Military EMBEDDED SYSTEMS

February/March 2014
Volume 10 | Number 2
MIL-EMBEDDED.COM

INFLUENTIAL WOMEN IN DEFENSE ELECTRONICS

CLOCKWISE FROM TOP LEFT P 14

- *Sondra Barbour, Lockheed Martin*
- *Jane Donaldson, Annapolis Micro Systems*
- *Lynn Bamford, Curtiss-Wright Defense Solutions*
- *Nan Mattai, Rockwell Collins*

Demystifying multi-core architecture for avionics
By Patrick Huyck, Green Hills Software

B-1 Bomber avionics upgrade

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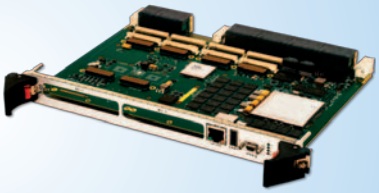
Module and System-Level Solutions from X-ES

Intel® and Freescale™ Single Board Computers

XPedite7570
4th Gen Intel® Core™ i7-based 3U VPX SBC with XMC/PMC



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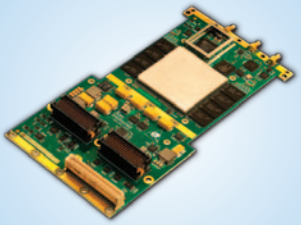

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ON THE COVER:

Top photos: Influential women in defense electronics include clockwise from top left: Sondra Barbour, Lockheed Martin; Jane Donaldson, Annapolis Micro Systems; Lynn Bamford, Curtiss-Wright Defense Solutions; and Nan Mattai, Rockwell Collins.

Bottom photo: Boeing's upgrade modification for the B-1, known as the Integrated Battle Station or IBS, is the most extensive mod program in the B-1's history and, among other things, replaces 25-year-old avionics.

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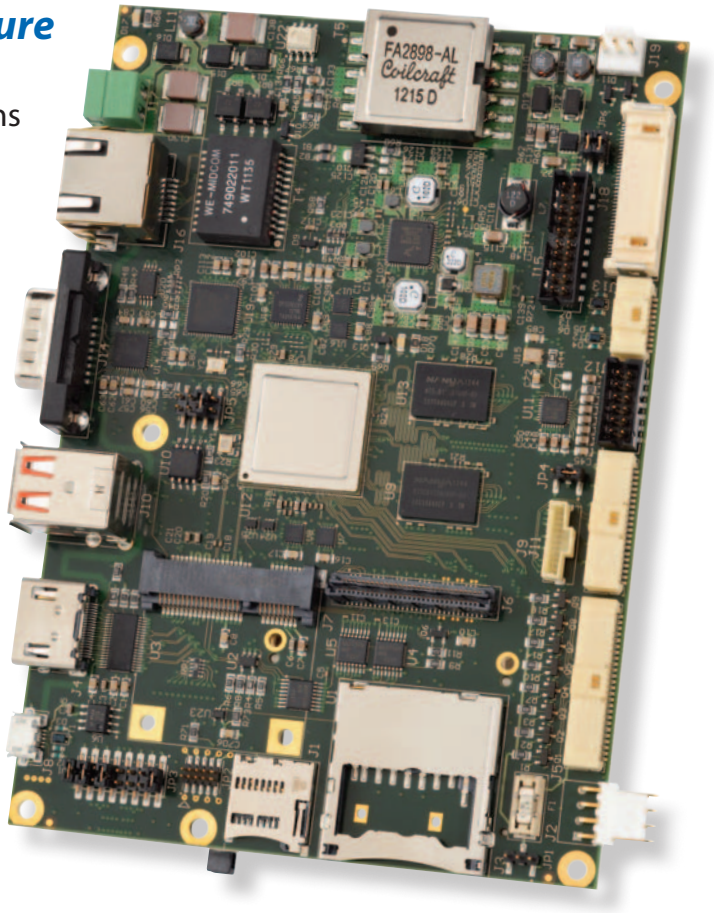

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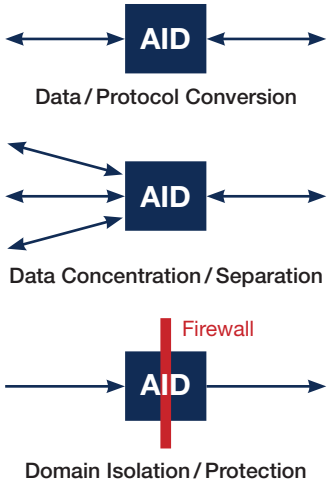

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Women leaders gaining more influence in defense industry

By John McHale, Editorial Director

When I told a friend that our next issue would focus on influential women in defense electronics, he suggested I read "Lean In," a book by Facebook COO Sheryl Sandberg. So I did and found remarkable similarities between her lean-in philosophy and the views of the women we are profiling in this issue.

One of Sandberg's themes is that women are outnumbered in the leadership roles in business today because they choose not to enter it. Men outnumbering women is never more apparent than in the military industry. Go to any trade show and you will see what I mean. Nan Mattai, VP of Engineering & Technology for Rockwell Collins, said in her profile this is one of her greatest challenges – "being the only woman in the room."

In her book Sandberg shares a wonderful Warren Buffet line on this subject: that he was so successful because he only had to compete against half of the population. She says women leave or don't enter the workforce for various reasons such as a desire to raise a family or fear of not being good enough to succeed. Sandberg writes that women – as a gender – suffer from low self esteem, often thinking they don't deserve to "sit at the table" with the men, so they don't. She suggests women frequently believe the negative stereotypes about themselves.

While it's not a 1950s atmosphere, gender stereotypes and overall insensitivity still exist. I've seen it first-hand multiple times. One instance was at a press briefing I attended about 15 years ago with a female reporter from another publication. Every time she asked the male briefer a question he would direct his answer to me. It caught me off guard and I asked her after if that was typical and she said, "unfortunately yes."

I witnessed more blatant insensitivity a few years ago on a military trade show floor. While speaking with a woman, who was VP of marketing and also an engineer for an embedded computing company, I overheard a sales rep for her company tell a visitor at their booth that the VP was "one of the girls from back at the office." My jaw dropped. She leaned toward me and said, "you see what I have to put up with?" I asked what she intended to do. She replied: "I will wait till you and his friend leave, then I will handle it." I found out later when confronted with his comment, the sales rep in question was shocked at what he said and made an immediate mea culpa. Unfortunately the stereotyping still persists and not everyone is embarrassed by that behavior.

"Real-life examples of women crushing the glass ceiling while managing work/life balance and gaining peer respect are inspiring" – Nan Mattai

In her book Sandberg writes that "we evaluate people based on stereotypes. Our stereotype of men holds that they are providers, decisive, and driven. Our stereotype of women holds that they are caregivers, sensitive, and communal." She says that when women take roles that stray from these stereotypes they are viewed negatively, such as being bossy or selfish when being decisive and showing leadership in the workplace.

Sandberg says women shouldn't accept these as valid reasons for holding themselves back. So she challenges women to lean-in and "end the self-fulfilling belief that 'women can't do this, women can't do that'… saying 'it can't be done' ensures it won't be done."

Not all advocates of women's rights agree with her philosophy. Suggesting that women need to lean-in and take more responsibility for their success doesn't always sit well with those who think industry and the government should step in and force more equality in the workplace. I don't get the impression that Sandberg thinks these policies and programs are bad in and of themselves, but she feels that women shouldn't wait for them. They should act now.

I noticed similar sentiments from all our profiles this month: Sondra Barbour, Executive VP of the Information Systems & Global Solutions group at Lockheed Martin; Lynn Bamford, Senior VP & General Manager of Curtiss-Wright Defense Solutions; Jane Donaldson, President and co-founder of Annapolis Micro Systems; and Mattai, who says that while being the only woman in a room can be scary "it also provides unique opportunities for networking and knowledge expansion."

They don't think of themselves necessarily as successful women, but rather as successful leaders, business owners, engineers, etc. "I have never found any challenges caused by just being a woman. My main challenges are as a businessperson in the high-tech community," Donaldson says.

Mattai says that showcasing these visible role models helps battle "professional and work culture stereotypes. Real-life examples of women crushing the glass ceiling while managing work/life balance and gaining peer respect are inspiring."

I think she along with Barbour, Bamford, and Donaldson are a good place to start. Learn their stories starting on page 14.

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DEFENSE TECH WIRE

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By Amanda Harvey, Assistant Editor

NEWS

U.S. Army, Lockheed Martin demonstrate autonomous convoy vehicles

In partnership with Lockheed Martin, the U.S. Army Tank-Automotive Research, Development, and Engineering Center (TARDEC) put on an autonomous convoy demonstration at Fort Hood. The demonstration took place in January 2014, and was part of the Army and Marine Corps' Autonomous Mobility Applique System (AMAS). The demonstration marked the completion of the program's Capabilities Advancement Demonstration (CAD). The autonomous vehicles navigated through obstacles and hazards in both rural and urban areas, including: oncoming traffic, passing vehicles, pedestrians, road intersections, stalled vehicles, and traffic circles. The AMAS hardware and software have been designed to automate driving on current tactical vehicles, and can be installed as a kit on virtually any tactical military vehicle.

Figure 1 | Autonomous vehicles navigated through real-world obstacles and hazards during a demonstration at Ford Hood. Photo courtesy of Lockheed Martin.

Aviation Command & Control System (AC2S) developed by General Dynamics passes critical design review

A General Dynamics C4 Systems-led team was part of the critical design review of the Aviation Command and Control Subsystem (AC2S), which is a part of the U.S. Marine Corps' new Common Aviation Command and Control System (CAC2S). Company engineers will now build four AC2S Engineering Development Models (EDMs) for use in a CAC2S system for developmental testing and operational assessment. CAC2S enables Marine Corps operators to share mission-critical sensor, voice, video, and other command and control data during any type of mission. The data sub-system fuses sensor inputs from various sources such as weapon systems, expeditionary radars, UAVs, and Intelligence, Surveillance, and Reconnaissance (ISR) resources into a high-resolution, real-time display that produces a common operational picture for Marine Air-Ground Task Force commanders and their staff.

New electronic warfare group formed by Raytheon

Raytheon Space and Airborne Systems officials announced a new mission area dubbed Electronic Warfare Systems that combines several of the company's Electronic Warfare (EW) programs. The new group will be based in El Segundo, CA and consists of the following programs/products: EW self protection systems; airborne information operations; Next Generation Jammer; advanced EW programs; EW communications systems; and other EW pursuits. Travis Slocumb, former vice president of Strategy and Business Development for Space and Airborne Systems, will lead the Electronic Warfare Systems mission area.

Other Raytheon EW solutions include: radar warning receivers; electronic attack and support; airborne decoys; tactical signals intelligence; jammers; EW battle management; and shipboard systems.

Curtiss-Wright Defense Solutions announces small, lightweight COTS air data computer module

Curtiss-Wright Defense Solutions announced the new Air Data Computer Module (ADCM) designed for civil and defense aircraft platforms at the 2014 Singapore Air Show. The Commercial Off-The-Shelf (COTS) ADCM is compact and lightweight, with a stable vibrating cylinder. The ADCM provides avionics designers a slot-based solution for integrating air data processing into existing avionics, such as Attitude Heading Reference Systems (AHRS), Electronics Flight Instrument Systems (EFIS), Inertial Reference Systems (IRS), or Global Navigation Inertial Reference Systems (GNIRS), which reduces fuel consumption, LRU count, and weight. The ADCM is configured for future airspace requirements such as NextGen and SESAR's advanced air traffic management.

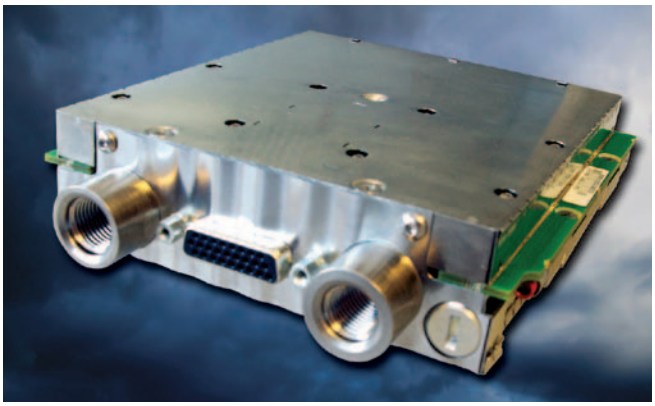

Figure 2 | The Air Data Computer Module (ADCM) from Curtiss-Wright Defense Solutions is compact and lightweight, and is designed for civil and defense aircraft platforms. Photo courtesy of Curtiss-Wright Defense Solutions.

British Apache targeting and pilotage system support contract won by Lockheed Martin

Lockheed Martin engineers will support the Modernized Target Acquisition Designation Sight/Pilot Night Vision Sensor (M-TADS/PNVS) system for the U.K.'s Apache AH Mk-1 aircraft under a sustainment and support contract from AgustaWestland valued at $60 million. The contract calls for in-country repairs, spares, and technical services, as well as for integrated logistics, engineering, and depot repair support. The work is for the overall Integrated Operational Support solution of the U.K. Apache fleet provided by AgustaWestland. Support under this contract will continue until March 2019.

The M-TADS/PNVS system enables Apache attack helicopter pilots to perform long-range, precision engagement in day, night, and difficult weather missions. Work will be performed at the Lockheed Martin facilities in Ocala and Orlando, FL, Lockheed Martin UK-Ampthill, and at the U.K. Wattisham Special Repair Activity Depot.

U.S. military awards Northrop Grumman contract for embedded GPS/INS

Northrop Grumman was awarded a U.S. Air Force Indefinite-Delivery, Indefinite-Quantity (IDIQ) contract for purchase and sustainment of its Embedded Global Positioning/Inertial Navigation Systems (EGI). The contract has a potential value of as much as $200 million. The Northrop Grumman suite of fiber-optic, gyro-based EGI systems will be available for U.S. Air Force, Army, Coast Guard, Marine Corps, and Navy use, as well as international allies. In addition to the systems, Northrop Grumman will also provide depot repair, flight tests and technical support, platform integration, modernization, training, and spares.

The IDIQ contract provides for ordering of equipment/services through December 2018. International military sales, including the first EGI order to Iraq and Thailand, are provided for under the IDIQ contract.

