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March 2017 | Volume 13 | Number 2

SYNTHETIC VISION SYSTEMS ON THE WAY FOR MILITARY AVIONICS

P 18

AVIONICS ISSUE

P 34

Interview with Jim McElroy, vice president of sales and marketing at LDRA

Automation, multicore processors in aviation certification process

P 22

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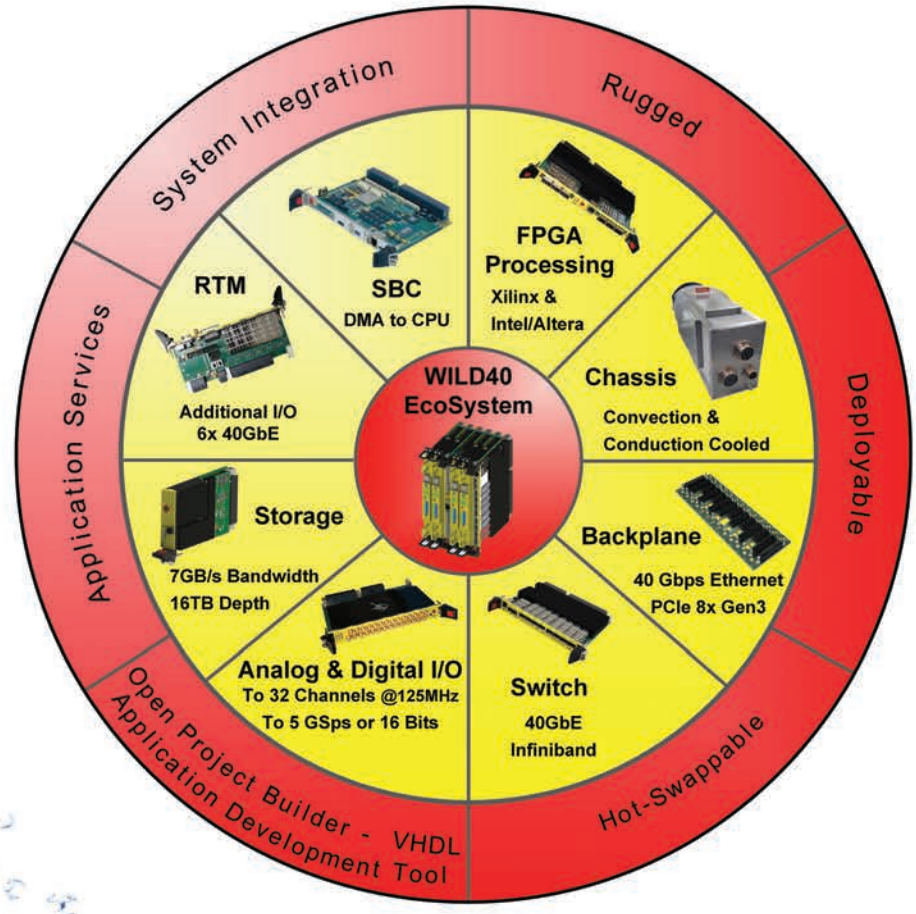

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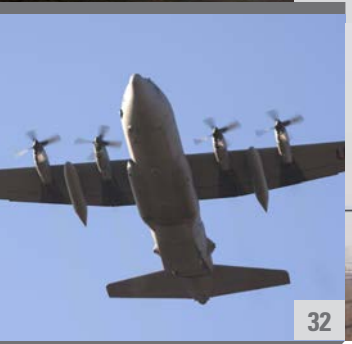

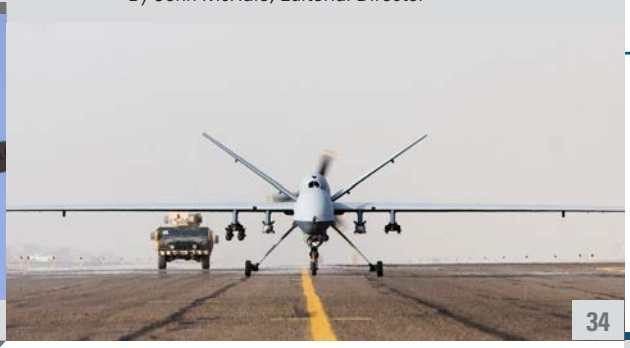

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ON THE COVER:

Top image:
HeliSure flight situational-awareness solutions combine 3-D visualization, sensors, and databases to provide situational awareness for helicopters. Credit: Rockwell Collins.

Bottom image:
F-16 Fighting Falcons demonstrate an "Elephant Walk" as they taxi down the flightline at Kunsan Air Base, South Korea. Photo courtesy of U.S. Air Force/Staff Sgt. Jonathan Fowler.

Open architecture and reuse initiatives make economic sense

By John McHale, Editorial Director

I'm often preaching in this space about how the demand for commonality is driving procurement and technology development within the Department of Defense (DoD), a demand brought on by the DoD budget cuts the last few years and sequestration. Now, with budget increases promised by the Trump administration, I see the demand only growing because it just makes good business sense; I also see a number of initiatives currently pushing for more open architectures and technology reuse across multiple platforms.

To return to old procurement models, where the DoD funded technology development from the ground up or paid more money for proprietary technology based on closed architectures, is just economically unsound.

Recent initiatives are gaining traction because the government – believe it or not – is getting better at working together across the services. The cost benefits of commonality happen not only on the front end with procurement, but also on the back end with supportability. Every piece of hardware needs personnel trained to both operate and maintain it. Enabling more commonality and reuse provides tremendous maintenance and training savings. The same goes for software, as reusing software components reduces recertification costs.

Industry efforts

During the Embedded Tech Trends (ETT) conference in New Orleans earlier this year, Charles Patrick Collier, Technical Lead with the Naval Air Systems Command (NAVAIR), briefed the audience of embedded computing suppliers on the Hardware Open Systems Technology (HOST) and the Sensor Open Systems Architecture (SOSA) initiative – each of which involve industry and military/government organizations working together to essentially shorten fielding times, lower life cycle costs, leverage economies of scale, and promote reuse.

I thought his most striking slide showed how military platforms are getting astronomically expensive, with the Joint Strike Fighter being at the apex with its nine million lines of code and 17 years of development. The slide rightly points out that anything beyond that is simply unaffordable.

Now, there are naysayers out there who claim that the government always comes up with ambitious initiatives that always fall apart as the various parts of government fail to agree. They're not wrong, but I believe those failed efforts are not predictors of today's models.

Today, the military services are taking active roles in standards bodies. For example, the Army Communications-Electronics Research, Development and Engineering Center (CERDEC) became a member of the VITA standards organization. Even more importantly, all the services are buying in. The recent budget-constrained environment has created a new reality: New platforms and upgrades must be affordable; to do so they must embrace commonality, open architectures, and a culture of reuse.

"That the HOST effort is taking place outside of the VITA Standards Organization is ideal, because NAVAIR would like to enforce common design approaches that will require a level of cooperation that might otherwise have been resisted if individual vendors were left to their own devices," says Michael Munroe, Technical Specialist at Elma Electronic, in his article on page 14 of this issue.

HOST and SOSA are just two examples. Another initiative is the Future Airborne Capability Environment (FACE) consortium, founded out of NAVAIR, but now involving the Air Force, Army, and nearly every major prime contractor and system integrator. FACE essentially enables the reuse of software applications from one aircraft platform to another and sometimes from one military service to another via the use of a common API.

"I think the FACE organization is doing a tremendous job from the standpoint of setting the standard for software interoperability and the verification process for those software components, ultimately [lowering] the cost of developing high-quality software and certified aircraft" says Jim McElroy, Vice President of Sales and Marketing for LDRA, in the Executive Outlook on page 34.

A precursor to FACE was a program that Rockwell Collins created for reuse of avionics components across multiple Army helicopters, called the common avionics architecture system (CAAS). This program worked because it enabled the Army to port capability from platform to platform without starting from scratch. In other words, it was a good business model. For more on Rockwell Collins avionics, see the Special Report on page 18.

These initiatives and others are creating momentum for the open architecture proponents within the DoD and convincing the leadership that they will save money in the long term while making the warfighter and his systems and tools that much more efficient.

Moreover, the government's increased engagement with the standards bodies cannot be overstated. The efforts by those like Collier and his colleague at NAVAIR, Ilya Lipkin, Lead Manager for SOSA at the Air Force Life Cycle Management Center (AFLCMC), has enabled enthusiasm and buy-in from industry to these programs. Collier led a previous effort while with the Air Force to create the SpaceVPX standard for military satellite applications.

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Safety-certifiable COTS case

By Charlotte Adams

An Abaco Systems perspective on embedded military electronics trends

In commercial aviation, one of the most safety-conscious industries, hardware and software developers must design and test their products according to rigorous safety standards. The most well-known are DO-254 for computer hardware, such as integrated circuits (ICs) and field-programmable gate arrays (FPGAs), and DO-178 for software, such as operating systems and application code.

The rationale for these standards is to assure – as far as humanly possible – that the millions of lines of software code and the hardware devices they interact with will perform their myriad functions on an aircraft, as intended per the requirements, and not do anything else. In other words, the standards attempt to eliminate surprises in avionics functions that might impair the safety of flight.

Although the DO-178 and DO-254 regulatory processes were invented to assure civil-aviation safety, pressure is growing for military programs to certify under these safety standards – not just to comply with them in a looser manner. Military aircraft routinely fly in civil airspace and have to communicate with FAA air traffic controllers and incorporate civil air-traffic-management technologies. Even more of a case can be made for unmanned aerial vehicles (UAVs) in the increasingly congested airways.

There are also sound business reasons for both the military and its suppliers to certify systems. Some of these reasons: higher quality, 50 to 75 percent faster integration, and greater module reusability. (See Vance Hilderman, CEO of AFuzion, Inc., "The Yin-Yang of Military Avionics & DO-254.") DO-254 imposes discipline on the design process in an effort to ensure that all the elements of a finished product are directly and verifiably traceable to the requirements.

Hardware developers have an additional certification incentive – in the form of a quicker return on investment – compared with software developers. Commercial off-the-shelf (COTS) hardware products are less customized and more commoditizable. Hardware that is designed, from the smallest component up, on a firm DO-254 foundation is easier to repackage and reuse, especially when accompanied by long histories of safe use in flight-critical avionics.

Unfortunately, however, it is not cheap to develop certifiable COTS hardware. COTS components such as chips and interconnects are mass-produced for the consumer market. Often little is known about the internals of a processor because those details are competition-sensitive. It would require a major investment for the military customer to come up with evidence – the so-called "artifacts" – that would pass muster for a DO-254 certification. If it takes several million dollars to certify a board, the cost for systems could rapidly become unaffordable.

Certifiable COTS

That's where the idea of vendor-supplied, certifiable COTS hardware comes in. A board developer designs a product with certifiable components and collects the artifacts – if necessary reverse-engineering them – to create a certification package. The documentation package helps the customer prove the system safety case in a DO-254 certification and reduces program costs and deployment time. The board vendor then recovers the investment through sales of a portfolio of certifiable standard products.

The practice is becoming common at the board level, although the extent of the various investments and scope of the various certification packages are closely held secrets.

An example of this trend toward certification is the Abaco Systems FORCE2 rugged, small-form-factor avionics box – for safety-critical display, mission, and flight computer slots – implemented with high-technology-readiness level software and hardware components and supported by DO-254 artifacts for systems requiring safety assurance, all the way up to design assurance level A. (Figure 1.)

Figure 1 | Abaco's FORCE2 small-form-factor avionics box is supported by DO-254 artifacts for systems requiring safety certification.

Time to get on board

Another advantage of adherence to DO-254 is the spotlight it shines on the supply chain, promoting component manufacturers with long safety records and those inclined to share product data and build in appropriate safeguards.

A further reason for component manufacturers to get on board is the advent of driverless vehicles and UAVs that will do everything from surveillance to package delivery. Semiconductor companies are beginning to address safety concerns in their architectures, a trend that is likely to increase options in the embedded market.

DO-254 is much newer than DO-178 and has not yet worked out all the kinks; for example, DO-254's requirements for multicore microprocessors have not yet been nailed down. But engineers are hard at work on these issues and are likely to find solutions in the near term, as single-core processors fade rapidly from the scene.

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Covering the spectrum: Meeting the challenge of electromagnetic spectrum domination

By Marc Couture

An industry perspective from Curtiss-Wright Defense Solutions

North Korea recently fired a missile across the Korean Peninsula and into the Sea of Japan. This latest threatening act highlights the increased volatility of the Pacific Region. Ongoing tensions in the Straits of Taiwan and China's construction of a string of artificial islands in the South China Sea also serve as stark examples of the need for effective SIGINT/ELINT [signals intelligence/electronic signals intelligence] coverage of the electromagnetic spectrum (EMS) by the U.S. and its allies.

During a tactical situation, what would that look like? Achieving effective order of battle and viewing the whole EMS map at once has always been a challenge. First and foremost, the mission requires a stand-off platform that can simultaneously cover as many targets as possible. The number of surveillance assets, such as unmanned aerial vehicles (UAVs), that can be flown at once is limited. What's more, the number of radio frequency (RF) channels that could be integrated into a payload was limited on older VME systems to only one or two channels per 6U slot. Another hurdle was the exploitation of the resulting EMS data, which would typically need to be back-hauled to a human for analysis, introducing costly delays between data accumulation and decision-making. Until now, the impossible dream has been a cost-effective open standards approach for covering far greater swaths of the EMS, coupled with the ability to analyze and act upon that data in real time.

A couple of months ago in this space (November/December 2016 MilTech Insider) we wrote about the technology breakthrough made possible by the recently introduced Vesper family of multichannel wideband RF receivers (DRS Signal Solutions). These RF receivers provide greatly expanded EMS coverage and channel count, up to nine RF channels in a single 6U slot – compared to the two channels previously possible – that system developers have long sought. The DRS devices are available in cost-effective, [size, weight, and power] SWaP-optimized 3U and 6U VPX modules. When combined with supercomputing-class multicore Intel Xeon processors, the SIGINT data flowing from these RF receivers are able to generate real-time actionable intelligence: not just information about what a signal of interest is, but information that

Figure 1 | The CHAMP-XD2 board plus associated updated RF receivers enable users to cover the electromagnetic spectrum during tactical situations and act upon the data in real time.

tells where the target is, in both space and time, thus enabling the warfighter to determine if the target is benign or a threat that needs to be attacked.

In the times since these open standard RF receivers were introduced, the potential that they deliver for SIGINT and ELINT applications has become clearer. Half of the story is the high frequency supported by the tuners: RF channel density for a 6U VME card in the past were limited to one or two channels able to cover a frequency range of 20 MHz to 3 GHz, and analog IF outputs were limited to a maximum 40 MHz instantaneous bandwidth. The new modules support as many as 10 RF channels per card, with intermediate frequency (IF) outputs more than doubled to 100 MHz instantaneous bandwidth. This improved performance brings us much closer to the goal of instantaneous coverage over as much of the EMS spectrum as possible, and for as long as possible.

