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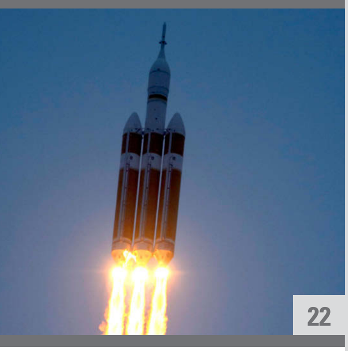
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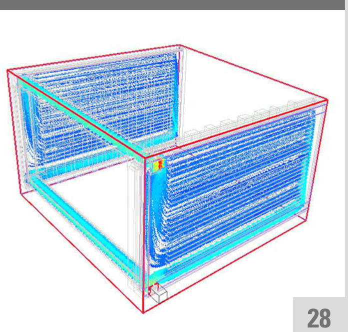
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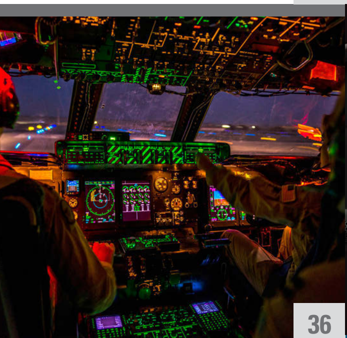
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ON THE COVER:
Top photo: The United Launch Alliance Delta IV Heavy rocket, with NASA's Orion spacecraft mounted atop, lifts off from Cape Canaveral (Fla.) Air Force Station's Space Launch Complex 37 at 7:05 a.m. EST, Friday, Dec. 5, 2014, in Florida. The Orion spacecraft orbited Earth twice, reaching an altitude of approximately 3,600 miles above Earth before landing in the Pacific Ocean. No one was aboard Orion for this flight test, but the spacecraft is designed to allow us to journey to destinations – including an asteroid and Mars – never before visited by humans. (Photo courtesy NASA/Bill Ingalls.)
Bottom photo: DDC-I's Deos embedded real-time operating system (RTOS) runs avionics functions and displays.

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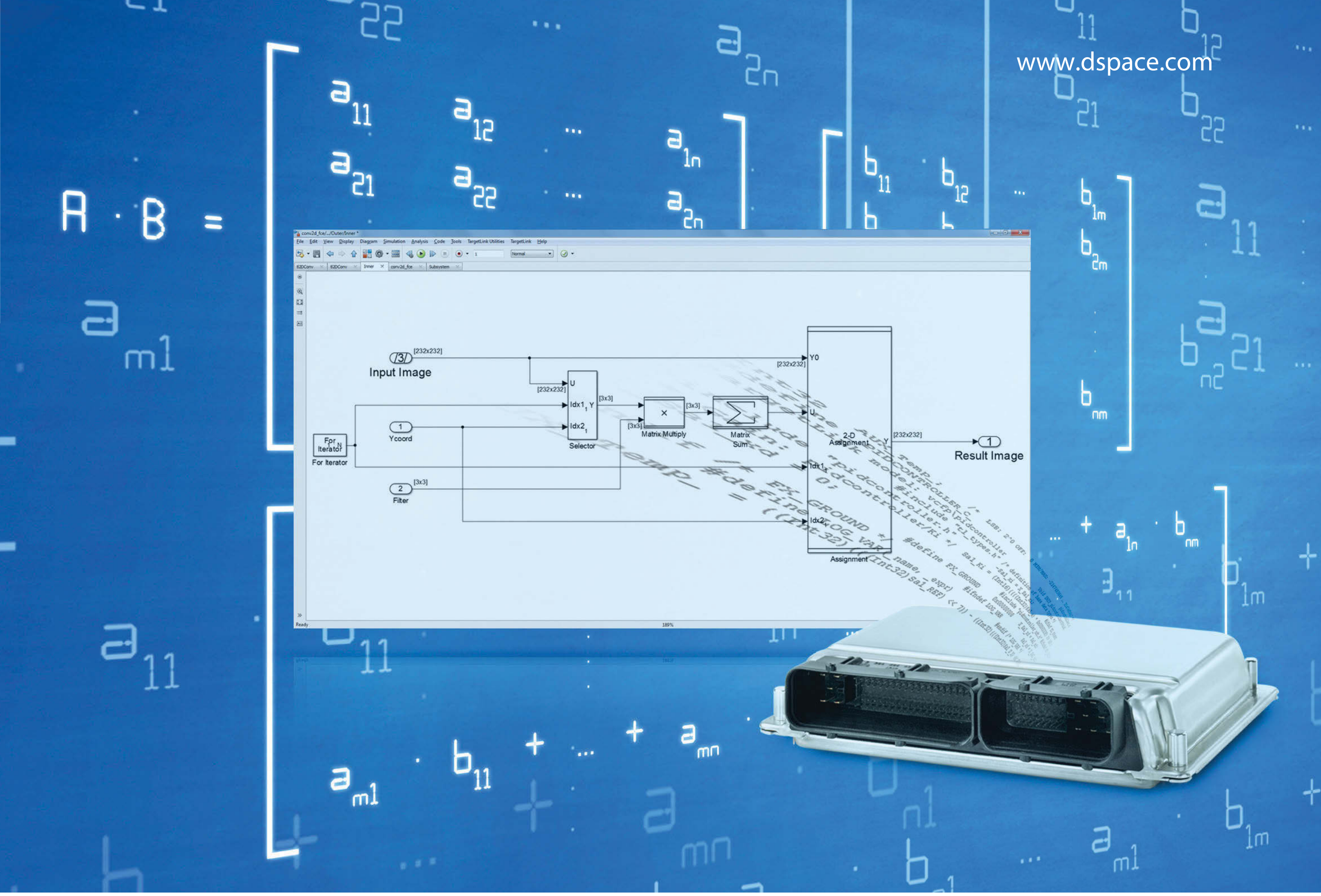

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Funding for avionics upgrades looks steady in DoD budget request

By John McHale, Editorial Director

While there does not appear to be an end to sequestration any time soon, the President's Fiscal Year (FY) 2016 budget request for the Department of Defense (DoD) shows an increase over 2015: For FY 2016, the Department is requesting base budget funding totaling $534.3 billion, an increase of $38.2 billion from the FY 2015 enacted budget of $496.1 billion.

It's a refreshing change, especially if it gets approved by Congress and sequestration goes away ... wishful thinking, I know. We shouldn't get too excited just yet as there are not many new platforms being funded, aside from the Long Range Strike program and continued support of the F-35. That said, there are pockets in the budget that bode well for commercial off-the-shelf (COTS) suppliers in avionics retrofits.

"While new production is down, there remain funding pockets within the budget for avionics upgrades and retrofits to bring new capabilities to fielded aircraft and meet other needs such as additional mission computing and to manage obsolescence challenges," says Troy Brunk, Vice President and General Manager of Airborne Solutions, Rockwell Collins Government Systems in a Q & A in this month's Avionics Issue (page 14). "Avionics remains a strong part of the aircraft Research, Development, Test, & Evaluation (RDT&E); procurement; and Operations & Maintenance (O&M) budgets because avionics systems are an integral part of the aircraft's mission capabilities."

Rotary-wing aircraft

Some rotary-winged aircraft programs getting continued avionics funding in the FY 2016 budget request include the UH-60 Black Hawk, the Apache AH-64 Block 3, the H-1, and the CH-47F tanker.

The Black Hawk is up about $90 million over the FY 2015 request, to a total of $1.563 billion in FY 2016 with procurement of 94 UH-60M aircraft requested. Funding for UH-60L digital upgrades are also included. Northrop Grumman is providing a digital cockpit upgrade based on an open-architecture design for the UH-60L variants, which will be called the UH-60V once it's upgraded.

The H-1 program, which replaces the AH-1W Super Cobra and the UH-1N Huey helicopters with the AH-1Z Viper and UH-1Y Venom, has an advanced cockpit common to both aircraft. The FY 2016 program funds the procurement of 28 new-build aircraft (16 AH-1Z and 12 UH-1Y) and also funds developmental efforts for avionics and other systems. Overall funding for this program is down slightly from FY 2015 to $856.2 million in FY 2016.

> ***"Funding for the F-35 Joint Strike Fighter (JSF) increased across all variants in the FY 2016 request."***

The CH-47F Improved Cargo Helicopter program, which procures new and remanufactured Service Life Extension Program CH-47F helicopters with an upgraded digital cockpit, gets a procurement request for 39 aircraft (12 new-build and 27 for the extension program) in FY 2016. Funding is at $1.124 billion, an increase of nearly $20 million over FY 2015.

The AH-64E Apache program, which consists of a remanufacture and a new-build effort, is slated to get funding for the remanufacture of 64 AH-64D aircraft to the AH-64E configuration and continued development of upgrades in the FY 2016 budget request, with a funding level of $1.378 billion in FY 2016, up more than $500 million over FY 2015.

F-35 & Long Range Strike

Funding for the F-35 Joint Strike Fighter (JSF) increased across all variants in the FY 2016 request – the F-35A Conventional Take-Off and Landing (CTOL), the F-35B Short Take-Off and Vertical Landing (STOVL), and the F-35C Carrier variant (CV). Total procurement requested for FY 2016 is 57 aircraft – 44 CTOL for the Air Force, 9 STOVL for the Marine Corps, and 4 CV for the Navy in FY 2016. Navy RDT&E funding for the F-35 increases in the FY 2016 request to $1.149 billion over the FY 2015 request of $1.022 billion, while Air Force RDT&E funding increases nearly $100 million to $704.8 million in the FY 2016 request.

The Long Range Strike (LRS) program covers both next-generation and legacy bombers. The LRS Bomber (LRS-B) is a new, high-tech long-range bomber that will eventually replace the Air Force's aging bomber fleet, but its mission details remain classified, according to the DoD. For the FY 2016 program, development of the next generation Long Range Bomber and modernization of the U.S. legacy strategic bombers continues, with an increase of $400 million in FY 2016 to $2.023 billion.

Orion spacecraft

NASA's budget is increasing modestly, from $18 billion in FY 2105 to $18.5 billion in FY 2016, with continued funding for the Orion program, which includes the Orion Crew vehicle and its new avionics system. Funding for Orion is only down about $89 million in the FY 2016 budget, at $1.096 billion. However, funding for this program is slated to increase each year through 2020. For more on the Orion vehicle's avionics, see our Special Report on page 22.

VME obsolescence prompts thoughts of alternatives

By Charlotte Adams

A GE Intelligent Platforms perspective on embedded military electronics trends

A supplier of a small but important VME component recently announced that the part will go obsolete this year. In all probability, the manufacturer plans to move on from VME to something in greater demand from the commercial world. Although the move was hardly surprising in the larger scheme of things, it made news in the corner of the electronics market devoted to the embedded-computing systems used in military and aerospace platforms.

Yet even in that sector, the news of a key component's imminent demise was far from a death knell for VME. Although the bus-based technology peaked at hundreds of megabits per second on the backplane, it remains an attractive alternative for systems like command and control, which stress board-level compute power more than board-to-board bandwidth. The latest VME designs, moreover, can compete successfully for slots in more demanding signal-processing applications such as radar and sonar. VME can claim all this, despite being directly descended from technology invented – and adopted by military programs – long before the official advent of the commercial off-the-shelf (COTS) era in 1994.

Military programs have used VME systems for decades; these programs have notoriously long gestation periods and even longer service lives. The investment has produced handsome dividends, though. As VME technology has evolved over the years, suppliers of embedded systems have developed products using the latest families of integrated circuits (ICs) while retaining the same card form factors and pin-outs and the same chassis sizes. When the time comes to upgrade a legacy VME-based system, there are always suitable VME candidates.

Reason to hedge

Over time, VME has eclipsed other technologies in the military and aerospace embedded-processing market. By the same token, however, most of the demand for VME today is from military users. This niche status is reason enough for customers to hedge their bets on new system designs. VPX, a point-to-point fabric-based architecture that offers a similar form factor (with a very different backplane), is well positioned for forward-looking programs with higher board-to-board bandwidth requirements.

VME currently has a far larger share of the board-level market than does VPX, with projected revenues of more than $200 million in 2017, according to IHS. Suppliers are still designing VME products and have extended the technology's reach into more demanding applications. Board manufacturers fully expect to be shipping VME systems five years from now.

