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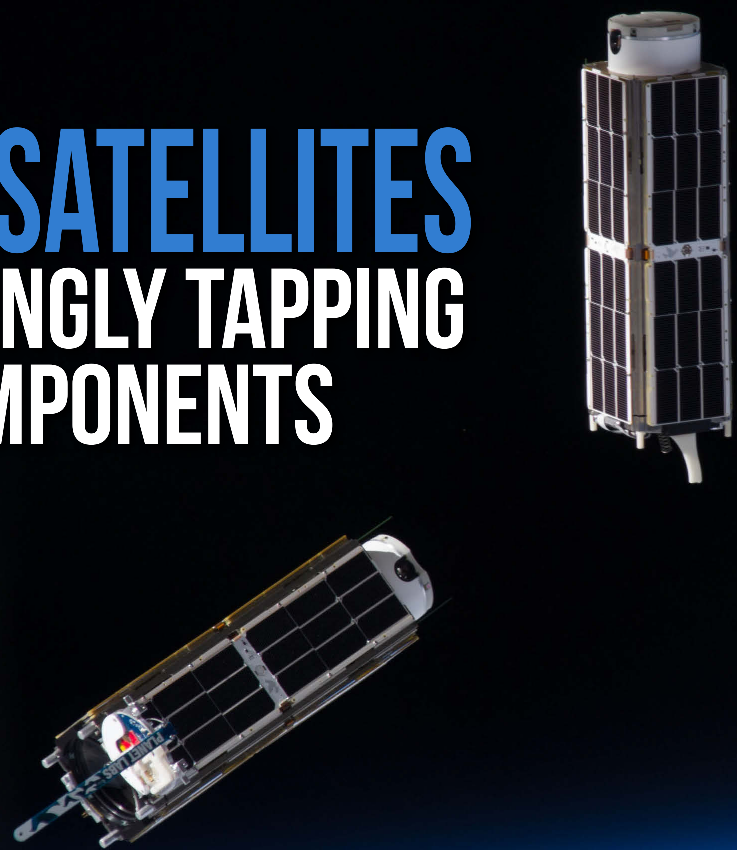

SMALL SATELLITES INCREASINGLY TAPPING COTS COMPONENTS

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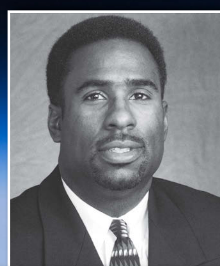

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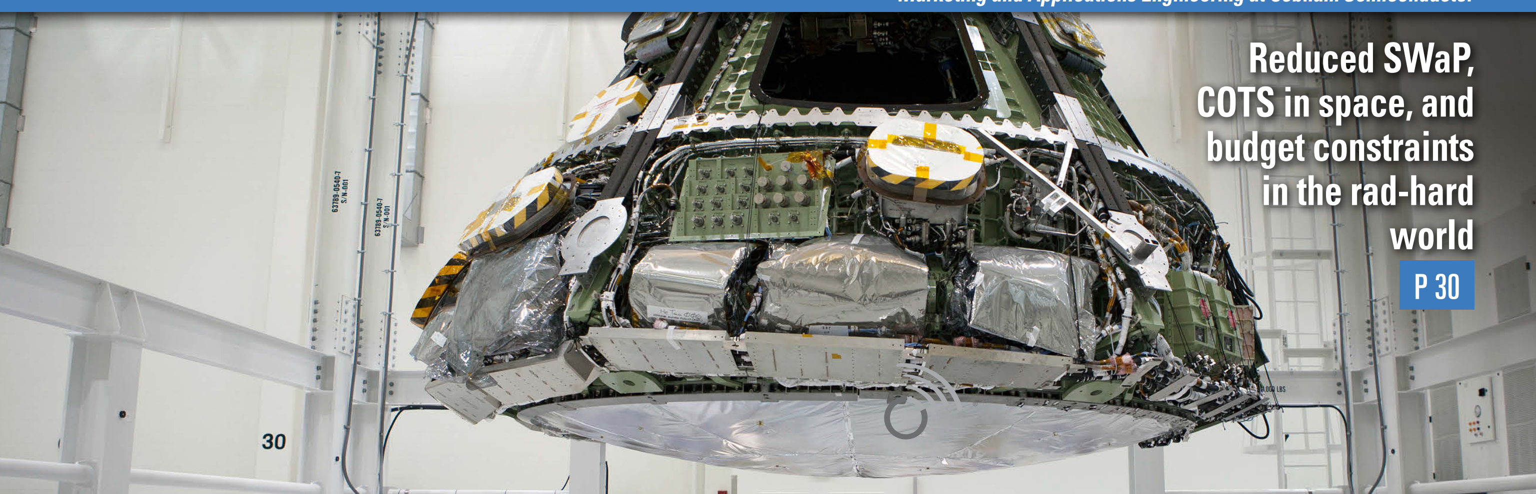

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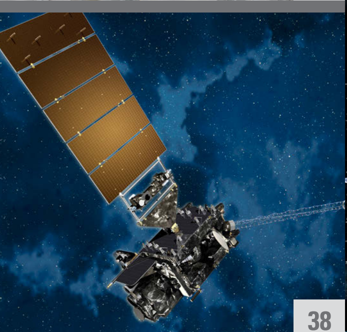
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ON THE COVER:

Top image: Since the 1940s, The Johns Hopkins University Applied Physics Laboratory has been designing, developing, and launching spacecraft – including small satellites – in partnership with NASA and the U.S. Department of Defense. Reprinted with permission from the Johns Hopkins APL Technical Digest, Vol. 29, No. 3. Photo courtesy of The Johns Hopkins University Applied Physics Laboratory.
Bottom image: At the Operations and Checkout Building at NASA's Kennedy Space Center, the Orion crew module and heat shield are being moved into position for the mating operation. Photo courtesy of NASA.

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It pays to be patient in the space electronics market, or does it?

By John McHale, Editorial Director

Patience is a virtue mostly everywhere, but in the space industry market it is a necessity, especially for space electronics designers. Waiting is part of the game, as qualifying electronic components for space is – at minimum – a 24-month period. Now designers are also seeing funding for NASA programs and some military satellite programs being pushed to the right, so their patience gets tested once again.

That has been the way of NASA programs for more than 40 years, ever since Apollo 17 in 1972 when astronauts Gene Cernan and Jack Schmitt were the last two humans to walk on the moon. As Cernan says in his book, "Last Man on the Moon," the astronauts, engineers, and scientists made going to the moon look too easy; NASA and the public lost interest and NASA lost funding. (Side note, I just finished this book and it's a straightforward read and interesting for any Apollo fan like me.)

Fast-forward four decades: NASA still gest little funding compared to other government agencies, rarely getting more than $18 billion. Flat is the new up.

"Regarding manned spaceflight, funding will continue as everyone knows we are in a not-so-secret race with China in this area. [Yet] NASA is a challenge as the market there is flat to down and research programs are typically hit the hardest by budget cuts," says Philip Chesley, Senior Vice President, Precision Products at Intersil in Palm Bay, Florida. "On the U.S. defense side I haven't really seen huge growth, but that said, I really haven't seen too much of a slowdown either."

Chesley makes a good point about China, but the public doesn't seem to care about the space race with China. Maybe they will if China beats us back to the moon, but for now the people spending billions on spaceflight are U.S. billionaires like Richard Branson and Paul Allen.

NASA is betting on these guys, too, and is contributing funding to their efforts as commercialization of space is probably the only way to get humans back exploring in this economic environment. So once again, patience is required for manned spaceflight, but what about unmanned space?

Small sats are not going to wait

NASA's CubeSat initiative and other small-satellite megaconstellation efforts are showing that satellites can be a low-cost commodity with shorter design cycles and faster deployments. For more on small sats, see the Special Report on page 26.

"Small satellites require less expensive options, which helps their risk versus cost formula," says Monty Pyle, Vice President of Sales and Marketing at VPT in Blacksburg, Virginia. "If they are buying material that's three times more expensive to build one small sat, it is wasteful when they can just build two, launch them both, and are still fifty percent ahead if one fails. This is not an option for most Department of Defense (DoD) programs where buying commercial COTS [commercial-off-the-shelf] seems wasteful. The small sat market also differs from the DoD in terms of what is tolerated regarding development cycle times. Typically on DoD satellite programs, there is about a 24-month minimum, but for small sats that is unacceptable, as long development cycles could mean millions in lost revenue."

It's all about the revenue and the business model. "If you make enough small sats to make them cheap to produce, make them with the ability for load sharing, make them with enough bandwidth, and can launch them cheap enough … who really cares if they fail," says Doug Patterson, Vice President of vice president of the Military & Aerospace Business Sector for Aitech in Chatworth, California. This mindset is quite likely creating some stress among prime contractors, who have charged hundreds of millions of dollars for small satellite systems that commercial companies are on the verge of producing at commodity pricing, he adds.

There will always be a need for strategic satellite technology and manned spaceflight programs, where redundancy is not so affordable and the parts can't fail, but these are not high-volume markets.

A paradigm shift is coming, but not in technology; rather, it will be a paradigm shift in mindset, says Anthony Jordan, Vice President, Product Marketing and Applications Engineering at Cobham Semiconductor in Colorado Springs, Colorado, in his interview on page 20. "The market is going to have to figure how to manage COTS in the space supply chain as satellites themselves become more disposable commodities that are driven by business models out of Silicon Valley that see satellites as a means to an end."

Jordan's right. The use of COTS in space is happening, as the satellites themselves will soon be COTS products. Electronics designers will need to strike a balance – to still provide strategic rad-hard technology to the classified defense satellites, while preparing internally to deliver products to those commodity satellite folks or lose out.

The concern over COTS in space makes me think of another part of Cernan's book, where he relates what astronaut Alan Shepard said he was thinking about when he was sitting in his spacecraft, Freedom 7, before it launched and made him the second man in space in 1962:

"The fact is that every part of this ship was built by the lowest bidder."

Getting the most out of ARINC 429

By Charlotte Adams

A GE Intelligent Platforms perspective on embedded military electronics trends

Four decades old and counting, the ARINC 429 bus protocol is going strong. Its presence on the A310/320, A330/340, B737, B747, B757, B767, and MD-11 means that it will be popular for many years to come. Even more recent products with highly integrated avionics architectures – such as the B777, B787, and A380 – still use 429 buses to transport sensor data. The same is true for military platforms based on commercial aircraft, including the Navy's P-8 Poseidon.

The question for suppliers, then, is how best to support users – from scientists in test and simulation labs to operators on the flight lines – with the latest, best performing, and most reliable hardware and software. The key attribute is flexibility: both the flexibility to transition from the lab to the embedded world and the flexibility to simulate and test a wide range of bus configurations with a single interface.

The ARINC 429 data bus is a straightforward, legacy bus. It is a one-direction communications channel that transmits 32-bit messages at a rate of either 12.5 or 100 Kbits/sec. As many as 20 nodes can be hooked to a single pair of cables, but often there are only two boxes per bus. One is always the transmitter, while the other always receives.

However, the simplicity of individual bus construction breeds complexity if there are numerous buses on an airplane. Each box that needs to send data to other boxes will have its own bus connecting it to one or more of them. A complex box may need inputs from multiple computers in order to make its calculation and send it on. All of this message-passing occurs on a preset schedule to ensure deterministic behavior, which leads to complex timing and synchronization issues. Simply wiring up the data bus infrastructure is a task in itself.

That's what happens in the embedded world. The test and simulation world has much more exacting demands: If a laboratory is testing a complex piece of equipment like a flight management computer (FMC), for example, the FMC may be receiving inputs from many 429 buses and sending out data to other buses. In order to find out whether the FMC is working

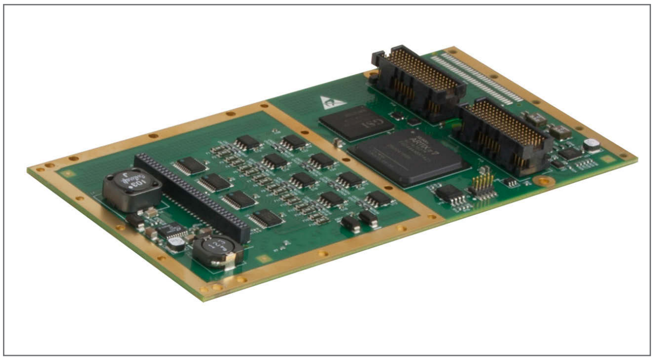

Figure 1 | GE's ARINC 429 RAR-XMC supports 32 channels, 16 of which are programmable to be either transmit or receive.

correctly, the tester needs to be able to replicate those data flows as if the FMC were actually in flight.

What's more, a test rig may be looking at an FMC for a 737 one day but may be evaluating the air data computer for an A320 the next day. One box may require 18 transmitters, while the next calls for only six transmitters. Therefore, the interface that is used to bring all these inputs into the flight box must be adaptable and rapidly reconfigurable. The more simultaneous channels it can handle, the better. If the channels can be software-programmable to function as either transmitters or receivers, better still.

ARINC 429 interface technology has moved with the computer industry from PCbus to VMEbus and on to switched fabrics like VPX and PCI Express. Ever more channels are being squeezed onto cards, along with higher-resolution time tags and enhanced programmability, along with software support. Boards have shrunk in size from PC cards to XMC modules and have added more memory and I/O.

Vendors also can provide support for multiple levels of ruggedization if customers choose to transition a card design from the benign environment of a desktop computer to the more challenging environment of an airplane. These rugged modules can be wired via front- or rear-panel connections with air or conduction cooling.

One example of the latest ARINC 429 products is the GE Intelligent Platforms RAR-XMC, a four-lane XMC card that provides a total of 32 channels – 16 of them programmable as either transmitters or receivers – overvoltage protection, support for ARINC 717 flight-data recorder protocol, and 64-bit time tag resolution (Figure 1).

Although ARINC 429 is a fairly simple legacy bus, the overall infrastructure is a complex wiring scheme with many interdependencies and timing issues. This intricacy requires bus interfaces to provide both flexibility and smarts whether they are used to emulate bus activity in a lab or they are used to connect the cockpit switches to aircraft sensors and computers so that pilots get the information they need.

defense.ge-ip.com

Dual-node SBCs: A hardware-based approach to red/black architectures

By Michael Slonosky
An industry perspective from Curtiss-Wright Defense Solutions

As the need for data security increases, the need to support both encrypted data and less sensitive data within the same system is also on the rise. One approach for providing so-called red/black separation of sensitive and encrypted data in embedded computer systems is the use of partitioning operating systems such as MILS (Multiple Independent Levels of Security/Safety). For some users, though, a software-based partition solution is unappealing, because of concerns about robustness, design risks, or the associated costs of commercial operating systems, which have to undergo a rigorous National Security Agency (NSA) certification process.

A better solution for many of these customers is to handle the architecture separation in hardware. Partitioning done in hardware provides the most secure and easy to validate alternatives. One way of accomplishing this is to provide a fully separated, dual-node single-board computer (SBC) on a single 6U VPX card. Essentially, you're making a two-headed SBC.

It's possible to run different applications on a multiprocessor, treating individual cores or combinations of cores as an independent processor. However, the process of defining the partitions so that application performance can be guaranteed and determining how peripherals – such as PCIe and serial ports – will be shared can be challenging and time-consuming. The multiprocessor approach requires a hypervisor on the board to properly handle the separation and the sharing of resources, which can add complexity and reduce overall performance.

"A truly independent dual-SBC card must provide each node with its own memory, FPGA, XMC site, backplane I/O, and power supply ... Each of the card's nodes effectively functions as though it were in its own slot."

While there have been single-card dual-node SBC hardware designs in the past, they failed to provide true independence in that their onboard SBC nodes still depended to some extent on shared resources such as mezzanine sites, memory, or data networks. A truly independent dual-SBC card must provide each node with its own memory, FPGA, XMC site, backplane I/O, and power supply. While there is a compromise in I/O and data plane information that results from the reduced amount of onboard real estate available to a single node, the advantages in terms of robustness and size, weight, and power (SWaP) optimization for many applications can make it an attractive tradeoff. Each of the card's nodes effectively functions as though it were in its own slot.

Even better, using a dual-node SBC to reduce board count in technology refresh applications also significantly improves mean time between failure (MTBF). The robustness of the system in terms of MTBF is only affected by half of the VPX board. If one half of the card

Figure 1 | The VPX6-195 single-board computer (SBC) offers two fully independent processor nodes on one 6U VPX board. The board's SBC nodes are isolated from one another so that failure in one does not conversely affect the other.

fails the other half will continue to run, maintaining its functionality. That means that the MTBF of the card isn't the MTBF of two cards, but is instead the MTBF of a single card.

Another advantage of a dual-node SBC is the ease with which legacy software can be reused when moving an application to a new platform. Since each node is independent, and associated with its own processor, the system designer can take the applications that used to run on two separate SBC cards and port them each to a node on the dual-node SBC. This approach frees the system designer from having to worry about rewriting the applications to function together on a single processor. For example, many legacy applications have a significant investment in Altivec code; when migrating such an application to a new platform, the task of rewriting that code can be daunting.

A dual-node SBC designed with the latest Power Architecture processor, such as the T2080, retains support for Altivec while delivering nearly three times the performance of earlier devices. That means that just one dual-node card can deliver the GFLOPS performance of as many as three previous SBCs. In addition to the performance improvement, the SWaP advantage is significant: Compared to the two SBCs it replaces, the slot count and weight can be halved while the power burden is reduced by nearly two-thirds. What's more, the cost for the single dual-node SBC will be competitive with the cost of just one of the two earlier SBCs that it replaces.

An example of a dual-node Power Architecture OpenVPX SBC is Curtiss-Wright's VPX6-195 (Figure 1). It has two fully independent processor nodes on a single 6U VPX board. Each node features a Freescale 1.5 GHz quad-core T2080 processor and is also provided with its own power, I/O, FPGA, and XMC expansion site. This processing engine is designed so that both of its SBC nodes are isolated and incapable of impacting the other. To ensure the highest level of security, the board also supports Curtiss-Wright's Trusted COTS and Freescale's Trusted BOOT technology.

