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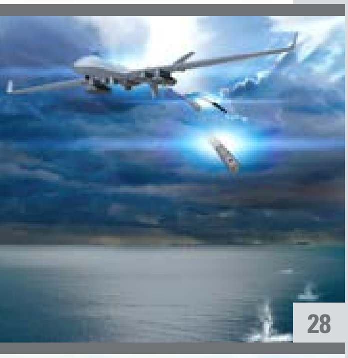

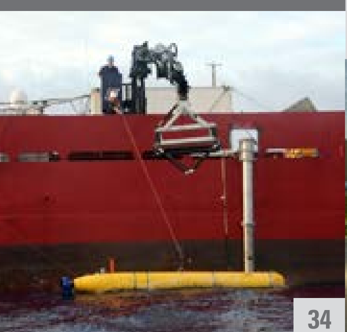

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ON THE COVER:

Top image:
The multi-mission Predator B is highly modular and configured easily with a variety of payloads. Shown here, Predator B drops sonobuoys for an anti-submarine warfare mission. (Photo courtesy of General Atomics – Aeronautical Systems, Inc.)

Bottom image:
Pictured are an Apache AH-64 and an MQ1-C Gray Eagle after the completion of a MUM-T exercise. Photo courtesy of U.S. Army.

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Human space flight funding, remembering the Challenger crew

By John McHale, Editorial Director

Televisions were rolled into classrooms at our high school when the news spread about the crash of the Challenger space shuttle. We watched the coverage all day: footage of the launch, the explosion, and President Reagan's speech. All of it made life a little darker for us sheltered teenagers. The memory came back earlier this year while watching the coverage commemorating the 30th anniversary of the death of teacher Christa McAuliffe and six NASA astronauts when their spacecraft disintegrated moments after liftoff.

Thinking back to that day in 1986: The class went quiet as the disaster played out on the screen. By then we had grown used to shuttle missions going off without a hitch; we were too young to remember the tragedy that occurred in 1967 with Apollo 1, when a fire killed three astronauts.

I wondered if the space program would continue. It did continue, and many more missions followed, including another that ended in tragedy, the destruction of the space shuttle Discovery in 2006. Eventually the shuttle program was retired, but exploration continues, although at a pace much too slow for some of us.

Human space flight funding is getting cut again in the Obama administration's fiscal year (FY) 2017 budget request, released earlier this year. Overall, the request is $19 billion, down about $300,000 from FY 2016 enacted, with funding for exploration at $3.337 billion, down nearly $700,000. Even though it is slated to increase each year until it reaches $4.262 billion in 2021, more money will likely be spent by billionaires Jeff Bezos and Richard Branson on their respective space flight companies – Blue Origin and Virgin Galactic.

Funding requested for the Orion program – the replacement for the now-retired space shuttle program – is at $1.120 billion, down from FY 2016 funding of $1.270 billion; the number is expected to remain flat through 2021. Dollars slated for operating the International Space Station (ISS) are also decreasing, at $1.431 billion in this year's request, and decreasing slightly each year through 2021. NASA officials say that they will continue commercial development of U.S. crew-transportation systems to be certified to support the ISS by the end of 2017, eliminating the need to pay Russia for crew transport services. Regarding space transport, commercial crew funding is at $1.185 billion for FY 2017, with crew and cargo at $1.573 billion.

While manned space flight continues to take a hit in the budget, NASA is increasing funding for research and development (R&D) programs and efforts such as CubeSat, which sees its funding tripled to $10 million. The FY 2017 request aims to invest $579 million for R&D in space technology and

$213 million for Small Business Innovative Research and Small Business Technology Transfer programs. About $30 million in funding is also slated for the Small Satellite Constellation, while funding for the Small Spacecraft Technologies program increases by about 50 percent. This request also increases Planetary Science research to about $1.519 billion.

All of these research projects, small satellites, and unmanned science missions are important and contribute to our understanding of space. They also help to enable future manned missions. Unmanned platforms are also crucial for the lethality and reconnaissance advantages they offer to the military (for more on this, see our Special Report and Mil Tech Trends sections on pages 20 and 28) and offer many new applications for both earthbound applications and safe space exploration for missions where humans just can't go.

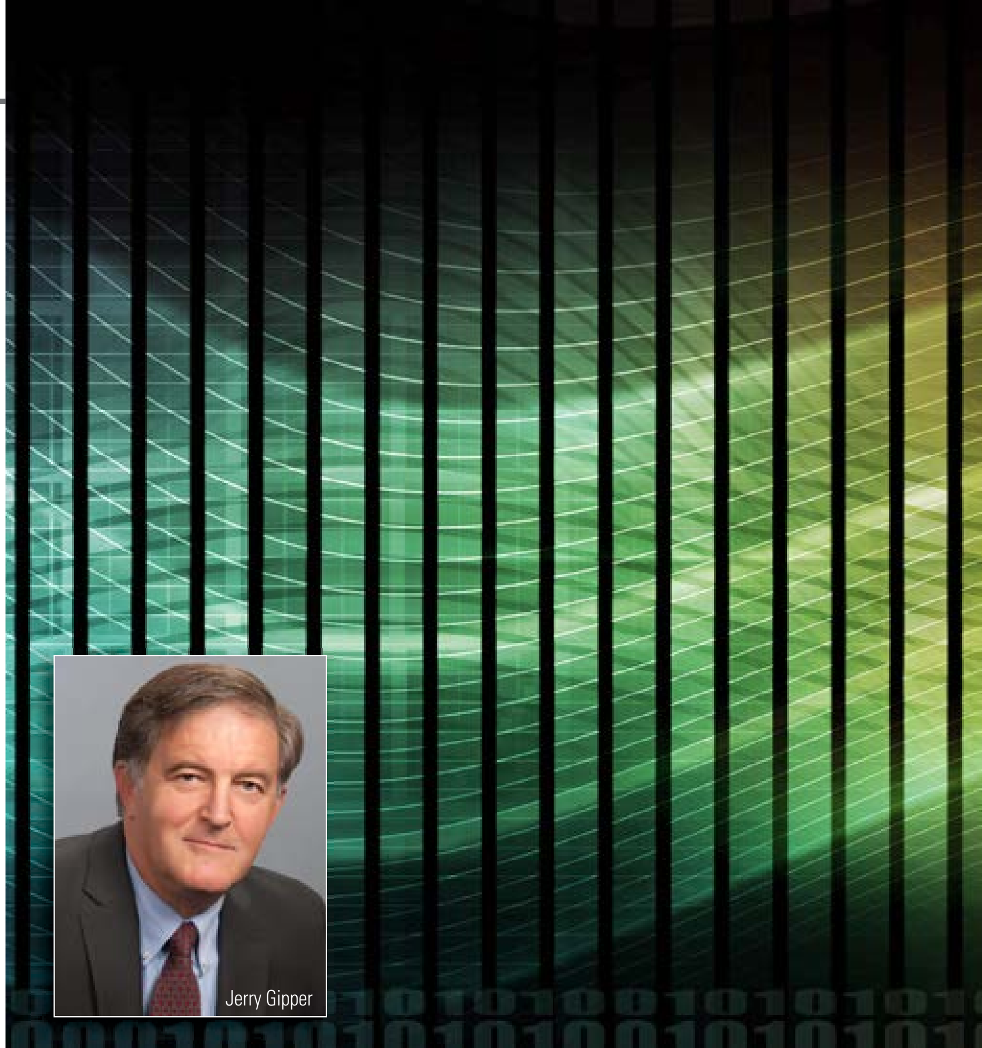
And yet … unmanned missions are just not as sexy or appealing to the public as a manned mission to Mars, the space shuttle missions, the Apollo Program, or what the original Mercury 7 astronauts accomplished. So maybe that's the answer: The American public needs a reason to be interested and get behind NASA manned missions. Unfortunately, that pace will not likely pick up unless China gets there first. Americans like a competition, they like winning, and they will want to win with human heroes.

The good news is that NASA is hiring a new crop of astronauts and future heroes. But for now, let's remember the seven who died 30 years ago and think about how they and their predecessors inspired us. Their names are Dick Scobee, Michael Smith, Ronald McNair, Judith Resnik, Ellison Onizuka, Gregory Jarvis, and Christa McAuliffe.

President Ronald Reagan said it best that day in his address to the nation – I still get choked up each time I watch it: "We will never forget them, nor the last time we saw them, this morning, as they prepared for their journey and waved goodbye and 'slipped the surly bonds of earth' to 'touch the face of God.'"

To watch his address, go here: https://www.youtube.com/watch?v=Qa7icmqgsow&spfreload=1.

EXECUTIVE INTERVIEW


Jerry Gipper

Military open architectures and VITA standards

By John McHale, Editorial Director

Custom designs and closed architectures are quickly becoming anachronisms, as commonality and interoperability of components are now standard requirements in military programs. More than two decades have passed since the famous commercial off-the-shelf (COTS) initiative hit the U.S. military market, and today common standards and COTS are now essential factors in every defense procurement equation. In this Q&A with Jerry Gipper, Executive Director of VITA – the trade association behind standards such as VMEbus and VPX – he discusses how the defense community has moved away from the custom, roll-your-own designs of embedded systems and is embracing open standards and open architectures in programs such as the U.S. Army's MORA and VICTORY. He also provides an introduction to a new initiative being developed between VITA and the U.S. Navy, called HOST. Edited excerpts follow.

MIL-EMBEDDED: *Please provide a brief description of VITA, the markets it serves, how many members it currently has, member countries, and your role within the organization.*

GIPPER: I am Executive Director for VITA, which is a trade association with a standards arm. VITA has been in existence for more than 30 years promoting open architectures, open standards, and open markets. Key standards developed by VITA include VMEbus and OpenVPX. We have about 130 members and are growing internationally, with our latest member joining VITA from South Korea.

MIL-EMBEDDED: *Today, VITA standards form the backbone of many key military embedded-electronics systems such as radar, electronic warfare (EW), sonar, avionics, etc. Was the military always the primary market for VITA products or has that evolved over time?*

GIPPER: Actually, the original focus of VMEbus was the industrial controls market. Then the telecommunications industry picked it up about same time the U.S. Department of Defense (DoD) became interested. What drove the DoD's interest was the commercial off-the-shelf (COTS) initiative pushed by former DoD Secretary William Perry in 1994. The military's use of VITA technology has only grown over the years, with initiatives such as VICTORY [Vehicular Integration for C4ISR/EW (Command, Control, Communication, Computers, Intelligence Surveillance, and Reconnaissance/Electronic Warfare) Interoperability] for vehicle electronics and Modular Open RF Architecture (MORA) leveraging open architectures and VITA standards. New legislation was also recently proposed to encourage even more open architecture designs in U.S. defense systems.

MIL-EMBEDDED: ***The VME standard essentially made VITA famous. Is the market for VME-based products still growing, even three decades after the standard was first ratified? What military applications is it most likely to be designed into today?***

GIPPER: I wouldn't say VME use is growing, but it is rock-solid. Curtiss-Wright Defense Solutions has produced a Helix PCI Express-to-VME64x interface that is FPGA-based and enables VME technology to be available for even longer, addressing the challenge created when the Tsi148 (Tempe) VME interface device announced end-of-life. Military embedded systems will use VME forever and the Curtiss-Wright announcement extends the current technology at least 15 years. It is used in C4ISR applications, as control and communications have always been the standard's strong spots.

MIL-EMBEDDED: ***VPX, the follow-on to VME, has shown significant growth in military radar and EW systems. Are there any new updates on the horizon for VPX?***

GIPPER: We are working with the Naval Air Systems Command (NAVAIR) and the U.S. Army Materiel Command's Communications-Electronics Research, Development and Engineering Center (CERDEC) to extend the VICTORY program to the Navy and Air Force through a program called Hardware Open Systems Technologies (HOST). Under HOST, a working group with folks from NAVAIR and VITA are writing a three-tier VPX standard that will have open architecture characteristics on the top two tiers, with the bottom tier being proprietary and containing the secret sauce for NAVAIR, Air Force, or any other U.S. military end user. The secret sauce, as it were, would most likely be in the software or IP on an FPGA. This is essential when working with foreign militaries. They can share the first two tiers, but the third would be proprietary.

The same concept is used with SpaceVPX when it comes to sharing satellite specifications. Tiering the architecture means you don't have to rewrite the standard for each individual application, enabling end users to define specific tweaks to each standard that are proprietary, while the system as a whole remains interoperable and compatible with multiple suppliers, driving commonality. Last spring SpaceVPX (VITA 78) reached ANSI recognition as ANSI/VITA 78.00-2015.

MIL-EMBEDDED: ***How is VPX adoption faring outside of the U.S.?***

GIPPER: I think it's starting to really pick up, especially in Asia. Of the 30 new members VITA gained in the last 12 months, about half of them are from Asia. They are producing VITA-based products, but I don't know exactly what markets they are focused on. They do have their own defense departments/ministries, but they are also focused on transportation for safety-critical applications in trains, for example. Europe is still very much a stubborn market when it comes to VPX. Defense budgets are down in these countries and there are not as many companies in Europe focused on

VITA specs. Most of the market share in Europe is owned by U.S. companies such as Curtiss-Wright, Mercury Systems, and Abaco Systems.