An example of the latest in VME is the GE Intelligent Platforms XVR16 Rugged 6U VME single board computer (SBC), a sixth-generation, Core i7 board that aims at signal processing applications such as intelligence, surveillance, and reconnaissance (ISR); sonar and radar; and command and control.

Life cycle management

Nevertheless, the end-of-life (EOL) announcement for the VME part should not and will not be ignored. Managers understand that obsolescence is a fact of life in the COTS world. Life cycle management contingency planning is mandatory in military procurements, given their dependence on the commercial market.

In this particular instance there are at least four options. Military customers, integrators, or board suppliers could make EOL buys to ensure the availability of the expiring part for the remaining life of their programs. These components could be stored indefinitely in specially controlled chambers until needed. Alternatively, other VME parts could be substituted, perhaps lowering performance but containing costs. Third, an equally performing part could be designed, using a technology such as a field-programmable gate array (FPGA).

Life cycle management contingency planning is mandatory in military procurements, given their dependence on the commercial market.

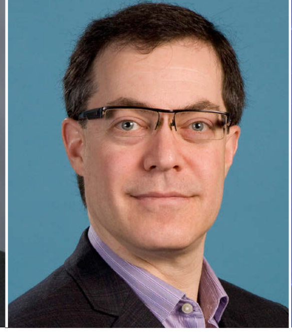
A fourth alternative, more attractive to new programs than legacy efforts, would be to transition to a higher-performance architecture such as VPX. While the VPX route would be more expensive than the other alternatives, it might be an acceptable investment for an ISR application requiring significantly greater bandwidth than VME can provide.

To sum up, the news of the imminent demise of a key VME component – the bridge that translates chip language to the lingua franca of the bus – presents military customers with a host of choices and tradeoffs, not with a crisis. Through careful advance planning, a range of alternatives is available to meet industry need and maintain continuity at an acceptable price.

defense.ge-ip.com

ROcE protocol brings 40 Gbps Ethernet to VxWorks

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



For many defense and aerospace system integrators, Wind River's VxWorks retains its stature as the operating environment of choice thanks to the real-time operating system's (RTOS's) trusted and proven deterministic performance. One area of frustration for system designers, though, is VxWorks' network performance when used with faster variants of Ethernet. VxWorks works great when used with Gigabit Ethernet (GbE) links since the VxWorks network stack is able to support full line-rate performance using protocols such as TCP and UDP. As the network pipe increases to 10 GbE or 40 GbE, however, throughput becomes limited to around 4-5 Gbps even with today's fastest processors, due to inherent network architecture limitations. At these speeds, VxWorks network performance is often far below that of competing Linux systems.

For many demanding embedded applications, such as signal/image/radar processing, VxWorks' limited 40 GbE throughput can reduce its appeal while the use of Linux may not offer the real-time responsiveness of VxWorks. For those designers who prefer VxWorks, and for those customers who have extensive legacy investment in pre-existing VxWorks applications – sometimes measured in millions of lines of code – there's a strong demand for faster Ethernet performance under VxWorks.

The good news is that now there's a way to achieve full-speed 40 Gbps Ethernet over VxWorks on today's highest performance 4th generation Intel Core i7 processor-based OpenVPX digital signal processor (DSP) engines and single-board computers (SBCs). The solution is an alternative network stack that makes use of the high performance, low latency, and low CPU overhead features of the RDMA over Converged Ethernet (RoCE) protocol. Until now, RoCE (pronounced "Rocky"), developed by the InfiniBand Trade Association (IBTA) in mid-2010 to ensure efficient, low-latency data transfers between servers in commercial data centers, has been available only for the Linux community.

The RoCE-based stack's breakthrough performance – almost 10 times over the standard VxWorks Ethernet interface status quo – results from porting an ibverbs interface to the board's VxWorks standard board support package (BSP). Use of the ibverbs API enables the system integrator to program the board's Mellanox ConnectX-3-Gigabit Ethernet network device to deliver previously unobtainable levels of bandwidth with VxWorks. The key is remote direct memory access (RDMA), which supports direct data movement between the application memories of multiple CPUs without requiring any CPU involvement. Previously, RDMA could only be used with InfiniBand fabrics, but RoCE brings RDMA to Ethernet networks. Using RoCE, Ethernet handling overhead is reduced to near-zero (~1 percent). According to the IBTA, RoCE "provides the best of both worlds: the familiarity and ubiquity of Ethernet combined with the features and efficiencies of InfiniBand."

With a RoCE-enabled BSP, boards can achieve near full-line-rate 40 Gbps data throughput over each Ethernet port (recent measurements: ~38.7 Gbps over a single 40 GbE Ethernet port). This solution also eliminates the need for additional components, such as a TCP offload engine (TOE) to boost Ethernet performance over VxWorks.

While a TCP/IP network can be used to send large amounts of data, the need to inspect each Ethernet packet can detrimentally affect system latency. In critical defense applications, latency can be a matter of life and death. RDMA delivers the lowest possible latency for bulk data transfers. Compared to using TCP, RDAM is ideal for moving large bulk data from one processing node to another where maximum bandwidth, minimal latency, and minimal CPU overhead is desired. RoCE uses RDMA to transfer large amounts of data directly from one node's application memory to the application memory of another, thereby bypassing the network stack and its processing speed limitations. This technique eliminates the need for the CPU to "process" data messages transferring between nodes. These bulk data transfers are typically used for HPEC applications where massive amounts of data are processed and transferred between nodes for such applications as radar, graphics, and image processing.

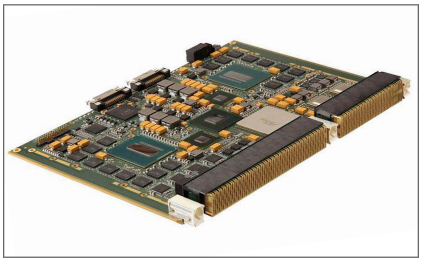


Figure 1 | Curtiss-Wright's 10 Gbaud Fabric40-based CHAMP-AV9 multiprocessor 4th-gen Core i7 ("Haswell") DSP engine [shown] and VPX6-1958 Haswell-based SBC support a RoCE-enhanced VxWorks BSP.

TCP or UDP protocols do provide a superior approach when two nodes need to communicate to exchange interprocess communications, which requires CPU interpretation such as messaging, interprocess coordination and signaling, etc. Fortunately, the RoCE data is packaged and transmitted as standard Ethernet packets so both types of data communications, RoCE and TCP/UDP, can coexist across the same Ethernet pipe.

Examples of OpenVPX products available today that support an RoCE-enhanced VxWorks BSP include Curtiss-Wright's Fabric40-based CHAMP-AV9, which supports VxWorks; and the VPX6-1958, a Haswell-based single-board computer (Figure 1). Both of these products feature Fabric40 10 Gbaud performance which was developed by the company's recently announced "Bicycle Shop" technology incubator. The RoCE-enabled software driver is provided at no additional cost in the boards' standard VxWorks BSP.

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EXECUTIVE INTERVIEW

New aircraft production down, avionics upgrade funding steady

By John McHale, Editorial Director

Budget cuts and sequestration have reduced funding for new aircraft platforms but there are still pockets of funding for avionics and flight decks in existing military aircraft. In this Q&A with Troy Brunk, Vice President and General Manager of Airborne Solutions for Rockwell Collins Government Systems, he discusses his outlook for military avionics technology, what pilots want avionics technology to do for them, and the situational-awareness benefits of synthetic vision technology. Edited excerpts follow.

Troy D. Brunk

Rockwell Collins engineers developed the Pro Line Fusion Synthetic Vision system developed for the Bombardier Global 5000 business jet's flight deck (left) and and have since adapted it for use in the MH-60 Black Hawk helicopter. (Photo courtesy of Rockwell Collins.)

MIL-EMBEDDED: *Please provide a brief description of your group's role within Rockwell Collins such as key technology areas, platforms, etc.*

BRUNK: From the military side of Rockwell Collins, Airborne Solutions addresses avionics and flight deck solutions for military fixed- and rotary-wing aircraft platforms including fighters, bombers, trainers, tanker, transport, special mission, and unmanned aircraft. When I say avionics, I refer to traditional large-format, high-resolution cockpit displays, head-worn displays, advanced mission computers, and highly integrated navigation and flight-control systems. In addition, we provide transponders, traffic collision avoidance systems (TCAS), satellite communication (SATCOM) terminals, and weather radar. We address the full gamut for the military avionics world.

We also support commercial rotary-wing avionics applications as there is much similarity between these platforms and military rotary-wing platforms in terms of environmental requirements.

MIL-EMBEDDED: *The Department of Defense (DoD) released its FY 2016 budget request this month with an increase in overall funding, almost a reverse trend from the last few years. That said, how do you see the funding outlook for military aircraft and – as a direct result, avionics systems – within the DoD? Is activity still strong even with the budget-constrained environment of the last few years?*

BRUNK: From a macro perspective, what we're seeing and have been seeing is an overall reduction of new aircraft in production over the next five years plus, aside from key platforms like the F-35, KC-46, and Long Range Strike. However, we do see in the budget a strong commitment to recapitalize platforms such as Joint Surveillance and Target Attack Radar System (JSTARS), Airborne Warning and Control System (AWACS), T-X, etc. By and large there are still opportunities out there, but with the fewer number of platforms and restarts we have to make sure we are capturing the key platforms.

While new production is down, there remain funding pockets within the budget for avionics upgrades and retrofits to bring new capabilities to fielded aircraft and meet other needs such as additional mission computing and to manage obsolescence challenges. Avionics remains a strong part of the aircraft Research, Development, Test, & Evaluation (RDT&E), procurement, and Operations & Maintenance (O&M) budgets because avionics systems are an integral part of the aircraft's mission capabilities.

MIL-EMBEDDED: ***Please provide an example of current avionics programs Rockwell Collins is involved in for rotary, fixed, and unmanned aircraft.***

BRUNK: For rotary platforms, our avionics technology is on the MH-47G/60M, the CH-47F Chinooks, the UH-60 Black Hawk platforms, MH-53E, and the new VH-92 Presidential helicopter platform. On the civil side, we supply avionics into many OEMs with strong positions at Sikorsky and Agusta Westland helicopters.

Regarding fixed-wing platforms, we have avionics systems on the KC-46, the C-130, KC-390, and AWACS. We also are positioned well on fourth-generation fighters such as the F-18 and Eurofighter. On the F-35 our real focus has been on the helmet-mounted-display (HMD) system that we developed in a joint venture with Elbit Systems.

We are also looking at leveraging some of the F-35 technology we developed for the HMD, such as digital night vision and data links for use on fourth-generation fighters.

For unmanned aircraft, we're delivering flight-control systems and communication systems for platforms such as Black Jack, Shadow, Grey Eagle, and others. We are also continuing to assess what requirements need to be met for civil unmanned aircraft. There is a growing emphasis for unmanned aircraft to be able to operate in the same space as manned aircraft, which will present opportunities for new technology that we provide.

MIL-EMBEDDED: ***What are the key technological trends/areas you are focusing on to meet current capability requirements?***

BRUNK: Consumer electronics is the driver in electronics miniaturization and improvements in display technology. We continually focus on how to leverage the consumer-electronics advancements into the aerospace and defense sector in a way that adds value for our customers without burdening them with the challenges of obsolescence due to rapidly evolving technology. A couple of specific areas are improved optical performance in our head-worn and head-down displays and multicore processing.

There is also a focus on providing enhanced vision in degraded visual environments by putting sensors on board aircraft to fuse the data coming into the avionics system. This will give the pilot better situational awareness in brownout conditions and unimproved landing zones. Rockwell Collins won the first of three phases in a U.S. Army program two years ago to develop the Degraded Visual Environment Pilotage System (DVEPS) for the Army's Special Operations Aviation Regiment (SOAR) helicopters. Rockwell Collins will be leveraging its synthetic vision technology, which they developed for use in business-jet cockpits to improve pilots' situational awareness. The program goal is to develop, qualify, and field a DVE solution by 2018.