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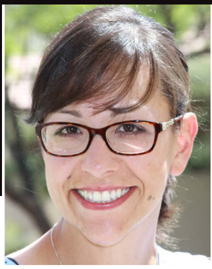

DEFENSE TECH WIRE

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By Mariana Iriarte, Associate Editor

NEWS

Navy nuclear-powered submarines to get new Voyage Management System

U.S. Navy officials have given the green light for the use of Northrop Grumman's Voyage Management System (VMS), dubbed version 9.3, for use onboard Navy SSN and SSGN nuclear-powered submarines. The VMS software package will be deployed on 55 SSNs and four SSGNs operating globally from all U.S. Navy submarine home ports. The installations have already started and are expected to be completed by the end of next year.

Version 9.3 of the VMS, which supports polar operations, has increased rendering speeds, integrates with combat radar and mission planning submarine systems, and enables real-time checking of installed charts. "Submarine Force feedback on VMS 9.3 has been very positive and the boats are excited to have it installed," says Capt. John D Zimmerman, Program Executive Office, Submarines (PEO SUB), PMS 425.

Figure 1 | Navy nuclear-powered submarine with Voyage Management System. Photo courtesy of Northrop Grumman.

U.S. Army body armor system reaches final stages of evaluations

Company officials at Mission Ready Services have announced that its Next Generation Body Armor System has reached the final stages of prototyping and user evaluations. The U.S. Army and Mission Ready Services have been developing this new upper-extremity system, which integrates modular items such as those found in the Improved Outer Tactical Vest deltoids, neck, yoke, collar, and upper back.

After the initial evaluations in May 2014, the U.S. Army decided to take the program to level II testing. Mission Ready Services initially built 36 units; the company has since built an additional 100 units for second and third user evaluations, which were conducted in early 2015.

P-8A training system gets first international customer with Australia

The Royal Australian air force (RAAF) has purchased a complete training system for the P-8A Poseidon maritime patrol aircraft under a contract with Boeing that also covers the sale of four P-8A training systems to the U.S. Navy. The system uses simulators to train pilots and mission crews to operate the P-8A and its sensors, communications, and weapons systems without having to rely on expensive live flights.

In early 2014, Australian government officials approved the acquisition of eight P-8As and supporting infrastructure to include training, initial spares, and support equipment. Aircraft deliveries are expected to begin in 2017, with the P8-A training system expected to deploy to Australia in 2018.

Live-fire test on guided bullet in EXACTO program completed

Engineers in the Defense Advanced Research Projects Agency (DARPA) Extreme Accuracy Tasked Ordnance (EXACTO) program completed a round of live-fire tests on their self-guided bullets that were developed to increase accuracy on dynamic and difficult long-distance targets.

The test consisted of an experienced and novice shooter. According to officials, the experienced shooter – using the technology of the program – repeatedly hit moving and evading targets, while the novice shooter was able to hit a moving target for the first time. EXACTO's engineers designed a real-time optical guiding system together with guided small-caliber bullets to help track and direct the projectile to the target, all while compensating for weather and target movement. The purpose of the EXACTO program is to improve the range and accuracy of sniper systems.

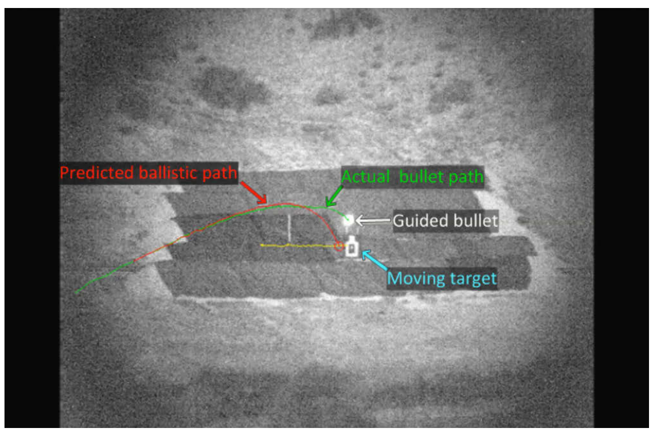

Figure 2 | Program demonstrates flight path of bullet as it hits static and dynamic targets. Photo courtesy of DARPA.

Firestorm targeting system digitally guides F-35 aircraft

A United Kingdom Forward Air Controller (FAC) utilized the FireStorm Integrated Targeting System from Rockwell Collins, digitally guiding an F-35 Lightning II aircraft using a complete air strike mission thread as part of a ground test and live flight. The flight test was performed at the Edwards Air Force Base (southern California) F-35 Lightning II flight-test facility, in coordination with the integrated project team from the U.K.'s F-35 Joint Program Office.

"The FAC approached the test from a practical standpoint and was able to use the system under simulated tactical conditions," says Tommy Dodson, vice president and general manager of Surface Solutions for Rockwell Collins. "The test was also significant because FireStorm is currently fielded by the British army, and has now been proven to be interoperable with the F-35."

FireStorm is a modular Joint Fires system that offers digital connectivity with nearly all coalition aircraft, field artillery systems, and command-and-control center battle managers. Its systems are used by five NATO countries.

Figure 3 | Soldier using FireStorm targeting system during a ground test. Photo courtesy of Rockwell Collins.

Milestone C completed for Small Diameter Bomb II

The U.S. Air Force and Raytheon have completed the Milestone C decision briefing for the Small Diameter Bomb II (SDB II). This step will allow the program to proceed to the low rate initial production phase.

SDB II uses Raytheon's tri-mode seeker operating in millimeter-wave radar, uncooled imaging infrared, and semi-active laser modes. It is an all-weather solution that can be used in limited-visibility scenarios.

With a dynamic warhead that can destroy soft and hard targets, SDB II can strike targets from a range of 40 nautical miles or more. Moreover, by using a secure data link, the bomb can change targets in-flight. SDB II has already passed a functional configuration audit, production readiness review, and system verification review.

Cockpit display showing sonic boom over land to be developed by NASA and Rockwell Collins

NASA officials have tasked engineers at Rockwell Collins to develop a conceptual cockpit display that will enable a visual representation of an aircraft's sonic boom over the Earth's surface to reduce the impact on populated areas. Under the two-year contract, NASA's Armstrong Flight Research Center will lead the project, working with experts at Rockwell Collins' Advanced Technology Center. Findings made by Rockwell Collins will be applied to NASA's High Speed Project, which is focused on providing the research and leadership necessary to enable the development of a new generation of supersonic civil-transport aircraft.

Rockwell Collins officials say that they will look to leverage the company's avionics-display technologies and human-factors research team to develop the sonic boom cockpit display, integrating variables such as the aircraft's movement relative to the ground and the influence of weather on shock waves. Both ground-based and aircraft-measured weather information will be examined and integrated into the sonic boom display's software to compute the best flight path.

EASA certifies militarized H145M helicopter

The European Aviation Safety Agency (EASA) has certified Airbus Helicopters' H145M craft. Deliveries to the Bundeswehr – the German armed forces – of the twin-engine military rotorcraft are set to begin later this year.

The H145M helicopter is based on the Airbus helicopters' enhanced H145 civilian version. It has a maximum takeoff weight of 3.7 metric tons, can be equipped with a pintle-mounted door gun, has the ability to carry weapons on external pylons, and features electro-optical/infrared sensors with targeting capability. It carries the Turbomeca Arriel-2E engines with dual-channel, full-authority digital engine controls (FADEC), and carries a Fenestron shrouded tail rotor.

The helicopter is built with ballistic protection, self-sealing fuel tanks, and electronic warfare self-protection against missile threats. It is also equipped for rope-down situations for special operations.

Figure 4 | Pilot flying the militarized H145M helicopter. Photo courtesy of Airbus.

U.S. Marine Corps P-19R firefighting vehicle enters production phase

The production and deployment phase has begun for the Oshkosh Defense P-19 Replacement (P-19R) Aircraft Rescue Fire Fight (ARFF) vehicle. Since Oshkosh has completed all the required government evaluation and reviews to move the program past the Milestone C approval phase, the project has moved into the low rate initial production phase (LRIP).

To support LRIP, Oshkosh is slated to deliver the first P-19R vehicles for the Production Verification Testing (PVT) at the end of 2015. The U.S. Marine Corps contract with Oshkosh extends through 2018 as the P-19A vehicle nears the end of its service life; the goal of the P-19R ARFF program is to replace all P-19A vehicles.

The P-19R vehicle – built to help firefighting crews respond and carry out missions – can travel as fast as 70 mph with a 600 horsepower engine. It is equipped with Oshkosh's TAK-4 independent suspension system and delivers 16 inches of wheel travel for off-runway emergencies. The TAK-4 independent suspension system enables the vehicle to carry 1,000 gallons of water, 130 gallons of foam agent, and 500 pounds of Halotron auxiliary firefighting agent.

Figure 5 | The P-19R firefight vehicle demonstrating its off-road capabilities.

Unmanned aerial system helps in cyclone Pam disaster relief mission

After the devastation of Cyclone Pam, the Vanuatu government and the World Bank contacted Australian operator Heliwest to deploy Lockheed Martin's Indago, a small unmanned aerial system (UAS). The Heliwest UAS operators helped the small island in the South Pacific assess post-disaster damage following Cyclone Pam.

The Indago UAS weighs five pounds, provides operators with 360-degree surveillance of the area, and can last about 45 minutes at a range as far as three miles when operated with a handheld controller. The entire system is carried in a single backpack. Due to Indago's endurance and size, operators could field a mapping capability on the small island nation without requiring a large clear area for launch and recovery.

Astro Aerospace's reflector helps NASA's SMAP satellite become operational

Officials at NASA'S Jet Propulsion Laboratory have announced that the Soil Moisture Active Passive (SMAP) satellite is operational. This marks the beginning of the satellite's three-year mission to provide global measurements of soil moisture.

The purpose of SMAP is to improve weather and climate prediction models by increasing scientists' understanding of the processes that link Earth's water, energy, and carbon cycles. SMAP will identify soil moisture levels and frozen or thawed water, which will help scientists understand how much carbon plants absorb from the atmosphere each year.

For the satellite, Astro Aerospace engineered AstroMesh, a spinning 20-foot reflector that enables data capabilities. The six-meter reflector and boom encompass a critical system for SMAP allowing the spacecraft to spin at 15 revolutions per minute to create a conically scanning antenna beam of approximately 620 miles, with a total global map rendered every two to three days. A verified mass properties model had been previously developed because the reflector could not be dynamically tested on the ground.

DRS and RADA join hands to bring Israeli company's AESA radar to North American market

Officials at defense contractor DRS Technologies, a Finmeccanica Company, have announced that DRS has signed a strategic teaming agreement with Israeli radar company RADA Electronic Industries (Netanya, Israel) to bring its tactical active electronically scanned array (AESA) radar technology into the North American market.

Under the agreement, DRS personnel will sell, market, support, and produce tactical AESA radars as part of its tactical radar portfolio. The marriage of RADA's technology with the DRS market presence, market awareness, engineering, and production capabilities is expected to create more interest in the North American defense industry market, DRS officials say.

Figure 6 | AESA radar technology being used on military vehicle.


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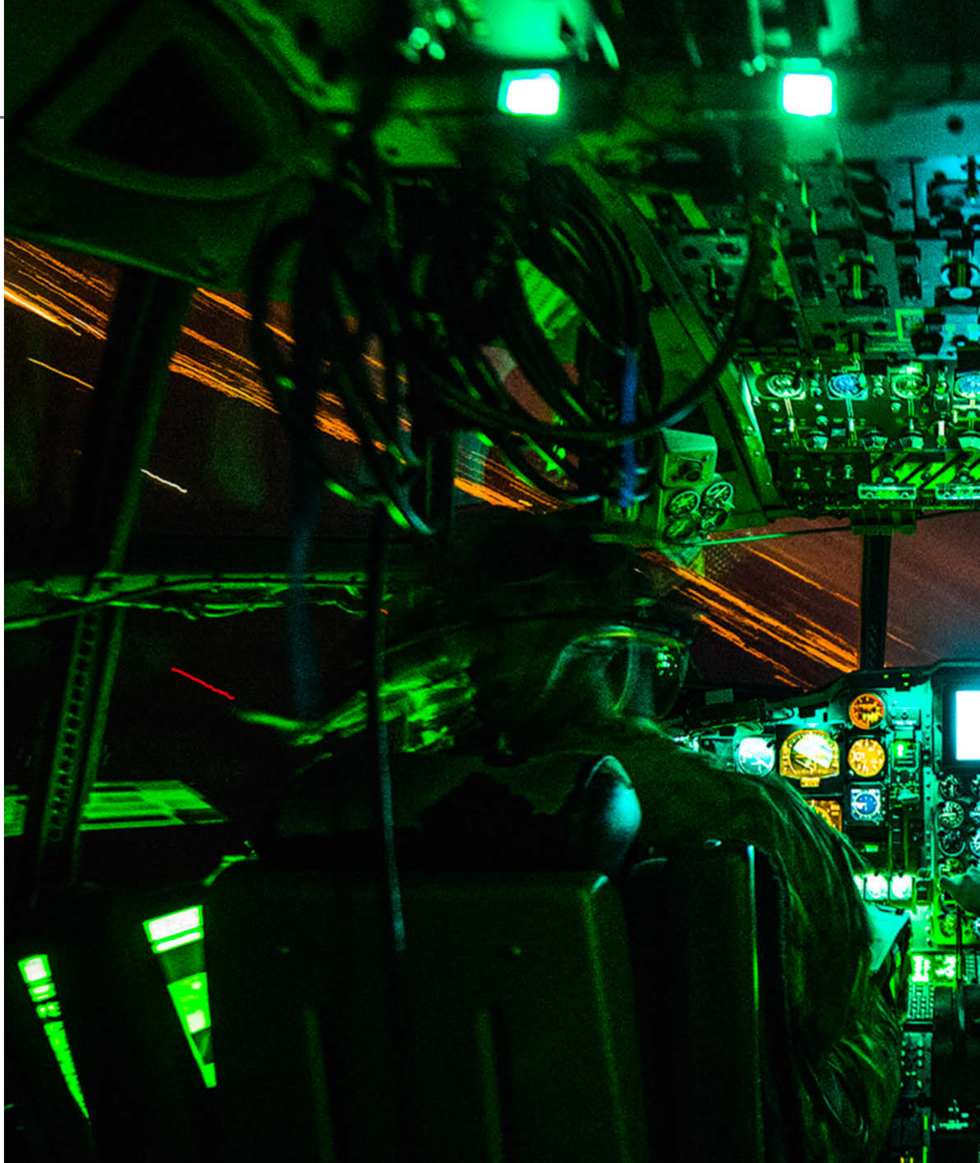
ITAR reforms for defense and satellite industries take hold

By Kay Georgi and Marwa Hassoun

Over the last two years, the Obama administration has implemented reforms to export regulations aimed at improving the competitiveness of U.S. military and satellite companies in the global technology market. In this article, export attorneys from Arent Fox, LLP provide an overview of those changes and discuss which items with electronic content are affected.



Some military electronics technology such as computers, ASICs, etc., are moving from the State Department's USML to the Commerce Department's CCL. (In this photo an Air Force pilot and co-pilot return to base in an AC-130W Stinger II. U.S. Air Force photo by Senior Airman Cory D. Payne.

Responding to industry concerns that export controls – specifically the State Department's International Traffic in Arms Regulations (ITAR) and the Commerce Department's Export Regulations (EAR) – are stifling business opportunities for U.S. military and space electronics companies in the global economy, the U.S. government has implemented reforms – or rule changes – that essentially move a number of controlled items from the State Department's U.S. Munitions List (USML) to the Commerce Department's Commerce Control List (CCL).

We wrote a detailed review – "Export Control Reform – 2014 in Review" – of the reforms and what items were transferred from the USML to the CCL under the rules changes in 2014. To read the review in full, visit http://bitly.com/1GIlI1W.

This is a high-level overview and those seeking to classify their items post-Export Control Reform (ECR) of their category should seek expert advice and assistance. These changes affect a wide range of industries. As with all changes associated with ECR, the amendments to the ITAR and the EAR have resulted in the creation of positive or enumerated lists of ITAR-controlled items in the USML and the transfer of many commodities, parts, components, and accessories to the new Commerce 600 Series (in the case of spacecraft, to the 500 Series). The 600 Series refers to a new sequence of Export Control Classification Numbers (ECCN) that contain the number 6 in the third position from the left to indicate the military nature of the controlled items.

Those products that move over to Commerce are now authorized for export to 36 countries – provided that exporters meet all requirements of license exception Strategic Trade Authorization (STA). However, they will not just be able to export to just anyone. Exports are only for the approved countries and must be for the end use of government organizations such as the military, police, search and rescue, etc.

Below are excerpts from our review that apply to suppliers of electronic systems and components for military and space applications.

Changes common to all USML and CCL categories

Many of the less important parts, components, accessories, and attachments that are used in and with defense articles have been removed from the USML. Instead, unless

such items are enumerated on the revised USML or fall within one of the remaining "specially designed" catch-alls, such items are controlled in their respective CCL category, either specifically enumerated in ECCNs XA6XX.y or potentially caught in ECCNs XA6XX.x. More significant parts and end items are typically enumerated in XA6XX. [Editor's note: "An ECCN categorizes items based on the nature of the product, i.e. type of commodity, software, or technology and its respective technical parameters," according to the Bureau of Industry and Security (BIS).]

The USML now provides a generally positive list of parts, components, accessories, and attachments that are still controlled under the ITAR. The USML still contains, however, a number of "catch-all" categories for "specially designed" parts, components, accessories, and attachments for certain special defense articles. The USML also continues to control commodities even if not specifically enumerated in the USML, but that are classified or are being developed using classified information.

[Editor's note: Even if all the technology that a company produces is controlled under the CCL, it is possible that some technical data a company receives from its prime contractors will remain under the USML. Thus, even a company now producing 100 percent Commerce-controlled products, it might still need to ensure internal ITAR compliance to protect ITAR controlled technical data from unauthorized export, for example, to foreign person employees.]

"Specially designed"

The changes have defined "specially designed" such that it becomes a complicated catch-and-release system. The first part of the test – the catch – defines the universe of items that may be "specially designed." The second part – the release – provides several criteria that, if any one of which is met, will release the item from being treated as "specially designed." The new "specially designed" definition plays a major role in determining which items that are not specifically enumerated in the USML or in the 600 or 500 Series will nevertheless remain there, because they are "specially designed" for an item that is called out in the USML or 600 or 500 Series. For example, printed circuit board (PCB) manufacturers will need to evaluate whether their PCBs are "specially designed" for an item on the USML or in the 600 or 500 Series.

