COTS® JOURNAL

Tech Focus: Ethernet Switch Boards Roundup

# SPACE ELECTRONICS

## GRAVITATE TOWARD OPEN ARCHITECTURES

Volume 9 Number 8 August 2007 www.cotsjournalonline.com

**PLUS:**

**Rugged Box-Level Systems Muster for Defense Apps**

**Cooling Challenges Drive Revamp in Materials and Mechanicals**

An RTC Group Publication

# Need a small system?

## PC/104

**2050 PC/104 SBC**

**2732 I/O card**

**HE 104 power supply**

| | | | | | |
|---|---|---|---|---|---|
| **2050** | –40° to 85° C | Ethernet | CompactFlash | | Linux & Windows available |
| **2060** | –40° to 85° C | Drives CRTs & flat panels | CompactFlash | | 265 MB DRAM for large programs |
| **2133** | –40° to 85° C | 17 digital I/O lines | Serial port used as console | | "headless" systems |
| **2732** | –40° to 85° C | Analog module, autocalibrating | 16-bit resolution | 32 analog inputs | Settings constant over temp. range |
| **2851** | –40° to 85° C | CardBus card adapter | Type I, II, III formats | Supports 8-, 16-, 32-bit data widths | Linux & Windows support |
| **HE 104** Mobile Power Supply | –40° to 85° C | 6–40 VDC input | 40–60 watts | +5V, +12V, –12V | Mounts on PC/104 stack |

# Need reliability?

## –40° to +85°

**EPIC™ XE–900 1.0 GHz CPU**

| Features | XE-900 | XE-800 | XE-700 |
|---|---|---|---|
| **CPU** | Via Eden | AMD Geode GXI | STPC |
| **Clock speed** | 400 MHz; 733 MHz; 1.0 GHz | 300 MHz | 133 MHz |
| **BIOS** | General software | Phoenix | Phoenix |
| **DRAM support** | to 256 MB | to 256 MB | 32/64 MB |
| **Compact/Flash** | Type I or II | Type I or II | Type I or II |
| **COM 1** | RS-232 | RS-232/422/485 | RS-232 |
| **COM 2** | RS-232 | RS-232/422/485 | RS-232/422/485 |
| **COM 3** | RS-232 | NA | RS-422/485 |
| **COM 4** | RS-232 | NA | RS-232 |
| **COM 5** | RS-232/422/285 | NA | NA |
| **COM6** | RS-422/485/TTL | NA | NA |
| **LPTI** | 0 | 0 | 1 |
| **EIDE** | 2 | 2 | 1 |
| **USB** | 2 | 6 | 2 |
| **CRT** | 1600 X 1200 | 1280 X 1024 | 1280 X 1024 |
| **Flat panel** | LVDS | yes | yes |
| **Digital I/O** | 24-bit prog. | 48-bit prog. | 24-bit prog. |
| **Ethernet** | 10/100 Base-T | Dual 10/100 Base-T | 10/100 Base-T |
| **Expansion** | PC/104 & *Plus* | PC/104 & *Plus* | PC/104 |
| **Power** | 3.6A operating | 1.6A max. | 1.6A max. |
| **Temp. range** | –40° to 70/85° C | –40° to 80° C | –40° to 80/85° C |
| **Shock/vibration** | 40/5g | 40/5g | 40/5g |

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COTS JOURNAL

# Features

August 2007 Volume 9 Number 8

## Special Feature

Stand-Alone Rugged Boxes



## Tech Recon

Cooling Solutions



## System Development

Space-Qualified Systems



## Technology Focus

Ethernet Switch Boards



## COTS View



COTS (kots), *n.* **1.** Commercial off-the-shelf. Terminology popularized in 1994 within U.S. DoD by SECDEF Wm. Perry's "Perry Memo" that changed military industry purchasing and design guidelines, making Mil-Specs acceptable only by waiver. COTS is generally defined for technology, goods and services as: a) using commercial business practices and specifications, b) not developed under government funding, c) offered for sale to the general market, d) still must meet the program ORD. **2.** Commercial business practices include the accepted practice of customer-paid minor modification to standard COTS products to meet the customer's unique requirements.

——**Ant.** When applied to the procurement of electronics for the U.S. Military, COTS is a procurement philosophy and does not imply commercial, office environment or any other durability grade. *E.g., rad-hard components designed and offered for sale to the general market are COTS if they were developed by the company and not under government funding.*

## Departments



**Coming in September...**

**...See** Page 69

**Cover Story ..... Page 42**

Circling in a low Earth orbit, the International Space Station is a research facility currently being assembled in outer space. The ISS is a joint project between the space agencies of the United States, Russia, Japan, Canada and several European countries. High-performance embedded computer systems are expected to play an increasing role for tasks like robotic control of docking between the ISS and visiting space vehicles.

