based microcontroller in a hi-rel ceramic package.

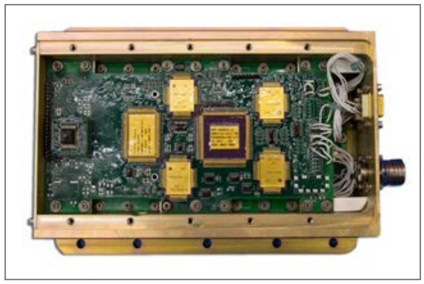


Figure 2 | Hi-rel embedded system using ceramic packaged ARM-based MCU. Image courtesy Vorago Technologies.

A robust MCU that doesn't cost an ARM and a leg

The good news is that after years of watching the ARM microcontroller world blossom into a treasure trove for embedded designers, there are finally products being developed for hi-rel environments such as military end uses. It is now possible to take advantage of the benefits that these offerings bring to embedded designs while conforming to the hi-rel specification. It is still true that ICs that are designed for USB sticks are not suitable for defense systems; in this spirit, designers must still choose carefully.

Why are these chips just now being developed? There is a demand for a higher volume of reasonably priced processor products such as ARM Cortex-M microcontrollers to support new growth applications such as megaconstellations of small and picosatellites. These applications need components that are sure to work in extreme environments but cannot have the high price of traditional space/mil FPGAs. These demands are driving the development of this new class of hi-rel ARM microcontrollers. **MES**

Ross Bannatyne is director of marketing for VORAGO Tech-nologies, based in Austin, Texas. He was educated at the University of Edinburgh and the University of Texas at Austin. Ross has published a college text called "Using Microprocessors and Microcomputers" and a book on automotive electronics called "Electronic Control Systems" (published by the Society of Automotive Engineers); he also holds patents in failsafe electronic systems and microcontroller development tools. Ross can be reached at rbannatyne@voragotech.com.

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OPEN STANDARDS

Certifying COTS avionics hardware to DAL A is common sense

By John McHale, Editorial Director

Paul Hart

Modern avionics systems continue to become more complex for military aircraft and commercial aircraft alike as they adapt the latest digital cockpits. Photo of P-8A Poseidon aircraft courtesy of Boeing.

Modern avionics systems continue to become more complex for military aircraft and commercial aircraft alike as they adapt the latest digital cockpits. This complexity and demand for increased performance has placed more pressure on industry and civil-safety certification authorities for aviation worldwide to develop processes for certifying commercial off-the-shelf (COTS) hardware to the highest safety certification level – Design Assurance Level (DAL) A. In this Q&A with Paul Hart, chief technology officer (CTO) for Curtiss-Wright Defense Solutions, he discusses the objections from the civil aviation authorities to this concept as well as the benefits that accrue from certifying COTS hardware to DO-254 DAL A, its similarities to certifying software to DO-178C, and how it might apply to unmanned aircraft. Edited excerpts follow.

MIL-EMBEDDED: ***Please provide a brief description of your responsibility within Curtiss-Wright and your group's role within the company.***

HART: My position is chief technology officer for the Avionics and Electronics group within Curtiss-Wright Defense Solutions. I am also Technical Fellow to the Curtiss-Wright Corp. The Avionics and Electronics group develops and manufactures various ice-detection and air data sensors, flight test instrumentation, flight recording systems, and data acquisition and processing avionics for commercial and military aviation as well as satellite launchers and low-earth-orbit spacecraft. It's my job to research new disruptive technologies that could be introduced into our future avionics and space systems that will provide better product value to our customers and continue to differentiate us from our competitors. I provide guidance and oversight to our engineering teams and advise senior management on technical matters. I also travel extensively, working with customers on future programs and presenting new ideas and technologies on the conference circuit.

MIL-EMBEDDED: ***During the Aviation Electronics Conference in Munich [April 2016], you started a bit of controversy during your presentation when detailing the growing demand for certifying COTS hardware technology to Avionics Design Assurance Level (DAL) A. Why is the demand increasing?***

HART: The ongoing digitization of cockpits has created a demand for commercial technology advancements that enable increased sophistication as well as more use of common avionics subsystems in military and commercial aircraft. Also, there is increased demand for synthetic vision systems (SVS) for landing, which increases the Design Assurance Level (DAL) of mission computers on aircraft that use SVS. All of this, combined with the increase of military aircraft — manned and unmanned — flying over civilian airspace has increased FAA [Federal Aviation Administration] scrutiny on U.S. military self-certification processes.

MIL-EMBEDDED: ***What are the benefits to certifying COTS hardware to DO-254?***

HART: The biggest ones are reduced cost, improved reliability, added quality, and maintainability, which all equates to

reduced risk for the end user. Our customers in military and commercial avionics platforms also have accelerated time-to-market demands. Prime contractors and avionics suppliers need to provide support for selected RTOS [real-time operating systems] vendors and graphics drivers, provide required artifacts available for the modules, and provide functionally equivalent modules available for air-cooled lab use along with rear transition modules for easy interface to I/O. All of this means they need to embrace COTS hardware and enable its certification to the highest safety levels, as it's the only way to effectively take advantage of this commercial technology.

MIL-EMBEDDED: ***What are the objections from the avionics certification community to certifying COTS hardware to this level? Who objected during the conference?***

HART: At the [Aviation Electronics] Conference there were three specific areas that caused sparked debate. Firstly, regulatory agencies take issue with term "COTS" if a manufacturer is attempting to use the track record or, more formally, "product service experience" of say, a single-board computer that has been fielded extensively in rugged operating environments in another industry, as compliance evidence to meet certain DO-254 requirements. This is a valid point, as such a board would need to meet the relevant DAL requirements, irrespectively.

Secondly, there is much debate about using multicore processors for safety-certified applications and guaranteeing that all the potential failure conditions can be mitigated. For the aerospace industry, this is a significant problem as multicore processors, and indeed most electronics today, are developed for the mass consumer market, not for avionics. The skill in our industry is being able to adapt these electronics for flight-critical applications and upgrade and support the resulting avionics products for more than 20 years, long after the original components have become obsolete. In the case of multicore processors, most manufacturers will not release detailed documentation of internal electronics that could be used to develop certification artifacts. All these factors present considerable certification challenges to meet the DO-254 DAL A/B criteria, and the "Acceptable Means of Compliance" to demonstrate these requirements have been met is often debatable. Thirdly, there are different routes to achieve certification through EASA [European Aviation Safety Agency] and FAA.

MIL-EMBEDDED: ***Are there different views regarding this topic based on the civil authority in question? For instance, does the FAA differ in their views on certifying COTS hardware from EASA, and if so, how do they differ?***

HART: There are pointed differences between EASA and the FAA on how they certify hardware to DO-254 for FPGA [field-programmable gate array] and other programmable logic devices. For example, the FAA states: "We recognize that the hardware life cycle data for commercial off-the-shelf microprocessors may not be available to satisfy the objectives of RTCA/DO-254. Therefore, we don't intend that you apply RTCA/DO-254 to COTS microprocessors." In contrast, the EASA Certification Memorandum requires deterministic tests and analysis for simple COTS and simple microcontrollers under all foreseeable operating conditions to demonstrate compliance. This can be tremendously challenging to a designer to produce test cases for the considerable number of code paths even in simple systems.

Furthermore, despite the existence of a reciprocal agreement between EASA and FAA on a certified item, the routes to certification are notably inconsistent as regards the signoff of DO-254 and DO-178C test evidence to achieve certification. Under FAA jurisdiction, a third-party Designated Engineering Representative (DER) – or more recently company-level Organization Designation Authorization (ODA) – can approve certification artifacts through the Supplemental Type Certification (STC) process as part of an equipment upgrade on an already Type Certified (TC) aircraft. The DER or ODA would need to have been involved with the Stages Of Involvement (SOI) during the development cycle and approve the 4xSOI audits. Under EASA, the DER/ODA process does not exist. Instead, companies – not individuals – should be approved to EASA Part 21G as Production Organization Approvals (POA) and Declaration of Design and Performance (DDP) signatories within those companies, appointed by the regulatory agency, able to sign off conformity checks. This does not, however, certify the equipment on an aircraft, even with a TSO application via the EASA Part 21 Subpart O route. There is a further step, which would normally be part of the STC under the FAA process, to design and produce an EASA-approved installation design. This requires an EASA Part 21J Design Organization Approval (DOA) and splits into "Minor" and "Major" modification categories, the latter applied to significant aircraft modifications that affect handling qualities or increase pilot workload. An EASA 21J Major modification cannot be authorized by the DOA and requires EASA approval. This is sometimes referred to as an "EASA STC" but the path to this approval differs considerably from the FAA-approved STC route.