More Boeing search and rescue radios ordered by U.S. Air Force

U.S. Air Force officials ordered 2,550 more Combat Survivor Evader Locator (CSEL) radios, which are used in the rescue of downed pilots and other warfighters in dangerous situations. The CSEL is a global emergency call system that helps recover warfighters in harm's way and is used not only by the Air Force, but also by the Army, Marine Corps, and Navy for Search and Rescue (SAR) operations. The system consists of hand-held radios, over-the-horizon relays, and other ground and user equipment. Boeing also received separate contracts to enhance the capabilities and information security of the global CSEL base station network. Boeing has delivered about 55,000 CSEL radios so far. These deliveries are scheduled for later this year and also 2015. The contract is valued at $24 million.

Figure 3 | Boeing's Combat Survivor Evader Locator (CSEL) is a global emergency call system that aids in locating and rescuing downed pilots and other warfighters. Photo courtesy of Boeing.

Future cooling concepts for HPEC programs

By Charlotte Adams

A GE Intelligent Platforms perspective on embedded military electronics trends

In High Performance Computing (HPC) data centers, more powerful processors – with their greater heat output – are routinely accommodated by simply turning the air conditioning up a notch. However, high performance computing has now moved out of the data center and into the embedded world where cooling is not such a simple process.

High Performance Embedded Computing (HPEC) is at the heart of many current military programs; whether it's mission-critical corporate computing or mission-critical military computing, heat is the enemy because it limits processing power and can cause system unreliability and even failure. Turning up the AC isn't an option in the embedded world.

The problem is compounded on two fronts. Military embedded computing is becoming increasingly sophisticated and requires the most powerful processors. At the same time, those powerful processors are being deployed in environments that are constrained in terms of Size, Weight, and Power (SWaP) – and SWaP-constrained systems are notoriously difficult to cool.

That's why there's a growing focus in the military embedded systems world on next-generation cooling technology. Many embedded processing systems today use conduction cooling, where heat is conducted away from a component to the card edge and out to the chassis, which acts as a heat sink, dissipating the heat into the air. Forced-air convection cooling may speed the process, but fans add weight and increase the potential for failure. Although much thought has gone into the design of heat sinks and the development of the thermal interface materials that conduct heat from the component to the heat sink, the relentless growth in power density and heat output limits the effectiveness of traditional cooling methods.

Innovative cooling doesn't just mean that faster processors can be deployed. The U.S. Defense Advanced Research Projects Agency (DARPA), which is driving much of the work in advanced cooling systems, envisions large reductions in SWaP if the problem can be solved by integrating cooling systems at the chip level. SWaP has transitioned to SWaP-C, where C stands for cooling. Some of DARPA's research into new cooling technologies has been undertaken in collaboration with GE's Global Research Center and has resulted in innovative approaches that could find their way into the military embedded computing systems of the future. More information on the outcome of that collaboration can be found at http://opsy.st/1dQHyUe

Researchers classify cooling technologies into "remote" or "embedded" paradigms. Remote cooling conducts heat out of a chip to a heat sink; embedded cooling designs cooling right into the chip. DARPA's Thermal Management Technologies (TMT) program focused primarily on the first approach; the agency's more recent Intrachip/Interchip Enhanced Cooling (ICECool) program advances the second approach. Both strategies apply micro- and nano-scale engineering to enhance heat dissipation at their respective levels.

Miniaturization

The latest prototypes take both conduction and convection cooling to their technological extremes, with tiny pumps, fans, pipes, and valves. On the remote cooling side, for example, a thermal interface has been developed that minimizes the heat effects of thermally mismatched materials used in the processor, such as silicon – and the heat sink, such as copper. One new material sandwiches high-conductivity, nano-scale copper "springs" between layers that match the thermal characteristics of the heat source and the heat sink, respectively. The copper's conductivity and geometry reduce thermal stresses in the heat path.

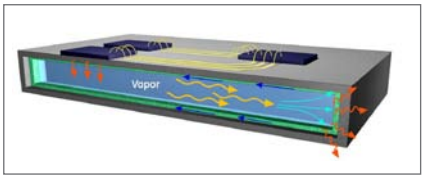

Figure 1 | A Thermal Ground Plane (TGP) is a micro-/nano-engineered "machine" that fits into a cavity in a multichip module.

On the embedded cooling side, companies have designed tiny pipes into chips for microfluidic cooling. Microchannels in the chip, for example, could take in a continuous flow of chilled fluid from a network built into a computer and carry away heat by evaporation and convection. *

Between the remote and embedded cooling poles, researchers have developed a two-phase "vapor chamber" heat-transfer system that can be squeezed into a cavity in a multichip module substrate. Fluid in this thermal ground plane cavity – like a miniature weather system – absorbs the heat, converts to vapor, condenses against a cold wall, and flows back to the hot section via capillary action induced by the micro-/nano-engineered internal surface of the case (see Figure 1).

While these devices are not in production yet – and some of them probably never will be – they represent significant R&D trends. Dealing with heat more efficiently is an urgent need, and these new cooling technologies could revolutionize military embedded computing.

defense.ge-ip.com

* "DARPA's Intra/Interchip Enhanced Cooling (ICECool) Program," by Avram Bar-Cohen, Joseph J. Maurer and Joanathan G. Felbinger, May, 2013, page 172, published in association with the CS MANTECH Conference in New Orleans.

Intel integrated graphics in deployed defense systems

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

The graphics display support built directly into the latest generations of Intel Core i7 processors is now more than sufficient for providing video processing for many types of low- to mid-end deployed military applications. The use of a Single-Board Computer (SBC) that features an "Ivy Bridge," "Sandy Bridge," or "Haswell" class of Intel processor can often eliminate the need for an additional embedded card such as a dedicated 3U VPX or XMC graphics display module. However, there are a number of cases in which an integrated Intel graphics approach won't be able to meet the requirements of a particular military system, either because of performance, lack of support for specific hardware interface types, or the lack of software drivers for supporting OpenGL in real-time operating environments and safety certification.

At the low- to mid-end of video-display applications, the graphics processing capability of the newest Intel processors is typically satisfactory. For example, if the graphics processor will be used to drive a mission computer type of Human Machine Interface (HMI) to an HD touch-screen video display, the integrated Intel GPU will be able to handle the job. On the other hand, if the application places great demands on system memory and has critical performance requirements, the integrated GPU might not be sufficient because of the shared-memory model used by the Intel processors. Applications that require intensive processing and near-real-time display of complex images, such as digital mapping systems, need to be closely analyzed to ensure that the use of integrated graphics will suffice.

Where embedded graphics fit

Applications requirements that call for embedded graphics typically fall into one or more of three different categories: performance, hardware interface requirements, and/or real-time OS driver support. Because the performance requirements of a graphics display application will vary greatly from system to system, the system designer needs to ensure that the integrated graphics available on the SBC can handle the job. For the most demanding video-intensive applications, such as embedded training, moving maps, Geographic Information Systems (GIS), 360-degree situational awareness, and Diminished Vision Enhancement (DVE), the integrated Intel graphics may not be able to deliver the graphics horsepower needed to support real-time video processing at the required frame rates. For the most graphics-intensive applications, a dedicated high performance GPU such as an AMD Radeon should be considered.

Interface limits

Usually, Intel-based VME and VPX SBCs do not provide all the possible interface types supported by deployed displays. Only the most popular contemporary interface types, such as VGA and DVI, are typically made available to the user. If the application requires legacy interface types, such as STANAG 3350 or RS170, the system may require the use of a separate embedded-graphics module designed to support those interfaces.

Another issue arises when an application requires a large number of interfaces. Typically, Intel-based SBCs are limited to three graphics heads. Many applications – such as those that support multiple video sensors – require multiple displays used by a large number of operators, and graphic-intensive training scenarios often need access to far more than three interfaces. For these cases, an embedded-graphics module with a discrete GPU can be used to add from two to six additional interfaces.

Supporting OpenGL in a real-time environment

An embedded-graphics module is also required when support for the open standard graphics language OpenGL is needed in a real-time operating environment. Today, many VME and VPX SBCs are supported with RTOS drivers in the Board Support Packages (BSP) that the board vendor provides for use with popular Real-Time Operating Systems (RTOS) such as VxWorks. However, there are not yet any vendors who provide embedded-graphics RTOS drivers with support for OpenGL on Ivy Bridge or Haswell-class Intel processors. When both OpenGL and an RTOS are required, the system's Intel SBC can be augmented with the addition of an embedded graphics card.

Figure 1 | The Curtiss-Wright Defense Solutions' VPX3-716 3U OpenVPX module is designed for use on deployed airborne and ground vehicle platforms.

One example of a high-performance graphics display module that can be used to overcome the limits of integrated Intel graphics for demanding applications is Curtiss-Wright Defense Solutions' VPX3-716 3U OpenVPX module (see Figure 1). This rugged 3U module is the first rugged graphics card based on AMD's next generation GPU, the AMD Embedded Radeon E8860, codenamed "Adelaar," and features six independent graphics outputs, 2 GB of dedicated video memory, and H.264 MPEG4 motion video decoders. Designed for use on deployed airborne and ground vehicle platforms, this graphics engine meets the long life-cycle availability required for military programs through use of a suite of CoreAVI software drivers supported with a 20-year component supply program.

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Sondra Barbour is Executive Vice President of Lockheed Martin's Information Systems & Global Solutions (IS&GS) business area and an officer of Lockheed Martin Corp. Under her leadership, IS&GS employs 26,000 experienced professionals, who provide advanced information systems, security, and services supporting the critical, complex missions of customers worldwide. Headquartered in Gaithersburg, MD, IS&GS operates throughout the U.S. and 20 countries worldwide. It generated $8.4 billion in sales in 2013. Her more than 20-year career at Lockheed Martin includes extensive leadership and technology experience, notably in the design and development of large-scale information systems. Ms. Barbour was selected by Fortune magazine as one of the "50 Most Powerful Women in Business" in 2013.

Q: *What are the biggest challenges you face every day as an executive at one of the largest defense prime contractors in the world?*

Currently there are two challenges that stand out. The first is our obvious tough economic environment and continuing budgetary challenges. The second is maintaining our innovative edge over competitors to provide our customers with the best capabilities for their missions. These two challenges interplay with each other in that we need to balance being fiscally responsible to both our shareholders and customers while still developing new technologies.

Q: *How do you overcome those challenges?*

To overcome these challenges, it is crucial for us to work closely with customers to ensure we are providing them with the technology they need while balancing resources. We can accomplish this by establishing true partnerships with understanding and appreciation for each individual mission. This type of listening is done at every level of our organization – whether one of our executives is meeting with a director responsible for an entire agency or one of our systems analysts is discussing the tactical element of a program's execution.

Also, being part of one of the largest technology companies in the world allows us to bring innovations from across our company to customers. For instance, we apply our big data analytics experience to other Lockheed Martin business area supply chains to expedite service to our customers and ensure we deliver on schedule.

Q: *The defense industry has many differences from other consumer markets, especially in its culture. Those cultural differences and recent economic setbacks in the military market may make it less attractive to new college graduates. What can defense companies and the Department of Defense (DoD) do to encourage and motivate young engineers and business minds to enter the defense industry?*

Lockheed Martin is a unique company where young engineers develop cutting-edge, innovative technologies that assist with the world's most challenging missions – those that save lives and serve citizens around the world. I think that is a very noble cause and one that resonates with college students today. I think the defense industry would benefit from highlighting more of the technology aspects of our field and demonstrating the global impact of them.

Q: *How can they be more prepared when they do enter?*

I would recommend college students today not only understand their engineering field, but also gain exposure to business concepts and refine their communications skills. To be a leader in our field in the future, you need to be more than a great engineer. You need to be able to share your ideas and lead others. You need to be able to link those ideas to the overall business strategy. College students today who learn these skills will be the most marketable in the future.

A section of Lockheed Martin's career website is geared toward college students. At www.lockheedmartinjobs.com/college-students.asp we have intern, co-op, and leadership development programs for those just getting into the workforce. Examples of technology innovations they can dive into at our company are cyber security; ocean, wind, and solar technologies for energy problems; bionic exoskeletons for warfighters; hybrid air vehicles for defense; intelligence and transport applications; magnetic wave communications for locating trapped miners; and more. Programs to help warfighters transitioning from the military to the business world are also offered.

Q: *During your career in the defense electronics industry what have been the most significant events and disruptive technologies?*

I think the biggest changes to our industry have occurred due to the volume of information available, the speed at which we receive it, and the need to protect and analyze this data set into actionable intelligence. To address this challenge Lockheed Martin has been at the forefront of cyber security and data analytics for much of our 100-year history. In fact, our cyber kill chain capability, that we developed internally, is now recognized by the industry as a best practice for protecting networks and information. Many partners are involved with Lockheed Martin on its cyber efforts such as APC by Schneider Electric, ArcSight, CA, Cisco, Citrix, Dell, EMC Corporation and its RSA security division, HP, Intel, Juniper Networks, McAfee, Microsoft, NetApp, Symantec, Trustwave, Verizon, and VMware. For more on the cyber kill chain, visit www.lockheedmartin.com/us/what-we-do/information-technology/cyber-security.html.

Nan Mattai

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Nan Mattai is Senior VP, Engineering & Technology for Rockwell Collins where she's responsible for the Engineering & Technology organization, including the Advanced Technology Center. Mattai holds a M.S. degree in Nuclear Physics from the University of Windsor, Canada and has completed all graduate courses for a Doctorate in Physics.

Q: *What are the biggest challenges you face every day as a woman in the defense industry?*

Being the only woman in the room. I am often the only female in my peer group at work and in industry forums. This creates a high degree of visibility and exposure, a feeling of constantly being in a fishbowl. At times, it can be downright scary; it's hard to speak up but it also provides unique opportunities for networking and knowledge expansion. Another challenge is the limited access and availability of female role models. I'm fortunate to have had excellent male mentors who have helped to guide and steer my career development and advancement – supporting, encouraging, and believing in me. However, there are times when it would be really helpful to have some guidance and support from women who have successfully navigated the field, learned the hard way of what works and what doesn't, to speed up the learning process and have a shoulder to lean on. Work/life balance on a daily basis is a third challenge and requires special attention. The challenges have changed since my children were at home and today it is more about ensuring some "me" time for rest, relaxation, and family time.

