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October 2012
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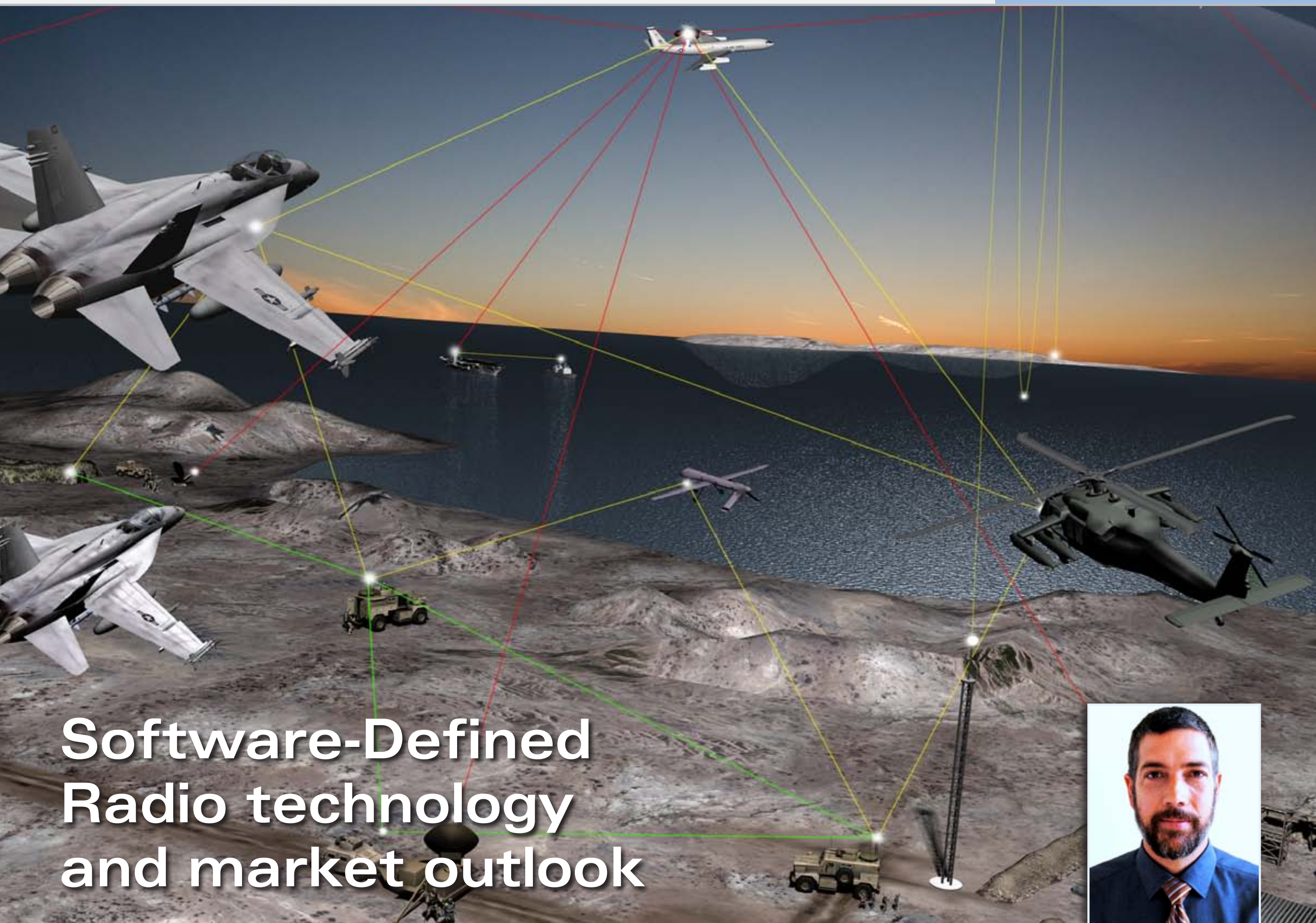

Software-Defined Radio technology and market outlook

Military simulation demands high-end realism

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ON THE COVER:

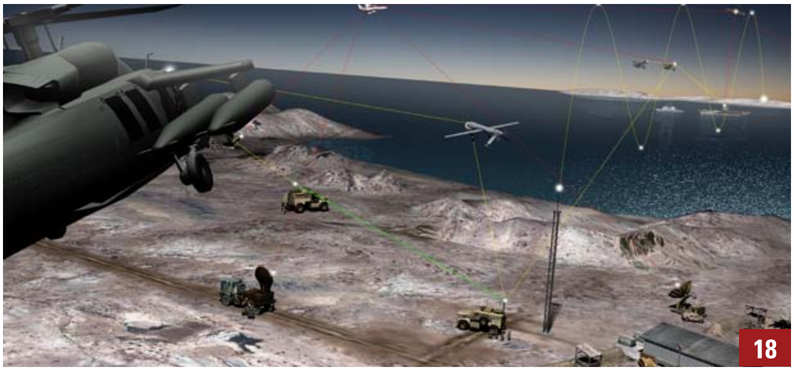
Top photo: This graphic depicts the capability of Software-Defined Radios (SDRs), which deliver secure, real-time communication capability for multiple platforms in the air, on the ground, or at sea. Photo courtesy of Rockwell Collins

Bottom Art: Military simulation today provides realism, enabling warfighters to train for specific missions with multiple scenarios such as this combat simulation from CAE that involves ground and air units.

October 2012 | Volume 8 | Number 7

COLUMNS

DEPARTMENTS



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Celebrating 28+ Years of Success

Radio technology trends and NDIs

By John McHale, Editorial Director

An article I wrote years ago on Software-Defined Radio (SDR) technology said SDR was "here, there, and everywhere." Well it seems it finally is everywhere. SDR is well beyond the Joint Tactical Radio System (JTRS) program and everywhere from the warfighter's hands to high-speed railway transportation to public safety applications.

The JTRS program itself has evolved quite a bit over the years, and it is debatable how successful it was as an acquisition model – especially after considering the multiple delays and high cost of development. However, as a result of the program, warfighters are getting radios that are compatible with traditional waveforms like Single Channel Ground and Airborne Radio System (SINCGARS) and new ones like the Soldier Radio Waveform (SRW) to enable video, data, and voice communications.

"It is important to remember that JTRS is not the equivalent of SDR. JTRS is a program and SDR exists independent of that program," says Lee Pucker, CEO of the Wireless Innovation Forum. "I personally think there have been a lot of successes coming out of JTRS. A lot of technology has been developed that would not have been developed without JTRS. I cannot say for a fact that the adoption of SDR technology worked in defense communications because of the leading position the JTRS program took. Maybe if JTRS had not been around maybe another would have taken on that role, but the JTRS program is the one that did." For more from Pucker on SDR, see his article in the Special Report section on page 22, cowritten by David Renaudeau of Thales.

"An article I wrote years ago on Software-Defined Radio (SDR) technology said SDR was 'here, there, and everywhere.' Well it seems it finally is everywhere."

We probably won't see another long-term development program like JTRS any time soon. Today's budget pressures and the reluctance of the Department of Defense to fund any type of research and development effort might quickly make the JTRS acquisition concept a thing of the past. From here on, procurement through Non-Developmental Items (NDIs) will be the norm. Capability sought from the now-canceled JTRS Ground Mobile Radio (GMR) segment is being procured as an NDI: the Mid-Tier Networking Vehicular Radio (MNVR).

"There are multiple defense industry participants that have the capability and services the government needs. Therefore, instead of funding a five-year program, they can leverage work that already has been done on a broader scale," says Troy Brunk, Senior Director, Airborne Communication Products at Rockwell Collins in Cedar Rapids, IA. "This also helps them better navigate the budget constraints everyone is going to face across the industry. It does not matter whether or not there is a program of record with NDI; it is about the ability to take technological capabilities and have them available across platforms in terms of funding and support."

In this edition's Special Report on SDR on page 18, Manuel Uhm, Chair of the User Requirements Committee of the Wireless Innovation Forum, says, "SDR is now considered to be largely a solved problem … and JTRS is essentially now a production program with very little funding for research and development." He says cognitive radio is the next big technology problem being solved for not only military but commercial applications as well.

SDR technology will be used as the backbone for developing cognitive radio, which is radio in which communication systems "are aware of their internal state and environment … and can make decisions about their radio operating behavior by mapping that information against predefined objectives," according to the Wireless Innovation Forum website (www.wirelessinnovation.org).

General Dynamics C4 Systems engineers are currently investigating a cognitive radio capability that would enable the identification of possible radio and sensor jamming threats without affecting "friendly signals," says a company representative. They are also working on the intelligence of cognitive radio. For example, your smartphone could sense where you are by automatically and continuously checking the availability of radio spectrum in the area. It plans how your call or access to the Internet will be fastest, the best quality, and with the least amount of power necessary, she adds.

"We are doing and have been engaged for a while with early algorithms and concept demonstrations for cognitive radio fundamentals and spectrum intelligence gathering via SDR radios," Brunk says. "We also are looking at other capabilities we can engage through advanced networking waveforms. Most of the work being done in this area [is] either sensitive or classified, so there is not a lot of disclosed information available. Cognitive radio capability will take time to develop and mature as a technology – think about how long we've taken to mature SDR."

John McHale
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Game changer in signal processing

By Charlotte Adams

A GE Intelligent Platforms perspective on embedded military electronics trends

Situational awareness is key on the battlefield. Today's sensors can pack hundreds of imagers on a platform and provide 360-degree coverage. But how can that ocean of data be sifted for relevant information within tactical timelines?

Enter the Graphics Processing Unit (GPU). This specialized silicon combines large numbers of arithmetic logic units that can execute thousands of fairly simple math instructions simultaneously and repetitively. This feat is essential for tasks like wide area sensing in real time.

Although spawned by the $80 billion video gaming industry, GPUs play a vital role in advanced signal processing applications, where they are used to deconstruct masses of real-world, 3D data into targets and threats rather than to render an imaginary 3D world on a computer screen.

These sensor processing applications are known as General-Purpose computing on Graphics Processing Units (GPGPUs) because they involve math operations that traditionally would have required a Central Processing Unit (CPU). While CPUs are still necessary in GPGPU applications to set up a transaction between a sensor back-end and the GPU, and to retrieve the GPU's final result, the graphics processor is key. Today's GPU architectures – with their scale, memory techniques, and power efficiency – make it possible to execute large-scale sensor processing tasks at a rate that would be impractical for conventional processors.

GPUs are all about data reduction. In an image processing system, for example, a GPU or GPUs might take sensor data at a rate of 1 GBps and boil that down to a couple of targets. These components are found in GPGPU applications such as target recognition, ground moving target indication, and Synthetic Aperture Radar (SAR).

How they do it

One GPU architecture on the market today is Kepler, designed by NVIDIA for the video game market. Although the Kepler family currently scales up to 1,344 cores, embedded applications use GPUs that burn less power. The GK107, for example, features 384 cores and burns only 50 W with a power efficiency of about 15 GFLOPS per watt.

These masses of relatively simple cores are orchestrated internally by core aggregates called Streaming Multiprocessors (SMPs). The GK107 chip, for example, features two 192-core SMPs. Sharing cache and registers, the SMPs work together on a similar task. SMPs solve the challenging problem of keeping all of the cores busy all of the time by assuming the scheduling function and telling the cores what to do.

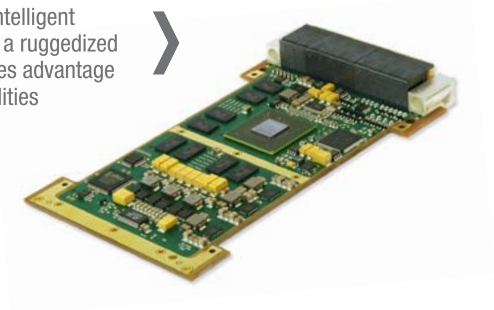

Figure 1 | The GE Intelligent Platforms GRA112 is a ruggedized 3U VPX card that takes advantage of the GPGPU capabilities of NVIDIA's Kepler technology.

But the SMPs are crucially aided in this task by GPUDirect, a new Direct Memory Access (DMA) technology that allows applications to stream digitized sensor data directly to the GPU. Previously all this data first had to go into CPU memory. Then the GPU would copy it back from CPU memory. This chokepoint meant that you couldn't get the data into the GPU fast enough.