THE SKILL IN OUR INDUSTRY IS BEING ABLE TO ADAPT THESE ELECTRONICS FOR FLIGHT-CRITICAL APPLICATIONS AND UPGRADE AND SUPPORT THE RESULTING AVIONICS PRODUCTS FOR MORE THAN 20 YEARS, LONG AFTER THE ORIGINAL COMPONENTS HAVE BECOME OBSOLETE.

MIL-EMBEDDED: ***What steps need to be taken from a design perspective that haven't been taken to enable certification of COTS hardware to DO-254?***

HART: Safety-monitoring features need to be incorporated into designs to meet DO-254 requirements. For example, loopback testing of interfaces, watchdog timers to reset the processor if the software misvectors, discrete electronics to monitor power supply, temperature levels, and report fault conditions to supervisory BIT (Built In Test) software. FPGAs need to be evaluated for race hazards and timing margin analysis. Board support packages between the target hardware and RTOS need to be certified and incorporate safety-monitoring features – as does the RTOS, which will typically incorporate time and space partitioning to run applications of different DAL criticality on the same processor. All of these features need to be approved via the SOI audit process by an EASA Certification Verification Engineer (CVE) or FAA Designated Engineering Representative (DER). Lastly, the devices must meet environmental requirements including RoHS, REACH, and CE certification.

MIL-EMBEDDED: ***How would the process for certifying hardware to DO-254 DAL A compare to the certification of software to DAL A under DO-178B & C?***

HART: There are many parallels with the hardware and software certification processes. For example, an organization is required to produce a PHAC/PSAC [Plan for Hardware/Software Aspects of Certification], which are similar format and follow similar design processes. It is worth noting that DO-178 software processes are much more mature in a typical avionics company, the standard having been around since the "A" issue in 1985, conversely DO-254 was first issued in 2000 and only really became adopted during the mid-2000s and hence there is more industry focus on hardware certification – especially since hardware is "software" given the that programmable FPGAs start life as VHDL [Very High Development Language] code.

MIL-EMBEDDED: ***How does COTS hardware fare when meeting DO-160 environmental concerns?***

HART: There are 23 different tests within DO-160, then categories within these tests – such as vibration curves and loss of altitude – based on the type of aircraft and the zone within the aircraft where the equipment is installed. For benign, low-DAL applications where equipment is installed in a cabin or "Airborne Inhabited Cargo" area, COTS can be employed extensively. In-flight entertainment is such an example. For higher-criticality applications in more severe environments – such as unpressurized areas, high-ingress areas (such as landing-gear wells), or high vibration zones – COTS boards will need to use extended-temperature-range devices with conformally coated boards such as Parylene or Humiseal. As well as test articles meeting DO-160 qualification and EMC tests, production units will need to meet Environmental Stress Screening (ESS) requirements such as four-day burn-in and multi-axis vibration before they leave the factory.

MIL-EMBEDDED: ***Would the process be any different for certifying avionics hardware for unmanned aircraft?***

HART: That's a very topical question. Both EASA and FAA are developing certification standards for UAVs [unmanned aerial vehicles] that weigh more than 55 pounds and operate above 500 feet outside of the line of sight of the operator. Right now, several operators have been granted waivers known as Section 333 exemptions, but these are an interim gap prior to future rulemaking. UAVs in the future will almost certainly be required to meet the same certifications standards as their manned counterparts, although additional safeguards are anticipated such as sense-and-avoid capability, geofencing to avoid inadvertent straying into protected airspace, and autonomous safe landing in the event of command-and-control link failure.

MIL-EMBEDDED: ***Can the same approach for certifying COTS hardware be applied to space applications, where many in that community shy away from using COTS technology in radiation-heavy environments?***

HART: For low-earth-orbit applications, the use of rugged COTS electronics and the certification routes are wholly relevant. However, specialist electronics such as radiation-hardened ASICs [application specific integrated circuits] and verification and validation (V&V) techniques are required once above mid-earth orbits, to mitigate effects of intense radiation from solar activity and Van Allen belts. **MES**

***Paul Hart** joined Curtiss-Wright/Penny & Giles in 1982 as a student electronics design engineer and thereafter has held several engineering and business-development positions in the fields of flight-recorder design, flight-data replay and analysis, avionics certification, and aircraft-performance software since graduating in 1987. In 2000 Paul moved to Thales Avionics in London for three years as product manager for Military Helicopter Flight & Mission Management Systems. After Thales, Paul moved to Smiths Aerospace (now GE Aviation) as project manager for engine sensors on the F-35B Joint Strike Fighter. He subsequently became Head of Mission Systems for Cobham Aviation Services/FR Aviation for seven years, being the single point of accountability for development and operational readiness of the electronic warfare and towed-target suite on a fleet of 15 Falcon 20 aircraft delivering more than 3,300 sorties per year, including 20-plus overseas Royal Air Force, Royal Navy, and NATO detachments. In 2011 Paul rejoined Curtiss-Wright as Director of Avionics Engineering and was promoted in 2013 to Chief Technology Officer for the Avionics & Electronics Group and was appointed as a Curtiss-Wright Technical Fellow in 2015.*

OPEN STANDARDS

Implementing FACE-conformant systems

By Wayne McGee and Stephen Simi

An Army UH-60 Black Hawk helicopter prepares to unload airmen during an air assault mission as part of exercise Rail Yard at Warren Grove Gunnery Range in New Jersey, September 21, 2016. Air National Guard photo by Tech. Sgt. Matt Hecht.

The Future Airborne Capability Environment (FACE) is a government/industry/academia initiative started by U.S. Naval Air Systems Command (NAVAIR) and the U.S. Army Aviation and Missile Research, Development, and Engineering Center (AMRDEC) in 2010 to create a standard for avionics application development. The goal of FACE is to lower the cost and amount of time necessary to create open systems applications and promote reusable applications across multiple platforms. To facilitate collaboration with industry and academia, The Open Group created the FACE Consortium for the purpose of developing, publishing, and administering conformance to the specification. Besides NAVAIR and Army, to date more than 90 companies and over 1,175 members involved in the avionics sector have joined the FACE Consortium. Most recently, in 2016, the Air Force Research Lab (AFRL) officially joined FACE, rounding out the participation of the entire U.S. military services. Today each military branch has and continues to require FACE in their proposals for any future capabilities.

The first release of the FACE specification was made in January of 2012. Subsequent work has resolved a hosting library for FACE-conformant applications, proper use of the FACE logo to protect branding, requirements for an application to be labeled conformant, and standard data models to allow applications to share data in a common format. Since the initial release, the original specification has evolved, as attempts to implement the specification required further clarification. Where other open systems initiatives have failed, FACE's attention to both technical and business processes have proved successful.

The first demonstrations of candidate applications for conformance branding occurred at the Face-to-Face Technical Information Meeting (TIM), held by NAVAIR in 2012 in Solomons Island, Maryland; the latest and largest U.S. Army-hosted TIM was held in February 2016 in Huntsville, Alabama. The first two FACE applications that have successfully completed the FACE verification process were announced publicly in July 2016, with additional promises of many other verified products and capabilities to follow soon. During a May 2016 panel on the future direction of unmanned aircraft systems (UASs) in the Army, Col. Paul Cravey, capability manager for UAS at the Training and Doctrine Command (TCM-UAS) asserted that those companies that want to do business in tomorrow's environment, must know FACE.

Finding a home for a reusable FACE architecture

While the intent is to create hardware-agnostic FACE application software, at some point the software must find a home, a host, and target platform to fly within. Today's battle space is not unified, but is instead made up of dissimilar aircraft platforms using various configurations of architectures and operating systems. Unfortunately,

porting hardware-agnostic software to a host architecture with a hosting operating system is not a trivial task.

Once a suite of aircraft is capable of hosting FACE open systems architectures, then FACE applications can plug right in. Once plugged in, those application capabilities can interoperate across a network-centric battlespace, thereby increasing the situational awareness across what was once a raft of dissimilar aircraft.

Discussion of FACE architecture

Figure 1 illustrates the system software segmentation of the FACE architecture on one of the first FACE verified applications – Reusable Radio Control Component (R2C2) – developed by AMRDEC and hosted on an open systems FACE architecture. The segments of the FACE architecture include the operating system, I/O services, platform-specific services, transport services, and portable components.