Q: *How do you overcome those challenges? What or who is your inspiration?*

You must believe in yourself, believe that you are capable, find your own inner strength, and always be prepared. You have to build and display confidence because those who show confidence typically get noticed more, regardless of gender. I've never paid any attention to those people who say that you have to change to fit into a pre-formed mold. I learned to embrace my unique value and perspectives while embracing my shortcomings, as well as the need for collaboration with those whose strengths compliment my own. I work hard to develop trusting relationships and partnerships with my peer groups inside the company and the industry, reaching out for advice and guidance whenever needed. It's also a must to build a strong support structure at home with those who are there for you unconditionally. My immediate family are my biggest cheerleaders and support group. We must always take things in stride, recognizing that balance doesn't mean 50/50. There are times when work will require 100 percent and what's most important is being there 100 percent at that time, placing other busy thoughts aside for later.

My personal inspiration is my mom. Growing up, she instilled the importance of learning and a strong work ethic. She taught me that to succeed in life you need to study, work hard, set goals for yourself and don't stop until you reach them. She often said "you can do anything and don't accept that it can't be done." In moments of uncertainty, these words ring true and I know that I have the will and capability to succeed. The values she taught me remain with me to this day. Professionally, it's inspiring to see women increasingly filling prominent defense positions. Hopefully this encourages more women to enter the field. Seeing Phebe Novakovic and Marilyn Hewson rise to the top of General Dynamics & Lockheed Martin respectively signals strongly that female influence in this male-dominated industry is growing.

Q: *How can more women be prepared to enter the male-dominated defense industry and, for that matter, traditionally male fields such as the engineering profession?*

All industries need a balance of women and men working alongside each other, as both genders bring different viewpoints and opinions to the table. In a male-dominated industry or company, as in any, you have to be flexible, willing to learn, deliver results, and be a team player. Ways to prepare women for these challenges include:

- Early intervention efforts – as early as middle school – that focus on increasing participation in science and math for female students. Programs such as "Introduce a Girl to Engineering" exposes more young women to an engineer's job environment and to successful women engineers who can serve as mentors and role models.
- Share stories of successful women who have stayed in the defense industry and the engineering profession to address perceptions that there are no advancement opportunities in male-dominated fields or that the engineering culture is male-centric with high expectations for travel and little personal time. Showcasing these visible role models combats professional and work culture stereotypes. Real-life examples of women crushing the glass ceiling while managing work/life balance and gaining peer respect are inspiring.

Q: *During your career in the defense electronics industry what were the most significant events and disruptive technologies?*

Significant events would be: 9/11, post-9/11 wars in Iraq and Afghanistan, and the Budget Control Act/sequestration. Disruptive technologies I've seen include the miniaturization of electronics that resulted in significant size, weight, and power reductions; Global Positioning Systems (GPS)/satellite navigation; digital glass cockpits; networked communications; and unmanned platforms.

Q: *The defense market's budget-constrained environment makes forecasting tough. Given that fact, what segments of the military market will have the most growth potential over the next five years for producers of defense electronics?*

There are exciting prospects for unmanned aerial systems, cybersecurity, adaptive communications, and international market expansion.

Lynn Bamford

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Lynn Bamford, Senior Vice President and General Manager of the Defense Solutions division of Curtiss-Wright, is responsible for directing five business units located around the globe. She has held various engineering, marketing, and operation positions at Curtiss-Wright and other defense electronics companies. Ms. Bamford earned a B.S. in Electrical Engineering from Pennsylvania State University, and a M.S. in Electrical Engineering from George Mason University.

Q: *What are the biggest challenges you face every day as a woman in the defense industry?*

The reality is that the challenges I confront are no different from those that a man must face. Ours is a very competitive industry and I face challenges as an individual and as a leader. Over and over again the keys for personal success for each gender prove to be integrity, well-maintained relationships, and leadership performance. As a leader you need to create a world-class company that attracts talent, measures performance, values customer satisfaction, and strives to be technically excellent. I believe – especially today – that industry decision makers want a person they can trust and one they can count on during a crisis. While some people think a woman must work harder to prove her capabilities, my own experience tells me that what matters most, regardless of gender, is proving you keep your word, ensuring your company lives up to its promises, and seeing that your company delivers compelling industry solutions.

Q: *How do you overcome those challenges? What or who is your inspiration?*

During my career I've seen many people who have understood and embraced, or completely misunderstood and disregarded, the motto, "only the paranoid survive," made famous by Andy Grove when he served as CEO of Intel. Consequently, I have witnessed, depending on which camp a person fell into, their particular successes and failures. We have all seen once-great companies fail completely. For me, Grove's valuable message is to never take your company's position in the industry for granted. I believe that your company and you as an individual must continuously evolve along with your industry or you will simply be left behind. Companies can stay nimble by encouraging and developing a highly diverse work force that enables flexibility via the myriad viewpoints that people from different industries, professional backgrounds, and cultures bring to the mix. Ensuring that our company evolves and continues to lead the industry is a challenge that I am paranoid of – in the best sense of the word – every single day! I believe in data and measuring as much as you can, while also staying as close as possible to your customers. Many failures come from ignoring reality and only believing what you want the truth to be, regardless of what the data tells you.

Q: *How can women be more prepared to enter the male-dominated defense industry and, for that matter, traditionally male fields such as the engineering profession?*

My answer is straightforward, and for some, perhaps a bit surprising: Relax. Don't proceed in your career under the assumption that you will be treated differently. Your greatest asset is the person that you are. Assert your best self by being technically excellent and then demonstrating it. A smart way to conduct yourself is to act as though the age-old adage that a woman needs to be better and work harder than a man would in the same position, is true, even if it isn't. Better to challenge yourself to be a leader than to settle for a place in the middle of the pack. Today, the best companies recognize the value that comes from diversity in leadership. There's never been a better time, no matter who you are, for achieving success by being your best, which really comes down to having integrity, being technically capable, and working hard. More than anything people respect and want to work with people who possess these attributes.

Q: *During your career in the defense electronics industry what were the most significant events and disruptive technologies?*

If you go back 10-15 years, our industry was very fragmented, with many small, private companies. During the past decade the industry has experienced a lot of consolidation, resulting in a platform for Curtiss-Wright, as well as our main competitors, to deliver much more technically capable and mature offerings to the industry. I take great pride in knowing that our industry and my company have played a significant role in helping to maintain our military's unmatched strength and ability to respond as needed around the globe. Our industry has consistently proven the value proposition of the COTS approach – complex electronics technology qualified and developed on a company's own IRAD [Internal Research and Development] dollars. While there are still pockets in the industry wanting embedded subsystem designs kept in-house, time will continue to prove this a losing strategy, both financially and technically.

Q: *The defense market's budget-constrained environment makes forecasting tough. Given that fact, what segments of the military market will have the most growth potential over the next five years for producers of defense electronics?*

With defense budgets tightening, the days of defense programs spending billions of dollars to develop new custom technology are gone. Defense acquisition reform has placed an increased emphasis on affordable, mature technology already developed by industry. Program managers want suppliers that provide the lowest priced, technically acceptable solution. Based on this trend, market forecasters predict an increased use of COTS technology and open architectures to manage funding cuts in defense programs. Having said that, the military market segments I see having the most growth potential are C4ISR and electronic warfare, and I see this growth across all military services. Upgrades to existing platforms in these segments will see more growth compared to new program starts.

Jane Donaldson

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Jane (Jenny) Donaldson started Annapolis Micro Systems, Inc. in 1982 with Bob Donaldson and Lawrence Marshall, Jr., serving as the company's first president. Annapolis performed custom engineering: software for ground stations for Comsat, point-of-sale terminals for Schlumberger, medical instruments, contract assembly for IBM, and ASIC design for Atmel, in addition to touch technology work with IBM fellow Evon Greanias. In 1994, Jenny guided the company's transition from custom engineering to FPGA-based products. She has a B.A. in Philosophy and a minor in English from the University of Washington and took Computer Science classes in the late 1970s at the University of Maryland.

Q: *What are the biggest challenges you face every day as a woman in the defense industry?*

Oddly enough, I have never found any challenges caused by just being a woman. My main challenges are as a businessperson in the high-tech community: Pick the right product and develop and implement a tight plan for getting it developed, marketed, manufactured, and sold under budget and within a reasonable timeframe. Keep the customers happy. Keep the cash flowing in and out.

Q: *How do you overcome those challenges? What or who is your inspiration?*

I think hard all the time, work hard all the time, and constantly review everything and try to do better at everything. I work with the staff, particularly senior management, to help them do the same thing. For inspiration it starts with my parents, Ben and Jane Van Zwalenburg, who taught me by example that:

1. Every human being has a unique and intrinsic value.

2. Work has an inherent worth and we should do every task to the best of our ability.

3. I could and should use my talents to do something significant, to be a useful member of society.

My husband, Bob Donaldson, has stood by me and worked with me through every challenge life has offered us.

Our mentor, Evon Greanias, IBM fellow, taught us that in technology, if you are not pushing the envelope then you are wasting everyone's time and money, and that doing your absolute best is not good enough. It must work and must be on time.

Q: *How can women be more prepared to enter the male-dominated defense industry and, for that matter, traditionally male fields such as the engineering profession?*

My advice for others, both male and female:

1. Figure out your strengths, and play to them.

2. Be brave. You need to make mistakes in order to learn. If you never make mistakes, then you are not pushing yourself hard enough.

3. Challenge yourself. Often and always. You will be surprised to see what you can accomplish.

Q: *During your career in the defense electronics industry what have been the most significant events and disruptive technologies?*

Technology-wise it would be FPGAs and their development as a key tool for high-level signal processing in radar and electronic warfare platforms. We have been using FPGAs for processing since 1992. Today we are designing our 14th modular family of FPGA processing boards. A significant event would be a procurement one – the COTS initiative, introduced 20 years ago by then Secretary of Defense William Perry. COTS has changed the way the defense industry procures state-of-the-art technology and, along with common standards such as OpenVPX, enabled commercial processing technology to quickly and efficiently benefit the warfighter.

Q: *The defense market's budget-constrained environment makes forecasting tough. Given that fact, what segments of the military market will have the most growth potential over the next five years for producers of defense electronics?*

I foresee at least another four or five years of technology improvements in FPGAs, A/D, D/A, and Solid State Drives (SSDs) – the fields we currently care most about. We've geared our new line of products, which combine the latest FPGA technologies, the connectivity and speed possible from OpenVPX architectures, and high-performance A/D and D/A, to meet the current and near-term needs of our customers in defense applications such as radar, signal processing, Signals Intelligence (SIGINT), Electronics Intelligence (ELINT), and communications. We see these applications having the most growth, especially in the current budget-constrained environment where the government and primes will look to outsource more to embedded computing companies who develop COTS products to fit needs not being filled in the market. This is something that we believe customers have the money for and will pay for, if it were available. We review the latest available technology and put that together with our technical abilities.

Over the next few years it will be about advancing the state-of-the-art, providing a good resolution to needs, and doing it within the budget customers have for particular problems and within the timeframe in which the need will exist. Then we go for it.

Avionics upgrades enhance situational awareness for military pilots

By Sally Cole, Senior Editor

Military avionics retrofits to aircraft such as the B-1 Bomber are leveraging powerful commercial processors and high-speed networking in a distributed architecture to enable future capability upgrades. Meanwhile, safety concerns related to degraded visual environments are driving synthetic vision designs for rotary-wing platforms.

The B-1B Lancer was upgraded with Boeing's Integrated Battle Station, which included a Fully Integrated Datalink, a Vertical Situational Display Unit, and a Central Integrated Test System upgrade. Photo courtesy of Boeing.

Avionics upgrades currently underway on the U.S. Air Force's B-1 bomber fleet are integrating glass cockpits featuring larger, full-color displays and moving maps – supported by a Gigabit distributed Ethernet network and two types of datalinks – to significantly enhance communications and situational awareness within the battlespace.

The Boeing (Oklahoma City, OK; www.boeing.com) upgrade modification for the B-1, known as the Integrated Battle Station or IBS, is the most extensive mod program in the B-1's history and, among other things, replaces 25-year-old avionics. The IBS modernization program essentially merges three separate development programs – Vertical Situational Display Unit (VSDU), Fully Integrated Datalink System (FIDL), and Central Integrated Test System (CITS) to upgrade the B-1's front and back cockpits.

For perspective on just how massive this upgrade is, according to Boeing, the IBS kit consists of roughly 2,400 line items, which equates to about 16,000 parts. This mod requires removal of both front and back cockpit seats, redoing all wiring and consoles, installing the new displays and controls, and then testing the aircraft (see Figure 1).

Figure 1 | One major upgrade for the B-1 integrates a modern datalink communication network to enable real-time communication with other aircraft, ground stations, and allied forces. Photo courtesy of Boeing.

"Boeing's responsibility under the IBS contract is to produce kits that go into the B-1s. Then the Air Force 76th Aircraft Maintenance Group installs our kits at Tinker Air Force Base in Oklahoma, in two hangars, which can hold two aircraft per hangar," says Rick Greenwell, B-1 program director for Boeing. It took nearly 10 months to complete the first B-1 mod, but the goal is to reduce the install time to seven months.

New avionics hardware and software

Boeing's mod brings four new processors onboard the B-1: two each for its front and back cockpits. "These processors are equipped with eight slots for PowerPC single-board computers, but the slots aren't all populated, which leaves room for growth," explains Dan Ruder, B-1 strategic development and advanced programs manager for Boeing. "The processors' key function is to provide display processing for the new moving map capability, while a dedicated processor handles all datalink processing."

For its Real-Time Operating System (RTOS), the aircraft runs Integrity from Green Hills Software. "Each processor communicates over Gigabit Ethernet on the aircraft now," Ruder says. "Previously, the B-1 used a federated architecture, but replacing it with a distributed architecture onboard allows us to easily add new capabilities in the future."

To make it easier to maintain the system, the B-1 is shifting from Jovial programming language to C and C++, according to Greenwell.

The B-1 now also has two types of datalinks: Link 16 and a beyond-line-of-sight datalink satellite system. What do the new datalinks enable? Fast digital data uploads onto a computer; reprogramming an entire weapons load with a new set of coordinates now simply requires a mere two or three keystrokes. In the past, as Greenwell describes it, the process involved "a voice conversation and 'fat fingering' in at least 200 keystrokes and then verifying it."