A revolutionary mil/aero Kepler implementation, and the flagship of a larger family, is GE Intelligent Platforms' GRA112 – a ruggedized 3U VPX card that will use individually soldered NVIDIA subcomponents, a unique advantage that allows developers to maximize ruggedization and cooling performance (Figure 1).

Secret weapon

Kepler uses NVIDIA's Compute Unified Device Architecture (CUDA), a parallel computing model that enables programmers to easily access GPU cores' resources and map a sensor processing task onto the parallel platform. Using the CUDA model, a software developer can create an application that launches millions of threads, each corresponding, say, to a single pixel in a sensor image. Each core can multiplex between up to four threads at a time, so that hundreds of threads execute simultaneously.

The result is that GPUs outperform CPUs in compute-intensive sensor applications that can exploit the GPUs' parallelism. A SAR task, for example, can run 225 times faster on a GPU than on a CPU implementation. Tasks that took minutes can be executed in milliseconds.

A further advantage of Kepler's GPUDirect technology, compared to the DMA function in earlier architectures, is that it's free and open and doesn't require any special code to use. GPUDirect is supported in NVIDIA's standard CUDA programming environment available from their developer website. NVIDIA GPUs are also backward-compatible, so that older applications will run faster on newer chips.

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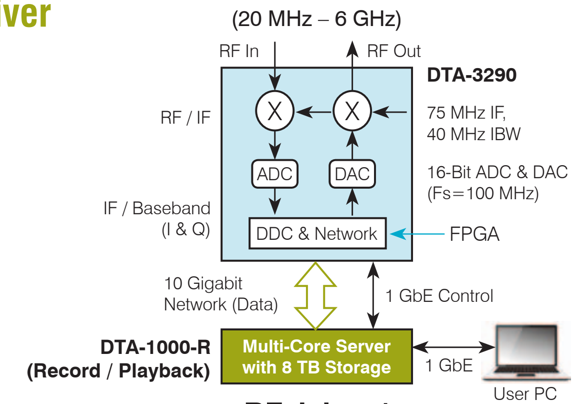

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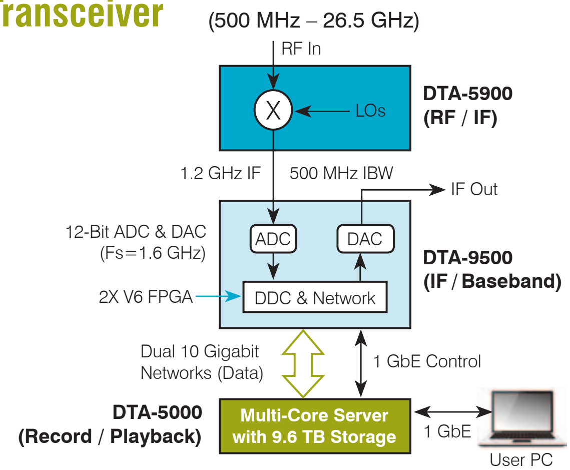

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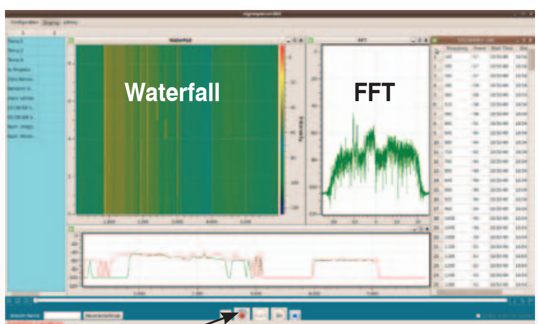

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Embedded COTS drives advances in military training systems

By Curtis Reichenfeld
An industry perspective from Curtiss-Wright Controls Defense Solutions

Embedded COTS technology is helping to transform military training systems. Open architecture 3U small form factor processing is making it possible to deploy high-performance simulation/emulation systems in SWaP-constrained platforms such as training aircraft. And advances in data storage and Video Management Systems (VMSs) are driving improvements in capturing and archiving – and the ability to later review and analyze – video and sensor data from real-world missions and training sessions in ground vehicles and aircraft.

Another boon for embedded training systems is advances in high-density Solid State Drives (SSDs) with higher capacities, faster speeds, increased modularity, and additional functionality such as encryption. These SSDs are easily removed from the deployed training platform for near-instant review of the just completed mission on a desktop PC. Meanwhile, advanced VMSs are able to support the greater number of cameras onboard today's vehicles and route the multiple inputs to mass storage systems to ensure that all critical mission data is available for review and analysis.

One example of a leading-edge embedded COTS-based training system is Pilatus Aircraft's Pilatus PC-21 trainer. Using an onboard rugged 3U small form factor-based open architecture subsystem from Curtiss-Wright Controls, this next-generation turboprop trainer provides an exceptional level of advanced technology, configuration flexibility, and life-cycle cost savings compared to the expense of using an actual jet for training. Its embedded processors simulate the console and controls of any jet aircraft for which the student needs training. This enables intensive core competency training, including elements such as radar proficiency, to take place on the P-21. The ability to integrate high-performance computer power in a small, lightweight mission computer also enables the PC-21 to perform sophisticated radar system emulation (Figure 1). The P-21 supports embedded simulation of air-to-air and air-to-ground radar, by emulating, for example, an F/A-18 or other jet's cockpit and radar. This eliminates the cost, weight, maintenance, and safety issues associated with using an actual radar system.

Solid state memory is portable, more rugged than rotating disks

SSD memory, inherently more rugged than spinning disk-based hard drives, continues to provide ever larger amounts of storage, making it increasingly more practical and attractive for use in training systems. SSD systems, such as the SANbric storage system, are made more rugged by use of a shock isolation system. Ideal for SWaP-constrained platforms, such SSD storage systems can provide up to 4.8 TB of solid state memory, while reducing memory system weight up to 5 lbs. compared to comparable capacity rotating disk-based configurations. When combined with a high-performance data recorder board, SSD memory storage can provide rugged, high-capacity, secure storage for archival and analysis of critical data.

Figure 1 | The ability to integrate high-performance computer power in a small, lightweight mission computer enables the Pilatus PC-21 to perform sophisticated radar system emulation.

High capacity and security

To ensure that mission data doesn't fall into the wrong hands, it's now possible for designers of embedded training systems to specify the use of high-capacity, rugged SSDs that meet the most cryptographic standards. New 3U VPX solid state memory cards have undergone the stringent Federal Information Processing Standard (FIPS) 140-2 Level 2 cryptographic validation at the National Institute of Standards and Technology (NIST). These small form factor cards are ideal, integrating secure data storage in deployed military training systems that require the integrity of "data at rest." This is often desired in demanding military environments such as those endured by helicopters, UAVs, and radar systems. These cards support 1 TB of SLC NAND flash memory and can be configured as a JBOD or RAID. Security of critical data is provided with NIST-certified 256-bit AES data encryption.

More cameras, more data

Training is also becoming increasingly dependent on video and display imagery. Today's COTS VMSs handle up to 18 video inputs (HD-SDI, RGB, DVI, and so on) and up to 12 video outputs for viewing, compression, recording, or distribution over a standard Ethernet network. Real-time HD video compression ensures that no critical data is lost and that it can be more easily shared and reviewed for effective training.

COTS drives improved, more cost-effective training

As embedded training systems are becoming more sophisticated, higher-end COTS equipment is enabling designers to implement complicated training scenarios. It is also providing our warfighters with the best in vehicle training and readiness levels while reducing overall training costs.

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NASA's Curiosity Rover
Developed with Wind River Workbench and built on VxWorks RTOS
Image courtesy NASA/JPL-Caltech

What use are test tools for applications based on software reuse?

By Mark Pitchford

When it comes to military software technology development, the software development paradigm is very different from that of, say, automotive technologies. In military technology, duplicate applications and systems are the exception, not the rule. Yet, if there were a way to adapt software test processes to maximize code reuse in military applications, the certification process could be simplified and the software could be reused effectively, making development faster and more economical. Even better, it has the potential to bring the benefits of increased confidence through use of software modules already qualified for a previous application, rather than on the basis of the sheer weight of numbers of a family sedan's production run.

A look back influences the future

Although the aforementioned approach has merit, issues remain. For instance, it assumes that when we set out to reuse source code, the code is sound because the application has been proven in the field. But what if some of the new functionality builds on paths through the code that in practice were rarely or never exercised? Even well proven code is likely to now be handling very different data. How will it behave?

Dipping into the toolbox of modern software testing tools can help to answer these questions and ensure that code is robust, despite the varying demands of an endless series of different applications.

Anyone who has read of the Ariane 5 failure on June 4, 1996 knows the dangers inherent in any false assumptions. Ariane 5 failed because of a software exception raised in the Inertial Reference System – even though the design was almost exactly the same as that used successfully on the Ariane 4, particularly in the case of the software [1].

If the Ariane 4 Inertial Reference System source code had been subject to structural coverage analysis, all the relevant paths through the code would have been proven to behave in a robust manner. The use of appropriate boundary cases to show robustness *in extremis* would have shown there to be an unprotected data conversion from 64-bit floating point to a 16-bit signed integer value. At the time, that would probably have appeared pedantic and irrelevant from a developer's perspective – something that could never cause a problem with the Ariane 4. But it was relevant to the Ariane 5.

> *"If the Ariane 4 Inertial Reference System source code had been subject to structural coverage analysis, all the relevant paths through the code would have been proven to behave in a robust manner. The use of appropriate boundary cases to show robustness in extremis would have shown there to be an unprotected data conversion from 64-bit floating point to a 16-bit signed integer value. "*

Fast forward to structural coverage analysis

Move on 16 years and these structural coverage analysis principles have been embraced by the best test tool suites not only in dynamic analysis, but they have also been automated across the entire scope of software development. Requirements traceability tools, for example, provide a traceability matrix that is permanently up to date and relevant throughout the application's development life cycle.

Where a new custom application is being developed from an existing one, tools can alert developers when source code can potentially be affected by the revised requirements. In Ariane 5's case, such a capability could have highlighted the need to retest the Inertial Reference System. It might even have had relevance at the design phase, when it could have allowed a comparison of the overhead implied by different approaches to meeting each revised requirement.

Static analysis tools not only confirm that source code meets the coding standards in force at the time of writing, but they can also analyze the code from the perspective of a revised standard at the time of reuse. Dynamic testing proves the capability of reused code *in extremis* at the time of writing, and facilitates automated regression testing to show that any enhancements for the latest project have not compromised the previously proven functional capability and robustness.

Test tools and software reuse – the perfect match

Test tools are useful for far more than custom developments, but as these examples show, the customer environment is arguably the one to which they bring the biggest quality assurance benefits.

Reference:

1. www.di.unito.it/~damiani/ariane5rep.html "Ariane 5 Flight 501 Failure – Report by the Inquiry board"

***Mark Pitchford** is a Field Applications Engineer with LDRA Ltd. and has more than 25 years' experience in software development, working in industrial and commercial project development and management in the UK and internationally.*

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By Sharon Hess, Managing Editor

NEWS | TRENDS | DoD SPENDS

Raytheon/Navy contract mod benefits SSDS

SSDS MK1, SSDS MK2, and CVN 78 are poised to benefit from a recent $22 million U.S. Navy/Raytheon Co., Integrated Defense Systems contract modification for “Fiscal 2012 Ship Self Defense System (SSDS) Platform Systems Engineering Agent efforts,” according to the DoD website. Specifically, the modification provides for continued funding for tech refresh efforts for SSDS MK1, in addition to development and test for SSDS MK2 to ride aboard CVN 78 (Figure 1). Ninety percent of the work occurs in San Diego, CA, while Portsmouth, RI and Tewksbury, MA both host another 5 percent of the efforts. The contracting activity is the Naval Sea Systems Command in Washington, D.C., and work completion is anticipated by August 2013. Meanwhile, SSDS defends certain amphibious ships and aircraft carriers against cruise missile attacks. It does this “by integrating existing and programmed anti-air warfare stand-alone defensive systems, and providing an automated quick response and multitarget engagement capability … in the littoral environment,” according to the DoD.