Military electronics, USML Category XI

The final rule for military electronics – which impacts nearly all who read this publication – went into effect on December 30, 2014.

Military electronics that State and Commerce have transferred to ECCN 3A611 include radar, telecommunications, acoustic, or computer equipment specially designed for military application and are not enumerated in the USML, high frequency surface wave radar; application specific integrated circuits (ASICs) and programmable logic devices (PLDs) programmed for 600 Series items, certain printed circuit board assemblies; and multichip modules. BIS has included all these items in 3A611 instead of creating new 600 Series ECCNs in CCL Categories (Computers), 5 (Telecommunications), 6 (Radar), and 7 (Avionics). Those categories contain references to the Category 3 600 Series. Technology, software, materials, and equipment for these commodities are controlled under the related 3X611 product groups. Other than the .y

Changes proposed to USML Category XII for fire control, range finder, optical, and guidance and control equipment

On May 5, 2015, the Bureau of Industry and Security (BIS) and the Directorate of Defense Trade Controls (DDTC) issued proposed rules concerning the transfer of certain items from U.S. Munitions List (USML) Category XII to the Commerce Control List (CCL) as part of the President's Export Control Reform Initiative (ECR). As with previous ECR proposed rules, both BIS and DDTC request comments from the public for consideration prior to finalizing the rules. The deadline to submit comments is July 6, 2015.

Like other USML categories that have already undergone reform, the proposed rules create a positive list of items controlled under Category XII, including removal of the "catch-all" parts and components subcategory. BIS will create "600 Series" Export Control Classification Numbers (ECCNs) on the CCL to capture items that will move off the USML. However, the proposed rules also transfer several USML items to existing ECCNs.

To accommodate most items that will be moved off the USML, the proposed rules create 600 Series ECCNs in CCL Category 6, 6X615, and amend the existing 600 Series in Category 7, 7X611. ECCNs 6X615 will contain military fire control, range finder, and optical equipment, while ECCNs 7X611 will include military guidance and control equipment.

Several items transferred from the USML Category XII to the CCL are considered dual use by the Wassenaar Arrangement. [Editor's note: "The Wassenaar Arrangement has been established in order to contribute to regional and international security and stability, by promoting transparency and greater responsibility in transfers of conventional arms and dual-use goods and technologies, thus preventing destabilizing accumulations," according to www.wassenaar.org.]

As such, the proposed rules do not add these items to the 600 Series but rather fit them within existing ECCNs. ECCNs outside of the 600 Series that will be amended include the following commodity ECCNs:

0A987, optical sighting devices for firearms;

2A984, concealed object detection equipment;

6A004, optical equipment and components;

6A005, lasers, components, and optical equipment;

6A007, gravity meters and gravity gradiometers;

6A008, radar systems, equipment, and assemblies;

6A107, gravity meters and gravity gradiometers other than those controlled by 6A007;

7A001, accelerometers;

7A002, gyros or angular rate sensors;

7A003, inertial measurement equipment or systems;

7A005, Global Navigation Satellite Systems receiving equipment;

7A101, accelerometers; and

7A102, gyros other than those controlled by 7A002.

Critically, the control parameters for the above listed ECCNs, and their related software and technology ECCNs, will not change. However, other ECCNs proposed for revision will have additional controls added. For example, ECCNs 6A002 and 6A990 will include regional stability control, which will result in an interagency license review for commodities in those ECCNs and a license requirement for all exports or re-exports, including export to Canada. The proposed rules will restrict the availability of the Strategic Trade Authorization license exception (STA) for certain items in the following ECCNs: 0E987, 6A002, 6A004, 6A990, 6A990, 6D002, 6D003, 6E001, 6E002, 6E990, and the new 6E994. Additionally BIS proposes to amend Section 744.9, the provision restricting exports and re-exports of certain cameras, systems or equipment, to expand the ECCNs covered and include a restriction on in-country transfers as well as exports and re-exports of the ECCNs specified.

Both BIS and DDTC take the public's comments very seriously in establishing the final rules. BIS specifically asks for responses related to (1) any potential lack of coverage; (2) items proposed for control on the CCL that are not controlled on the Wassenaar Agreement's Munitions or Dual Use List; (3) specific examples of control criteria that do not establish a bright-line rule between the CCL and USML or the 600 Series and the rest of the CCL; and (4) specific examples of items that are controlled under the revised Category XII, 6X615, or 7X611that are now in normal commercial use and should be controlled elsewhere on the CCL.

paragraph, which is only controlled for antiterrorism reasons, the remainder of Category 3's 600 Series is controlled for national security, regional stability, anti-terrorism, and U.N. embargo reasons.

Certain microwave monolithic integrated circuit (MMIC) power amplifiers and discrete microwave transistors are now controlled as ECCN 3A001.b.2 and b.3 and not in the 600 Series. In exchange for this reprieve, BIS has added a control for NS1, except if the commodities are exported or re-exported for use in civil telecommunications applications.

While the majority of Category XI consists of enumerated lists, XI(b) is a catch-all for electronic systems or equipment specially designed for intelligence purposes that collect, survey, monitor, or exploit the electromagnetic spectrum or for counteracting such activities. The corresponding CCL subcategory, 3A611.b, is reserved for the time being.

Spacecraft and related articles, USML Category XV

On November 10, 2014, the Departments of State and Commerce implemented final rules for spacecraft and related articles. The Departments of State and Commerce staggered the implementation of this rule in response to industry concerns highlighting the quickly evolving nature of microelectronic circuits. On June 27, 2014, controls on radiation-hardened microelectronic circuits currently in USML Category XV(d) and microelectronic circuits in Category XV(e) were transferred to the ECCNs 9A515.d and .e, and related software and technology transferred to 9D515.d and .e, respectively. On November 10, 2014, the rest of the proposed changes concerning all other spacecraft, satellite, and related items were implemented.

BIS has determined that spacecraft will be included in a new 500 Series rather than a 600 Series in Category 9 Aerospace and Propulsion, which recognizes the commercial nature of many of the items transferring to the 500 Series.

Commerce will treat licensing for the 500 Series as it has for the 600 Series – there will be a policy of denial for China and Country Group E:1 (Cuba, Iran, North Korea, Sudan, and Syria), and license applications for Country Group D:5 will be reviewed consistently with ITAR § 126.1.

Defense services definition in relation to spacecraft and related articles

Category XV contains a revised definition of "defense services" as applicable to spacecraft and satellite that is broader than the ITAR's general definition of defense services as it may apply to the furnishing of assistance and training for spacecraft and satellites now subject to the EAR.

Specifically, defense services as related to spacecraft and satellite include the furnishing of assistance, including training, in 1) the integration of a satellite or spacecraft to a launch vehicle, including both planning and onsite support, regardless of the jurisdiction, ownership, or origin of the satellite or spacecraft, or whether technical data is used; and 2) the launch failure analysis of a satellite or spacecraft, regardless of the jurisdiction, ownership, or origin of the satellite of spacecraft, or whether technical data is used.

Generally, an ITAR-controlled item continues to be subject to the ITAR even if it is incorporated into a higher-level assembly, making that assembly also subject to the ITAR. Manufacturers of ITAR-controlled spacecraft and satellite components are often unable to compete in the global market because their parts will "taint" the satellite or spacecraft into which these ITAR-controlled parts are incorporated. The Departments of State and Commerce have added notes to Category XV(a) and ECCN 9A515, respectively, resolving this concern.

USML Category IV: Launch vehicles, missiles, rockets, etc.
On July 1, 2014, the Directorate of Defense Trade Controls (DDTC) and the BIS implemented final rules for launch vehicles, guided missiles, ballistic missiles, rockets, torpedoes, bombs, and mines.

Changes to Category IV transfer demolition blocks, blasting caps, and military explosive excavating devices from the USML to the CCL. Category IV continues to control certain rockets, space launch vehicles (SLVs), missiles, bombs, torpedoes, depth charges, mines, grenades, and launchers, together with the apparatus and devices specially designed for handling, controlling, activating, monitoring, detecting, protecting, discharging, or detonating such commodities. Also controlled under the USML are certain rocket, SLV, and missile power plants and non-nuclear warheads.

Ground vehicles, USML Category VII
On January 6, 2014, the Directorate of Defense Trade Controls (DDTC) and BIS implemented final rules for ground vehicles. Major changes to the USML include adding 121.4, which explicitly defines "ground vehicles." Similarly, the CCL also defines ground vehicles in a note to the new ECCNs.

Additionally, DDTC has removed most manned and unmanned unarmored and unarmed military vehicles from the USML, unless such vehicles are specifically designed as firing platforms for weapons above .50 caliber, and armored vehicles, either unarmed or with inoperable weapons manufactured before 1956. Armed vehicles and vehicles that incorporate "mission systems," as defined above, remain subject to the ITAR. **MES**

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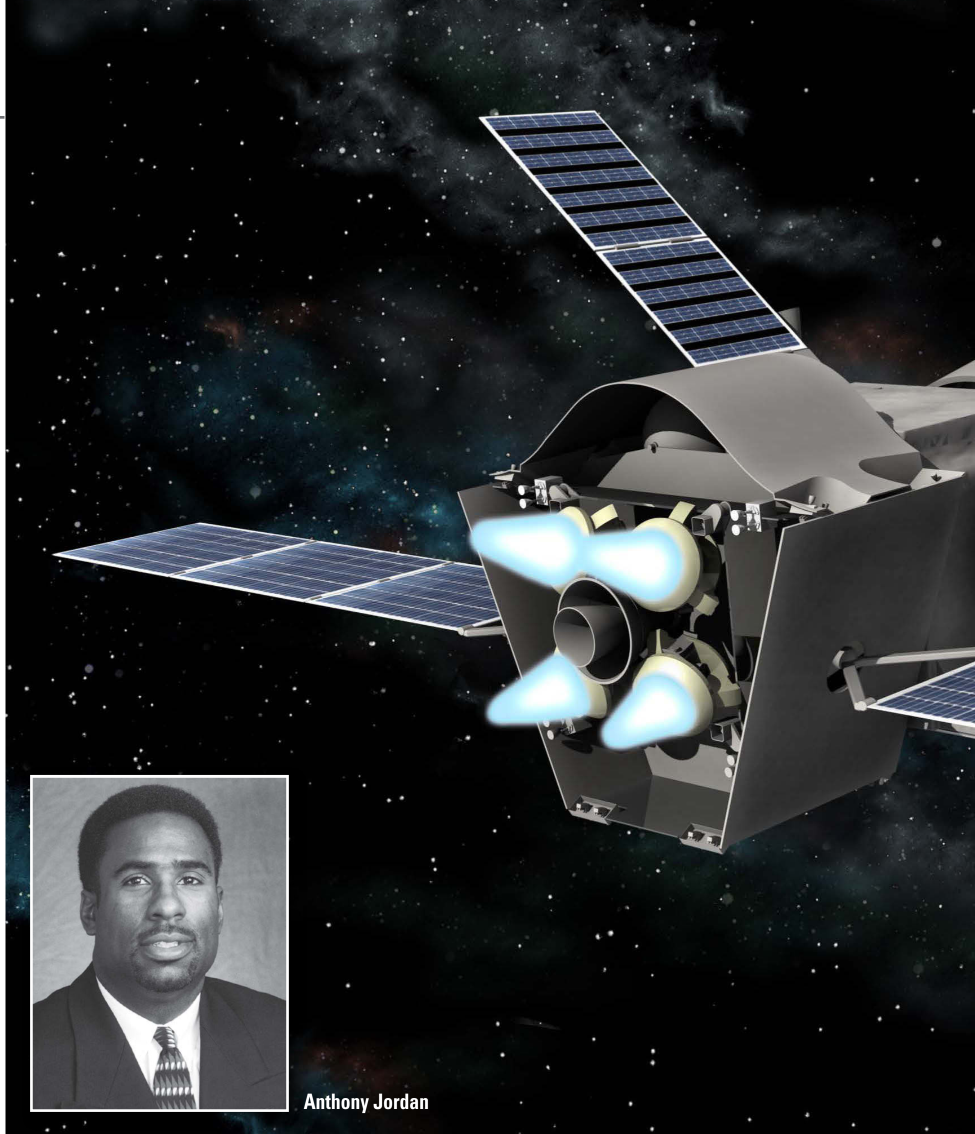
Kay Georgi

Marwa Hassoun

Military rad-hard market and COTS usage in space

By John McHale, Editorial Director

In this Q&A with Anthony Jordan, Vice President, Product Marketing and Applications Engineering at Cobham Semiconductor in Colorado Springs, Colorado, he discusses the market for radiation-hardened (rad-hard) electronics in military and civil satellite systems and explains how the proliferation of small satellites will encourage more COTS usage in satellite payloads.



Anthony Jordan

Cobham Semiconductor Solutions standard products are used on the BepiColombo spacecraft, the European Space Agency's first mission to the planet Mercury that is set to launch in 2017.

MIL-EMBEDDED: ***Cobham acquired your company, Aeroflex, last fall. Can you provide a brief description of your group's (formerly the Aeroflex HiRel Microelectronics group) new role within Cobham?***

JORDAN: We are now part of Cobham Advanced Electronics Solutions (CAES), one of four sectors within Cobham PLC. CAES is a vetted contractor for the U.S. Department of Defense (DoD) and all the services: Navy, Air Force, etc. Underneath CAES there are five business units: Integrated Electronic Solutions; Microelectronic Solutions; Motor Control Solutions; RFMW Solutions; and my group, Cobham Semiconductor Solutions, which is composed of the Aeroflex groups that are located in Colorado Springs, the group in Plainview, New York, and our European arm in Sweden now called Cobham Gaisler. Cobham Semiconductor Solutions is a vetted contractor for the DoD and all of the services [as it is under the umbrella of CAES].

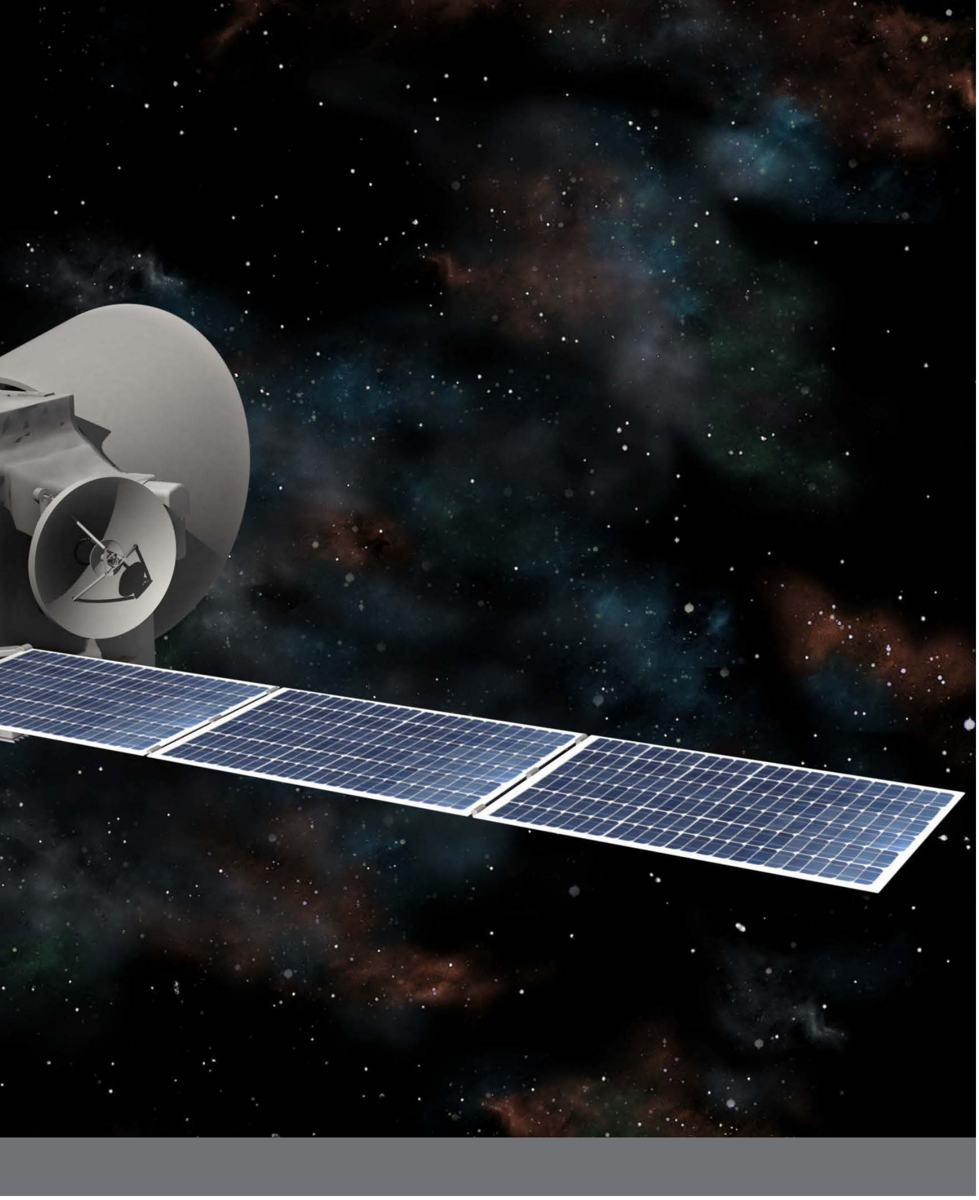
MIL-EMBEDDED: ***Does being part of Cobham create new opportunities within the rad-hard market?***

JORDAN: Yes it has. We are working directly with the DoD and system integrators to deliver rad-hard components. We are also seeing some opportunities to act as a supplier for larger DoD contracts, but that is tied in via Cobham, where we supply other Cobham groups, such as Electronics Solutions, with components for radar and electronic warfare (EW) systems that are supplied directly to the DoD.

Cobham is very interested in revenue synergy and bought us with the goal of creating additional revenue based on synergy. As a result, we are exploring some very interesting areas specifically for Cobham. It's been an exciting time.

MIL-EMBEDDED: ***The DoD released its FY 2016 budget request in February with an increase in overall funding, almost a reverse trend from the last few years. How do you see the funding outlook for high-reliability space electronics?***

JORDAN: We are cautiously optimistic about the DoD market. The classified world has stayed flat for Cobham, as has the rest of our DoD business. NASA has seen an uptick, as has the commercial market. Our motion-control devices are now orbiting Mars on NASA's Mars Atmosphere and Volatile Evolution (MAVEN) satellite and we



have standard products being used for the European Space Agency's BepiColombo spacecraft. There are a lot of new systems in weather satellites as well. Hosted payloads are another growth area for us, especially with geosynchronous platforms.