We are focused on fusing other sensor data such as radar and lidar to create an actual image on the pilot's display. This will enable pilots to avoid obstacles or obstructions on the ground such as a ditch or other obstruction they otherwise could not see with the naked eye due to environmental conditions.

MIL-EMBEDDED: ***How much of what you develop for commercial avionics applications do you then leverage for military applications? Please cite an example.***

BRUNK: Much of avionics development starts on the commercial side and then is leveraged over to military platforms. We leverage significant investments in technology and products from our Commercial Systems business into all of our military markets. The level of reuse varies by the program and the program specific requirements. For example, for the Embraer KC-390 program, we started with the Rockwell Collins Pro Line Fusion integrated avionics system for the Embraer Legacy 500 business jet and added the necessary capabilities to meet the additional military mission requirements. Another example of commercial reuse is for the KC-46 program, where Rockwell Collins leveraged the Boeing 787 large-format display system and added the KC-46 mission features to enable greater mission situational awareness.

We are also adapting our commercial synthetic vision system that was developed for commercial business-jet applications for use on helicopters in both civil and military markets to enable safer flight in brownout and adverse weather conditions (See image on pages 14-15).

We also have taken our Pro Line Fusion commercial flight-management system (FMS) and have put it into ground control stations for [unmanned aircraft systems] (UASs), enabling operators to control the aircraft from a civil-certified FMS.

MIL-EMBEDDED: ***It seems every piece of electronic equipment is getting smaller – handheld computers, GPS devices, etc. How are reduced size, weight, and power (SWaP) requirements affecting new avionics systems? What are the tradeoffs with smaller tech?***

BRUNK: What miniaturization has enabled is enhanced computer processing and display technology with each generation of commercial chip displays. This enables more integration in the same footprint – or same SWaP constraints we are used to – bringing in a lot more features such as synthetic vision and enhanced navigation in the same space, essentially. The new capabilities come in at a fast pace, but the hard part is being able to determine when to take advantage of the new technology for introduction into a program of record or block insertion perspective.

That's just the way the military environment works. You can have those capability enhancements, but might not have the opportunity to integrate them as they are not addressed in the DoD's budget.

It's also not just about putting more capability in the same footprint. Reducing the SWaP constraints of the footprint is important as well. For example, anything you can do to reduce the SWaP on an HMD can provide direct benefits such as reduced weight on the HMD and in the helicopter or fixed-wing aircraft itself. For avionics, anything you can do to take weight out at a system level is an advantage. Sometimes we reduce the weight of avionics and combine other functions' overall weight benefit. There are tradeoffs based on what space you are addressing and what a particular end user wants.

MIL-EMBEDDED: ***What feedback do you get from military pilots regarding new avionics features?***

BRUNK: On our commercial side, we bring in pilots who use our avionics system into focus groups and discuss their needs and challenges and have started doing this on our military side. We are directly applying what we learned on the civilian side from commercial-pilot focus groups as we address new avionics systems.

In general the feedback we get from pilots is that they want improved situational awareness – eyes out and not down – more intuitive menu selection, and more information available more readily to help reduce pilot workload. They also are driving us toward a larger-format display where synthetic vision is part of the head-up display.

Where military rotary-wing pilots differ from fixed is in their need for more sensors that enable them to safely land in unknown landing zones. They also traditionally fly lower and land different, which gives them a few unique needs from a sensor and information standpoint. We are developing synthetic vision technology to help those pilots navigate in low flying conditions, to sense wires and obstacles, and then fuse that information on synthetic displays.

MIL-EMBEDDED: ***Rockwell Collins was a key player in the creation of the Future Airborne Capability Environment (FACE) Consortium. Please describe your role and how the initiative is progressing within the DoD community.***

BRUNK: What FACE really does is standardize interfaces that are more widely adopted and that enable reuse of software for military avionics systems through a common, open-architecture system design. We have been a big supporter of the FACE Consortium and one of three founding companies at the sponsor level and continue to be active in tactical and technical working groups. We are all in on FACE. It will help the end user achieve their vision of taking avionics software capability and applying it across multiple avionics platforms. Software and hardware roadmaps in the future will be competitively structured to lower costs and FACE will enable that.

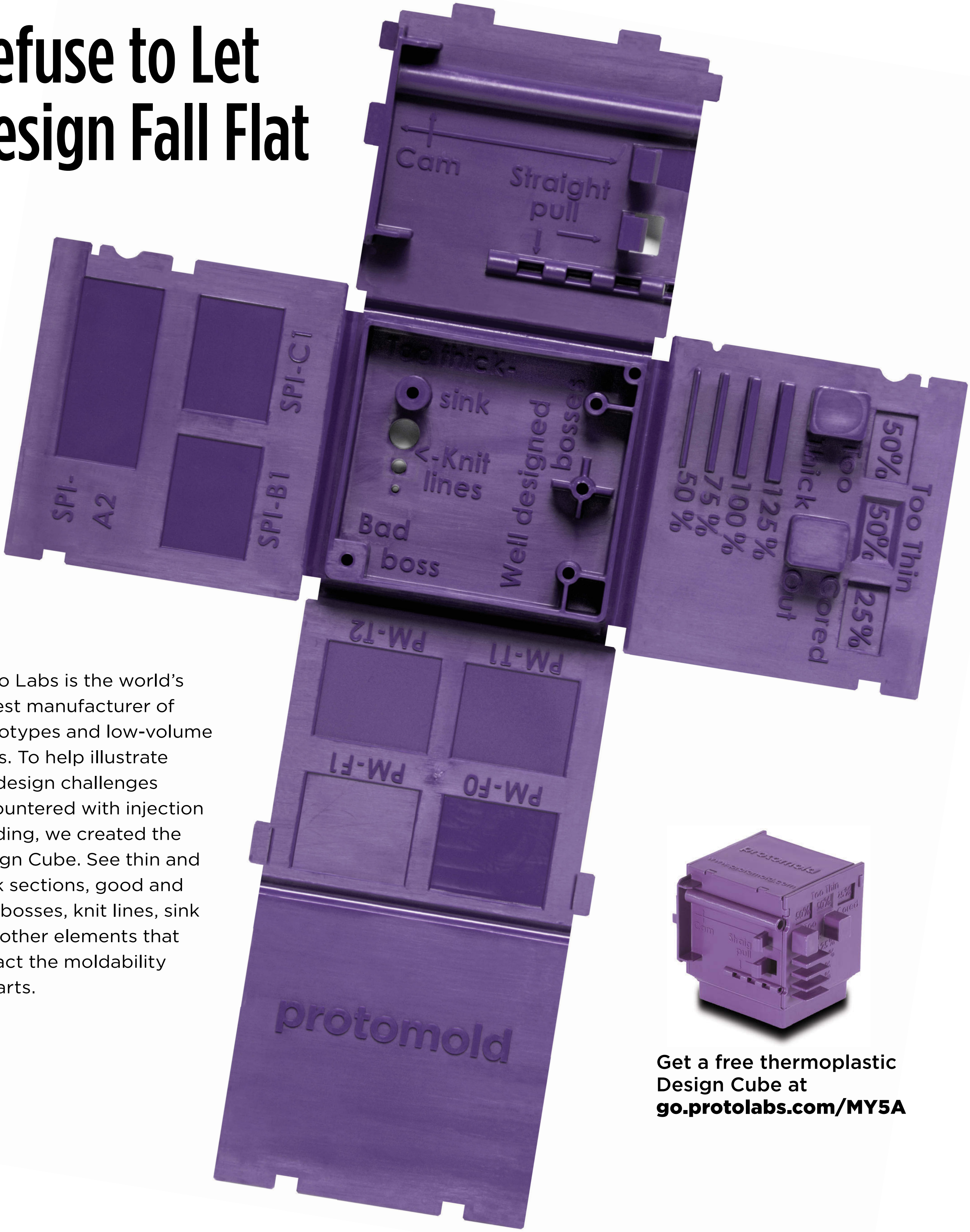
FACE is similar to what Rockwell Collins and the U.S. Army Special Operations Aviation Command did years ago with the development of the Common Avionics Architecture System (CAAS) for rotary-wing helicopters, enabling capability reuse. FACE just takes that and expands it in a more defined standard that enables use across multiple avionics platforms and is not vendor-specific. Standards will enable avionics software tools and applications to move from one open system to another without having to spend time and money developing a new application each time. The DoD can't afford to spend new development dollars on every new platform for avionics software. It is a matter of enabling commonality to reduce development cost in the long run in avionics systems.

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

BRUNK: Anything that enables better situational awareness, such as more heads-up display functionality like goggle displays or digital night vision, better flight control in adverse weather conditions. Anything we do to reduce pilot workload, enabling a better environment for pilot performance and decision making will be key – from embedded training features to autonomous systems. It's not just what information you see but how you see it that will determine what display solutions win out over the next decade. **MES**

Troy D. Brunk, *Vice President and General Manager of Airborne Solutions for Rockwell Collins Government Systems, has been with Rockwell Collins for more than 20 years. He was named to his current position in 2012 after serving as Senior Director of Airborne Communications Products, where he was responsible for the company's portfolio of communication products including tactical radios, data links, weapon data links, and advanced airborne networking programs. He has a Bachelor of Science degree in Industrial Engineering and a Master of Business Administration degree from the University of Iowa.*

Refuse to Let Design Fall Flat



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By Lisa Daigle, Assistant Managing Editor

NEWS

Due Regard Radar tested onboard Predator B aircraft by General Atomics

General Atomics Aeronautical Systems, Inc. (GAASI) officials announced that they have flight-tested a preproduction Due Regard Radar (DRR), which marks the first functional air-to-air radar on an unmanned aerial vehicle (UAV) that meets the requirements for "Due Regard" operations in international airspace. Enabling such technology will, in the long run, help to integrate UAVs into international and domestic airspace.

The purpose of the test performed was to verify the DRR's functionality onboard a Predator B UAV, as well as test its integration with the Traffic alert and Collision Avoidance System (TCAS) II with Resolution Advisories, the collision-avoidance system used on many commercial aircraft today.

Figure 1 | Due Regard Radar is aimed at enabling users to operate the Predator B unmanned aerial vehicle independently in international airspace without the need for land-based, sea-based, or off-board airborne airspace surveillance. Photo courtesy of General Atomics.

FAA proposes new regulations for small unmanned aircraft

Officials with the Federal Aviation Administration (FAA) have announced a framework of new regulations that would enable routine use of certain small unmanned aircraft systems (UASs) in today's airspace, while maintaining the flexibility to accommodate future technological innovations. The FAA proposal provides safety rules for small UASs – those weighing under 55 pounds – conducting non-recreational operations. The rule would limit flights to only daylight and visual-line-of-sight operations. The proposed regulations also address operator certification, height restrictions, aircraft registration and marking, optional use of a visual observer, and operational limits.

The current unmanned aircraft rules remain in place until the FAA implements a final new rule.

NTDS developer Sabtech now called IXI Technology

Michael Carter, CEO and owner of Navy Tactical Data System (NTDS) designer Sabtech, has changed the company's name to IXI Technology as part of a strategic approach to designing advanced technology and as a way to enter new industrial markets worldwide. IXI Technology still retains its heritage of design, manufacture, and support of tactical data-communications solutions for military and government agencies, most notably NTDS solutions for the U.S. Navy. Since joining and then acquiring 100 percent of the company a year ago, Carter has launched more than 12 new designs; a third of IXI Technology's staff is dedicated to engineering. The company's technology development efforts are concentrated on data I/O conversion, high-density processors and computing, digital data links, emulation of systems, high-definition video sensors and processing, and advanced software algorithms.

Lockheed Martin wins Apache targeting and night-vision system sustainment contract from U.S. Army

The U.S. Army has awarded Lockheed Martin an $82 million performance-based logistics (PBL) contract for AH-64 Apache helicopter Modernized Target Acquisition Designation Sight/Pilot Night Vision Sensor (M-TADS/PNVS) system sustainment. The M-TADS/PNVS enables Apache helicopter pilots to have long-range precision engagement and pilotage capabilities for both mission effectiveness and flight safety in day, night, or adverse weather conditions. Forward-looking infrared (FLIR) sensors enable enhanced image resolution that allows Apache aircrews to prosecute targets and provide situational awareness in support of ground troops outside detection ranges.