Figure 1 | SSDS MK1, SSDS MK2, and CVN 78 are poised to benefit from a recent $22 million U.S. Navy/Raytheon Co. contract modification. This CVN 78 conceptual rendering is courtesy of the U.S. Navy and Northrop Grumman Newport News Shipbuilding

General Atomics boosts Army’s ground ops

The U.S. Army’s ground operations are going to get an efficiency boost, per the two contracts the U.S. Army and General Atomics Aeronautical Systems Inc. penned in one day. The first contract totals nearly $26 million, providing a platoon set of ground equipment. Work is expected to be completed in June 2015, in Poway, CA. The second contract stipulates that General Atomics aids in the Army’s procurement of universal ground data terminals. Work is again slated in Poway, CA, but with an expected fulfillment in April 2014. For both contracts, the contracting activity is the U.S. Army Contracting Command in Redstone Arsenal, AL.

JAGM seeker development: To be continued …

Lockheed Martin Corp. will continue developing technology for the U.S. Army’s Joint Air-to-Ground Missile (JAGM) Seeker/Guidance Unit, as specified in a recent $32 million contract. Work will occur in Orlando, FL, and completion is expected in November 2014. The contracting activity is the U.S. Army Contracting Command in Redstone Arsenal, AL. JAGM weighs 108 lbs. and resides in the MH-60R Seahawk, AH-64D Apache, MQ-1C Gray Eagle UAS, AH-1Z Cobra, F/A-18 E/F Super Hornet, and OH-58 CASUP Kiowa Warrior. It can passively or actively engage moving or stationary targets any time of the night or day, regardless of obscurants, harsh environmental conditions, or countermeasures; these capabilities make JAGM effective against multiple targets. Its point-designation engagement modes mean wide target sets can be struck by a single missile. Specific target sets for JAGM include radar sites, patrol craft, air defense units, C2 nodes, artillery, bunkers, launchers, and more.

Boeing to fulfill Navy’s F/A-18E/F order

The U.S. Navy recently awarded The Boeing Co. a $19 million delivery order for F/A-18E/F efforts related to an existing basic ordering agreement referred to on the DoD website as “Engineering Change Proposal 6253R1, Distributed Targeting System, Low Rate Initial Production 2” (Figure 2). The order calls for the delivery of 20 spare bulk data cartridge units, 64 “B” kits, and 113 “A” kits, with order fulfillment anticipated by October 2014. The bulk of the order’s work transpires in Melbourne, FL (75 percent), with another 21 percent occurring in St. Louis, MO; 1.5 percent in Muskegon, MI; and the remaining 2.5 percent at several unnamed U.S. locales. The contracting activity is the Naval Air Systems Command in Patuxent River, MD.

Figure 2 | The U.S. Navy recently awarded The Boeing Co. a $19 million delivery order for F/A-18E/F efforts including delivery of 20 spare bulk data cartridge units, 64 “B” kits, and 113 “A” kits. U.S. Navy photo by Photographer’s Mate 2nd Class Mark A. Ebert

More Bradley maintenance occurs in Kuwait

The U.S. Army recently awarded BAE Systems Land and Armament L.P. a $14 million contract for Bradley vehicle maintenance services (Figure 3). The contract's work transpires in Kuwait, anticipated for completion in February 2013. The contracting activity is the U.S. Army Contracting Command in Rock Island, IL. Meanwhile, Bradley vehicles, first deployed in 1981, perform cavalry scout missions; defeat enemy tanks, infantry fighting vehicles, reconnaissance vehicles, attack helicopters, bunkers, and dismounted infantry; and provide protected transport. The M2 version is the infantry version, used to close in on enemies via maneuver and fire. The M3 version is the cavalry version, used as part of a squadron or troop for flank guard, security, and reconnaissance missions. Tipping the scales at 67,0000 lbs. when loaded for combat (or 50,000 lbs. unloaded), Bradley M2A3 and M3A3 vehicles have a cruising range of 250 miles.

Figure 3 | Bradley vehicle maintenance will take place in Kuwait, anticipated through February 2013, per a recent U.S. Army/BAE Systems $14 million contract. Bradley fighting vehicle photo courtesy of U.S. Army (www.army.mil)

Navy preps for USS Abraham Lincoln overhaul

The USS Abraham Lincoln's (CVN 72's) refueling complex and reactor plants will soon be overhauled, thanks to some more advance planning efforts secured by a recent $22 million U.S. Navy/Huntington Ingalls Inc. contract modification. The modification provides for ship checks, documentation, design, engineering, and preliminary support facility or shipyard labor, along with procurement and fabrication. All the modification's efforts go toward the overhaul, in addition to the refueling, routine work, and modernization of the ship as well as its reactor plants. Work occurs in Newport News, VA by February 2013. The contracting activity is the Naval Sea Systems Command in Washington, D.C.

Figure 4 | A $29 million C-20 Contractor Logistics Support contract modification has Northrop Grumman Technical Services, Inc. providing six months of support to C-20s in fiscal year 2013. U.S. Air Force photo by Airman 1st class Kenny Holston

USAF's C-20 gets more support

The venerable C-20 turbofan, twin-engine aircraft will gain six months of services from Northrop Grumman Technical Services, Inc. in fiscal year 2013, per a USAF-exercised contract modification option under the C-20 Contractor Logistics Support contract (Figure 4). The $29 million modification's efforts comprise flight line maintenance, contractor-maintained and -operated base supply, depot maintenance, and field team support. Services extend through March 30, 2013 under the modification, which was contracted by Tinker Air Force Base in Oklahoma. Built for airlift missions, the first C-20 (a C-20B) was deployed in 1988, and the USAF currently has five C-20Bs and two C-20Hs on active duty.

Scan Eagle UAS to see more in real time

Keeping up with the UAV/UAS trend, the U.S. Navy recently put pen to paper with Insitu, Inc. for a $23 million contract modification calling for more maintenance and operational services for the Scan Eagle UAS (Figure 5). Specifically, the modification stipulates that Insitu renders mid-wave IR and EO/IR imagery in real time, supporting Operation Enduring Freedom's ground operations. Modification labor is slated for completion in Bingen, WA by August 2013. The contracting activity is the Naval Air Systems Command in Patuxent River, MD.

Figure 5 | A U.S. Navy/Insitu, Inc. $23 million contract modification calls for more maintenance and operational services for the Scan Eagle UAS. U.S. Navy photo by Mass Communication Specialist 3rd Class Lauren G. Randall

The SDR technology evolution continues

By John McHale, Editorial Director

The Software-Defined Radio (SDR) concept is now a mature technology enabling radio functions to be defined in warfighters' radios across the globe, not just in large government programs such as the Joint Tactical Radio System (JTRS).

This graphic depicts the capability of Software-Defined Radios (SDRs), which deliver secure, real-time communication capability for multiple platforms in the air, on the ground, or at sea. Photo courtesy of Rockwell Collins

Software-Defined Radio (SDR), a concept that first deployed with the General Dynamics Digital Modular Radio (DMR) system to the Navy in 1998, has become the *de facto* enabler of current and upcoming military radio designs. The ability to define radio functionality in software has enabled radio systems that can work with decades-old waveforms and new ones like the Soldier Radio Waveform (SRW). Many SDRs are already fielded by companies such as Harris RF in Melbourne, FL, while JTRS radios have entered full production. Future innovations will come from waveform and system developments.

"SDR technology continues to evolve," says Lee Pucker, CEO of the Wireless Innovation Forum. "The SDR evolution occurred over the last decade, making it easier for radio manufacturers out there to do their jobs, getting new products deployed faster and enabling them to upgrade their radios while in the field. They just have to reprogram the functionality for new features. This solves big problems from the operational user and manufacturer perspectives."

"We commissioned a study last year to size the market for SDR technology," says Manuel Uhm, Vice President of Sales and Marketing at Coherent Logic and Chair of the User Requirements Committee of the Wireless Innovation Forum. "The study was done by an independent research firm, Mobile Experts. SDR technology is now prevalent in mobile terminals, mobile infrastructure, and public safety communications, as well as military communications."

"The study shows pretty much every military radio has some form of SDR technology in it that's been built in the last few years," Pucker says. "SDR is pervasive everywhere. Our study found almost every commercial basestation uses SDR technology: 95 percent. For commercial handsets it is a different story, as they are disposable with only 50 percent using SDR."

What's next for SDR?

"Obviously the trends are toward smaller, lighter, and faster devices. Our customers demand bigger bit pipes to get more capability yet still be interoperable with their narrowband legacy equipment," says Matt Nearpass, International Product Line Manager at Harris. "Next-generation radios still need the capability to work with waveforms that date back to pre-Vietnam and all the way up to the latest wideband waveforms. Generally the lifespan of a family of radios is about 15 to 20 years. We're delivering additional capability on the same platforms because of SDR. It gives customers an insurance policy on the hardware platform they bought. We have to look ahead when developing radio platforms because not every waveform that will be used currently exists."

One of the most popular SDR-capable systems from Harris is their Falcon III AN/PRC-117G radio, which is designed to host government waveforms. "It has a JTRS-SCA and is NSA Type 1 certified for information security," Nearpass says. "The Falcon III leverages the SCA operating environment. We leverage the radios with SCA as an operating environment for international customers. It is the SDR nature of the radio that we're utilizing, which makes it easy to roll out upgrades and new features.

"For SDR on the front end, the initial list of waveforms still remains the same – SRW, Wideband Networking Waveform (WNW), the Mobile User Objective System (MUOS), Tactical Targeting Network Technology (TTNT) – with not

Figure 1 | The Rockwell Collins ARC-210 Gen5 radios use a Multi-Waveform Architecture, which is an optimized Software Communications Architecture (SCA).

a lot changing or developing," says Troy Brunk, Senior Director, Airborne Communication Products at Rockwell Collins in Cedar Rapids, IA. "The focus is on migrating those waveforms across a broader portfolio of products for all services – ground soldier platforms, air, and sea. The Rockwell Collins ARC-210 Gen5 radios use a Multi-Waveform Architecture – an optimized Software Communications Architecture (SCA) – and have the capability to host waveforms such as SRW and the MUOS (Figure 1).

"We also produce SDR technology internationally with a product called FlexNet." Rockwell Collins fielded an SCA-compliant variant of that radio with a different security architecture. The JTRS waveforms were not exploitable, but the same basic protocols were developed to work with international waveforms. "Right now funding is the biggest constraint," Brunk says. "However, radios are a large enough market to generate standards and protocols that drive interoperability across all platforms."

"There are still limitations on many commercial SDR implementations," Uhm says. "For example, while all 3G and 4G basestations are SDRs, many of them use hardware accelerators for computation-intensive functions such as turbo decoding for forward error correction. This limits the flexibility of the basestations since they are no longer future-proof at that point since the hardware accelerators cannot be upgraded in software. I believe processor technology is now advancing to the point where commercial radios can be fully software defined, including turbo decoding. This would enable SDRs to be fully virtualized where each new waveform is an application that can run on the hardware, even if the method of forward error correction is different."

"Some of the things we see from the design side are on our 'most wanted' wireless innovation wish list," Pucker says. Included was an improved certification process when it comes to third-party software. "A process that enables third-party software to be used across multiple platforms would significantly reduce development cost and speed up the time it takes to get a new waveform into the hands of the warfighter."

"On the military side, interference mitigation is a key need for the warfighter, especially as tactical radios get jammed by other emitters for applications like electronic warfare and anti-IED," Uhm says. "New equipment and algorithms for interference mitigation are critical to ensuring the warfighter can communicate at all times and receive actionable intelligence when needed."

"Commercial technology helps us drive innovation to the tactical side," Nearpass says. "However, we still don't quite see civilian waveforms fully transitioning to the battlefield yet. Those networks still require a vast amount of infrastructure to provide that quality of service. On the battlefield you have to roll with your own infrastructure because it does not exist like it does back home and there are adversaries out there trying to disrupt communications. The waveforms must be made specific for military operations and threats, with dedicated military communications devices with military-specific encryption and anti-jam capabilities."

SDR and JTRS

The JTRS program has been reorganized with the JTRS Joint Program Executive Office (JPEO) becoming the Joint Tactical Networking Center, responsible for managing SDR technology and waveform development within the DoD. The Handheld, Manpack, Small Form Fit (HMS) and the Airborne, Maritime, Fixed Station (AMF) will be run by the Army, while the Multifunctional Information Distribution System (MIDS) will be placed under Navy oversight.