MIL-EMBEDDED: ***Reduced size, weight, and power (SWaP) requirements are hitting all applications in defense electronics. How has the VITA standards organization addressed these concerns in their specifications?***

GIPPER: The nature of electronics is that they will get smaller and more powerful. This is nothing new and is not causing any changes to how we develop standards. Our VNX small form factor – for applications where VPX is too large – is slowly picking up steam.

MIL-EMBEDDED: ***Is the roll-your-own crowd – primes and integrators who design their own VME or VPX SBCs instead of outsourcing – still the biggest competitor for your members in the military marketplace?***

GIPPER: That model is pretty much gone. These guys don't roll much of anything on their own anymore. They are buying whole systems from embedded suppliers. That's what VPX is all about – it's a system sell. If you have a platform with the Navy and don't roll your own VPX systems, you might throw a custom card or the like into the system, but it's not like the old days. Companies such as Pentek still design FPGA-based signal-processing boards, but often these are integrated in with systems designed by companies like Curtiss-Wright.

MIL-EMBEDDED: ***What are the biggest roadblocks remaining against adoption of open standards in military systems? And why?***

GIPPER: If roadblocks exist, it would be with proprietary designs or with unique form factors that open systems cannot fit into. Cost can also be a roadblock, but usually not in signal-processing applications that must use VPX. Cruise missiles and very small drones with very unique size requirements will likely not be leveraging open architectures. But these are exceptions to the rule, as open architecture and open standards requirements are commonplace in DoD applications today.

MIL-EMBEDDED: ***How will having the military as part of the VITA Board of Directors enable greater adoption of VITA open standards?***

GIPPER: They buy in from the beginning and it gets more people at the military and system-integrator level interested in supporting a standard. For example, CERDEC has been mostly concerned with growing their supplier base as this drives down costs and increases options. CERDEC joined VITA last fall.

MILITARY EMBEDDED SYSTEMS WILL USE VME FOREVER ... IT IS USED IN C4ISR APPLICATIONS, AS CONTROL AND COMMUNICATIONS HAVE ALWAYS BEEN THE STANDARD'S STRONG SPOTS.

MIL-EMBEDDED: ***With the U.S. military currently as the primary user of VITA standards-based technology, what new regions and markets will be adapters of this technology across the globe?***

GIPPER: VITA member companies reside in Russia, China, India, South Korea, the Middle East, Europe, etc. This is wonderful for the long-term growth of the technology, but as VITA standards-based solutions are used in U.S. military platforms, we have to be very careful about International Traffic in Arms Regulations (ITAR) issues. So now that the data is protected according to ITAR under the HOST effort (see 4th question above), we can talk about not only more use of VPX and other VITA standards in foreign military systems but also the growing use of them in other markets such as transportation for intelligent highways and intelligent rail systems.

VPX systems are too big for automotive radar systems, but are ideal for the larger computer systems used for safety-critical functions in intelligent highways. Smart highways need to have special control setups that are fast and high performance in a bay-station type of structure. The same concept applies to smart rail transportation.

MIL-EMBEDDED: ***Looking forward, what disruptive technology or innovation will be a game changer for embedded electronics in military applications? Predict the future.***

GIPPER: Optical solutions and new memory technologies as disc drives are obsolete. We also need to take advantage of multicore and processor technology. Some studies have shown that military users only take advantage of 30 percent of the capability that modern processors have. They need to find ways to use more of it, whether through new software algorithms or some slightly different architectures. Once that happens. our application base at VITA will only grow. **MES**

__Jerry Gipper__ is Executive Director of VITA. He also cofounded Embedify LLC, a marketing services firm for embedded computing businesses. His background includes product marketing, sales, business development, and strategic planning. Jerry earned his Bachelor of Science in Computer Engineering at Iowa State University and his Master of Science in Computer Engineering at San Jose State University.

Next-gen tactical Ethernet switches

By Charlotte Adams

An Abaco Systems perspective on embedded military electronics trends

Ethernet technology is the common denominator for communications between networks and is a foundational building block of IP networks. This *lingua franca* of the networking world also has evolved to meet the needs of the tactical environment; it is found on tanks, ships, submarines, manned aircraft, and unmanned aerial vehicles (UAVs).

The most basic unit in the Ethernet world is the switch, a hardware/software component that moves data packets from one address to another at speeds as fast as 10 gigabits per second. There are many suppliers and a wide range of performance categories – from size and power consumption to configurability and port density.

Military requirements are quite demanding, especially regarding SWaP-C, the mantra for size, weight, and power plus cost. The U.S. Army's VICTORY initiative, for example, drives toward high-performance, small-form factor standardization in vehicle electronics, or vetronics. (VICTORY is the acronym used for Vehicular Integration for C4ISR/EW Interoperability.)

Picture, for example, the cramped confines of a tank or armored personnel carrier. These vehicles currently have multiple local area networks, outputting data to multiple screens. Crews have to correlate this data in their heads in order to maintain situational awareness. All this hardware takes up space as well, making it more difficult for soldiers to function. VICTORY aims to recapture that space, slash equipment weight, and reduce power consumption by sharing information between systems via an IP-based open architecture, optimally aggregating data into fewer displays. SWaP-C-optimized Ethernet switch implementations are key to this plan.

For UAVs, performance and power per unit of weight are even more critical. In surveillance and reconnaissance applications, for example, where huge amounts of data are being passed around internally, SWaP-C-optimized, high-port-density switches are in keen demand.

Port density a vital factor

Port density and data throughput per port are important factors. The more high-bandwidth gigabit Ethernet and 10 Gigabit Ethernet ports that can be squeezed into a small switch volume, the higher-performance the device. Power consumption per port is also a key metric.

Meanwhile, the enclosure has to meet all the military requirements for shock, temperature, humidity, pressure, vibration – not to mention rain water, sand, and salt fog – support military communications protocols, build in mil-spec connectors, incorporate robust security features, and continue to get the traffic through when links are broken. At the same time, the military wants minimal latency, flexibility, built-in test, redundancy, and configurability – a tall order.

Managed switches a benefit

Ethernet switches come in managed and unmanaged flavors. An unmanaged switch is hardwired to perform predesignated functions but is basically a dumb plug-and-play device that merely lets nodes communicate. A managed switch, on the other hand, is flexible and programmable and can be configured to meet particular customer requirements. Managed switches also provide advanced features that enable users to monitor and control the traffic and to manage functions such as addressing, routing, and protocols.

Security is another area in which managed switches shine, as these devices allow users to control access to individual ports at a high level of granularity. Other security features include denial-of-service protection, filtering of untrusted messages, and logging information on who is connecting and disconnecting from switch ports.

Figure 1 | The Abaco Systems RES3000 is a family of rugged, compact, high-performance managed Ethernet switches.

An example of a rugged, high-port-density, small-form-factor, fully managed Ethernet switch is Abaco Systems' RES3244, which carries 24 1000BaseT and four 10GBASE-SR ports, plus a power supply, in a 5.7-pound package, dissipating approximately 28 watts, with 50 millisecond holdup time. (Figure 1.)

Ethernet has come a long way in the last 40 years – from 10 megabits per second to 10 gigabits per second and beyond, to take just one example. It has also moved from a local-area network configuration connecting two computers in an office to a rugged and robust switch fabric supporting connectivity between huge, disparate networks in business, industrial, and military applications. Like the Internet, Ethernet has become a fact of life. At the heart of this progress – and in part driving its evolution – is the switch, the core element that enables communications between nodes. Its ultimate embodiment in the military sphere is the high-port-density, small weight and volume managed switch, which not only connects thousands of nodes but controls and protects the traffic that passes through it.

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Automate cyberdefense with AI reasoning?

By Sally Cole, Senior Editor

Is it possible to automate the cyberdefense process with machines that can discover, confirm, and fix software flaws in real time? The U.S. Defense Advanced Research Projects Agency (DARPA) certainly hopes so: DARPA is hosting its Cyber Grand Challenge's (CGC) final competition in Las Vegas in August 2016 in conjunction with DEF CON – home of the longest-running attack/defend Capture the Flag global competition for elite hackers – to find out. CGC will challenge fully automated high-performance systems to reverse-engineer unknown software, locate weaknesses, search for deeply hidden flaws, and then create securely patched replacement code in a live network competition.

DARPA chose a "Grand Challenge" format for the contest to explore multiple approaches and improve the odds of seeing innovative advances in cybersecurity. The souped-up supercomputers of seven teams – CodeJitsu, ForAllSecure, TECHx, CSDS, DeepRed, disekt, and Shellphish – will compete. The winning team will walk away with $2 million, the second-place team earns $1 million, while the third-place finisher nets $750,000.

Just as IBM's Deep Blue supercomputer became the world's best chess player, "DARPA's CGC aims to make a computer the best hacker in the world," says Mike Walker, program manager, DARPA's Information Innovation Office.

With the constant onslaught of malicious attacks, an automation revolution in computer security can improve defense by "discovering, confirming, and fixing software flaws within seconds – rather than waiting a year, on average, under the current human-centric system," Walker says. "A computer could scour the trillions of lines of code we depend on and fix the toughest flaws. We want to upend the economics of computer security and level the playing field between attackers and defenders. With CGC, automated systems may take the first steps toward enabling a defensible connected future."

What are autonomous "reasoning systems"? Hacking systems designed "to analyze software, detect and patch vulnerabilities, and counterattack adversaries – with zero human involvement," explains Mike Stevenson, mission manager, Raytheon Centers of Innovation. DeepRed is the Raytheon team participating in the CGC, named with a nod to both the company's red logo and IBM's Deep Blue. CGC is literally a hands-off event: "Once the game begins, all we can do is watch how our system performs against the other competitors," Stevenson adds.

A key aspect of the challenge is that these systems must be capable of reasoning about software. "It must understand what it means for a program to be either secure or insecure," points out Stevenson. "We're developing a system that answers the question: What was the software designed to do versus what does it actually do?" Autonomous systems are desirable because they eliminate challenges associated with conventional human defenders. "Unlike people, machines are always on, working, and looking for attackers," Stevenson says. "With the Internet of Things (IoT), an exponential increase in the number of devices coming onto the network will make it impossible for humans to defend every configuration. Automation is the best way to defend a system with potentially thousands of sensors and devices."

Artificial intelligence (AI) plays a central role in these systems. "We've applied AI techniques for search, reasoning, and decision-making as part of the program analysis function," Stevenson notes. "And we also use AI for game strategy against our competitors because teams are scored on the speed and effectiveness of their attacks against each other. Strategic decisions on the timing and selection of the attack are critical."

One of the main CGC challenges, according to Stevenson, is to write programs designed to understand other programs – as opposed to performing a simple task. "Teaching programs to rapidly scan code to identify bugs and automatically patch them will lead to more secure software," he adds.

In terms of capabilities, during the CGC qualifying event, machines worked on 131 pieces of software, all within 24 hours. "Some teams' systems secured single pieces of software in less than an hour," Walker says.

Today, the technology is intended to protect systems: to reduce opportunities for criminals to identify, exploit, or weaponize vulnerabilities within a defender's system. The technology offers the U.S. military "increased resiliency to safely and quickly bring up cyber assets that have been attacked," Stevenson says. "Using techniques and technologies developed for CGC will give them new capabilities to autonomously isolate malicious software, identify vulnerabilities, automatically patch, and safely restore services."

A timeline for the technology is difficult to predict and much development work remains. "Real-world malware is much larger and more complex," Stevenson explains.

However, anyone who watches the CGC finals may well "witness a 'Kitty Hawk' moment as the contestants lay a foundation for machine-based cybersecurity solutions," Walker notes.

Safety-certifiable COTS modules speed and ease DO-254 safety certification

By Gregory Sikkens
An industry perspective from Curtiss-Wright Defense Solutions

Increasingly, Federal Aviation Administration (FAA) and European Aviation Safety Agency (EASA) regulations are requiring that airborne electronics used in military applications meet the DO-254 safety certification standard. The good news is that there are safety-certifiable commercial off-the-shelf (COTS) modules able to meet the demanding FAA/EASA criteria. What's more, compared to standard COTS boards, modules designed to a DO-254 design process may also deliver significant reliability benefits for many aerospace and defense applications that do not require DO-254 compliance.

Traditionally, prime contractors serving the defense market have required COTS system software to be DO-178 certified; in recent years, however, the field has seen a growing requirement for COTS suppliers to also provide DO-254 hardware certification. This trend is being driven by a number of market factors, including cockpit digitization, multicore processing (enabling a reduction in the number of separate systems), the growing use of common avionics subsystems, the increasing number of unmanned aerial vehicles (UAVs) and other military aircraft flying over civil population centers, and the use of synthetic vision systems (SVS) for landing (which affects the Design Assurance Level [DAL] required of mission computers).