One prototype mission-computer hardware system that can host the FACE architecture and applications is pictured below the line in the boundary diagram, where other externally connected hardware devices reside.

The first two segments that enable the architecture are the operating system segment (OSS) and the platform-specific services segment (PSSS). The OSS includes a FACE-conformant operating system with run-time support, necessary frameworks, and generic health-monitoring services. The PSSS provides the specific device drivers necessary for the OSS to function on the computer and provides low-level health-monitoring functions to insure proper operation. The I/O services segment (IOSS) provides additional functionality beyond the low-level device drivers. For its part, the transport services segment (TSS) provides the architecture with common data types and formats, configuration, quality of service, and the ability to transform data from one format to another.

The R2C2 FACE application resides within the PSSS. The green lines in the diagram depict the FACE architecture interface between the segments. These interfaces are key to open systems architectures and are well-defined in the FACE technical standard.

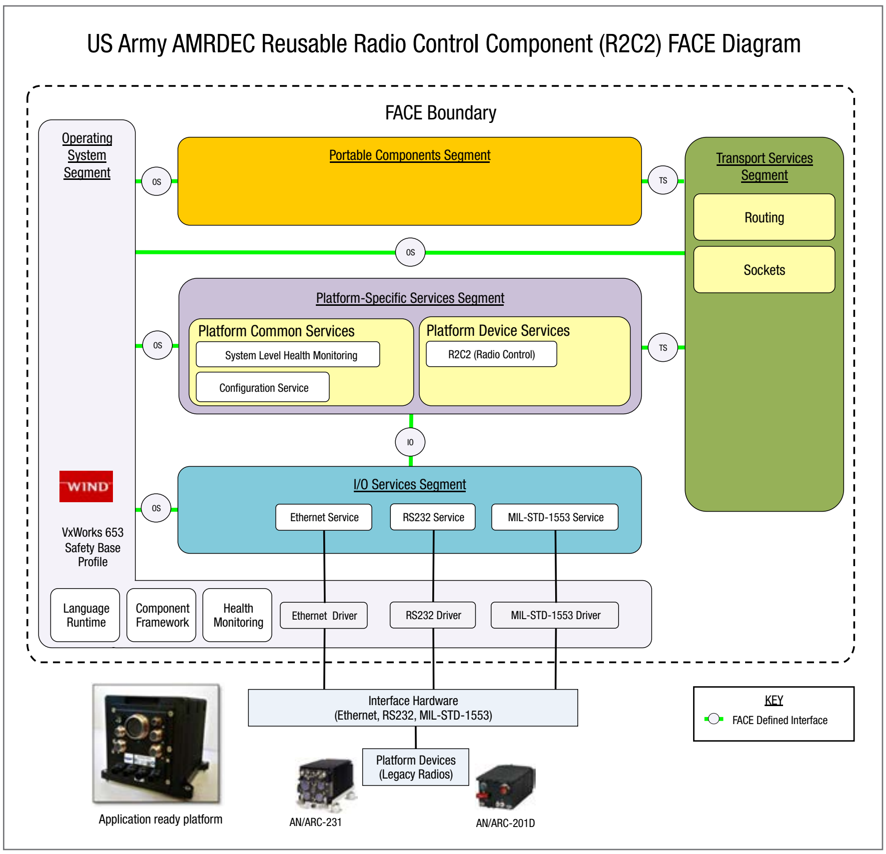


Figure 1 | Architecture diagram of a FACE-verified application operating on a FACE application-ready host platform.

As simple as it sounds, plug-and-play is aligned to a plug (i.e., application) and its receiving socket outlet (i.e., architecture); the two ends must interface via well-defined standards such as FACE. The FACE application's interface must align with the FACE architecture of the hosting hardware processing platform. The interface software libraries must both compile and have variable names and data types known on both sides. If the software applications and architecture line up, all is well – it is lights on.

Next step: port the software to another FACE-aligned architecture – lights on there as well. One day soon, reusable FACE capabilities will be integrated across a battle space of dissimilar aircraft and vehicles, etc., all able to host a FACE architecture and FACE applications and ready to assist with enhanced capabilities where they are most needed.

Implementation example

Avionics plug-and-play can be achieved by combining open systems applications with open systems architectures. For example, the U.S. Army's AMRDEC-SED [Software Engineering Directorate] developed, successfully verified, and integrated the R2C2, a FACE Platform-Specific Service (PSS) software component. The R2C2 is a reusable platform-portable software component that will facilitate the integration of (legacy and next-generation) military radio systems onto Army aviation platforms. It was demonstrated during previous FACE TIM events; the Army's FACE Verification Authority verified the R2C2 in July 2016. In a parallel effort, Boeing-Philadelphia successfully integrated R2C2 in July on a target platform designed to represent platforms on the Future Vertical Lift (FVL) platforms.

R2C2 is integrated into each aviation platform's operational flight program (OFP), which provides the interface between the platform's computing and radio equipment. The first increment of the R2C2 software provides control interfaces to the AN/ARC-231 and AN/ARC-201D radios. Follow-on software increments are underway, adding in the control interfaces to future airborne networking and satellite communications radio equipment. While initially focused on reuse among Army aviation platforms, adding in Link-16 capabilities opens up software reuse on NAVAIR platforms across military branches. (Figure 2.)

The R2C2 software implements a communications control application programming interface (API) that provides access to the capabilities of the radio devices. The API is a set of software methods that standardize control of the radios from the host platform and replaces the platform-specific protocols of individual radios with a single abstracted software interface mechanism.

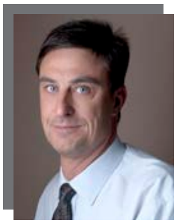
Next up

Open systems applications and architectures show great promise in lowering the cost and time necessary to create new applications and promote reusable applications across multiple dissimilar platforms and, eventually, across military branches. Operating system and portable component applications-conformance

Figure 2 | TESseract mission computer from TES-SAVi with AN/ARC-231 and AN/ARC-201D radios.

testing is now underway, which will lead to filling the FACE Registry with reusable software capabilities. Government, industry, and academia will continue to support the Open Group's FACE Consortium and forge new business strategies for future capabilities for designers and users. **MES**

Wayne McGee *is the vice president of sales and general manager for North American Operations for Creative Electronic Systems, a member of the FACE Consortium. Wayne has served in various senior management positions in his career and has more than 30 years of experience in the VME, CompactPCI, ATCA, and VPX markets. Wayne is also the chairperson for the VNX VITA-74 Marketing Alliance. In the past, Wayne has worked for such corporations as Motorola Computer Group, VMIC, SBS Technologies, and GEIP. He holds a BSEE from the University of South Carolina.*



Stephen Simi *is the vice president and program manager of Military Aviation Programs for Tucson Embedded Systems, also a member of the FACE Consortium, and serves as vice president of product and services for TES-SAVi. Stephen is chairperson of the FACE Integration Workshop committee. Stephen has more than 30 years of experience in design, reusable open systems software development, embedded systems integration, and product and business development in the software engineering, optical engineering, and military aviation spaces. Stephen has also held positions with Boeing-Space Station, MITRE, the U.S. Army, and Breault Research Organization. He earned a Master of Science in Engineering from the University of Maryland.*

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OPEN STANDARDS

Technology-integration trends in avionics displays

By John Rodwig

As avionics technology advances, display manufacturers are challenged to design displays that are more functional for the operator yet cost-effective for the customer. New software and hardware advancements are leading the way, while system upgrades and standardization of components create ongoing cost efficiencies for the future.

An F-15E Strike Eagle flies over Afghanistan, where its primary role is to provide close-air support for ground troops. U.S. Air Force photo/Staff Sgt. Aaron Allmon.

As the airborne operator relies on more complex and larger amounts of data and video to improve situational awareness, the time the operator has to make a decision has steadily decreased, emphasizing the need for better organization, processing, and distribution of actionable information.

Technology upgrades produce vast increases in computing power, enabling centralization of previously distributed sensor, video, and data functions. This centralization results in the need for high bandwidth, low-latency communication links that allow for direct mapping of video to display unit pixels. An integrated video and data communication protocol, such as ARINC 818, provides this solution.

ARINC 818 features high-resolution, low-latency video, and bidirectional data over a single fiber pair. Known for its flexibility, ARINC 818 can accommodate a variety of video and data applications.

ARINC 818 was initially developed for avionics applications requiring high-bandwidth, time-sensitive information, such as moving images with real-time overlays. For example, a weapons control application requires data from various sources to be fused and displayed to the operator with perfect position and time alignment. At a critical decision point, such as an aircraft crossing the boundary of a defended area, accurate presentation of information will help the operator make the best-informed decision.