Capability sought from the now-canceled Ground Mobile Radio (GMR) segment is being procured as a Non-Developmental Item (NDI) – the Mid-Tier Networking Vehicular Radio (MNVR). "MNVR will essentially meet the capabilities of the canceled GMR program, which was supplied by BAE Systems," says John Byrnes, Director of Business Development at BAE Systems in Wayne, NJ. "MNVR will address the Army's demand for a Mid-Tier Wideband Networking (MWN) capability, which provides an extension of data services from the upper tactical network at brigade and battalion levels to the lower tactical network at company and platoon platforms."

A representative for General Dynamics, the prime contractor for the JTRS HMS family, says that two HMS radios, the AN/PRC-154 Rifleman radio and the two-channel AN/PRC-155 Manpack radio, will be part of the Army's Capability Set 13, which is to be delivered to Infantry Brigade Combat Teams this fall. The HMS PRC-154 Rifleman radio uses the U.S. government's SRW. The two-channel PRC-155 Manpack utilizes three government waveforms – SRW, WNW, and MUOS. It is interoperable with legacy radios so soldiers can use one channel for line-of-sight SINCGARS and SRW waveforms, while bridging to the second channel using the MUOS satellite system. Rockwell Collins and Thales are also part of the JTRS HMS team.

"As JTRS goes into production, a major focus is on volume production and cost reduction," Uhm says. "This is an indication of the maturation of SDR technology. In many ways, SDR is now considered to be largely a solved problem, so technologies and tools that lead to even more efficient waveform and system development and lower SWaP-C are now desired, as opposed to basic enabling technologies. JTRS is essentially now a production program with very little funding for research and development. … This means that more effort will be spent on cost reducing JTRS radios. Unfortunately, it may also result in less innovation for the future."

Managing SWaP

"In the military space, Size, Weight, Power, and Cost (SWaP-C) is still the major concern, with cost becoming a more important issue as JTRS radios go into production," Uhm says. "Reducing the overall engineering cost of the program is critical to reduce the total cost of ownership of the program. Development productivity, at the waveform and system level, has a large impact on the overall engineering effort and cost and still needs improvement. Coherent Logix's HyperX DSP processor uses an ANSI C-based development environment to improve developer productivity compared to the use of specialized languages like VHDL, enabling the HyperX code to typically compile in a minute or two, allowing developers to perform multiple design iterations in a day."

MIDS SWaP-C upgrades

Engineers at Data Link Solutions (DLS) – a joint venture between BAE Systems in Wayne, NJ, and Rockwell Collins in Cedar Rapids, IA – are providing the Link 16 capability with variants of the MIDS, including MIDS LVT and MIDS JTRS. "BAE Systems is the integrator of the MIDS and MIDS JTRS terminals. Rockwell Collins is the designer, developer, and manufacturer of the RF subsystems side of the terminal," BAE Systems' Byrnes says. "BAE Systems is responsible for the digital side, operating environment software, and waveforms for Link 16. There are several variants of MIDS that we are looking to reduce in SWaP-C upgrades – for land, air, and maritime domains."

"DLS has developed a tactical Link 16 product with MIDS LVT and MIDS JTRS that reduces Size, Weight, and Power (SWaP) by designing a small form factor product in a conduction-cooled package that also will bring Link 16 to users who have not previously had access to this capability," Rockwell Collins' Brunk says (see Figure 2). "The reduced SWaP systems are needed for constrained space platforms such as Army helicopters and Unmanned Aerial Vehicles (UAVs) – which are becoming a big focus in the military communications arena. Select users will also have the TTNT waveform on their systems."

"Link 16 is unique because it is interoperable with the U.S. and coalition forces: To date, 38 countries use the technology," Byrnes says. "The military wants to increase the capability of Link 16 bandwidth and users that can deploy, as it is a closed network waveform. Link 16 works the same, whether using a MIDS LVT or MIDS JTRS. Both of these terminal variants are undergoing changes to provide additional capabilities [and] be backward compatible and totally interoperable with every Link 16 system. The MIDS-LVT was developed to provide Link 16 capability at a lower weight, volume, and cost as a replacement to the legacy JTIDS terminal," Byrnes says. "It enables real-time data communications, Ultra-High Frequency (UHF) and Line of Sight (LOS) situational awareness and navigation, digital voice and TACAN, in a crypto-secured, jam-resistant package.

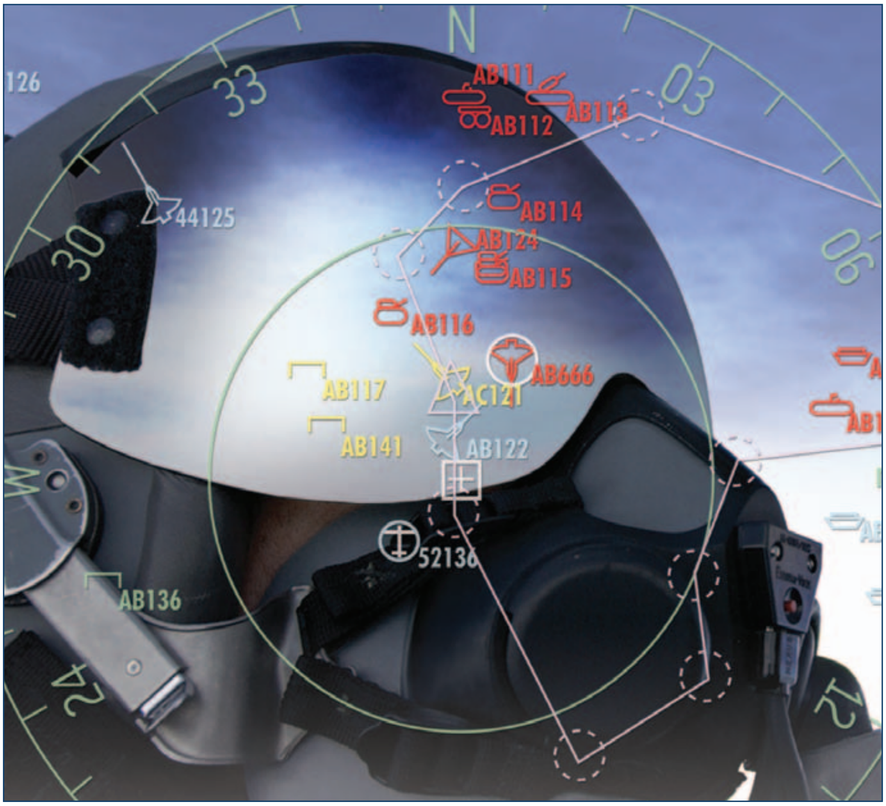

Figure 2 | This image shows a Link 16 display as seen by a pilot. Photo courtesy of DLS

"What we're doing today on the LVT side is a block upgrade to the entire installed base incorporating crypto modernization of Link 16 encryption," Byrnes continues. "Frequency Remap (FAA mandated) allows Link 16 carrier frequencies to be remapped to avoid interfering with other systems, and enhanced throughput to pack more information into Link 16 time slots. That will be an upgrade down the road. Industry will develop a kit or set of cards that will be installed on every terminal in service today to perform the upgrades. We are currently working the design and development that will be integrated into the terminals in the field in 2014/2015.

"The upgraded systems for the LVT Variant will not totally be SDR, but will have SDR capability as the new card will have much more software enabling more capability to be added without changing the hardware in future upgrades like on MIDS JTRS," Byrnes says. "This will provide increased performance, producibility, and sustainability to ensure Link 16 through 2035. For the MIDS LVT SWaP modification, we redesigned and condensed all the card sets for the MIDS JTRS Terminal. This design change provided a new terminal with Link 16 capability on one channel and provides three additional new channels supporting expanding waveforms and capability in the same package. We also are working on enhancements to Link 16 itself to improve throughput and more.

"MIDS JTRS is an SDR and is more sophisticated than the LVT version," he continues. "It is a four-channel terminal that includes Link 16 capability with the ability to incorporate additional networking waveforms as they become available. MIDS JTRS has jam-resistant capability, information distribution, position navigation, and mission management. On his terminal screen, a warfighter can tell who the good guys and bad guys are, where they are, and how they are moving. MIDS JTRS has now entered full rate production and fielding. Future MIDS JTRS upgrades will have Concurrent Multi-Netting (CMN), Concurrent Contention Receive (CCR). CMN enables the ability to receive as many as four Link 16 networks simultaneously while maintaining the ability to transmit on one Link 16 network. Warfighters would be able to operate in Link 16 on fighter networks, tanker networks, etc., no matter the tactical situation." **MES**

Conquering SDR tactical radio market challenges

By Lee Pucker and David Renaudeau

Contractors, suppliers, module providers, and value chain stakeholders in the tactical radio communications worldwide ecosystem need to understand the various possible business models for introducing SDR technologies in tactical communications programs in order to make informed decisions. The following identifies various possible business models to enable successful new generation of tactical radio programs based on examples taken from existing programs.

U.S. Air Force photo by Senior Airman Christopher Gross

Software-Defined Radio (SDR) has been defined by the members of the Wireless Innovation Forum (SDR Forum version 2.0), working in cooperation with IEEE on the P1900.1 standard, as a collection of hardware and software technologies where some or all of the radio's operating functions (also referred to as *physical layer processing*) are implemented through modifiable software or firmware operating on programmable processing technologies.[1]

A recent evaluation of tactical radio shipments shows that SDR has become a mainstream technology in defense communications, with more than 200,000 SDR-based tactical radios expected to ship this year alone and expected to increase annually (Figure 1).

The success of SDR has been largely driven by manufacturers and government agencies worldwide that saw the promise of SDR and invested early in its development. Based on this success, a number of new organizations are now exploring the adoption of SDR technology. To support this second generation of SDR tactical radio market adoption, the members of the International Tactical Radio Special Interest Group (ITR-SIG) of the Wireless Innovation Forum have undertaken a

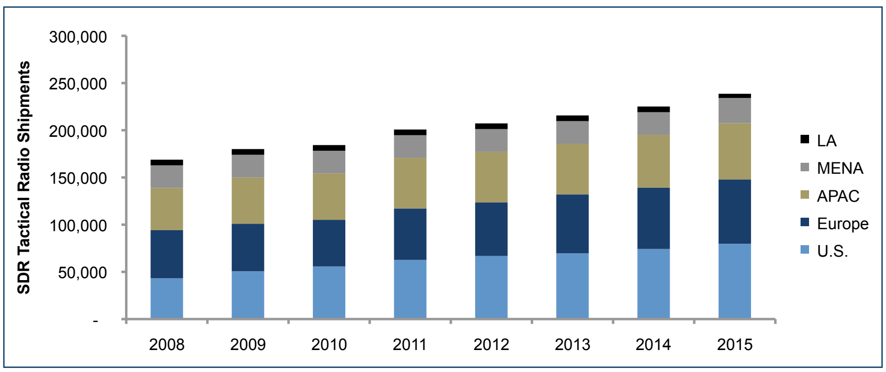

Figure 1 | SDR tactical radio shipments 2008 to 2015 (Source: Mobile Experts and the Wireless Innovation Forum, "SDR Market Size Study," 2011)

1. Wireless Innovation Forum, "Cognitive Radio Definitions," http://groups.winnforum.org/d/do/1585

project to explore possible business models that can be adopted by value chain stakeholders introducing SDR into their tactical communications programs. By capturing trends from existing programs and leveraging them into lessons learned, the Wireless Innovation Forum's members will provide recommendations that will reduce development cost and time to deployment in future radio-centric programs. While this report is still a work in progress and has not yet been balloted and approved for general release, portions of the report have been summarized here.

Market overview and drivers

The defense communications market is driven by an increased diversity of operations types: high-intensity conflicts, police-type operations, peacekeeping activities, disaster assistance and recovery, and so on. Through these operations, the need to participate in joint or coalition multinational forces has become imperative; these operations include combined units that are smaller, more agile, and dispersed, and use new networking waveforms that are high data rate and multiservices-capable to sustain network-centric operations transitions. This is possible for units at the tactical edge through the introduction of new C4ISR capabilities and applications.

Software-Defined Radio offers multiple technical advantages in supporting these requirements. First, the use of SDR technology allows a common multimode, multiband radio to support disparate communications requirements, providing seamless anytime, anywhere connection between various levels of deployed forces. In addition, SDR-based radios can host waveforms that are common to different nations. This has led to the emergence of coalition waveforms, such as the COALWNW, to facilitate the level of interoperability required at the international level on the battlefield. This capability can be extended to support a mix of commercial, civil, and defense waveform applications, allowing additional interoperability with the civilian communications as required.