Until recently, DO-254 safety-certifiable systems were built with expensive custom systems. The cost of ensuring that these systems can meet FAA standards – including the hardware, software, and required artifacts – is typically in the millions of dollars. Using safety-certifiable COTS modules can greatly reduce these costs, while also reducing the customer's risk and accelerating their time to market.

The first step in the process is to determine the system's intended DAL level. After the DAL level is determined, the system integrator can design the system for certifiability: This procedure entails the production of a variety of artifacts that can be later submitted to certification authorities such as the FAA and EASA for verification.

COTS vendors who have developed safety-certifiable modules are able to provide users with the necessary

Figure 1 | The VPX3-611 avionics I/O module is designed to work with previously introduced safety-certifiable SBCs and graphics cards.

document package of artifacts to support system safety assessments and the customer's certification efforts. These artifacts document the system's planning, requirements, design, integration, configuration, and low-level testing. While this process may appear time-consuming and expensive, the end result – DO-254 and DO-178C certification – has been proven to increase safety, improve quality and maintainability, and reduce long-term costs. Today, COTS vendors offer single-board computers (SBCs), graphics modules, and I/O cards designed to comply with DO-254 DAL C through A. Many more safety-certifiable modules are in development, which will greatly expand the configuration options available to system engineers.

Using these safety-certifiable COTS modules can also help reduce a user's design risk and cut development schedules. When used in a new system design that does not yet, but will later need, to undergo DO-178 or DO-254 certification, a standard safety-certifiable COTS module ensures that the user's system can be successfully integrated into the next higher level of assembly.

The reason: these modules are already designed, available, and known to work, whereas new designs inherently have the potential for greater risk, which can cause extensive delays and unforeseen costs. Safety-certifiable COTS modules can also greatly reduce a system development schedule because they enable application development to begin immediately. In contrast, with a custom-built system, the certification process must start from scratch. The COTS safety certification evidence provided by the board vendor, along with service history collected for a given program, enables the customer to accrue significant benefits for their next program when using similar hardware and board support packages, which will ultimately speed future integration and certification processes.

An example of a safety-certifiable standard COTS module is the Curtiss-Wright VPX3-611 avionics I/O module (Figure 1), which is designed to work with previously introduced safety-certifiable SBCs and graphics cards. The I/O module's field-programmable gate array (FPGA) I/O blocks can be factory-configured to DO-254 DAL C and DO-178C DAL C. Because DO-254 certification artifacts are available for the module's I/O interfaces at the FPGA block macro level, I/O configuration variants can be created quickly and less expensively than a custom solution. Safety-certifiable I/O interfaces supported by the VPX3-611 include MIL-STD-1553B, ARINC 429, CANbus, asynchronous UARTS, discretes, analog in, analog out, and Serial Peripheral Interface (SPI).

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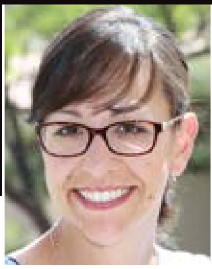


DEFENSE TECH WIRE

NEWS | TRENDS | DOD SPENDS | CONTRACTS | TECHNOLOGY UPDATES

By Mariana Iriarte, Associate Editor

NEWS

DARPA selects four teams for its Gremlins program

For phase 1 of DARPA's Gremlins program contracts were awarded to four teams: Composite Engineering, Inc. in Roseville, California; Dynetics, Inc. in Huntsville, Alabama; General Atomics Aeronautical Systems, Inc. in San Diego, California; and Lockheed Martin Corp. in Dallas, Texas.

The Gremlins program will develop technologies and systems that enable existing large aircraft – such as bombers and transports – to launch volleys of unmanned air vehicles (UAVs) that are low-cost, can be reused, and can be retrieved in midair.

The Gremlins Phase 1 will focus on the flight demonstration proof-of-concept that can validate an air recovery of multiple gremlins. DARPA officials say the expected lifetime of a Gremlin is about 20 uses.

Figure 1 | Artist concept of DARPA's Gremlins taking flight. Photo courtesy of DARPA.

First upgraded Assault Amphibious Vehicle delivered to Marine Corps

Science Applications International Corp. (SAIC) officials have announced delivery of the first Assault Amphibious Vehicle Survivability Upgrade (AAV SU) to U.S. Marine Corps Base Quantico during the month of April. It will be the first of 10 AAV SU vehicles scheduled for delivery for testing by the Marine Corps by May.

Following this initial delivery, the Marine Corps Program Executive Officer (PEO) Land Systems will have about a year to test and evaluate SAIC's solution.

The company is currently under contract with the Marine Corps to execute initial upgrades to 10 AAV SU prototypes. SAIC has nine teammates on the program, including hull manufacturer Demmer Corp., located in Lansing, Michigan.

Navy Tactical Cloud contract won by Charles River Analytics

Officials at the Office of Naval Research (ONR) have selected Charles River Analytics Inc. for a contract to develop Navalytics, a framework for probabilistic, multisource naval analytics and analytic services that will enable rapid development and deployment of rich, mission-critical analytics.

The work will be performed under the Navy Tactical Cloud effort, which brings big-data capabilities to the warfighting environment. The 11-month, broad agency announcement (BAA) contract is valued over $400,000, with options, if exercised, for an additional $1 million over two years.

Navalytics marries Charles River's Figaro probabilistic programming language with a modular, reusable framework for developing reusable analytics modules. Charles River engineers will add distributed, big-data-enabled algorithms to Figaro as part of the Navalytics effort. The reusable architecture for distributed analytics may be used in many domains, such as real-time health monitoring, threat assessment, and intelligence analysis.

Navy special comms contract won by BAE Systems

BAE Systems will support the Naval Air Warfare Center Aircraft Division (NAWCAD) Special Communications Mission Solutions Division by providing technical services.

Under the two-year contract, BAE Systems' engineers will provide support and maintain the life cycle of communications and electronics. This agreement will include logistics management, planning and integration support, technical publications, configuration management, training, and hardware tracking.

Work will be performed at BAE Systems sites in southern Maryland; Chesapeake, Virginia; Fayetteville, North Carolina; San Diego, California; as well as multiple locations around the world. The contract is worth an estimated $34 million.

Figure 2 | The Naval Air Warfare Center Aircraft Division will receive a range of technical services. Photo courtesy of BAE Systems.

One more Littoral Combat Ship ordered by Navy

The U.S. Navy has contracted a Lockheed Martin-led team for one fully funded Freedom-class Littoral Combat Ship (LCS). The contract includes funding for seaframe construction, testing, and systems integration. Navy officials say that they used savings from its original block buy contract to take advantage of an option to build an additional Freedom-class LCS –dubbed LCS 25.

The new build will be the 11th ship procured under the 2010 block buy contract and the 13th Freedom-class variant overall. LCS 25 is planned for delivery to the Navy in 2020. Under the current 10-ship block buy, costs per ship have been reduced to half the cost of the first ships of that class; two ships per year are being delivered to the Navy.

The Lockheed Martin team is now in full-rate production. Fincantieri Marinette Marine is building the Freedom-class Littoral Combat Ship in Marinette, Wisconsin, with naval architect Gibbs & Cox of Arlington, Virginia, providing engineering support.

Figure 3 | The LCS's steel monohull design has 40 percent reconfigurable shipboard space. Photo courtesy of Lockheed Martin.

U.S. Navy sonobuoy contract won by Sparton/Ultra Electronics joint venture

Officials at Sparton Corp. and Ultra Electronics Holdings announced that their ERAPSCO joint venture won subcontracts from the U.S. Navy worth about $53.7 million to manufacture sonobuoys that will enable greater sensor capability for the Navy in antisubmarine warfare applications.

The win is a GFY16 ERAPSCO indefinite delivery, indefinite quantity (IDIQ) release for sonobuoy requirements under the joint venture's five-year contract. ERAPSCO experts will provide production subcontracts in the amount of $26.1 million and $27.6 million to Ultra Electronics USSI and Sparton De Leon Springs, respectively.

Production of the sonobuoys will then take place at Ultra Electronics USSI's Columbia City, Indiana, facility and Sparton's De Leon Springs, Florida, facility and is planned to be completed by September 2017.

Software enables modern weapons integration into older military aircraft

Raytheon engineers have developed a software solution for integrating of new weapons into older aircraft. The software can be implemented across various platforms and current bomb rack systems.

The software tool, called Envoy, enables integration of non-Universal Armament Interface (UAI) weapons – a process that has been expensive and time consuming, requiring changes to aircraft operational flight programs – into legacy platforms. It has already been demonstrated on F-16 and F-18 fighter aircraft and work is underway for integration on the MQ-9 unmanned aircraft system (UAS) and other international platforms.

The tool consists of adaptable software with an optional hardware suite that will enable a communication bridge between MIL-STD 1760 and Miniature Munition Store Interface (MMSI) weapon interfaces. This functionality enables older platforms to communicate with new, UAI-type weapons. Envoy allows conversion between the physical layer (MIL-STD 1760/MMS) and converts the legacy interfaces into the UAI message set so that advanced weapons can receive initialization and tasking messages.

Marine Corps squadron receives first variant of Advanced Precision Kill Weapons System

Marine Attack Squadron (VMA) 233 operating the AV-8B Harrier received the first fixed-wing aircraft variant of the Advanced Precision Kill Weapons System (APKWS).

The 2.75-inch rockets, equipped with Semi-Active Laser (SAL) guidance capability, were fielded by the PMA-257 and the Direct and Time Sensitive Strike program office (PMA-242). The Navy's program offices conducted the two-phase program within seven months of the initial requested requirement by the Marine Corps, officials say.

The first phase expedited fielding of a limited AV-8B fixed-wing APKWS employment flight envelope capability, which included the delivery of 80 guidance kits. The second phase will expand the fixed-wing APKWS limits to the maximum extent for the AV-8B.

Figure 4 | An AV-8B Harrier equipped with the Advanced Precision Kill Weapons System (APKWS). Photo Courtesy of U.S. Navy.

COMMUNICATIONS BETWEEN UNMANNED SYSTEMS

Unmanned aircraft leverage PC/104, COM Express, and other small form factors

By John McHale

Unmanned aircraft systems (UASs) continue to shrink in size, as do their payloads, requiring system designers to leverage small-form-factor, embedded-computing standards like PC/104, COM Express, and others.

The MQ-1 Predator assigned to the 163rd Reconnaissance Wing flies over Southern California Logistics Airport in Victorville, California. U.S. Air Force photo by Tech Sgt. Effrain Lopez.

Reduced size, weight, and power (SWaP) requirements in military UAS payloads, ground control stations, avionics, reconnaissance (ISR) applications, and other military electronics systems are forcing designers to leverage small-form-factor designs such as COM Express, SMARC, and the PC/104 standard.

While PC/104 has been around for decades it has never been healthier. Its main advantages – ruggedness, compact size, and modularity – have never been more in demand in the military electronics market, especially in unmanned systems.

"Because of their low-SWAP characteristics and affordability, systems based on embedded PC/104 and Computer-on-Module (COM) technologies routinely find a home in a multitude of military and civil applications, including MALE and HALE UAS platforms in ISR/combat roles, attack/utility/cargo helicopters, various fixed-wing cargo/fighter/ISR aircraft, and a host of tactical and combat ground vehicles, along with missile defense platforms and shipboard applications," says Mike Southworth, Product Marketing Executive at Curtiss-Wright Defense Solutions. "As electronics payloads on board manned and unmanned platforms look to add new technical capabilities – such as high-speed network backbones, ISR sensor/video processing, and/or avionics databus interfaces – the smaller system architectures like PC/104 and COM modules have been well received by [our] customers."

Not just SWaP, but stringent ruggedization and extreme environmental requirements may also preclude users from choosing PC/104 products.

"With the long history that PC/104 has in the marketplace, the list of applications is significant, the technology is an ideal fit for any rugged commercial, industrial, or military applications," says Michele Kasza, vice president of sales for Connect Tech in Guelph, Ontario. "PC/104 is as well-suited to vehicle-based solutions, manned or unmanned, as in industrial environments where unregulated power is a concern as is dirt and dust; also outdoor applications where extreme temperatures, rain, humidity, and salt can be factors. PC/104 is often living in environments where the user may not realize that PC/104 is the architecture driving their application. Crack open a number of small-form-factor, rugged system solutions and you will find PC/104 at its finest; quite often a multivendor stack carefully architected for the ultimate in interoperability."

PC/104 lives on

"I believe that in the case of PC/104 [military users] are looking to use a proven platform that they have seen years of success with," Kasza says. "These customers may also prefer to stay with a known footprint as it may reduce their design efforts from a mechanical perspective. That said, we at Connect Tech are seeing our military customers wanting the rugged and compact features of the PC/104 of the past combined with the most current technologies.

"Here is where PCIe/104 (The PCI Express version of PC/104) comes into play, offering single-board computers (SBCs) with the latest generation low-power Intel Atom [processors], through to high-performance Intel Core i7 options," Kasza continues. "Stack this with high-end GPU solutions such as NVIDIA GTX950Ms and high port density Managed Carrier Ethernet Switches or a 10G Ethernet Controllers and suddenly what was old technology is now leading edge." Connect Tech offers the Xtreme/GbE 24-Port Managed Carrier Ethernet Switch solution for military small-form-factor requirements. Ports can be accessed via a breakout board/carrier that can mate directly to the XDG024/25 or by mating to a high-density high-speed Twinax cable. The XDG025 is designed for standalone applications, with all thermal extraction on one layer and connector/cabling on the opposite layer, whereas the XDG024 is intended to stack directly into a PCIe/104 stack. (See Figure 1.)