The other half of the story is the benefits that come from the modules' support for 10 Gigabit Ethernet. Because the RF receivers support VITA's standardized VRT protocol (VITA 49/VITA Radio Transport) for transferring IF data between analog front ends and processing cores, a whole new level of flexibility is realized.

For example, using advanced multicast Ethernet modes, one tuner channel can send out its result to a subset of the Xeon D cores, or the data from multiple tuner channels can be aggregate to a single Xeon core. This support for standards-based switched Ethernet enables "all-to-all" connectivity, so any tuner channel can communicate with a Xeon core. This raises the bar on the ability of the SIGINT/ELINT system to correlate RF emitters in three-dimensional time and space, resulting in a magnitude of improvement in density. To duplicate the flexibility achievable from this commercial off-the-shelf (COTS)-based open standards approach using proprietary solutions would be extremely difficult, if not impossible.

Curtiss-Wright has developed high-performance embedded computing (HPEC) architectures that take advantage of the Vesper RF receiver's support for Ethernet and the VRT protocol in both 6U and 3U VPX systems. (Figure 1.)

__Marc Couture__ is the senior product manager for Intel, PowerPC, and GPGPU-based digital signal processors in the ISR Solutions group at Curtiss-Wright.

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By Mariana Iriarte, Associate Editor

NEWS

U.S. Navy approves full rate production of Lockheed Martin's avionics test system

U.S. Navy officials approved a full rate production contract with Lockheed Martin for an additional 63 of the company's Electronic Consolidated Automated Support System (eCASS) avionics-testing system. The contract is worth an estimated $166 million.

The eCASS technology has a smaller footprint than the legacy CASS, officials say. Users will be able to handle a larger workload with less equipment to ensure aircraft avionics are mission-ready. eCASS will also lower the Navy's costs dramatically, to the tune of as much as $1 billion annually, by averting the repair of avionics at the next level of maintenance or sending the parts back to the original equipment manufacturer.

Figure 1 | U.S. Navy sailors performing diagnostics tests on the eCass system. Photo courtesy of Lockheed Martin.

Afghan Trainer logistics support contract won by Textron Systems

U.S. Air Force officials selected Textron Systems Support Solutions (a Textron Inc. business unit) for an Afghan Trainer Contractor Logistics Support (CLS) follow-on contract to provide training and maintenance in support of U.S. Air Force and Afghan air force Cessna C-208B Caravans, which are used for military transport and training.

The contract is valued at an estimated $9.35 million and has a five-year maximum value of $50 million. Over the duration of this contract, Textron Systems will transfer capabilities and offer maintenance training to the Afghan air force to allow them to work independently.

Work under the contract began on February 1 at Kabul Air Base and Kandahar Air Base, Afghanistan.

Carbon nanotube tech licensed for aircraft deicing

UTC Aerospace Systems obtained an exclusive license from Metis Design to use a carbon nanotube (CNT) heater-based technology for aircraft electrothermal ice protection. This technology – codeveloped by Metis Design and the Department of Aeronautics and Astronautics at the Massachusetts Institute of Technology – responds to the needs of the military, aviation, and unmanned aerial vehicle (UAV) markets for low-power, lightweight ice protection.

According to UTC, using thin layers of carbon nanotubes in an aircraft-deicing system will distribute heat uniformly, enhance damage tolerance on the aircraft wing, and improve material fatigue resistance, all in a lightweight system.

Integration of the new deicing systems with CNT technology will take place at the UTC Aerospace Systems facility in Uniontown, Ohio, supported by Metis Design in Boston and the United Technologies Research Center in East Hartford, Connecticut.

U.S. Army and allies invest $202 million in enhanced Patriot missile

The U.S. Army Contracting Command announced that the Department of Defense (DoD) has awarded a contract to Raytheon for $202 million to perform enhancements to the Patriot Air and Missile Defense System.

The contract work – to include software development, systems analysis, testing, and logistics support – will sustain highly skilled jobs across four U.S. states; contract work will be performed at locations in Alabama, Massachusetts, New Hampshire, and Texas.

According to the company, the work on the Patriot will sustain more than 500 highly skilled jobs, while adding to the functionality of the Patriot system.

Figure 2 | Patriot is a long-range, high altitude, all-weather solution. Photo courtesy of Raytheon.

Clemson team partners with DTRA to develop nuclear-activity sensor

Research targeted at building a biosensor that would help the military detect signs of nuclear activities – including indications of weapons development – has been approved, to be conducted under the leadership of a former naval officer who is now a Clemson University faculty member.

Nicole Martinez, an assistant professor in the Clemson environmental engineering and earth sciences department, is the lead investigator on the $866,884 project; the research will last three years and could be eligible for a two-year extension, boosting the total to about $1.5 million.

Dr. Martinez and her team – with funding from the U.S. Defense Threat Reduction Agency (DTRA), an agency within the U.S. Department of Defense (DoD) – are beginning to lay the groundwork for a biosensor that could help determine whether any detected radiation is natural or manmade and peaceful or weapons-grade. A biosensor of the sort under development would improve upon current radiation-detection systems that are easily identified, must be placed close to the radiation source, and report on radiation emitted only at the time the detection system is present.

Figure 3 | Dr. Nicole Martinez during the research project. Photo courtesy Clemson University.

SiCore Technologies and Charles River partner to protect against avionics malware

SiCore Technologies and Charles River Analytics are partnering to protect against avionics malware in a program for the U.S. Air Force Avionics Vulnerability Assessment, Mitigations, and Protections (AVAMP) program.

As part of the SiCore team, Charles River will develop technologies to detect, analyze, and mitigate vulnerabilities and attacks on airborne intelligence, surveillance, and reconnaissance (ISR) missions. The AVAMP program aims to understand and improve the cybersecurity of its platforms and weapons systems.

In this partnership, Charles River engineers are also building on previous cyberdefense efforts with the Air Force Research Lab (AFRL) and the Defense Advanced Research Projects Agency (DARPA); these previous projects focused on vulnerability analysis and automated attack analysis.

FLIR lands $50 million Coast Guard contract for navigation electronics

The U.S. Coast Guard has awarded FLIR Systems a $50 million indefinite delivery/indefinite quantity (ID/IQ) contract to provide marine electronics systems under the Coast Guard's Scalable Integrated Navigation Systems 2 (SINS-2) program over a five-year period, with the option to extend delivery for an additional five years.

FLIR will provide electronics systems – to include FLIR's Raymarine multifunction navigation displays, radar, sonar, remote instrument displays, and autopilot – that will be standard fit on over 2,000 U.S. Coast Guard vessels ranging from small-class boats through large cutter-class vessels. The system components will be integrated with the Raymarine Lighthouse operating system and will include some advanced features specifically developed for the U.S. Coast Guard.

The Raymarine LightHouse operating system enables users to opt for preprogrammed search-and-rescue (SAR) patterns, allowing for coordinated multivessel SAR operations. The LightHouse based SINS-2 system also features graphical target intercept tools and encrypted communications designed to increase safety, ensure situational awareness, and enhance mission success rates.

USS Roosevelt to receive $51 million modernization from BAE Systems

The U.S. Navy has awarded BAE Systems a $51.3 million contract to perform maintenance and modernization of the USS Roosevelt (DDG 80), an Arleigh Burke-class guided missile destroyer.

Under the terms of the competitively awarded contract, BAE Systems will initially dry-dock the ship at the company's shipyard and then complete the work at Naval Station Mayport, both located in Jacksonville, Florida.

The modernization is set to begin in April and is expected to be completed in April 2018. If all contract options are exercised, the full value of the award could reach $68.4 million.

Figure 4 | The guided-missile destroyer USS Roosevelt (DDG-80) transits the Atlantic Ocean. Photo courtesy of the U.S. Navy.

Prototype demonstration catches 400-pound unmanned system

Aurora Flight Sciences engineers performed a full-scale technology demonstration system that repeatedly captured a 400-pound Lockheed Martin Fury unmanned aerial system (UAS) that accelerated to representative flight speeds via an external catapult. The test was conducted for the Defense Advanced Research Projects Agency's (DARPA) SideArm research effort, which seeks to create a self-contained, portable apparatus able to horizontally launch and retrieve UASs weighing as much as 900 pounds.

The SideArm program is part of DARPA's individual investment in Phase 1 research for Tern, a joint program between DARPA and the U.S. Navy's Office of Naval Research (ONR). With the demonstration of the capture system complete, DARPA engineers are now working to identify potential transition partners and exploring using SideArm with other UAS platforms.

Figure 5 | DARPA's SideArm research effort seeks to create a self-contained, portable apparatus able to horizontally launch and retrieve unmanned aerial systems (UASs) of up to 900 pounds. Photo courtesy of DARPA.

DISA chooses RedSeal for DoD cybersecurity

The Defense Information Systems Agency (DISA) has awarded RedSeal in Sunnyvale, California a multiyear contract for its computer network-modeling and risk-scoring platform; the contract is valued at $33.8 million.

As part of the agencywide effort to create a highly resilient global Department of Defense (DoD) network, DISA will use RedSeal to model and continuously monitor the infrastructure of the Joint Regional Security Stacks (JRSS) security architecture, provide visibility into network segmentation, and measure overall resiliency to deliver risk-based situational awareness. JRSS performs firewall functions, intrusion detection and prevention, enterprise management, virtual routing and forwarding (VRF), and other network-security capabilities.

According to DISA, the regionally distributed JRSS will eventually support more than 95 percent of the DoD's network.

Ball Aerospace, Infoscitex to continue Air Force cognitive tech R & D

Ball Aerospace and Infoscitex have received contract modifications worth $75 million to continue to provide research and development support in the areas of human perception and cognitive technologies for the U.S. Air Force.

The award is a modification to a previously awarded ID/IQ contract in support of the Air Force's Human Interface Research and Technology program, which is aimed at developing cognitive platforms that will work to provide the warfighter with decision-making and situational awareness capabilities to help service members perform synchronized operations in the air, in space, and in cyberspace.

The work will be performed at the Air Force Research Laboratory at Wright-Patterson Air Force Base and an Infoscitex facility in Dayton, Ohio.

ESA taps Curtiss-Wright for COTS-based telemetry on Vega-C launcher

The European Space Agency (ESA) selected Curtiss-Wright Defense Solutions to provide its radiation-tolerant Smart Backplane chassis for its new Vega-C launcher. Under the contract, Curtiss-Wright will provide Vega-C prime contractor ELV with a full telemetry system, which will handle data-acquisition, data-handling, and radio-frequency transmission capabilities.

ESA is designing the midsized Vega-C to deliver government, commercial, and science payloads weighing three tons or less to low-earth orbit. The Curtiss-Wright/Vega-C development contract, which runs from January 2017 until the Vega-C's first launch in June 2019, is estimated at $5 million; the subsequent production phase is estimated at more than $10 million over the lifetime of the program.

The Vega-C rocket will be launched from the ESA's primary spaceport in Kourou, French Guiana.

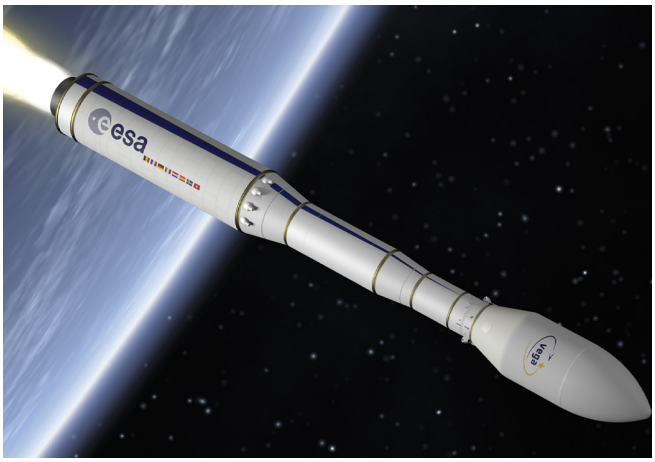


Figure 6 | Artist's rendering of Vega-C. Photo courtesy of the European Space Agency.

U.S. Air Force receives F-22 Raptor after maintenance at Lockheed's Speedline facility

Engineers at Lockheed Martin recently completed maintenance on the U.S. Air Force F-22 Raptor at the company's Inlet Coating Repair (ICR) Speedline facility and delivered the aircraft back to the Air Force.

In August 2016, U.S Air Force officials selected Lockheed Martin to establish the Speedline in Marietta, Georgia; the F-22 arrived in early November. A second aircraft arrived in early December 2016, with a third in late January 2017. Lockheed Martin is on contract to perform this work on a total of 12 aircraft. Additionally, the company is providing modification support services, analytical condition inspections, radar cross-section turntable support, and antenna calibration.

Periodic maintenance on this particular aircraft is required to maintain the special exterior coatings that contribute to the fifth-generation Raptor's Very Low Observable (VLO) radar cross-section. The increase in F-22 deployments, including ongoing operational combat missions, has increased the demand for ICR. Lockheed Martin provides sustainment services to the F-22 fleet through a U.S. Air Force-awarded performance based logistics contract and a comprehensive weapons management program called Follow-on Agile Sustainment for the Raptor (FASTeR).

Figure 7 | Technicians inspect an F-22 Raptor at the F-22 Speedline facility in Marietta, Georgia. Photo courtesy of Lockheed Martin/Andrew McMurtrie.

Thales tasked to deliver GaN CWI transmitters to Royal Danish navy

Officials at the Danish Defence Acquisition and Logistics Organization tasked Thales to deliver 14 Continuous Wave Illumination (CWI) transmitters to be integrated in the current ESSM fire-control systems onboard the Absalon and Iver Huitfeldt-class vessels of the Royal Danish navy.

Thales's CWI transmitter uses gallium nitride (GaN) technology and incorporates a missile waveform generator (MWFG) building block to provide system performance.

The first delivery will be made mid-2019 and the last system will be delivered in 2021. A second contract was signed for the sustainment support of the CWI systems until 2049.

Space Systems Loral and DARPA partner to service satellites in GEO

Defense Advanced Research Projects Agency (DARPA) officials partnered with Space Systems Loral (SSL) for the Agency's Robotic Servicing of Geosynchronous Satellites (RSGS) program. The aim is to develop technologies that would enable cooperative inspection and servicing of satellites in geosynchronous orbit (GEO) and demonstrate those technologies on orbit. Depending on the outcome, the research effort could open the door to lowering the risks and costs of operating in GEO.

Under the agreement, the two parties would share costs and responsibilities. The Agency's selection of SSL and the pending agreement have been submitted for review by the Defense Department's Under Secretary of Defense for Acquisition, Technology, and Logistics. With RSGS, DARPA plans to develop a robotic module, including hardware and software, and provide technical expertise and a government-funded launch. SSL would provide a spacecraft and would be responsible for integrating the module onto it to create a robotic servicing vehicle (RSV) and the RSV onto the launch vehicle, as well as providing a mission operations center and staff.