There are a number of other advantages also accrued by defense organizations in adopting SDR technologies. Software-Defined Radio allows waveform software to be reused from platform to platform, reducing the time to deployment for new radio systems and over time lowering the overall acquisition costs. SDR-based systems also reduce the cost in upgrading a radio system to meet with evolving requirements, thus extending the life of the platform and protecting the original investment.

Current business models for SDR tactical radio programs

Given these advantages, governments and their industrial partners worldwide have been initiating SDR programs and driving innovation in SDR technologies (Figure 2). The SDR tactical radio market originated in North America, thanks to the launch of the Joint Tactical Radio System (JTRS) program in 1999. This program is currently in transition; however, as a whole, the U.S. Armed Forces are now engaging in multiple acquisition programs utilizing developed SDR capabilities. Also in North America, Canada is launching an "Integrated Soldier System" program that may make use of SDR technologies.

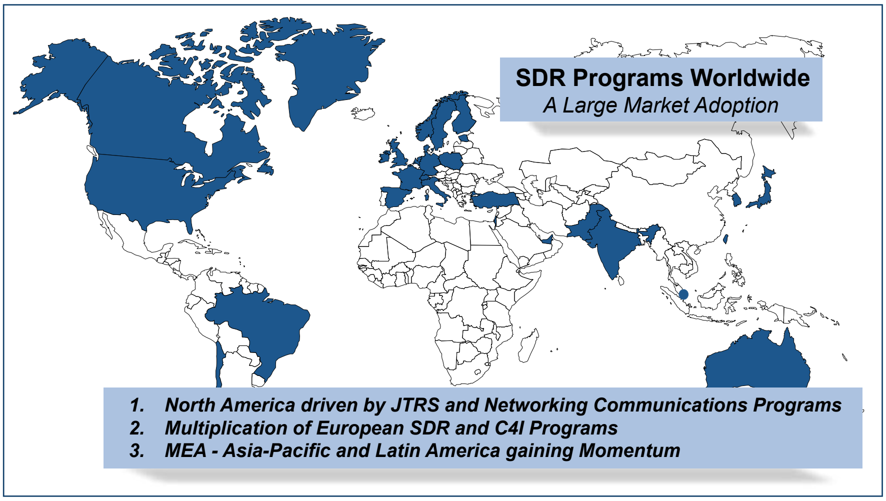

Figure 2 | The SDR market is growing with multiplication of new-generation tactical communications programs.

In Europe, the European Secure SOftware Radio (ESSOR) program was launched in 2009 by six nations (France, Italy, Spain, Sweden, Finland, and Poland) to create the normative referential architecture required for software radios in Europe. SDR-based systems are also being developed for national SDR programs in Europe that include Sweden (GTRS program), Germany (SVFuA program), France (Contact program), and Italy (Forza NEC program).

In India, the Indian Armed Forces have started several network-centric operation programs that are expected to utilize SDR capabilities in their associated communication applications. SDR programs are also underway in many other countries around the world, including South Korea, Japan, Singapore, and the United Arab Emirates.

Investment models followed by these programs separate into acquisition of the waveforms, acquisition of the radio platform, and integration of the waveform onto the platform for deployment. The models followed in each of these areas generally fall into one of three types:

- **Development funded by the government:** Under this model, the government procurement authority defines the requirements, selects a vendor to meet those requirements, and then takes the risk that the final products provided by that vendor fully meet operational needs.
- **Industry development of Military Off-the-Shelf (MOTS) solutions:** This model follows a commercial development cycle, with products developed at industry expense to address the requirements defined by the government. This model places most of the risk on the radio manufacturer, and this risk is compounded by the fact that the commercial model assumes that there are many customers and that vendors compete for market share; however, in the tactical radio market there might only be a single customer for a given product.
- **Shared government/industry development:** In this model, government and industry coinvest in development, allowing the risk to be shared between both parties. Many variations of this model exist. For example, in one model the government funds an independent waveform development program, with waveforms kept in a repository

as Government Off-the-Shelf (GOTS) products to be ported to industry-developed radio platforms supplied separately.

Multiple other aspects are also influencing the SDR business model implementation in different markets. For example, the desire to port the same waveform onto multiple and different radio platforms leads to the requirement for standards that lower costs and reduce efforts inherent in waveform porting. Porting a common waveform into multiple and different platforms also leads to the requirement to establish over-the-air waveform interoperability centers. Finally, access to Intellectual Property Rights (IPR) is often required to ensure waveform porting onto multiple and different radio platforms. For new waveforms, this can be managed from the beginning of the development program, but the issue is problematic for legacy waveforms that are typically owned by the radio manufacturer.

Another key consideration in the business model implementation that varies across markets is security. Security and information assurance requirements in the military domain differ from country to country, which leads to complications in the business model and often restricts the accessible market. In addition, the access to SDR and waveform standards could be restricted to a nation or an international organization (such as NATO), which could further limit the accessible market.

Applying existing models for new market entrants

In evaluating these programs, some business models have emerged that appear to be providing some clear benefit in the SDR tactical radio market:

- **Sharing the cost of development among different nations or different suppliers:** This is particularly important with waveform and radio platform development costs with a near-stable total addressable market.
- **Transitioning from complex and long-development, government-funded programs:** This means going toward a more pragmatic, "good enough" approach taking

> "... Access to Intellectual Property Rights (IPR) is often required to ensure waveform porting onto multiple and different radio platforms. For new waveforms, this can be managed from the beginning of the development program, but the issue is problematic for legacy waveforms that are typically owned by the radio manufacturer."

advantage of some MOTS, or near MOTS, solutions together with a focus on the importance of networking waveforms owned by the government; this will ease the porting of this interoperable WF into different supplied platforms from different vendors.

- **Encouraging competition by permitting multiple radio platform suppliers:** This could result in product innovations with a reduced time to market.

As with any new defense program, national sovereignty issues may also come into play in defining the business model, with countries choosing to ramp up a native SDR industry. Such decisions need to take into account the cost and lead time required to acquire the necessary technical skills to be successful.

Choosing the best model

In reviewing the existing tactical radio market, current business models, and possible emerging model characteristics, it becomes clear that interoperability is a key driver for SDR, and that achieving the required interoperability has a cost. The business model has to absorb this cost, either through some competition gain, through government funding, or by access to volume markets. The ITR-SIG of the Wireless Innovation Forum is evaluating how variations on existing business models can be used by new entrants into the SDR tactical radio market to address these cost issues and will publish its findings in a publically available report. The ITR-SIG encourages feedback on this important topic, as well as participation by the broader international tactical radio community. **MES**

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EMBEDDED TECH FOR MIL SIMULATION AND TRAINING

Training in a virtual world is cost effective

By John McHale, Editorial Director

Warfighters are spending more time than ever in virtual environments as military leaders take advantage of commercial technology that finds itself in simulators with a realism unheard of 10 years ago – all while saving millions in infrastructure and live training expenses.

Enhanced realism in military simulators enables warfighters to be better prepared for combat scenarios such as this virtual rendition of a firefight in Yemen. Photo courtesy of CAE Inc.

Training even one warfighter or pilot continues to be a multimillion dollar endeavor, with the soldier, sailor, airman, or Marine deserving every penny of that expense. "Train like you fight" is still the motto, but more and more, modern training and mission rehearsal constitute a virtual experience – whether it's flight training or practicing for urban combat scenarios.

Military leaders are leveraging Commercial Off-the-Shelf (COTS) hardware and software to create complex training environments before warfighters even get to live training. The use of COTS technology also makes virtual training attractive from a cost management perspective – which is good news for military simulation designers in today's budget-constrained environment.

"One cannot have a conversation about the military market today without talking about budget constraints and cuts," says Chris Stellwag, Director of Marketing Communications at CAE Inc. in Montreal, Quebec. "This is the condition that defense suppliers are operating under in the U.S. and elsewhere. However, there are positives for those in the simulation business as simulation can be an economical solution to budget constraints. The advantages of simulation play right into a budget-constrained environment as the military looks to more of a live and virtual blend. Military leaders will want their aircraft for operational use to make them last longer, so they will use more virtual training. It's not that they don't use simulation extensively now, but we see the Services moving more toward virtual training."

"With everybody worrying about sequestration, Department of Defense (DoD) funding is getting hit across the board," says LeAnn Ridgeway, Vice President and General Manager Simulation and Training Solutions at Rockwell Collins in Cedar Rapids, IA. "However, there is a cost benefit by using more virtual training in simulators and less in live aircraft. We do really believe the simulation technology piece of the DoD budget is a little more isolated from budget cuts in the overall market."

"Most of us [simulation and training managers] agree that budget cuts will ultimately require an increase in the use of virtual training because there is no other way to maintain readiness with reduced funding," says Dave Janke, Vice President Sales and Marketing, Simulation Division, North America at Barco. "However, there is currently much uncertainty, even chaos, in defense budgets, and we may experience a short-term dip in simulator purchases as governments sort out what funds they have to work with and then make formal allocation decisions. The long-term outlook for simulation is very positive. Air forces will have no choice but to extend the life of existing platforms by moving flight hours to the simulator. This inevitable transfer poses two challenges to industry: 1) to increase simulator fidelity so that training effectiveness is not sacrificed, and 2) to decrease operational costs."

"Because of the high operational tempo over the last decade, U.S. military airframes in particular have had their life expectancy shortened, with aircraft that have been used more than was expected," Stellwag says. "We have been doing upgrades on the 19 KC-135 flight simulators because they need to

extend the life of those aircraft as the next-generation KC-46 platform comes onboard. The KC-135 will be around for another 10 to 20 years, so the [USAF] needs to maximize operational use of the aircraft.

"The U.S. Navy also is changing its curriculum to move more into virtual simulation by 2020 for the MH-60R helicopter," Stellwag continues. "Currently 39 percent of training is done in a virtual training environment; the rest is in a classroom or in live training. They want to move to close to 50 percent by 2020. That is a significant increase, as the total number of helicopters in the fleet is not expected to grow. A new platform – the Navy's P-8A maritime patrol aircraft – will have at least 10 simulators built for training on 117 aircraft. CAE is subcontracted to Boeing to build the P-8A simulators. The Navy is shifting its curriculum to virtual partly due to economics and partly due to the improved quality of training and enhanced realism of the simulators. You can do more in simulation than you could a decade ago."

COTS and simulation

Much of the realism in today's simulators comes via the commercial world where the billion dollar gaming industry drives innovation. The COTS displays, projectors, graphics processors, and so on, are being leveraged by the military to enhance the realism of virtual training for the warfighter.

"The best example of realism is the visual 'out the window' views driven by the display technology and the graphics hardware that generates the image," Stellwag says. "Displays and graphics cards are both leveraged for simulation from general commercial industries such as gaming. The display technology used today is mostly Liquid Crystal on Silicon (LCoS) projectors. Since the mainstream consumer electronics industry drives those technologies, they are much more cost effective as well. For modern simulation you need to have open systems that use COTS and are interoperable with other types of systems. When the technology is proprietary, it can be difficult to get systems talking together. Time sensitivity then becomes critical as you don't have months and months to build interoperability between proprietary systems."