Reliability and consistency have ensured continued support for the PC/104 standard in military applications that often have various levels of requirements.

"The requirements of military customers for PC/104 varies from program to program," says Dr. Paul A.T. Haris, president and CEO of RTD Embedded Technologies, Inc., in State College, Pennsylvania. "But some of the common threads have included a need for rapid prototyping, development, and uptime that the PC/104 architecture provides, given its vast array of product functionalities and numerous manufacturers found on the market.

"Additionally, users have required the need for an inherently rugged architecture at the board level, which also provides modularity for future maintainability and upgradeability," he continues. "Very few standards over the history of the embedded market have been able to provide these capabilities in such a small form factor. And none can boast the history of this standard and its ability to advance with time while maintaining backward compatibility. This provides military customers with the ability to reduce total lifetime program costs

Figure 1 | The XDG024 from Connect Tech is intended to stack directly into a PCIe/104 stack for small-form-factor embedded computing applications.

as well as reduce the need for product changeovers. This is why you find many military customers making the PC/104 architecture the architecture of choice for a vast number of military applications in all extremes of environments."

Military users "are increasingly looking for small-form-factor embedded technologies that reduce the size, weight, and power for their deployed line-replaceable units (LRUs) and reduce or eliminate NRE fees and development schedules," Southworth says. "At the same time, [they] are seeking increased multicore processor and graphics performance, along with I/O scalability from modular open standard PCI-Express based architectures like PCIe104 [as well as] COM Express, SMARC, and Mini-PCIe."

Reduced SWaP

Every defense application today wants five to 10 times more performance in system upgrades, but they want it in the same – if not smaller – footprint of the previous system and with lower power characteristics. This is something PC/104 has been doing for years; it is also a feature of standards such as COM Express and SMARC.

"The PC/104 architecture family of specifications has been serving SWaP requirements even before SWaP was an acronym," Haris says. "The unique stackable architecture, which also can serve as a true SBC architecture, as well as a mezzanine architecture, has been providing the military with embedded, rugged board, and system-level solutions for years. With its embedded stackable bus system and onboard I/O connectivity, reductions in enclosure size and weight can be either tailored for each application or realized in standard modular enclosures. With the addition of considering the overall program life cycle cost factor, the PC/104 architecture enables users to quickly upgrade and maintain their systems with backward compatibility and interoperability of multivendor products, all based on well-defined and controlled standards and specifications."

Just as no military application is the same with the same embedded computing requirements, no small-form-factor architecture is the right size for every application.

"We live in a world of many small-form-factor options which simply means that one size does not fit all," Kasza says. "At a small footprint size of 90 mm by 96 mm, PC/104 has a solid ecosystem that allows for easy integration of current technologies with multivendor support and interoperability. In some cases, the physical footprint of a system is what a customer least wants to change as they may be working within a space that was previously defined around PC/104. From a processor perspective, PC/104 single-board computers are available with lower-power ARM processors as well as x86 options ranging from low-power solutions through to Intel Core i7s."

JUST AS NO MILITARY APPLICATION IS THE SAME WITH THE SAME EMBEDDED COMPUTING REQUIREMENTS, NO SMALL-FORM-FACTOR ARCHITECTURE IS THE RIGHT SIZE FOR EVERY APPLICATION.

"Small-form-factor CPU card standards like PC/104, COM Express, and SMARC offer a physical size that is a fraction of traditional 3U or 6U VME/VPX architectures," Southworth says. "This provides an obvious advantage when it comes to packaging for lowest SWaP. In addition, COM Express and SMARC have multiple physical footprint options, including boards roughly the size of a credit card, which allow for further miniaturization targeted at demanding SWaP requirements. For this space, Curtiss-Wright offers the 39-inch, 1.5-pound rugged mission processor, the Parvus DuraCOR 310, which makes use of integration of a low-power SMARC COM CPU card with Mini-PCIe I/O card expansion slots," Southworth says. (Figure 2.)

Other companies – such as Diamond Systems and WinSystems – continue to offer PC/104-based products to meet the demand for reduced SWaP in military systems.

Diamond Systems has a family of Jupiter PC/104 & PC/104-Plus DC/DC high-efficiency, high-precision power supply modules. Each power supply consists of a PC/104 form factor module with complete DC-DC voltage regulator circuitry, integrated thermal solution, detachable screw terminal block I/O connections, and PC/104 bus connectors. Its input voltage range of 7 to 34 VDC is compatible with industry-standard 12 V, 24 V, and 28 V inputs.

Engineers at WinSystems leverage the Intel E3800 Atom processor family for their PPM-C407, a fanless low-power PC/104 SBC. The solution is designed for harsh environments and has soldered RAM for added shock and vibration resistance with an operating temperature range from -40 °C to +85 °C.

Figure 2 | The Parvus DuraCOR 310 from Curtiss-Wright Defense Solutions integrates a low-power SMARC Computer-on-Module (COM) CPU card with Mini-PCIe I/O card expansion slots for military small-form-factor applications.

Looking forward with PC/104

"The number of applications where one finds PC/104 is vast," Haris says. To say that any one application dominates would be misleading and would do a disservice to the PC/104 architecture: PC/104 is based on standard stackable and modular bus architectures widely accepted across most industries and then packaged on a standard small form factor. The use of the vast array of functionalities of these products is endless.

"The architecture provides all the building blocks for designing SWaP-based products to enable overall lifetime program cost reductions," Haris continues. "This architecture has been proven from the depths of the oceans to outer space, and from the Antarctic ice caps to the desert sands. You will find PC/104 running mission-critical weapon systems as well as general-purpose monitoring, tracking, and processing systems. In the end, the question should not be what are the types of applications that often make use of PC/104 technology, but are there any applications that have not made use of it." **MES**

COMMUNICATIONS BETWEEN UNMANNED SYSTEMS

MUM-T operations on the U.S. Army's UAS roadmap

By Mariana Iriarte, Associate Editor

Manned-unmanned teaming (MUM-T) operations combine the strengths of each platform to increase situational awareness, allowing the armed forces to conduct operations that include combat support and intelligence, surveillance, and reconnaissance (ISR) missions.

Pictured are an Apache AH-64 and an MQ1-C Gray Eagle after the completion of a MUM-T exercise. Photo courtesy of U.S. Army.

Giving pilots in rotary and fixed-wing aircraft the ability to control unmanned aircraft systems (UASs) will definitely be a force multiplier on the battlefield. Through the use of sophisticated data links, manned aircraft can take advantage of UAS ISR payloads to enhance decisionmaking and mission effectiveness.

U.S. Army officials have taken the lead on MUM-T by demonstrating a dual-manned AH-64 Apache connecting and communicating with UAS platforms such as the General Atomics Aeronautical Systems Inc. (GA-ASI) Gray Eagle and Textron Systems' RQ-7B Shadow.

"The U.S. Army is making MUM-T an established part of its tactics, techniques, and procedures (TTPs) by outfitting its combat aviation brigades (CABs) with Boeing's AH-64D/E Apache helicopters and Textron Systems RQ-7B Shadow Tactical Unmanned Aircraft Systems (TUAS)," says Henry Finneral, vice president of Tactical Unmanned Aircraft Systems Textron Systems in Cockeysville, Maryland. "Unmanned systems have proven their capability for missions too 'dull, dirty, and dangerous' for manned aviation. Today, users are harnessing these capabilities to extend the reach of their manned platforms as part of MUM-T. The teaming theory allows the man-in-the-loop to cover additional ground, complete additional actions, and communicate information and actions across the space quickly and efficiently."

By adding the eyes and ears of UAS to their battlefield picture, pilots can grow the reach of their situational awareness and improve safety.

"Unmanned systems extend the breadth of a human system's comprehension of their surrounding environment," Finneral says. "This enhanced understanding enables more informed decision quality, which in turn leads to more synchronized, responsive actions. This teaming theory also provides a level of safety for the manned platform. While the Shadow provides the forward scout mission, the soldier remains in a protected, nonhostile area until targets are identified and enemy positions are known."

Evolving role for UAS platforms

The Army has reached the midterm period on its roadmap for UASs, which defines the scope of UAS development and deployment between 2010 and 2035. The middle portion of the U.S. Army's UAS roadmap spans from 2016 to 2025; the plan decrees that by the end of this period, UASs should be fully integrated into missions – such as MUM-T operations.

"I have been part of this project since 2001 when I was in the Army. It has been evolving; the customers are continually learning how to use it. The new and upgraded technology will essentially reduce the crew workload in the cockpits. We call it manned-unmanned teaming on the move. We can do things quicker than with pre-mission planning alone," says Robert J. Johnston, director of business development of the Army Programs at L-3 Communications in Salt Lake City.

Figure 1 | Textron Systems' Shadow V2 during flight operations. Photo courtesy of Textron Systems.

The success of initial MUM-T operations will drive innovation for the technology that enables the concept. "As MUM-T starts to grow, everyone wants better user interfaces, and more bandwidth. It's an evolving capability within the Army and everyone understands what the Gray Eagle does for the Wide Area Security (WAS) mission," says Chris MacFarland, director of strategic development for Army Programs at GA-ASI in Madison, Alabama. "The interesting part is what we are starting to look at, which is that the Gray Eagle is a significant enabler for the Combined Arms Maneuver (CAM) portion of the Army's new CAM-WAS operational concept. CAM is what we are looking at for mission growth. We are looking at the broader missions of full-spectrum warfare."

For MUM-T operations, Textron experts provide their Shadow UAS and are currently fielding an upgraded, all-digital Shadow system known as Version 2 (Figure 1). "Since the U.S. Army began utilizing the Shadow, it has amassed nearly one million flight hours, Finneral says. "The U.S. Army's program of record is our 'One System Remote Video Terminal' (OSRVT). OSRVT began as a tool used by ground operators to receive video from airborne assets. Today, it can be integrated into any helicopter to deliver full-motion video to the pilot."

Teamwork enabled by common data link

Just as in any team exercise it essential that the teammates communicate with each other, MUM-T operations are no different. The MUM-T communication is enabled by Common Data Link (CDL) technology from L-3 Communications.

"CDL technology is the main thread of interoperability for ISR missions [and] the heart of CDL technology is the waveform and the protocol for communications," says Aurora Taylor-Rojas, director of systems engineering at L-3 Communications. "CDL is the U.S. military's main protocol for securing imagery and signals intelligence. Interoperability is essential to the manned/unmanned mission. We not only provide the data link equipment for Apache aircraft, but we also provide the data link equipment for the Shadow UAS and the Gray Eagle UAS."

In addition to the data link, L-3 was awarded the MUMT-X contract and is "currently in the design and development stage of the program and we are close to finishing the design aspects of the contract," Taylor-Rojas adds. MUMT-X is based on the MUMT-2 system. Its communications suite includes a ROVER 6 modem (see Figure 2), multiband radio frequency equipment, and a directional antenna capable of relaying multiple video streams back to the command center. MUMT-X increases the Apache aircrews' situational awareness and combat effectiveness, while keeping the decision-making time at a minimum.

Figure 2 | L-3's Rover 6 modem provides full-motion video and data for situational awareness. Photo courtesy of L-3 Communications.

L-3 engineers use various architectures and technology-refresh methods to maintain performance as requirements change and systems evolve. "As technology rapidly changes, we have implemented the solutions on any variety of custom ASIC (application-specific integrated circuits), programmable commercial FPGAs, COTS (commercial off-the-shelf) components, and/or a hybrid solution," Taylor-Rojas says. "The architecture of each system and the different requirements of each mission demand different solutions; we choose a best-of-breed approach to custom technology, existing technology, and COTS components in order to give our customers the best value while always meeting the mission needs.

"This equipment will go on an aircraft, so to reduce the SWaP was really important," she continues. "That's a careful balance: how to give our customers more functionality while meeting the SWaP requirements for the aircraft. Here we are able to combine older existing technology, bleeding-edge technology, and COTS technology."

Looking forward

The U.S. Army will continue to test and evolve current technology to reach its ultimate goal of having UAS be a standard in all aviation operations.

"A lot of this is ready to be fielded but some of it is early on its maturity," McFarland says. "For example, some swarm technology is early in its maturation;

it's not at a point that we can use it in a combat environment. Some of those are right on the cusp. Reducing manpower requirements for a ground-control station – those kinds of technologies are really close, while others are further away. Part of the dividing line is those that are affected by public-policy requirements. Technology has to be vetted through multiple agencies for use in the National Airspace System (NAS)."

Moving forward, the biggest challenges are "increasing autonomy, reducing workload, and manpower," he continues. "Those are three key areas coming next. There is a very high pilot workload with MUM-T operations.