We are not expecting a huge amount of growth overall, as, like everyone in this market, we are still the early stages of satisfying megaconstellation requirements. The government is still trying to figure out how to leverage swarms of satellites tied together in megaconstellations and the missions they would perform. They are asking, "How do we satisfy two-year missions with small to nano satellites?"

The satellites themselves are a reasonably good size – 100 to 200 kilograms – not something you could fit into a shoebox. They have a reasonable power budget – less than a couple hundred kilowatts – have onboard avionics, and good capabilities management. They are the way of the future.

MIL-EMBEDDED: ***How do you manage reduced cost requirements from the government? You can't cut corners in space.***

JORDAN: I think our challenge flows down almost like a repeating record. To a certain extent, we see customers wanting to put more capabilities into their boxes with more sensors and instruments that provide more capability in every payload, whether its function is communication, surveillance, etc. But they also at the same time want reduced cost and reduced size, weight, and power (SWaP). Having to meet power budgets and cost budgets while increasing capability remains our challenge.

Then when you start talking about megaconstellations, the world changes significantly with cost targets that are so much lower than what has been traditionally set. In order to hit these cost targets to make the megaconstellation more feasible, I think it will be a combination of manufacturing improvements and being smarter about how we drive cost out of electronics, while still delivering products that meet mission requirements.

MIL-EMBEDDED: ***Regarding the radiation-hardening process, what method is most preferred today?***

JORDAN: I think we have to be smarter with rad-hard-by-design and rad-hard-by-process. These processes are affording us a certain level of radiation hardening that we can take advantage of, but we can't afford to overdesign, especially with high-performance digital solutions. If we do that we won't hit the customer's size or power targets. We have to be careful when we design in next-generation technology, as we are very focused on SWaP-C [size, weight, power, and cost] (Figure 1).

MIL-EMBEDDED: Do you consider any of your space products commercial off-the-shelf (COTS)? Will there be a time when we see "COTS in space," or is "COTS" still a four-letter word in the space and rad-hard community?

Figure 1 | Pictured is the Cobham Gaisler GR712 microprocessor, which is flying on multiple space platforms.

JORDAN: The pendulum may be swinging. I don't know where it's going to stop, but I think there will be strong desire to use more COTS components in the satellite community – in both military and commercial markets.

While failure is not an option in manned space platforms, there is more flexibility when dealing with satellites and unmanned platforms. With cost-effective small satellites, if you lose one year's work it may cost a couple hundred thousand dollars compared to millions spent on more life-critical applications. The reduced cost of these satellites will enable integrators and the government to place more solutions in space at lower cost, and if some fail then the cost can be amortized. If you need five, then you throw up ten.

However, while this trend is emerging it won't really affect the classified world, where those risks are unlikely to be taken with their billion-dollar programs.

FOR MORE ON RAD-HARD TECHNOLOGY TRENDS SEE INDUSTRY SPOTLIGHT ON PAGE 30

MIL-EMBEDDED: ***Looking forward, what disruptive technology/innovation will be a game changer for space satellite systems? Predict the future.***

JORDAN: The industry game changer will be more of a disruptive mindset as we are going to see more and more reliance on COTS technology. The market is going to have to figure how to manage COTS in the space supply chain as satellites themselves become more disposable commodities that are driven by business models out of Silicon Valley that see satellites as a means to an end.

This is a change that will disrupt our world and we've had a lot of conversations about how we will think about satellites from an electronics perspective if they become disposable. It will likely result in even more reliance on COTS and open standards such as SpaceVPX. We can leverage Ethernet to immediately get to 10 Gbps. Leveraging open standards will also enable more capability for the sensor payloads. It's early yet with this disruption, but the changes, when they come, will happen fast and we need to be prepared for how we manage them. **MES**

***Anthony Jordan** has been at Aeroflex (now Cobham) for 26 years and brings 30-plus years of semiconductor experience to the company. Jordan has held various standard product marketing and applications engineering positions with Aeroflex. He was promoted to his current position in April 2014. Jordan received his BSEE degree from Bradley University and MSEE from Rochester Institute of Technology.*

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Small satellites increasingly tapping COTS components

By Sally Cole, Senior Editor

Many of the COTS technologies prevalent in today's low-cost ground applications are now being adapted for space and making their way into small satellites.

Since the 1940s, The Johns Hopkins University Applied Physics Laboratory has been designing, developing, and launching spacecraft – including small satellites – in partnership with NASA and the U.S. Department of Defense. Reprinted with permission from the Johns Hopkins APL Technical Digest, Vol. 29, No. 3. Photo courtesy of The Johns Hopkins University Applied Physics Laboratory.

Improved launch access to space is helping to drive the small satellite market and is behind a new focus on using small systems. Now that it's possible to readily place small satellites on launch systems being sent up to the International Space Station or to low-Earth orbit (LEO) at a fraction of the cost compared to in the past – for hundreds of thousands of dollars now, rather than millions – and on a fairly regular basis, people are finding unique ways to use space and create new disruptive capabilities.

Small satellites are broadly defined as those having a mass of as much as 500 kg. "There's a continuum of intertwined sub-demarcation that corresponds to increasing mass and volume, including nanosatellites, which are typically referred to as 'CubeSats.' CubeSats range from one to 10 kilograms and are described in canonical units of 10 by 10 by 10 centimeters," explains Aaron Q. Rogers, a small-satellite expert at the Johns Hopkins University Applied Physics Lab.

COTS in space

Interestingly, commercial-off-the-shelf (COTS) technologies are playing an increasingly significant role in small satellites. "Clearly, as we see a move toward commercial endeavors with fairly aggressive cost points for small satellite designs, it involves using industrial- and automotive-grade electronics and other elements from nontraditional space markets … so COTS use is becoming much more prevalent," Rogers says.

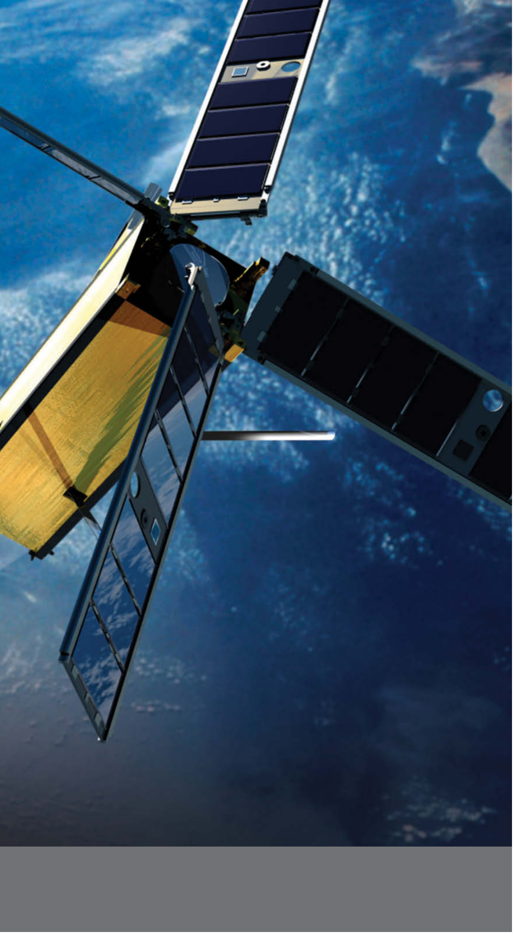
With COTS, no parts can be used whimsically – every part still requires pragmatic selection and screening. "And you need to reconcile that process with your expectations for the success and outcomes for those parts," Rogers points out. "We're seeing a lot of electronics – imaging technologies, radio technologies, navigation and GPS receivers, and other things we take for granted in our cellphones – moving into space designs."

The key to using COTS parts is to not need to modify them to work in your system with any repackaging. "You want to take advantage of their cost, so it's sort of intrinsic to buying them off the shelf. I can speak to experience that we've taken COTS components and had to shrink them in one dimension and it can become very expensive," Rogers adds.

Testing can vary

Sometimes small satellites require very little testing, "driven by both a high risk posture in which the design can be made so cheaply so that there is minimal financial impact of a loss, or it's schedule-driven to support market opportunities so testing needs to be made simple and efficient," Rogers says.

There are, however, other cases in which greater priority "is placed on ensuring the satellite will work for an extended period of time with a higher confidence level that it will deliver its designed capability as expected," points out Rogers. "So even if there's a decision to use commercial parts, these mission developers may put them through additional screening levels – derate them, meaning operate them at levels lower than they're actually specified to provide some headroom on how much they're exercised, or using redundancy and things of that nature. It's a bit of a continuum that depends on the application, what the customer or the sponsor demands, and, of course, the cost and schedule."



Historically, a detector or optical system needed to be run through a series of tests or had to be of a certain quality or greater. "Now, some companies are taking systems more akin to those used in automotive or industrial applications – with a pedigree for operation within severe environments with thermal extremes and shock – and finding that they can translate them to space applications," Rogers says.

There's still plenty of physics and work that goes into, for example, ensuring parts such as cards are radiation-hardened for space. Embedded computing company Aitech Defense Systems Inc.'s next-generation microprocessor, the SP0, uses Freescale's MPC8548e processor, which they "worked on with NASA and used the cyclotrons at the University of California-Davis to subject all parts and products to radiation testing," according to Doug Patterson, vice president of the Military & Aerospace Business Sector for Aitech (Figure 1).

New ways are being discovered to adapt COTS technologies that are prevalent in low-cost ground applications for use in space, Rogers says. "It's really more of an acceptance of risk and finding ways to maneuver around and mitigate that risk to be more successful and to realize all the cost and scheduling savings that can come from it," he adds.

Another trend within this area is "a new move afoot within NASA and at the big primes to use non-EEE (electrical, electronic, and electromechanical) parts," Patterson says. "While it hasn't gained much traction yet, it's significant because these are the most reliable parts available today. The tradeoff is that EEE parts are extremely expensive, so reduced cost enables you to build more satellites and possibly put them into LEO and interconnect them through a wireless network capable of loadsharing." (Figure 2.)

Redundancy concerns

Do you need to worry about redundancy when using COTS parts? "Yes, maybe. It really depends on what you're trying to do or what your approach is," Rogers explains. "If you have a mission that needs to work for one to three years or more, or if you're using a lot of parts that have less traceability in terms of parts' pedigree, performance, or reliability, one way to overcome the uncertainty is to fly redundant parts and have spares onboard so that if a part fails you can bring the backup online. This isn't typically done, but flying extra copies of a memory unit or power system or something is a way to work with commercial parts."

While there are many commercial forces pushing the cost model toward very cheap providers and suppliers, "some missions still require high assurances of performance success – particularly, ones that the military or government count upon operating as expected," Rogers says. "For those, there's still a need to do good testing and to use good parts and have a well-thought out, pragmatic, and enduring design approach."

That's not to suggest that these two types of missions can't coexist and hopefully benefit from each other, "because the products and offerings that fit the needs of a more high-performance low-risk mission can also move downward to support the more cost-driven missions as production scales and qualified low-cost COTS solutions can migrate upward," Rogers notes.

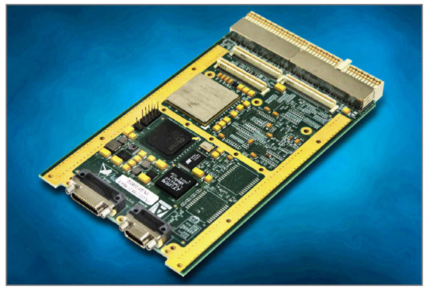


Figure 1 | Aitech's SP0 3U CompactPCI single board computer passed 100 kRad (si) testing.

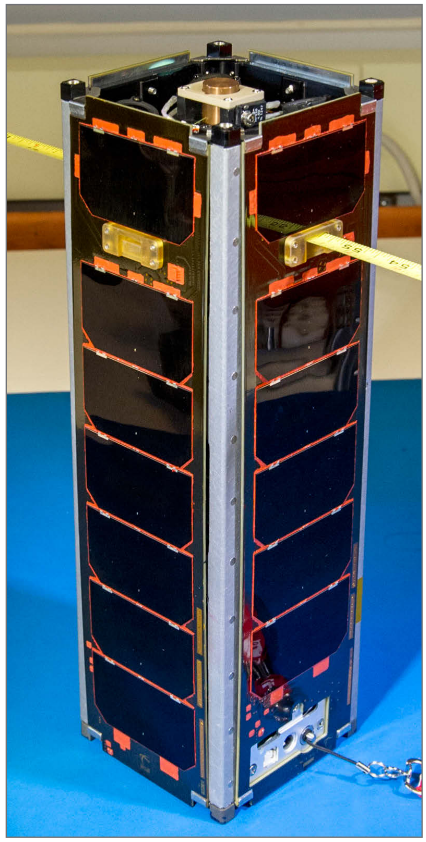


Figure 2 | Although three cans of soda would fill this Firefly CubeSat to its brim, NASA has big plans for these tiny satellites. Photo courtesy of NASA/ Bill Hrybyk.

Right now, a bit of bifurcation exists in which some players entering the small sats space can't afford to lose a mission for political reasons, unlike commercial endeavors that can go up and take gambles and learn on the fly, then iterate. Rogers says he expects to see these two communities "probably further converge within the next five years. It's going to be a real change in terms of how space is used and accessed," he adds.

A number of small companies – such as Rocket Lab and Firefly Space Systems – are trying to build dedicated launch systems for small satellites and are receiving big investments from venture capital firms. "When these come to market, and they have credible goals of flight demonstrations within the late 2015 to 2016 time frame, then we can really start talking about where we want to go for these small Earth missions to create constellations of purposely built deployments and really bring the cost bar down even further," Rogers says.

Rightsizing small sats

CubeSats are very small – nominally four to five kg for a 3U or "triple" – and limited in volume, but "it turns out that making them a bit larger by moving to a 6U form factor or as much as a 50 kg 'Express class' small satellite, the additional cost for manifest doesn't typically directly scale as long as you can still take advantage of launch access and rideshare missions," he says.

This means that greater volume "enables greater use of COTS components, which provides more performance or accommodation to sensors and payloads. This could be a tremendous value position that we, as a community, are figuring out right now," Rogers notes.

Avoiding becoming space junk

There's a concern about small satellites being considered space debris. "If small sats go up and do meaningful things – providing value to their users or operators – they should have as much claim to space as a big system," says Aaron Q. Rogers, a small-satellite expert at the Johns Hopkins University Applied Physics Lab.

"The important part is to be good stewards of space and to make a timely exit from LEO (low-Earth orbit), when the mission is over to avoid contributing more debris that could result in an impact or conjunction with another satellite or the International Space Station," Rogers asserts. "It's about being good stewards of space as a global enterprise … and developers and operators of small sats need to be cognizant of this as well as everyone else."

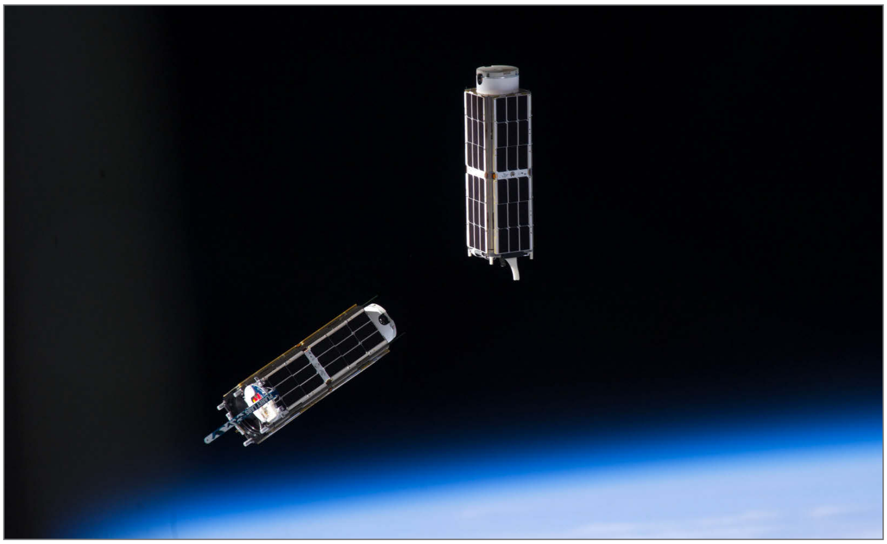


Figure 3 | A set of NanoRacks' CubeSats as photographed by an Expedition 38 crew member aboard the International Space Station. The CubeSats program contains a variety of experiments, including Earth observations and advanced electronics testing. Photo courtesy of NASA.

It also appears an inflection point has been reached in terms of small satellite size. "A good analogy is comparing the right size for small sats to iPhones or other smartphones," Rogers notes. "They kept getting smaller until they became too small, and now we're moving back to slightly larger sizes to gain a little more capability, performance, and utility." (Figure 3.)

Small satellites also bring new security concerns. Satellite command and control (C2) links require encryption or other data privacy methods to prevent intrusions and unwanted access. "Keeping control of your C2 networks is very important and people are actively working on methods that are effective and consistent with the more limited resources of small satellites," Rogers notes.

Military applications for small sats

Plenty of missions are now driven more by high temporal or spatial access rather than by exquisite performance from a large platform with a single aperture or sensor. "This means it may be possible to support a mission with a very modest sensor – a radio or a camera system – by using lots of them," Rogers says. Creating constellations of these systems enables huge revisit rates or access to areas on the Earth in a way that can provide a lot of details at a heightened repeat cadence. "We're seeing this on the commercial side with global imagery and weather … and it's sort of driving itself backward into the Department of Defense side," Rogers continues. "The government is really starting to take note of opportunities to supplement their systems with these additional data sets to improve overall knowledge. Constellations are currently being explored for automatic identification system (AIS) tracking applications, for example."

For its part, the U.S. Air Force Space Command (AFSC) is exploring several cost-saving measures like smaller satellites, disaggregation, commercial leasing arrangements, and block buys, which provide the benefit of economies of scale.