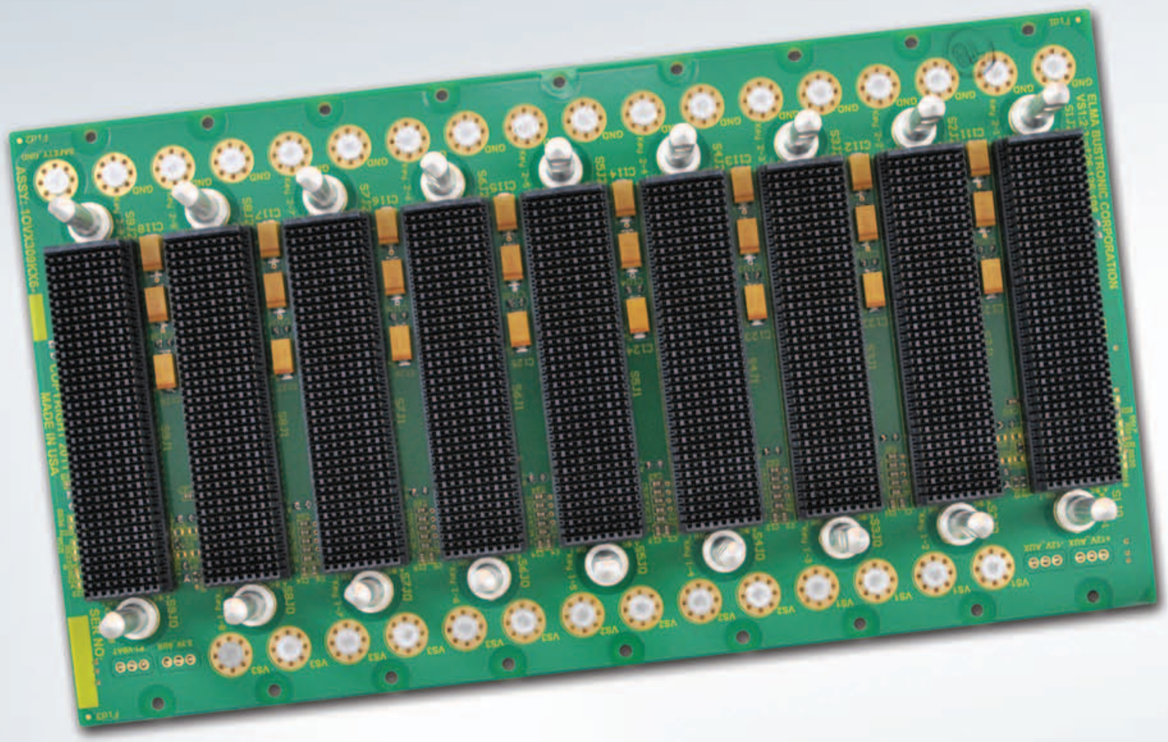
However, not everyone thinks COTS is always the best choice. "I think it is a dichotomy with COTS versus custom technology," Ridgeway says. "Commercialization does help reduce cost through open architectures, and COTS provides an advantage with less expensive equipment and components. However, for highly complex missions, COTS isn't always the best choice because it is at the whim of consumer markets and difficult obsolescence issues. Some simulation systems are so complex that the software tends to need the specialized displays not found in the commercial markets. For the more complex training solutions, you have to be careful when deciding COTS versus custom so you are not held hostage by these issues. Custom designs can have a higher price tag, but have surer footing for long-term life cycle support.

"There are complex training problems and very complex ones," Ridgeway continues. "It is kind of a bit of a duopoly in the market where you have the easier training issues solved by one end of the market and the more complex training issues solved in the other end where Rockwell Collins resides. We're solving complex issues for platforms such as the F-35 Joint Strike Fighter (JSF) program. The JSF visual solution is a 360° field of view with night vision goggle stimulation and advanced sensor capability. We also are heavily involved with Navy E-2C and E-2D aircraft programs where we're working on integrated cockpits and avionics systems. The fact that we develop avionics systems for military aircraft also makes it easier to transition the technology to simulation and training sessions."

Display and projector technology

"Today's full-mission simulation displays are 360° immersive displays with deeper black levels and higher resolution than ever before, mimicking the quality of night sky in a simulator," says Peter De Meerleer, Director of Product Management for Barco Simulation and Training in Kortrijk, Belgium (see Figure 1 on page 32). "These capabilities are made possible by LCoS technology, which offers the highest resolution and deepest black level. Projectors today can provide as many as 10 million pixels, simulating almost to eye liming resolution level. The contrast ratio of the projectors can be superior to 10,000:1 with dynamic ranges that go over 1 million:1. Black levels can still be improved. Deeper, better black levels will be important as users demand more night scene and stimulated [Night Vision Goggle] NVG training to be integrated into simulator designs."

"A feature of Barco's SIM 7 LCoS projector is its ability to stimulate … NVGs," Janke says. "It has extraordinarily high contrast, which provides excellent NVG stimulation and an optional version of that emits an enhanced light spectrum with more infrared light and produces especially robust IR imagery that very accurately reproduces the night sky spectrum and its effects on genuine



night vision goggles. Pilots can use their own goggles and experience highly realistic NVG training."

"The cutting-edge improvements on the projectors and the immersive aspect of systems enable pilots to look all around them in a full 360° horizontal field of view, seeing images of other airplanes or targets, which requires a very large amount of pixels that was not previously feasible or affordable before high resolution LCoS technology," De Meerleer says. "The simulators can make use of fully immersive screens with multiple projectors at the same time with brightness and color automatically adjusted between the different projections."

Rockwell Collins projector technology enables deeper black levels for JSF training. "The Rockwell Collins 2015 projectors are used in the JSF simulation program," Ridgeway says (see Figure 2). "We've got a patented technology in there that absolutely allows for the blackest

Figure 1 | Barco's RPD-360 360° fully immersive rear projected dome is used for full-mission military simulators.

black – levels you can't get from other commercial technology such as LCoS projectors. Typically LCoS systems have higher ambient light. We have patented technology that enables us to reduce the overall ambient light and reduce contrast so you can see the required black levels. I think this is a case where COTS doesn't just quite cut it. For high-end, complex simulation like the JSF, you need to move away from commercial theater projectors.

Virtual flight training via datalink

"Rockwell Collins also has been working on building an embedded training

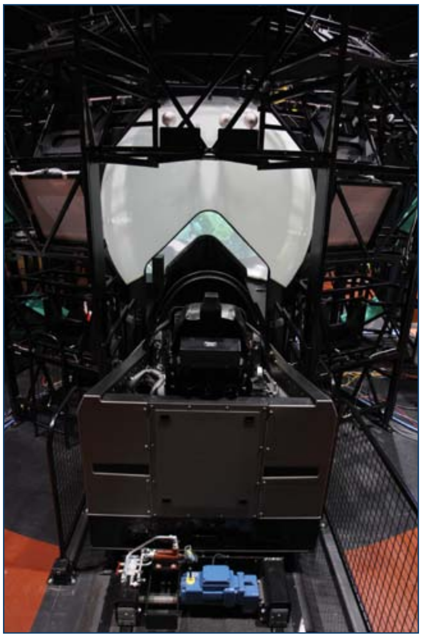


Figure 2 | The F-35 Joint Strike Fighter Simulator uses Rockwell Collins simulation technology such as their 2015 projector. Photo courtesy of Lockheed Martin

architecture – Live Virtual Constructive Training – that is built around adding virtual simulation capability in a light training aircraft via a datalink, so pilots can do virtual training while flying the aircraft," says Kevin Hynes, Director of Simulation and Training Solutions Engineering at Rockwell Collins. "It would simulate functionality not currently present in the aircraft such as radar and other sensors.

"The process enables us to have a simulation environment tied into a datalink," Hynes continues. "It is similar to a typical simulator, except we drive those same simulation entities up the datalink with the simulator residing in the aircraft from a conceptual standpoint. For example, light aircraft without a radar system can have this functionality – entities, radar display and controls, etc., replicated virtually on the flight deck. The replication is viewed on an additional display or we can inject the graphics onto actual aircraft displays. We are currently implementing it as an embedded mode. It is important to note that this is a partitioned architecture, run on lower levels of criticality, so that it does not interrupt aircraft symbology. This enables new functionality to be added without having to recertify aircraft software."

Portable simulation

"Simulators that are portable or what the military calls 'deployable' are in containerized packages that are brought in theater to maintain concurrency and readiness when warfighters are not operational," Stellwag says. "Budget issues partly drive this too, as shifting soldiers to live combat training centers is much more costly than having them train at their home station."

"The Army has really embraced mobile training systems such as our Transportable Black Hawk Operations Simulators (TBOSs)," Rockwell Collins' Ridgeway says. "It saves time and money by enabling pilots to be trained in the field. We can rapidly relocate the T-BOS to a garrison or field environment. It takes only eight hours to set up complete training and has a modular architecture that can be reconfigured in just four hours in the field. T-BOS has UH-60M avionics including cockpit displays from Rockwell Collins. Mobile simulators also reduce fixed operating bills and lower long-term capital and maintenance costs." **MES**

GUEST EDITORIAL

Trial by fire: Training for the ISR flight

By Justin Snider

Part math and part art form, sensor planning should not be confused with the standard flight or mission plan.

U.S. Air Force photo by Senior Airman Nadine Y. Barclay

BASE X – 0200hrs ZULU – 2008: "Your mission plan looks horrible," barked Carlos. "Why on Earth would you place the third flight line coming in from the east when your pilot will exit the second flight line on the west side? It's all about getting the aircraft on the line in an efficient manner that makes life easy for the pilot without sacrificing your depression angle! If you do, your imagery is going to be toast."

Having been in Iraq only a few days, I was struggling to find my rhythm in sensor planning for a Synthetic Aperture Radar (SAR) aboard a Predator-class Unmanned Aircraft System (UAS), flying counter-Improvised Explosive Device (IED) missions in support of a U.S. Army task force. My many years of Intelligence, Surveillance, and Reconnaissance (ISR) experience were doing nothing for me on this cold evening at BASE X inside a small Ground Control Station (GCS) with a two-person, young Army UAS crew (pilot and sensor operator) and my reluctant instructor, Carlos, who reminded me, "It's an art form, man! Get out of the seat and let me show you some magic."

Few understand that the cornerstone of good imagery collect, especially for Coherent Change Detection (CCD), is precision sensor mission planning. Part math and part art form, sensor planning should not be confused with the standard flight or mission plan. Sensor planning is focused on ensuring that the imaging sensor and aircraft are in the proper point in the sky and looking in the proper direction, all at the right time, to ensure the best chance of success for a good imagery collect. On paper it sounds easy, but throw in poor weather conditions, closed kill-boxes, a poorly constructed target deck from an overworked collection manager, and constantly changing altitude stacks and an easy day just went out the window. Thankfully, a new sensor control and exploitation software system takes care of figuring out aperture timing and other radar-specific complexities. And, when combined with a hands-on multisensor ISR simulator called the Tactical Airborne Reconnaissance Simulator (TARS), simulation of UAS flight paths and waypoints based on sensor collection parameters is reduced to a (much easier) science.

We need something to train with

How is one trained in the art of sensor mission planning? My training was done either on a live flight aboard our company-owned Twin Otter aircraft in San Diego at the tail end of a production radar burn-in event, or at my desk running a version of Claw, which is the GA-ASI-developed sensor control and exploitation software mentioned earlier. The problem at the time was that even if I built a mission on the ground, there was no way to run the plan with a live sensor to see if it would work and actually provide valid, usable imagery. Time, availability, and cost were, of course, prohibiting factors in allowing our entire sensor operator cadre to spend instruction time either airborne or in a GCS linked up to a UAS.

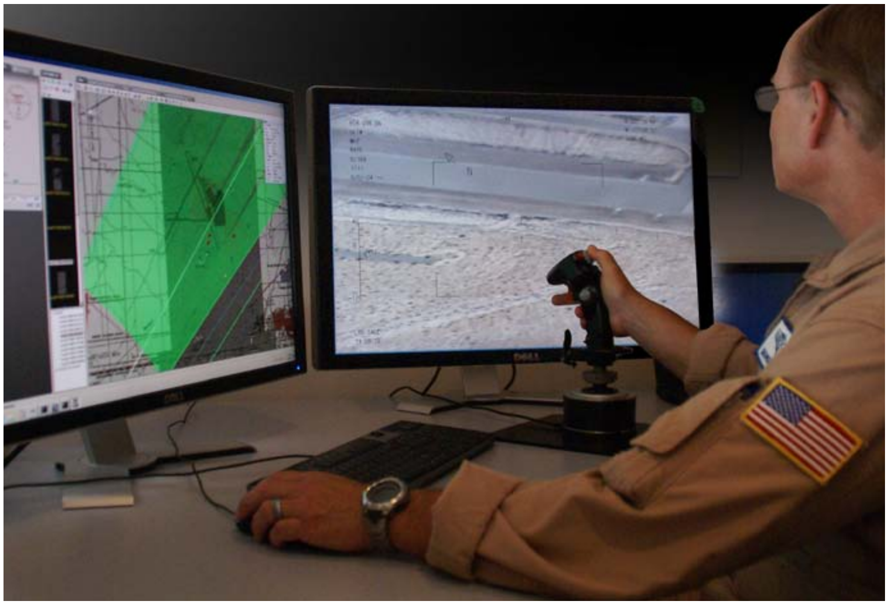


Figure 1 | A sensor operator trains on the TARS system.