"We want to build into the system the autonomy or artificial intelligence (AI) so that it can do the simple tasks itself and the crew only has to act if something is wrong, or a 'management-by-exception' system," McFarland explains. "We are putting the burden on the system to reduce the workload. Current planned and future capability enhancements can potentially provide weapons support, passive and active electronic warfare, signals and intelligence, communications support, and counter-IED (improvised explosive device) detection."

Regarding communications, McFarland says "we need to get more on the expeditionary side and start working on options to [enable] satellite communications for beyond-line-of-sight cases. There is also emerging technology for using nano-UASs, along with countering other UAS technologies."

Textron Systems engineers are working on qualification of several new enhancements to the Shadow system. The V2 "will soon be configured with high-definition, full-motion video (FMV) payloads, improved environmental performance, and enhanced reliability features on the data link and propulsion systems," Finneral says. Other enhancements the company is developing include system survivability and a more powerful power plan, he adds.

"The new enhancements that are currently in qualification will be introduced to the fleet starting in the fall, while the enhancements that are in development will be brought forward in the next several years," Finneral notes.

Security in the long run

As the MUM-T concept evolves, nothing will be more important than maintaining security.

"The technology is actually not new," McFarland says. "The technologies that enable interoperability are radios and data links. The issue is that there's always a need for increased bandwidth, quality, and data security. The biggest challenge is to keep it secure. As we build more capabilities in those areas, we have to be cognizant of those requirements. However, we've already had interoperability with systems like Link 16 and some other waveforms. It's not new, but it's about making them better and faster, and it's about keeping it protected." **MES**

Increasing the range between UAS platforms

While UASs continue to use existing technology to provide communications between themselves and the Apache, the range boundary between manned and unmanned aircraft continues to be tested.

Ultimately, the range depends on the mission. "Every signal has limits. There are a number of things that impact any signal to support a MUM-T operation with the Gray Eagle. For each mission, the commander has to make a tradeoff. With an increase in power, there is a weight cost. Everything comes down to a size, weight, and power (SWaP) tradeoff," says Chris MacFarland, director of strategic development for Army Programs at GA-ASI in Madison, Alabama.

"For manned systems, they can probably get more power generation," he continues. "They have terrain obstacles that limit their range. That's when mission planning comes into effect. There have been exercises that show how far Apache-to-Gray Eagle MUM-T communications can go. In a less-than-optimal environment, range will be limited. However, every single exercise has proven that the range was significantly extended between the Apache and Gray Eagle."

Small UAS payloads pose SWaP and bandwidth challenges

By Sally Cole, Senior Editor

The payloads of military unmanned aircraft systems (UASs) continue to evolve – using smarter sensors and a smaller overall footprint – but must overcome size, weight, and power (SWaP) design hurdles, as well as slower-than-desirable sensor processing, lack of bandwidth in downlinks, and security challenges.

The multimission Predator B is highly modular and configured easily with a variety of payloads. Shown here, Predator B drops sonobuoys for an anti-submarine warfare mission. (Photo courtesy of General Atomics – Aeronautical Systems, Inc.)

As military UASs continue to evolve and shrink in size – think swarms of tiny drones – their resulting payload footprints pose numerous tight SWaP design space constraints and tradeoffs, together with sensor processing, datalink bandwidth, and security issues as well.

"There's a trend for ever-smaller [payloads] that's driven in part by the trend to smaller [UAS platforms]," says Stuart Heptonstall, product manager of graphics and GPGPU Products for Abaco Systems in Huntsville, Alabama. "These smaller [platforms] must be lighter, nimbler, faster, and have longer ranges, which all affects the electronic systems within. Every square inch counts."

Most applications are demanding increased functionality while maintaining the SWaP envelope, which translates to more performance per slot. "This means leading-edge system-on-chip (SoC) technology on our cards," Heptonstall notes. Other systems demand a significant reduction in SWaP, which "can mean smaller board form factors within the [payload], with optimized application-specific functionality," points out Heptonstall. "The challenge in this scenario? Trading a certain level of flexibility to meet a challenging reduction of SWaP."

Then there's the issue of weight: The trend toward smaller [payloads] means "trends for the potential of smaller distributed systems," Heptonstall continues. "These systems can be placed in smaller spaces within smaller [UAS platforms] and also have the potential for balancing the [UAS's] weight distribution better. Stripping weight out is always a challenge that directly impacts the design of the cards within." At the board level, as with size, lowering weight means "providing significant increments in performance per slot in applications where maintaining a SWaP envelope is required," Heptonstall says. "Conversely, a less-is-more design approach can be deployed in significantly reduced SWaP applications. For these scenarios, certain tradeoffs may be required for wider COTS (commercial off-the-shelf) applications and homing in on an application-specific, weight-optimized design. This is sometimes necessary." (Figure 1.)

In terms of power, performance is closely linked. "Balancing performance with thermal-power dissipation in small form factors and enclosures is always a primary challenge," Heptonstall explains. "Endowing the system with industry-leading performance while managing the thermal envelope gives engineers headaches. Again, similar principles apply such as optimizing the board-level design by selecting the right SoCs for the application and optimizing the design and PCB for thermal efficiency. Both board-level design and mechanical-enclosure design must be closely aligned so that the electronics designers are cognizant of the thermal and mechanical challenges, and vice versa."

Figure 1 | The Abaco Systems ICS-8560 video-compression board XMC provides the minimal size and weight required by the constrained environment of a typical UAS.

Sensor processing for ISR payloads

Reduced SWaP also means packing more performance into shrinking design footprints to meet the insatiable demand for more sensor data in real time.

The U.S. military is "becoming more interested in fusing data and accessing it closer to real time," says Robin Snider, director of electronic payloads for General Atomics Aeronautical Systems Inc.'s Mission Systems business unit. "You can get information much faster if you do the processing in near-real time onboard the aircraft and then get the data down the link." (Figure 2.)

"Most larger platforms offer multiple modalities, so the ability to merge those apertures with onboard processing to improve situational awareness is highly desirable," says Peter Thompson, director of business development and technology for Abaco Systems.

Military UAS users "are seeking actionable intelligence from their sensors in real time – whether the sensor is part of a radar, electronic warfare, or ISR (intelligence, surveillance, and reconnaissance) sensor chain," says Shaun McQuaid, director of product management for Mercury Systems' Embedded Products Group in Chelmsford, Massachusetts. "This intelligence then needs to be presented cohesively as part of a total situational-awareness package. These capabilities are derived from powerful digital and RF and microwave processing resources that are increasingly being mounted directly onto the platform itself. The issue is that these sensors are becoming so much more capable and more data is flowing; it's both unadvised and virtually impossible to send all of that data down to an analyst on the ground."

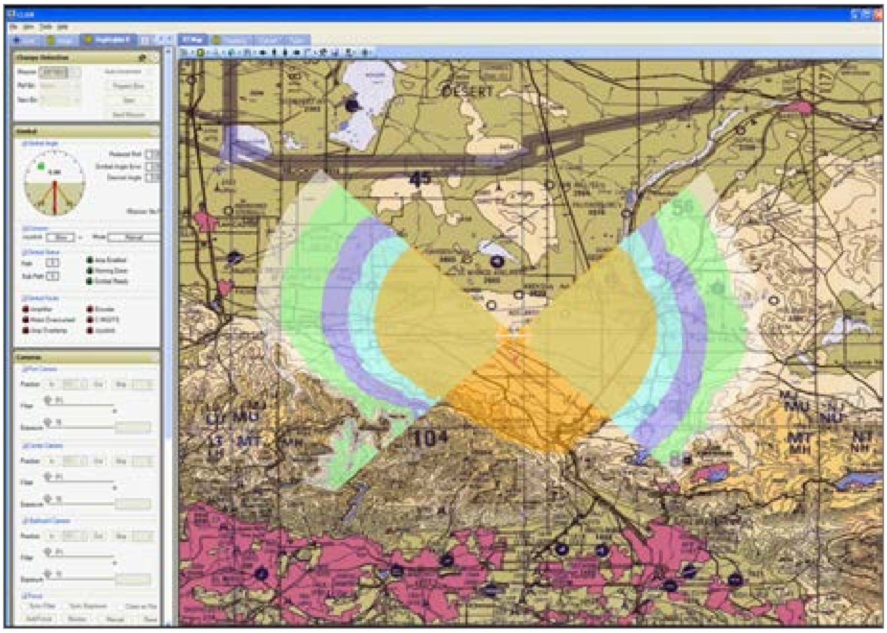


Figure 2 | The Claw integrated sensor payload control and analysis software package is used on unmanned and manned aircraft to cross-cue a variety of sensors and payloads. (Photo courtesy of General Atomics – Aeronautical Systems, Inc.)

More processing at the sensor

What are some options to bring the processing closer to the sensor? UAS integrators "are approaching this in one of two ways," McQuaid says. "One is that the highest processing performance possible should reside on the UAS, but the SWaP required to perform this may be restrictive – it's platform-dependent. In some cases, we're seeing our customers stack six or eight 3U modules onto platforms or pods. Alternatively, at a chassis level, it's entirely possible to gain similar capabilities from just one or two 6U modules using the same SWaP footprint. There are many tradeoffs in risk, reliability, cost, pre-integration effort, and so forth." (Figure 3.)

Mercury Systems is also seeing interest in direct digitization – taking RF directly from the sensor and digitizing behind the sensor itself to avoid tuning and down-conversion, says McQuaid. "UASs require wide-spectrum bandwidth and the ability to digitize it on the fly. With this, you have an extremely broadband digital data stream emerging directly out of the sensor. This is made possible with FPGA processing that's attached directly to the sensor and with efficient backend processing."

As a result, [we see] a push toward "high-density, server-type architectures, which are designed to duplicate the server architectures you'd find in Amazon's or Google's data centers," McQuaid continues. "They use the same Intel processors and similar general-processing architecture. Our customers are placing these processing capabilities right behind their sensors to perform server-class, big-data analytics. At the end of the day, what we're really doing with these high-end sensors is solving a big-data problem – and it has to be solved on the platform because we don't have the data link bandwidth or time to deal with it in a traditional ground-based scenario."

Figure 3 | The rugged OpenVPX Ensemble LDS6526 processing blade from Mercury Systems integrates the Intel Xeon processor D-1500 system-on-chip (SoC) for intensive signal processing applications such as ISR payloads for UAS platforms.

Bandwidth challenges

Innovation in embedded computing and signal processing have enabled reduced SWaP and sensor fusion, but the downlinks for getting actionable intelligence off the payload are still stubbornly bottlenecked. To solve this, embedded computing companies and system integrators are driving the processor closer to the sensor to parse the vast amounts of sensor data being generated before it is downlinked.

Lack of bandwidth in downlinks is always an issue, but it's one the industry has lived with for decades and has sort of come to grips with, notes Snider. "You'd think there'd be a continual struggle to get more bandwidth, and there is at some level, but the reality is that we can do almost everything with relatively small data link pipes," he adds. "But there are new kinds of capabilities, specialized sensors with lots of pixels and data that small data links do limit, so the way they're being handled now is by recording the data and post-processing it. In these cases, wider-bandwidth data links have value."

"Video is a significant challenge," says Abaco Systems' Thompson. "As with all sensor-derived data, the trend is for resolutions to increase to provide more detailed information; that's certainly true for video, where high definition is rapidly becoming the norm. The trick here is compression – JPEG2000 or more, increasingly H.264 (AVC/Advanced Video Coding), and in the future H.265 (HEVC/High Efficiency Video Coding)."

Securing UAS payload data

Security is a challenge for UASs because it's extremely difficult to secure something on the tether of an RF link. "We're working to improve security because threats within this realm are continuing to worsen," says General Atomics' Snider.

All UAS applications out there today are dealing with cybersecurity or system-integrity concerns, and security must be tightened because of the possibility of nation-states or other malicious actors taking over control of drones – or even worse, swarms of drones – by gaining access to their data or communications.

"Many nation-states would love to play that game, so we need to be very careful about what we're exposing," Mercury Systems' McQuaid notes. "Secure processing is definitely the path to the future and soon may not be optional."

Future of UASs

Looking forward, smaller and cheaper UASs are the way to go, according to Abaco Systems' Thompson. "Expect to see more networking and intelligence on these smaller platforms to enable cooperative swarming," he says. "Sensors will be bigger and better – with more dense focal-plane arrays and new modes such as through-the-wall imaging of the inside of buildings. This, of course, will drive data rates and the required compute power ever higher."

Not surprisingly, SWaP will continue to play a central role. "Watch for a continued focus on SWaP reductions and greater moves toward leveraging the best commercial processing and software technology – especially from the data-center domain – and applying it to unmanned vehicles," McQuaid says. "As a result, the tactical, mobile cloud-based architecture will gain further traction. By using a pool of computer resources that are made available, numerous unmanned platforms can tap into it to offload some of their sensor processing. Discrete platforms don't have to handle the entire processing burden alone anymore … this is a form of swarm architecture and it's starting to make its presence felt."