Functional disaggregation "means that sensors or submissions previously contained on a single satellite are now dispersed across several smaller, less complex, and more affordable satellites," explains Anthony D. Roake, chief of Current Operations Division, AFSC Public Affairs. "AFSC is interested in the concept of disaggregation because it can increase resilience by dispersing capability across smaller, less complex satellites to avoid single-point failures that could cause a catastrophic outage over the battlefield."

The Air Force's Operationally Responsive Space (ORS) Office is interested in capabilities to get on orbit faster and cheaper, and some of its programs involve CubeSats. The AFSC is now "taking advantage of lessons learned from the ORS program to explore building smaller satellites, some of which represent disaggregated capabilities and others that would merely take advantage of smaller sensor packages," Roake adds.

Increasing use of COTS and open standards ahead

For the sub-100 kg regime of CubeSats and small microsats, the community of suppliers for space-qualified components is currently limited.

"Many developers are trying to build their own or use COTS parts in new ways, and as those are realized to be successful – or lessons learned are brought back and iterated on to make the design more suitable for space applications – this market should stabilize and grow," Rogers says. "Similarly, because there are limited vendors to draw upon as a satellite developer, not many standards exist at this point, so people doing design work tend to do whatever makes sense in their individual case. There is some consistency on electrical and data, and, in some cases, mechanical interfaces, but there's still a lot of variance involved."

Commercial companies are "building CubeSats now, so we're starting to see them give the large primes some competition," Patterson notes. "But there are plenty of opportunities – hardware is still expensive and no one wants to send it to space only to have it drop out of orbit."

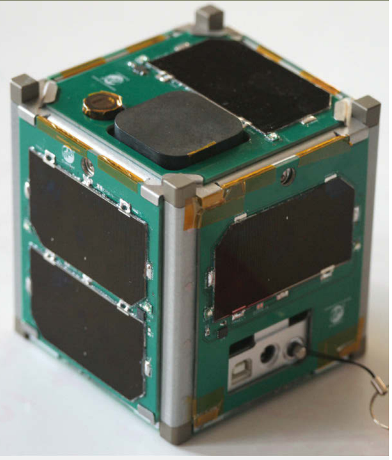
Moreover, as Patterson points out: "Companies with experience producing space products – ones with commercial as well as military and space experience – are able to offer customers the choice and ability to move back and forth between components or to even selectively choose a component that seems to be less susceptible to radiation than others."

Right now, "we're in the nascent stage where many people are entering the mission development market," Rogers adds. "As subsystem suppliers start to converge and drive consistency across standards interfaces to make their product offerings more producible and interchangeable, some of those things will converge, similar to what exists in the larger-scale aerospace industry. Expect to see this stabilize within the next few years." **MES**

Ada code enables NASA-sponsored CubeSat to stay functional in orbit for more than 18 months

By John McHale, Editorial Director

More than 18 months ago, faculty and students from Vermont Technical College in Randolph Center, Vermont, launched a CubeSat satellite into a 500-kilometer Earth orbit as part of NASA's Educational Launch of Nano-satellites (ELaNa) IV program. Their satellite – dubbed Vermont Lunar CubeSat – launched with 11 other university CubeSats, but now is the only one still working in orbit and the only one running on Ada software, which Vermont Technical College faculty say is not a coincidence.



Sidebar Figure 1 | The Vermont Lunar CubeSat – launched more than 18 months ago by a team at Vermont Technical College together with NASA – is now the only one of the original 12 university CubeSats still in orbit.

The Vermont school's tiny satellite, measuring only 10 cm x 10 cm x 10 cm and weighing just 1.0 kg, will remain in its 500-km Earth orbit for about three years to test the systems that will be used for an eventual lunar mission under the NASA program. The 12 university CubeSats were launched in November 2013 along with two NASA and 14 Air Force CubeSats.

Project leader Professor Carl Brandon and his team at Vermont Technical College developed the navigation and control software in SPARK/Ada using GNAT Programming Studio (GPS) IDE and GNAT Pro compiler from AdaCore in New York and exploiting the SPARK toolset from Altran in Paris, France, to prove the absence of runtime errors. The software was developed by a team of undergraduate students at Vermont Technical College under the direction of Dr. Peter Chapin.

"We specifically chose to write the control program for our CubeSat in SPARK/Ada because it offers increased reliability over the C language software used in almost all CubeSats to date," says Prof. Brandon. "The success of the fairly complicated software on this ELaNa CubeSat gives us confidence in using SPARK 2014 for the much more complicated and expensive lunar mission."

In discussions with other experts in the CubeSat community, there seems to be a consensus that the majority of failures are software-related, Brandon says. The Vermont CubeSat was the first one programmed in Ada and the first satellite of any kind using SPARK as well, he continues.

Considering the reliability of Ada and how the commercial aviation and military markets – where lives are at stake – rely on Ada, it was surprising that it is not used more in CubeSat development, Brandon notes. "Using Ada makes complete sense because it is so much more reliable than C code," he adds.

"The CubeSat project has created an increased awareness of the benefits of SPARK and Ada within the space-applications industry," says Ben Brosgol, senior software engineer at AdaCore. "Ada is used heavily in this domain, for example, in a number of European Space Agency (ESA)-sponsored programs, and we expect that successful projects such as the Vermont Tech CubeSat will attract greater attention in NASA."

Brandon and his team will continue relying on Ada and SPARK as they work on sending a CubeSat to the moon for a project that will use an infrared spectrometer to fully survey the moon in day and night to look for water and other volatile resources.

For more information, visit http://www.cubesatlab.org.

TRENDS IN RADIATION-HARDENED ELECTRONICS

Reduced SWaP, COTS in space, and budget constraints in the rad-hard world

By John McHale, Editorial Director

Defense and space agency budgets remain flat while commercial small-satellite opportunities are heating up, all forcing radiation-hardened (rad-hard) electronic component designers to tackle reduced size, weight, and power (SWaP) requirements as well as re-examine the viability of using commercial-off-the-shelf (COTS) equipment in space environments. Meanwhile, radiation testing and qualification requirements are getting tougher and embracing TOR standards.

Intersil's HS9-1840ARH radiation-hardened 16-channel analog multiplexer is onboard the NASA Orion's crew module in both the inertia measurement unit and the navigation and flight controls. Orion photo courtesy of NASA.

Radiation-hardened electronics designers, facing the heat of reduced SWaP requirements in satellite programs and customer budget constraints, find they need to be even more innovative and open-minded to deliver commercial-level capability to space systems in low-cost packages.

The government segments of the space market look to be flat or slow growing for the foreseeable future, even as the development of megaconstellation small satellites begins to heat up. Meeting the needs of one doesn't necessarily meet the needs of the other; as a result, companies are diversifying their rad-hard product lines and even considering the use of commercial-off-the-shelf (COTS) technology.

"Military space customers want smaller and lighter components with higher levels of overall performance while also reducing cost," says Monty Pyle, Vice President of Sales and Marketing at VPT in Blacksburg, Virginia. "This can definitely be an engineering challenge. The budget constraints many integrators in the military space market face forces them to take a hard look at what exactly is needed in terms of radiation resistance within individual programs and try to strike a balance to help reduce the costs. In other words, for areas that require only minimum rad-tolerance, they are moving away from using devices with maximum rad-tolerance and more toward components that fit the exact need. It's too expensive to make every component with maximum radiation resistance in modern space systems and it's not necessary."

"A big trend right now is to reduce size and weight, a demand which will only increase with the rise of CubeSats, where weight is critical especially when using a 'pound for launch' cost metric," says Philip Chesley, Senior Vice President, Precision Products at Intersil in Palm Bay, Florida. Regarding reduced size and weight, Intersil offers a rad-hard temperature sensor called the ISL71590SEH, he adds. The device is a two-terminal temperature-to-current transducer that is accurate over time, temperature, and radiation exposure – specifically with a ±1.7 °C accuracy over temperature and less than –1 °C change in accuracy over low-dose-rate radiation. "Developers of the most advanced next-generation satellite systems require temperature sensors that provide accuracy over the mission life of a satellite, eliminating the need for expensive radiation lot acceptance testing or spot shielding," Chesley notes. The Intersil device is qualified over the full military temperature range and to over 50 krad (Si) low-dose-rate and 300 krad (Si) high-dose-rate irradiation.

COTS in space

Budget constraints and the growth of the CubeSat market is also giving commercial electronic suppliers confidence that they can succeed in the space markets, although some have their doubts.

Figure 1 | Pictured is the Intermediate eXperimental Vehicle (IXV) spacecraft, the European Space Agency's experimental re-entry vehicle that is using Curtiss-Wright's data acquisition, networking, and recording subsystems.

[For more on COTS in space see Executive Interview on page 20.]

"Folks are trying to bring COTS technology to space," Chesley says. "This industry is cyclical in that way. Every ten to 15 years the pendulum swings to trying a COTS approach to meet budget constraint challenges, which is true today as the pressure to use more COTS is actually coming from government programs rather than commercial satellite systems as government outlets are facing pressure to slash costs."

"The barrier of entry in this market is huge and to be successful companies need to build up a heritage of product success as the customer base is very conservative," says Danny Gleeson, Business Development Manager for Space Market at Curtiss-Wright in Dublin, Ireland. "Our move into space began with SpaceX using our modular avionics data acquisition device – the KAM-500 – in the flight test phase and then it was retained for the production vehicle and we found that it met all the necessary requirements." The product also has a Microsemi ProAsic FPGA that is inherently rad-tolerant.

"We have integrated our COTS modules in a smart backplane that we call a radiation safety net," Gleeson says. "It enables the use of those modules in a radiation environment and protects them from latchups and other destructive events. Due to competitive reasons I cannot say more about the COTS backplane except that the radiation protection is at the board module level. Total ionizing dose (TID) resistance of commercial components varies depending on the technology, but typically is between five and 20 krad TID and this is compatible with a range of space missions."

The Curtiss-Wright backplane has just gone through radiation testing at NASA and the next phase will be to create a rad-hard ASIC that will contain the company's data acquisition, Gleeson continues. "The new ASIC will form the building block for creating a family of rad-hard modules for remote terminal units onboard satellites. The Intermediate eXperimental Vehicle (IXV) spacecraft, the European Space Agency's experimental re-entry vehicle, is using Curtiss-Wright's data acquisition, networking, and recording subsystems (Figure 1).

"Our space COTS products are equipment that was never intended for space that we retasked for use in space radiation environments on a mission-by-mission basis," he continues. "As we started entering the market, we did performance characterizations and qualifications for different radiation conditions in space and mapped our products to match mission profiles. It comes down to the risk versus cost analysis or what some call the eighty percent solution. In other words, if the environment in space does not call for components that meet extreme radiation requirements, then why procure them? This mindset is helping drive the use of COTS in space environments. Even though it may be COTS, if it meets the requirements, why not use it?"

TOR and radiation testing

"A key trend we are seeing is the industry embracing TOR – or Technical Operating Report – standards," says Monty Pyle, Vice President of Sales and Marketing for VPT in Blacksburg, Virginia. "Aerospace TOR refers to reports developed by Aerospace Corp. and flowed down as requirements on space asset procurements that cover technical requirements on electronic parts, mechanical parts, materials, and processes involved in the manufacture of components used on space-based systems. The requirements include guidance on analysis, component deratings, prohibited part types, part element evaluation, and screening that in many instances exceeds the requirements of MIL-PRF-38534 Class K.

"The SVR series (of products) was developed based on TOR requirements and designed to accommodate TOR requirements over and above class K," he continues. "At industry gatherings designers and integrators now they talk specifically about what TOR means to suppliers. They have embraced it because it is the best way to serve the highest level of applications in the space market.

"One other trend we are seeing is a change in the amount of radiation testing per component required by our military space customers," Pyle says. "In the past integrators typically accepted a rad-hard comparison to a similar component we produced before, but that is not acceptable anymore. Each part now needs its own testing data. To meet this need, we bought our own testing facility – called VPT Rad, which covers all levels of testing such as total dose, enhanced low-dose-rate sensitivity (ELDRS), single-event upsets (SEUs), etc. The VPT Rad facility also serves the general space electronics manufacturing market."

"There has been an evolution in radiation assurance as in what type of testing data users want before they will commit to purchasing a rad-hard component," says Philip Chesley, Senior Vice President, Precision Products at Intersil in Palm Bay, Florida. "In the past, what people cared about was total ionizing dose (TID), but now they want more specifics especially how transistors will react under ELDRS. Essentially they want assurance that any part they buy will be truly be EDLRS-free."

Intersil also offers radiation testing in its facility in Florida, where products can go from concept to production of radiation-hardened components with both wafer-by-wafer radiation-testing at high and low dose rate as well as single-event testing, he adds.

> "IT'S TOO EXPENSIVE TO MAKE EVERY COMPONENT WITH MAXIMUM RADIATION RESISTANCE IN MODERN SPACE SYSTEMS AND IT'S NOT NECESSARY." – MONTY PYLE, VPT

Not everyone in the rad-hard industry agrees with that analysis. "Maybe COTS will take over the rad-hard business and prove me wrong, but the physics don't back up that theory," Chesley says. "I'm skeptical of any radical change, as commercial parts – designed for the automotive world or similar consumer markets – do not work in space. I've tested thousands of them and they simply do not have the reliability necessary for rad-hard environments.

"If the government looks at what SpaceX is doing – just launching things into space – they realize they can't do the same as they have to keep things in space, which is a big difference," he continues. "To keep it in space, the parts must not fail. A distributed architecture works great for an Iridium-type program but can be problematic in strategic military space programs. It's not worth the risk of the parts failing. Many people in the strategic satellite business struggle to see how distributed architectures solve that problem."

Rad-hard Intersil integrated circuits (ICs) such as voltage regulators, multiplexers, dual analog switches, MOSFET drivers, quad differential receivers, and microprocessor supervisory circuits flew on the crew module on the first flight of NASA's Orion spacecraft, the uncrewed Exploration Flight Test 1.

Product trends: SpaceVPX, FPGAs, power ICs

Engineers at Cobham are now offering their Gen6 single board computer (SBC), which is based on the LEON microprocessor, says Anthony Jordan, Vice President, Product Marketing and Applications Engineering, at Cobham Semiconductor in Colorado Springs, Colorado. "It has a Technology Readiness Level (TRL) of 6, which we believe allows us to offer an off-the-shelf onboard SBC or for use as a payload or instrument controller. The SBC leverages Cobham's standard product portfolio including LVDS, SpaceWire, logic, volatile, and non-volatile memory solutions. Based on the 3U CompactPCI form factor, the Gen6 SBC is designed for fault-tolerant, mission-critical applications."

Cobham's entrance into the space SBC market puts them up against companies such as Aitech in Chatsworth, California, and Maxwell Technologies in San Diego. Aitech produces the SP0 3U CompactPCI SBC that is used by Boeing on the Commercial Crew Transportation System (CCTS) and Crew Space Transportation (CST)-100 spacecraft. Maxwell also offers a 3U CompactPCI SBC for space called the SCS750 (Figure 2).

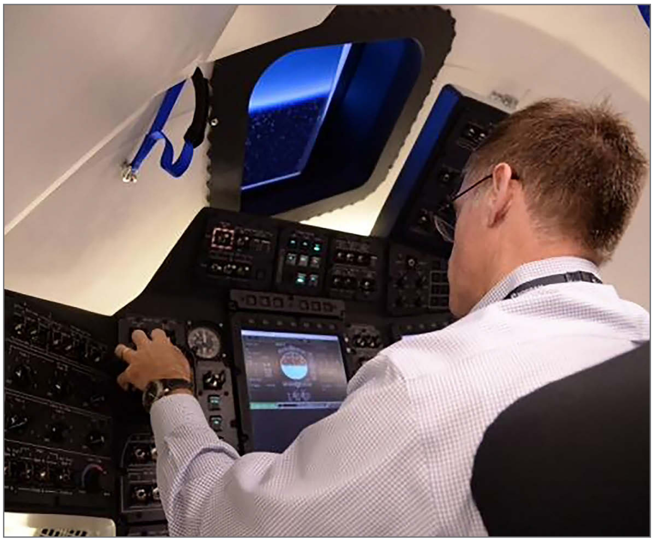


Figure 2 | Aitech's SP0 3U CompactPCI SBC is used by Boeing on the Commercial Crew Transportation System (CCTS) and Crew Space Transportation (CST)-100 spacecraft.

All these designers are keeping an eye on the development of the SpaceVPX standard out of VITA. "We look forward to low-cost and SpaceVPX board-level solutions, as we are very interested in extending this base capability," Jordan says. "Weather instrumentation, remote sensing, and data-intensive applications will drive the use of RapidIO and SpaceVPX in the space market."

[For more on SpaceVPX see article on page 34.]

Crane Aerospace & Electronics in Redmond, Washington, saw its Interpoint MFP0507S POL DC-DC converter fly onboard NASA's Orion spacecraft. The company has delivered more than 90 MFPs to the Orion program. The MFP0507S converters reside on network interface cards that are used throughout the spacecraft. The converter can be used with a 3.3 VDC input bus or 5.0 VDC input bus, has the flexibility to be set for any output voltage from 0.8 VDC to 3.5 VDC, and requires no external components to achieve all specified performance levels.