Thankfully, while I was deployed to Iraq running our system in combat, a team of software engineers back in San Diego was busy working with SDS and SAIC to develop TARS, an inexpensive, hands-on multisensor ISR simulator. TARS was born out of the need to train our deployed operator crews on a realistic simulator that could accurately emulate the conditions and flight parameters seen in a GCS during a typical ISR mission flown in theater by the Army or Air Force (Figure 1).

The beauty of TARS is that a student or seasoned operator can practice with a highly realistic simulation without having to step on an airplane or find a GCS hooked up to a UAS (Figure 2). TARS provides three basic software components loaded onto a COTS workstation: 1) Remotely Operated Vehicle Adaptable Training/Tracking Systems (ROVATTS), provided by SDS and controlled by a Thrustmaster joystick, provides the background UAS flight track simulation and simulated Electro-Optical/

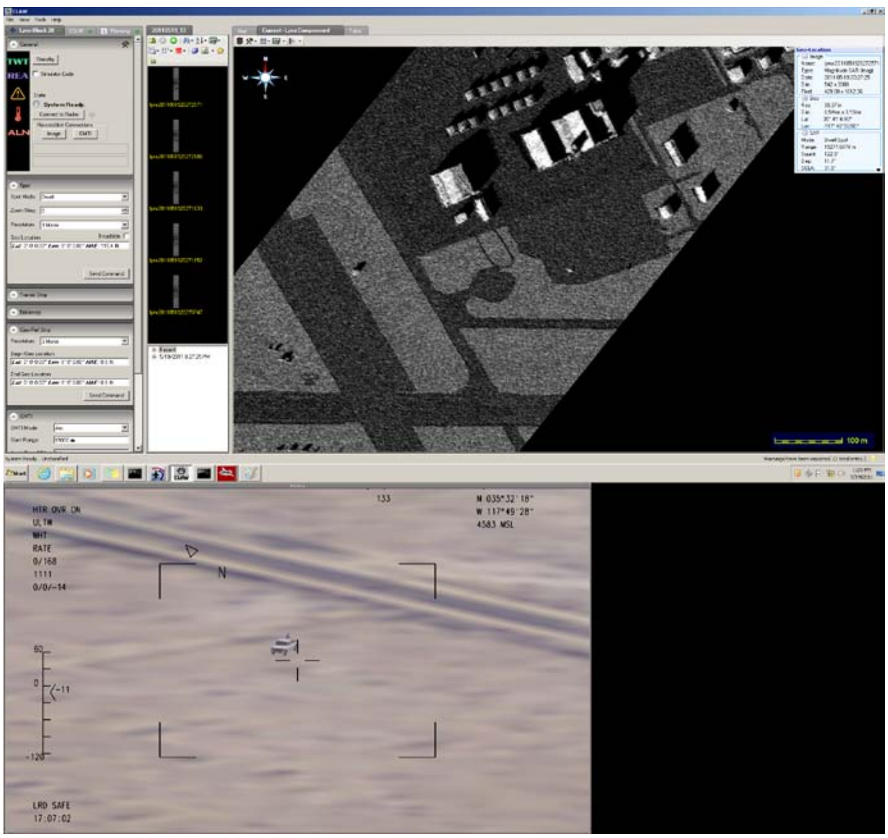


Figure 2 | Simulated SAR and EO imagery

Infrared (EO/IR) Full Motion Video (FMV); 2) GA-ASI's Claw system, which provides sensor mission planning, command, control, visualization, and exploitation for the FMV and Lynx Multi-mode Radar payloads; and 3) RADSIM, which is furnished by SAIC. The RADSIM, utilizing a proprietary process, uses overhead imagery to produce high-fidelity synthetic SAR imagery products that include terrain features, texture, and radar shadow, all consistent with real-world SAR imagery. Various SAR resolution levels are available to the student, enabling him to practice utilizing low-resolution SAR for a wide-area search followed by high-resolution imagery to refine specific targets of interest.

Bringing it all together – A typical training scenario

A typical training scenario entails the student receiving a mock target deck that details a specific ISR request. These targets are applied to the map in the sensor control and exploitation software to ensure the student can make sense of the request. The student double checks that the target points match up to roads, specific buildings, areas, and points of interest, just as is done in the real world. Once satisfied with the tasked targets, the student builds the sensor mission plan for the SAR collect in the sensor control and exploitation software portion of TARS. The student creates imaging points and paths and then provides specific numerical inputs for the SAR sensor geometry, to include desired depression and squint angles, collection altitude, and SAR image type and resolution. The sensor control and exploitation software will then take the sensor collection parameters and autogenerate the flight path and waypoints for the aircraft to fly. The instructor now places the student-generated flight waypoints into RADSIM, and the simulation is started.

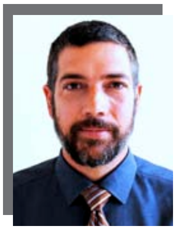
> "'Practice does not make perfect. Only perfect practice makes perfect.' With ISR operations, second chances are far and few between. TARS ensures that those who are charged with actually employing a sensor will be ready for the real thing."

The simulated aircraft moves along the flight path generated by the student's inputs, and the SAR payload is automatically triggered at specific points along the path to image the ground targets. The student will see indications in the sensor control and exploitation software that the SAR aperture is firing, as well as image processing and formation signals. The artificial SAR images will populate on the map and in the exploitation window in the representative time that it would take during an actual mission. The student can practice first-phase analysis of the imagery and identify any items of interest. During aircraft repositioning, the student might want to utilize Ground Moving Target Indicator (GMTI) – a sensor capability utilized on numerous manned and unmanned aircraft throughout the DoD – in an attempt to identify moving ground targets. TARS includes a host of moving vehicle targets, to include trucks and tanks that the student attempts to locate by using the simulated radar set to "GMTI mode" to search large areas on the ground in a sweeping arc pattern, looking for the telltale "dots" on the screen, identifying a moving target. If a moving target is found using the GMTI sensor, the student can cross-cue the FMV sensor to the GMTI-identified target for further target identification and tracking.

The ISR simulation beat goes on

In a nondescript office building in the San Diego area sits GA-ASI's Test Operations Center, a working mockup of a typical operations center that can be found overseas, complete with numerous large LCD monitors displaying maps and various examples of sensor imagery. Here, the training process described is repeated daily. A student sensor operator is handed a slip of paper with 15 ground targets. He has 30 minutes to interpret the ISR requirement and translate it into a workable solution that will enable a UAS to collect from the critical intelligence points properly. TARS allows the student to run this drill to perfection before heading overseas to do the same thing, deployed in theater with soldiers on the ground who are counting on timely, relevant intelligence data.

Vince Lombardi said it best, "Practice does not make perfect. Only perfect practice makes perfect." With ISR operations, second chances are far and few between. TARS ensures that those who are charged with actually employing a sensor will be ready for the real thing. **MES**



Justin Snider *is a Program Manager at General Atomics Aeronautical Systems, Inc.'s Reconnaissance Systems Group (RSG). He directs contracts providing manpower and technical support to various customers; he also manages the RSG Tactics and Training Department. Justin serves as a USAF Reserve Intelligence Officer and has deployed on multiple tours to Iraq and Afghanistan.*

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VITA 65, serial fabrics, and HPEC: Decisions, decisions

By Michael Stern

Organizations going the VITA 65/ OpenVPX route as part of a planned HPEC deployment have an important decision to make in terms of choice of serial switched fabrics. The decision is based, however, not only on technical specifications and performance, but on other factors as well – factors that are potentially more critical.

U.S. Air Force photo by Rob Densmore

When VITA 65 – OpenVPX – was ratified by ANSI in June 2010, it turned the technical promise and potential of the VITA 46 (VPX) standard into a commercial reality. Where VPX was focused at the board level, OpenVPX created a framework for turning boards into useful systems. The relationship between the two is perhaps best characterized as: VPX provided the ingredients – but VITA 65/OpenVPX provided the recipe.

Fundamental to the OpenVPX philosophy was the idea of interoperability – of fostering an ecosystem of VPX hardware and software from multiple vendors that was guaranteed to be able to play nicely together. Competition between those vendors would help drive prices down, while a burgeoning infrastructure of complementary products and services could help minimize program risk and time-to-market.

But while VITA 65 answered many of the questions that VITA 46 had implicitly posed, there were others that it – intentionally – did not. A significant element of the attraction of VITA 46 and VITA 65 lay in their flexibility. Program managers planning to take advantage of what VITA 65 offer are still left to answer questions – and none of these is more fundamental than the choice of serial switched fabric, the technology at the heart of VPX.

That choice is, however, about much more than relative performance. Other factors are as important – and perhaps more so. Those questions have become even more pressing as increasing numbers of military programs look toward what High Performance Embedded Computing (HPEC) can do for them. HPEC takes the principles of High Performance Computing (HPC) – massed ranks of powerful servers operating in parallel on the world's toughest processing tasks – and brings them to the world of embedded computing; this brings game-changing levels of performance to deployed embedded platforms using Modular Open System Architectures (MOSA), an architectural approach enabled by VITA 65.

In conjunction with other open architectures and middleware such as Future Airborne Capability Environment (FACE), Open Fabric Enterprise Distribution (OFED), and OpenMPI, OpenVPX provides a compelling proposition. Take, for example, the processing of sensor-acquired data. "Behind" the sensors, DSP and image processing algorithms extract and track targets, and the applications apply powerful algorithms to deduce identities and patterns and deliver actionable graphic information to the screen – in the minimum possible time. It's the kind of demanding application that lends itself readily to the parallelism that is possible with multiple processors including multicore processors and many-core Graphics Processing Units (GPUs).

High-speed communication between those processors is essential in HPEC applications – and that's the province of

Item	Interconnect Fabric	Link Speed in Gbits/s per lane	OpenVPX Backplane Interconnect	OpenVPX used today	Number of lanes	Raw channel speed in Gbits/s	Physical Coding Sublayer (PCS) Encode/decode	Theoretical peak throughput in Gbits/s	Theoretical peak throughput in GBytes/s
1	10Gigabit Ethernet	3.125	Copper	Yes	4	12.5	8b/10b	10	1.25
2	40Gigabit Ethernet	10.3125	Optical	No	4	41.25	64b/66b	40	5
3	100Gigabit Ethernet	10.3125	Optical	No	10	103.125	64b/66b	100	12.5
4	Single Data Rate (SDR) InfiniBand	2.5	Copper	Yes	4	10	8b/10b	8	1
5	Double Data Rate (DDR) InfiniBand	5	Copper	Yes	4	20	8b/10b	16	2
6	Quad Data Rate (QDR) InfiniBand	10	Optical	No	4	40	8b/10b	32	4
7	Serial RapidIO gen 1	3.125	Copper	Yes	4	12.5	8b/10b	10	1.25
8	Serial RapidIO gen 2	6.25	Optical	No	4	25	8b/10b	20	2.5
9	PCIe gen 1	2.5	Copper	Yes	4	10	8b/10b	8	1
10	PCIe gen 2	5	Copper	Yes	4	20	8b/10b	16	2
11	PCIe gen 3	8	Optical	No	4	32	8b/10b	31.51	3.94

Figure 1 | While performance characteristics are important, there are other considerations in choosing a serial switched fabric.

serial switched fabrics. But which is best? 10 GbE? PCI Express? InfiniBand? Serial RapidIO? Let's consider their differences.

10 GbE, PCIe, InfiniBand, and Serial RapidIO in depth

10 GbE, PCI Express, Serial RapidIO, and InfiniBand (Figure 1) are all part of a class of interconnects that uses switched serial fabrics. These are point-to-point connections that are typically (but not always) directed through one or more switches. Smaller systems can be constructed without switching where either all-to-all connection is not needed – say a pipeline dataflow – or the number of endpoints is not more than the number of fabric ports per endpoint plus one. (That is, if a board has two fabric ports, three of them can be connected with a full mesh without a switch.)