Designing with modularity and reuse in mind

Modular software and hardware components are designed to interoperate with other elements through careful specification and interface control, and suitable abstraction from platform-specific details. The Future Airborne Compatibility Environment (FACE) and ARINC 818 are two enabling architectures.

FACE is a technical standard designed to promote portability and re-use of software lines across different military aviation programs. It was developed to address affordability initiatives related to the high cost of new complex mission equipment and electronic systems.

Software applications designed to FACE standards have the potential to be seamlessly integrated on multiple mission computers and other devices on most any aircraft, offer common aircraft data interfaces, run operational flight programs (OFP) designed to FACE guidelines, and host FACE-compatible apps that meet customers' unique system and application requirements. The portability of FACE applications makes the addition of avionics functions, such as moving maps, less expensive and with fewer defects.

FACE architecture defines a segmented Common Operating Environment (COE) that supports the reuse and rehosting of application software across different computing platforms.

The "Portable Components Segment" of the FACE Architecture is designed to be independent of the lower level hardware and software input/output (I/O) functions that are typically unique to each avionics device. This – with the additional segments of "Transport Services," "Platform-Specific Services," and "I/O Services" – form the successive abstraction layers that progressively allow for the reuse of software at the portable component layer across devices.

An additional benefit of these stacked segments is the ability for simulated operations to be inserted at virtually any point in the successive abstraction layers so that any function can be tested without with need for the complete operational environment.

ARINC 818 hardware is similarly modular in that the transport is identical and only the video and data format and content changes across platforms. ARINC 818 hardware can remain relatively stable because the video and message formats are contained in firmware. With two

DEVELOPING DISPLAY TECHNOLOGY THAT LEVERAGES BOTH FIBER-BASED ARINC 818 AND FACE STANDARDIZATION CREATES FUTURE COST-EFFICIENT INTEGRATIONS FOR CUSTOMERS AND BECOMES THE NEXT GENERATION OF AVIONICS EFFICIENCY.

different FPGA loads, one ARINC 818 circuit board can operate in different platforms with differing ARINC interface specifications that reflect display size, color depth, and command and status messages as long as the bit rate is not exceeded. In some cases, the ARINC 818 hardware drives the display panel directly and in others it may provide video to a frame grabber to be combined with other video. ARINC 818 hardware with multiple video inputs can provide additional cross-platform capability and future proofing.

Developing display technology that leverages both fiber-based ARINC 818 and FACE standardization creates future cost-efficient integrations for customers and becomes the next generation of avionics efficiency.

Leveraging open architectures

Over the last few decades, the government set a goal for adopting a combination of industrial standards in the design of new equipment. Previously customized avionics equipment has now been replaced with modular designs that benefit from the efficiencies of interoperability, portability, and scalability. Once in place, the performance of these airborne systems can be incrementally improved is by implementing system upgrades or technology insertions with the latest state-of-the-art components. There is a cost savings with exponentially improved functional capabilities – it is truly an improved value proposition.

The building blocks of several electronic aircraft systems are the avionics "black box" and line replaceable units (LRUs). Open architecture is widespread in these systems. This fact, combined with the use of more industry standard communication interfaces, allows tremendous flexibility in the direct specification and procurement of replacement hardware. What started as a "form-fit-function" replacement goal in the design of new displays has now significantly improved the life cycle management process with the selection and procurement of LRU components.

Designers and program managers are also encouraged and in many cases required to find commercial off-the-shelf (COTS) components for their projects. The theory is that COTS products reduce development time, and assumes a cost savings based on competitive pressures in the commercial marketplace. Importantly, the use of COTS components in avionics lowers total life cycle costs for a program.

Transitioning older to newer technology

An example of aging technology can be seen with the CRT components in existing military cockpit displays. The Air Force has needed a suitable replacement for the aging CRT utilizing current liquid crystal display (LCD) technology while still maintaining the same form, fit, and function of the existing unit. They look for qualified and fielded displays that can quickly and accurately be modified without changing outline and mounting surface or rewiring the airplane.

For the F15E Strike Eagle program, the Air Force chose the IEE 6-by-6 multi-purpose display (MPD) to replace CRT components in existing F-15 cockpit displays. The LCD system was able to slot directly into the cockpit area with minimal modifications needed. (Figure 1.)

CRT replacement may also require raster and vector, or stroke, signal compatibility. NTSC-conversion integrated circuits are becoming less common, which may eventually force custom solutions. Vector signal conversion is more involved and off-the-shelf solutions are rare or nonexistent. Any analog conversion is subject to aliasing or other artifacts that may have to be smoothed for acceptable image quality. Once in place, though, these solutions allow the legacy signals to be held in place indefinitely, awaiting future technology insertion.

Figure 1 | The 6-by-6 multi-purpose display is a liquid crystal display (LCD) component that fit directly into the cockpit of existing F-15 with minimal changes to the mounting surface. Photo courtesy IEE.

It is no small feat to replace aging military equipment. Since the first installation of initial designs, industry is just now beginning to address replacement issues. From old, hot, high-voltage, power-consuming displays with less than optimal images to new displays featuring touch and gesture, LCD screens, 4K images, and OLED [organic light emitting diode] screens – to name a few – advanced technology is finally slowly but surely making its way into avionics display designs.

There is no doubt that technology advancements in processing information are leading to operator efficiencies in the cockpit. The standardization and modularity of hardware and software in display design are also creating the cost efficiencies necessary to improve the overall value proposition of display systems. **MES**

***John Rodwig** is a Director of Program Management at Industrial Electronic Engineers, Inc. (IEE). He has over 30 years of technical and management experience in defense and telecommunications, and co-holds a patent for a Radar Scan Converter. John earned a BS in electrical engineering from Tulane University and an MS in engineering management from California State University, Northridge. John can be reached at jrodwig@ieeinc.com.*

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Themis High-Density Computing and Storage Solutions

What is behind the growing demand for high-density server solutions in the defense industry?

Function consolidation, virtualization, and big data analytics are driving more compute capability in a smaller footprint. The DoD requires feature-rich systems that interoperate in multiple applications and allow information sharing between applications. Demand is also driven by "Common Operating Environment" requirements, the use of common components, and "right-sizing" systems to deploy solutions in as many places as possible. To support big data analytics, the DoD utilizes the Map/Reduce function initially developed by Google for search purposes and provided by Apache in Hadoop clusters. The DoD utilizes Hadoop for mining sensor data in the DCGS-A program. The DoD is constrained by size, weight, power consumption, and heat. Themis HD/HDS systems provide robust thermal management and double compute density with a weight savings of nearly 50 percent when compared to a 1U server stack.

How does HD enable enterprise RAS features for embedded mission-critical systems?

Themis HD servers utilize the latest RAS features provided by Intel, including data and address path protection through parity and ECC for CPU and memory. These units incorporate built-in out-of-band management features for accessing system health. Through the KVM function, any network-connected client can access the console for BIOS setup, system boot, or software installation. The fans in each server module are managed locally and are over-provisioned. In the event of fan failure, remaining fans manage the required cooling load until the failed fan is replaced. Server, storage, and power modules are hot-pluggable. Front-mounted air filters protect electronic components and can be easily cleaned or replaced. The Resource Management HD module puts system management at the fingertips of the IT user.

How do Themis HD solutions address DoD requirements?

Themis HD servers deliver increased capability while allowing systems to be built up of standard, modular, lightweight, rack-mount components. Combined with a network switch and a transit case, a complete server solution can be deployed to any service region required. Available in a 2U (four bay) or 3U (six bay) chassis, RES-HD servers provide maximum system configuration flexibility and functionality with hot-pluggable processor, storage, high-speed switch, and system management module options. Additionally, there are both front and rear I/O chassis options. Combining leading-edge components that include Intel® Xeon® E5-2600 v3/v4 Series processors and SuperMicro motherboards, up to 1 TB of memory, dual GbE ports, and a single PCIe slot, RES HD modules feature expansion slots, extensive high-speed front or rear I/O, storage, and enhanced reliability options. Themis HD systems are modular. A 2U Chassis can host up to one HDS8 module plus two HDS8 Storage Expansion modules (2.5 inch SSD or HDD drives) for a total of 24 drives (including eight drives in HDS8 Storage module) or 48 TB. A 3U Chassis can host one HDS8 module plus four HDS8 Storage Expansion modules for a total of 40 drives (including eight drives in HDS8 Storage module) or 80 TB.