A new product line for VPT that is just completing DLA (Defense Logistics Agency) qualification is the SVLD (Low Dropout) family, which is designed to work the Xilinx 5 and other FPGAs for space applications that require extremely tight bus regulation with very low noise. "The Xilinx 5 has really set the standard for space FPGAs in my personal opinion as it is re-programmable after launch," VPT's Pyle says. "Many of our customers have been asking about interfacing with the Xilinx 5 and we see it as being there for the long haul. Previously they had to provide their own interface from our traditional isolated DC-DC converters to their sensitive FPGA applications. With VPT's upcoming SVLD Series, a VPT space customer can address all their power requirements from the main power bus, through our EMI filter, isolated DC-DC converter, point-of-load non-isolated DC-DC converters, and SVLD to their Xilinx 5 or other FPGAs." **MES**

SpaceVPX adds fault tolerance, cuts cost for space-bound HPEC systems

By Brandon Lewis, Assistant Managing Editor

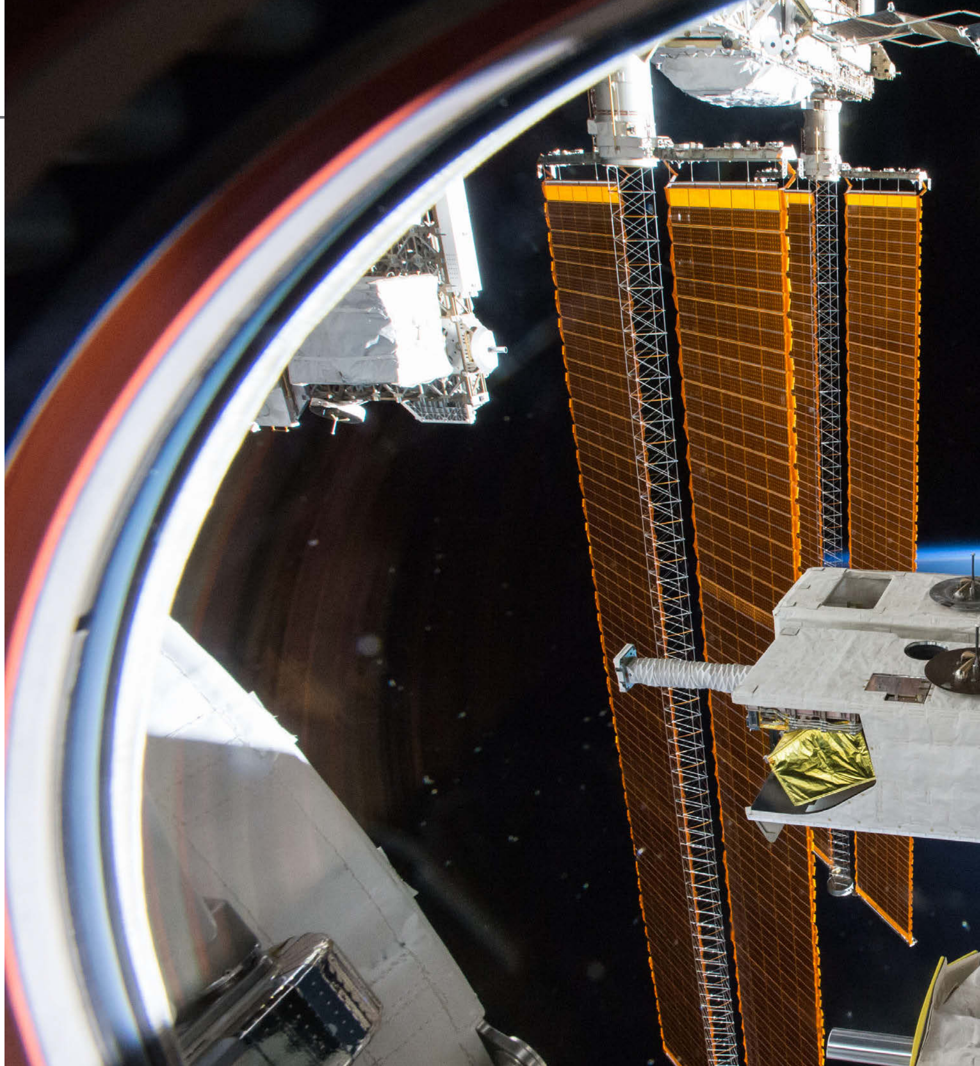


Photo of equipment and data from the SpinSat investigation of the sixth SpaceX cargo resupply mission to the International Space Station by NASA astronaut Terry Virts.

Reliability and fault tolerance combine in a new, high-performance embedded computing open standard called SpaceVPX that is aimed at the space electronics industry.

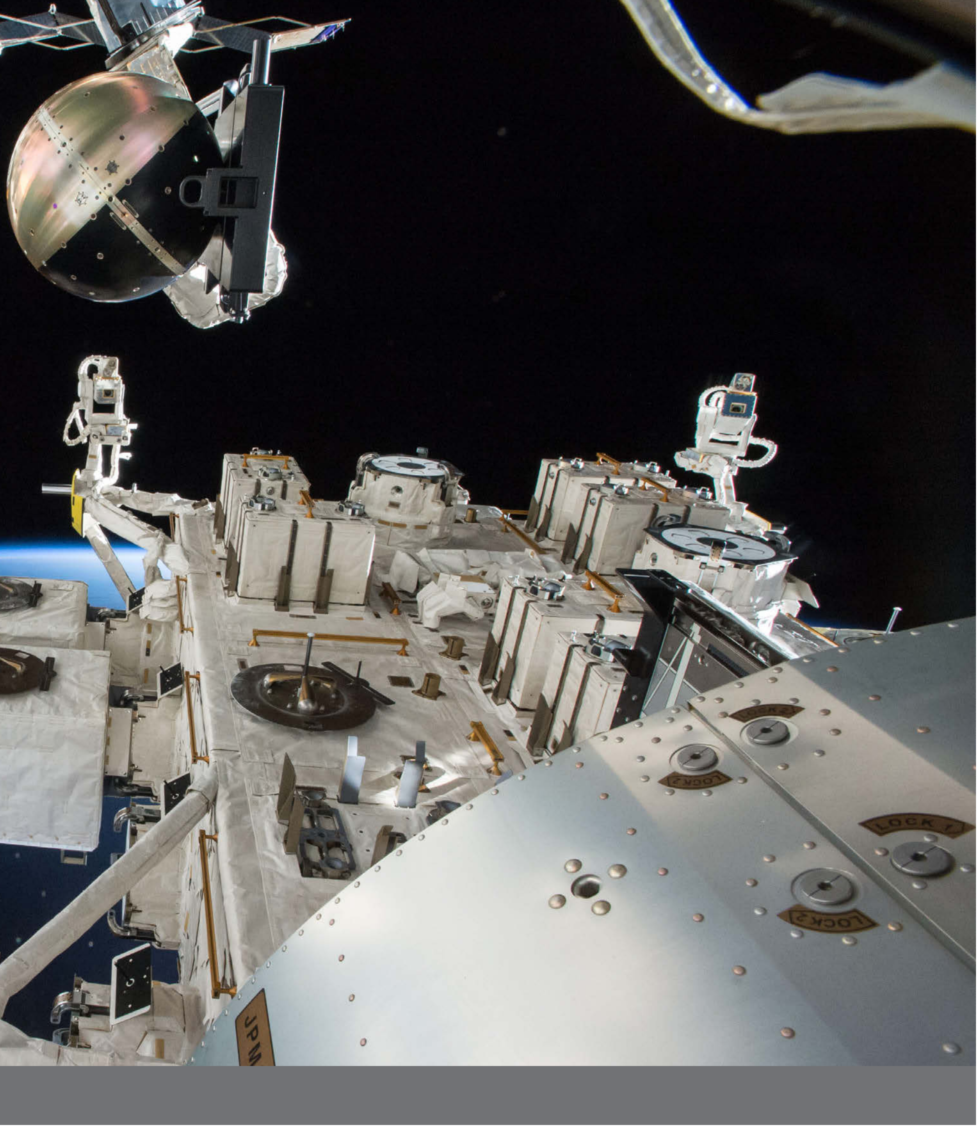
In the rigors of space, fault tolerance is a prerequisite for high-performance embedded computing (HPEC) systems responsible for the transmission of mission-critical data. Faced with extreme temperatures and radiation levels, extended deployment, and the improbability of hardware maintenance, space-bound technology platforms must be designed to standards of reliability and resilience seldom matched by applications on Earth. Meanwhile, space agencies are being asked to do more with less since the effects of sequestration began to take hold in the earlier part of the decade, as are the agencies' suppliers, who are perpetually tasked with delivering components that are smaller, more powerful, and more affordable.

Though certain off-the-shelf architectures have had successful flight heritages in space, their use beyond prototyping and development has been largely spotty. On the whole, commercial-off-the-shelf (COTS) technology has been viewed as incapable of offering the robustness required by an industry that has traditionally turned to custom solutions, but as the space sector becomes increasingly international and more commercialized, historical perceptions are beginning to change. This is evident through the recent ratification of VITA 78, or SpaceVPX.

SpaceVPX: Dual-redundant, fault-tolerant COTS

SpaceVPX began as part of an industry/government collaboration called the Next Generation Space Interconnect Standard (NGSIS), and is a retrofit of the VITA Standards Organization's (VSO's) OpenVPX specification that adds fault tolerance to meet the demands of space flight, says Patrick Collier, Senior Electrical Research Engineer, Space Communications Program at the Air Force Research Laboratory (AFRL) Space Vehicles Directorate and NGSIS and VITA 78 Working Group Chair. Looking to define a modular open systems architecture (MOSA) for space system interconnects that removed bandwidth constraints, the NGSIS working group selected OpenVPX as a physical baseline for SpaceVPX due to its broad ecosystem support, which helps reduce cost and promotes technology reuse, he says.

"Originally, the whole effort was under the NGSIS umbrella, which started close to three years ago," Collier says. "It was an option from an effort that focused on protocols. When we started, NGSIS didn't have SpaceVPX, and we were talking about which commercial protocol would be best for space systems. After about a year or so there was a discussion among people in the group because they started to see that all of the vendors were looking to use VPX to build their chassis, and they started to



ponder whether it would be a good idea to see what we could do to OpenVPX to enhance it for space. So a separate study group was formed and it turned into a working group under the VSO. I proposed the effort to VITA at one of their face-to-face meetings, and they accepted it as a study group. Then it moved from there into a working group.

"Specifically, [SpaceVPX] provides for fault tolerance and dual redundancy, which you don't get in OpenVPX," he continues. "You have single-stream systems in OpenVPX, which is basically just one set of cards. With SpaceVPX, it provides for greater resiliency by having dual redundancy in the system, and one thing that we added to provide a greater degree of fault tolerance is a new board type called a Space Utility Management (SpaceUM) module that collocates all of the management and utility signals that you might have on a separate payload card or SBC, and then distributes those signals to all of the cards in the chassis and also distributes power. The idea here is that there are not meant to be single points of failure, so you have it such that if you see losses in signals or in certain sets of signals that it won't bring down the whole system."

In particular, the SpaceVPX SpaceUM receives utility and management signals from an independent management controller, which, along with power from an independent power supply, are then distributed to SpaceVPX modules in each of eight system slots to enable fault tolerance. An example SpaceVPX backplane topology can be seen in Figure 1.

In addition, the SpaceVPX specification limits the number of OpenVPX slot profiles to a subset that accommodates the current and future needs of the space electronics community, Collier says. Of the 17 total backplane profiles, one of the payload slot profiles and one of the data switch profiles were directly mapped from OpenVPX, while several new, backward-compatible profiles and special slot definitions that enable

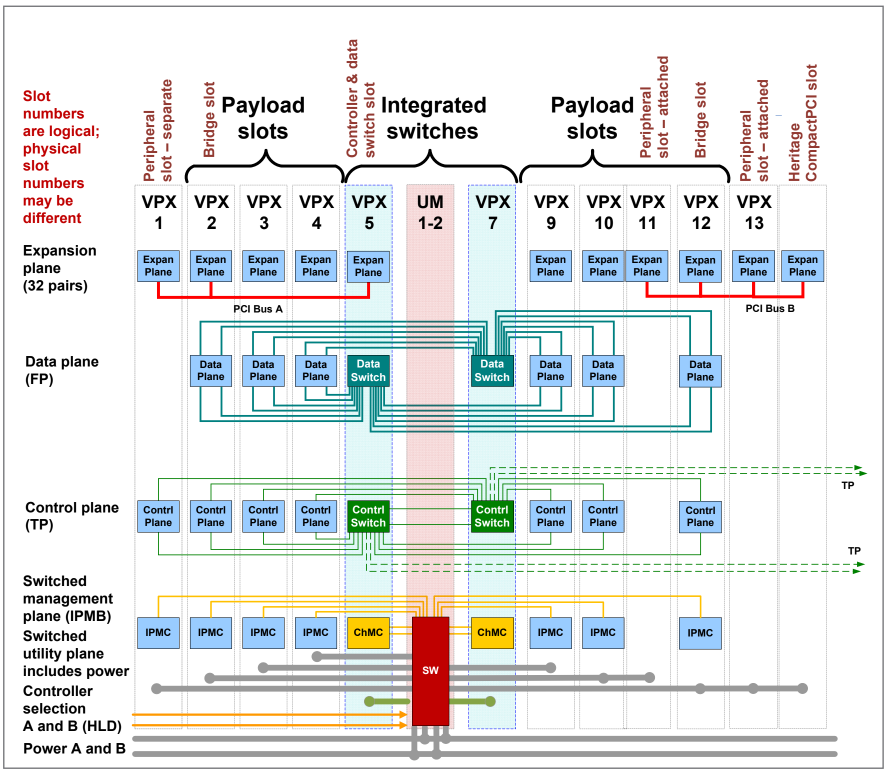


Figure 1 | The SpaceVPX specification includes a Space Utility Management (SpaceUM) module that provides dual redundancy for space systems.

the bridging of SpaceVPX modules to heritage CompactPCI (cPCI) modules were introduced. Table 1 includes a description of the backplane profiles contained in the SpaceVPX specification.

Commercializing cost for space electronics

Rather than building custom development platforms, NGSIS and SpaceVPX also reduce the cost of designing, testing, and integrating system prototypes before they are ported to deployment-ready models, Collier says, which over the life of a program can yield significant savings.

"From a quantitative perspective it would be hard for me to gauge at this point how much savings, but what we're hoping over the long term is that you would see a significant cost savings.

"Given what vendors might do today if they had to build their own custom systems to do development work before porting them over to a space system, we're hoping that we'll see a lot of people using OpenVPX systems that they then port over to a SpaceVPX system, mainly because there are restrictions on the types of slot profiles that are available from COTS vendors," he says. "That's why we tried to make sure we mimicked particular slot profiles so that they could be used in a SpaceVPX system.

"There are some slot profiles that we have that directly map to what OpenVPX uses; an example would be one of the payload slot profiles," Collier continues. "There are others that you won't find in OpenVPX, but it could still be used with a foreign OpenVPX system since it is backward-compatible, he adds.

"It's over the lifetime of a project or a program that you'll see significant savings, and hopefully as the market grows you'll see more people building a subset of those slot profiles for different uses – maybe you'll see some of these used for non-space systems, maybe for a high-reliability air platform or some other type of high-reliability application that could be non-aerospace or non-space," Collier notes.

Future SpaceVPX applications

Currently, NASA is evaluating SpaceVPX, and Collier points to "significant interest" from the European Space Agency (ESA) and its suppliers as another area of potential growth.

"Over a year ago I approached Space Systems Loral (SSL) to discuss the space systems that we were using and the spec that we were developing, but at the time it may have been too soon," Collier says. "For [commercial space] companies like SSL or Iridium, they

Topology Config	Fat Pipes per Connection	Payload Fat Pipes	Data Plane Switch or Mesh Size	Control Plane Switch Size	Control & Mgmt Plane Hubs Integrated with Data Plane Switch	Control & Mgmt Plane Hubs with Data Plane Connection	Control & Mgmt Plane Hubs w/o Data Plane Connection	Payload Slots	Data Switch Slots	Controller Slots	SpaceUM Slots (Supports 8 Slots)	Payload Supports Expansion Plane	PCI Bridge Position (P=Payload C=Controller)	Max Total Slots
Switch 1	1	2	12S	16	X			12	2		2	J2	P	16
Switch 2	1	2	22S	26		X		20	2	2	3	J2	P/C	27
Switch 3	1	2	22S	28			X	22	2	2	4	J2	P/C	30
Switch 4	2	4	7D	11	X			7	2		2	J2	P	11
Switch 5	2	4	11D	15		X		9	2	2	2	J2	P/C	15
Switch 6	2	4	11D	17			X	11	2	2	2	J2	P/C	17
Switch 7	4	8	4Q	8	X			4	2		1	J2	P	7
Switch 8	4	8	5Q	9		X		3	2	2	1	J2	P/C	8
Switch 9	4	8	5Q	11			X	5	2	2	2	J2	P/C	11
Mesh 1	1	12	13S	15		X		11		2	2	J2		15
Mesh 2	1	22	23S	27			X	23		2	4		C	29
Mesh 3	2	14	8D	10		X		6		2	1	J2		9
Mesh 4	2	22	12D	16			X	12		2	2	J2	C	16
Mesh 5	4	16	5Q	7		X		3		2	1	J2		6
Mesh 6	4	20	6Q	10			X	6		2	1	J2	C	9
Mesh 7	4	20	6Q	10			X	6		2	1		C	9

Table 1 | Listed here are details of the slot profiles defined by SpaceVPX.

"IN PARTICULAR, THE SPACEVPX SPACEUM RECEIVES UTILITY AND MANAGEMENT SIGNALS FROM AN INDEPENDENT MANAGEMENT CONTROLLER, WHICH, ALONG WITH POWER FROM AN INDEPENDENT POWER SUPPLY, ARE THEN DISTRIBUTED TO SPACEVPX MODULES IN EACH OF EIGHT SYSTEM SLOTS TO ENABLE FAULT TOLERANCE."

already have their buses defined. Now whether or not they see it from a box level that this makes sense, I haven't seen an indication that their interest is increasing.

"I'm hoping [the European interest] will take hold. In that way you might see the market grow with contractors in Europe starting to use SpaceVPX boards and chassis," he continues. "The ESA would be the end user, but part of it would also be to get their end contractors, say, like Airbus or Thales. If they're looking to design new architectures and they're looking to save costs, this would be one way they could save."

Current efforts

Currently, Collier cites BAE Systems and Honeywell as two companies that have already publicly started building and could ship SpaceVPX products as early as Q2 2016, though many of the organizations involved in VITA 78 are possible vendors as well (Table 2).