There are many similarities between the different fabrics; in fact, most of them share the same electrical characteristics but vary in the protocols that are used to convey the data. Because of this, the raw transmission rates are generally comparable, making any of them a potential candidate for an HPEC implementation. Where they differ is in the higher protocol levels. Each is constructed from a number of "lanes" ganged together, where a lane is two differential signaling pairs occupying four physical wires or traces. One pair transmits data, while the other receives in a full-duplex link. The signal clock is embedded in the data stream, which mitigates some of the restrictions seen in parallel buses as signal frequencies and transmission lengths increase. Most of the protocols use a form of encoding that is designed to reduce DC bias on the lines and to provide enough edge transitions to allow efficient clock recovery. The most common scheme is 8b/10b where the 8 bits that comprise a byte of data are coded to 10 bits for transmission. This places a 25 percent overhead burden on the data transmission. Some newer protocols have adopted 64b/66b coding with a more efficient 3.125 percent overhead or 128b/130b, which has half of that overhead.

There are several clock rate options, but for OpenVPX systems using the current connectors and backplane construction, the most commonly seen ones are 3.125 GHz for 10 GbE and 5 GHz for the other three. So, for a typical x4 backplane link, all three 5 GHz fabrics produce comparable results. As InfiniBand and Serial RapidIO are designed for message passing schemes, they tend to be used on the OpenVPX data plane.

PCI Express is most often used to connect peripherals to processors (as is implied by its full name – Peripheral Component Interconnect Express) and so shows up most often on the expansion plane. PCI Express can be used as a peer-to-peer interconnect, but several factors can complicate this. The PCI Express architecture assumes one root node that is tasked with enumerating the fabric. Connecting several processors in this manner usually requires employing nontransparent bridging to separate out each node into its own domain. The domains are then connected with mapping windows. Typically, these windows are limited in size and number, and this tends to be the restricting factor in how many nodes can be interconnected. This can work fine for smaller clusters, but for larger systems, Serial RapidIO and InfiniBand offer better scalability. 10 GbE yields slightly lower bandwidth because of the lower clock rate, but with RDMA technology, it is comparable in latency and processor overhead and benefits from ubiquity and user familiarity.

So, when it comes to HPEC applications: Why do we care so much about interconnect bandwidth? One reason is that, as processor speeds increase – or as is prevalent these days, more cores are included per processing node – the interconnect scheme needs to follow suit in order to build multiprocessor systems that actually scale application performance (Figure 2). It is no use adding processors if they are starved for data. Locality of data can become increasingly important. In other words, the further a processor has to reach for data, the slower the data transfers are. The closest locations are the caches, then local memory, and finally data located on other processors connected by the network fabric.

Performance isn't everything

But, increasingly, the argument is no longer about "feeds and speeds." Each serial switched fabric has, inevitably, its strengths and weaknesses – but these are not always about performance.

Figure 2 | GE's NETernity GBX460 data plane switch module supports HPEC cluster architectures.

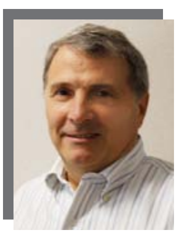
Oftentimes, the application may demand that one is preferred to another. 10 GbE, PCI Express, InfiniBand, and Serial RapidIO all have their place.

Despite some – largely inaccurate – assertions to the contrary, there is little difference among the various serial switched fabrics in performance terms. More important than a faster clock speed or a higher bandwidth, there are likely to be those same commercial considerations that saw the development of VITA 65/OpenVPX in the first place: Much, much more important to today's military embedded computing programs is the minimization of cost, risk, and time-to-market – and that points to the ready availability of a broad range of potential suppliers, tools, software, support, and expertise.

While PCI Express has the required supporting infrastructure, it is not ideal as a contender for scalable peer-to-peer interboard communication simply because, architecturally, that's not what it was designed to do nor where its strength lies. That leaves 10 GbE, InfiniBand, and Serial RapidIO. The latter fails both the test of interoperability with the GPGPU technology that is a fundamental element of many HPEC implementations, and the test of the widespread commercial support within the HPC cluster computing market that is central to harnessing the full potential of VITA 65 MOSA platforms. Serial RapidIO is typically found within the commercial communications infrastructure market, notably in Power Architecture environments, and some specialized DSP devices in which it is natively supported.

InfiniBand, on the other hand, brings with it a strong market presence within the world's TOP500 (www.top500.org) HPC platforms along with wide community support in the form of tools, middleware, and know-how. It coexists well with the Intel architectures that are now assuming increasing significance in military embedded computing. It is also a natural partner for GPGPU technology: NVIDIA and Mellanox have worked together to develop an efficient mechanism that allows InfiniBand to deliver data directly to the GPGPU's processor memory – rather than incurring the performance overhead of delivering the data first to the host processor's memory before transferring it to the GPGPU, as would be the case with other switched fabrics.

Which leaves 10 GbE. Benefiting from the widest possible commercial and technology support, it is an obvious choice – where it can deliver the required performance for the customer application – for both interprocess communication in multi-CPU systems and for I/O from sensors to the data processor and on out to the user interface. For users requiring higher levels of performance in interprocessor communication, InfiniBand is superior, benefiting from the fact that it was not designed as a general-purpose communications technology, but as a flexible, fast, and scalable fabric specifically for this type of task. Hence, 10 GbE and InfiniBand are highly complementary (a fact seemingly reinforced by acquisitions by Intel) and provide the optimum fabric choice for VITA 65 platforms and for HPEC applications. **MES**



Michael Stern is a Senior Product Manager at GE Intelligent Platforms, where he is responsible for the company's High-Performance Embedded Computing (HPEC) product line. He has spent 20 years within the defense and aerospace market. He can be reached at michael.stern@ge.com.

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Rugged flash drive has built-in security

Engineers at Apacer have designed a rugged flash drive for extreme military environments that comes with built-in security features to prevent enemy eyes from ever seeing the secure data. The 2.5" Serial ATA Flash Drive (SAFD 25P) has ATA secure erase and S.M.A.R.T. functions that basically act as a kill switch, erasing the data if it is about to be taken by unwanted entities. Once the signal to erase is sent, the device will continue to purge the drive even if the enemy takes possession of it. The Apacer device's mil-spec secure erase and write protect features can be triggered through hardware and software, and are integrated into the SSD firmware to make sure it fulfills military requirements.

Apacer's new device is fitted in a rugged aluminum housing for greater heat resistance. Its storage capacity is as much as 512 GB, and it uses industrial SLC NAND flash chips with an extended temperature range of -40 °C to +85 °C. The new device replaces 2.5" SATA HDDs and has global wear-leveling and block management, intelligent power failure recovery, and trim command support. The SAFD 25P's 7+15 pin male connector comes in 32 GB, 64 GB,128 GB, and 256 GB capacities. It sequential read and write speeds are as fast as 265 and 230 MBps.

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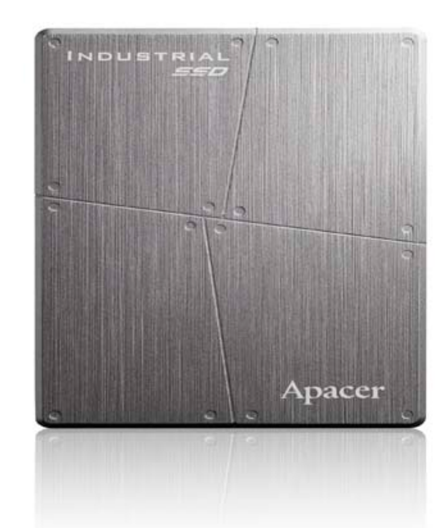

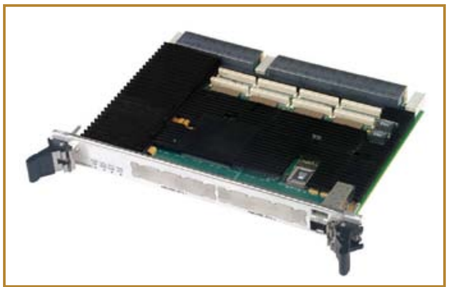

VPX SBC building block hastens time-to-market for C4ISR apps

Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) is a hot focus in mil tech these days, and so is fast time-to-deployment. The good news is that Parvus' CPU-111-10 6U VPX SBC can act as a ready building block in C4ISR applications, helping the Armed Forces achieve both focal points efficiently. Suited specifically for C4ISR apps riding in ground vehicles, unmanned/manned technologies, and shipboard, this SBC is powered by an Intel L5408 Xeon processor @ 2.13 GHz, including 4 GB DDR2 RAM. CPU-111-10 also has an integrated 10 GbE switch, which provides as many as eight SBCs aboard one chassis with interconnectivity in full-mesh backplane data layer style. Meanwhile, the full array of I/O resources onboard comprises two 1 GbE, as many as eight 10 GbE, two USB 2.0, four SATA, and one RS-232/485 port. Dual PMC/XMC expansion module sites facilitate I/O expansion.

The SBC is available in ruggedized conduction-cooled and also convection-cooled versions, both compatible with VPX backplanes with a 1.0" pitch. Also, air-cooled versions have a front-panel SFP+ port, enabling fiber and CX4 copper applications for rack-to-rack and chassis-to-chassis communications. A Rear Transition Module (RTM) is optionally provided, and ruggedness meets MIL-STD-810 for VPX chassis ejection/injection stresses and also for environmental conditions.

Parvus Corporation, a Eurotech subsidiary | www.parvus.com | www.mil-embedded.com/p365631

Vetronics displays help with incremental upgrade path

Sometimes taking a huge leap forward in military technologies isn't reality – technologically or budget-wise – whereas incremental upgrades are often the name of the game. Case(s) in point: GE's IVD2010 and IVD2015 rugged intelligent vehicle displays, which provide an incremental, low-risk upgrade avenue for vetronics platforms. Designed for the tough environments that ground combat vehicles such as tanks occupy, these rugged displays are suited to gunner and commander display consoles, terrain visualization, 360-degree situational awareness, and embedded training. Boasting a high Technology Readiness Level (TRL), the displays are self-contained and COTS based, to minimize program risks and yield shorter time to deployment.

IVD2015 has a 15" screen, while the IVD2010 (pictured) has a 10.4" screen, both at 1,024 x 768 resolution. Powered by an Intel Core 2 Duo processor at 2.26 GHz and an NVIDIA GT 240 GPU (96 cores), the displays provide symbology and picture-in-picture overlay, meshing several videos into one panorama. Other notables are the displays' sunlight readability via LED illumination, also making the displays compatible with MIL-STD-3009 Night Vision Imaging System (NVIS) requirements. Toughened glass lends its high quality, and a multitouch resistive touch screen makes the displays user friendly. Options include MIL-STD-1553 or CANbus/MilCAN interfaces.

GE Intelligent Platforms | http://defense.ge-ip.com | www.mil-embedded.com/p369402

NIST-certified, rugged SSD provides AES encryption and durability

With national and technological security as vital concerns, Microsemi's NIST-certified TRRUST-Stor SSD aims to help government and military officials rest (at least a little bit) easier. Having recently achieved National Institute of Standards and Technology (NIST) certification for its hardware-implemented, 256-bit key AES encryption utilizing an XTS block cipher mode, the TRRUST-Stor SSD also works in tandem with other sanitization protocols and the company's TRRUST-Purge technology, which only needs less than 30 milliseconds for its data to become forensically unrecoverable when purge is activated.

The key to TRRUST-Stor's endurance is its concentration of processing power on wear leveling, error correction, and downtime/drive corruption elimination. As removable, nonvolatile, up-to-512 GB media, the SSDs are built to last in security-critical, rugged environments. For example, the MSD200 and MSD400 members of the TRRUST-Stor family can operate from -40 °C to +85 °C and are successfully stored at -55 °C to +105 °C, with vibration tolerance per MIL-STD-810F. With MTBF of more than 2 million hours and 100 percent burn-in – along with custom form factors and optional ruggedized SATA connectors – these SSDs aim to provide the security and durability needed for fighter aircraft, UAV, avionic, data recorder, ruggedized mobile system, vetronic, mobile manpack, and helicopter applications.

Microsemi | www.microsemi.com | www.mil-embedded.com/p365327

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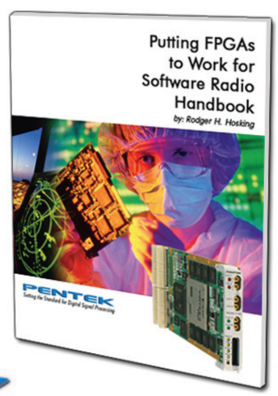

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