Another big feature of the FIDL upgrade is a distributed architecture, which means data can be shown on any display within the aircraft. Collaboration tools within this architecture also enable the aircraft's crew "to look at each other's displays with a ghost cursor, so if one weapons system officer wants to see what someone else is looking at, he can see a ghost cursor over on his own display – this allows the crew to collaborate and ensures they're all looking at the same thing," Ruder says.

Future upgrades "may involve integrating improved datalinks or radar or sensors. If we decide to improve systems, the new IBS architecture will allow us to incorporate them into the B-1 more readily," Greenwell says.

B-1 pilots get new displays

Old-style monochrome displays didn't have much to offer in processing or display capabilities, which meant the B-1's front cockpit pilots lacked situational awareness about what was occurring around them in the battlefield. The "backseaters," however, had excellent situational awareness and were able to direct the front cockpit pilots where to fly, explains Ruder.

The VSDU portion of the upgrade brings "much larger displays that can show significantly more information," says Karl Shepherd, director of marketing and strategic development for Rockwell Collins (Cedar Rapids, IA; www.rockwellcollins.com), Boeing's long-time partner on the B-1. A big overall upgrade trend in displays is to go to larger sizes. "About 15 years ago, 10 x 8-inch displays were emerging as the largest size. Now, we're making 9 x 15-inch displays for cockpits," Shepherd says.

Demand for increased display sizes and processing improvements is being driven by the desire to host more software applications. "This is, in turn, driven by connectivity from aircraft to aircraft, sharing and exchanging information," he explains. "Once the aircraft are connected together they can exchange information in a digital fashion and interact with it."

Now, with moving maps and displays in the front cockpit, "the B-1 pilots' situational awareness is improved and they can actually interact with the offensive software. This unloads some of the workload from the backseaters to the frontseaters," Greenwell says.

The new color displays provide "better cuing about where threats are, such as 'friendly' blue force or 'enemy' red force tracking, and with the full moving maps they know exactly where they're going and have some control of their navigation," Ruder notes. "Now the pilot and copilot have the ability to have full control of their navigation, but the primary responsibility for navigation is still with the offensive system officer."

Diagnostics upgrade

Before the CITS upgrade of the diagnostics system, the B-1 had an antiquated Light Emitting Diode (LED)-type three-line display and could only monitor three parameters at a time, which were displayed in voltage units that required using a paper chart to plot it out and convert it to engineering units. Now, Boeing officials say that as many as 24 of 20,000 different parameters can be simultaneously monitored – everything from engine temperatures to hydraulic pressures to flight controls – whether the aircraft is inflight or on the ground.

"With the new display, everything is converted to engineering units so the maintainer doesn't need to do the paper chart lookup anymore," Ruder notes. "We've also given them display pages so they can view all of the important information for a specific system." Once the entire upgrade on the B-1 is complete, "it's a brand new aircraft to the flight crews," Greenwell says.

Figure 2 | C-130 cockpit before (left) and after upgrade (right). Photos courtesy of Rockwell Collins.

CNS ATM mandates, more glass cockpits

While the B-1 avionics mod created an essentially new cockpit for the pilots, other military avionics upgrades are being driven by two primary factors.

"The first factor is related to getting access to civil airspace, so they're trying to meet Communication, Navigation, Surveillance/Air Traffic Management (CNS ATM) mandates to ensure they won't be denied or get less-than-desirable access to airspace," Shepherd says. "This is a big issue and we're responding to it with our upgrade programs."

The second factor is simply that older aircraft tend to have analog or federated instruments. "As maintenance and sustainment costs become prohibitive, we're seeing upgrades to replace those legacy electromechanical instruments with either a full-glass or partial-glass cockpit, which lowers sustainment and maintenance costs and gives them a significant increase in capabilities," Shepherd adds.

Several other notable military avionics upgrades are also occurring now, primarily on the fixed-wing side. For example, Rockwell Collins engineers are working with the U.S. Air Force on ongoing tanker upgrade programs that include the KC-135 and KC-10, as well as multiple customers for C-130 upgrades around the world (see Figure 2).

Honeywell Aerospace (Phoenix, AZ; aerospace.honeywell.com) is also working on avionics upgrades of "everything from F-16s and F-15s to [rotary wing

platforms such as] OH-58s, CH-47s, [to transport aircraft like] C-130s, and even older aircraft like P-3s and B-52s around the world," notes Bob Olson, director of Military Integrated Avionics for Honeywell Aerospace.

Many military rotary-wing platforms are being recapitalized today and replaced with new aircraft that have upgraded avionics suites and glass cockpits. Next up for these platforms will be new avionics capabilities that focus on safety challenges.

Degraded visual environments

One of these safety features that hasn't evolved into an upgrade yet, but is likely to in the future, addresses the challenges of operating in degraded visual environments for rotary-wing military aircraft. Both Rockwell Collins and Honeywell Aerospace are working on approaches to deal with these challenges.

"When helicopters come into a landing zone and kick up either dust or snow, pilots want a way to increase situational awareness and reduce their workload by having information presented on glass cockpit displays to help them understand what the aircraft is doing relative to the terrain and the environment around them," Shepherd says.

Honeywell recently demonstrated a system with the U.S. Defense Advanced Research Projects Agency (DARPA), in which they operated in a degraded visual environment using a Blackhawk. They call this capability "Synthetic Vision Avionics Backbone (SVAB)," and it uses a "sensor impartial" approach with multiple sensors and databases to create an integrated 3-D scene for pilots.

"With SVAB, the pilot can look at a synthetic environment of obstacles to help land safely," says Olson. "Helicopters are the equivalent of off-road vehicles because they land in all kinds of conditions, so this feature is designed to enable much better situational awareness. It's not in production yet – we're at [Technology Readiness Level] TRL 6 now – but it's the kind of thing you might see in the future."

Rockwell Collins is also focusing on this area and recently completed a DARPA program to develop an SVAB that will fuse landing zone sensor data with terrain and obstacle data to produce an integrated 3-D view of the operational environment. "We're in Phase I of the U.S. Army's Degraded Environment Pilotage System (DVEPS) program, in which they're taking technology developed by DARPA and Rockwell Collins and transitioning it into their fleet of helicopters," Shepherd says (see Figure 3). **MES**

FACE Consortium's role in avionics upgrades

The Future Airborne Capability Environment (FACE) Consortium – an aviation-focused group comprised of industry suppliers, customers, and users – is working to create an open architecture, standards, and business model geared to help speed new capabilities to the warfighter faster.

"For avionics upgrades, our customers and users want to adopt and incorporate improvements on their aircraft at a much faster pace," says Karl Shepherd, director of marketing and strategic development for Rockwell Collins (Cedar Rapids, IA; www.rockwellcollins.com), which is a founding member of FACE. "We view the FACE Consortium's initiative as an enabler to add capabilities to aircraft much more quickly through software updates. FACE also publishes technical standards that specify the software architecture and how the applications communicate and interact."

Honeywell Aerospace (Phoenix, AZ; aerospace.honeywell.com) is also a FACE member. "The vision of developing standardized approaches and process models for avionics systems – with an eye toward reducing costs – is creating, in a simplified way, modular software building blocks that customers can choose from to assemble systems that essentially leverage work that's already been done," says Bob Olson, director of Military Integrated Avionics for Honeywell Aerospace. "Aircraft systems are sort of 'siloed' today, which makes it difficult to take a piece from one system and put it into another system cost effectively."

Expect FACE to be rolled into aircraft programs within the U.S. Army and U.S. Navy in the future. "Once they put it into their avionics – whether it's mission computers, displays, or other avionics – it'll bring new capabilities to the warfighter much faster, thanks to open systems around software applications," Shepherd says.

For more information on FACE, visit www.opengroup.us/face.

Figure 3 | Degraded Visual Environment Pilotage Systems (DVEPS) is fully compatible with the Common Avionics Architecture System on the U.S. Army's MH-47G and MH-60M helicopters, as well as many other tactical avionics systems. Photo courtesy of Rockwell Collins.

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Demystifying multi-core architecture for avionics

By Patrick Huyck

The Gen II Mission Computer for the U.S. Marine Corps UH-1Y and AH-1Z helicopter upgrades uses the Green Hills Software INTEGRITY-178 tuMP Multicore Operating System. tuMP is a registered trademark of Green Hills Software.

Avionics system architects making design decisions today are often frustrated by an expensive problem – having to perform a substantial redesign because an existing system lacked the flexibility required to support an update. Such inflexible barriers in the design process may be overcome by using new, highly-integrated multi-core processors that can provide long-term system flexibility. Multi-core processors are now being utilized to not only address the dwindling availability of new single-core processors, but also to take advantage of increased throughput while maintaining equivalent power consumption.

Discussions of the various multi-core operating system (OS) architectures often come to a common faulty conclusion: that they all provide similar capabilities, reducing the importance of architecture in design selection. A more detailed examination highlights the significant differences among some of the key multi-core OS architectures. Careful consideration of these differences can help prevent today's multi-core OS architecture choices from becoming a multi-million dollar roadblock to future system updates.

Background

In a single-core system, multiple applications may share a computing resource by robustly partitioning the memory, resources, and processor time between the hosted applications. A common approach to time partitioning is to divide a fixed time interval into a sequence of fixed sub-intervals referred to as "partition time windows." Each application is allocated one or more partition time windows, with the length and number of windows being factors of the application's worst-case execution time (WCET) and required repetition rate. The OS ensures that each application is provided access to the processor during its allocated time.

A concern in any system is how to account for application growth, especially for systems that tend to expand in scope (e.g., flight management or onboard maintenance). Approaches for single-core systems include using unallocated time, shifting and/or shortening the time allocations of other applications, and moving applications to more capable computing platform. A port to a multi-core platform should continue to support these methods as well as permit techniques that were not feasible under single-core architecture.

Multi-core – concurrent scheduling

At the most basic level, the cores of a multi-core processor can be allocated to concurrently execute independent applications or to concurrently execute multiple threads within an application. Any contention that can occur through the resources shared by two or more cores (like main memory or system interconnects) must be taken into account. Unfortunately, today's COTS multi-core processors currently lack hardware controls that permit administrating access to all the shared resources.

SMP multi-core architecture

Symmetric multi-processing (SMP) is a multi-core-based architecture in which a single OS controls all resources, including the allocation of cores to applications. "Symmetric" refers to all cores being considered as equal, permitting an OS to utilize any core to execute application threads. Even though an

application may have been designed to be multi-threaded, this does not mean that it will execute the same when multiple cores are available. For robust partitioning, the OS should include support to configure which cores are allocated to an application and which core a thread will have an affinity to execute on.

With SMP support, a conservative approach may be taken when porting a set of applications from a single-core to a multi-core processor, including preserving the existing partition schedule. By ensuring that all threads have an affinity for the same core, the threads will execute as if on a single-core processor. As illustrated in Figure 1, application growth can now be achieved by parallelizing specific applications as needed to gain throughput, choosing which core each thread will run on. New applications can be specifically designed to utilize multiple cores concurrently, potentially with shorter time allocations. In addition, the continuous built-in-test (BIT) application would be extended to confirm the correctness of all cores and the shared resources.

AMP multi-core architecture

When porting an application, even a multi-threaded one, there may be practical limits to how many cores can be effectively used in parallel. Asymmetric multi-processing (AMP) is a multi-core-based architecture in which each core operates essentially as a separate computing resource, permitting concurrent schedules. Such an architecture is referred to as "asymmetric" as it permits (but does not require) implementations to use different types of processor cores and/or operating systems. Since multiple dissimilar operating systems cannot all run at the highest processor privilege level, there is likely a monitor function (sometimes referred to as a "hypervisor") that provides this support across all cores. A strength of an AMP architecture is that different applications can run concurrently on the available cores. With some level of virtualization support (e.g., as part of the monitor function), this includes applications of dissimilar operating environments (think Linux or proprietary OS).

When porting applications from a single-core processor to an AMP architecture, a similar approach as described with the SMP architecture can be taken. However, the number of concurrently executing cores that can be realistically analyzed (for example, WCET) will be bounded until contention issues are resolved. As Figure 2 illustrates, server applications such as file systems are potentially good candidates for parallelism even under contention because of application codependency. Assuming contention for shared resources can be accounted for, each core in an AMP architecture could be configured to run independent application schedules or an entirely dissimilar environment such as a guest OS. A difficulty associated with running independent schedules is that analysis of resource utilization across the schedules will still be required. If the independent schedules cannot be coordinated in time, analyzing and accounting for resource availability and coordinated hardware BIT may be impossible. If one of the cores is running a virtualized OS (Linux, for example), a lack of assurance activities on the OS combined with an inability to coordinate hardware BIT can result in significant limitations in what can be run in parallel.

When an application update requires more bandwidth than its current core can support, the application can be ported to one of the other cores. Such porting will be complicated by several factors inherent to an AMP architecture.

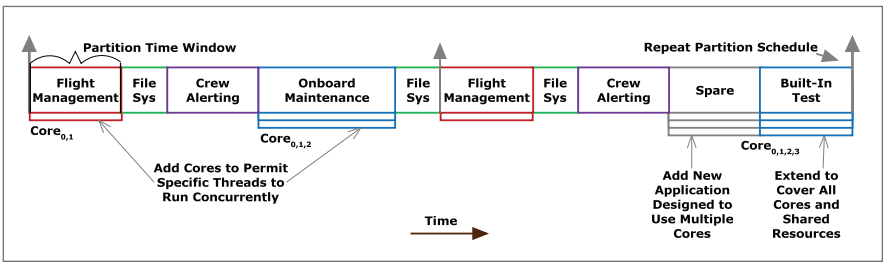


Figure 1 | Application growth considerations with SMP

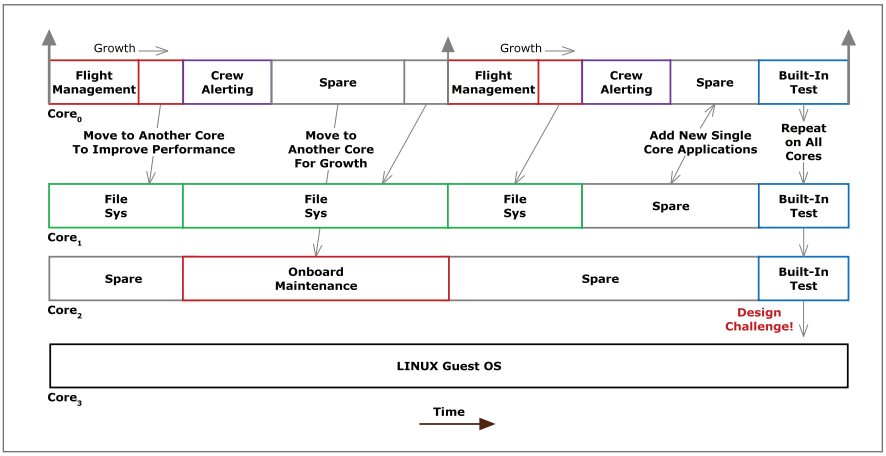


Figure 2 | Application growth considerations with AMP

For example, the bandwidth must all come from one core, porting may break assumptions about the order applications execute, and transport delay may be impacted as a result of differences in the on/off core communication mechanisms. These complications contradict the popular thought that an AMP architecture is easier to certify as a result of its less complicated scheduling.

tuMP multi-core architecture from Green Hills Software

Other architectures include heterogeneous multi-processing (HMP – individual cores are statically divided into independent AMP or SMP subsystems, each with their own OS) and unified multi-processing (UMP – individual cores are statically divided into subsystems on an application basis but with a single "unified" OS). A common limit to AMP, SMP, and other similar architectures is that core usage is fixed during execution and does not change once allocated. This limitation is resolved by a multi-core architecture developed by Green Hills Software, currently undergoing DO-178B Level A certification efforts as part of the INTEGRITY-178 product line. This architecture, referred to as "time-variant unified multi-processing" (tuMP), significantly improves the flexibility in how the processor cores can be utilized. (tuMP is a registered trademark of Green Hills Software.) The feasibility of the tuMP architecture is demonstrated by its implementation as an update to the INTEGRITY-178 single-core product, preserving 12 years of safety and security assurance pedigree and product service history.