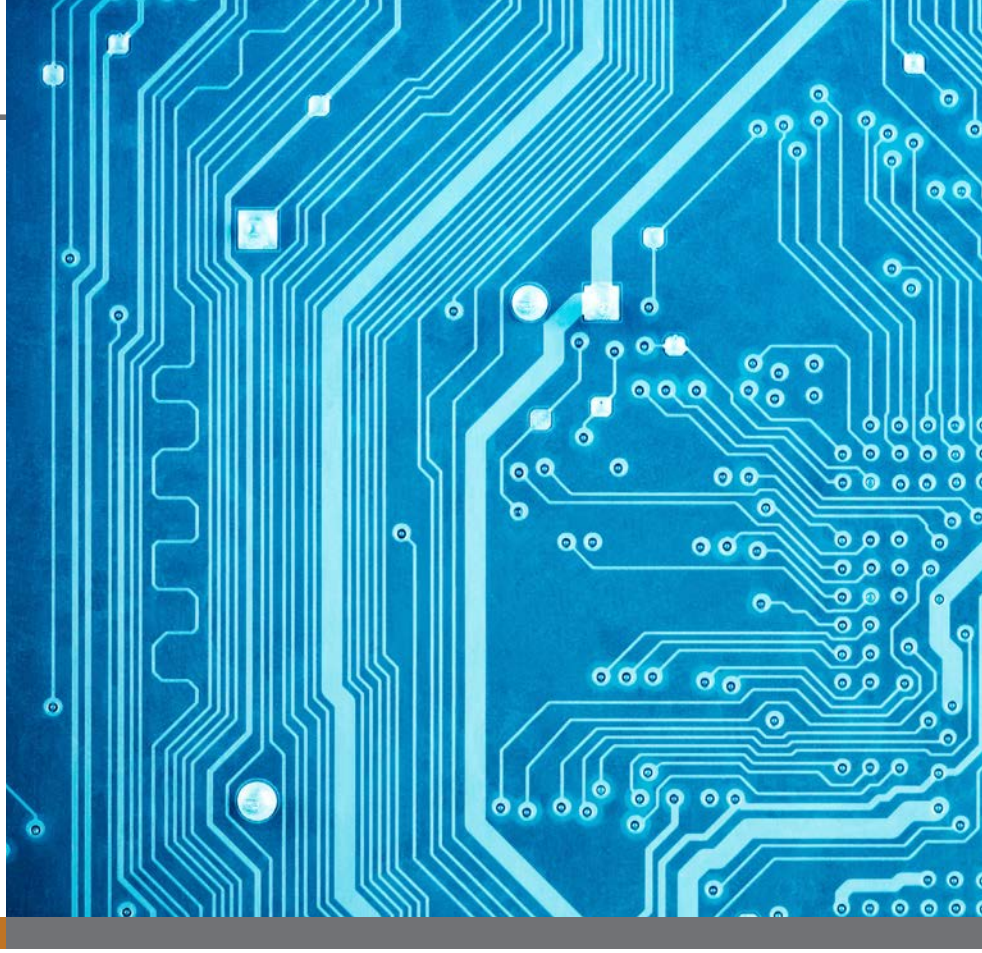
Research ongoing into avoiding aircraft icing

U.S. Naval Research Laboratory (NRL) researchers believe they are close to cracking the code regarding how to provide aircraft with a way to avoid potentially hazardous icing conditions.

The accumulation of ice on airborne aircraft is the result of a weather phenomenon called "supercooled liquid clouds," which – says Ian Adams, an electrical engineer in NRL's Remote Sensing Division – can cause aircraft to ice over quickly because the liquid water droplets are below the freezing point and will freeze after contact with the surfaces on an aircraft.

The NRL team is investigating the feasibility of a forward-looking passive millimeter-wave radiometer as a sensor. Using a computer-simulated instrument response of a forward-looking sensor, simulations showed promise: "So far, the model shows a strong signal at two distances when compared with a clear-sky scenario," Adams says. "It shows supercooled liquid layers not visible to ground-based radar."

Figure 8 | A CH-53E Super Stallion with Marine Heavy Helicopter Squadron 464 lands in snow during Exercise Frigid Condor near Brunswick, Maine. Photo courtesy of U.S. Naval Research Laboratory.



Continued support for VPX found in recent hardware and software developments

By Michael Munroe

VITA's Standards Organization (VSO) has been working diligently to finalize a major update to the VITA 65 standard, also known as OpenVPX. In addition, CERDEC [U.S. Army Communications-Electronics Research, Development and Engineering Center] has been instrumental in supplying some of the additions to the standard. Even broader than these specification updates are additional efforts being made on other VITA standards that strengthen the overall VPX environment itself.

From field-programmable gate arrays (FPGAs) to radio frequency (RF) and optical connectors, faster, more efficient technologies are being incorporated into the fabric of VPX. More and more organizations are becoming involved to ensure interoperability and cohesion among VPX systems and components (Figure 1).

The VPX movement continues

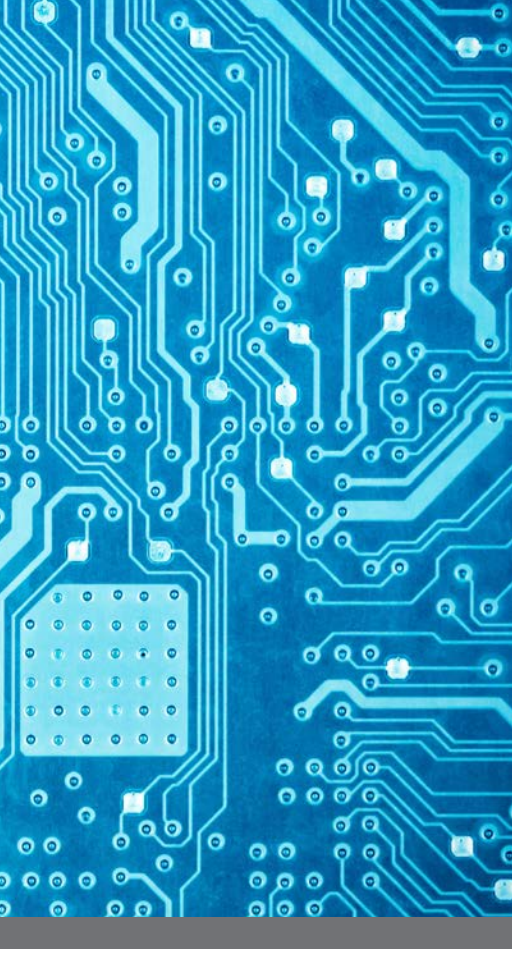
The activity level within VITA, and within the VPX ecosystem itself, has been intensely busy over the past year, with both VITA 65.0 and VITA 65.1 being on the cusp of ANSI balloting. The most recent working group ballots for these two documents ended on February 28th, and solicitation for an ANSI ballot group ended on March 2nd.

A tremendous amount of effort has gone into what will be the third release of VITA 65, and there have been many significant additions since the document was last updated in 2012. Even though all the charts associated with module and backplane dash numbers have been moved into newly created VITA 65.1, the base document is still expanding by more than 40 percent, to a massive 800 pages.

Working in tandem with the balloting of the VITA 65 updates are other related efforts, which are nearing completion as well:

- VITA 46.9, which defines rear I/O PMC/XMC mapping on VPX modules, recently completed a working group ballot and is expected to go to ANSI ballot soon.
- VITA 57.4 FMC+, being led by Samtec and Xilinx, involves a higher-speed FPGA mezzanine that will support data rates in excess of 28 Gb/s between a base card and the FMC mezzanine. This standard will allow the newest FPGA devices to enhance the performance of 3U and 6U VPX modules by allowing the support of additional features as required.
- VITA 67.3, a new standard, is both flexible and far-reaching, defining a detailed connector format that enables the development of far more complex VPX RF modules. Optical modules have already been produced that use the newly defined VITA 67.3 backplane apertures as well as a combined RF and optical module in accordance with VITA 67.3.

VPX provides much higher data rates to the robust Eurocard form factor. Optical interfaces will allow continued support of even higher speeds, while RF interfaces



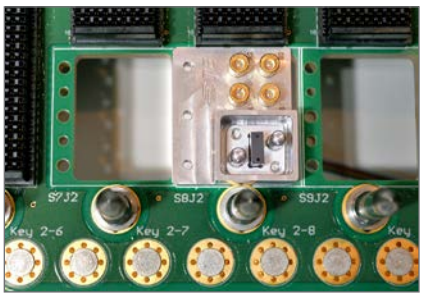


Figure 1 | Examples of RF and optical connector interfaces being used by the updated specifications.

bring radio and radar antenna connections directly to the backplane. VPX integrated switches are already available to handle both data and control plane communication. Compatibility with existing XMC mezzanines, as well as the new faster FMC mezzanine standard, give VPX the flexibility to meet every challenge.

Support throughout military environments

With roots in the long-used military technology VME platform, VPX modules are being developed to support communications, surveillance, electronic warfare, and many other types of defense applications, especially for vehicles. It seems clear today that all three military services

COMPATIBILITY WITH EXISTING XMC MEZZANINES, AS WELL AS THE NEW FASTER FMC MEZZANINE STANDARD, GIVE VPX THE FLEXIBILITY TO MEET EVERY CHALLENGE.

have concluded that the VPX architecture is critical to the future development of their electronic hardware. Further evidence of this expanding adoption is the Air Force's support of VITA 78 for aerospace applications.

Additionally, the Office of Naval Research's support of a 3U 12-slot VPX convergence backplane – and a similar effort within the Army CERDEC command for its own 3U 12-slot convergence backplane – are very visible efforts that have resulted in

new standard VPX development backplanes that are part of the new VITA 65.3 release (Figure 2).

Power in numbers

Currently, there are at least 44 different companies producing VPX modules for the open market and at least six connector companies that make various connector modules used in VPX products (Figure 3). There are also many larger suppliers building special VPX modules for their own customer programs.

Massive software initiatives supporting the hardware development are augmenting both the Army and Navy efforts, although these actions are far less visible. For example, the Navy is heavily committed to extending the capability of VITA 49 (VITA Radio Transport). This standard will allow a common control interface that defines the management of RF waveforms and packetized data necessary to support multiple software radio modules and other electronic warfare hardware that is being built in accordance with the VPX architecture.

These software and hardware developments within the Army and Navy have required new clocking and timing architectures to be developed with VPX that have been done in a very clever fashion. The new architectures allow some "Ref_Clk" and "Aux_Clk" signals to be driven either as traditional bused multi-drop signals and other modules to receive their "Ref_Clk" and "Aux_Clk" signals radially within the same backplane.

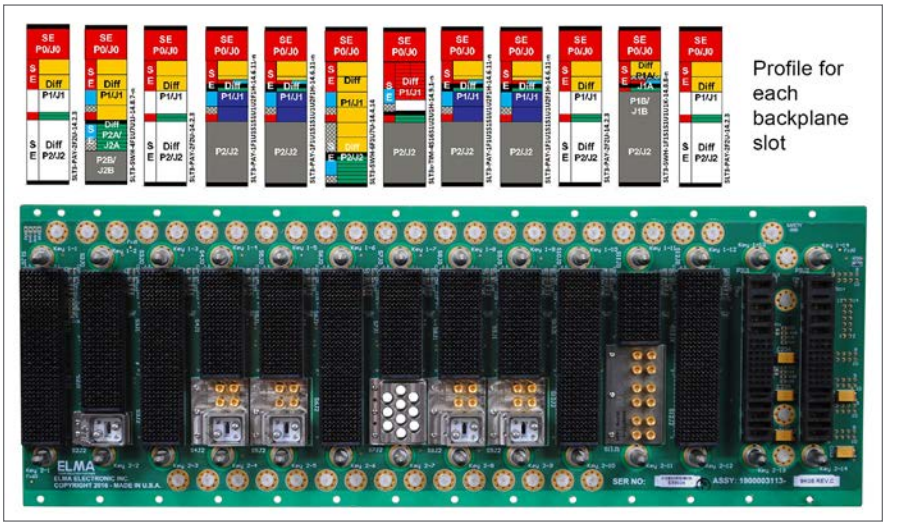


Figure 2 | New backplane topologies, with diagrams.

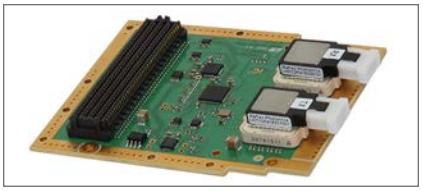


Figure 3 | Example of a FPGA mezzanine card (FMC) using the latest connector modules and VPX standards.

Continued strides toward interoperability

Another major effort focused on making VPX hardware more interoperable and more manageable for defense applications is being driven by NAVAIR [U.S. Naval Air Systems Command], but being done mostly outside of the VSO. A VITA 84 study group serves as a Q&A forum for the NAVAIR engineers and their contractors, who are independently developing a multitiered hardware open systems technology (HOST) document. This document will draw heavily on the VITA 46.11 standard for VPX system management. The HOST effort is intended to reduce some flexibility of key modules to improve interoperability and interchangeability of VPX modules.

VPX, with its high degree of flexibility, has made it increasingly difficult for the end customer to ensure that multiple vendors will have interchangeable modules with respect to a given backplane slot. The development of both hardware and software test fixtures is a particularly interesting aspect of the HOST effort.

That the HOST effort is taking place outside of the VITA Standards Organization is ideal because NAVAIR would like to enforce common design approaches that will require a level of cooperation that might otherwise have been resisted if individual vendors were left to their own devices. The HOST specification is also being followed closely by the Army CERDEC team. Until now, VPX system management has seen less than favorable adoption, but the HOST standard is on track to make the broad benefits of VPX system management a reality.

Next on the horizon

There are many significant key standards and specifications responsible for driving VPX today. With more than 47 separate VITA standards addressing various aspects of the VPX architecture – as well as a number of other external specifications such as HOST, MORA, and Victory – also supporting VPX system development, there is obviously continued development and interest in building out the ecosystem.

The VPX architecture is already 10 years old, but with all the new features added in the past 24 months, it would be fair to say that this architecture is still in its infancy. As more vendors implement the newest optical and RF technologies and HOST management is rolled out, military and aerospace applications of VPX will only continue to grow. **MES**

Michael Munroe *is the technical specialist for Elma Electronic. He is a significant contributor to open standards committees, including PICMG, VITA, and OpenVPX. He serves on the technical committee for VITA 65 and is the secretary-treasurer of PICMG.*

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Synthetic vision systems on the way for military avionics

By Sally Cole, Senior Editor

Synthetic vision systems, already flying on some commercial aircraft, are now finally on their way to U.S. military avionics platforms. These systems will provide a tactical advantage within degraded visual environments while taking advantage of commercial off-the-shelf (COTS) processing solutions and open architecture initiatives, such as the Future Airborne Capability Environment (FACE), enabling their design and deployment.