Figure 2 | The Modernized Target Acquisition Designation Sight/Pilot Night Vision Sensor (M-TADS/PNVS) system is the advanced electro-optical fire control system used by AH-64D/E Apache helicopter pilots. Photo courtesy of Lockheed Martin.

NEWS

U.S. Navy awards Raytheon contract to support V-22 Osprey systems

Raytheon Company won an indefinite-delivery, indefinite-quantity contract – with a potential value of $270 million – from the U.S. Navy's Air Systems Command to support V-22 Osprey systems, testing, and software. The work will be performed by Raytheon Intelligence, Information and Services at its facility in Indianapolis. The V-22 is a joint-service, multi-mission combat aircraft that combines the mobility of a helicopter with the long-range, high-speed cruise performance of a turboprop aircraft.

Under the contract, Raytheon IIS employees will provide V-22 software-support activity systems and software engineering, avionics integration, testing, and acquisition support.

Figure 3 | The V-22 Osprey is a joint-service, multimission combat aircraft combining the mobility of a helicopter with the long-range, high-speed cruise performance of a turboprop. Photo courtesy of U.S. Navy.

Report mixed: Global defense spending down, aerospace spending to grow in 2015

Revenue and earnings growth in the commercial aerospace sector is expected to be a bright spot and driving force behind the global aerospace and defense industry performance in 2015. While the rate of growth for the overall industry has been slowing over the last two years as a result of declines in defense-sector spending, the commercial aerospace sector is likely to enjoy close to an 8 percent growth rate, according to the Deloitte Touche Tohmatsu Limited (Deloitte Global) Manufacturing Industry group 2015 Global Aerospace and Defense Industry Outlook.

Over the next few years, the defense sector will be challenged in two major ways: First, how to grow profitably in a declining market; next, what actions are necessary to cut costs to maintain acceptable financial performance. The report states that successful defense companies are addressing these challenges by branching out into adjacent markets, focusing on foreign military sales, and investing in next-generation product development in cyber-security, defense electronics, precision strike, unmanned systems, and advanced analytics.

Unmanned-aircraft industry finds open skies in North Dakota

ComDel Innovations signed a $3.2 million manufacturing agreement with Altavian to build aircraft and sensors, the first unmanned-aircraft systems (UAS) manufacturing project in the state. The ComDel announcement follows close on the heels of a release from the Federal Aviation Administration (FAA), which announced that it would be expanding the Northern Plains Unmanned Aerial System Test Site. The expansion makes the test site in North Dakota the largest available for flying UASs anywhere in the United States, according to ComDel.

In similar news, the Grand Forks (North Dakota) Air Force Base will officially sign an Extended Use Lease Agreement on the Grand Sky aerospace technology park, a 217-acre park that will provide state-of-the-art technology-incubation space for businesses developing in this emerging industry when it opens in 2017.

General Dynamics UK/GE Intelligent Platforms subsystems ordered for British Army SCOUT fighting vehicles

GE's Intelligent Platforms business has announced that it has secured orders valued at approximately $100 million from General Dynamics UK to provide a range of embedded computing subsystems that will be deployed onboard the British Army's armored SCOUT Specialist Vehicle (SV) platforms. The scalable, open architecture subsystems – which include Ethernet switches, gateway processors, data servers and video servers – will allow SCOUT SV platforms to be easily upgraded during their lifetime as new requirements and technologies emerge.

The SCOUT SV platforms replace the British Army's CVR(T) vehicles and are all-new, heavily protected, high mobility, fully digital platforms featuring state of the art ISTAR (intelligence, surveillance, target acquisition, and reconnaissance) capabilities. The embedded subsystems provide the backbone of the vehicles' electronics architecture.

Figure 4 | The British Army's SCOUT SV platforms will use embedded computing subsystems ordered from GE Intelligent Platforms and General Dynamics UK. Photo courtesy of General Dynamics UK.

Orion spacecraft's avionics designed for "reliability" in deep space

By Sally Cole, Senior Editor

The United Launch Alliance Delta IV Heavy rocket, with NASA's Orion spacecraft mounted atop, lifts off from Cape Canaveral (Fla.) Air Force Station's Space Launch Complex 37 at 7:05 a.m. EST, Friday, Dec. 5, 2014. The Orion spacecraft orbited Earth twice, reaching an altitude of approximately 3,600 miles above Earth before landing in the Pacific Ocean. No one was aboard Orion for this flight test, but the spacecraft is designed to allow us to journey to destinations – including an asteroid and Mars – never before visited by humans. (Photo courtesy NASA/Bill Ingalls.)

Unlike those used in manned spaceflight platforms of the past, the avionics and other electronics used in NASA's Orion spacecraft are driven mostly by software and commercial processor technology ruggedized and radiation-hardened to endure extreme radiation and temperature fluctuations. Orion's updated avionics also can handle the severe acoustic and vibration environments associated with launch, orbit, a fiery reentry, and a saltwater landing.

The Orion spacecraft, named after the constellation it resembles, is ushering in a new era of human space exploration. NASA aims to use Orion to transport humans to an asteroid by 2025, and then to Mars in the 2030s.

While Orion is similar in shape and size to its Apollo-era predecessors, its avionics design, technology, and capability are light-years beyond those early platforms as well as the space shuttle fleet that Orion will be replacing.

During development and production, NASA's Orion avionics team faced numerous design challenges, including building a spacecraft that would be exposed to an extremely inhospitable deep-space radiation environment, as it would be flying through the Van Allen belts (see sidebar on page 26). These efforts culminated late last year, when Orion's avionics capabilities were demonstrated during its first flight test (EFT-1), where the spacecraft was equipped with 1,200 sensors for a two-orbit flight that lasted 4.5 hours.

> "ALL FOUR FLIGHT COMPUTERS 'THINK' THEY'RE FLYING THE VEHICLE," SAYS MATTHEW LEMKE, ORION'S MANAGER AVIONICS, POWER, AND WIRING FOR NASA.

Orion's avionics system consists of six main subsystems: Command and Data Handling (C&DH); Guidance, Navigation and Control (GN&C); Communications and Tracking (C&T); Displays and Controls (D&C); Instrumentation; and Power.

Figure 1 | Spacesuited engineers demonstrate how four crew members would be arranged for launch inside the Orion spacecraft, using a mockup of the vehicle at Johnson Space Center. (Photo credit: NASA/Robert Markowitz.)

"Redundant components are provided for the majority of subsystems," says Paul Anderson, Orion avionics director for Lockheed Martin. "The overall hardware and software integration of Orion's avionics and network system represented a significant technical challenge." The success of the "avionics, software system, and subsequent EFT-1 flight can be attributed to the tremendous amount of integration and testing that was performed in multiple development labs," Anderson says. "This team included numerous NASA and industry partners located across the U.S." (See Figure 1.)

Computers "fly" the spacecraft

For EFT-1, Orion relied on two flight computers. For its next flight, which is slated for 21 days, the vehicle will have four flight computers aboard – all built by Honeywell Aerospace engineers and powered by the IBM PowerPC 750 FX processor chip, which was introduced more than a decade ago, in 2002.

Interestingly, "all four flight computers 'think' they're flying the vehicle," says Matthew Lemke, Orion's manager of avionics, power, and wiring for NASA; Lemke is essentially responsible for almost everything that generates or uses electrons on the spacecraft. "It's not like the shuttle, which used four computers that all voted on the output and had to be in agreement to fly the vehicle. In this case, each computer thinks it's in charge of the vehicle, independently, sending commands. Our power and data units (PDUs) have a priority table that says 'If I get a command from Computer 1, I'm going to use it. If for some reason it's not there, I'll use Computer 2.' This is much different than programs that rely on a voting architecture."

"The flight computers are a derivative of the computer Honeywell built for the Boeing 787," Lemke says. "We took their commercial processors and ruggedized them for the environment of space, but the basic architecture is the same."

This computer is an example of commercial off-the-shelf (COTS) use in Orion, Anderson points out. This approach "is based on a commercial aircraft computer architecture that incorporates a 750FX microprocessor," Anderson adds. COTS technologies are playing "a selective but critical role throughout Orion," he notes.

The reason for this approach: COTS parts can provide affordable design alternatives through shorter development schedules at a much lower cost than fully qualified components. "Wherever possible, we try to leverage what's available commercially or from defense to help reduce our costs," Lemke says.

COTS or not, before any components can be used on Orion, they must first undergo an extensive program that includes "radiation screening, vibration and shock testing, thermal vacuum testing, and electromagnetic compatibility," he notes.

Although individual COTS processors can be susceptible to radiation upsets, Orion's overall architecture relies on self-checking pairs of processors to minimize system effects of radiation upsets. "Orion also uses COTS hardware in several non-mission-critical areas within development of flight instrumentation and video subsystems," Anderson says.

While the use of commercial components helped reduce costs, Orion achieved huge savings in mass and volume by combining typically separated functions within a single component – the PDU. "This saved overall spacecraft mass and volume significantly by performing command and data handling, power switching, pyrotechnic, network switching, instrumentation collection, and environmental control functions within integrated units," Anderson says.

Software drives Orion avionics

How important is software to Orion? "It's everything," Lemke says. "Think back to Apollo: every system from propulsion to life support to displays to power – each was a self-contained system, run with something very simple to control."

Now, on Orion, NASA engineers use flight computers and "boxes called PDUs, and everything on the vehicle connects in via the PDUs to the flight computers," Lemke elaborates. "Very little isn't under computer control. We have few switches – in the neighborhood of 40 on the vehicle total – compared with an airline or even the shuttle cockpit with all the switches."

Orion uses a Federal Aviation Administration (FAA)-certified operating system for multitasking and high criticality applications. This is to ensure that "one part of the software can't affect another part of the software. The whole goal is reliability," Lemke says.

New tech for Orion's data network

For its data network, NASA experts are leveraging 1 GB/s time-triggered Gigabit Ethernet (TTGbE) network, which was developed by Austrian company TTTech, who worked with Honeywell to build the system commercially. Lockheed Martin and NASA then joined in to make it work for Orion.

"The Orion Data Network (ODN) is the first space-based implementation of TTGbE technology and provides a deterministic, synchronous, and congestion-free Ethernet network communication," Anderson says.

It's essentially standard Ethernet, but with protocols layered on top to guarantee timing and delivery. The system is designed "to run all of our data over three separate links so that if any of the network switches or cables or anything else experiences a problem…as long as one of those three get across, the data is all there and it will work fine," Lemke points out. That's a level of redundancy you don't normally find in networks.

TTGbE also enables hosting asynchronous Ethernet traffic without interference to critical deterministic traffic. "The deterministic nature of Orion's ODN guarantees timing of messages traveling through the network, allowing us to integrate a complex suite of redundant main flight computers, backup flight computers, guidance and navigation sensors, radios for off-board communication, crew display and command interfaces, and primary and developmental instrumentation systems," Anderson notes.

"In space, we want to know if the computer issues a command to a thruster and that it really happens right then and has the highest priority," Lemke adds. "So in TTGbE, we guarantee commands get across and data goes exactly when it should. Then, with functions like video or audio, it fills in the free time on the data network. It's 'best-effort traffic,' which is guaranteed delivery." The TTGbE technology has now become an industry standard – SAE AS6802 – and "hopefully others will begin using it as well," he says.

Avionics survive splashdown

Orion's flight computers, software, and data network all did their job during the launch and flight in orbit, but NASA also wanted to make sure the electronics survived the splashdown. Upon returning from space, Orion makes saltwater landings with the help of specially designed parachutes to slow its descent, so the avionics design team had yet another extreme environment to factor in. To handle it, "all of our connectors and harnesses or enclosures are designed to be able to handle immersion in saltwater," Lemke notes.

During Orion's EFT-1, its highly complex avionics system "performed near flawlessly," says Anderson. "Very few anomalies were experienced across the entire mission. The stability of Orion's data network was demonstrated by 'zero' bit errors during flight – despite operating and flying through extremely challenging radiation and thermal environments," Anderson adds. (See Figure 2 on following page.)

Orion's imaging system also provided spectacular, high-resolution video of key mission events – including capturing the service module fairing jettison, launch abort system separation, forward bay cover release, and drogue and main parachute deployments for the water landing.