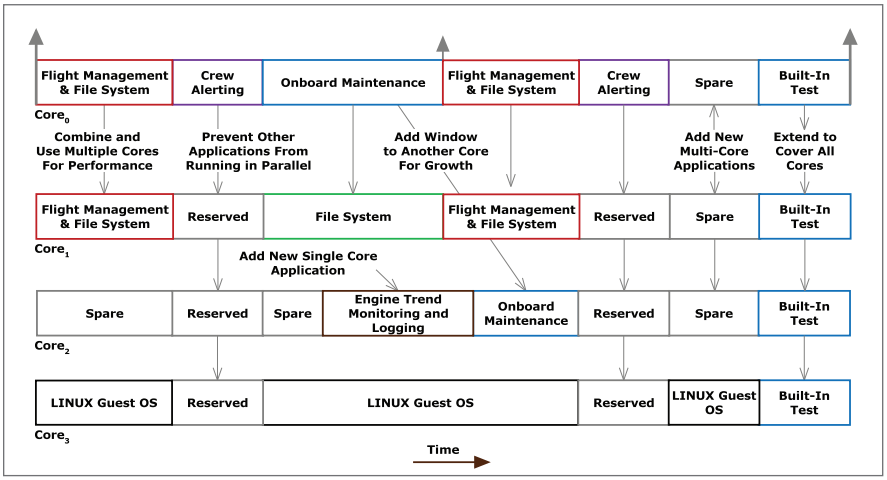


Figure 3 | Application growth considerations with tuMP

The benefit of the tuMP architecture is that it retains all AMP and SMP scheduling capabilities while resolving their significant limitations. The tuMP architecture provides flexibility through a new schedulable entity referred to as an "affinity group," which is an association of applications, cores, and scheduling characteristics. Only the applications assigned to the affinity group can use the cores assigned to that same affinity group during their scheduled time window. By creating multiple subsystem schedules, independent affinity groups (i.e., non-overlapping use of applications and cores) can be scheduled simultaneously and without restriction that the time windows must be aligned across all cores. In addition, applications can run on different sets of cores by creating unique affinity groups for each combination. With tuMP there is complete flexibility to utilize the available cores for concurrent application and concurrent thread execution and change these relationships when required (that is, time-variant).

The tuMP architecture is referred to as "unified" in that a common OS controls the scheduling of all cores and the overall communications between applications. This characteristic resolves the AMP application porting concern when moving between cores; the same mechanisms can be utilized to communicate

Guest OS challenges

The ability to integrate dissimilar operating systems is considered an advantage and a reason to move towards the use of multi-core processors, in particular for systems that may have dependencies on a legacy OS. The choice of guest OS and how it must interact with the hardware may restrict the software safety levels of other applications that can be integrated onto the same multi-core processor.

The integration of dissimilar operating systems onto a multi-core processor will introduce some unique certification concerns. Fundamentally, integration of dissimilar operating systems will require a shift in the basic processor hardware-separation characteristics that are relied upon. Partitioning operating systems utilized in avionics for the last decade have generally relied on two processor execution modes (kernel mode, in which the assigned operating system has full access to all system resources; and user mode, in which an assigned application only has access to the resources it has been authorized to use). When a guest OS such as Linux is introduced, the guest OS will need a privileged processor state that has more authorization than its applications. As a minimum, a monitor (or hypervisor) must occupy the highest processor privilege (to support the dissimilar operating systems), and thus a third processor mode between user and kernel mode must be available and assigned to the guest OS. The service history of using three processor modes in commercial avionics is poor or nonexistent, meaning that this capability may have novel considerations that will have to be resolved in addition to adding multi-core support.

Regardless of assurance activities performed on the guest OS, the guest OS will not be authorized to execute all of the privileged instructions it previously executed. The monitor operating in kernel mode will need to include exception handlers for these capabilities. Depending on the capability, the monitor may deny the request, perform the request at the guest OS's behalf, or send the request off to another application for processing. These activities require execution time that the guest OS did not require when it controlled the entire processor directly. This execution time, context changes, cache impacts, and related assurance activities add risks and costs that are in addition to those associated with basic multi-core support.

between applications on the same or different cores.

The port of a partition schedule from a single-core processor can be accomplished by creating an identical subsystem schedule with an affinity group for each application bound to the same core. If some applications need additional throughput, additional cores can be allocated to their affinity groups or they can be allocated unused time from any core.

In the AMP system (seen in Figure 2), a degree of parallelism was achieved by running a file system application in parallel with the codependent applications. If the application requires more throughput than the file system, the file system underutilizes its core. As shown in Figure 3, tuMP resolves the underutilization by creating an affinity group that combines the file system with the applications dependent upon it – such as flight management – and assigning multiple cores to it. In this scenario, the file system can have an affinity for a specific core that the application also utilizes when not in use for file system operations.

Integration of a guest OS on a core is a design challenge in an AMP system when other applications (BIT, for example) require simultaneous control over all cores or when an existing application is not tolerant to other applications running in parallel. In tuMP, the guest-OS affinity group can be assigned to multiple partition time windows that break up the usage of the core to support these other requirements. Now the BIT application's affinity group can be assigned all the cores so that it can perform the necessary hardware tests.

In the AMP system, an application whose core had insufficient throughput to support an update could be supported if another core had sufficient unallocated time to support the updated application. With tuMP, the application (e.g., Onboard Maintenance) can be spread across time windows associated with multiple cores, not just one core.

Application portability standards updates for multi-core

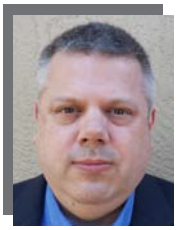
Application portability will be a key characteristic that some system designers will want to carry forward into a multi-core based platform. In support of this, multi-core efforts have been initiated by Green Hills Software to update both of the primary portability standards: ARINC 653 and POSIX (through the Real-Time Embedded Systems forum of the Open Group). As the updates to these consensus-based standards mature, these capabilities will be available for use with multi-core supporting operating systems such as INTEGRITY-178 tuMP. Another standard with plans to incorporate multi-core capabilities is the Future Airborne Capability Environment (FACE) Technical Standard that is managed by the FACE Consortium within the Open Group. As the ARINC 653 and POSIX multi-core updates are completed, these updates are planned to be incorporated into the FACE Technical Standard.

Integrating multi-core processors

Avionics-certification efforts require thorough understanding of the complexities and consequences of the use of those technologies. System designers should keep in mind the importance of carefully choosing their architecture as they integrate multi-core processors into their avionics platform designs. System designers should consider selecting a multi-core architecture based on its system flexibilities to optimize core usage and manage certification risks. For their part, users should understand that their supplier's choices of today will impact the economic feasibility of future software expansions. **MES**

Certification authorities prepare for multi-core

Some vendors have reported a lack of certification authority guidance as a reason to delay multi-core architecture decisions. In reality, both EASA and the FAA are progressing on addressing multi-core system, hardware, and software concerns. At the 2013 Certification Together International Conference, EASA shared its research and concerns in regard to safe usage of multi-core processors. Earlier in 2013, EASA and the FAA met with the Multi-Core for Avionics (MCFA) Working Group. According to MCFA, the working group was formed in 2010 to assist avionics suppliers in certifying equipment that utilized multi-core processors. EASA has developed a draft certification review item (CRI) for multi-core based systems. The CRI includes a number of objectives that should be accounted for in order to achieve certification of a multi-core-based system, covering systems, hardware, and software concerns that must be addressed as part of certification. EASA solicited and received comments on the draft multi-core CRI from MCFA and is preparing guidance planned for publication in FY14. Representatives of the FAA have publicly expressed concerns similar to EASA in regard to multi-core, and have plans to also provide guidance in FY14 with the goal that it is harmonized with the EASA CRI. Companies such as Green Hills Software are addressing the concerns raised in the available guidance as part of their plans for certification.



Patrick Huyck, *Systems Certification Manager at Green Hills Software, has more than 27 years' experience in the development of real-time embedded products for commercial avionics, military, and security products. Patrick supports the certification of DO-178B Level A and Common Criteria EAL 6+ real-time operating systems and middleware products. He is an active member of the ARINC 653 standard committee, the FACE consortium, and is an FAA software Designated Engineering Representative (DER). His career also includes 15 years with Rockwell Collins. Patrick has a B.S. in electrical engineering and an M.S. in computer engineering.*

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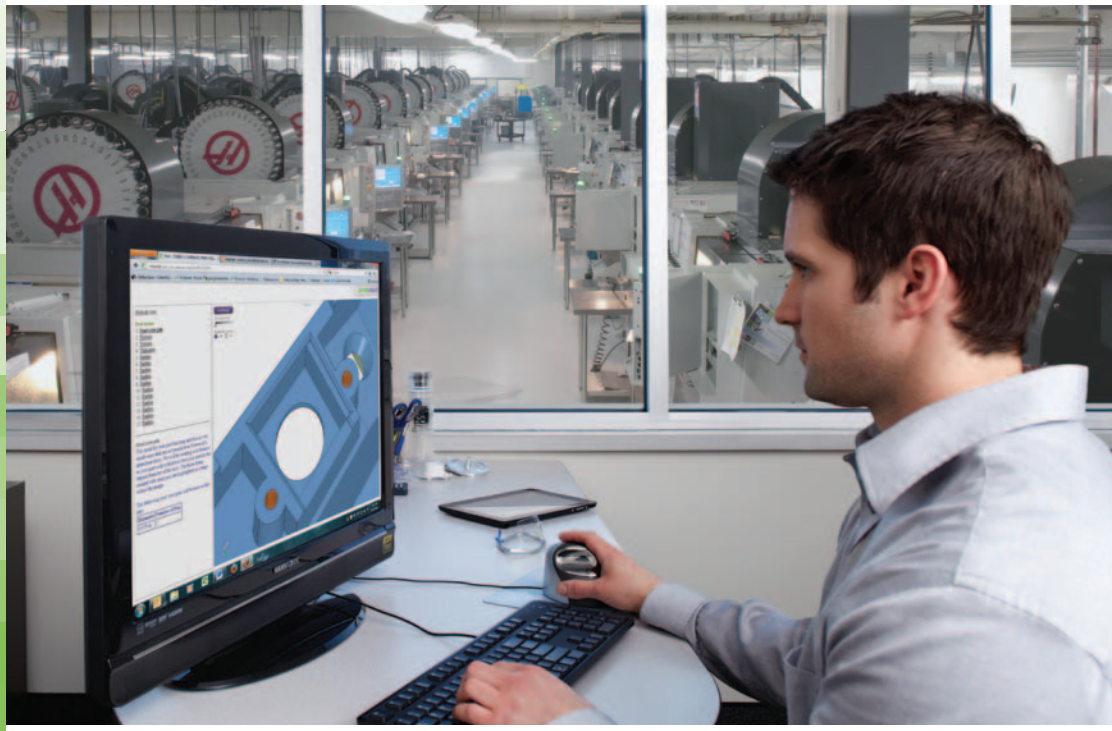