HeliSure flight situational-awareness solutions combine 3-D visualization, sensors, and databases to provide situational awareness for helicopters. Credit: Rockwell Collins.

Degraded visual environments (DVE) – in which visibility is obscured intentionally or unintentionally by fog, sand, snow, clouds, or anything else – are among the most dangerous environments for military helicopter pilots. Yet pilots must be capable of both operating within these dangerous flight conditions to complete the tasks they took to the sky to manage and also safely reaching their destinations.

Operating within DVE conditions has "cost the U.S. military many lives and hundreds of millions of dollars during the past decade," points out Howie Wiebold, manager of business development for Honeywell Aerospace.

Synthetic vision systems offer the potential to save lives and reduce costs by providing aircraft operators with a three-dimensional view of the world outside the cockpit, enabling pilots to see clearly through DVE situations during any phase of flight.

Synthetic vision systems can "provide helicopter pilots with a real tactical advantage – by bringing the capability of 'owning the environment' to the flight," Wiebold says.

What is synthetic vision?

Honeywell's approach to synthetic vision, which is called "Synthetic Vision Avionics Backbone" or "SVAB," is an "information 'fusion' engine capable of merging data from various sources such as an infrared camera, visible light camera, millimeter-wave radar, and more," Wiebold explains. "SVAB fuses that real-time sensor with existing military databases, current navigation data, and other sources of flight information into an unparalleled visualization of the environment outside the cockpit."

SVAB has been rigorously put to the test in snow and dust during the past year, and Honeywell hopes to continue its self-funded efforts throughout 2017 by testing in rain and fog conditions.

"Our continuing research efforts are focusing on testing various sensors and integrating data and information into a synthetic view of an aircraft's surroundings, which is shown on a pilot's flight display," he says. "So far this has included testing a Honeywell millimeter-wave radar, light detection and ranging (LIDAR) sensors, and an infrared (IR) camera fused with existing terrain and obstacle data. The result was an 'out-the-window' view for pilots that allows for safer operations in DVE, which is a potential tactical advantage."

Honeywell's efforts are focused on determining the strengths and weaknesses of each sensor type, but – more importantly – on demonstrating the significant benefits of fusing all of the real-time sensor information with existing data.

Figure 1 | Rockwell Collins' Transportable Black Hawk Operation Simulator (T-BOS) meets high-fidelity training requirements and is also capable of being deployed to forward operating bases via ship, rail, military air, or road. Credit: Rockwell Collins.

"We've also recently been awarded a contract with DARPA [the Defense Advanced Research Projects Agency]," Wiebold notes. "As part of our research for DARPA's Multifunction Radio Frequency program, we'll program, update, and integrate our SVAB with an advanced radar on a U.S. military test helicopter. Safety is a top priority – we're working to ensure that flying within DVEs is as safe as possible and to provide warfighters with an advantage."

Evolution of synthetic vision

Synthetic vision systems use onboard digital terrain elevation to display "real-world" imagery of terrain along the aircraft's flight path in a manner quite similar to those pilots normally see and are trained to use as they fly.

"Information from databases of vertical obstacles – such as tall buildings, radio towers, wind turbines, etc. – may be added to provide additional insight into hazards at or near the aircraft's altitude," says Nick Gibbs, vice president and general manager of Simulation and Training Solutions for Rockwell Collins.

This information "increases the pilot's situational awareness and allows better decision making within the cockpit," Gibbs continues. "Our HeliSure Helicopter Synthetic Vision System (H-SVS) uses a three-arc-second (~10 meter) high-resolution base to deliver the most detailed display available today."

Synthetic vision systems are evolving as the embedded processing power of avionics continues to grow: "Greater detail in terrain-rendering capabilities, detail and content of obstacle databases, and presentation techniques enabled by processing will continue improving the imagery and alerting features of synthetic vision systems with a more realistic view of the outside world," Gibbs adds.

Is synthetic vision ready for widespread military use?

To date, the military has moved slowly toward adopting synthetic vision systems mainly because it tends to "focus resources on sensor applications for DVE," Gibbs says. "Synthetic vision systems rely on databases of information developed, verified, and loaded onto the aircraft before flight."

Unlike the highly controlled environments of civil flight, "operations must fly demanding missions within highly dynamic battlefield environments where an enemy can create new threats virtually overnight and safe operations require real-time information," he continues. "Beyond this, the military's need for operations from unimproved landing zones is a somewhat unique challenge with a greater likelihood of encountering a brownout or whiteout – emphasizing the need for sensor-augmented landing capabilities, which is something that synthetic vision on its own isn't good at."

The U.S. military is continuing its science and technology investments to develop solutions for DVE capabilities and may "be expected to field a solution within the next three to five years," Gibbs notes. "Once the technology issues surrounding systems for DVE are overcome, training for aviators will be addressed next as training systems – such as our Transportable Black Hawk Operational Simulators that are used extensively by the U.S. Army and numerous international services – are updated and new training programs are developed." (Figure 1.)

Honeywell's SVAB "continues R&D to set the foundation for insertion into military platforms," says Wiebold. "We're targeting several insertion points for our technologies into military systems. The key challenge, particularly for rotary-wing applications, is size and weight. As part of our effort, we're continuing to enhance the system to meet

the performance requirements while reducing size and weight. We see several potential opportunities within the next one to three years for insertion."

COTS and synthetic vision

Are Honeywell and Rockwell Collins tapping COTS for their synthetic vision systems? In essence, yes.

The synthetic vision system that forms the foundation of Honeywell's SVAB product "is already used by business jets around the world," Wiebold says. "We customize the synthetic vision system for military use with military databases and real-time sensors and input into rotorcraft, but the basic foundation of the system uses a large majority of COTS components."

For its part, Rockwell Collins "relies heavily on COTS processing components in our display and mission-computing products that support synthetic vision capabilities," Gibbs notes. "General-purpose processing and graphic processing units are used for hosting the highly computationally intensive H-SVS applications. Our Flight2 systems also use COTS Ethernet components, along with high-integrity traffic management software to manage latency and the integrity of data communications between database storage devices and processing components." (Figure 2.)

Figure 2 | Flight2 transformed a federated system – one using distributed avionics functions packaged as self-contained units – into a modern digital system by providing commonality with commercial aircraft. Credit: Rockwell Collins.

Open architectures/FACE standard

Are synthetic vision systems embracing open architectures such as the FACE technical standard? Yes, and they play a central role.

It's worth noting that Rockwell Collins was the first to field fully open system architecture (OSA) systems with the U.S. military. "Our Flight2 flight deck on the U.S. Air Force's KC-135, USCG HC-144, and the common avionics architecture system (CAAS) that was widely fielded on the U.S. Army's Chinook helicopters in early 2000 guided a change within the military avionics industry," Gibbs points out.

Several of the characteristics and features of the OSA approach used in Rockwell Collins' Flight2 and CAAS systems have been adopted by the current FACE standard.

Rockwell Collins recently announced "certification of a fully FACE-compliant application – providing required navigation performance (RNAV) capabilities for military fixed- or rotary-wing aircraft," Gibbs says. "We're currently developing more FACE-aligned offerings in support of the U.S. Army's initiative to use the FACE architecture as their common operating environment for aviation."

Honeywell is equally committed to open architectures. "A major priority for our SVAB unit was that it be platform- and sensor-impartial," Wiebold says. "The solution should be one that operators want to put on every type of helicopter – and use various and multiple sensors, regardless of whether it's for commercial or military use. SVAB is meant to receive information from different sources, no matter what created the information. It's open so it can adapt by taking in that information, and the system displays a highly accurate representation of what's actually going on outside."

Honeywell was heavily involved with the FACE Consortium and the creation of its technical standard. "We've won every S&T [science and technology] contract offered by the government focused on the reference architecture demonstration, which includes meeting the FACE standard," Wiebold notes. "Honeywell has also conducted internal research programs to study the necessary steps to make a key product – a navigation system – FACE-compliant."

Avionics safety-certification challenges

Are avionics safety-certification challenges – or a lack of established requirements – slowing adoption of synthetic vision systems by the military? It's part of the holdup, but is being addressed right now.

"All DVE systems must meet similar certification challenges as other avionics systems," Wiebold says. "Safety levels and their requirements are under discussion, and Honeywell is involved in several studies to address certification and validation standards."

Rockwell Collins has already certified multiple synthetic vision systems within their Pro Line Fusion system for business and regional aircraft, as well as for its HeliSure HS-SVS for AW169, AW189, and AW101 helicopters. "It'll be more difficult, but possible, to certify synthetic vision and other DVE-related systems for the full spectrum of military operations," Gibbs says.

This work is well underway. The U.S. Army is working with its counterparts within NATO to develop recommendations for performance and design requirements focused on safety certification. "NATO has sponsored an industry advisory group to study this specific problem and to provide recommendations," Gibbs adds. "Rockwell Collins is an active member of this group, bringing our expertise certifying safety-critical components and systems for both civil and military applications to help solve this problem." **MES**

Next-gen aviation systems see push for automation, multicore processors in the certification process

By Mariana Iriarte, Associate Editor

F-16 Fighting Falcons demonstrate an "Elephant Walk" as they taxi down the flightline at Kunsan Air Base, South Korea. Photo courtesy of U.S. Air Force/Staff Sgt. Jonathan Fowler

As the complexity of aviation systems rises, certifying safety-critical systems in manned and unmanned aircraft has pushed engineers towards automation and working in parallel to increase the efficiency of the process. Multicore processors are playing a major role in this push, along with added tools to ease the process. However, challenges remain as the Federal Aviation Administration (FAA) and European Aviation Safety Agency (EASA) work toward streamlining the process.

The complexity of systems has grown exponentially over the years, pushing the industry to look for ways to make the process more efficient.

In fact, "The sheer complexity of next-generation systems is demanding that suppliers need to provide more than raw hardware and software to systems integrators – they also need to provide safety certification artifacts to enable the rapid integration and certification testing of systems," says Chip Downing, senior director of the aerospace and defense unit at Wind River in the San Francisco Bay area.

In response, designers are using automated tools to ease the certification process in unmanned and manned aircraft. "The use of automated tools in the life cycle of a system is a dramatic change," says George Romanski, president and CEO of Verocel, Inc. in Westford, Massachusetts. That's because "the standards require a very rigorous approach to certification. You have to produce requirements and review those requirements, produce design, review the design, produce code, review the code, and so on. In a typical system, we'll have thousands of artifacts and these artifacts have to be developed and they have to be reviewed and we have to make sure that these requirements are sound and fit well to each other."

The process is becoming quite unrealistic. "Keeping an Excel spreadsheet of the massive number of requirements and derived requirements is very cumbersome and tedious," says Rick Hearn, product manager at Curtiss-Wright Defense Solutions in Ottawa, Canada. "Any automation that you can put in place through software tools to be able to trace all of those requirements, both up and down through the life cycle, the better off you are."

Designers are certifying safety-critical systems in phases: "What most people are trying to do is to start working in parallels so you can have requirements, you may have five thousand requirements, and a thousand of them might be ready so you can start implementing those, but another four thousand are still being developed, and while you've developed the design, now you can start doing implementation," Romanski explains. "In other words, you start overlapping these processes and if you manage the information very tightly, then it's possible to make this process much more

efficient. To do this, it requires use of a database, it requires linking that database to a configuration control system, and it requires very tight baseline."

The process also requires automated authentication, he adds. "People can now review within the database and you can maintain the whole development process for the whole project, and you can have distributed teams working on this concurrently."

"The magnitude of the testing that has to be done on these systems because of the complexity is growing exponentially and there has to be automation for that testing," says Scott Engle, director of business development at Mercury Mission Systems, in Tucson, Arizona. "There's no way that one could do this manually."

Romanski explains that Verocel's VeroTrace manages and controls all life cycle data including requirements, design, source code, test cases, results, documents, and more. More importantly, VeroTrace manages the states of each life cycle data item and provides traceability links between each item to satisfy a number of standards including DO-178C, IEC61508, and ISO26262. (See Figure 1).

> "ANY AUTOMATION THAT YOU CAN PUT IN PLACE THROUGH SOFTWARE TOOLS TO BE ABLE TO TRACE ALL OF THOSE REQUIREMENTS ... THE BETTER OFF YOU ARE."
>
> – RICK HEARN, CURTISS-WRIGHT DEFENSE SOLUTIONS

The rise of the multicore processor

The enabling factor will be the use of multicore processors. The move away from single-core processors and towards working in parallel has grown over the years to the point that "there is an interest to certify multicore processors for safety applications," says Greg Tiedemann, Director, PLM & BD, Mission Systems Group, Mercury Systems, in New York City. "From a safety perspective, it's easier to certify when you just have one processor. It's a bit more challenging when you have multiple processors working on the same application. The demand for that really is pretty straightforward. You see it in other markets as well and in other parts of Mercury. We've adopted multicore because of the efficiencies that you gain in processing and power and just general SWaP [size,

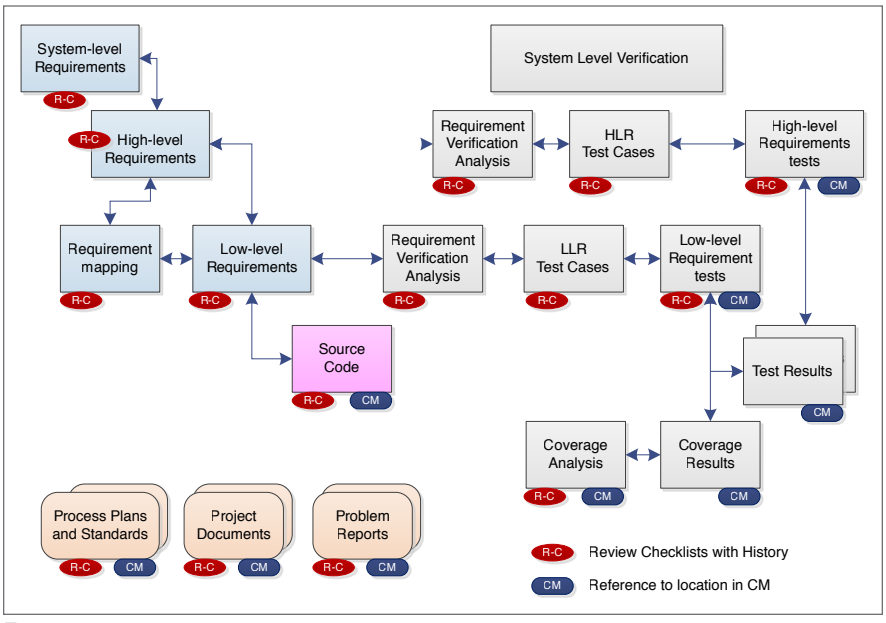

Figure 1 | Verocel's VeroTrace database can be exported to a DVD ROM that allows hyperlinked browsing of all data and documents. Courtesy of Verocel.