Moving forward, the VSO has begun work on a VITA 78 dot spec for 3U SpaceVPX systems, which Collier hopes will help drive the technology into smaller low size, weight, and power (SWaP) systems and applications. **MES**

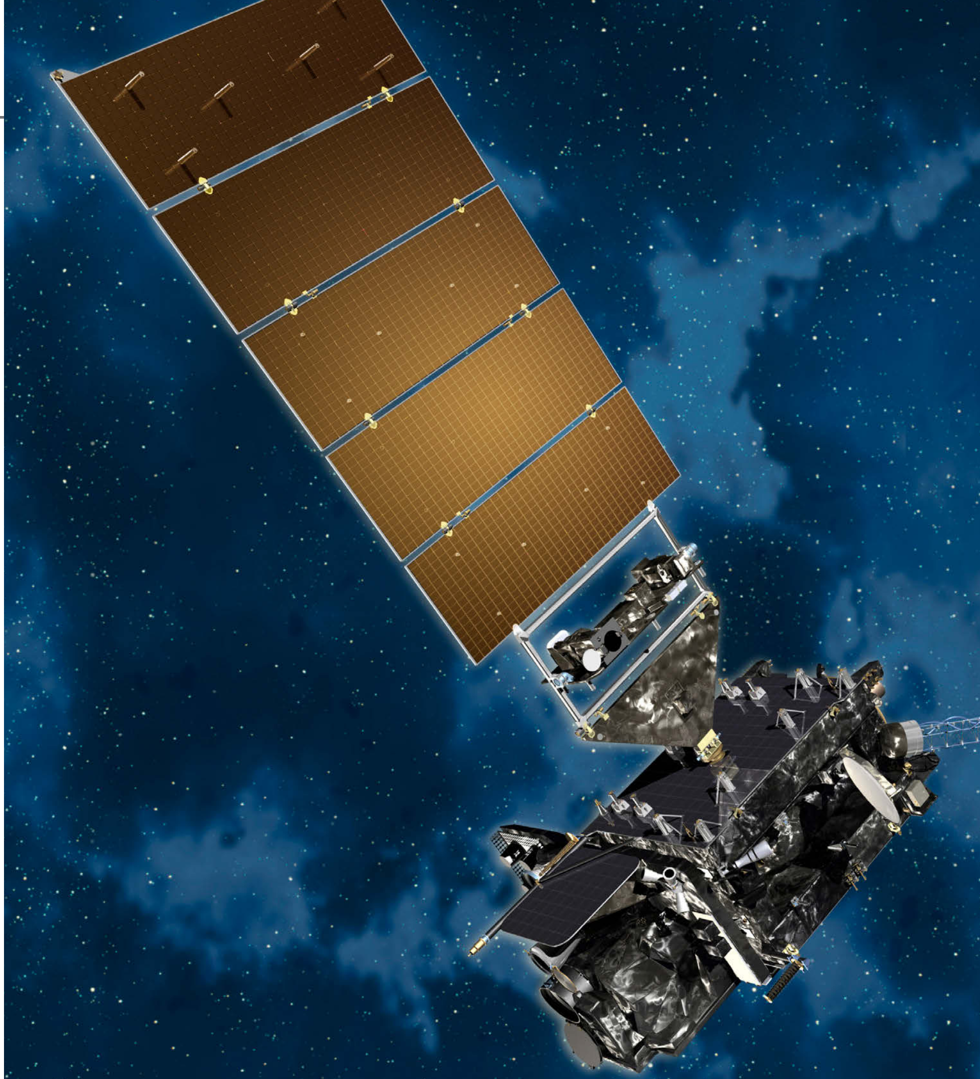
For more information, visit the Air Force Research Laboratory (AFRL) Space Vehicles Directorate website at www.kirtland.af.mil/afrl_vs.

NGSIS SpaceVPX Subcommittee	
Patrick Collier, Chair	Air Force Research Laboratory (AFRL) Space Vehicles Directorate
Yutao He	CalTech/JPL
Michael Enoch	Lockheed Martin
Paul Toledo	
Joe Marshall	BAE Systems
Alan Berard	
Cliff Kimmery	Honeywell
Gregory Powers	TE Connectivity
Scott Goedeke	Northrop Grumman Electronic Systems
Michael Biemer	
Richard Haraguchi	
Khoa Pham	
Ron Smith	Northrop Grumman Aerospace
Michael Munroe	Elma Electronic
John Martiney	Harris Corporation
Scott Wolaver	
Kristine Skinner	Boeing
Bob Evans	Amphenol
Zachary Pokornowski	Smith Connectors
Mike Chenoweth	SEAKR

Table 2 | Listed here are members of the original Next Generation Space Interconnect Standard (NGSIS) SpaceVPX Subcommittee.

Radiation-tolerant FPGAs solve the satellite signal processing bottleneck

By Ken O'Neill

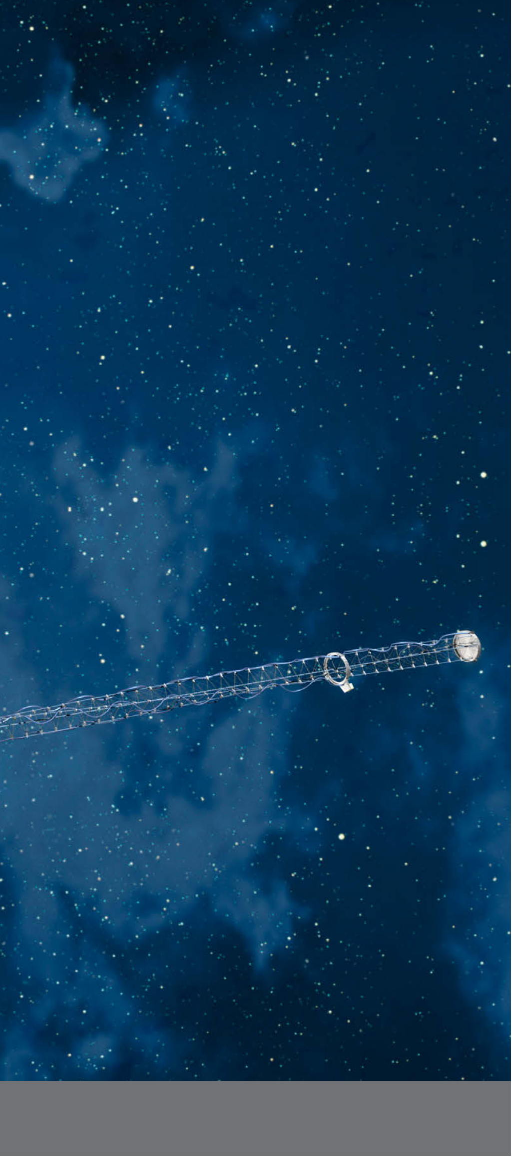


Satellites performing remote-sensing missions, like this GOES-R (Geostationary Operational Environmental Satellite R Series, a collaborative effort between NASA and National Oceanic and Atmospheric Administration [NOAA]) can implement radiation-tolerant FPGAs to heighten reliability and decrease the chance of data errors. (Photo courtesy of NASA/NOAA.)

Dramatic increases in sensor resolution in remote-sensing space payloads are causing a processing bottleneck, as downlink bandwidth is not keeping pace. Operators require onboard processing so that satellites send processed information, not just raw data. It is a growing challenge for the roughly 100 remote sensing satellites launched each year, each carrying as many as eight payload instruments. Flash-based field-programmable gate array (FPGA) technology is now being applied to the problem, combining high-speed signal processing with special built-in radiation mitigation techniques to keep systems operational in harsh radiation environments.

Military satellite operators have an insatiable thirst for data, and are therefore specifying remote-sensing satellites with ever-increasing sensor capabilities. In addition to increased resolution, imaging sensors are required to cover broader spectra, infrared detectors are required to have higher sensitivity and finer spectral channelization, and synthetic aperture radar systems are required to perform additional processing steps such as polarimetry or interferometry in order to extract additional useful information from the radar data. While sensor developers have been able to meet the need with increasingly sophisticated and capable sensors, the available bandwidth to transmit data back to Earth has not been increasing as quickly. This information glut creates a growing requirement to perform signal processing on board the satellite, so that downlink bandwidth is used efficiently. Figure 1 shows the architecture of a generic remote sensing satellite payload instrument.

Historically, this data-overload problem has been solved by using radiation-hardened application-specific integrated circuits (ASICs), which have sufficient density and performance to accomplish the high-throughput signal processing required. ASICs have some significant disadvantages, however: For one thing, ASIC developers are required to pay a large nonrecurring engineering charge (NRE), which covers tooling costs for the ASIC (for example, making masks for the 40-plus diffusion, deposition, and etching steps involved in making a modern integrated circuit). The NRE also compensates the ASIC vendor for first silicon wafers, and also for the time and effort expended by the application team in supporting the developer through the design, timing closure, and verification process. NRE costs can run as high as several million dollars; for satellite designs, these costs are amortized over a small number of units. The fabrication cycle time on a radiation-hardened



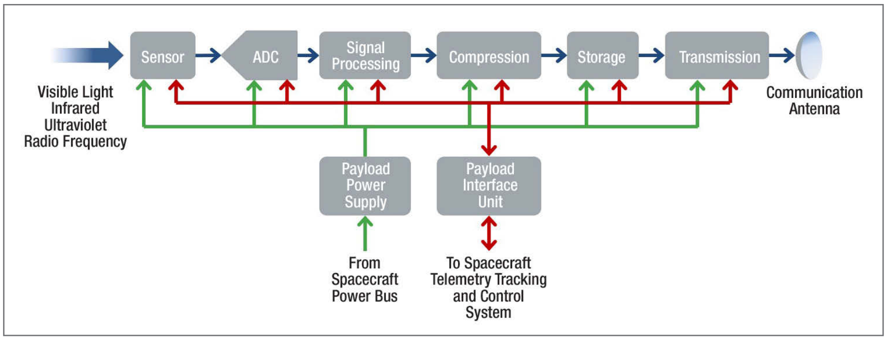


Figure 1 | Generic remote sensing payload architecture.

ASIC is long, and it can be as much as six months before a design team gets to see if their ASIC design actually works as intended. If part of the ASIC needs to be redesigned, then additional NRE must be paid, and delays to the project will be incurred as another cycle through fabrication is necessary. This presents a very high degree of risk to satellite program managers. Many military satellite programs charge subcontractors penalties for late delivery of systems that can run into thousands of dollars for each day of delay. More significantly, delays to the launch of a military satellite can create a national-security risk, as it may mean that a key component of a reconnaissance or missile-detection mission is not in place in time.

ASIC alternatives

An alternative to using an ASIC is to use large high-performance FPGAs. The largest FPGAs with packaging and testing suitable for space applications have historically been static random-access memory (SRAM)-based. While these FPGAs bring some benefits of rapid prototyping and validation due to their reprogrammability, which mitigates the risks of using an ASIC, they introduce some other disadvantages. SRAM-based FPGAs use SRAM cells to switch pass transistors on or off. These pass transistors connect or disconnect routing tracks and configure the function of the programmable logic resources in the FPGA. Any radiation upsets in the SRAM cells can cause the FPGA's design configuration to change, causing a malfunction in the system. Designers working with SRAM FPGAs need to be aware of the risks of malfunctions caused by radiation upsets in SRAM configuration cells, and must be prepared to take steps to mitigate their design. The latest SRAM FPGAs intended for radiation environments include modifications that reduce, but do not eliminate, such errors. Designers need to take further mitigation steps which involve reading and correcting the FPGA configuration memory with a radiation-hard scrubber circuit, which increases power consumption, board space, and system mass. This technique doesn't prevent errors, it only corrects them after they have occurred. In this situation, a military mission may be compromised as the SRAM FPGA is not functioning correctly during the period between occurrence and detection of the configuration error.

Clearly, an alternative approach to digital logic integration in space-based signal processing applications is required, which mitigates the risk of the ASIC and SRAM FPGA approaches. Flash-based FPGAs offers a new angle to solving this signal processing congestion problem. Today's flash-based FPGAs combine an architecture optimized for signal processing applications with a 65 nm flash process, which is intrinsically hard against loss of configuration due to radiation in space.

What's needed

Many architectural features are needed to enable high performance in signal processing applications. An abundance of flip-flops in the programmable logic fabric is a prerequisite, as high-performance designs often make heavy use of data pipelining in order to maximize the operating clock frequency. High density and high performance of the programmable fabric is necessary but insufficient. To be successful in high-speed signal processing applications, FPGAs must also have ample hardwired multiply-accumulate blocks, copious amounts of embedded SRAM memory, and high-speed I/Os, both serial and parallel, in order to get signals on-chip and off-chip quickly.

Modern geosynchronous satellites are required to remain functional for up to 20 years after launch. For deployment in space, FPGAs must be able to survive the radiation environment for the duration of the satellite life without any destructive or catastrophic failures, such as single-event latch-up or configuration upsets. The flash cells that control the configuration of 65 nm flash FPGAs are intrinsically immune to upsets caused by subatomic particle radiation in space. This has been demonstrated through several rounds of radiation testing using high-energy heavy ions in tests. In these tests, FPGAs are bombarded by energetic heavy ions at rates literally millions of times greater than they will be subjected to in the space environment, allowing radiation scientists to gather enough data to simulate a satellite lifetime in a few hours. In this testing it has also been shown that

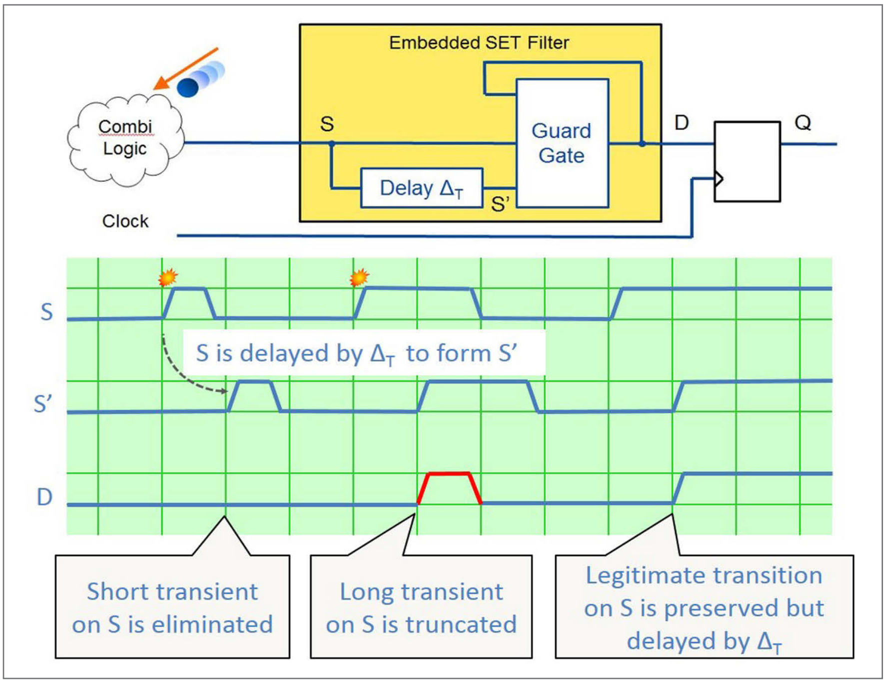


Figure 2 | An embedded single-event transient filter.

"radiation-hardening-by-design" techniques in combination with the 65 nm process used to build these FPGAs have eliminated the possibility of single-event latch-up in space applications.

For data paths carrying mission-critical or flight-critical data, flip-flops require protection against radiation single-event upsets, and combinatorial logic may require single-event transient mitigation. Protection of flip-flops against upsets caused by subatomic particle radiation is usually accomplished by using triple module redundancy within each flip-flop in conjunction with a self-correction scheme, which corrects any radiation upsets asynchronously and prevents upsets from propagating outside of the logic cell.

Single-event transients have become significantly more important in modern submicron integrated circuits. Firstly, as manufacturing processes shrink to finer geometries, the energy a subatomic particle needs to transfer in order to cause a glitch in combinatorial logic decreases. Compounding this situation, as clock frequencies increase, the probability of a glitch in combinatorial logic occurring within the sample-and-hold time of flip-flop increases. As a result, single-event transients have become a significant concern for designers of electronic systems that are intended to be deployed in environments with large amounts of particle radiation, such as space. The length of the delay (ΔT) will determine the maximum duration of transient which the circuit can filter. The ΔT must be chosen carefully by the FPGA vendor so that it is effective at screening out the majority of radiation-induced transients, while at the same time having as little impact on the performance of the FPGA as possible.

In FPGAs offering embedded single-event transient mitigation circuits such as this, the value of ΔT is derived after a series of radiation experiments on test chips representative of the final design of the FPGA logic element. Figure 2 shows a scheme for embedding single-event transient mitigation into an FPGA logic element.

SRAM memory blocks can be protected against radiation upsets by built-in error detection and correction (EDAC) encoding, which will correct any single-bit error, and detect any double-bit error. It is particularly helpful if the memory EDAC decoder circuit raises a flag if it corrects a single-bit error, and raises another flag if an uncorrectable double-bit error is detected. The probability of encountering a double-bit

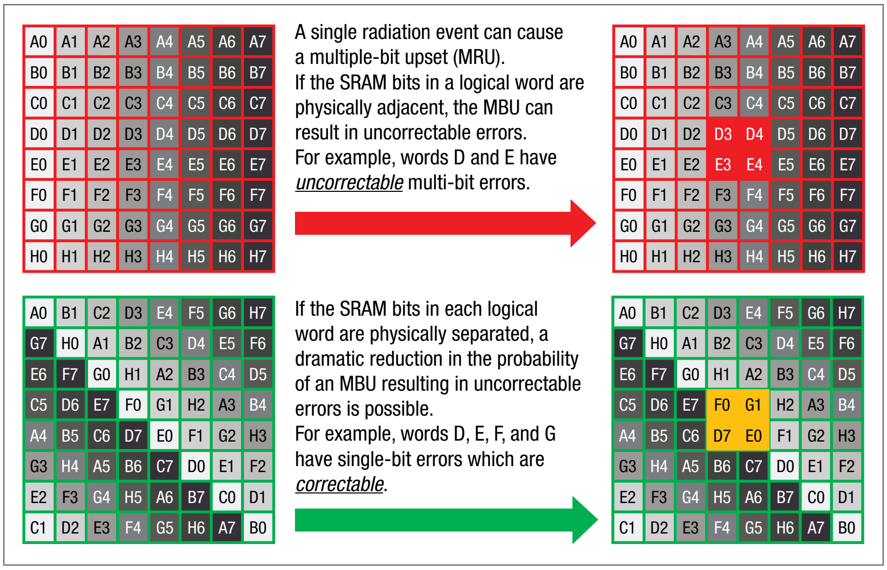


Figure 3 | Physical separation protects SRAM blocks against multiple bit upsets.

error can be dramatically reduced by the use of physical interleaving, so that logically-adjacent memory bits are physically dispersed in the FPGA. The probability of a single subatomic particle causing two upsets in the same logical word is made extremely low by the physical separation between logically adjacent bits. Figure 3 shows the use of physical separation to protect memory structures against multiple bit upsets.