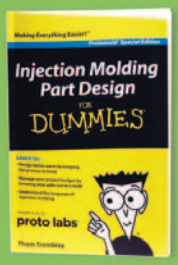

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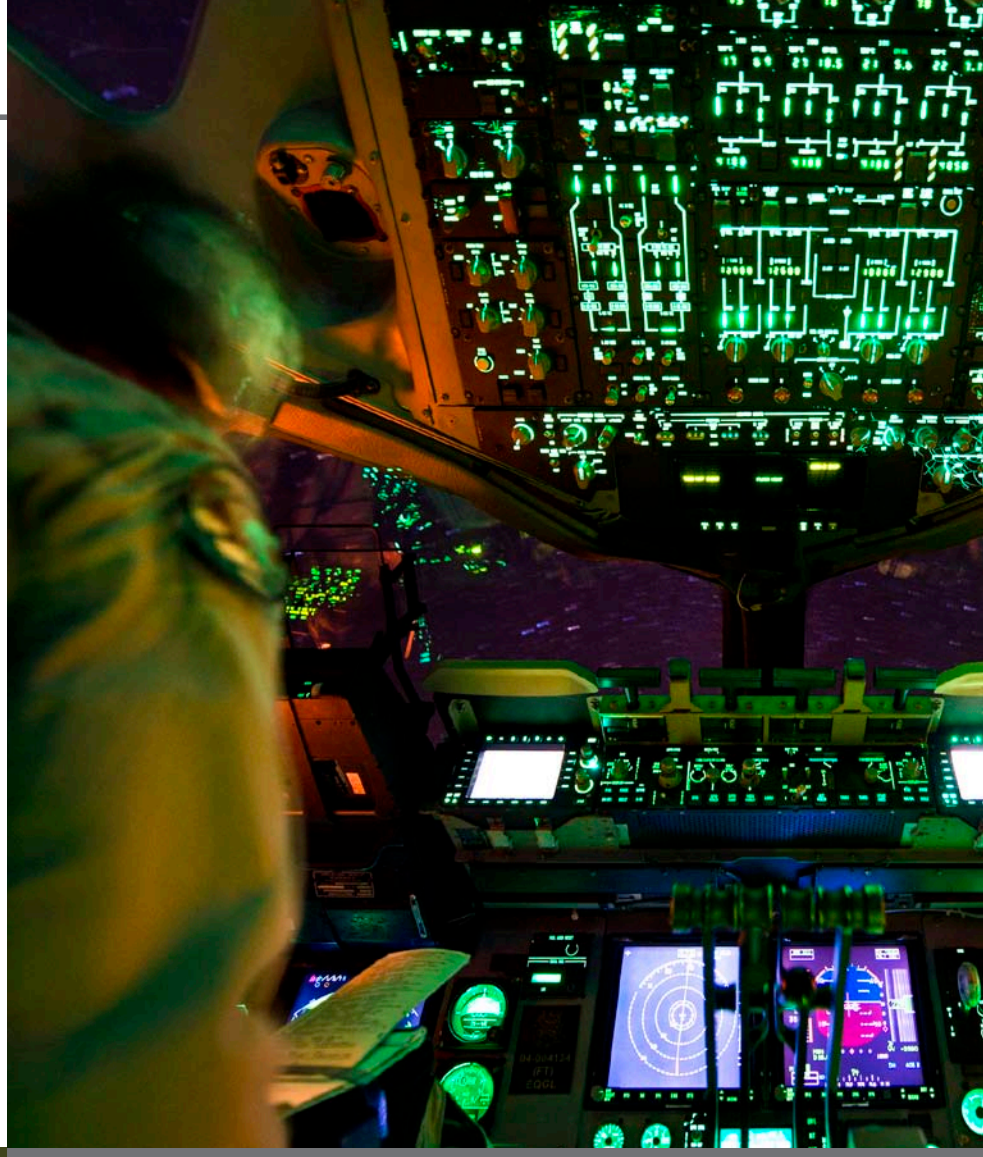
MIL-STD-1553 IP cores challenge traditional IC implementation

By Marc Foster

Forty years since its release, MIL-STD-1553 is evolving from traditional Integrated Circuits (ICs) to Intellectual Property (IP) cores integrated with Field Programmable Gate Arrays (FPGAs). The advantages of IP core implementation include cost reduction, the ability to upgrade and adapt a design over time, a smaller size footprint, and improved sourcing. Designers choosing IP cores must consider validation testing, code size, FPGA support, and compatibility with legacy software.



U.S. Air Force Capt. Lauren Hoyt and U.S. Air Force 1st Lt. Mark Benis check the 816th Expeditionary Airlift Squadron fly a C-17 Globemaster III aircraft over southern Afghanistan. The crew landed at Kandahar Airfield to airlift mine-resistant, ambush-protected vehicles out of Afghanistan for Operation Enduring Freedom retrograde operations. U.S. Air Force photo by Tech. Sgt. Jason Robertson.

MIL-STD-1553 overview

MIL-STD-1553, introduced in 1973, is a dual-redundant serial bus widely used in avionics and space applications. Originally used in the F-16, 1553 connects a Bus Controller (BC) to as many as 31 Remote Terminal (RT) devices at a 1 Mbps data rate.

Those early 1553 designs were quite complicated: BC and RT units connected to the processor's bus using transformers, while transceivers converted the analog signals to and from digital signals. A digital controller converted the digital signals to and from Manchester code, managing the entire process of receiving and transmitting data in accordance with the 1553 specifications.

Approximately 15 years later, the first gate-array Application-Specific Integrated Circuits (ASICs) were produced, offering a single chip that could handle the entire digital portion of the 1553 board. About the same time, the analog transceiver was condensed from discrete devices into a single module. Next, several companies created hybrid circuits integrating the required digital and analog parts into a single IC. Once introduced, these single mixed-signal ICs dominated the market as the solution for 1553 communications.

Fast-forward to today: The latest emerging technology in MIL-STD-1553 is the IP core. The 1553 IP cores integrate with other user logic into an FPGA, offering designers numerous advantages over traditional 1553 ICs.

Benefits of IP cores

Lower cost

Embedding 1553 functionality into an FPGA with other design requirements yields significant cost savings. In addition to the cost of the FPGA, the incremental price per 1553 node is only the cost of the analog transceiver and the IP core use-license. Since there are many suppliers for analog transceivers, pricing is competitive, and this architecture can deliver more than 50 percent cost reduction in 1553 node price for moderate quantities.

Ability to upgrade

Once a 1553 IC is soldered to a board the device's functionality cannot be changed. Since FPGAs can be reprogrammed, the 1553 functionality can be enhanced, modified, or even replaced by a new IP core if required. This architecture also allows for various bus device configurations – such as one, two, or more channels, or even different interface types such as WB-194 or H009 – without any change in FPGA technology or PCB

hardware. FPGAs make upgrades simple as they can be reprogrammed in the field – even via the 1553 bus in some cases.

Less board space

The IP core typically consumes 2 to 15 percent of a common FPGA, often enabling it to be integrated into an FPGA already handling other functionality in a particular design. In this case, only an additional small analog receiver is required to implement 1553, reducing the size required for the PCB. Figure 1 (on page 32) shows a PCI Mezzanine Card (PMC) that packs eight 1553 channels into a 74 mm by 143 mm footprint.

Easy evaluation before committing

Free IP core evaluations can be quickly supplied by IP vendors upon request and all functionality can be evaluated and simulated before a single trace is routed for the PCB. These samples may include

a limited version of the core, allowing 95 percent of the functions contained in the full core. The designer can check simulations, integrate the limited IP core, and test the behavior in the lab, which will reduce risks, costs, and design time.

Future-proof designs

IP cores are not FPGA specific and the core can be moved to a different FPGA part if the first FPGA part becomes obsolete. This compatibility enables users to easily update their board and FPGA device while maintaining the proven functionality.

Eliminates single source

Each 1553 IC has a unique interface and functionality, making it nearly impossible to easily change vendors for the parts since it would require a hardware and software redesign. Having a sole source raises price, availability, and obsolescence concerns. An IP core implementation eliminates these problems. Once the IP core is licensed to a customer, the supply chain is simplified. The customer integrates the IP core in the form of EDIF netlist into the FPGA and procures the FPGA from a variety of distribution sources themselves, eliminating the dependence on the 1553 IC vendor.

Important considerations in choosing IP cores

MIL-STD-1553 IP cores are available from several companies and, as you might expect, performance and quality can vary. To choose the best solution for their particular application, designers should compare key attributes of 1553 IP cores.

The first would be 1553 validation testing. Full 1553 validation testing is required to certify proper IP core compliance to MIL-STD-1553 electrical and software requirements. Choosing an IP core that has been approved through third-party testing will prevent surprises and delays later in the project. Another piece to consider is that of small code

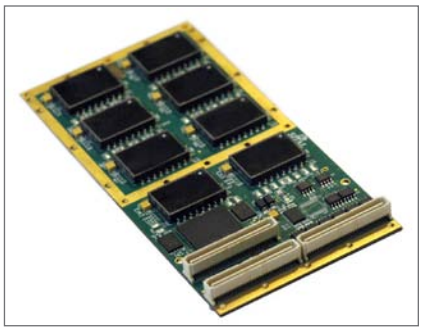


Figure 1 | MIL-STD-1553 eight-channel PMC module.

size. As discussed before, one of the advantages of IP cores over ICs is the fact that IP cores can reside within an FPGA that performs other functions as well. To allow room for this additional functionality while keeping FPGA cost reasonable, the IP core should require minimum FPGA resources.

Support for a range of FPGA vendors and families

Another consideration for designers is that IP cores should fit any FPGA vendor

and family. FPGA families range from general purpose to devices with specific characteristics such as radiation resistance, low power, non-volatile, and high memory volume. Designers can select the appropriate FPGA for their application and IP vendors should be able to supply the appropriate netlists for the parts. The VHDL source code from which the netlist is produced should be vendor independent in code style to support all FPGA families.

Multiple clock domains may cause overhead in FPGA design, or in some cases bad data read/write cycles. It is important, therefore, that the IP core support a clock frequency that is already available on the target board, such as PCI Express (125 MHz) or PCI (33/66 MHz).

One last consideration is compatibility with legacy software. Software integration is a critical consideration for applications migrating from an IC-based design to an IP core. In many cases, designers will not want to make changes to their existing, working software environment. IP cores should be software compatible with legacy 1553 ICs, allowing the designer to replace an existing 1553 IC with an FPGA-based IP core with minimal risk.

IP cores specifically for military, avionics

IP cores offer many advantages over traditional 1553 ICs including lower cost, reduced size, easy ability to update, improved availability, and lifecycle control. Combining the benefits of FPGAs and IP cores provides a small-size, robust, reliable, and future-proof solution for MIL-STD-1553 interface, perfect for custom board implementations.

Sealevel Systems, Inc. has partnered with Sital Technology to supply MIL-STD-1553 IP core products engineered for military, aerospace, and avionics applications. Users can choose between various available configurations and interfaces. From the small 1553 Front-End, designed for simple applications where no CPU is controlling the system, to the most complex implementations, where a local bus is used by the CPU or where PCIe or PCI bus is used.

All IP cores available from Sealevel work with any FPGA, clock frequency, and 1553 transceiver. Each IP core is third-party tested and offers software compatibility with existing ICs. **MES**

Marc Foster,
Director of Strategic and Government Sales at Sealevel Systems, Inc., has more than 12 years of experience designing solutions for military applications. Marc graduated from Clemson University in 1997. Before joining Sealevel's team in 2001, Marc worked in business development for Synnex Corporation where he developed solutions for communications platforms. Readers may reach him at marcf@sealevel.com.

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Safety certification concerns for UAVs in national airspace

By Amanda Harvey, Assistant Editor

The transition to DO-178C continues to improve guidelines for avionics certification – however, big questions still surround the regulation of Unmanned Aerial Vehicles (UAVs) in national airspace and how industry and government will go about ensuring that these drones are safe to fly daily in the same skies as passenger aircraft.

An RQ-7B Shadow unmanned aerial vehicle is catapulted into flight at Forward Operating Base Fenty, Afghanistan. U.S. Army photo by Spc. Margaret Taylor.

The Federal Aviation Administration (FAA), typically a stickler for documentation and certifications when it comes to avionics hardware and software, recently opened national airspace to UAVs with a "certificate of authorization" being the only prerequisite for domestic flight, says George Romanski, President and CEO of Verocel, Inc. in Westford, MA. The lack of guidelines has led to retroactive certification development so that UAVs can continue to be used in the future, he adds.

"There's still a long way to go – some of these systems were not designed well, or the software was not designed well for certification," Romanski continues. "Very often we have software in a control segment that may have a huge number of lines of code without proper partitioning into smaller parts, and when we have a huge system then it's really difficult to certify. In the future, we'll have architectures where you can split the software into critical components and non-critical components and then focus on the certification of the critical components. Until they are separated properly – or as we call it, robustly partitioned – then it's going to be very difficult and expensive to certify these huge software systems."

"We need a top-down approach that clearly identifies the safety critical elements in the architecture and thus allows you to focus on those elements for an eventual design upgrade," says Wayne McGee, VP of Sales and General Manager of Creative Electronic Systems (CES) in Raleigh, NC. "Re-design from scratch is not an option for obvious economic reasons. In-service history can help to boost confidence in the safety of some components, but is not available in all cases. Current UAV designs tend to use [Commercial Off-The-Shelf] COTS solutions, which allows them to keep costs down in spite of relatively low volumes, and to benefit from rapidly evolving technology. Meeting safety criteria with these architectures, which are usually met by complete custom designs in commercial aviation, is a real challenge."

Although a certificate of authorization is required from the FAA, is it safe for UAVs to fly in the national airspace alongside passenger airliners?

"The fact of the matter is, one serious accident in the airspace is going to mean the end of using UAVs for anything anywhere," says Robert Dewar, Co-founder and CEO of AdaCore in New York City. "[However,] 'UAV' covers a huge range of what things actually are – some of them are no more than toy helicopters with a little camera aboard. If you're an amateur, you can fly impressive gizmos around if you obey certain rules and keep them out of populated areas, and the low-end UAVs are little more than that. But at the top-end, something like a Predator drone is a full-blown aircraft, and there's everything in between. We tend to lump everything together with UAVs without enough attention to that huge range of things – if it's a tiny toy helicopter it's unlikely to cause any real damage. It can likely be swallowed up by the jet engine. Is it more dangerous than a bird? Birds are quite dangerous to jets in flight, but we have plenty of those flying around, so I think you could argue that small UAVs are no more dangerous to fly than birds. It doesn't mean there's zero danger but it does mean it's something we can tolerate and deal with as we have to."

Law enforcement and UAV safety

Some believe that the FAA's safety concern with UAVs is stronger than the police department's or military's because these organizations have casualties all the time, whereas if the FAA or private companies such as Amazon (who may implement potential drone delivery services) have accidents, it would be a huge liability and mark an end of UAV use in the national airspace.

"I think the FAA on its own would be inclined to be very conservative," Dewar says. While there is pressure from police departments to gain access to UAVs, "police departments aren't particularly fundamentally focused on safety," continues Dewar. "They're always willing to accept a little bit of collateral damage in effort to get the bad guys. Whether civilians are killed in high speed chases, or accidentally shot – it's very regrettable, but it happens. Of course that's even more true of military applications. The people who most want to use the UAVs are not really the people who you can most trust with safety concerns."

The future of UAV safety certification

"The small Unmanned Air Systems (UASs) might be a lot easier to approve. It may be that we'll start getting lots of tiny aircraft being approved ahead of the medium and large aircraft," Romanski says.

The future of safety certifications for UAVs is still unknown, but making civil airspace certification part of the initial requirements is key, McGee says. "This way, safety considerations have been taken into account from the start, so that a formal certification process can be filed based on current regulations and best engineering practices. By taking safety considerations into account early, the effort of carrying through the actual certification process can be spread over time."

DO-178C update

Retroactive certifying for UAVs is made a little easier by the safety certification improvements to DO-178C. DO-178C was officially implemented in January 2012; however, work is still being done to transition avionics systems to the new standard.