Unmanned aircraft certification challenges

The industry understands how to enable safety certification for manned aircraft – fixed and rotary, commercial and military – but enabling such reliability on unmanned platforms remains a challenge.

"Unmanned systems are kind of hard because we still don't have a full understanding of how to certify them," says George Romanski, president and CEO of Verocel, in Westford, Massachusetts. "They are using DO-178C for aircraft components and aircraft systems, but even the FAA hasn't fully found a way of certifying the unmanned vehicles. For the small ones it's easy, class one and class two, they are light, they're simple."

Calling these platforms unmanned may also be inaccurate, say some. "There really aren't any unmanned aircraft," says Greg Tiedemann, Director, PLM & BD, Mission Systems Group, Mercury Systems in New York City. "At the end of the day, a UAV [unmanned aerial vehicle] is manned, it's just the person isn't in the aircraft. Rather, they're on the ground. That's a big difference. That's important because even though UAVs are flying around up there, somebody's controlling it. There is a level of safety that's already in the system. The person is making a decision on whether to turn left or turn right and they can see ahead of that there's another aircraft that must be avoided, whatever it might be."

Sidebar Figure 1 | Mercury Mission Systems' Rock 2 for C4ISR applications. Photo courtesy of Mercury Mission Systems.

On the one hand, "the challenges are going to be when the UAVs are taking data from the sensors in the UAV, and then the UAV is going to autonomously decide what to do based on that sensor data," he continues. "You can draw some similarities to what's going on in the automotive market today, where you've got sensors in a high-end Audi or a BMW or a Tesla. You don't see that completely in the UAV market today, but that could be coming, where some sensor data in the UAV is going to decide whether the aircraft climbs or turns or does something dramatic to avoid collision or steer to a particular mission or whatever they're going to do."

Mercury Missions Systems offers the Rock-2 (see Sidebar Figure 1), a 3U OpenVPX, safety-certifiable, processing subsystem for avionics and command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) applications.

The real challenge will be with military certifying unmanned aircraft. "The military had a pass for a little while for UAVs, and that is starting to end now, so the challenge is that the military now has to adopt the civil requirements," Romanski adds. "They have to meet the DO-254 and DO-178C requirements. They have to generate that much more documentation and they can't self-certify anymore, so they'll have to get the FAA involved."

The certification process for military and civil aircraft are similar "in that the military side tends to use DO-178C for certification except where the FAA says, 'you must use DO-178C or equivalent,' he continues. "The military then makes their own assessment as they look through the materials."

With a number of military projects under Verocel's belt, the DO-178B or DO-178C were called out as a requirement. "So we developed everything as if it was for the FAA, but now the aircraft certification office from the military site takes a look at this, and then they say, 'Yep, good enough. Yeah, we like it.' And then they sign off," Romanski explains.

"DO-178C has a pedigree, it's been written and developed and we follow what the good book says," he adds. "On the military side, some programs are very true to the interpretation of DO-178C, but what I found is some other programs tend to say, 'well it's good enough, it's okay. If it's cheaper you don't have to do this part.' That's a little bit disappointing at times."

The military does not mandate DO-178C, but they require the equivalent processes and activities of DO-178C, Romanski continues. "In fact, one of the things that is currently used, that the FAA uses, is an SOI, Stages of Involvement. During the audit, they will use the SOI checklist to make sure that all of the requirements of the DO-178C has been completed. The military uses the same SOI checklist. Now we don't like it, or at least I don't like it, because I think it draws out a 'checklist' mentality, but we find that the auditors much prefer to use a simple checklist because it makes their job easier."

In the long run it will be up to the lawmakers to give the public confidence that UAVs can fly safely in civilian space with commercial aircraft. "I think we, as a society, really haven't yet addressed how to integrate unmanned vehicles of all types," says Scott Engle, director of business development at Mercury Mission Systems, in Tucson, Arizona. "I think the legislation is woefully behind the technology at this point."

weight, and power] requirements. You can do a lot more in a smaller space."

"The trend is toward multicore, but it's also a trend for much higher complexity in the systems," Engle clarifies. "Back when we had federated aircraft design where the avionics were single-purpose, special-purpose boxes located throughout the aircraft, and now with consolidation and Integrated Modular Avionics (IMA) onto much fewer number or pieces of equipment, and now adding multicore on top of that, these systems are getting incredibly complex. With that complexity is just a lot more potential for error."

The industry has struggled to create viable multicore safety solutions for the past ten years. "We have struggled because we have tried to apply the same test and examination processes we used in single-core processors to multicore designs," Wind River's Downing explains. "When using a single-core processor, that memory management unit (MMU) was very good at creating memory-protected partitions; when coupled with a robust scheduling foundation, this was a low-risk path to certification.

"In multicore environments, the use of an MMU on one to many cores simply cannot manage all of the resources that need to be controlled in a safety-critical solution," he adds. "In the future, multicore safety solutions must use a capability called 'hardware virtualization assist.' This capability creates and manages all resources for virtualized partitions/containers/virtual machines (VMs) that cannot be done reliably by software alone. Hardware-assisted virtualization creates another, more powerful, more reliable, more encompassing separation environment that resolves many of the issues with trying to use MMU-based separation and processor/driver controls of single-core systems."

In spite of this progress, "the use of multicore processors is not quite ready for deployment, because of a number of challenges," Tiedemann states. "However, there's generally a lot of interest in it. I think it's a significant trend in the market that we're tracking very closely to make sure that we're ready to take advantage of it when the solutions are there to support it."

"Hardware-assisted virtualization creates an opportunity to do more," Downing points out. "First, it adds an execution envelope that controls the processor and board resources so operating systems (OSs) running in these virtual machines can run as if they control the entire processor. This virtual machine can also be allocated on one to many cores, providing another level of separation and abstraction.

"Additionally, each core can use the MMU for separation of tasks/threads on each core, creating multiple levels of separation," he adds. "Virtual machines also enable the use of unmodified guest-OS execution environments, enabling the insertion of both embedded and enterprise OSs, like Linux, on a shared compute platform.

Finally, with virtual machines controlling and separating the computer/board resources, this technology creates very good packaging for supporting mixed safety-criticality environments, providing hardware-controlled access to shared board/devices."

A holistic approach to streamlining the process

The growing interest in using automated tools and multicore processors comes at a time when increasing numbers of unmanned aircraft are taking to the national airspace.

To address those challenges, the Federal Aviation Administration (FAA) and the European Aviation Safety Agency (EASA) are working to streamline the process. "There is a trend for an increase in FAA and EASA alignment," Hearn states. "They're calling it 'harmonization.' What we've seen in the past is that the EASA and the FAA have much the same set of rules for certification but they tend to differ in their implementation. Increasingly, though, we're seeing rules being harmonized through the standards bodies and through some of the meetings that they have between the two certifying bodies."

The FAA has "a set of overarching principles that they've been discussing to streamline the overall certification process," Romanski says. "They're looking at it from a more holistic perspective and more of a system perspective rather than the very prescriptive rules that they set out in DO-178B and DO-254."

The process began about a year and a half ago with a group of people working for the FAA, EASA, and other certification agencies. "We are developing a new streamlined approach for certification," he adds. "This is only a start and the current version was published in September, and we are continuing to refine it, but this is a process where we are trying to meld together the system standard, ARP4754A; the software standard for DO-178C; and the complex hardware standard for DO-254.

"Together the overarching properties will try to meld the essence of the other standards so that you can develop certification evidence using these overarching properties, instead of the traditional ones like DO-178C. It's still in the early stages, but this way gives users more flexibility on how to approach certification," Romanski says. "The other approach the FAA is taking is trying to work out a risk-based software certification process, especially for the smaller aircraft, the general-aviation aircraft. What the FAA has found is that in these general-aviation craft, there are new devices coming onboard, which should be certified because they are safety-critical; the problem now is currently you can either fly without these devices, or you can put these devices on the plane to make the small planes safer." **MES**

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Formal program verification in avionics certification

By Yannick Moy

A C-130J Super Hercules from Dyess Air Force Base, Texas, lands at Donnelly Landing Zone, Alaska, as part of an exercise in Alaska during October 2016. SPARK was originally used to design the control software on the U.S. and U.K. military's C-130J aircraft. U.S. Air Force photo/Master Sgt. Joseph Swafford.

Five years after the official adoption of the new DO-178C/ED-12C standard and its supplements, including the DO-333/ED-216 supplement on formal methods, no avionics-certification project has yet acknowledged using this new supplement. However, formal method technologies do exist that would ease the development of avionics software.

A major roadblock preventing the adoption of formal program verification for avionics certification is the absence of a general consensus on how to apply DO-333/ED-216, despite significant dissemination efforts from the committee that developed it. There now exists a detailed process for the use of SPARK to satisfy objectives of DO-333/ED-216 as a replacement for certain forms of testing, with a focus on checking that the source code is consistent, accurate, and complies with low-level requirements.

The process addresses the alternative objectives for coverage when using formal methods and the objective of property preservation between source code and executable object code. The former is required when some testing is replaced by the use of formal methods. The latter is required in order to benefit from source code verification of executable object code. This process has been discussed with both the Federal Aviation Administration (FAA) and European Aviation Safety Agency (EASA) for future applicants using SPARK in DO-178C/ED-12C.

Formal methods in avionics

Although the addition of a formal methods supplement in version C of DO-178 is somewhat recent (2012), the use of formal methods to develop avionics software dates back to the 1990s at least, when John Rushby wrote a thorough guidance document about their use for the FAA. ["Formal Methods and the Certification of Critical Systems," Rushby, FAA, 1993.] While Rushby focused on deductive methods, increases in automation and computer power since then have made two other kinds of formal methods attractive to develop avionics software: model checking and abstract interpretation. DO-333 specifically addresses the use of these three categories of formal methods for developing avionics software. Examples of use of all three categories are presented in a NASA report from 2014 ["DO-333 Certification Case Studies," Cofer and Miller, Rockwell Collins, 2014.]

While abstract interpretation and model checking are well-suited to check simple program properties across a codebase with minimal human intervention, they suffer from the so-called state explosion problem, when the size of the model analyzed (whether supplied explicitly in model checking or constructed by the tool from an abstract interpretation) is too large for analysis to complete. Deductive methods do not suffer from these drawbacks, but they have the cost of requiring users to write function contracts. These contracts are (partial) specifications of the function behavior that define both the objective for verification and a suitable summary of the function behavior for analyzing calls to that function. This allows deductive methods to apply

powerful verification techniques that can prove non-trivial properties of software, because function contracts enable the focus to be on the verification on individual functions, one at a time.

Two toolsets provide formal program verification based on deductive methods for industrial users of C and Ada: the Frama-C toolset for C programs and the SPARK toolset for Ada programs. Both have been used in the context of DO-178 avionics certification. For example, Lockheed Martin initially used SPARK in 1997 for the control software of the C-130J U.S. military and U.K. Royal air force aircraft. BAE Systems has since used SPARK to prove critical properties of the C-130J control software during maintenance. As another example, one which is documented in DO-333, Airbus used Caveat (the predecessor to Frama-C) in 2002 to prove low-level requirements on the Airbus A380 civilian airplane, as a replacement for unit testing.

Verification objectives addressed

SPARK can be used as the primary source of evidence for many verification objectives in DO-333, from low-level requirements (LLR) to source code and executable object code (EOC). Formal verification is a particular case of analysis, hence the guidance needed for applying formal analysis to LLR and source code is simply the criteria and conditions for the use of formal analysis. ["Guidance for Using Formal Methods in a Certification Context," Brown et al., SC-205/WG-71, ERTS 2010.] Usage in the EOC requires more justification, particularly when replacing unit tests.

When LLR are expressed as contracts in SPARK, the formal notation guarantees that LLR are precise and unambiguous, so accuracy is guaranteed. Consistency is also guaranteed because contracts on distinct functions cannot conflict. Contracts are also verifiable and conform to a (programming language) standard by design. These cover objectives 2, 4, and 5 of table FM.A-4 from DO-333. (op. cit. Cofer and Miller.)

One of the main resources of SPARK is that it automatically shows that the source code complies with LLR expressed as function contracts. Function contracts can also express data dependencies and the SPARK toolset can show automatically that source code complies with this part of software architecture. SPARK code is verifiable and conforms to a (programming language) standard by design. The source code of a function is implicitly traced to the LLR expressed in the function contract. Finally, SPARK code is unambiguous, so the consistency of the source code can be analyzed automatically to show that it is free from reads of uninitialized data, arithmetic overflows, other runtime errors and unused computations (variables, statements, etc.) These cover objectives 1 to 6 of table FM.A-5 from DO-333.