Applications for UASs are expected to continue to grow. "We're seeing new types of missions, such as using UAVs to monitor sonobuoy fields, which hasn't been done before," Snider points out. Another area to watch is the "radical trend toward vertical takeoffs and landings. "This is an area being actively explored for a whole new generation of UASs. There's also a push for autonomy; initially, there was resistance to it, but now we're seeing greater interest in having at least some level of autonomy on the aircraft. Eventually they'll need to become more or less fully autonomous." **MES**

Leveraging COTS in UASs

One would think that as more and more unmanned aircraft systems (UASs) become available – many off the shelf – that the components for the payloads would be commercial off-the-shelf (COTS) in nature. But that is not always the case.

The lack of COTS use in UASs is somewhat surprising, says Robin Snider, director of electronic payloads for General Atomics Aeronautical Systems' Mission Systems business unit in San Diego. "You'd think COTS components used in quadcopters could be used in higher-end systems because consumer electronics are capable of providing a lot of performance," he elaborates. "But it turns out that it's difficult to use them, usually because of the environmentals involved. So there's surprisingly little opportunity for us to use COTS, at least the low-end COTS equipment. We've tried to do it, but the environmentals and testing required are holding it back. We always end up using military-grade equipment for real weapons systems. But a big push to reduce costs may change this in the future."

From Mercury Systems' perspective, some level of COTS can be leveraged. "If your application can run happily on a 3U board, a 6U board, an ATCA blade, or a desktop PC you bought from Dell, then that's the ultimate in COTS leverage. It's better buying power in action," says Shaun McQuaid, director of product management for Mercury Systems' Embedded Products Group in Chelmsford, Massachusetts. "And software tends to be the largest portion of any UAS program in terms of cost and risk involved, so being able to mitigate it and leverage that software for use in unmanned platforms is the key to success."

Today, the best commercial industry technologies from a performance perspective are cloud-based ones using high-end processors, the same approach used within data centers. "Mercury is leveraging the bests of this commercial capability, including high-end Intel processors and fabrics, and cloud-based analytics software," he says.

It's important to note that when using COTS today for UAS applications, a trusted supply chain is crucial: customers are basing requirements on knowing where the sensors, modules, or COTS involved were manufactured. "Can you point to the provider of your source code and software architectures? All of this is coming into play in a big way," McQuaid says. "All of our products are designed, developed, manufactured, and supported in the U.S."

UNMANNED SYSTEMS
PAYLOAD DESIGNS

Self-destructing, vanishing electronics on the way

By Sally Cole, Senior Editor

A flock of small, single-use drones capable of making precise deliveries or completing other military missions and then vaporizing into thin air sounds suspiciously like science fiction, but the U.S. Defense Advanced Research Projects Agency (DARPA) and its partners participating in the ICARUS program have developed and are bringing this technology into the realm of reality.

Small unmanned delivery systems built with transient materials could ease military units' shipment burden, bringing water, batteries, or other supplies and then self-destructing. Inset: DARPA's VAPR program aims to develop electronic systems capable of physically disappearing in a triggered, controlled manner. (Inset photo courtesy DARPA.)

"ICARUS" is the mythology-alluding acronym for DARPA's $8 million Inbound, Controlled, Air-Releasable, Unrecoverable Systems program. The program builds upon recent innovations in its Vanishing Programmable Resources (VAPR) program, which is focused on developing self-destructing electronic components.

"Our VAPR program partners are developing structurally sound transient materials with mechanical properties that exceeded our expectations," says Troy Olsson, program manager of VAPR and ICARUS for DARPA.

One intriguing example of these ephemeral materials: small polymer panels that sublimate directly from a solid phase to a gas phase. Another option? Electronics-bearing glass strips with high-stress inner anatomies that can be easily triggered to shatter into ultrafine particles after use.

The goal of DARPA's VAPR program is to create electronics made of materials that can be made to "vanish" if they are left behind after battle – primarily to prevent their retrieval by adversaries, but also to avoid making a mess of the battlefield environment.

With the progress made via VAPR, "it became plausible to imagine building larger, more robust structures using these materials for an even wider array of applications," Olsson says. And it raised the question: What sorts of systems would be even more useful if they simply "disappeared" right after use?

That's where the ICARUS program comes in, with parallels to the ancient story of Icarus soaring with youthful abandon on wings crafted from feather and wax, until he flew too close to the sun, the wax melted, and the wings disintegrated. The program seeks to mimic the material transience that ultimately led to Icarus's demise, while leveraging it for scenarios with nontragic endings.

For the military, small unmanned delivery systems with structural and avionics components built with transient materials offer many possibilities, including mentionable ones such as easing the provision of water, batteries, or emergency medical supplies without adding to a unit's pack-out burden.

"Vanishing delivery vehicles could extend military and civilian operational capabilities in extenuating circumstances where there currently is no means to provide additional support," says Olsson, who is optimistic that the program will attract talented and creative partners because it involves such fascinating science and engineering.

"Inventing transient materials, devising ways of scaling up their production, and combining these challenges with the hard control and aerodynamic requirements to reach the precision and soft-landing specs we need here makes for a challenging and compelling engineering problem," he points out.

One of the partners publicly working with DARPA to develop and demonstrate a "disappearing electronics" platform as part of VAPR, is PARC, a Xerox company. PARC's approach is called DUST, short for "Disintegration Upon Stress Release Trigger," which has obvious implications for the military.

This particular technology enables electronic devices using full-performance microchips to be physically disintegrated upon command.

The transient materials involved provide performance on par with commercial off-the-shelf (COTS) electronics, according to PARC, but with a limited device persistence that can be programmed, adjusted in real time, triggered, or even designed to be sensitive to the deployment environment.

An issue DARPA hopes to address with this type of technology is that although large numbers of sophisticated electronics are increasingly pervasive on the battlefield – used for applications such as distributed remote sensing and communications – it's nearly impossible to keep track of or recover each of these devices. This situation can lead to the undesirable loss of intellectual property and technological advantage.

In terms of its transient technology, PARC has performed several dozen live demonstrations in which a standard laser pointer provides a remote logical signal that triggers a current pulse within a resistive heater. This, in turn, provides energy to initiate a defect and disintegrate the electronic device within mere seconds. Optical or radio frequency signals can be used as triggers, but physical or chemical triggers are also possible.

Not surprisingly, PARC's technology is intended to be compatible with COTS electronic devices and fabrication processes, which should lead to a wide range of complex transient functionality. (See "Small UAS payloads pose SWaP and bandwidth challenges," page 28.)

Because the company specializes in developing sophisticated electronics with a focus on novel form factors and manufacturing approaches at a reduced size and cost, DUST is a natural fit for PARC. Expect to see its transient devices used for applications such as objects embedded with sensors to support the fast-growing Internet of Things (IoT) or as a destructive option to enhance data security. **MES**

Intelligent I/O eases shifting payload requirements in unmanned underwater vehicles

By Lino Massafra

Embedded systems comprised of commercial off-the-shelf (COTS) components designed around an integrated modular architecture (IMA) facilitate time- and mission-critical applications for unmanned sea vehicles while reducing size, weight, power, and cost (SWaP-C) constraints.

U.S. Navy contractors lower the U.S. Navy's Bluefin-21 into the Indian Ocean from the deck of the Australian Defence Vessel Ocean Shield. The submersible was used to search for Malaysia Airlines flight MH 370, which went missing in March 2014. (U.S. Navy photo by Mass Communication Specialist 1st Class Peter D. Blair.)

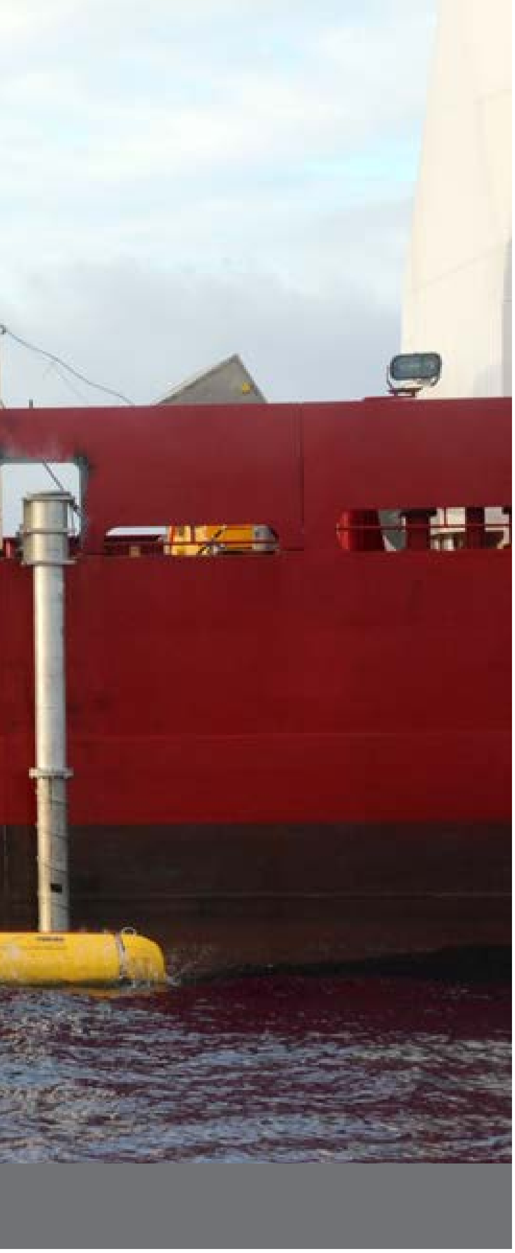
The development and deployment of unmanned sea vehicles is rapidly expanding as the military continues to find new ways to use these intelligent machines in combat, reconnaissance, and countermine missions. Unmanned underwater vehicle (UUV) manufacturers are confronting crucial design challenges that include cost, time, size, weight and power consumption. Moreover, adding functionality to the existing I/O and communications systems, specifically to expand payload options, is a critical design consideration in unmanned sea vehicles. Enter the advanced embedded computing architectures that marry I/O and communications to mission-critical computers without expensive chassis or backplane redesign. These Ethernet communications-based systems can be configured with multiple I/O functions to meet changing payload requirements.

UUVs are growing up in the age of mounting high-sea (though shallow water threats are also an issue) threats. These vehicles are more inclined toward using COTS-based embedded systems and modular architectures amid the need for greater operational efficiency, shrinking military budgets, and time-to-mission design constraints.

The interchangeable mission-centric electronics is the hallmark of UUV design because of the constantly changing nature of naval missions – underwater search, coastal defense, sea denial, blockades, and the like – demands alternate payloads capable of executing a diverse range of applications. In these cases, a modular design architecture saves developers from integration headaches while enabling them to quickly configure the system or box according to current and future mission requirements. (Figure 1.)

In other words, UUV manufacturers can employ intelligent I/O and communications systems and subsystems, based on application-specific and standard COTS products instead of merely using single-board computers (SBCs) that could eventually lead to uncertainties about how I/O will connect in the box given the specific nature of backplane and chassis design. Moreover, the nonrecurring engineering (NRE) costs could go through the roof while system integrators are forced to requalify the box all over again.

Not surprisingly, therefore, early UUV designs like Bluefin-21 and Knifefish have relied on the embedded computing solutions with modularity and



distributed interfaces while using COTS products. The advances in embedded computing, energy efficiency, sensors, robotics, and position-guidance technologies now allow the Navy to augment expensive manned systems with less-expensive and fully autonomous UUVs.

Why a modular design?

An unmanned sea vehicle is usually comprised of a multitude of off-board sensors – including compasses, Doppler velocity loggers, inertial navigation systems, and sound-velocity sensors – that carry out search, avoid, or follow operations in a highly automated manner. First and foremost, the vehicle requires a stable control system to perform vehicle autonomy, mission planning and execution, payload data management, and other processing-centric tasks.

Next, UUVs are required to understand features in their environment so they can intelligently detect and classify items and then respond to sensor data in an automated manner. In this realm, the vehicle's control system, based on low-power and high-performance processors, reacts to physical or tactical tasks using appropriate payloads in close collaboration with monitoring sensors.

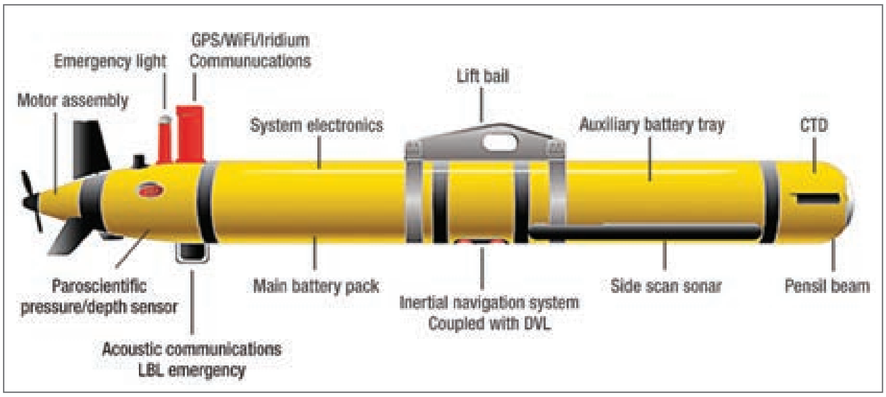


Figure 1 | A design using advanced embedded systems helps address size, weight, power, and cost (SWaP-C) challenges in unmanned underwater vehicles.