Themis
2U HD Storage Chassis

Themis
2U HD Storage Expansion

Themis
3U HD Storage Chassis

What are the Themis server's primary size, weight, and power-cost (SWaP-C) characteristics?

Themis HD systems offer a four-bay 2U (3.5 inches) or six-bay 3U chassis (5.25 inches) height. System depth is 20 inches. The 2U HD system typically weighs 40 pounds, and the 3U system typically weighs 55 pounds when fully populated. The HD system power consumption is -1,300 W and the HDS power consumption is -750 W. HD systems enable customers to double compute density and enable a 50 percent rack space savings with system module weights as low as six pounds. Depending on the configuration, total system weight is reduced by nearly 50 percent.

Do HD designs enable regular technology refresh or technology insertion?

Yes. Themis follows the Intel road map. HD systems are refreshed at the same interval. These systems enable individual module upgrades with the main chassis in place, in the rack.

Where can Themis HD servers be used in applications outside of defense?

HD systems can be used in any application where high compute density and large, local storage are needed. Add in the robust environmental capability and they can easily be deployed in industrial or energy-exploration applications.

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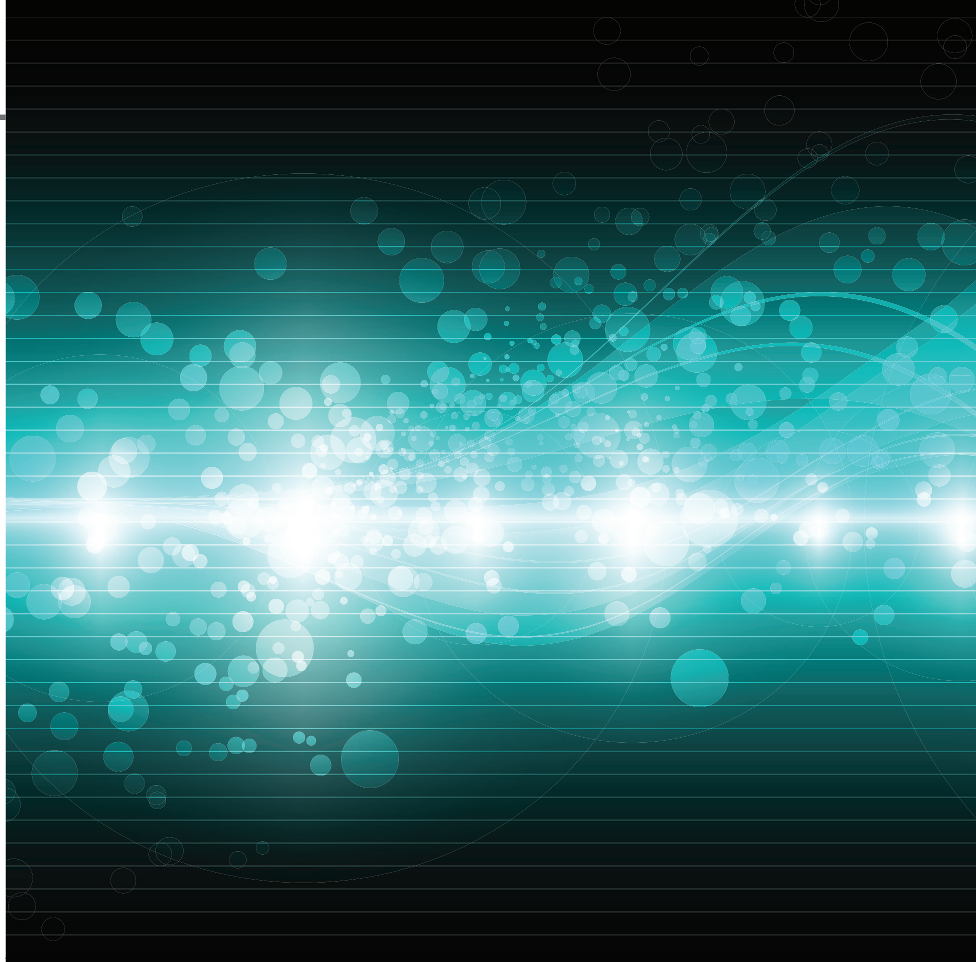


FPGA coprocessors for acceleration of shape recognition algorithms in hybrid VPX HPEC systems

By Thierry Wastiaux

To reach the level of performance requested by the latest military specifications, electronic warfare (EW) systems designers rely more and more on VPX high-performance embedded computing (HPEC) platforms. To handle the global IP traffic growth – predicted to reach 132 exabytes (EB) per month in 2018, according to Cisco's Visual Network Index – electronic systems must manage the data flow in and out of the semiconductor devices. Designers of field-programmable gate arrays (FPGAs) have developed devices offering high bandwidth and performance with very high-speed interfaces that can bring superior parallel processing power. This reality enables the design of high-performance hybrid HPEC systems that can be used for such demanding applications as ultrafast shape-recognition systems.

Leading FPGA companies have developed some quite high-performing devices. A Xilinx VU13P UltraScale+ FPGA offers more than 3.5 million logic cells, 11,904 DSP enhanced slices for signal processing, and as many as 128 32.75 Gb/s GTY transceivers, allowing massive data flow and routing while supporting multiterabit per second throughput. These new GTY transceivers feature autoadaptive equalization and major power reduction. Integrated 100 GbE MAC architectural blocks and PCIe Gen3 cores are also included for faster communications. Designers tend to use very high-width buses, typically up to 2,048 bits, allowing massive parallel applications. The challenge in these parallel architectures is the clocking: Advanced clock management, clock network centered on user logic, and distributed clock buffers enable designers to maximize performance and reduce dynamic power.

These new FPGAs offer an extremely high parallel-processing power relative to power consumption. In parallel computing these FPGA can bring more than ten times the Gigaflops per watt performance of the last processors. To benefit from these enhanced numbers, HPEC systems are now based on tight coupling between FPGAs and high-end processors. High-speed VPX backplanes can allow for huge data flow between clusters of FPGA boards and digital signal processor boards. The VITA 66.1 and 66.4 standards have been developed in particular to reach the high transceiver line rate of these FPGAs.

Innovative FFTs and DCTs in low-power implementations

Interface Concept is participating in a research and development program, in cooperation with France's University of Brittany (UBO), aimed at using these technologies in the field of shape recognition. The first part of this program consisted of developing innovative implementations of fast Fourier transforms (FFT) and discrete cosine transforms (DCTs) in FPGAs, greatly reducing execution time while decreasing the necessary resources. In this joint endeavor, the teams have considered the FPGA resources in term of number of LUTs [Look Up Tables] used, both in terms of level of output of the FFT per second and full execution time. Compared to the IP now on the market,

the team improved by a factor of four the throughput versus the number of LUTs, with a nearly twofold improvement of the logic resources multiplied by execution time. As for the DCT, the joint project improved by a factor of three the logic resources multiplied by execution time. These improvements were achieved while keeping close control of power consumption. The execution, in continuous mode, of one 1,024-point FFT consumes about 100 mW of power in a Virtex-6 FPGA. For 4,096 points, the power consumed rises to 150 mW; for a 64-point FFT, power consumption drops to only 50 mW.

In the second part of this research program, these performance improvements and power conservations have been used to increase the performance of shape-recognition algorithms implemented on HPEC platforms.

The base of the shape-recognition algorithm is the processing of a digital correlation between a target image and a reference image. This correlation is carried out by multiplying the spectrums of the target image and the reference image (using a 2-D FFT to get the spectrums of the images), and then taking the inverse 2-D FFT of the result. Finally, the energy of the correlation peak normalized to the total energy of the correlation plan is processed. If the correlation peak is above a given threshold, a decision is made that the target image is identical to the reference image. If the threshold is not reached, another target image is loaded and the process is repeated. To improve the performance of the process, some transformations are made on the spectrum of the reference image (called the filter) to get an adapted filter used for the spectrum multiplication and before the inverse FFT transformation. Overall, this process leads to a high-performing algorithm that has fine discrimination when applied to face recognition. This same approach may be applied to other kinds of shape recognition.

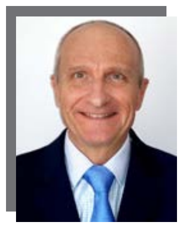
This correlation architecture has been implemented into Xilinx FPGAs. One XC7VX690T can simultaneously support around 30 correlation architectures described above, with each correlation architecture being able to process around 4,000 images per second. At this rate, that means that one XC7VX690T can process and decide on 120,000 images per second.