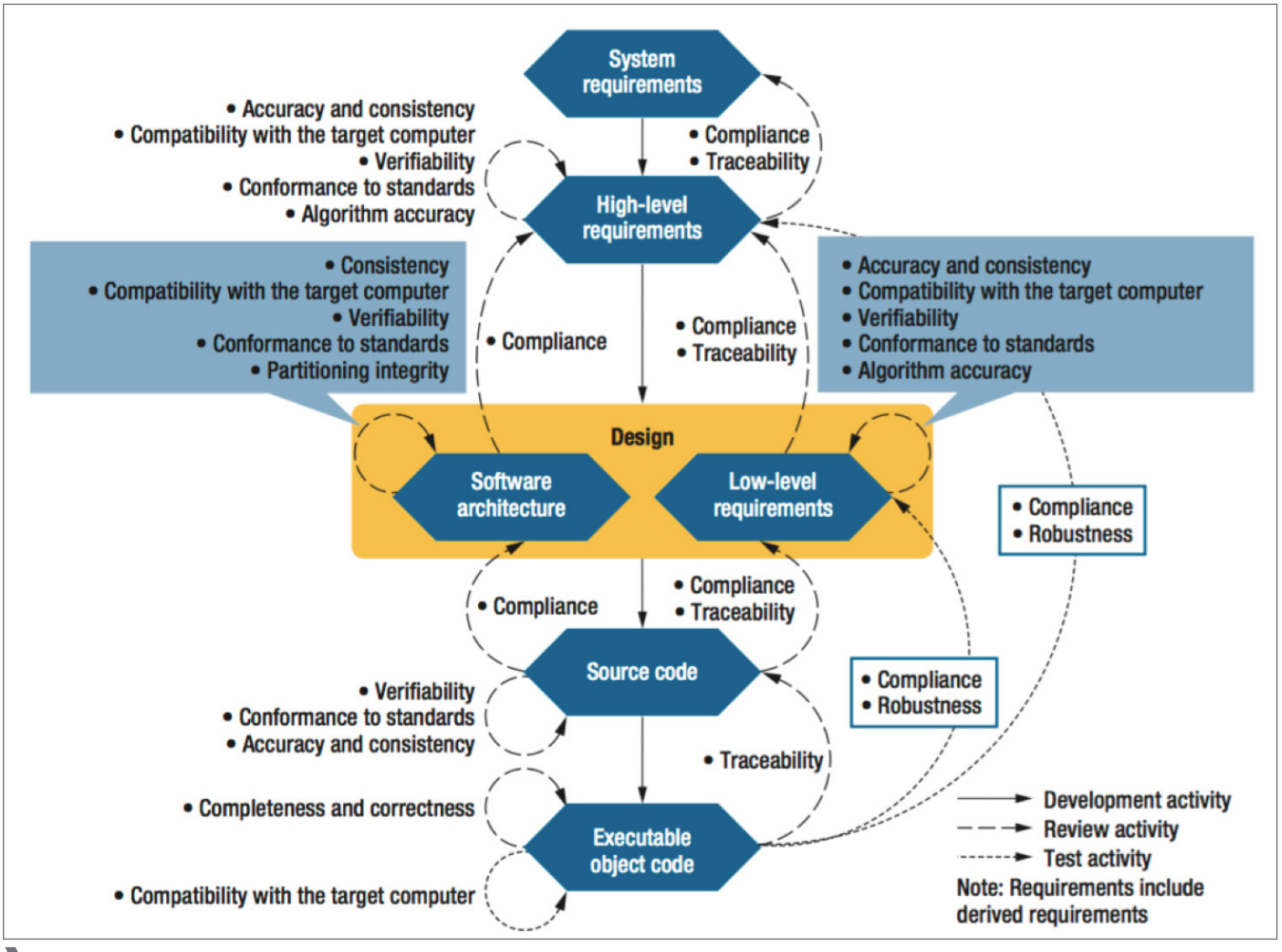


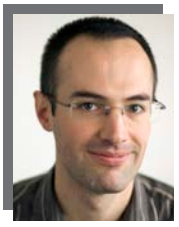
Figure 1 | DO-333 verification activities. Graphic courtesy IEEE.

The objectives of compliance and robustness of EOC with respect to LLR (objectives 3 and 4 of table FM.A-6 from DO-333) can be addressed by relying on corresponding objectives for source code, provided one also provides a demonstration of property preservation between source code and EOC. One way to show property preservation would be to demonstrate with reasonable confidence that in all possible cases the compiler preserves the semantics of programs from source code to EOC. Unfortunately, no reasonable approach seems to be able to provide that confidence. By running integration tests in a mode where contracts are executed in SPARK, the user can be confident that the compiler properly preserved the semantics of source code in EOC; if it did not, the contracts proved in individual functions would have (with very high probability) failed during integration tests. By running integration tests both with and without contracts being executed and checking that the outputs are identical, the user can be confident that compilation of contracts does not impact compilation of code, because otherwise the outputs would most probably be different on some tests.

Of course, a major benefit of using SPARK is the ability to replace unit tests by SPARK analysis. In such a case, DO-333 also defines additional objectives 5 to 8 of table FM.A-7. A combination of formal verification and reviews can address these objectives, as demonstrated by past experiences at Airbus and Dassault Aviation. ["Testing or Formal Verification: DO-178C Alternatives and Industrial," Moy et al., IEEE Software 2013.] Several features of SPARK are in use here, such as the ability to state data dependencies in function contracts and the possibility of expressing function contracts by disjoint cases.

Coming up

Formal program verification toolsets have been used by a few pioneers since the 1990s. Progress in automation of formal program verification in the certification of avionics software now makes these techniques accessible to more companies. SPARK enables users to address many of the verification objectives defined in the Formal Methods Supplement DO-333 of DO-178C. Certification authorities in the United States and Europe are now looking favorably at applicants who use such methods in avionics certification. **MES**



Yannick Moy *is the SPARK product manager at AdaCore. He has led the development of the SPARK language and tools since 2010, and he supervised the major technology revision resulting in SPARK 2014. Previously, he worked on software source code analyzers CodePeer, Frama-C, and PolySpace Verifier C++. Readers can contact him at moy@adacore.com.*

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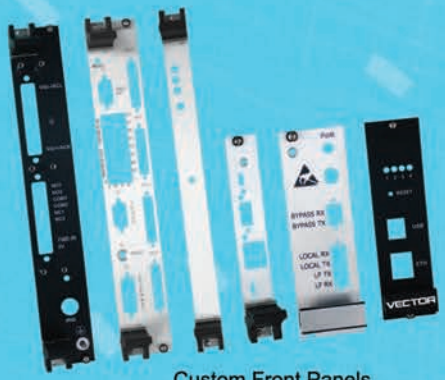

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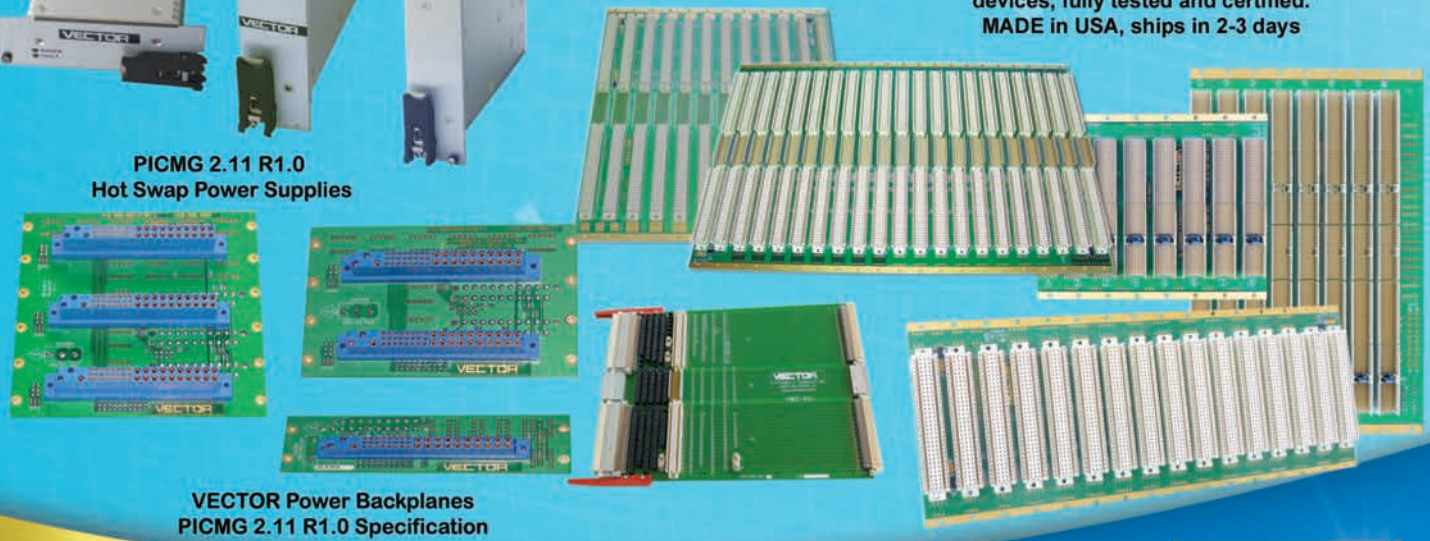

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Avionics data bus users demand more reliability and flexibility

By John McHale, Editorial Director

New and old military aircraft platforms are continuing to embrace high-speed networks in their new avionics data bus selections, choosing protocols such as high-speed Ethernet and ARINC 429. Meanwhile, MIL-STD 1553 continues to live on in new designs and sustainment contracts despite its slower speeds.

Photo courtesy U.S. Air Force.

Reliability and flexibility in design are what military avionics integrators want from a data bus solution, whether it is MIL-STD 1553 or 40 GBit Ethernet. While this is a commercial off-the-shelf (COTS) market, avionics data bus users typically want the flexibility to tweak the COTS offerings for their specific needs from size, ruggedization, and cost perspectives.

"Both legacy and new-design aircraft are adding modern, high-speed networks where the requirements and the cost fit within the customers' budgets," says Mark Grovak of Curtiss-Wright Defense Solutions. "For new aircraft, it's a no-brainer to go to 1 or 10 Gb Ethernet networks as they are laying out the wiring in a new aircraft. For legacy aircraft, the math is harder because of the additional cost of rewiring a legacy aircraft with the wiring that supports faster data rates."

"Proven reliability is a key factor in the selection of an avionics data bus solution," says Michael Hegarty of Data Device Corp. (DDC). They also want flexible options when it comes to make or buy, he adds. For example, he says, leveraging "COTS board-level solutions or chip-level solutions that can be used to design custom cards."

Popular protocols

Flexibility is also important when it comes to protocol support, Hegarty notes, with designers wanting the option to go with MIL-STD 1553, ARINC 429, CANbus, RS232/485, discrete I/O, or the like, as well as network-attached solutions using Ethernet or USB.

"One of the most popular commercial avionics data bus solutions today remains ARINC 429," says Jon Neal, vice president and general manager, Astronics Ballard Technology. "This is commonly used for new avionics displays and systems that are retrofitted onto military aircraft."

Hegarty says that ARINC 429 "continues to be used for commercial aircraft, although the use of ARINC 664 Part 7 appears to be increasing in those commercial aircraft applications."

Fibre Channel still has market share in many military avionics applications that called for faster speeds than 1553, says Jack Staub, president of Critical I/O. Now many of their customers are also moving toward Ethernet solutions, he adds. One of Critical I/O's Fibre Channel offerings is the FCA2540-XMC family, which has two copper or optical interfaces and offers two independent channels of 8/4/2/1 Gbps Fibre Channel in an XMC form factor with PCI-Express host interface.

For its part, DDC offers the ACE Extreme family of products for flexible avionics I/O solutions: A chip-level solution (Total-ACE Extreme), a board-level solution (ACE Extreme boards are available as PMC, XMC, PCIe, Mini-PCIe, and other form factors),

or a box-level solution. All ACE products share a common software platform.

Ethernet, Ethernet, Ethernet

"The use of Ethernet as a data plane within mission systems appears to be increasing," Hegarty says. "Historically, Ethernet has had two main drawbacks – the lack of 'determinism' and the overhead associated with the TCP/IP protocol. Both of these factors limit the real-time performance of Ethernet as compared to FibreChannel. There are some new real-time extensions to Ethernet, but their use in avionics is very limited."

Grovak says he sees growing demand for Ethernet, as it's the 1 Gb and 10 Gb Ethernet that are the main new data buses that Curtiss-Wright's customers are requesting. "As the processing capability on aircraft continue to increase, the need for faster networks to move the resulting information around the aircraft will also increase. We see Ethernet as it increases from 10 GbE to 40 GbE and beyond as the main road map. Legacy applications of 2 Gb FibreChannel on F-35 and F/A-18 will be used for the foreseeable future because of the fiber-optic infrastructure in place."

MIL-STD 1553 demand still strong

As mentioned above, reliability is the key demand from every avionics data bus customer, and what's more reliable than 1553?

"There are a number of factors for the continued use of 1553," Hegarty says, starting with the fact that the vast majority of legacy aircraft are using it for command/status between major functional subsystems. Replacing 1553 with an alternative bus would require replacing every electronics box connected to the buses; many existing systems on the platform "don't need higher bandwidth so it is not worth the investment to replace 1553 with a different technology. [It is a] bulletproof data bus. Other data buses may be faster, but they do not provide similar robustness in terms of their tolerance to electromagnetic effects."

For modernization and technology upgrades. 1553 has become indispensable for translating signals. "For technology-insertion and aircraft-upgrade programs, new 1553 interface equipment is vital for translating data bus signals to other protocols and networks [such as ARINC 429, Ethernet, CANbus] in order to extend the life of current aircraft and add functionality, while avoiding costly rewiring to change networks," Neal says. Astronics Ballard Technology offers the rugged AB3000, an airborne computer optimized for processing data between various avionics data buses (MIL-STD-1553, ARINC 429, etc.) and other links such as Ethernet and RS-232. (Figure 1.)

"Eventually, the transition of command/control to Ethernet data transfer buses will occur, enabled by the incorporation of enabling standards within Ethernet such as Precision Time Protocol version 2 (IEEE 1588-2008), Time Sensitive Networking, and other optimizations," Grovak explains. "In the meantime, phased migration will occur – as the LRUs are replaced, Ethernet will be available on new hardware alongside 1553, giving platform architects options for changeover at a future point when fewer and fewer legacy LRUs are solely dependent on the existing 1553 cabling infrastructure on a platform."

Another company finding success with MIL-STD 1553 products is North Atlantic Industries (NAI), which offers the MIL-STD-1553B – Dual Channel/Dual Redundant module that provides dual-channel, dual-redundant MIL-STD-1553B Notice 2 interface channels within multifunction embedded boards.

Immortalizing 1553

Some things are certain in life, such as death, taxes, and – it appears – 1553, as there are initiatives underway to give the venerable standard a touch of immortality and of course more speed.

"An important effort to extend the life of the 1553 cabling infrastructure is underway," Grovak says. "In 2016, STANAG 7221 was released by NATO and was driven by an international effort over the last five years to standardize a high-speed data bus technology that could operate concurrently on the MIL-STD 1553B data bus without impacting the MIL-STD 1553B signaling and without modification to the existing data bus infrastructure. STANAG 7221 has been successfully validated in both fixed- and rotary-wing platforms."

Figure 1 | The AB300 from Astronics Ballard Technology enables processing of data between various avionics data buses.

Avionics data bus testing

Military and commercial end users also want flexibility in data bus test solutions: "Our military customers are consistently looking for avionics data bus solutions that are secure and reliable for both embedded and test applications," Neal says. "Typical applications include operational systems, protocol translation, and data bus test, simulation, and troubleshooting."

"Open architectures and flexibility of functionality of FPGA [field-programmable gate array] FW [firmware] and APIs [application program interfaces], with the APIs common across operating systems and board types; also, real-time support (pre- and post-sale) is a key component of what they are expecting," says Abaco Systems' Ben Daniel. "As hosts move to current tech, there is an obvious migration from PCI to PCIe, both in rackmount/desktop hosts and in PMC to XMC migration for embedded applications. In parallel, the host operating systems are constantly updating, so there is a continuous migration to support those. Again in parallel, new designs take advantage of the latest available components, so the capability versus footprint and price benefits the market. There is also an increase in interest around small-form-factor applications, not just in low SWaP [size, weight, and power] systems – VPX and the like – but in nontraditional, very small systems for embedded applications." Abaco Systems offers the R15-MPCIE two-channel 1553 board with discretes and the RAR-MPCIE 8RX/4TX ARINC 429 board with discretes. **MES**


Jim McElroy

Getting the requirements right in avionics safety certification, FACE compliance, and certifying UAVs

By John McHale, Editorial Director


An MQ-9 Reaper takes off on a mission in Afghanistan. The MQ-9 has nearly nine times the range, can fly twice as high, and carries more munitions than the MQ-1 Predator. (Air Force courtesy photo.)