"The video showed incredible live views of Earth from 3,600 miles while Orion traveled through the Van Allen radiation belt," Anderson says. "This unique video imagery also captured the multicolor plasma trails that occurred during the 20,000 mph reentry."

Orion's next flight will involve a journey beyond the orbit of the moon, with the goal of getting NASA within one step of being able to fly humans to an asteroid or Mars.

"Our EFT-1 test flight was a big flight to prove out our heat shield and parachutes and that all of it would work during the mission – our highest risk areas," Lemke says. "This next flight is to test out all of the other systems on the vehicle to ensure it's one step away from putting an astronaut on it." Now NASA will start putting on all of the systems that may not have been on the first vehicle.

"In terms of avionics, we're so excited that NASA had a successful first launch and we're now able to move toward getting people into space," says Lemke. "We're shooting for our next flight to be at the end of 2018, using the Space Launch System being built at the Marshall Space Flight Center." **MES**

Figure 2 | Recovery-team members in rigid-hulled inflatable boats approach NASA's Orion spacecraft following its splashdown in the Pacific Ocean. A combined team from NASA, the Navy, and Orion prime contractor Lockheed Martin retrieved it for return to shore. (Photo courtesy of U.S. Navy.)

Navigating Van Allen radiation belts

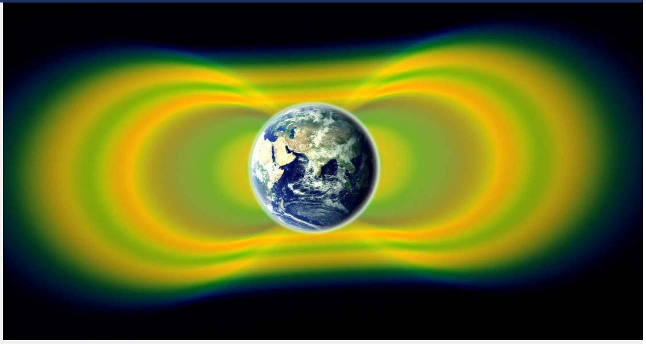
One of the biggest challenges facing Orion and all other spacecraft operating within the deep-space environment is the task of maneuvering through the "donut-shaped" radiation-seething Van Allen belts surrounding Earth.

The Van Allen radiation belts were the first major discovery of the space age, measured in 1958 during the launch of U.S. satellite Explorer 1. Since then, NASA scientists have figured out that the size of the belts varies, merging or even separating into three belts. Generally, the inner belt stretches from 400 to 6,000 miles above Earth's surface, while the outer belt stretches from 8,400 to 36,000 miles above Earth's surface.

What exactly are the Van Allen radiation belts? A collection of charged particles held in place by the Earth's magnetic field, according to NASA, which can "wax and wane in response to incoming energy from the sun, sometimes swelling up enough to expose satellites in low-Earth orbit to damaging radiation." (See Sidebar Figure.)

So how are spacecraft electronics ruggedized to withstand the brutal Van Allen radiation belts? Space electronics "must be designed and qualified to withstand extreme radiation," says Paul Anderson, Orion avionics director for Lockheed Martin. High-speed computer processing platforms, in particular, are susceptible to single-event upsets caused by exposure to radiation. This requires "mitigations through a combination of parts selection, redundancy, and real-time single-event upset firmware management," Anderson explains.

Another ruggedization consideration is that "in zero gravity, heat doesn't rise off boards and must be pulled out through a base plate via conduction cooling," points out NASA's Matthew Lemke, manager of Orion's avionics, power, and wiring.

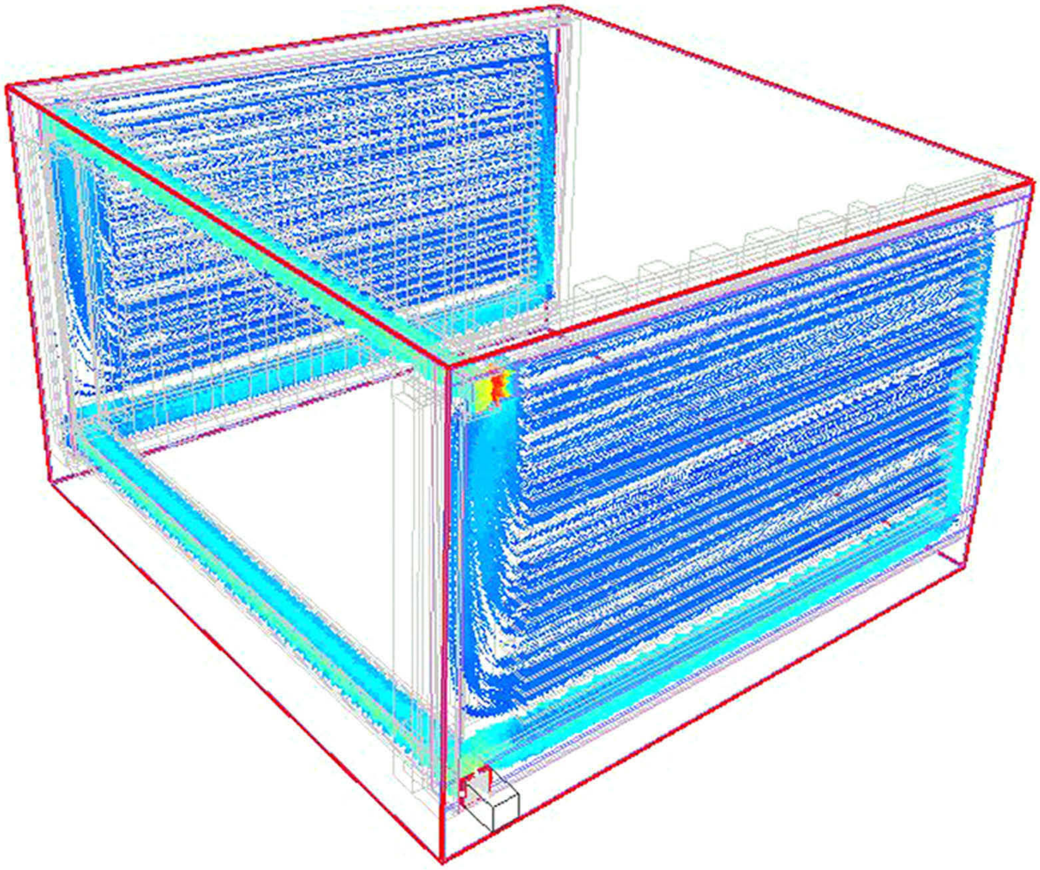


Sidebar Figure | Two giant swaths of radiation, known as the Van Allen Belts, surround Earth. The radiation is depicted here in yellow, with green representing the spaces between the belts. (Photo courtesy of NASA/Van Allen Probes/Goddard Space Flight Center.)

Orion isn't currently using any off-the-shelf radiation-hardened boards, according to Anderson. One reason is that radiation-hardened parts tend to be much older and lack the required performance.

"Say, for example, that we were required to build our flight computer out of all radiation-hardened parts. This would mean going back to products anywhere from two to four generations old – and it wouldn't have the required computing power," Lemke says. The other option would be "to build something using much bigger computers to get the computing power. So it's essentially a tradeoff between mass, parts availability, and radiation performance. It's not about spending a little more money to get radiation-hardened parts ... it's that we couldn't because there simply are no up-to-date parts available to buy."

NEXT-GENERATION AVIONICS FOR MILITARY AND SPACE APPLICATIONS



Meeting the challenging performance and thermal requirements for today's enclosure designs

By Andrea Schott

Fluid velocity vectors – Liquid-cooled seven-slot 6U VPX enclosure.

The defense and aerospace rugged-systems market demands a wide range of computing capabilities at extreme environmental conditions. Across the board, applications need more processing power; inevitably, thermal management becomes more challenging as the amount of processing power grows.

Users who need custom electronics enclosures typically specify low volume runs (quantities between one and 15 units) with production delivery in approximately 12-20 weeks; this aggressive delivery schedule leaves no time for prototyping or testing. The makers of these custom enclosures rely completely on engineering experience, along with structural and thermal simulation, to meet client requirements. State-of-the-art simulation tools enable enclosure makers to iterate multiple scenarios in a short period of time; this allows optimization for not only thermal performance, but also weight reduction, noise reduction, cost, and schedule.

Often what is supplied is a metal enclosure (typically brazed aluminum), a high-speed backplane, and a power supply designed to meet specific user requirements. The designers then populate the enclosure with their own suite of electronics, or "payload." Often, however, the enclosure team is provided very little information on the design or end function of the payload. Typically, the team knows only the specifications for the subsystem's overall sizes, power levels, ambient conditions, and the temperature requirement for the electronics-card mounting. From this limited amount of system detail, the designers must craft a solution that is capable of meeting the required temperature in all environmental conditions at the given power levels.

Another challenge design teams often face is that in many cases, the enclosures are sold to the end customer by a third party, with the designed enclosure acting essentially as a component, not a product-level complete system. In these cases, the enclosure designers rarely receive feedback about results.

New designs put strain on enclosures

As applications require more processing power, the trend for new designs of military embedded systems is the transition from VME to OpenVPX standards[1]. These new OpenVPX systems can be configured with an array of new processing elements, driving huge performance leaps relative to the VME systems of just a few years ago. With this transition comes an equally huge leap in power: Typical 6U VME systems will dissipate a maximum of 60 W per slot, whereas a typical 6U VPX system can dissipate as much as 200 W per slot.

This change is an ongoing challenge in the thermal management of enclosures. It is not enough to replace a backplane in an existing chassis and run VPX in an enclosure originally designed for VME, as the cooling system is not going to be adequate to dissipate the higher heat generated. Many systems operating VME often did not even consider thermal analysis or simulations because the power levels were so low. With the advent of VPX and multiple slots, however, the heat to be dissipated in an

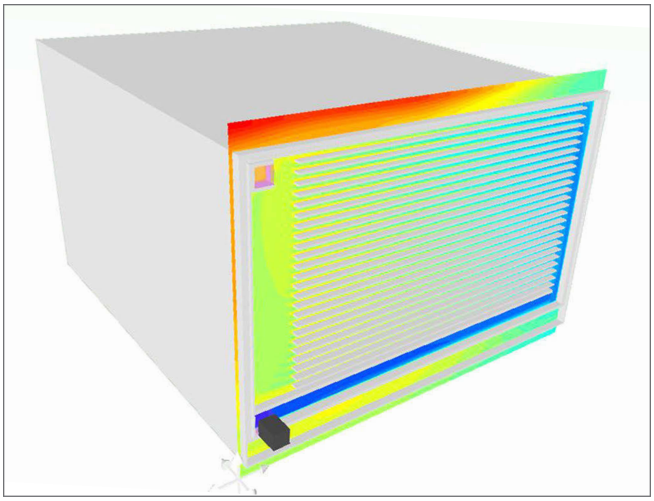


Figure 1 | Fluid temperatures – Liquid-cooled seven-slot 6U VPX enclosure.

enclosure can easily top 1 KW. Pair this increase in power with the harsh environmental conditions these systems must operate in, and thermal management becomes one of the highest risk factors in the project. What was originally a nonissue for VME thus becomes critical to the success of VPX-based projects. Therefore, thermal simulation must be an essential part of the design process (see Figure 1).

Many factors affect the thermal management of a ruggedized electronics enclosure, but the main factor in an air-cooled system (or a conduction payload system cooled by air) is the operating temperature. Many ground-based platforms are required to operate in extremely high temperature conditions, as well as harsh sand and dust environments – all adding to the difficulty of thermal management. Fans must be specifically designed to meet not only the high operating temperatures, but also take special precautions to deal with the sand and dust. Air-cooled systems must be filtered, with a maintenance schedule provided so that a system does not shut down from over-temperature caused by a clogged filter.

Another important consideration is operating altitude. As altitude is increased, air density decreases, with the cooling capacity of the air mover decreased by the same amount. A 50 percent reduction in air density (approximately 20 kft altitude) will result in a 50 percent decrease in cooling at the same cfm.

Because these enclosures are primarily used in military applications, the environmental conditions can vary greatly and are often extreme. New products are often retrofits for older existing equipment, and the new higher-powered enclosures must be cooled by existing platform cooling systems. Often, the new designs are required to meet specifications that were not required of the system it is replacing, and what worked in the past may or may not be sufficient for the replacement system.