Interface Concept has designed signal processing FPGA boards specially designed for heavy signal processing and for communicating with the processor board. One example is the IC-FEP-VPX6b board, which features two Virtex-7 XC7VX690T and two FMC slots (Figure 1). It also features a QorIQ processor acting as a PCI Express Root Complex to control the board. The PCIe protocol is used for the VPX data plane communication between the boards. Four PCIe fat pipes are available on the P1 connector as a data plane communication. Each FMC slot can receive one IC-OPT-FMCa connected to 12 optical fiber connections at a rate of 10 Gb/s each; this rate can be sustained by the FPGA transceivers in front. Eight lanes are connected through the FMC VITA 57.1 connector to eight GTH transceivers, thus enabling the device to feed the Virtex-7 FPGA with the flow of images that will be filtered by the convolution algorithm. All these products can be plugged into a conduction-cooled VPX architecture, which allows operation in constrained environments in the absence of a cooling air flow.

Figure 1 | IC-FEP-VPX6b featuring two Virtex-7 FPGAs.

By using a VPX hybrid HPEC platform integrating five IC-FEP-VPX6b boards, each one having two FMC optical mezzanines as the IC-OPT-FMCa and integrating one IC-INT-VPX6b, users can build a platform based on the above correlation architecture that is able to process as fast as 1.2 megaimages per second.

By taking advantage of the latest FPGA technologies, optical low-power transceivers, and processors, it is possible to build very high performance hybrid HPEC rugged architectures that can tremendously accelerate the execution of algorithms that can be processed in parallel, such as shape-recognition algorithms like those used in EW systems. **MES**



***Thierry Wastiaux** is senior vice president of sales at Interface Concept, a European manufacturer of electronic embedded systems for defense, aerospace, telecom, and industrial markets. He has 25 years of experience in the telecom and embedded systems market, having held positions in operations, business development, and executive management. Prior to joining Interface Concept, he was responsible for the operations of the Mobile Communication Group and the Wireless Transmission Business Unit in Alcatel-Lucent. He holds an M.Sc. from France's Ecole Polytechnique. Readers may contact him at twastiaux@interfaceconcept.com.*

Interface Concept
www.interfaceconcept.com

Nail down software security with dynamic analysis

By Jay Thomas

You've secured your Internet of Things (IoT)-connected system with components for authentication such as password, retina scan, physical key, plus encryption/decryption and more. But building these things in is not enough. You've got to be certain that they all work together properly and that the code doesn't contain any flaws that could grant access to hackers. Security needs to be built in at the very start of the project by using secure protocols and continuing on up to functional elements in the application. One powerful tool for gaining this assurance is dynamic analysis.

Dynamic analysis examines the compiled, running code and relates it back to the source code. It is a major component in a suite of tools that includes code coverage, requirements traceability, and static analysis. Of course, that means that dynamic analysis is but one important piece of what is needed to make a secure application. But analyzing the code as it executes has two advantages.

First, it can measure the effectiveness of testing by using code coverage to indicate what parts have been executed or tested. That means it can also identify "dead" code that is either not needed or could serve as a gateway for hackers.

Second, it can make use of automated test generation along with manual testing to examine the application's behavior in the face of expected and unexpected input. Such input could either be from a user or perhaps from sensors. It lets us see what the system would do in such cases and what that means in terms of safety and security.

Both manual and automatically generated tests should relate to the program's requirements. Having requirements that can be traced back and forth to the code is essential to understanding the system's intended behavior. Also, for whatever the desired level of coverage, the ability to link the code behavior back to the requirements helps assure us of correct operation. This can be particularly important for security requirements. If you can see how the code is behaving and can link it back to security requirements, you can test the effectiveness of those requirements (for example, by simulating attacks) and determine if they are adequate or should be improved.

The ability to understand control flow and data flow gives insight into how the data – in the form of variables, parameters, etc. – is being manipulated. This lets us see dependencies between software components and whether each component is producing the expected results from the data presented.

Dynamic analysis is not only intended for testing the completed program. It can also be used to great advantage in unit and integration testing. Combined with static analysis, which looks at the uncompiled code, it can be used to automatically generate the test cases, test harnesses, and the whole framework to verify the work of different teams and integrate them smoothly into the full system.

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As mentioned earlier, dynamic analysis is just one of a set of tools that can be used together. When combined with static analysis to test for security properties, this phenomenon is often identified as hybrid application security testing, or HAST. For its part, static analysis is used to check for coding standards compliance in order to eliminate code vulnerabilities using standards such as MISRA or CERT C.

It is also useful in determining the data and control flow relationships and dependencies between software components before execution. Once the code is cleaned up from the static analysis perspective, it can move to dynamic analysis, where the code is subjected to automatically generated tests and manual tests using expected and unexpected inputs.

The bottom line: Dynamic analysis supported by complementary tools like static analysis and requirements traceability can go a long way toward ensuring a secure, safe, and ultimately certifiable software effort.

__Jay Thomas,__ a technical development manager for LDRA Technology, has been working on embedded software applications in aerospace systems since the year 2000. He specializes in embedded verification implementation and has helped clients on projects including the Lockheed Martin JSF and Boeing 787, as well as medical and industrial applications.

Next-gen navigation: Tapping signals of opportunity

By Sally Cole, Senior Editor

Need to navigate and global-positioning system (GPS) signals are unavailable? No problem.

Amidst increasing concerns about heavy reliance on the U.S. NAVSTAR GPS and global navigation system (GNSS), a team of University of California–Riverside (UCR) researchers has created a navigation system that takes advantage of existing cellular signals — no GPS signals required.

Led by Zak Kassas, assistant professor of electrical and computer engineering in UCR's Bourns College of Engineering, the team's highly reliable and accurate navigation system exploits existing environmental signals of opportunity – cellular or Wi-Fi – rather than GPS signals.

Their technology is being touted as a "standalone alternative" to GPS or as a complement to current GPS-based systems to enable highly reliable, consistent, and tamperproof navigation.

In terms of applications, their method of exploiting signals of opportunity may be used to develop navigation systems capable of meeting the stringent requirements of fully autonomous vehicles – yes, driverless cars and drones.

Today, navigation systems in cars and portable electronics rely primarily on GNSS. But precision military technologies, such as aerospace and missiles, require navigation systems that combine GPS with a high-quality, onboard inertial navigation system (INS) capable of providing backup within GPS-denied areas, whether caused by terrain, jamming, spoofing, or catastrophic GNSS failures. INSs can deliver a high level of short-term accuracy, but it eventually "drifts" when it loses touch with external signals.

During the past few years it's become increasingly clear that, despite advances in INS technology, today's GPS/INS systems won't be able to meet the demands of future autonomous vehicles for several reasons. For starters, GPS signals alone are extremely weak and unusable in terrains such as deep canyons or underwater. GPS signals are also highly susceptible to intentional jamming or unintentional interference. And civilian GPS signals are unencrypted, unauthenticated, and specified in publicly available documents – making them hackable and spoofable.

A current trend for autonomous vehicle navigation systems is to rely not only on GPS/INS but also on several other sensor-based technologies such as cameras, lasers, and sonar.

"Adding more and more sensors allows researchers to throw everything but the kitchen sink at preparing autonomous vehicle navigation systems for the inevitable scenario in which GPS signals become unavailable," Kassas says. "We took a different approach by exploiting signals already out there in the environment."

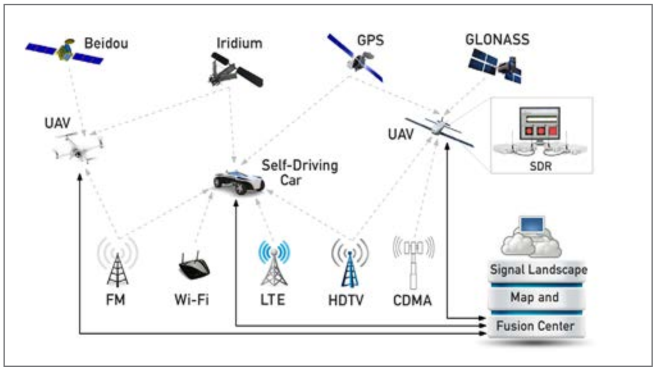


Figure 1 | A schematic showing how researchers at UC Riverside are using existing communications signals to complement satellite-based navigation systems like GPS for the control of driverless cars and unmanned aerial vehicles. Image courtesy of ASPIN Laboratory at UC Riverside.