Microsemi's latest family of radiation-tolerant flash-based FPGAs, the RTG4 family, features a high-performance architecture tuned for signal processing applications. Benchmark results on RTG4 indicate a signal processing performance advantage of up to 40 percent against SRAM-based radiation tolerant FPGAs on a variety of signal processing designs. The 65 nm flash process used in RTG4 is intrinsically immune to configuration upsets. These FPGAs are designed to eliminate single-event latch-ups due to radiation in space, and feature radiation protection of data in flip-flops and combinatorial logic elements, embedded SRAM cells, and multiply/accumulate blocks. Radiation testing has demonstrated that the radiation-hardening-by-design techniques are successful in providing sufficient protection for the vast majority of space missions, including 20-year geosynchronous Earth-orbiting missions.

Satellites performing remote-sensing missions face a significant signal processing bottleneck, as advances in downlink bandwidth are not keeping pace with developments in sensor resolution. As a result, satellites are required to perform more on-board processing, so that useful information – not just raw data – is transmitted to Earth. ASICs and SRAM FPGAs have significant disadvantages when used in these applications. However, modern radiation-tolerant flash-based FPGAs provide a compelling alternative, reducing program cost and schedule risk while at the same time providing the necessary mitigation of radiation effects to assure reliable operation and mission success. **MES**

__Ken O'Neill__ is Director of Marketing, Space, and Aviation, with Microsemi's SoC Products Group. He has supported FPGA applications in space, aviation, and other high-reliability markets for 25 years. O'Neill originally joined Microsemi in June 1990 as a Product Marketing Engineer and has held several marketing and field applications engineering positions. Before joining Microsemi, O'Neill served as a Design Engineer with Hewlett-Packard's Computer Peripherals Group. Prior to that, he was a Design Engineer with Racal-Comsec Ltd. O'Neill holds a bachelor's degree in electronics engineering from the University of Reading, England. Readers may reach Ken at keno@microsemi.com.

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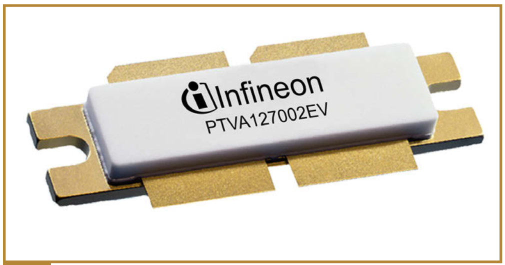


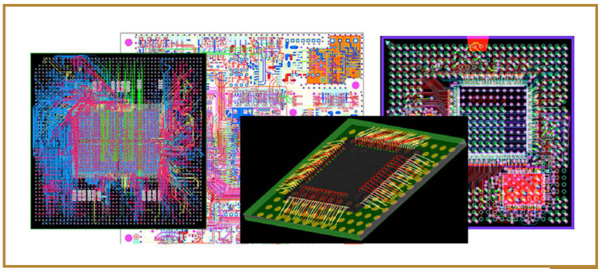
Thermally enhanced high-power RF for amplifier applications

Engineers at Infeon have designed a LDMOS field-effect transistor (FET) designed for use in radar power-amplifier applications in the 1,200 to 1,400 MHz frequency band. Dubbed PTVA127002EV, it features high gain and thermally enhanced package with bolt-down flange.

Featured on the FET are broadband input and output matching, high gain and efficiency, integrated electrostatic discharge protection, and low thermal resistance. The rugged FET is lead-free and RoHS compliant; it is also capable of withstanding a 10:1 load mismatch (all phase angles) at 700 W peak under RF pulse, 300 µS, 10 percent duty cycle. The transistor is based on a 50-V LDMOS power transistor, with a tested drain efficiency of typically 55 percent across the rated band. Voltage at the drain source tested at 105 V, with voltage at the gate source 3 to 4 V.

Infineon | www.infineon.com | www.mil-embedded.com/p372795

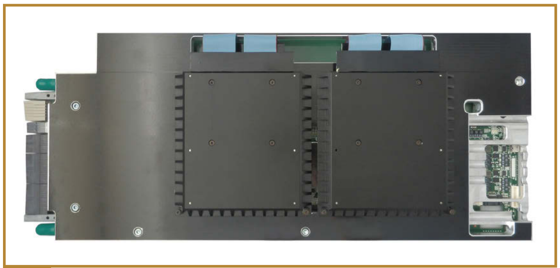
Xpedition Package Integrator aimed at codesign teams



The Xpedition Package Integrator from Mentor Graphics is aimed at enabling integrated circuit, packaging, and printed circuit board (PCB) codesign teams to visualize and optimize single or multichip packages integrating silicon on board platforms. The software, according to the maker, can reduce the cost of the entire system while enabling greater control of the design process. Its codesign methodology targets many PCB platforms automating the planning, optimization, and connectivity from a chip through multiple packaging variables. Package Integrator users can drive rule-based I/O-level optimization and perform pin- and ball-out studies from their respective domains, visualizing the impact across the complete system, and generating an automated central data library in the process. Additional features include integration platform, collaboration, model analysis and verification, physical design, and manufacturing preparation.

The physical design includes interactive and customizable multipass auto-routing controls for design challenges such as differential pair routing, net tuning, manufacturing optimization and HDI/microvia and buildup technology. This capability allows Xpedition Package Integrator to be a single layout flow for PCB, MCM, SiP, RF, hybrid, and BGA designs. The single flow – using familiar user environments – reduces design times, says Mentor, compared to other tools that use proprietary scripting languages.

Mentor Graphics | www.mentor.com | www.mil-embedded.com/p372796

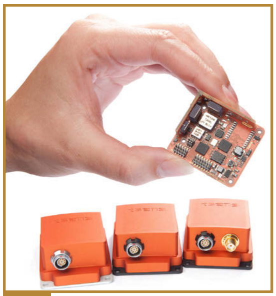


ACPU 20-10 leverages GPUs for more performance with less energy

The ACPU-20-10 is Dynatem's offering of a dual-socket soldered memory (up to 128 GB) board, with two GPGPU PCIe slots and optional FPGA. The board can be configured in different ways; for example in the high-end, high-power configuration, with a peak performance of 3.3 TFlop/s peak. The ACPU-20-10 is ideal for both datacenter and embedded usage, including such applications as high-performance computing (HPC), heavy computational loads, simulation, signal processing, and rugged HPC cooling. The ACPU-20-10 board is water-cooled to maximize the board's performance, energy efficiency, and ability to deploy in demanding environments. It has the ability to connect to a heat exchanger through Dynatem or a third party.

For applications under a restricted power budget, the company says that the board can be configured for low power, with an average power absorption of less than 100 W. The board is optionally liquid-cooled and can be used in a chassis that fits a standard 19-inch rack and can also be provided in a ruggedized version. The board can also be mounted on third-party devices.

Dynatem | www.dynatem.com | www.mil-embedded.com/p372797



Inertial sensor for unmanned system payloads

The MTi-100 series of inertial sensors is part of the motion-tracker product portfolio by Xsens that is designed for use in unmanned systems, underwater systems, or heavy industry. Company engineers have added Active Heading Stabilization (AHS) to its core sensor fusion algorithms on the MTi 10-series and MTi 100-series IMU/VRU/AHRSs. The amended harmony search algorithm is included to provide additional heading tracking accuracy. The updated series features vibration-rejecting gyroscopes and an industrial design, with the anodized aluminum housing aimed at protecting the internal components against damage. The housing is tested to meet the IP 67 water-resistant standard and is rated to withstand temporary immersion at a depth of 1 meter.

The sensors feature rugged 9-pin waterproof connectors for reliable integration in vibrating environments. The sensors also feature what the company calls smart mounting, with special alignment studs for mounting and aligning. Xsens' product line of Vertical Reference Units (MTi-20 and MTi-200), says the company, provide stabilized heading tracking, delivering 20 times less drift than pure gyroscope dead reckoning for most application scenarios. This level of accuracy means heading tracking drift as low as one degree after one hour for many applications, while remaining immune to magnetic distortions. The MTi line of products can be used when accuracy is key in robotic/indoor navigation, camera stabilization, satellite communication, directional drilling, borehole/pipeline inspection, and pedestrian navigation applications.

Xsens | www.xsens.com | www.mil-embedded.com/p372798

A power solution for space applications

VPT's SVR Series of DC-DC converters deliver a power solution for the low-Earth orbit (LEO), medium-Earth orbit (MEO), geostationary orbit (GEO), deep space, and launch programs. The SVR series is rad-hard qualified to MIL-PRF-38534 Class K on DLA SMDs, and designed for TOR compliance. Space-level characterizations include a total ionizing dose (TID) performance to 100 krad(Si), with single-event effect characterized to 85 MeV-cm^2/mg with no dropouts, shutdowns, latch up, or burnout. Performance in space of these parts is guaranteed through the use of hardened semiconductor components, radiation lot acceptance testing on non-hardened components, and analysis. All characterizations are performed according to VPT's DLA-approved RHA plan per MIL-PRF-38534, Appendix G, Level R.

Delivering 40 W from a small hermetic package, the SVRTR Series DC-DC converter is guaranteed radiation hardened including enhanced low dose rate sensitivity (ELDRS), plus it is designed for compliance with the Aerospace TOR requirements for space power systems. Additional features include (on the DLA SMD 5962R132090 single outputs of 3.3, 5, 12, and 15 V; up to 40 W output power; radiation-immune magnetic feedback circuit without the use of optoisolators; a voltage range of 18 to 37.5 V; high input transient voltage (50 V for one second); and a low output noise.

VPT, Inc. | www.vptpower.com | www.mil-embedded.com/p372799

Satellite Antenna Control Module to control satellite transmitter and receiver antennas

The Mini-Circuits H-Switch control module is designed specifically to control satellite transmit and receive antennas. The module – configured with two receive modules and one transmit module – can also be configured for other antenna options. The H-Switch control module has a self-contained 10-MHz rubidium clock with lock detect, operates on a 24 VDC supply, and comes contained in a 3.5 by 19 by 20-inch rack-mountable case. All RF connections are PDK-style multi-connector, while all control lines are D sub connectors. BNC front-panel test ports are available for transmit and receive paths.

For the receive paths, the antenna switch features two receive modules, each capable of handling two "L" band input signals, with each of these signals able to be cross-coupled via internal switching. Both of the "L" band paths have separate digital attenuators programmed using a front panel control with attenuation readouts. Moreover, says Mini-Circuits, each L band path contains separate gain blocks and outputs to drive various modems or beacon receivers. Internal switching enables the user to select the active receive path to the system modems.

Mini-Circuits | www.minicircuits.com | www.mil-embedded.com/p372800

DoD's new cyberstrategy includes academia partnering

By Sally Cole, Senior Editor

The U.S. Department of Defense (DoD) operates the world's largest network – a diffuse patchwork of thousands of networks – and, as you can imagine, it's a giant target for state-sponsored and other malicious cyberattackers. One of the biggest factors enabling cyberspace attacks is the fact that security simply wasn't factored in when the Internet was designed. It was intended to serve as an open system to allow scientists and researchers around the world to connect and share data quickly and easily, which it does, but at the same time it creates an Internet-security "Achilles' heel" that allows attackers to do the same.

As U.S. Secretary of Defense Ash Carter spelled out during an April speech at Stanford University, the extent of our reliance upon technology without adequate security equates to real vulnerabilities that "adversaries are eagerly exploiting."

In a move to tackle the overall lack of visibility that comes with operating an enormous patchwork of networks, as well as to improve its defense against the relentless onslaught of attacks, DoD has come up with a new multifaceted strategy that includes working with academia and industry. The DoD's new cyberstrategy centers on "deterrence by denial" by building a single security architecture for its widely dispersed networks, while also putting what it calls "offensive" options on the table.

Of the three key goals of this strategy, as outlined by Carter, the first is "defending our own networks and weapons because they're critical in what we do every day … and they're no good if they've been hacked." The second goal is to "help defend the nation against cyberattacks from abroad – especially if it would cause loss of life, property destruction, or significant foreign policy and economic consequences," he added. The third goal is to "provide offensive cyberoptions that, if directed by the president, can augment our other military systems."

During future conflicts, DoD presumes that adversaries will target U.S. or allied critical infrastructure to gain strategic advantages. DoD's 2015 cyberstrategy calls these types of disruptive, manipulative, or destructive cyberattacks "a significant risk to U.S. economic and national security." Beyond its own networks, DoD relies on civil critical infrastructure across the U.S. and overseas for its operations, "yet the cybersecurity of such critical infrastructure is uncertain."

With disruptive and destructive attacks viewed as a real threat on the horizon, DoD's new strategy encourages U.S. government agencies, companies, and organizations to "carefully prioritize the systems and data they need to protect, assess risks and hazards, and make prudent investments in cybersecurity and cyberdefense capabilities to achieve their security goals and objectives." Beyond these defense investments, DoD recommends that all organizations build business continuity plans and be prepared to operate within a degraded cyberenvironment.

Another crucial aspect of DoD's strategy is to re-establish close ties with academia and the tech industry. "We want to partner with businesses on everything from autonomy to robotics to biomedical engineering; from power, energy, and propulsion to distributed systems, data science, and the Internet of Things," explained Carter in his speech, "because if we're going to leverage these technologies to defend our country and help make a better world, DoD cannot do everything in all these areas alone. And the same is true with cybersecurity – we have to work together on this one."

Cyberthreats against U.S. interests are increasing in severity and sophistication, Carter noted, and it's a problem the entire country faces, not just DoD. "Networks nationwide are scanned millions of times a day," he said.

Nation-states – most notably Russia, China, and Iran – have "advanced cybercapabilities and strategies ranging from stealthy network penetration to intellectual property theft," Carter pointed out, but criminal and terrorist networks are also ramping up their cyberoperations. "Low-cost and global proliferation of malware has lowered barriers to entry and made it easier for smaller malicious actors to strike in cyberspace. We're also seeing blended state and nonstate threats in cyber … which complicates potential responses for us and for others."

To better defend DoD information networks, the goal is to adopt deterrence by denial by building a single security architecture that's more easily defendable, while remaining flexible enough to adapt and evolve to mitigate any threats. This single point will replace the myriad of networks currently operated by DoD.

DoD needs to "strengthen our network defense command and control to synchronize across thousands of these disparate networks and conduct exercises in resiliency … so that if a cyberattack degrades our usual capabilities, we can still mobilize, deploy, and operate our forces in other domains – air, land, and sea – despite the attack," Carter said.

Themis high-density computing Q & A

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

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

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

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

How do Themis HD solutions address DoD requirements?

Themis HD servers deliver increased capability while allowing systems to be built up of standard, modular, lightweight, rack-mount components. Combined with a network switch and a transit case, a complete server solution can be deployed to any service region required. Available in a 2RU (four bay) or 3RU (six bay) chassis, RES-HD servers provide maximum system configuration flexibility and functionality with hot pluggable processor, storage, high-speed switch, and system management module options. Combining leading-edge components that include Intel® Xeon® E5-2600 v3 Series processors and SuperMicro motherboards, up to 256 GB of memory, dual GbE ports, and a single PCIe slot, RES HD modules feature expansion slots, extensive high-speed front or rear I/O, storage, and enhanced reliability options. Themis HD systems are modular. A 2RU Chassis can host up to one HDS8 module plus two HDS8 Storage Expansion modules (2.5 inch SSD or HDD drives) for a total of 24 drives (including eight drives in HDS8 Storage module) or 48 TB. A 3RU Chassis can host one HDS8 module plus four HDS8 Storage Expansion modules for a total of 40 drives (including eight drives in HDS8 Storage module) or 80 TB.

Themis 3RU Chassis populated with one HDS8 module plus four HDS8 Storage Expansion modules provides a total of 40 drives (including eight drives in HDS8 Storage module) or 80 TB.

Themis 2RU RES-HD System

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

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

Do HD designs enable regular technology refresh or technology insertion?

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

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

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

THEMIS

Themis Computer
www.themis.com/hd

CONNECTING WITH MIL EMBEDDED

By Mil-Embedded.com Editorial Staff

CHARITY

The Intrepid Fallen Heroes Fund

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

This month we're featuring The Intrepid Fallen Heroes Fund (IFHF), an independent not-for-profit organization that supports the families of military personnel who have lost their lives in service to the U.S. and serves severely wounded military personnel and veterans. Originally established in 1982 by the founders of the Intrepid Air, Sea, and Space Museum and the Fisher House Foundation, the organization's mission has expanded, to where its efforts are now totally funded with donations from the public.

To date, the IFHF has supported families, service members, and veterans with close to $150 million in benefits. From 2000 to 2005 the IFHF donated nearly $20 million to families of U.S. and British military lost in service to their nations, mostly in Iraq and Afghanistan. Because of 2005 federal legislation that substantially increased the benefits granted to those families, the IFHF has redirected that support toward service members who have been grievously injured.

The Fund administers the Center for the Intrepid, a $55 million physical-rehabilitation facility at Brooke Army Medical Center in San Antonio, Texas, which aids severely injured military personnel and veterans. Also under the umbrella of the IFHF is the National Intrepid Center of Excellence (NICoE), which is a 72,000-square-foot facility – located next to the new Walter Reed National Military Medical Center in Bethesda, Maryland – dedicated to the treatment of traumatic brain injury suffered by service members and veterans.

The IFHF is now in the midst of building nine "Intrepid Spirit" centers at military bases around the country, aimed at extending the reach of the NICoE to more troops. The first three centers – at Fort Belvoir, Virginia; Camp Lejeune, North Carolina; and Fort Campbell, Kentucky – are operational, with the fourth and fifth Intrepid Spirit Centers under construction.

For more information, visit www.fallenheroesfund.org.

WHITE PAPER

Preintegrated systems meet expanding defense system needs

By Kontron AG

Build or buy? Developers want a fully tested, cost-effective design that allows them to meet expanding system requirements while accelerating the development-to-deployment schedule. In this white paper, learn how Kontron's family of COBALT embedded computers can offer a modular building-block solution with the integration of established system profiles.

By using a pre-integrated system, designers can choose from a proven alternative to building the system from scratch in a ready-to-use, rugged enclosure. In addition, pre-integrated systems' configurations include known, established profiles: removable storage, situational awareness, and switch-stacked/server. By using a trusted platform that leverages carrier-board attributes and mezzanine-option flexibility, designers can significantly reduce development resources.

Read the white paper:
http://mil-embedded.com/white-papers/white-vs-buy-dilemma/

More white papers: http://whitepapers.opensystemsmedia.com/