The challenge for design teams, including thermal and mechanical engineers working together, is to meet all of the customer's requirements in a very short time frame. Because the ambient conditions in which the resulting system must perform are harsh and the power levels required are typically high, thermal simulation is critical.

Based on customer specifications and boundary conditions, Curtiss-Wright's Engineered Packaging Group designs and builds powered enclosures that meet the performance requirements as well as the thermal requirements. Based on the cooling system onboard the platform, the group designs enclosures that provide thermal management for air-cooled payload, air-cooled conduction payload, liquid-cooled conduction payload, as well as several hybrid designs; for example, a self-contained, liquid-cooled heat exchanger for a suite of air-cooled payload.

The first step in the overall system design process is to define the system's required functions or capabilities. The next step is to determine the system's (and platform's) physical constraints, and then, based on those constraints, select which existing modules can provide the required functions.

Frequently, the enclosure space is dictated by mechanical constraints that are not fully defined at the quoting stage. This is a result of numerous system features such as I/O connections, cabling, and air plenum allotment that may not yet be determined at the early stage of development. After the results of a preliminary thermal simulation, using Mentor Graphics FloTHERM cooling fin design (CFD) thermal simulation software, indicate that the customer requirements can be met, the mechanical design process begins.

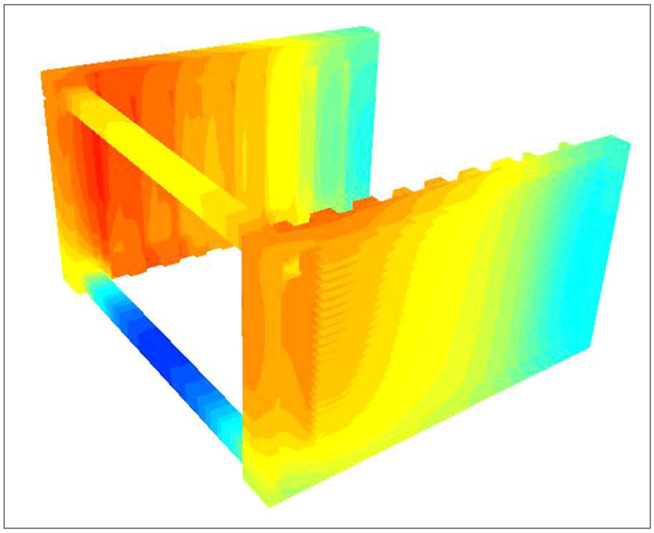
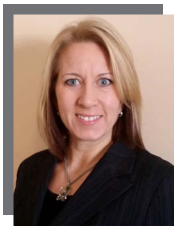


Figure 2 | Solid temperatures – Liquid-cooled seven-slot 6U VPX enclosure.

There are often several iterations back and forth between the design-engineering and thermal-engineering teams to reach a final solution. One design aspect that demands this level of attention is CFD optimization. CFD simulation enables quick optimization for pitch, thickness, number of fins, or base thickness (see Figure 2). Because each product is customized, there is little opportunity for design reuse. For example, the cooling wall (heatsink) geometry is designed for each particular application to ensure the best design at the lowest cost for each product. While the final solution may be similar to the starting point in the thermal design, it is never exactly the same. Although the time and cost saved by eliminating early prototypes, testing, evaluation, and redesign is hard to measure, when delivery schedules are tight, any and all time savings are crucial. **MES**

References

1. VPX Marketing Alliance, VITA Open Standards Open Markets, http://www.vita.com/vpx
- http://www.cwcdefense.com/media-center/white-papers/openvpx-chassis-thermal-management.html



Andrea Schott *is a principal thermal engineer for Curtiss-Wright's Engineered Packaging Group. She holds a BS in Mechanical Engineering from Rensselaer Polytechnic Institute and has over 20 years of experience in the design of high-performance packaging and systems, both commercial and military. Her many years of thermal experience includes enclosure designs ranging from forced-air cooled telecom equipment to liquid-cooled military enclosures. Andrea's work also includes complete thermal analysis, design, and testing of projects ranging from component die level to overall system level. She is currently pursuing an MBA at Rivier University.*

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AVIONICS SAFETY CERTIFICATION

Multicore processors and unmanned aircraft trending in avionics safety certification circles

By Amanda Harvey, Assistant Editor

DDC-I's Deos embedded real-time operating system (RTOS) running avionics functions and displays.

Avionics safety certification – for software and hardware – is increasingly seen as an ongoing evolving process, reflected in the enhancements to standards such as DO-178C. This long-term understanding is enabling avionics experts to account for complex situations in certification standards such as the growth of multicore processors, avionics computing, and the role of safety certification in unmanned aircraft systems (UASs).

"Certification is finally being correctly perceived as a life-of-product activity, where lives are measured in decades, not months or years like consumer products," says Vance Hilderman, director of global services for Vector Software (www.vectorcast.com). "Certification is increasingly seen as an ecosystem of systems and operations, instead of application to single system boundaries. This certification ecosystem theme permeates all certification."

This is reflected in the demands from "our customers, [who] are asking for integrated, one-stop-procurement solutions and tighter integration of tools for both development and verification, including traceability and verification," Hilderman says. "They want to ensure 20-plus year viability, with the lowest possible lifetime costs, not necessarily the cheapest one-time solution that won't work tomorrow," he continues. "Vector Software's VectorCAST tools cover the full suite of avionics software testing to promote continuous-based testing."

Tighter integration requirements and development of certification ecosystems are also related to the popularity of the agile development process.

"A number of companies, including Wind River, have moved from a more conventional software-design methodology of building software, testing it, and releasing it, and more monolithic ways that tend to take longer, the updates tend to occur at a slower rate; now they've adopted what's called an agile model of development where these customers can release functionality almost on a monthly basis," says Joe Wlad, senior director of product management for Wind River (www.windriver.com). "You can do incremental updates to software, you can build a product foundation, and the objective there is to give your customers more functionality more quickly.

"The agile process is now being adopted in safety-critical design, and there are some restrictions of course that have to take place but it requires more tooling, more testing, more analysis, and more of a thought process if you're to use an agile development model," Wlad continues.

"Now we also want to have massively parallel testing, which is really cool," Hilderman says. "It used to take days to execute all the tests on a single computer, so every time you make a change you'd spend days retesting. Well, now, we can farm it out automatically on the Internet, to 100, 500, 1,000 different servers that emulate that avionics system and what used to take two days to test can now be done in two minutes,

because it's using a thousand different servers to speed up the work."

Multicore processors and safety certification

Faster processing speeds are also a feature of multicore processors, which have brought many performance advantages to not only military avionics applications, but also to radar, electronic warfare, and intelligence, surveillance, and reconnaissance (ISR) applications. However, the complexity of the devices necessitates more verification and testing, which add to an already complex certification process when it comes to avionics systems.

"Probably the most prevalent trend today is the need to adopt multicore silicon for use in safety-critical designs. This has been a trend that's been going on for the last five years, but one of the challenges when you use a multicore part is it's very difficult in some cases to understand the complete behavior of those parts because they're so complex, there's so much functionality that's substantiated in the part that it brings about a lot more scrutiny, a lot more tests, and a lot more verification when trying to deploy that part in a safety-critical platform," Wind River's Wlad says. "Some of the customers are wary to adopt multicore silicon for that reason.

"[However], in this past year there's been a couple of things that have happened that I think will finally move us in a positive direction and one of those things is the FAA [Federal Aviation Administration] released some guidance called CAST-32 on some of the criteria and objectives that would apply if one wants to use multicore silicon in safety-critical designs," Wlad continues. The CAST-32 document, written by a team of industry and FAA personnel, is a foundation upon which to judge all applicants, he adds.

"We're seeing a real strong desire to be able to certify multicore capability on both ARINC 653 and MIL applications. Again, I think the common theme here is more complex systems and having a desire for multicore," says Wayne McGee, vice president of sales and general manager of North American operations for Creative Electronic Systems (CES) (www.ces.ch). "CES is pulling a lot of cases where you would normally have a purpose-built, single box for each function, but now customers want to combine these functions into a multicore processor in a single box." The ultimate goal for customers is to be able to make more complex systems but still have them be certifiable, he adds.

"People are looking for easier ways to do the multicore certification and there are a number of techniques out there," McGee continues. "I hear that this year we're liable to start to see some DO-178C multicore certifications. The rumors in the industry are too rampant and too consistent to not be based in truth. I just think it's going to be a very interesting time."

Design complexity always influences certification standards. "Classically, complexity and newness of the technology is the enemy of trying to get a DAL-A certification, so we are seeing people who are wanting to push forward to get much newer circuitry certified at higher DAL levels," McGee says. CES has a primary flight control unit that is DAL-A and DO-254 certified and is currently shipping (see Figure 1).

Along these lines there is "a trend toward distributed intelligent sensors with an increasing focus on ARM processors that offer a high degree of I/O integration on chip," says DDC-I's technical marketing manager, Gary Gilliland (www.ddci.com). Companies are finding this trend useful because having the device drivers in user space enhances the reliability and code reuse, plus it simplifies the certification process, according to Gilliland.

Figure 1 | The Primary Flight Control Unit from CES is DO-254 DAL-A certified.

FACE Consortium enabling common standards in avionics software

In the effort to reduce development costs in avionics software, the U.S. military and the avionics industry are looking to share more common functionality with commercial applications, says Joe Wlad, senior director of product management for Wind River. "So ideally, what they want to do is build one platform that suits the needs of both military and commercial applications. We're starting to see now the common sets of standards apply to both military and commercial development. Where this mainly has taken place recently is with the FACE Consortium."

The Future Airborne Capability Environment (FACE) Consortium is developing standardized interfaces to enable the reuse of avionics software across multiple military aircraft platforms (www.opengroup.org/face). "They're [FACE] starting to design standards that take advantage of interoperability between multiple platforms, interoperability between software components, etc," Wlad continues. "The common denominator between FACE applications and FACE initiatives between military and commercial use are in two domains, and those domains are in the ARINC-653 standard and the DO-178 software-certification guidance document. So that's where you see commonality."

"FACE is very promising and is gaining traction," says Vance Hilderman, director of global services for Vector Software. "FACE doesn't require formally certified avionics, however, 'compliance' is a mandatory requisite. So we ensure we adhere to, or 'comply with' certification objectives just as if it was going to be later certified by the FAA or EASA."

"Most military customers are also looking at FACE as the standard for building new applications. The FACE Consortium is developing standards for application development that will provide portable components that can be reused across multiple avionics architectures," says Gary Gilliland, technical marketing manager for DDC-I. Deos, DDC-I's safety-critical embedded RTOS, which has been designed with a focus on modularity and reuse, is a FACE-compliant software in a DO-178C certification environment, states Gilliland.

"The FACE community has set up a number of verification authorities to certify product conformance to the FACE standard, but since we're a platform provider and FACE is primarily a software standard, the primary areas of compliance for us are by working with the RTOS vendors and the graphic library vendors," explains Wayne McGee, vice president of sales and general manager of North American operations for Creative Electronic Systems. "We work with them to make sure that the basis is compliant, that their development environment is compliant, and we just make sure that the board-support packages that we provide are compliant with those OS guidelines."

Wind River released a version of their product VxWorks 653 in November 2014 that fully aligns with the requirements of FACE. "That means that an avionics developer in the military could take our VxWorks 653 product line, integrate it into their environment, and ultimately show conformance to FACE and get approval to FACE conformance while also using that FACE line as a reference for DO-178 certifications," Wlad says. "They kind of check two boxes with that one product line and technology."

DDC-I and CES Cal (owned by CES SA) are members of the FACE Consortium, and Wind River is a principal member, involved since its conception. Vector participates in the Consortium indirectly though their partners who are members.

The future of unmanned aircraft in national airspace

Managing complexity may be an understatement when it comes to determining the path to safety certification for unmanned aircraft systems (UAS) platforms in the national airspace.

Although there are still no solid ground rules from the FAA pertaining to UASs in the national airspace, the FAA has committed to having a roadmap ready later this year, DDC-I's Gilliland says.