The transition is going to be gradual, Dewar says. "There are certainly some important advantages to DO-178C and I think what's happening at least in some cases is people are taking some of the inspiration from DO-178C and applying it even now to certifications using DO-178B," he continues.

Some methods that have been included in DO-178C are five additional tool qualification levels, objectives to be met if model-based or object-oriented design methods are used, and objectives to be met if formal verification methods are used, McGee says. "The step from DO-178B to DO-178C represents good progress in addressing tools and best practices in certification; nevertheless, safety will always come with a price tag attached in terms of additional development costs."

Model-based and object-oriented development

There seems to be a lean towards model-based and object-oriented development in DO-178C, Romanski says. Many people are moving towards developing systems using a model, and then simply using tools to convert that to code, he adds.

"The model-based supplement describes how to certify software when using

a model-based approach and the FAA has added some clarification, or at least emphasis, on how the model-based supplement should be used," Romanski explains. "So they've added some emphasis that there has to be a clear separation between the representation of models and the implementation with models. Some people tried to use a model to represent requirements and design and then they would do auto-code generation from the design and then try and take credit for testing the model and then not doing much testing on the hardware itself, on the final software. The FAA has now made it very clear there has to be a clear separation between the different representations, which is good."

One trending technique for simplifying certification and reducing costs is code reuse. "Certification involves two things – it involves generating all the materials for certification, and then actually doing the testing. There's a lot of interest in combining artifacts with code so that they travel as a package. You're not going to escape the need to run at least full integration tests on the new environment, but if you can replace unit tests with formal proofs, the formal proofs don't change from one target to another," Dewar says.

An example of code reuse is the idea of Integrated Modular Avionics (IMA). Romanski explains that several companies may work together to develop separate components that are all tested individually within a system, which is the approach being used by the Future Airborne Capability Environment (FACE) Consortium. An advantage here, Romanski continues, is if someone has a component and they say, "'I have certification evidence that my component satisfies DO-178C' then that becomes a valuable commodity which doesn't have to be regenerated for every application, it could simply be taken and

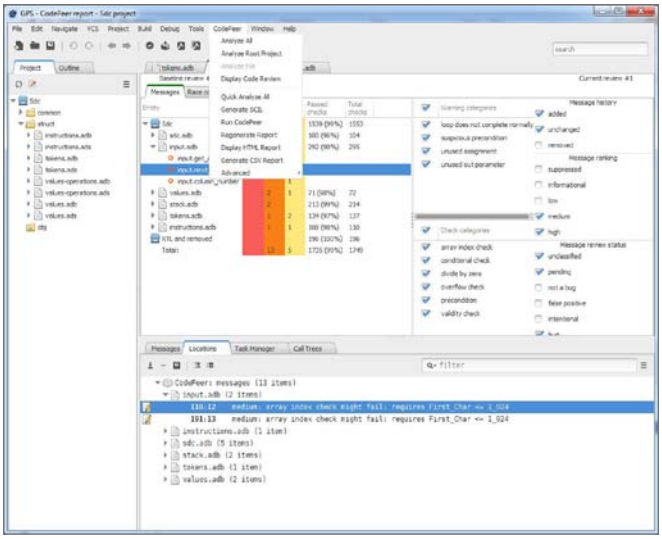

Figure 1 | AdaCore's CodePeer automatic code review and validation tool assesses potential bugs prior to program execution to find and report errors early in the software development lifecycle. Photo courtesy of AdaCore.

plugged into any application that you need. That's the direction that we're moving in and that's the new type of business model that the Department of Defense (DoD) is pushing."

FACE Consortium

FACE essentially enables software applications that have the common FACE Application Programming Interface (API) to have portability across multiple avionics platforms – from rotary wing to fixed wing to unmanned aircraft. In other words, the software can be reused without expensive recertification.

Code reuse is a key factor in this effort. FACE looks to bring commonality and reuse through common interfaces and data descriptions. Work on this standard is progressing and enthusiasm for it is high, but there is still much to be done. Once it defined the base architecture for FACE systems, the FACE Consortium began alpha/beta testing with FACE conformants, says Dudrey Smith, Senior Consultant for AdaCore in New York City. Conformant testing will ensure that connecting interfaces with FACE-compliant systems is not like "connecting oil and water," he adds.

"What's important to realize is no one has really [yet] architected their systems for [FACE], so now they have to convince industry and others" to take existing systems and see what is necessary to make them FACE conformant and then run the appropriate tests, Smith continues. "The big questions that we can't answer right now is how much of a performance hit are we going to take for this? How much is it going to cost to go through and re-architect a legacy system into a FACE architecture?"

Smith projects that the FACE standard will not be ready for deployment for another one to five years. The most current update to FACE – FACE Edition 2.0 – is published and available on the FACE website at www2.opengroup.org/ogsys/catalog/c137. **MES**

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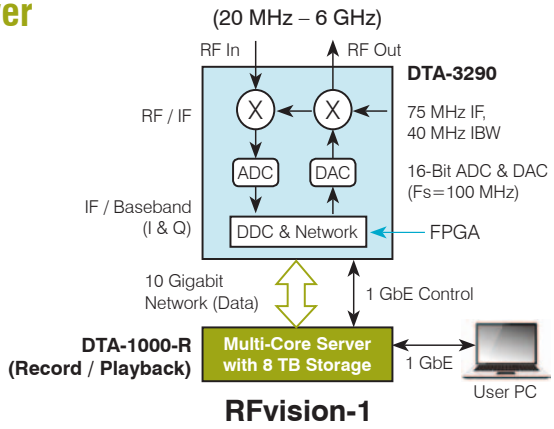

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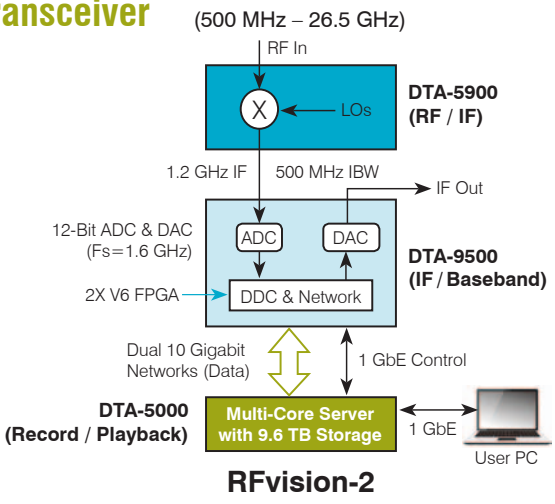

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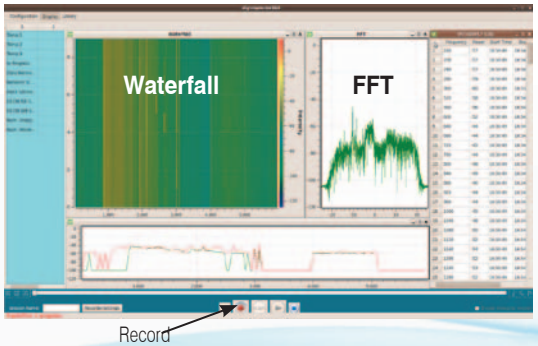

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ENCRYPTION

"Keys" to COTS encrypting of data-at-rest

By Paul Davis

Data security is a major concern for all businesses these days. One only has to follow the news coverage of data breaches at large retailers, major corporations, and government agencies to see the financial and security fallout from these attacks. However, for deployed military applications, data security has always been a concern and thanks to new Commercial Off-The-Shelf (COTS) options, data-at-rest security has become more efficient and affordable.

This MC-130J Super Hercules Commando II supports missions such as infiltration/exfiltration, in-flight refueling, and aerial delivery and resupply of special operations forces. Lockheed Martin photo by Todd R. McQueen.

After data that is "on-the-move" reaches its intended destination and is stored, it is considered "Data-At-Rest" (DAR). For deployed applications, the preferred DAR storage technology is solid-state memory. Rotating disks have been used in rugged deployed applications, but only with elaborate and costly vibration-damping systems. Today there are three types of NAND flash used as the basic building blocks for solid-state memory. Multi-Level Cell (MLC) memory is commonly used in USB sticks and SD cards, but its temperature range is too narrow for deployed applications. While significantly less costly than Single-Level Cell (SLC) memory, MLC has only one-tenth the endurance. SLC memory supports a wide temperature range and provides high endurance (100,000 writes to a single cell), making it today's preferred memory for deployed applications. A new type of memory provides a compromise approach: "enterprise MLC" (eMLC) offers a wide temperature range and good endurance at a cost between that of SLC and MLC.

All solid-state memory systems employ common methods to ensure that data is properly retained – methods that include wear leveling, bad-block mapping, error correction, and write-amplification techniques to improve the storage life. Now that we have cost-effective memory options for deployed applications, how do we protect that critical data?

Encryption choices

Regardless of whether SLC or eMLC memory is used to store the data-at-rest, choosing the optimal encryption method can be complicated. While a variety of encryption schemes and methods are available, the final choice will depend on the application. The decision about which level of encryption is required for a particular application rests with the program's Designated Approving Authority (DAA). When selecting and approving the ideal encryption approach, the DAA must trade off costs, schedule, risks, and operational constraints. The DAA may decide, for example, that even though an encryption method is below the level of NSA-certified, the security level is satisfactory for protecting classified data because the stored data will be protected by armed guard. The DAA will also likely evaluate other factors such as the storage medium's anti-tamper mechanisms.

Encryption built into the SSD

Today, encryption is frequently offered within the Solid-State Drives (SSDs). Some SSDs support AES 128-bit encryption, while newer models are upgrading to AES 256-bit. In either case, the SSD is shipped with the encryption key already installed. The user must log in with a password in order to use the drive. The current key can be cleared or purged by initiating a "Secure Erase" or "Enhanced Secure Erase" process. A new key can be internally generated, often using a random-number generator. However, any data that was encrypted with the old key will be irretrievably lost.

For deployed applications, having the key reside with the SSD poses concerns when the SSD (and data-at-rest) need to

be transported. If the SSD were lost or stolen and the password coerced from the user, the key can be accessed, making sensitive data readable. Purging the key prior to transport makes the data unreadable and irretrievable. Sensitive data, such as that captured on an airborne mission, may have been very costly to acquire, making its loss unacceptable.

By itself, encryption within the SSD may be satisfactory for Sensitive But Unclassified (SBU) applications, but the technique is unlikely to satisfy applications requiring higher security levels, such as Secret and Below Information (SABI) or Top Secret and Below Information (TSABI). As noted earlier, the DAA determines which method is acceptable for a particular application. If the SSD is guarded during transport by a soldier with an M-16, the DAA may find this method of encryption adequate.

FIPS 140-2 encryption

Encryption modules for use with SBU data are defined in Federal Information Processing Standards Publications (FIPS PUBS) issued by the National Institute of Standards and Technology (NIST). FIPS products are controlled by the U.S. Department of Commerce, and are not normally International Traffic in Arms Regulations (ITAR)-restricted. "Security Requirements for Cryptographic Modules," defined by the FIPS PUB 140-2 or FIPS 140-2 standards, specify the security requirements for a cryptographic module utilized within a security system to protect SBU data.

FIPS 140-2 provides four increasing qualitative levels of security, which cover the wide range of potential applications and environments. The standard provides guidance for design and testing for cryptographic module specification; cryptographic module ports and interfaces; roles, services, and authentication; finite-state model; physical security; operational environment; cryptographic key management; Electromagnetic Interference/Electromagnetic Compatibility (EMI/EMC); self-tests; design assurance; and mitigation of other attacks.

The Cryptographic Module Validation Program (CMVP), a joint effort between NIST and the Communications Security Establishment (CSE) of the Government of Canada, provides validation for cryptographic modules to FIPS 140-2. FIPS 140-2 validated products are accepted by the federal agencies of both countries for the protection of SBU information (United States) or Designated Information (Canada). CMVP-accredited labs – listed on the NIST website – are located in numerous countries, indicating the international nature of FIPS 140-2 and broad acceptance of FIPS 140-2 validated encryption products.

FIPS 140-2 certification can be pursued by any company, which then covers all costs for validating their particular product. Unlike certification for the higher-level Type 1 encryption, FIPS 140-2 does not require a program sponsor. The FIPS 140-2 validation certificate not only indicates that an encryption product is fit to handle SBU data, but also demonstrates a certain discipline in the design and documentation process. Some SSD manufacturers have already obtained or are in the process of obtaining FIPS certification.

FIPS 140-2 validated encryption (and storage) modules are available that incorporate FIPS validated 256-bit AES algorithms. These modules offer administrator options in which the AES key can be either internally generated or externally provided. The security risks of using an internally generated key were discussed above, and if the key is purged, the data-at-rest is lost forever. When the externally provided (or preplaced) key option is used, the AES key can be provided via commands after properly logging into the FIPS encryption module and the user is authenticated. An externally provided key also gives the DAA additional options. The key can be cleared, the module safely transported, and after, the key can be re-inserted providing access to the data-at-rest once again.

Secret and Below Information

If an application requires SABI data security, the encryption product used must be NSA Type 1-certified for at least SABI. Type 1 products contain approved NSA algorithms and are available to U.S. government users, their contractors, and federally sponsored non-U.S. government clients. Type 1 encryptors are subject to International Traffic in Arms Regulations (ITAR) restrictions.

An example of a DAR system with an encryptor certified for SABI is Curtiss-Wright's rugged Compact Network Storage (CNS). The CNS-T1 is a convection-cooled network file server that supports CIFS, NFS, HTTP, FTP, and PXE protocols for connection to any computer system supporting industry-standard protocols. Designed for use in manned and unmanned ground, air, and sea vehicles, the CNS features an internal third party SATA-to-SATA encryptor. This encryptor was developed and certified under the auspices of a program that required SABI encryption in an attended vehicle. It is now available for use in similar programs of record with a need for SABI encryption. It can support applications for secret data as well as SBU data.

The encryptor was embedded into the CNS. The CNS acts as the front-end interface to network clients. CNS converts the data from these clients to SATA, after which the data is routed to the encryptor, which encrypts it with an internally generated key. The encrypted SATA data is then sent to an encryption-free SSD-based storage module (see Figure 1).

Figure 1 | CNS Type 1 network file server for SABI applications.