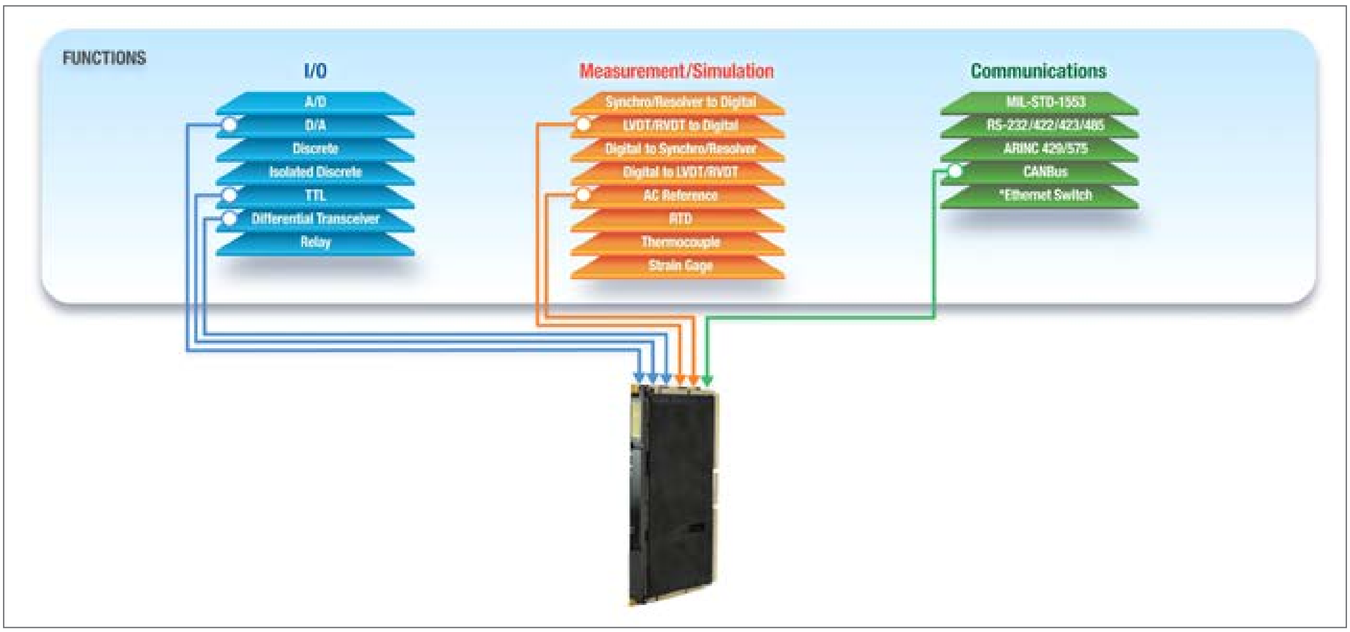


Figure 2 | Modular architectures enable UUV designers to select suitable COTS components for specific payloads, add them to the subsystem, and connect to the Ethernet network.

That complexity just shows how crucial the connection is between the control or processor part and the sensors parts. The ability to read and simulate that data simultaneously requires robust processing and I/O capabilities, and is a huge requirement in the UUV design.

A modular and highly adaptive architecture (Figure 2) allows UUV designers to add a controller board to the existing system and connect it to the Ethernet or CAN bus; the controller board will connect to whatever payload UUV manufacturers want to support. It has to be a flexible and scalable design solution because the main system cannot be changed significantly.

In contrast, creating a new box with all the functionalities outlined above could add to design complexities and cause additional NRE costs. Take the case of adding a new mission computer for a new payload: To begin with, a designer might not know how to interface a legacy sensor/transducer with the new board. The designer might then have to requalify the whole box, which could take months.

Intelligent I/O functions

The UUVs could be a game-changer – just like unmanned aerial vehicles (UAVs) are in the sky – by offering the naval fleets a complete operational picture. However, being the eyes in the open seas means that there is a sheer volume of water to be monitored. Providing intelligent multifunction I/O and communications capabilities is going to be a key requirement in the UUV designs.

The I/O functionality is specifically targeted on the payload that UUVs have to carry. For instance, if a UUV has to handle I/O functionality from Ethernet to synchro/resolver or Ethernet to CANbus, it is imperative that the I/O devices can be easily configured with multiple functions. Another example: Take the case of a UUV that needs to monitor temperature using resistance temperature detector (RTD) channels.

In this instance, a COTS modular and configurable board enables UUV designers to quickly create an application for this new payload. A configurable I/O module is flexible enough to accommodate different payloads with a diverse range of I/O devices. Furthermore, for a new payload on the UUV, a systems integrator can simply add a prequalified board to the box that has already been qualified and tested.

The UAV design redux

It's worth noting that UUVs aren't necessarily simply "sea drones," because they are not remotely piloted in most cases. Unlike UAVs, which are inherently well-placed to pluck radio signals from the air, sea water is opaque for radio communications; moreover, acoustic signals travel slower than wireless signals.

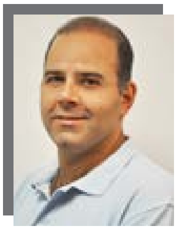
The fact that UUVs are fully autonomous and highly automated calls for extremely robust and reliable electronics based on the fundamental building blocks:

communications, power management, data management, and storage. At the same time, however, the anatomy of UUVs is quite similar to the UAV design blueprints. This reality is a welcome relief for the Navy engineers. UAVs set a precedent by using COTS components and modular architectures and now UUV designers are following suit to enable SWaP-C concerns.

The use of application-specific standard COTS systems like NAI's NIU1A (Figure 3) enables engineers to bypass costly box redesigns by using multifunction I/O and communications to Ethernet data concentrators instead.

Apparently, UUVs are reshaping the basic underpinnings of sea warfare. The U.S. Navy has acknowledged that UUVs are going to be a force multiplier for its regular fleets and has allocated a significant amount of funds for the expansion of its UUV fleet in the 2016 budget. Now it's up to the design engineers to show that they can create innovative electronic systems without making SWaP-C tradeoffs. **MES**

Figure 3 | Nanosized subsystem with Intelligent I/O capability connects to existing platform Ethernet networks, making data available to any system on the network.



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Next-generation UAVs require high-performance end-to-end connectivity

By Earle Olson

An MQ-9 Reaper equipped with an extended range modification sits on the ramp on Kandahar Airfield, Afghanistan. U.S. Air Force photo by Tech. Sgt. Robert Cloys.

Unmanned aerial vehicles (UAVs) present challenges for embedded computing, as high-performance, high-resolution sensors create massive amounts of data that must be processed. For example, the U.S. military's Gorgon Stare airborne surveillance platform can cover an area of 100 km² with the ARGUS imaging system. The system's 368 five-megapixel cameras can combine to create a 1.8-billion pixel image and video at 12 frames per second. The result is several terabytes of data per minute.

As UAVs move from platform-centric to network-centric models – ones that share sensor and payload information with ground-control stations, satellites, and remote terminals – computational-intensive processing is required both to separate the wheat from the chaff and to compress the data. VPX is a leading platform to meet these needs, as it gives users modularity, scalability, and support for board-level optical and RF connectivity.

Input/output and SWaP

To avoid performance bottlenecks, I/O connections need to keep pace with processors so that data is moved around quickly and efficiently. Systems are beginning to use gigabit and even 10 gigabit Ethernet to create onboard networks that connect sensors, processors, and communications. Saving space and weight are key design requirements for UAVs. In particular, weight savings are important to enabling UAVs to loiter on station for long durations and to carry heavier payloads. Savings measured in ounces at the component level yield pounds at the system level.

The combination of higher speeds and demands for reduced size and weight means that traditional military connectors, such as the ubiquitous MIL-DTL-38999 circular connector, are often too large and not well-suited for high-speed systems. For these reasons, designers are looking for alternative solutions; whatever solution is chosen must be robust and rugged enough to withstand the shock and vibrations, temperature extremes, and other mechanical and environmental hazards that come with deployment in a UAV.

As I/O speeds increase, issues of signal integrity and power budgeting create new challenges. Simply put, high-speed signals are harder to manage than low-speed signals. The higher the interconnection speed, the more difficult it is to manage return loss, insertion loss, crosstalk, and similar factors that can degrade signals. While an ideal cabling system would have no intermediate connections between

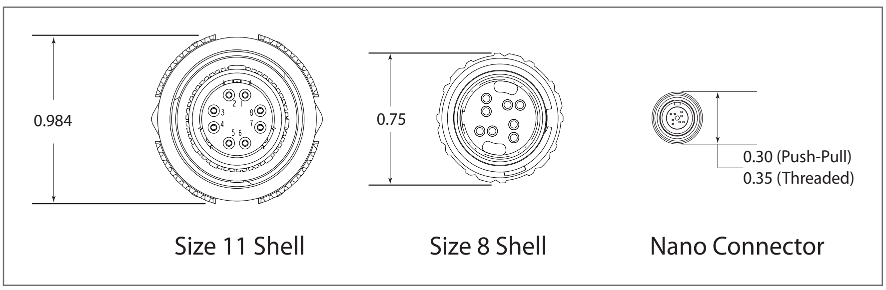


Figure 1 | Small circular connectors support the high speeds needed for end-to-end connectivity (Courtesy TE Connectivity.)

boxes, the real-world need for production breaks and modularity necessitates connectors in the path.

A poorly designed connector will appear as a significant impedance discontinuity. The impact of the discontinuity is frequency-dependent – return loss and crosstalk increase with frequency – meaning that high-speed I/O connectors must be more carefully designed. Attenuation in the cable and insertion loss in the connector are also frequency-dependent, making power budgets more challenging at high speeds.

Size, weight, and power (SWaP) issues remain most important in providing persistent surveillance, a better fuel-to-weight ratio, and the potential for smaller UAVs. While smaller, lighter connectors help meet SWaP goals, miniaturization cannot simply be accomplished at the expense of signal integrity or robust ruggedness. Nanominiature and microminiature connectors already exist, but these legacy connectors were not designed for high-speed signals.

Ready for 10 G

The gap in fast copper connectivity can be partially bridged with some connectors capable of 10 Gb/s performance.

A connector that maintains shield continuity through the connector can be concatenated multiple times without degrading performance. These connectors offer field repairability, supporting a single 10 G Ethernet channel in a size 11 shell or four channels in a size 25 shell. A smaller eight-position connector in a size 8 shell uses a T-shaped contact pattern to provide noise cancellation and decoupling to minimize crosstalk and increase signal integrity. In this size 8 connector, the backshell is integrated into the plug body to sport a low profile, provide low weight strain relief, and furnish electromagnetic (EMI) protection. Nanoconnectors use the same T-shaped contact pattern as the size 8 connectors, but in a nanominiature size, as plugs are only 0.3 inch in diameter. (See Figure 1, previous page).

Fiber optics: light weight, high speeds

Even as high-data-rate copper-based connectivity is evolving, fiber-optic transmission is finding increased use. Creating location-independent architectures means that different subsystems must not be constrained by cabling distances. Optical fibers have the well-known advantages of long transmission distances independent of data rate, noise immunity, and small size/light weight.

Figure 2 | The ARINC 801 optical terminus has been ported to 38999 Series III-style connectors. (Photo courtesy TE Connectivity.)

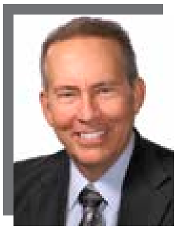
While there are many fiber optic connectors available, the two main categories of optical contacts are physical contact (PC) and expanded beam (EB). PC termini, typically using a ceramic single-fiber ferrule, achieve low loss by having the termini physically touching. EB connectors, on the other hand, rely on ball lenses to expand and then refocus the light across the interface. The noncontacting EB interface offers high-mating-cycle durability and easy cleaning, while the PC interface provides the lowest loss. The MT ferrule, with a capacity of 12 or 24 fibers, enables very-high-density fiber packaging. MT ferrules are available in both PC and EB versions.

For fiber connectivity, 38999-style connectors remain popular in UAV applications. TE recently introduced the MC801 connector, which combines ARINC 801 termini and a 38999-style shell (Figure 2). The genderless ARINC termini are considered easier to use, clean, and maintain than the pin and socket configuration of PC military-style contacts. ARINC 845, which covers expanded beam technologies, recently selected TE's PRO BEAM EB16 termini as the ARINC 845 industry standard for rugged optic applications within commercial aviation applications.

What's next for UAV connectivity?

With more sophisticated sensors, ever faster and more capable silicon, and more sophisticated computer architectures and software, one clear future for UAV systems is more bandwidth. Network backbones are already migrating from 1 Gb/s Ethernet to 10 Gb/s, with 40 and 100 Gb/s waiting in the wings. Streamlining designs with a goal of a common hardware set is also gaining ground. For example, designing interconnects to be compatible with a range of physical layer impedances – such as Fibre Channel, IEEE 1394, eSATA, and the like – can not only simplify system design but can also reduce the number and types of cables and connectors that must be stocked. Improved compatibility will enhance the idea of modularity and easy plug-and-play connectivity.