"As a result, we are seeing increasing interest in companies developing UASs moving from an in-house or Linux-based environment to a COTS DO-178 RTOS environment. There is a lot of interest in the ARM SoC [system-on-chip] platforms in this space because they have extreme requirements for minimum SWaP," he continues.

Wind River is getting inquiries from both large- and small-scale unmanned developers for DO-178 compliance, Wlad says. "So even though the FAA hasn't come out with policy, it seems to be trending in that direction and the developers are starting to prepare themselves for ultimately complying with FAA certification rules. That means from a software point of view, compliance with DO-178, and we're seeing that on unmanned systems that are less than five pounds all the way up to a few thousand pounds. It's running the gamut of almost every size of vehicle you could think of."

Of course, the FAA has many valid concerns regarding allowing unmanned aircraft into the crowded national airspace. One of these concerns deals with collision-avoidance capabilities, "since the USA has vastly more private, general-aviation aircraft flying in crowded skies and those aircraft usually do not have TCAS (collision-avoidance) systems," Hilderman says.

Without knowing exactly what the FAA will require, it's difficult to anticipate what the next move should be. "We're trying to make sure we've got a path to get to certifiability, but at this point in time we don't exactly know what's going to be required," McGee says. "The thing that people sometimes overlook is that if you're not looking at the system at a top-level design, it's difficult to go in and then piecemeal figure out how you're going to get safety certifiability on each part," he explains.

This relates to a wider trend where "we're seeing a lot of customers that used to get waivers for DO-178 and DO-254 are now saying that 'we don't think we're going to get a waiver on this next program, and so therefore we need a pass to certification,'" McGee continues. "I have a number of competitors who have advertised that they have 'certifiable' boards, but not 'certified' boards. They're saying it's 'certifiable' but if you ask them who is flying it as a certified unit, they can't answer you. That's where there really is a large barrier to enter into this market from a cost standpoint, both in dollars and in hours of engineering." **MES**

Shift left boosts avionics software verification

By Jim Thomas

Many organizations developing avionics software still suffer from poor verification practices. Certain verification techniques can benefit those seeking compliance to avionics certification standards through a strategy of defect avoidance.

The avionics testing and verification process can be improved by implementing a so-called shift-left process. (U.S. Air Force photo of the cockpit of a C-5M Super Galaxy by Staff Sgt. Jeremy Bowcock.)

Avionics standards encourage a structured approach for software development, but many organizations don't execute this well. In many cases there is pressure on the software team to start coding in order to meet squeezed time frames, so software requirements and design aren't fully analyzed and defined, unit testing is skipped, and testing is carried out on a large amount of software. An external company is then paid to produce the documentation and unit tests for the approvals process based on the final software. This situation can arise even if the development has complied with a standard such as DO-178B or DO-178C.

In the end, this approach may find a number of defects, but it typically isn't that effective – the delivered software has a higher than expected residual number of defects. Inevitably, problems with the initial requirements specification and software design are uncovered during testing; significant numbers of defects found during testing can mean that the software-integration phase takes three or four times longer than expected, or the whole project has to be scrapped and has to start again. All of this means that development costs are much higher than expected and software quality is lower than anticipated.

Improving the verification process brings advantages through shorter development times, dramatically shorter integration times, significantly reduced defects in the software, and a higher quality, on-time delivery.

Avionics standards provide definition

The standards deliberately do not define a particular life cycle or methodology. They define clear objectives and outputs, and these can be produced in different orders, from the planning, requirements, design, coding, integration, configuration management, process assurance, and verification processes.

Rather than producing the outputs as an afterthought, starting with a well thought-out verification plan means that these outputs can be integrated into the development process right from the beginning. Verifying them as they are produced creates a higher-quality product with a much greater chance of success.

Shift left for early verification

One way to do this is to use a technique called shift left. This puts more emphasis on improving the quality of the outputs of the early stages of the development life cycle (the left side of the V-shaped development, see Figure 1), with more rigorous requirements and design stages. This technique is about shifting testing in its widest sense to the left side of the V-model.

Every avionics project starts with the requirements stage, but this is not always done well. The requirements may not be analyzed in sufficient detail – there may be

ambiguities in some requirements, inconsistencies sometimes exist between requirements, and the handling of error cases may not be fully addressed. These conditions can lead to problems later in the life cycle.

The key is actually to start with a verification plan, which may seem to be putting the last things first. Verification is much more than just testing the software, however. If requirements and design are more effectively verified by review and analysis, there exists a much more stable base from which to develop the software. Following on from that, thinking about how you will test the source code, what test vectors and stimuli you will use, and from which tools and what environments all helps to construct a coherent and efficient design and verification flow.

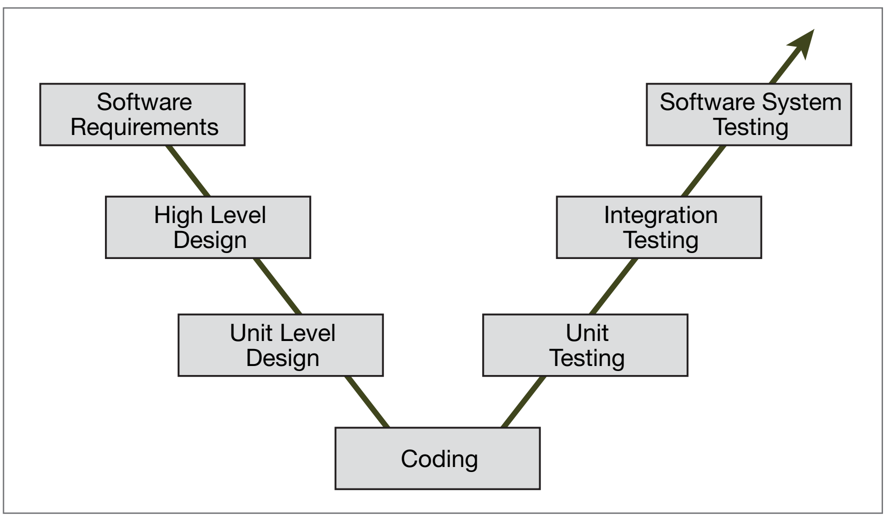

Figure 1 | The traditional V-shaped software development life cycle.

One key way to improve the process is to involve experienced testers right at the beginning, in both the requirements and design stages. While avionics experts will put together the requirements, testers can assess the requirements attributes, identifying how testable and traceable the requirements are. The testers will also – and this is critical – highlight ambiguities and inconsistencies. The testers will also be looking at whether failure conditions are fully addressed, an issue that is not usually well covered and which causes significant problems further down the line when an unexpected failure mode emerges in a corner case. Involving testers in the design phase means that the software is designed with testability in mind, features to simplify testing are designed in, and the traceability between requirements and design is assessed. Software that is better-designed from the start can be tested more easily on a host platform rather than having to be tested on the target. Additionally, structural test coverage targets can be more easily met, significantly speeding up test development and the resolution of problems.

When it comes to software testing, shift left also applies. Testing small units of code in isolation provides confidence that they work internally and creates a set of pretested building blocks that go together quickly. A unit may be about 50 to 100 lines of code, so perhaps 20 to 30 units can be integrated together at a time and also tested in isolation. Once tested, these larger software components can then be integrated with other sets of components, and so on. This step-by-step approach to test and integration avoids the difficulties encountered by big-bang integration testing. To be most effective, however, step-by-step testing needs the stable requirements and design base created by better verification earlier in the life cycle.

A verification plan that adopts the shift left concept will result in more predictable time scales and create software with a lower level of defects as defects are avoided or detected earlier on in the life cycle, rather than having to be removed at a later stage.

The future

The new DO-178C specification, approved by the FAA in the U.S. in July 2013, now includes guidance on formal methods. It also clarifies the difference between High Level Requirements, Low Level Requirements, and Derived Requirements and gives a better definition of the exit/entry criteria between systems requirements and system design, allowing the use of high-level models. New tools for model-based engineering use high-level models to generate code and even RTL for silicon automatically.

Formal methods and model-based engineering are consistent with the shift left concept of earlier verification in the development life cycle but they bring different challenges for testing the implemented software.

Avoid defects in the first place

There are ways to implement a verification process that don't add to the cost of development and still provide a higher quality result. Using a shift left process can significantly enhance the quality of the software for avionics systems. Using independent, experienced testers at the requirements and high-level design stages improves the quality of the requirements and design. This approach also enables the testers to start early with the production of system and integration tests. Developing small units of software that can be tested thoroughly in isolation, and integrating the software in a methodical, step-by-step way, simplifies the integration challenges for complex systems.

Using this process, verification becomes less about defect removal during testing and more about defect avoidance at all stages of the development life cycle. The compliance artefacts that are needed by an assurance process such as DO-178C are produced naturally without having to go back and develop them at the end of the project. The savings in integration time and the improvement in quality reduce costs and enhance reliability, which are key considerations for any software project but particularly for avionics. **MES**

***Jim Thomas** is Director of Software Testing at TVS. He has a PhD in Mathematics from Bristol University and more than 30 years of experience in the software industry with a focus on high-integrity software development.*

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Integrated modular and distributed avionics take flight

By Russell W. Graves

By treating connectivity as a system, aerospace designers can evaluate various tradeoffs – copper versus fiber, types of shielding, cable construction, and the like – to meet requirements for both signal integrity and the environmental and mechanical needs of the application.

U.S. Air Force Captains Vincent Levraea, left, and Jason Steinlicht conduct pre-flight checklists in Dakar, Senegal, Nov. 4, 2014. U.S. Air National Guard photo by Maj. Dale Greer.

Integrated modular avionics (IMA) are an important driver for achieving flexibility in aerospace embedded computing applications. With distributed avionics gaining new popularity as a way of achieving IMA, aircraft designers are taking advantage of recent advances in packaging to make distributed systems simpler and more cost-effective. Commercial aerospace applications are moving beyond traditional protocols such as ARINC 629 to higher speed Ethernet-based protocols like ARINC 664; likewise, the U.S. military is widely adopting Ethernet to take advantage of the high-volume experience in the commercial world. Already, we are seeing the release of 40 Gb/s Ethernet for military applications as application demands move beyond gigabit and 10 G capabilities.

Standardizing for flexibility and scalability

By creating standardized modules that can be mixed and matched as needed, designers gain a modular system that offers increased design flexibility compared to existing architectures. At the same time, standardization is a leading trend in the commercial aviation industry, creating more competition and ultimately driving down costs. Standardization can also enable modules to be used across different aircraft. Figure 1 shows a distributed system for a cabin system in commercial avionics.

Such integrated modular avionics can also reduce weight and save space. One example is the miniature modular rack principle (MiniMRP), which is being developed as an extension to ARINC 836. While similar to the established MRP systems in ARINC 836, MiniMRP modules are 40 percent smaller, which can also translate into weight savings of as much as 60 percent. Standardized modules can reduce development and qualification cycles. Modules are mounted in frames, with tool-less installation and removal. Designers will ultimately have the choice of customizing a module or selecting a module in a catalog-like fashion from suppliers.

While the ARINC 836 MiniMRP is initially aimed at commercial cabin systems, it will also find use in military/aerospace applications.

Smaller, lighter packaging

In the effort to reduce weight, composite MiniMRP enclosures are a replacement for traditional metal enclosures. Composite enclosures are not only sturdy, they can be

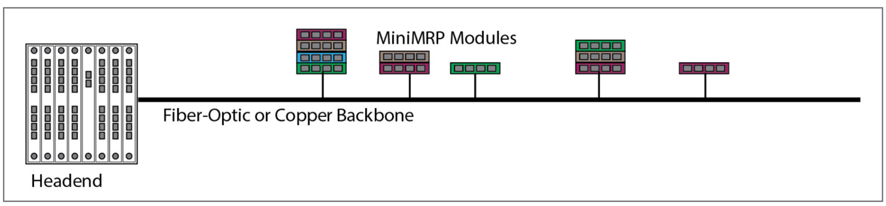

Figure 1 | Pictured is a distributed system for a commercial avionics applications. (Source: TE Connectivity.)

easily customized with shielding, circuit traces, embedded antennas, and other features. Composite formulations, including base materials and fillers, are selected according to the specific needs of the application. Fillers range from carbon fibers to microspheres and nanotubes. Composites may include selectively plating to add shielding, circuit elements, and other features. While none of this is necessarily new, the innovation lies in the advanced manufacturing techniques that move composite enclosures from expensive boutique devices to cost-effective, high-volume items fully capable of both replacing metal enclosures and adding additional features like embedded antennas or connector shells.