In this Q&A with Jim McElroy, vice president of sales and marketing at LDRA, he discusses how poor requirements can doom avionics certification efforts, common mistakes engineers make in this process, Future Airborne Capability Environment (FACE) compliance, and certifying commercial off-the-shelf (COTS) hardware to Design Assurance Level A for avionics safety certification. He also speaks about how certifying unmanned aircraft to fly in civilian airspace may require a new mindset for everyone involved. Edited excerpts follow.

MIL-EMBEDDED: ***Please provide a brief description of your responsibilities at LDRA and your group's role within the company?***

MCELROY: I manage a sales team here in the U.S. and marketing for the company as a whole. As a relatively small and focused company, we have lots of moving parts and being nimble and responsive to our customers is critical to our success.

MIL-EMBEDDED: ***LDRA is heavily involved in enabling safety certification of avionics technology to DO-178B & C and DO-254. What are the most common mistakes engineers and companies make in the certification/requirements process?***

MCELROY: Most mistakes occur from having poor requirements, which then affects the cost of software rework. The cost of software rework is a key business driver for our customers and they need to improve how they develop and verify their software. On the verification side of things, people don't plan well enough for testing, which stems from a lack of commitment to proper requirements definition and functional safety requirements. During their overall software development life cycle, they do not put enough time and effort into setting up and using proper software quality and test applications, which makes it hard for them to be competitive.

In the DO-178 world in particular, many of the suppliers frankly don't understand the requirements of the standard as they pertain to object code verification and data and control coupling, which ultimately leads to problems down the line toward integration testing. They need to leverage automation technology to address these requirements in a cost-effective manner.

Customers also need to view requirements from a behavior and security perspective. For example, if a requirement changes at the functional or security level they need to ask: What will be affected downstream in the life cycle by that changed design or changed code? Similarly, in the reverse direction, what if that piece of code needs to change? What is the impact of that change? What tests need to be rerun? They

need to know where it comes from and where it may go long-term in the design. It's important to get a 3-D picture so that you also look at it from different perspectives such as the viewer standpoint.

I also don't think a lot of companies to this day understand transparency in the bidirectional process requirement for high-assurance software. This is a fundamental concept, which ties into the above. At any point in the life cycle, developers and auditors should be able to easily poke in and understand the decision process on why a change was made and where it came from. Has it been properly tested? Where is the proof? Fundamentally, it is important to be able to see into the process at all phases of the development life cycle. Proof is provided through transparency, and this is important in the software qualification and certification process.

MIL-EMBEDDED: ***There has been discussion at various industry events over certifying COTS hardware Design Assurance Level (DAL) A. Do you see this eventually happening or are the requirements to stringent for off-the-shelf equipment to make that leap?***

MCELROY: I think at this point it will get to a maturity level where we are there. A big driver that may limit it is the IP issue. For suppliers to maintain a competitive stance, they will not want give up their IP.

The reality of the matter is that software has come so far, in particular software rework, and it will be the same thing with the hardware side. Not only has the process been well-defined overall, but reuse of components in the process has also become better defined. The next challenge here will be ensuring security in these devices. The reality is that many systems use parts from all over the world and not always with proper traceability so security should be a real concern.

MIL-EMBEDDED: ***How do your military avionics customers differ from those of your commercial avionics customers in terms of their requirements? Or are they quite similar?***

MCELROY: Over time, they're getting more similar. Historically, the defense customers have not had the requirement to put the same level of rigor into the software development life cycle because they were not concerned with standards like DO-178C. However, now, for example, with both commercial- and defense-related UAVs [unmanned aerial vehicles] entering commercial airspace, there is more demand for high-assurance software, and DO-178C sets the standard. As a result, defense customers are now more interested in following standards like DO-178C. At the same time, they are trying to produce software that can be leveraged on multiple platforms to save time, effort, and money. The Future Airborne Capability Environment (FACE) is the perfect example of this, where military branches like the Army and Navy are focused

on building high-assurance reusable software for the future.

Security is a very real concern for both our commercial and defense customers from both the hardware and software perspectives. Our customers are looking for assistance in building secure software and hardware, and this needs to be built into systems from the ground up. There are many aspects to security, but the bottom line is that both commercial and defense customers are looking for best practices in developing secure software and hardware.

MIL-EMBEDDED: ***What challenges remain for certifying avionics hardware and software for unmanned systems? Are the safety certification rules the same as for manned aircraft or do new regulations need to be developed?***

MCELROY: When it comes certification and regulations for UAVs, there needs to be a paradigm shift in terms of mindset to accommodate differences in decision making on the ground versus in the air. It needs a different perspective. The control logic in the UAV needs to adhere to rigorous software development processes, which need to incorporate where the decisions that are being made. The experts in the avionics and regulatory world are working hard to address the very real concerns of mixing UAVs into the commercial airspace. Personally, I believe the regulations for UAVs that fly in these spaces need to adhere to the same levels of assurance.

OEMS AND SUPPLIERS OF TODAY'S AVIONICS SYSTEMS NEED TOOL VENDORS TO GIVE THEM BETTER METHODS OF DEVELOPING TODAY'S COMPLEX SYSTEMS SAFER AND FASTER. TO BE COMPETITIVE, THEY MUST USE AUTOMATION AND LEVERAGE TODAY'S DEVELOPMENT AND VERIFICATION TECHNOLOGIES TO PRODUCE HIGH-ASSURANCE SOFTWARE FASTER AND AT A LOWER COST.

MIL-EMBEDDED: ***How does the FACE standard enable safety certification?***

MCELROY: I think the FACE organization is doing a tremendous job, from the standpoint of setting the standard for software interoperability and the verification process for those software components. From the safety-certification perspective, I would say that FACE is implicitly being drawn into the safety-certification process.

Airworthiness, although not at the head of discussions within FACE, is always present. FACE is about interoperability; as more and more software components become certified, these components will inevitably be driven to higher levels of software quality and reusability. FACE will ultimately lower the cost of developing high-quality software and certified aircraft. It follows that many of the stakeholders involved with FACE are also very interested in addressing safety in the airframes on which they are deploying their software.

MIL-EMBEDDED: ***What will be the game changer for safety certification and code analysis over the next five years? Predict the future.***

MCELROY: We don't see any one particular game changer; however, what stands out is the drive to efficiency and transparency in the software development life cycle. We see the life cycle becoming increasingly automated. Requirements traceability, application life cycle management, model-based design, software development, verification, and simulation are all becoming bidirectionally linked so impact analysis can be quickly determined, and quick and appropriate decisions can be made.

Personally, I believe security will be a major influencer in safety certification, as systems will not be safe unless they are also secure. The requirements for security will demand changes in the software and hardware development processes. Automation and risk analysis will play key roles in how systems will be developed efficiently, yet safely and securely.

As a result, we see an evolution of the tool chain. OEMs and suppliers of today's avionics systems need tool vendors to give them better methods of developing today's complex systems safer and faster. To be competitive, they must use automation and leverage today's development and verification technologies to produce high-assurance software faster and at a lower cost. Those who continue to use traditional manual methods will simply not be able to compete. **MES**

Jim McElroy, *Vice President of Marketing at LDRA Technology, is focused on expanding LDRA business in the embedded software verification market by improving developer productivity and software quality in critical application development. Before joining LDRA, McElroy held executive-level marketing and business development positions with Green Hills Software, Telelogic North America, and I-Logix, as well as holding industry-level software development positions at Lockheed Martin and Raytheon. McElroy has a Master of Science in Computer Science from Fitchburg State College and a Bachelor of Science in Computer Science from the University of Massachusetts.*

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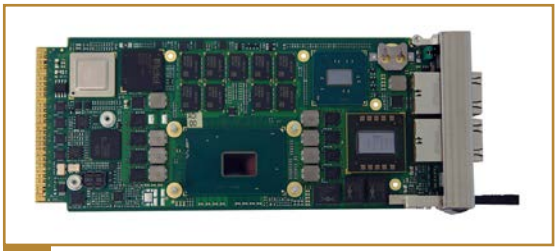

AdvancedMC module supports latest Intel Xeon processor

Concurrent Technologies' AdvancedMC (AMC) module, the AM G6x/msd, supports the latest generation of Intel Xeon processor E3-1500 v6. It is suitable for high-speed physics experiments, instrumentation, and test-based applications. AM G6x/msd users are able to specify a choice of processors, including the Intel Xeon processor E3-1505M v6 or Intel Xeon processor E3-1505L v6. Such processors are high-performance quad-core devices with Intel HD Graphics P630 onboard and are optimized to create board variants with high compute performance (E3-1505M) or low power consumption (E3-1505L).

AM G6x/msd has an onboard 64 GB solid-state drive (SSD) for reliable operating system and application storage. For high-speed mass storage, AM G6x/msd has two sites for M.2 storage modules based on PCI Express (PCIe) M-key interconnects supporting the new Non-Volatile Memory Express (NVMe) protocol, which is optimized for SSD storage performance. The module also supports the future Intel Optane range of 3-D XPoint modules. Intended for long life cycle applications, the AM G6x/msd offers improved CPU and memory performance. An upcoming version will be available offering dual 10 Gigabit Ethernet connectivity for higher speed networking with the ability to connect via either electrical or fiber links, making it more suitable for use in remote locations.

Concurrent Technologies | www.gocct.com | www.mil-embedded.com/p374053

Embedded SDR spans frequencies from 70 MHz to 6 GHz

The USRP E313 from Ettus Research, a National Instruments company, is a rugged and weatherproof software-defined radio (SDR) designed for outdoor deployment. Containing an embedded USRP E310 inside an IP67-rated enclosure, the USRP E313 provides ingress protection against dust and water to ensure operation under harsh environmental conditions. The USRP E313 supports power over Ethernet (PoE) with surge and lightning protection. This standalone SDR features a 2x2 MIMO transceiver providing as much as 56 MHz of bandwidth, spanning frequencies from 70 MHz to 6 GHz to cover multiple bands of interest.

The baseband processor uses the Xilinx Zynq-7020 SoC to deliver field-programmable gate array (FPGA)-accelerated computations combined with stand-alone operation enabled by a dual-core ARM CPU. The USRP Embedded Series platform uses the OpenEmbedded framework to create custom Linux distributions tailored to application-specific needs. To reduce development effort, the default operating system supports the USRP hardware driver (UHD) software API, as well as a variety of third-party tools including GNU Radio. Support for the RF network-on-chip (RFNoC) FPGA development framework enables deterministic computations for real-time and wideband signal processing. Users can prototype and deploy designs for embedded applications intended for the outdoors.

Ettus Research | www.ettus.com | www.mil-embedded.com/p374012

Omnetics SureCon 360 connectors for military and aerospace applications

Omnetics Connectors designed the SureCon 360° in a watertight, overmolded form; the military and aerospace version features a flame retardant, halogen-free, 32 American Wire Gauge (AWG) cable with a braided shield using by a black thermoplastic polyurethane (TPU) jacket. Omnetics' SureCon 360° connectors are designed with pin and socket elements positioned on 25 one-thousands of an inch spacing to reduce size and weight by as much as three times that of conventional microsized circular connectors.

The connectors were designed to withstand high shock and vibration, while maintaining their electrical integrity. Insulator sizes of six, 11, and 16 contact arrangements are available in a precabled format, with all three sizes available in both inline and protruding panel mount configurations. The product utilizes the Omnetics rugged Flex-Pin contact system. It is spaced on .025-inch (.64 mm) centerline and has very small outer diameters ranging from .325 inch (8.3 mm) to .384 inch (9.8 mm). Mating pin and socket models are available, as well as wire terminations with discrete wire and cable. Typically, the product's installed wiring is 32-gauge standard Teflon insulated copper wire and can carry as much as 1 ampere of current per line.

Omnetics Connectors Corp. | www.omnetics.com | www.mil-embedded.com/p374014

Intelligent power supply delivers 700 watts of DC power

The VPXtra 1000CM-IQ COTS DC to DC power supply from Behlman Electronics Inc. is a rugged, conduction-cooled, switch mode unit built for high-end industrial and military applications. It is a VITA 62, OpenVPX-compliant, 6U power supply that delivers 700 watts of DC power via five outputs. The VPXtra1000CM-IQ operates from a 28 VDC input, in accordance with MIL-STD-704, and supplies a high-power DC output. It is able to monitor and report status of multiple parameters via a PMBus interface and can support ANSI/VITA 46 signals.

The VPXtra1000CM-IQ power supply has no minimum-load requirement, carries overvoltage and short circuit protection, and handles overcurrent and thermal protection. The power supply is designed to support the rigors of mission-critical airborne, shipboard, vehicle, and mobile applications. The design incorporates Behlman's cooling technology, dedicated design, and rugged construction. Users may add intelligence features, the VPXtra 1000CD, and dual-output power supplies; the upgrade gives VPX system designers the ability to create compact systems with fewer additional instruments needed to accomplish their communication, measurement, and control functions.

Behlman Electronics Inc. | www.behlman.com/ | www.mil-embedded.com/p374015

Rugged 19-inch display for harsh environments

The RuggedView SD19-1002 by General Micro Systems integrates a 19-inch diagonal display with a fourth-generation Core i7 processor. The workstation is contained in a ruggedized, conduction-cooled, fully sealed system with an ultrabright display and Night Vision Imaging System (NVIS). The RuggedView SD19-1002 is targeted for applications in harsh environments, while using interconnects to provide a sealed smart-display system that is less than 3.25 inches thick.

The RuggedView supports the latest Intel Haswell Quad Core i7 processor with hyperthreading for a total of eight logical cores, each operating up to 2.4 GHz. The CPU is coupled with up to 32 GB of RAM organized in two banks that support error correcting code (ECC). The ECC RAM provides two-bit error detection and one-bit error correction and supports up to 1,600 mega-transfers per second (MTS) between CPU and memory. The SD19-1002 is offered with several screen options in 5:4 format, with or without touchscreen and bezel keys. The SD19-1002 supports standard definition of 1,280 by 1,024 resolution in standard format. It is viewable with up to 700 nits (units of visible light intensity) of brightness and supports antireflective (AR) and antiglare (AG) coating. The display also supports NVIS for applications where night vision glasses are used to reduce stress on the viewer.

General Micro Systems | www.gms4sbc.com | www.mil-embedded.com/p374054

400-watt DC/DC converter plugs into standard 3U VPX chassis

North Atlantic Industries' (NAI) VPX57-31 is a 400-watt DC/DC converter that accepts a +270 VDC input and plugs directly into a standard 3U VPX chassis with a VITA 62 1.0-inch power supply slot. This off-the-shelf solution for VITA 46.0 and VITA 65 systems is compatible with VPX specifications; supports all VITA standard I/O, signals, and features; and conforms to the VITA 62 mechanical and electrical requirements for modular power supplies. The VPX57-31 switching power supply is conduction-cooled through the card edge/wedgelock. It accepts +270 VDC input voltage and provides six outputs (per VITA 62) at up to 400 watts.