While designers, in the end, will look for standardized high-performance systems and components, they still have choices when it comes to performance-based alternatives. Today's performance-based system may well become tomorrow's new standard. **MES**



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Ethernet switches: Why time matters

By Abaco Systems

The differences in start-up time between unmanaged Ethernet switches and their managed equivalents are discussed. For the most part, unmanaged switches work well in simple networks, while managed switches are capable of more complex forwarding decisions.

Link: http://mil-embedded.com/white-papers/white-why-time-matters/

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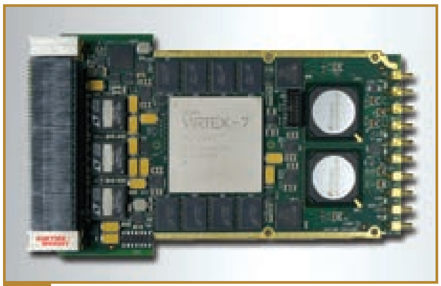


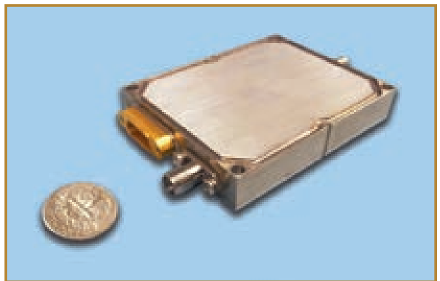
Rugged dual-channel 4 GSPS ADC/DAC in 3U form factor

The VPX3-530 3U VPX Xilinx Virtex-7 FPGA ADC/DAC card from Curtiss-Wright is designed for defense applications such as signal intelligence (SIGINT), electronic countermeasures (ECM), and radar warning receivers (RWR). The rugged dual-channel 4 gigasamples per second (GSPS) ADC/DAC is packaged in the 3U form factor and available in air- and conduction-cooled formats with a user-programmable Xilinx Virtex-7 field-programmable gate array (FPGA). It allows for two 4 GSPS 12-bit (or four 2 GSPS) analog inputs and two 5.6 GSPS update rate (maximum 2.8 GSPS data rate) 14-bit analog outputs with the XC7V690T FPGA. The VPX3-530 may be used in two ways: either alongside a single-board computer (SBC) or in a larger array of synchronized high-speed analog I/O components.

The VPX3-530 FPGA ADC/DAC card provides in a single unit the I/O resources needed for the ADC, DACs, high-speed DDR3 SDRAM, high-speed PCI Express (PCIe), and serial links, together with FPGA-driven parallel I/O to the OpenVPX backplane. VPX3-530 users have the choice of two RF sample clock sources available through the front panel. High-speed DDR3L memory resources support the user-programmable Xilinx Virtex-7 VX690T FPGA. The VPX3-530 3U VPX Xilinx Virtex-7 FPGA ADC/DAC card offers the choice of two memory banks: 256 M by 64-bit or 512 M by 64-bit DDR3L SDRAM. Flash and DDR SDRAM provide AES encryption for FPGA configuration.

Curtiss-Wright I www.curtisswrightds.com I www.mil-embedded.com/p373430

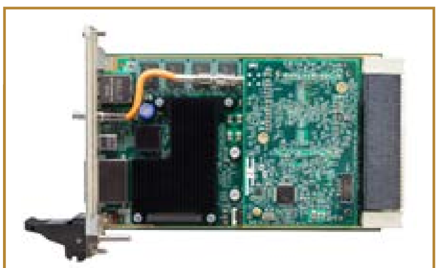
Family of GaN-based modular, non-ITAR amplifiers



The Teledyne Microwave Solutions family of gallium nitride (GaN)-based modular, non-International Traffic in Arms Regulations (ITAR) amplifiers is a smaller form factor threshold for the 0.1 GHz to 6.0 GHz frequency range. The line consists of five GaN wideband amplifier models that meet the airborne requirements of commercial and military applications. The dimensions, excluding connectors, are 2.5 inches long by 2 inches wide by 0.42 inch high, for a total size of 2.1 cubic inches. Engineers designed and manufactured the amplifiers to thermal requirements; therefore they have a calculated MTBF of over 40,000 hours at +85 °C.

Output power ranges between 15 and 40 watts, depending on frequency band. Each amplifier includes preamp and driver stages to produce a minimum overall gain of 50 dB. Internal control circuitry enables safe startup so supply voltages can be applied in any order. In addition to normal DC connections via a 15-pin Micro-D connector, other control/interface features are available via the connector, including a TX enable/disable "time-to-live" (TTL) command (100 ns typical, 200 ns max), over-temperature automatic shutdown and associated alarm, and the ability to monitor unit temperature via an analog voltage proportional to case temperature.

Teledyne Microwave Solutions I www.teledynemicrowave.com I www.mil-embedded.com/p373431



Multipurpose GPP for configurable systems with low power requirements

The IXI Technology configurable IXI-1 multipurpose general-purpose processor (GPP) is an SBC that integrates the high-performance and low-power Intel Atom Quad-Core CPU. An additional FPGA for flexible configuration of multistandard I/O interfaces provides support for the CPU. The accelerator unit for high performance graphic processing unit (GPU) or digital signal processing (DSP) functions is also available as an option. To minimize power consumption, the designers of the GPP devised a way to ensure that only circuitry selectively in use is powered up and that power-intensive devices can be selectively run at the minimum required frequency. Normal operating power consumption is reported at less than 25 watts while utilizing all available interfaces.

Interfaces include VPX, 10/100/1000 Mb/s Ethernet, MIL-STD-1553B, controller area network (CAN), multiple RS232/RS485/RS422 serial ports, USBs, general-purpose input/output, audio in/out, display output port, NTSC/PAL composite analog video, and the latest high-definition 3G-SDI display input port. The IXI-1 GPP features a scalable multiprocessor architecture over an Open VPX backplane, enabling additional SBC modules and boards to be added for supplemental processing requirements. Multiple PCIe lanes link the backplane, system-on-chip (SoC), and I/O units that can be configured via an integrated PCIe switch. The IXI-1 GPP is aimed at compact high-performance, embedded processing needs.

IXI Technology I www.ixi-tech.com I www.mil-embedded.com/p373432

Manage Ethernet switches with 12 or 24 ports

The Connect Tech LINQ/GbE is a rugged managed Ethernet switch box available for 12 or 24 Ethernet ports of 10/100/1000 Mbps. Using the Vitesse switch engine VSC7429, users have access to a range of Layer 2+ switching features, including VLAN support, IPv4/IPv6 multicast, QoS, and link aggregation. Management access is available via web interface, software API, SNMP, or command line interface; this capability allows for remote multi-unit updates.

The solid aluminum alloy construction meets the IP68 rating (waterproof-submersible) and is aimed at use in harsh high-shock and vibration environments. The box also meets also requirements for dust and waterproof sealing when mated or with a dust cap. Features include ruggedized sealed RJ-45 acclimate connector series, low-power passively cooled construction, and extended temperature range between -40 °C to +85 °C. The power and management ports on the box are Bayonet Sealed Circular Connectors (Samtec ACR Series). In addition, an embedded 416 MHz RISC 32-bit CPU with DDR2 external memory and DMA-based frame extraction and insertion supports timing over packet; Ethernet operations, administration, and management (OAM); and performance monitoring.

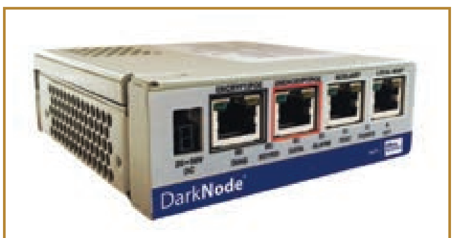
Connect Tech Inc. | www.connecttech.com | www.mil-embedded.com/p373433

10 Gb/s ruggedized system for military, aerospace high-bandwidth applications

Hercules Unleashed is a 10 Gb/s ruggedized commercial off-the-shelf (COTS) high-density interconnect system from Meritec. The Hercules Interconnection System is embedded in the rugged circular MIL-38999 shell to provide a durable and high bandwidth interconnect suitable for military and aerospace ruggedized high-bandwidth applications. The system meets USB 2.0 and 3.0, IB, SAS, SATA, Serial I/O, and PCIe protocols and is available in MIL-38999 Series III sizes: 9, 13, 17, and 23.

The Hercules Interconnect System was designed to be VITA 76.0 standard-compliant, which supports copper and active optic cabling to 10 Gbaud data rates. Hercules – packaged within rugged military shellwork – is available as plug-cable assemblies and either jam-nut or flange-mount receptacles for solder tail, press fit, or pigtail connections. Different jacket types are available – LSZH, PVC, FEP, and Halar Expando. The system supports data rates in excess of 10 Gb/s and carries differential-pair signaling with low-skew pairs and shielding for EMI/RFI protection. Meritec can also build custom lengths to order.

Meritec | www.meritec.com | www.mil-embedded.com/p373436



DarkNode appliance used to protect against internal and external cyberattacks

Ultra Electronics 3eTI’s DarkNode (3e-636L2) is a Layer 2 industrial information assurance (IA) appliance with a built-in application layer rewall that is designed to protect critical infrastructure facilities from internal or external cyberattacks. Its security platform reports over 150 Mbps of low-latency encrypted VLAN performance. The DarkNode suite provides protections such as remote logging, access control, and application-level packet inspection. The product is designed to provide cryptographic defense-in-depth protection for Ethernet connected program logic controller (PLC) devices without causing latency. DarkNode also provides VLAN encryption. The system is rated at temperatures between -40 °C and +70 °C.

The software design enables the system to be configured as an enforcement point to allow intended industrial protocols to pass through while filtering out unwanted traffic. The access control function is for machine-to-machine communication for utility-management networks and provides an additional layer of protection against attacks targeting critical infrastructure networks. The application level DPI in DarkNode can stop “ride-on” traffic through the open ports while allowing only the intended industrial protocols to pass through. It also offers another layer of protection to isolate vulnerability contamination on one device and prevent it from affecting the industrial control functions.

Ultra Electronics | www.ultra-3eti.com | www.mil-embeddded.com/p373437

CONNECTING WITH MIL EMBEDDED

By Mil-Embedded.com Editorial Staff

CHARITY

MusiCorps

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 featuring MusiCorps, a conservatory-level music-rehabilitation program based at Walter Reed Army Medical Center that helps wounded warriors play music and regain confidence. Musician and composer Arthur Bloom formed MusiCorps in 2007 after visiting returning service members at Walter Reed who had been injured in Iraq and Afghanistan.

Through MusiCorps, Bloom and his group have helped hundreds of injured troops learn or relearn how to play an instrument as a core part of their rehabilitation. MusiCorps – although not a music-therapy program per se – does aim to reduce participants' anxiety and even help heal injured brains. Program participants are able to practice technique, write and record music, or simply come together for a jam session.

It has also become a pioneer in the field of adaptive music. According to Bloom, some parts of the program could be called adaptive music making: "The folks who are missing limbs or have damaged hands and arms sometimes require specialized instruments, which we provide."

The MusiCorps Wounded Warrior Band, the performance component of MusiCorps, is made up of injured veterans who became musicians or retrained on their instruments through the program. The band has performed with Roger Waters, Yo-Yo Ma, and Sheryl Crow at such venues as the Kennedy Center, Grand Ole Opry, and Madison Square Garden, and on television on PBS, "The Colbert Report," and the 300th episode of "NCIS."

For more information, visit www.musicorps.net.

E-CAST

Static analysis in the context of dynamic testing

Presented by MathWorks

Software testing, an integral part of embedded code verification, can be very expensive, particularly if done in a rush towards the end of the development process. Test-driven development brings certain advantages that can help structure the process for efficiently validating the functional requirements. However, an approach relying on testing alone is incomplete as it may fail to meet the requirements of robustness explicitly called out in standards like DO-178, ISO 26262, or IEC 62304. Code proving, an advanced form of static analysis, provides a way to verify implementation correctness as the code is being written.

Participants will learn how combining code proving with dynamic testing yields safer, more secure, and more robust software early in the development process.

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WHITE PAPER

High-speed switched serial fabrics improve system design

By Rodger Hosking, Pentek

Well into its third decade of widespread deployment, VME adopted the new VXS gigabit serial interface, a move which represented the most significant leap in backplane data-transfer rates throughout its history.

Because VXS delivered such a dramatic improvement in embedded system performance, the use of gigabit serial technology was then extended to create VPX. The OpenVPX initiative – an industry working group of 28 defense contractors – followed shortly thereafter, as risk-averse government agencies mandated the need for industry-wide standards. This white paper defines the hallmark of any successful standard: one that continues to evolve with technology. An example of this is the way in which VME has evolved into VXS and VPX.

Read the white paper: http://mil-embedded.com/white-papers/white-design-seventh-edition/

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