Rather than simply adding more internal sensors, Kassas and his team in UCR's Autonomous Systems, Perception, Intelligence, and Navigation (ASPIN) Laboratory are developing autonomous vehicles capable of tapping into the hundreds of signals of opportunity around us at any point in time – such as cellular, radio, television, Wi-Fi, and other satellite signals. (Figure 1.)

The system can be used as a standalone, according to the team, but will more likely be used as a supplement to INS data in case GPS fails.

The team's end-to-end research approach includes theoretical analysis of signals of opportunity within the environment, building specialized software-defined radios (SDRs) that can extract relevant timing and positioning information from signals of opportunity, developing practical navigation algorithms, and testing the system on ground vehicles and unmanned drones.

"Autonomous vehicles will inevitably result in sociocultural revolution," Kassas says. "My team is addressing the challenges associated with realizing practical, cost-effective, and trustworthy autonomous vehicles. Our overarching goal is to get these vehicles to operate with no human in the loop for prolonged periods of time, performing missions such as search, rescue, surveillance, mapping, farming, firefighting, package delivery, and transport."

The team's research was funded with support from the Department of Defense's Office of Naval Research.

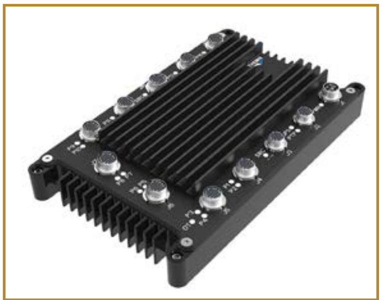
XPand4208 includes quad-core Intel Core i7 processors

The XPand4208 from Extreme Engineering Solutions (X-ES), designed for avionics and vetronics applications, is a high-performance, expandable, computing and networking platform. The system has qualified under the MIL-STD-810F, DO-160F, MIL-STD-461F environmental, and EMI/EMC standards. This line-replaceable unit (LRU) includes two quad-core Intel Core i7 processors, each capable of operating at up to 2.1 GHz. The XPand4208 provides various external I/O interfaces, including eleven Ethernet ports, two DVI ports, eight USB ports, nine serial ports, and an option for four isolated GPIO discretes. The internal processor modules communicate with expansion slots via four high-throughput PCI Express interfaces. The processor modules communicate with each other, as well as with external devices, over a managed Gigabit Ethernet fabric.

The Gigabit Ethernet fabric delivers wirespeed across all of its ports, supporting packets as much as 12 kB. It also supports IPv6, Energy Efficient Ethernet (EEE), and a set of IETF RFCs and IEEE protocols. The XPedite5205 Cisco IOS router XMC can be installed on the platform, providing secure data, voice, and video communications to stationary and mobile network nodes. The XPand4208 includes two removable SATA solid-state drive (SSD) flash memory modules, which feature 256-bit AES hardware encryption, connectors capable of thousands of insertions and extractions, and they include zeroization support. The XPand4208 can be configured to support Intel's Active Management Technology (AMT), which allows developers and installers to remotely access diagnostic information and perform system maintenance on each processor module via a network connection.

Extreme Engineering Solutions (X-ES) I www.xes-inc.com I www.mil-embedded.com/p37390

Rugged switch with embedded x86 PC for military vehicles



The Themis NanoSWITCH is a size, weight, power, and cost (SWaP-C)-optimized rugged multi-layer gigabit Ethernet switch with an embedded x86 PC. The NanoSWITCH enables enterprise-level layer 2/3 switching in the rugged environments found in military ground, air, and sea vehicles. Typical applications include vehicle network switching; distributed architecture vehicle controller; VICTORY-compliant switch, router, timing, and control; WAN-LAN interconnectivity and firewall; shared processing; and peripheral communications.

Engineers designed the NanoSWITCH to provide 10x or 16x external Gigabit Ethernet ports that operate at rates of 10, 100, and 1,000 Mbps. A full management suite is included, as well as a command line interface (CLI) for controlling switch and routing operations. The NanoSWITCH supports IPv4 and IPv6 routing, including tunneling and IP Multicast; VLANs; and IETF, IEEE, and DSL Forum standards. The switch includes Quality of Service (QoS) features to ensure that traffic is prioritized to deliver the performance needed for real-time applications. These QoS features include system management, voice, video, and bandwidth-intensive file uploads and downloads. Additional QoS capabilities – including IEEE 802.1p priority tagging, DSCP, and eight hardware traffic class queues – also support for real-time applications.

Themis I www.themis.com I www.mil-embedded.com/p373888

X-series adds M9290A CXA-m PXIe signal analyzer

Keysight has expanded its X-series of signal analyzers with the CXA-m, a PXIe signal analyzer that offers specified performance up to 26.5 GHz. Its measurement capabilities include swept and FFT modes in the same instrument. The testing capabilities of the M9290A CXA-m PXIe signal analyzer are aimed at use in military maintenance applications; RF and microwave signal analysis as fast as 26.5 GHz; testing of components, devices, boards and systems; characterization of military and public-safety radios; and testing of radios used in avionics, satellites, radar, and electronic warfare systems.

The M9290A CXA-m PXIe signal analyzer can accelerate tasks such as the identification of spurious signals and harmonics. The CXA-m also aids system development by providing compatibility with code written for Keysight's X-Series signal analyzers and ESA spectrum analyzers. The features include the choice of four models that range from 10 Hz to 3, 7.5, 13.6, or 26.5 GHz; ready-to-use drivers and SCPI commands; and interface and code compatibility with previous X-series products.

Keysight Technologies I www.keysight.com I www.mil-embedded.com/p373889

3U VPX features processor with mobile Intel QM77 Express chipset for radar applications

ADLINK's rugged 3U VPX 3rd-generation Intel Core i7 processor blade was designed for radar and intelligence, surveillance, and reconnaissance (ISR) applications. The VPX-3001 Series is a 3U VPX processor blade that features the processor with mobile Intel QM77 Express chipset. It provides as much as 8 GB DDR3-1066/1333 dual-channel error-correcting code (ECC) memory soldered onboard, one PCI Express x8 XMC.3 site with VITA 46.9 rear I/O, and onboard soldered 32 GB SLC SATA solid-state drive.

A VPX-R3001 rear transition module is available to access rear I/O signals, while a 9-slot 3U VPX test frame is available for users to validate VPX3001 functionality. Rear I/O via P1 and P2 includes 2x 1000BASE-T or 2x 1000BASE-BX (BOM option) interface, 1x SATA 6 Gb/s interface, 1x SATA 3 Gb/s, 2x USB 2.0, 6x GPIO, VGA, 1x RS-232, and 1x RS-232/422 interfaces. The VPX3001 Series – designed to be conduction-cooled with conformal coating – can also be designed into applications such as unmanned systems.

ADLINK Technology Inc. | www.adlinktech.com | www.mil-embedded.com/p373887

F-series computing platform designed to meet SWaP requirements in harsh environments

Elma Electronic's S50F computing platform was designed with an Intel Corei7 processor at its foundation. The F-Series of the S50F-Intel Gen 4 Haswell general computing platform is expandable both in terms of I/O options and overall system size for enhanced performance while meeting size, weight, and power requirements in harsh environments. The platform's I/O modules may be added or removed to keep pace with evolving system requirements. Additionally, the system comes in three basic size profiles to offer the correct starting point for most users.

The S50F series features Intel Haswell, 4th-gen quad or dual core processor; 8-series QM87 PCH chipset; and Intel high-performance HD4600 graphics engine. It comes with as much as 8 GB DDR3; has type 1 bottom-stacking PCIe/104 with Gen 2 PCIe x1 Lanes and Gen 3 PEG x16; 2x SATA 600 ports with RAID; 2x Gigabit Ethernet ports; 2x RS232 COM ports; and 13x USB 2.0 total/2x USB 3.0, backward and USB 2.0 compatible. The platform also has onboard VGA/DisplayPort, LVDS, HDMI/DVI, eDP interfaces; discrete 16-bit GPIO port; 7.1 HD audio with SPDIF I/O); mini PCIe/mSATA socket for onboard WiFi, CANBus, or additional storage; and a small-footprint aluminum box designed to meet MIL-STD-810F environmental standards.

Elma Electronic | www.elma.com | www.mil-embedded.com/p373892

Board provides server-grade performance with storage connectivity

The Concurrent Technologies TR C4x/msd board – intended for military, aerospace, transportation, and test markets – provides server-grade performance with storage connectivity for use in embedded computer applications. The 10G Ethernet dataplane connectivity enables users to build multiprocessor systems by slotting in additional processor boards at the same time, while high bandwidth coprocessing resources can be connected in adjacent slots via PCI Express expansion plane connections. Security, built-in test, and other options are available to suit users' application needs.