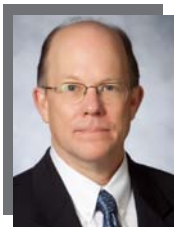
When using internal generated keys, both the encryptor and the storage module must be removed for transportation to a CNS in another location. For example, after an aircraft lands from a mission, you must remove the encrypted storage module from the aircraft and utilize a ground station to allow the analyst to read and interpret that data garnered during the mission. In the case of self-generated keys, you must keep the encryptor with the storage module or the data will be unreadable. For applications where this is not practical, mediation is being developed to support the use of Pre-Placed Keys (PPK). With PPK support, the encryptor can be left in place so that only the storage module need be transported. The same key can be loaded in the second location, providing access to the data. Transport of the data without any key is highly desired.

Top Secret and Below Information and unattended operation

For applications that require TSABI security, an encryption product will need a minimum of NSA Type 1 certification. A few TSABI encryptors, developed at government expense for a program of record, are currently available for DAR applications. At present, none of these encryptors have been certified for unattended operation on platforms such as unmanned air, ground, or undersea vehicles. Currently, some programs are considering combined requirements for TSABI and unattended operation. It will require one program of record and a Department of Defense (DoD) sponsor to step forward and drive TSABI encryptor certification for unattended operation.

Summary

System designers have broad encryption options, ranging from SSD encryption and FIPS to SABI and TSABI encryption. For unattended operation, the industry awaits the first program and sponsor to step forward before vendors can take the next steps needed to provide data-at-rest security in unmanned vehicles. **MES**



***Paul Davis has** 30 years of experience holding positions in Product Management, Sales Management, Engineering, and Engineering Management for various technical companies. Paul has been with Curtiss-Wright for 16 years, holding positions as Director of Engineering, Director of Sales and Marketing, Product Manager, and currently holds the position of Director of Product Management. Paul earned a BSEE from the University of Cincinnati and an MBA from Indiana University. Reach him at defensesales@curtisswright.com.*

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DLA's claims about DNA marking not correct

John,

I have read the column you wrote in December: "DNA marking for counterfeit parts: Problem solver or money pit?" I would like to respond to Ms. McCaskill's comments made on behalf of the [Defense Logistics Agency] DLA.

DLA claims that DNA marking will increase competition and decrease cost. I believe the actual record shows that this is not the case. In 2012, prior to the DLA mandate to mark with DNA, DLA procured approximately $12 million of 5962 microcircuits from just over 200 individual vendors. By their own admission the number of vendors is now 28. How does this increase competition?

A statistical anomaly is that although prior to the DLA mandate for DNA marking, DLA procured 5962 products from over 200 vendors, over 90 percent of those procurements were from the authorized distributors or [Original Component Manufacturers] OCMs of the products. Some of the largest sellers were Arrow, Avnet, Rochester Electronics, and Lansdale Semiconductor. Since the mandate has been fully implemented that statistic has changed – more than 90 percent of the 5962 products are now being procured from brokers. The authorized channels previously used (Arrow, Avnet, Rochester and Lansdale) have combined sales of zero with DNA marking.

The authorized distributors, Arrow and Avnet, really haven't been hurt too much by the mandate for two reasons: 1) DLA is really a small buyer in the overall military market at less than $12 million per year, and 2) They are still selling the OCM product. Instead of selling to DLA direct, they're just selling to the broker market, which is marking the parts with DNA and then selling them to DLA. All of these sales to the broker market are [Non-Cancelable/Non-Returnable] NCNR, meaning that there is no manufacturer support of the product, including no manufacturer's warranty, once it is obtained by the brokers.

So who is really supplying the DLA? The vast majority of procurements are from the 14 brokers that DLA calls their trusted suppliers (QSLD = Qualified Suppliers List Distributors). These companies procure product, often from the authorized distributors. They then alter the product by marking it with DNA, perhaps followed by a marking permanence test on the lot, and then they sell the modified parts to DLA. Obviously they are not in this for the excitement of selling parts – they are for-profit companies.

So when you understand that the minimum lot charge to the broker for marking with DNA is $500 per lot, and that the average buy quantity from DLA is under 20 pieces, and that these brokers normally obtain over a 25 percent profit margin on their sales, you understand why the part that would cost $10 from the authorized distributor without DNA marking now costs well over $40 with DNA marking. The question is for what? The broker does not mark parts with the authentic manufacturer's DNA; they mark with their own broker DNA. So is this a mark of product authenticity or is it just a method for DLA to track their inventory? These charges are on top of the $49,000 paid by each broker to the DNA manufacturer each and every year to license the ink. Currently, DLA is reimbursing this cost to 27 different suppliers to the tune of over $1.32 million in just over 12 months, before ever buying one single part from them. I don't understand the accounting methodology being used at DLA.

Because supporting the DLA is important to us, Lansdale pursued obtaining a license to put DNA marking on our product to try to meet the DLA mandate. We were working on a contract with the DNA manufacturer and had even received contracts from DLA requiring the DNA mark. Then we received a call from several directors at DLA Land and Maritime [formerly Defense Supply Center Columbus (DSCC)]. The conversation in a nutshell was that these directors believed that the price increase that Lansdale was quoting for product marked with DNA was too high. Lansdale explained that the price was directly proportional to our direct cost for marking and re-qualifying the product per paragraph A3.6.9 of MIL-PRF-38535. One of the directors on the call stated that if we (Lansdale) would not lower our price, he would label the part number unprocurable and have the part number cancelled. In an effort to not make enemies of these directors, we ended the call by stating that we would stop quoting product with DNA marking and would cancel the contracts we had already obtained.

Of the 21 QML manufacturers at the JEDEC JC-13 meetings only one (Sarnoff) is currently marking product with DNA, and the reason that they are doing so is because they are a captive line (the GEM program) funded directly from DLA. As a matter of fact, during a straw poll of QML manufacturers, 13 said they would not mark with DNA. Both the Semiconductor Industry Association (SIA) and JEDEC have come out publicly against the DNA mandate. Both have written letters to the DLA director and the Under Secretary of Defense for AT&L stating that the implementation is flawed.

The JEDEC JC-13 committee has also written a letter to the DLA director stating that the manufacturers of QML product do not agree that only Marking Permanence need be tested to re-qualify the product after the DNA marking and ink cure. The manufacturers believe the requalification testing outlined in paragraph A3.6.9 of MIL-PRF-38535 is more appropriate considering the additional handling and temperature exposure of the product.

DLA touts that nine OCM manufacturers as well as three OEMs have adopted DNA. Who are these companies? What products do they sell? Again, of the 21 QML manufactures at the JEDEC JC-13 committee meetings only one is signed up to do DNA marking. This leads us to another issue. There have been three documented instances where a QSLD broker has put DNA marking on a suspect counterfeit product. One of these instances resulted in a GIDEP Agency Action Notice from DLA. In all three of these instances, the suspect product was returned to the seller in violation of NDAA 2012 requirements. Most suppliers agree that the DNA is probably uncopyable, but if it is being misused and put on suspect counterfeit product what value does it add?

In parting I would like to state that the JEDEC JC-13 DNA marking task group has been cancelled. Both JEDEC and the SIA have written letters to both the Director of DLA and the Under Secretary of Defense for AT&L stating that the DNA marking mandated by DLA is not an appropriate fix for the problem of counterfeit product entering the supply chain. There are several industry standards written about the avoidance, detection, mitigation, and disposition of counterfeit product, which DLA is completely ignoring.

Like I have said many times, not buying counterfeit product is simple: don't buy them. If you procure product from the OCM or their authorized distribution channel the odds of obtaining a counterfeit fall nearly to zero. If you buy from the broker market the odds of buying a counterfeit increase dramatically.

Regards,
Lee Mathiesen, Operations Manager, Lansdale Semiconductor Inc.

E-CAST

Avionics safety and security certification challenges for military aircraft

Presented by AdaCore, Atego, DDC-I, Polarion

The budget-constrained environment in the DoD is forcing many manned aircraft platforms to operate longer than intended, which means more opportunities for avionics upgrades. These upgrades will introduce more complex avionics, which will require expensive and time-consuming certification. This webcast will discuss how designers are leveraging open architectures, common standards, and more to solve certification issues in this challenging climate.

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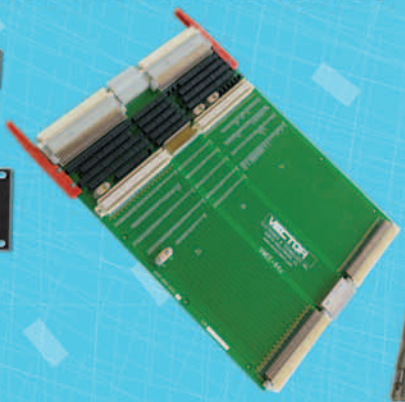

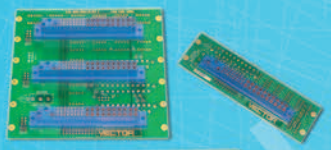

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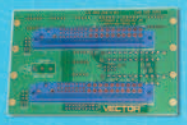

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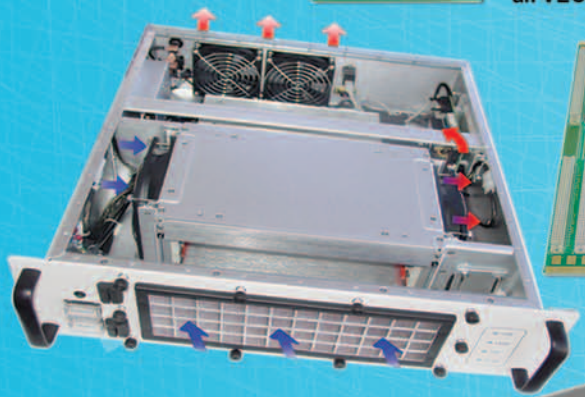

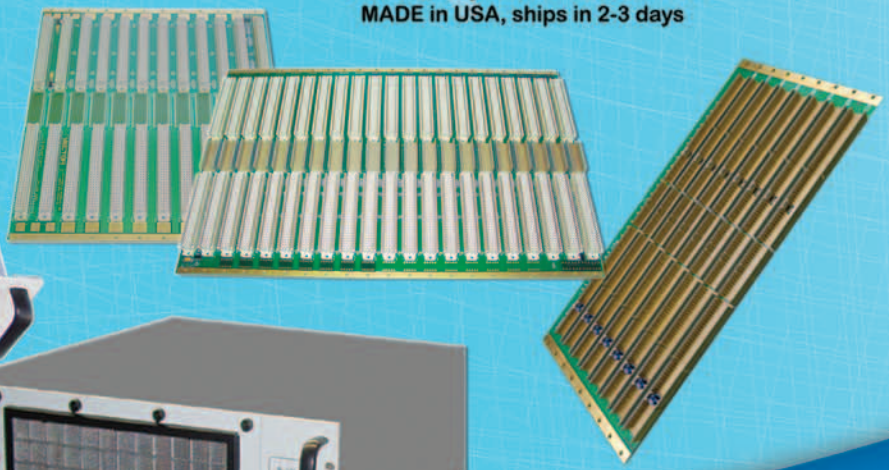

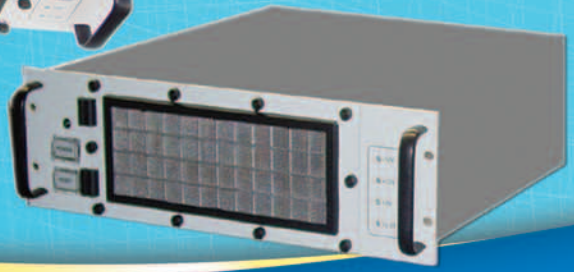

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CHARITY

Focus on Wounded Warriors

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

Many of you may be familiar with WWP through their television commercials. For those who are not its mission is to honor and empower veterans and service members who have incurred injuries or illnesses, physical or mental, in service on or after September 11, 2001. According to the WWP website its goal is to provide support and raise public awareness for injured service members, and to also help injured service members bond together through sponsored WWP programs.

As of February 1, 2014, there are 46,326 active WWP alumni and 6,163 registered family members. As the website attests, WWP alumni members do not pay any dues – "you paid those on the battlefield." Programs include tools to help heal and empower the mind (Combat Stress Recovery Program; Project Odyssey, an outdoor rehabilitative retreat that combines nature and recreation; family support programs), body (physical health programs; Soldier Ride, a four-day cycling event in various cities), as well as economic empowerment (higher education programs, technology training, employment assistance), and also engagement with a peer mentoring program and government benefits. Other programs include various 8k runs throughout the year in select cities and other networking opportunities for WWP alumni across the globe.

Please join OpenSystems Media and *Military Embedded Systems* magazine in supporting WWP through a donation or even hosting a fundraising campaign to benefit WWP. Volunteer programs and student ambassador positions are also available. Donation options include joining the Advance Guard, a monthly donation program, or making a one-time donation online. The proceeds benefit the WWP program, the wounded warriors, and their families.

For more information, visit www.woundedwarriorproject.org.

E-CAST

Avionics safety and security certification challenges for military aircraft

Sponsored by: AdaCore, Atego, DDC-I, Polarion

The current budget-constrained environment in the Department of Defense (DoD) is forcing many manned aircraft platforms to operate longer than their original planners intended, often requiring continued refresh of their avionics hardware and software, which means more opportunities for avionics upgrades. These upgrades will introduce more complex and sophisticated avionics, which will require expensive and time-consuming safety and security certification. FAA safety and security requirements are also starting to extend to Unmanned Aerial Vehicles (UAVs) as the FAA begins to open up the national airspace to them. This webcast of industry experts will discuss how designers are leveraging open architectures, common standards, and more to solve certification issues in this challenging climate.

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WHITE PAPER

High performance embedded computing and its impact on mil/aero applications

By: GE Intelligent Platforms, Inc.

High Performance Embedded Computing (HPEC) combines the latest processor and interconnect technologies with infrastructures such as OpenVPX and standard software components to allow military programs to pack more computing power into smaller Size, Weight, and Power (SWaP) for SIGINT, radar, EW, and many other applications. The drive toward Modular Open Systems Architectures (MOSA) is at the heart of GE Intelligent Platforms selection of technologies. Since GE has adopted Open Architectures, developers can migrate from commercial hardware (PCs or blade servers) to demonstration hardware (non-rugged embedded system) to deployment (fully rugged, qualified units) with minimal dis-ruption. This paper examines how this can positively impact programs.

Read the white paper: http://opsy.st/13xY5Do

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