System-level connectivity

Box-to-box connectivity is also an important issue in distributed avionics. While many links are relatively slow speed and short distances, both easily accommodated by copper cable, higher-speed interconnects are finding wider use. When high-speed interconnects are required, challenges arise in maintaining signal integrity over longer distances.

Figure 2 | A new generation of circular connectors supports 10 Gb/s Ethernet over copper. (Source: TE Connectivity.)

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

To address this gap in fast copper connectivity, TE Connectivity has recently introduced three families of CeeLok FAS-T and FAS-X connectors capable of 10 Gb/s performance (an example of which is shown in Figure 2), each of which offers specific advantages to designers in performance and size.

Fiber optics coming on strong

Interconnections present designers with three challenges: weight, speed/distance, and signal integrity. To meet higher speeds over longer distances, fiber optics is gaining greater use in backbone applications. Since copper interconnections are historically the prevalent technology – and continue to make gains in enabling gigabit data rates well within the distances required in aircraft, we will focus here on the reasons designers are turning to fiber optics. As 40 G and even 100 G links are deployed, fiber will become essential.

- **Speed and distance:** Simply put, optical fibers carry higher data rates over longer distances than copper cable. Where a twisted pair cable can carry a 1 Gb/s signal over a distance of 100 meters, a multimode fiber can carry the same signal 1,000 meters and a single-mode fiber can handle tens of kilometers. With wavelength-division multiplexing allowing multiple wavelengths, the capacity of the fiber is multiplied by the number of wavelengths.
- **Weight:** A fiber-optic cable is significantly lighter than a copper cable. A generic Cat 6 Ethernet cable weighs 31 pounds per 1,000 feet, while a fiber-optic counterpart offers weight savings of over 66 percent at 10 pounds. For aerospace applications, cable constructions are more complex than this simple example; more complex structures give additional weight advantages to fiber. On one hand, copper cable has benefited from advanced weight-saving thin-wall insulations and jackets and better control of electrical parameters such as characteristic impedance. On the other hand, shielded cables are common in aerospace applications for EMI control and achieving signal integrity.
- **Signal integrity:** Since optical fibers are made of dielectric materials, they neither emit nor receive EMI; compared to copper cables, fiber-optic cables offer ideal noise immunity. This immunity means additional EMI-control methods – in this case, cable shielding – are not required.

Fiber's previous reputation as a fragile and hard-to-use medium are long past. Fiber-optic cables also offer easier use over past versions: Today's constructions offer crush resistance and resistance to pinching during installation. Fiber preparation during termination is easier, while no-epoxy/no-polish connectors significantly simplify the skill and times required for installation.

Optical connectors are divided into two main categories, physical contact (PC) and expanded beam (EB). With PC, the mating termini physically touch. PC termini are further divided in ceramic ferrules for single fibers and MT ferrules of multiple fibers. Ceramic ferrule yield the highest performance, with the lowest insertion loss and return loss.

COPPER AND FIBER WILL COEXIST IN MOST APPLICATIONS. EACH BRINGS SPECIFIC ADVANTAGES, FROM THE COMFORTABLE FAMILIARITY OF COPPER TO THE HIGH-BANDWIDTH CAPABILITIES OF FIBER OVER LONGER DISTANCES.

Multifiber MT ferrules offer the highest fiber density. Of the three termini, the EB is the most tolerant of vibration, shock, and other mechanical hazards. Using a noncontacting interface to avoid any wear and tear on the fiber/ferrule face during vibration, EB connectors expand and refocus light at the fiber end faces and allow an air gap in the optical pathway. The EB concept uses optical lenses (typically a 3 mm ball lens) to expand and collimate the beam emitted from the launch fiber. The expanded beam remains collimated across the mechanical interface until the receiving lens focuses the beam onto the receiving fiber.

Because the ferrule end-face is enclosed and protected behind the lens, the fiber will never require cleaning. Only the exposed outer lens surface can be contaminated, but this is easily cleaned. Because the beam size is substantially expanded across the mechanical interface, the signal will not deteriorate by airborne contamination – for example, a 10 μm dust particle – that can seriously degrade the performance of connecting ferrules. The higher insertion loss of an EB connector is often outweighed by the long life, reliability, and consistency of EB.

Copper and fiber coexist

Copper and fiber will coexist in most applications. Each brings specific advantages, from the comfortable familiarity of copper to the high-bandwidth capabilities of fiber over longer distances. As avionics systems are challenged to offer users a seamless experience in handling data, video, infrared imaging, and other bandwidth-hungry processes, both optical and copper connectivity must ensure that the end-to-end solution can accommodate production breaks in the path. The good news is that both technologies continue to evolve, thereby giving give designers new options in meeting ever-increasing data loads. **MES**

***Russell Graves** serves as market development manager for the Commercial Aerospace segment within the Global Aerospace Defense & Marine business unit of TE Connectivity. He has more than 30 years of experience in the electrical-interconnect industry, and has led TE's market efforts on major commercial aerospace platforms like the B787 and A350. Readers can connect with Russell Graves at rgraves@te.com.*

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University UAS efforts focus on interaction with humans and wildlife conservation

By Amanda Harvey, Assistant Editor

For this month's University Update section we take a look at two innovative unmanned aircraft research projects, one being conducted by a university in the U.K. and one in the U.S. One involves flying quadcopters with programming that can enable them to work alongside humans, while the other looks to curb poaching in Africa.

Polite quadcopters

Researchers at the University of Sheffield in the United Kingdom are looking to improve robot and human relations with their work on a software system that "enables the robot to learn about its surroundings using a forward facing camera mounted at the front of the machine," according to a University news release.

The team – based in Sheffield's Department of Automatic Control and Systems Engineering (ACSE) – wants to enable robots to be able to work intelligently with humans; the aim is to have the robots perform search-and-rescue missions or work in harsh environments that are unsuitable to humans.

"We are used to the robots of science-fiction films being able to act independently, recognize objects and individuals, and make decisions," says Professor Sandor Veres, who is leading the research. "In the real world, however, although robots can be extremely intelligent individually, their ability to cooperate and interact with each other and with humans is still very limited. As we develop robots for use in space or to send into nuclear environments – places where humans cannot easily go – the goal will be for them to understand their surroundings and make decisions based on that understanding."

The robot, a quadcopter in this case, starts with no data about its environment and the objects within it. Different frames from the camera are then overlaid and key reference points are selected within the scene to build up a 3-D map of the world around it. Other sensors then pick up barometric and ultrasonic data, which provide the robot with additional clues about its environment. All this information is fed into autopilot software to enable the robot to navigate safely, but also to learn about the objects nearby and navigate to specific items, according to the Sheffield release.

The Sheffield team also developed a software program to enable "the Quadcopters to work out how to 'politely' fly past each other without colliding. The robots start off flying at the same altitude and then need to collaborate to work out which robot would fly higher and which would fly lower so they are able to pass."

"The learning process the robots use here is similar to when two people meet in the street and need to get round each other," says ACSE research fellow Dr. Jonathan Aitken. "They will simultaneously go to their left or right until they coordinate and avoid collision."

The researchers used game theory to program the quadcopters to learn each robot's behavior to determine how to get past the other robot – by using previous experience to estimate the behavior of the other robot. "The next step is to extend the programming capability so that multiple robots can collaborate with each other, enabling fleets of machines to interact and collaborate on more complex tasks," Professor Veres says.

For more on Sheffield's robotic efforts, visit http://www.sheffield.ac.uk/faculty/engineering.

Drones in the jungle

Students and researchers at the University of Colorado, Boulder are designing the payload, communications, and sensors for an unmanned aircraft system (UAS) as part of a competition called the Wildlife Conservation UAV Challenge, which aims to design, build, and fly a UAS to help stop poaching at the Kruger National Park in South Africa.

The Colorado team is one of four university teams working on AREND, which stands for Aircraft for Rhino and Environmental Defense. The others are the University of Pretoria in South Africa (fuselage and environmental testing), the University of Stuttgart in Germany (wings and empennage), and the Metropolia University in Finland (ground network), according to the mission section of their website: www.teamarend.com.

AREND's overall systems-engineering project leadership is housed at the University of Colorado, Boulder. Individual students assigned to select subsystems work with the teams at the partner universities to develop the correct system-interface documents.

The AREND aircraft will perform aerial surveillance over wildlife areas to protect "rhinos, elephants, and other endangered species" from poachers. The UAS sensors will detect people, large animals, and specific shapes such as crashed aircraft.

It has a modular sensor system that can be rearranged depending on its mission. Sensors that track rhinos or poachers may also be used cost-effectively locate people and vehicles, including aircraft that crash in the wilderness, according to the AREND website.

A search-and-rescue capability would enable this team to take their invention well beyond the world of poaching.

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CHARITY

NATIONAL MILITARY FAMILY ASSOCIATION
Together we're stronger

National Military Family Association

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

This month we're featuring the National Military Family Association, whose mission is "to fight for benefits and programs that strengthen and protect the families of those who serve in uniform."

The association – founded in 1969 – bases its efforts on the belief that all military families deserve accessible health care, comprehensive child care, spousal employment options, caring communities, top-notch schools, secure retirement, and support for widows and widowers.

Through its continued advocacy on behalf of military families, the association anticipates, listens, and reacts to the needs of military families through many programs. To date the National Military Family Association has:

- Sent about 45,000 children to Operation Purple summer camp, a free program for children coping with the absence of their deployed parent(s).
- Awarded more than $2.5 million in scholarships to more than 3,000 military spouses.
- Organized retreats for military families to help them reconnect after dealing with a war-related injury or after long separations.
- Conducted research for assessing the ever-changing military environment and its effect on families.
- Efficiently managed its funds, meeting all 20 standards for Charity Accountability from the Better Business Bureau, earning an "A" rating from CharityWatch as well as four-star ratings from the Charity Navigator for 10 straight years.

The association's website – www.militaryfamily.org – shares how military families can find tips on how to adapt to the military and the military culture and get advice on how to manage all things regarding deployment. It also contains information on moving and on educational opportunities for military spouses.

To learn more about the charity, donation options, and volunteer opportunities that may be available in your area, visit www.militaryfamily.org.

E-CAST

Managing avionics safety certification in UAS platforms

Presented by AdaCore, DDC-I, and IBM

Unmanned aircraft flight-critical electronics will now have to meet the same safety certification requirements as commercial aircraft and military jets, as the U.S. Federal Aviation Administration (FAA) starts to open up the national airspace to unmanned aircraft systems (UASs).

In this E-cast, learn how embedded software and hardware designers are already looking at ways for UAS platform integrators to solve certification challenges and manage the process of compliance with safety certification standards such as DO-178B & C. In addition, follow industry experts as they discuss how to enable safety certification of UAS platforms using efficient and cost-effective solutions.

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WHITE PAPER

Reduce SWaP and centralize control in a video-centric system

By Paul Davis, Curtiss-Wright Defense Solutions

Designers: Reduce size, weight, and power (SWaP) in your mobile video-centric systems with one multifunction device at the heart of the system. With one device for all video functions, a common API can be used for control by all network clients via Ethernet. Such a video-centric system must have the agility to support the display, conversion, distribution, scaling, windowing, and storage of a variety of video formats.

Learn about the VRD1, a modern, agile system that supports all the necessary video functions in a SWaP-optimized package. With a modern API and network connectivity, the VRD1 provides a single point of control within the video-centric system and offers a bridge to the network-centric system.

Read the white paper: http://mil-embedded.com/white-papers/white-control-a-video-centric-system/

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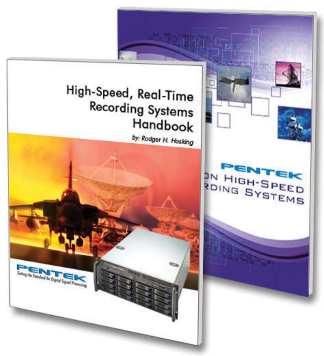

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