The 3U VPX board features the eight-core Intel Xeon Processor D-1548 and up to 32 GB of DDR4 ECC DRAM for high-performance embedded computing applications. For storage applications, TR C4x/msd has four SATA600 interfaces for external drives, plus two SATA600 connections for onboard solid-state disk options. Additional features include 3U VPX form factor, up to 16 cores and 32 GB DDR4 memory, an optional 128 GB SATA flash module and 2.5-inch SSD for local storage, 2x 10GBASE-KR data plane connectivity, and 4/8/16 PCI Express Gen3 expansion plane for local coprocessing and I/O resources.

Concurrent Technologies | www.gocct.com | www.mil-embedded.com/p373891

COTS makes its case for wider military adoption

By Charlie Kawasaki

BLOG

In its recently released report, Research and Markets forecasts that the global defense IT spending market will grow at a compound annual growth rate (CAGR) of 3.11 percent between 2016-2020. The market research firm adds, "The defense sector is investing in commercial off-the-shelf (COTS) products such as wearable computing, Internet of Things (IoT), 3-D printing, and mobile solutions to increase the defense capability through cutting-edge technology." Military organizations evaluating or using COTS products must consider the benefits and limitations of COTS products relative to custom-built hardware and software products, as well as the types of COTS products that best fit their mission requirements.

Growing adoption of COTS products by the military can be traced to a set of key market factors and attributes relative to custom-built hardware and software. The first factor to consider is economies of scale in research and development (R&D). Every day, many tens of thousands of engineers go to work at commercial technology companies, working diligently to advance the state-of-the-art hardware, software, networking, communications, and IT security. The vast majority of this R&D is paid for through commercial sales, at an investment rate that the military can't come close to matching. By adopting COTS, the U.S. military receives the benefit of that R&D, essentially for "free".

Second, COTS provides economies of scale in manufacturing. A large military ground-combat-systems program like the Abrams or Stryker vehicle is measured in the low thousands of vehicles. By comparison, a large commercial vehicle program is measured in the hundreds of thousands, while a large tactical radio program like the PRC-154a Rifleman Radio might be measured in hundreds of thousands of handheld radios. In contrast, a large smartphone company like Apple will produce hundreds of millions of smartphones. Thus, the cost reduction related to COTS manufacturing can be used to save costs for the military as well.

Additionally, the military can also take advantage of the large-scale support and logistics available from large global companies rather than having to build their own. The availability of trained administrators and operators when using COTS technologies saves cost and maximizes the ability to find technical experts to support systems. Additionally, the ability to adopt COTS technology to conform to international interoperability standards enables the military to communicate between different services and between with coalition and alliance partners.

Key COTS considerations for the military

As is true with any technology or product, COTS may not be suitable for every military use case. For that reason, decision makers should evaluate the benefits and drawbacks relative to COTS usage.

One drawback may be that COTS devices may not be sufficiently rugged for in-field use. This is particularly true of communications equipment designed to be used in office and datacenter environments, where the devices are intended to be installed in a fixed location and run in air-conditioned environments protected from dust, heat, rain, etc.

Another caution is that devices may not be sufficiently energy-efficient for in-field use, something that is particularly true for the types of devices that run in offices and rely on utility-provided power. Military equipment often must run on generator or battery power, and must be designed carefully to minimize power consumption – maximizing runtime and reducing the number of dangerous and expensive fuel-resupply missions.

Frequently, COTS devices may not be designed to minimize size and weight. When a device is shipped in the U.S. from a manufacturer to a customer, typically size and weight are not of paramount importance, since the devices will be shipped once. However, when equipment is flown into theater and relocated or jumped frequently, especially in hostile environments with limited transport options, minimizing size and weight are critical for reducing the number of trips or transport vehicles required to deploy systems.

Deploying COTS equipment typically requires choosing equipment from many different vendors, as no single vendor makes all of the equipment necessary to meet mission requirements. Examples of different types of equipment include network routers, satellite antennas/modems, wireless base stations/access points, servers, and firewalls. As a result, military IT administrators and operators are faced with enormous technical learning curves and complex setup and maintenance procedures. This is particularly true when paying close attention to the security configurations of the devices.

COTS and security

COTS equipment must meet well-documented and standardized security configuration requirements set by the Defense Information Systems Agency (DISA), the NSA, and the various communications programs for each service. Frequently (but not always), the best of enterprise-class COTS equipment is designed from the outset to meet these standards, and through that conformance, consumers and nonmilitary customers receive those benefits.

On occasion, leading COTS equipment manufacturers make adjustments to the products to meet military requirements, but typically those adjustments are modest compared to the overall R&D investment of the original product. Examples of standards that must be met include FIPS 140 standards for encryption strength, NSA/NIAP Common Criteria standards developed to ensure interoperability and security functionality across federal agencies, and DISA JITC UCR standards ensuring interoperability of devices connected to military networks.

Early COTS adoption by military

The depth and breadth of COTS adoption across the military will expand over time from the early adopter phase through widespread deployment. Early COTS use cases include:

- IP-enabled networking equipment typically found in office environments used for access to the internet and to private and classified military networks. This includes network routers, switches, and firewalls.
- Wireless equipment for long-range communications, such as satellite and point-to-point radio equipment. Typically used to establish communications links from operating basis in theater, to headquarters, or to remote/forward operating bases.
- Short-range wireless equipment for communications in bases. This includes Wi-Fi and cellular systems.
- Computer servers used to perform computation and large-scale data storage, provide email access, store and process intelligence information, or provide command-and-control applications.
- End user devices such as PCs, laptops, and smartphones.
- Cybersecurity devices such as VPN (encryption) gateways, firewalls, and user authentication servers.

The future of COTS adoption

The COTS value proposition has been proven, and military adoption will only increase over time since the benefits outnumber the drawbacks. In particular, a new wave of COTS technology is just beginning to roll out to the military in the form of Wi-Fi, LTE, and smartphones for use in classified (secret and top-secret) networks. This new capability, based on a new NSA program called "Commercial Solutions for Classified," will bring the previously unavailable benefits of wireless and smartphones to the warfighter, such as access to email, messaging, video, and applications – along with a wide array of mission critical, military-specific applications to be developed in the future.

Charlie Kawasaki is the chief technical officer of PacStar.

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CONNECTING WITH MIL EMBEDDED

By Mil-Embedded.com Editorial Staff

CHARITY

The Mission Continues

Each issue 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. To back that up, our parent company – OpenSystems Media – will make a donation to every charity we showcase on this page.

This issue we are highlighting The Mission Continues, a national organization founded in 2007 to empower veterans who are adjusting to life at home to find purpose through community-service projects and outreach programs.

The Mission Continues deploys veteran volunteers alongside nonprofit partners and community leaders to lead and assist in projects including improving community education resources, eliminating food deserts, and mentoring at-risk youth.

At the heart of the organization are fellowships, through which selected post-9/11 veterans volunteer part-time for six months at the community organization of their choice. In return, fellows receive a living stipend, complete a leadership development curriculum, and develop new skills and networks. According to the group, the fellowship program is ideal for veterans who wish to start a new career, gain practical work experience while attending school, or find a new way to serve at home and transition back into civilian life.

The Mission Continues also emphasizes the post-service contributions of female veterans: The organization says that 34 percent of its fellows are female veterans who are fanning out in their communities to lead service platoons, organize projects, and mount fundraisers.

Through this unique model, says the group, veterans build new skills and networks that help them successfully reintegrate to life after the military while making long-term, sustainable transformations in communities and inspiring future generations to serve.

For more information, visit www.missioncontinues.org.

WHITE PAPER

Implementing high-performance embedded computing hardware

By Trenton Systems

High-end embedded applications require robust computing performance, so the system host board (SHB) and system-level technologies must be able to take full advantage of the ever-increasing number of processor cores and the corresponding increase in native PCI Express 3.0 links available on the processor die.

The white paper discusses several hardware platforms, including a dual-processor system host board and related PCIe Gen3 backplanes, referred to as high-density embedded computing (HDEC). HDEC is a new SHB and backplane standard that builds upon the basic PICMG 1.3 specification by increasing the base number of PCIe lanes between the HDEC Series SHB and backplane from 20 lanes to a maximum allowable limit of 88 lanes.

Read the white paper: http://embedded-computing.com/white-papers/white-embedded-computing-hardware/

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