The VPX57-31 can be used either as a single-stage module or a back-end module in a multiple power supply configuration. It supports a variety of standard features, including continuous background built-in-test (BIT); user programmability; I^2C communication; remote error sensing; current share; and protection against transients, overvoltage, overcurrent, and short circuits. The VPX57-31 also is flexible enough to accommodate special needs. The design is aimed at meeting the many harsh environmental requirements of military applications.

North Atlantic Industries | www.naii.com | www.mil-embedded.com/p374055

Designing next-generation engineers

By Lisa Daigle, Assistant Managing Editor

BLOG

Enhanced emphasis on science, technology, engineering, and math (STEM) education in U.S. public schools continues to grow, with federal investment in STEM education totaling more than $3 billion annually for primary and secondary schools, according to the National Science and Technology Council. But even with schools' boosted interest in engineering and math, students often find themselves at a loss as they think about college and careers. Interaction with real-world engineers in actual work situations – especially in the students' local areas – may help as they make crucial decisions about their college years and beyond.

I have a vested interest in this issue, as my 16-year old son is one of these students. So I jumped at the opportunity to expose him to working engineers and their efforts in the space electronics industry, although neither of us expected our first instruction during our visit to be: "Here, clip on this dosimeter." Not a phrase commonly heard when visiting a workplace, this one meaning: "Please attach this radiation detector to your body."

But my son and I of course are interested in all things technical, and what could be cooler than encountering gamma rays? My son is at the beginning of his what-am-I-going-to-do-with-my-life journey. I've resolved not to interfere as he considers colleges, fields of study, and potential careers, but I'm also going to help him out in any way I can as he searches. He's interested and talented in both math and science – chemistry and physics, plus anything to do with space.

So we gamely clipped on the dosimeters, greeted our hosts – engineers at a local technology company called VPT Rad (Chelmsford, Massachusetts) – and began our tour. This facility handles the radiation and related test needs of high-reliability electronics manufacturers. The executive director and company founder of VPT Rad, Aridio Sanchez, showed us the testing labs and irradiation-analysis areas.

Aridio, his colleague Victor Brisan (a VPT Rad engineer who contributed an article on COTS components for space applications in the MES June 2016 issue), and my son talked about the use of electronics in orbit and in deep space, how equipment used in space needs to be certified as high-reliability before sending it on a mission, and what fields the older two had studied in college. Their 30-minute talk showed my son more about the practical applications of his studies than any magazine article or textbook entry. The three also discussed what might be coming up in the field in the next 10 years or so.

These next 10 years will be important for getting young minds into engineering fields: According to a 2014 study by the Bureau of Labor Statistics, although the job growth outlook for engineers over the period 2014-2024 is expected to be lower than the outlook for the labor market as a whole, the rapid pace of technological innovation and development will likely drive demand for electrical and electronics engineers in research and development, an area in which engineering expertise will be needed to develop distribution systems related to new technologies. The report states that engineers in these areas will play key roles in new developments having to do with semiconductors, solar arrays, and communications technologies.

Of course, any worries about workforce replacement seem to be balanced out by the nationwide focus on STEM education and curriculum. Even my daughter's seventh-grade pre-algebra class observes "STEM Fridays" every other week, during which the teacher and the class perform a math-related project or experiment. Moreover, anecdotal evidence tells us that students are constantly immersed in technology and connected with embedded devices.

The logical jump from school projects to college major to real-world application is a bit harder to bridge, however: Letting these students know how they can use these skills in the workplace of five, 10, 20, and 30 years from now; discussing college courses of study beyond the generic "engineering major"; clueing kids into what they may not know about electronics engineering or design. Here in Massachusetts, talented students have their pick of some of the best engineering colleges and universities in the country, but there's so much that even the smartest kids don't know about applying their knowledge to the workplace.

This is where you all come in. When you gather for holiday get-togethers and baseball games, talk to your nieces and nephews, your neighbors, and the kid who mows your lawn. Ask them – really talk to them beyond "How's school?" – what they're interested in. If they talk at all about engineering or electronics, take 10 minutes and get a little deeper into it. If they love math and science, ask what specific field they'd like to get into and whether they know what's out there in the real world. Don't worry about bugging them – human beings love to talk about themselves and what's interesting to them. Even a few minutes might give an aspiring scientist or engineer enough information to look in some new directions.

The takeaway – the actual quote – from my son on our VPT Rad visit with some real engineers: "Wow, there is some SERIOUS science going on in our town. I had no idea." My impression: The electronics-engineering world and the world at large benefits from sharing information about the field and filling the pipeline with up-and-coming scientists and engineers. Just ask around – they could be anywhere.

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Landing drones on moving targets

By Sally Cole, Senior Editor

Landing a drone on a moving target – and using fuzzy logic to do it – is simply badass.

In a move with intriguing potential for U.S. military applications, a group of researchers at the University of Cincinnati (UC) are using "fuzzy logic" to teach drones to land on moving targets by programming them to make better on-the-fly navigational decisions.

The ultimate goal for aerial drones is to make them autonomous, meaning that the unmanned aerial vehicles will eventually do most or all of their own flying. Drones will need to become autonomous if they're going to become commercially viable for uses such as making home deliveries to customers, according to Manish Kumar, an associate professor of mechanical engineering for UC's College of Engineering and Applied Science.

Kumar, working together with Nicklas Stockton, a UC researcher; and Kelly Cohen, a professor of aerospace engineering at UC, considered the difficulty drones have navigating the ever-changing airspace in a study the group presented at the American Institute of Aeronautics and Astronautics SciTech 2017 in January.

First, try to imagine landing a drone on a moving platform or target, such as a U.S. Navy warship pitching around in high seas.

A drone must land "within a designated area with a small margin of error," Kumar explains. "Landing a drone on a moving platform is a very difficult problem – both scientifically and from an engineering perspective."

To meet this challenge, UC researchers are applying a concept known as fuzzy logic. It's the kind of logic people use subconsciously daily. While scientists are concerned with precision and accuracy in all they do, most people get through their day by making inferences and generalities via fuzzy logic. Instead of seeing the world in black and white, fuzzy logic allows for nuances or degrees of truth.

"In linguistic terms, we say large, medium, and small rather than defining exact sets," Kumar says. "We want to translate this kind of fuzzy reasoning used in humans to control systems."

Fuzzy logic helps the drone make good navigational decisions amid a sea of statistical noise, he points out. This particular fuzzy logic is called "genetic fuzzy" because the system evolves over time and continuously discards lesser solutions.

The group was able to successfully apply fuzzy logic in a simulation to prove that it's an ideal system for navigating under dynamic conditions.

Figure 1 | University of Cincinnati researchers are tapping fuzzy logic to teach drones how to land on moving platforms. Credit: UC Creative Services/Andrew Higley.

Stockton, an engineering master's student, is doing cool work putting fuzzy logic to the test in experiments to land quadcopters on robots mounted with landing pads at UC's unmanned aerial vehicle (UAV) Multi-Agent System Research (MASTER) Lab. "This landing project is a real-world problem," Stockton says. "A delivery vehicle could have a companion drone make deliveries and land itself."

In case you hadn't already guessed that the military might be interested in this work, the U.S. Air Force has offered Stockton a federal position to continue his engineering research at Wright-Patterson Air Force Base when he graduates this summer.

Kumar and Cohen are encouraging cutting-edge fuzzy logic/artificial intelligence (AI) work at UC. Nick Ernest, a doctoral graduate and another student of Cohen's, started an artificial intelligence company, Psibernetix Inc., which demonstrated the power of fuzzy logic last year when a fuzzy-logic-based AI dubbed "ALPHA" bested a human fighter pilot in simulated dogfights.

Retired U.S. Air Force Col. Gene Lee describes ALPHA as "the most aggressive, responsive, dynamic and credible AI I've seen to date."

Compared with other state-of-the-art techniques of adaptive thinking and deep learning, "our approach appears to possess several advantages," Cohen says. "Genetic fuzzy logic is scalable, adaptable, and very robust."

UC has become a world leader in fuzzy logic and teaches it at the undergraduate level. "It's important to introduce students at an early stage to fuzzy approaches because it also provides them with an advantage as they enter the job market," Cohen notes.

The group's research was funded by a $500,000 grant from the National Science Foundation.

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Can you trust that drone?

By Russell Doty, Red Hat

The recent activities in the South China Sea involving the seizure and subsequent return by China of a U.S. unmanned underwater vehicle (UUV) – also known as an "ocean glider drone" – has once again brought drone security into the spotlight. Securing data collected as part of Internet of Things (IoT) environments is top of mind, and never more so than in military applications.

Collecting sensor data is one of many special communications requirements placed on drones. In many cases, sensor data collection is the very reason for the drone!

Securing that data is a challenge. Let's look at why. First, the sensor data is able to be stored but, more commonly, the data is transmitted as it is gathered, leaving it vulnerable to interception. Second, while some drones are fully autonomous, most are semi-autonomous and use a combination of local and remote control, resulting in another weak link in the security chain. Adding to the challenge, drones are commonly deployed in hostile environments; others may attempt to recover data from captured drones.

The encryption of communications between a drone and its ground station is vitally important. All command and control data, including high-bandwidth video feeds, should be encrypted. Modern systems can perform encryption with little overhead, so it is reasonable to require manufacturers to encrypt all communications.

Encryption can provide three critical capabilities. First, it can protect the contents of sensitive data. Second, it can protect the integrity of data – any corruption of encrypted data or attempts to modify it are immediately detected. Encryption offers complete end-to-end protection of a data stream from both disclosure and tampering. Note that it's possible to have multiple types of encryption on a single system, using different algorithms and different encryption keys. For example, sensor data could be encrypted with a relatively short key and a fast algorithm for minimal overhead, while command and control data can be encrypted with long keys and robust algorithms.

Finally, encryption can provide secure identity. Public-key cryptography can be used to prove the identity of a system. For example, to verify the identity of a drone, a base station would encrypt a message using the drone's public key. Assume that this message contains the base station's public key. The drone would decrypt the message using the drone's private key, giving the drone the base station's public key. The drone would then use this key to encrypt a message containing the drone's serial number. The base station would then decrypt this message with its private key and confirm the drone's serial number. At this point, the drone and the base station have confirmed each other's identity.

The encryption of communications between a drone and its ground station is vitally important. All command and control data, including high-bandwidth video feeds, should be encrypted.

One potential flaw in this approach is that someone might be able to retrieve the key pair from the drone and clone it or use it in other systems. A pure software implementation can be compromised if a hostile party can obtain access to the hardware.

This situation can be addressed by using a hardware root of trust, such as a Trusted Processing Module (TPM). The TPM can store encryption keys as well as perform crypto-operations entirely inside the TPM. The encryption keys are never visible outside of the TPM, ensuring the identity and trustworthiness of the system in question. A TPM can be physically captured and used, but it can't be copied or cloned.

A TPM is designed to resist a wide range of attacks. In the case of a captured drone, only that specific drone would be compromised. An attacker can't gain access to the secrets inside the TPM, and the drone can be securely isolated from the rest of the overall system by removing its public keys.

Use of X.509 certificates for key management – and this is strongly recommended! – can be effective for tasks such as certificate signing, delegating portions of roots of trust, key revocation, and key lifetimes. The combination of certificates, TPM, and an identity management system offers an effective and efficient infrastructure for maintaining the integrity, identity, and security of these mobile platforms and the distributed systems that use them.

Cryptography can be used in other ways. Blockchains, popularized by applications like BitCoin, are a powerful tool for verifying the integrity of data. A blockchain signature connected to a block of data can verify the integrity of that data as well as all data that precedes it. A related technology that can also aid in security is Perfect Forward Secrecy, which is used in applications such as the Linux journald logfile system to ensure that logfiles haven't been tampered with.

High-value distributed systems such as drones need to ensure that they are trustworthy and that they cannot be turned against their users. Crypto-technologies and hardware root of trust solutions are key tools for mission integrity.

Russell Doty *is senior product manager, Red Hat.*

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CHARITY

VFW National Home for Children

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

This issue we are highlighting the VFW National Home for Children, an organization open to families of active-duty U.S. military personnel, veterans, and descendants of members of the VFW and its auxiliary.

Since its founding in 1925 in Eaton Rapids, Michigan, the VFW National Home for Children has grown from an old frame farmhouse to a sprawling campus with playgrounds, park areas, and multiple buildings, including single-family homes, a community center and gymnasium, childcare center, guest lodge, chapel, and administrative offices. The Home offers a place to live for children of deploying troops, single-parent veteran families in crisis, families with a veteran-parent going through vocational rehabilitation, and children of veterans who need a safe place to live.

Over the years, the National Home's services have evolved to meet the changing needs of America's military and veterans' families: One aspect is the Helpline, which seeks to aid callers from around the country with solutions to problems they may have and connect them with service organizations in their own communities.

The National Home also assists military and veteran families with temporary housing, as the organization has single-family homes in 20-plus U.S. states, from Hawaii to Massachusetts. Recipients may stay rent-free in these homes for up to four years, during which time the organization helps with housing, vocational, and educational transition.

For more information, visit www.vfwnationalhome.org.

E-CAST

The many faces of IoT connectivity and how to deal with them

Sponsored by Ayla Networks, Anaren, MultiTech, PTC, RTI

IoT encompasses a wide range of embedded, network, and cloud systems where the value is unlocked by the data gathered from sensor and edge devices that can be used by gateways, cloud applications, and analytics to drive significant value. However, communications is not as simple as one protocol, one service, one language. Moreover, connectivity is multidimensional involving data transfer, authentication/security, and manageability from application to sensor.

In this e-cast, join industry experts as they pick an application and break down the communications requirements and methods for secure, manageable, and efficient operation.

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WHITE PAPER

Perform hardware-in-the-loop simulation with MATLAB and Simulink to test and validate control algorithms

By Nikhil Rai, Mathworks

Sophisticated control and logic algorithms are at the heart of smart machines. Designers of such systems know that identifying and eliminating errors in these algorithms is challenging before deploying software on hardware. Validating with hardware-in-the-loop simulation can help smart machine designers build, run, and test real-time applications and validate control algorithms before deploying them on equipment.

In this white paper, learn how you can master hardware-in-the-loop simulation, using Simulink Real-Time, by testing new system designs and algorithms before software-hardware integration, performing design iterations in minutes rather than weeks, and reducing risk later in development or when equipment is in the field.

Read the white paper:
http://embedded-computing.com/white-papers/white-simulation-matlab-simulink-test-validate-control-algorithms/

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