*Courtesy: NASA*

# 20% More Power

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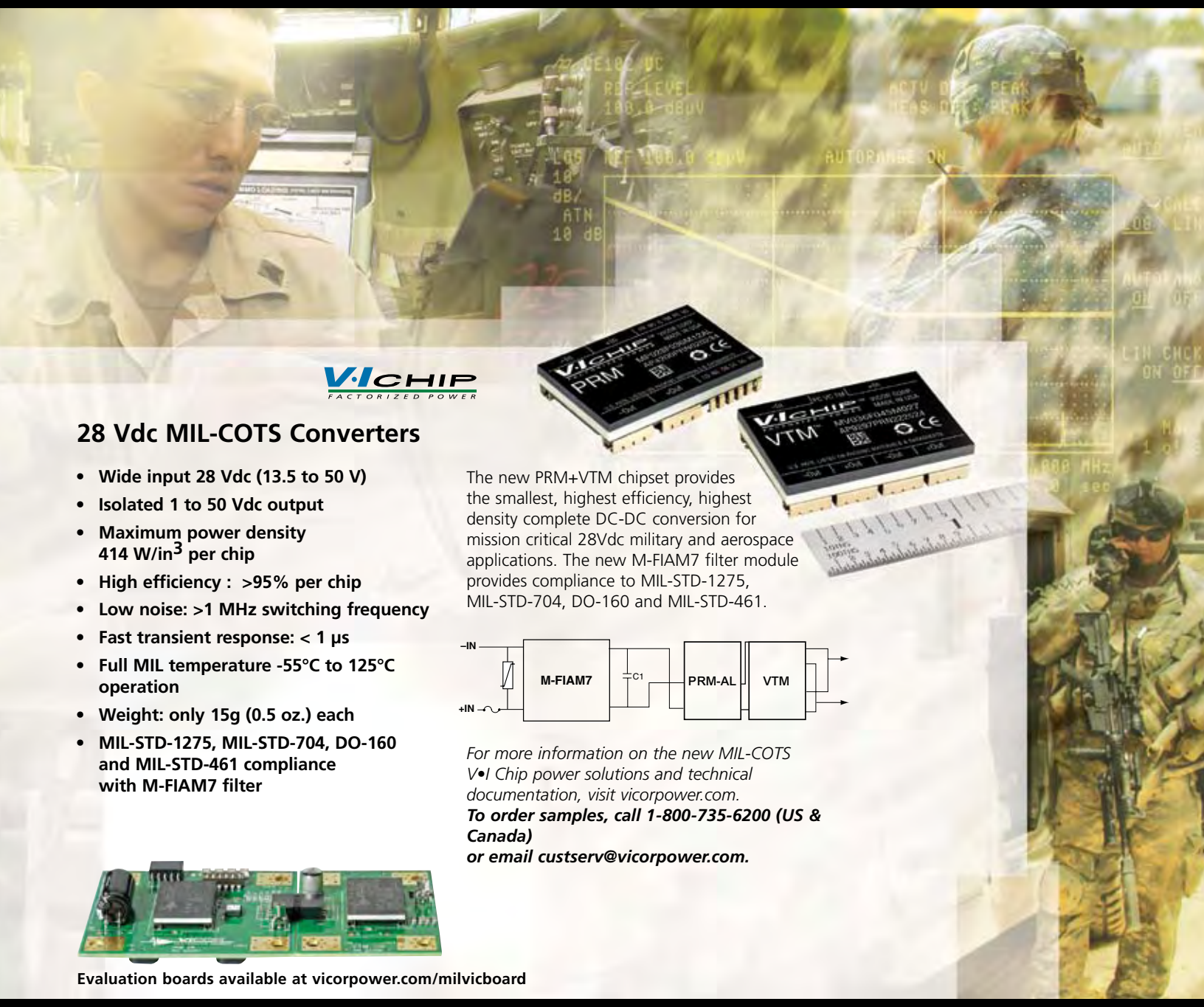

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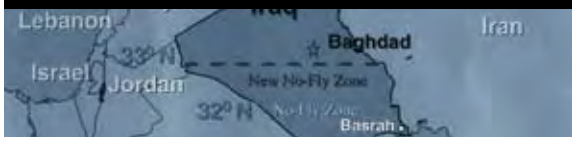


# What I Did on Summer Vacation

Here it is we're almost at the end of another summer. Most of us are probably starting to experience the same thing. The pressure is on to start thinking about back to school, the fall conference season, another federal budget, politics—I'm getting a headache just thinking about it. Back to today. Fellow employees are cycling through vacations, so is management and our company's customers. We have cookouts in the evenings, weekends at the park, go to the beach or mountains. And a lot more time in the office to surf the Web. For most of us there's less pressure in the summer than the rest of the year.

At present, I'm off for a couple weeks visiting my daughters and grandchildren. For refuge and to catch up, I brought all of the industry reading material with me that I hadn't had a chance to read before I left. To avoid commenting about how "I would do things" to the people I'm visiting, I seek out periods where I get away from everyone. Unfortunately I managed to catch up on all my reading in two days. Now I'm surfing the Web and really finding out what a vast universe of information it really is. To me the Web on the whole is like a big "Catch 22." You have to know the answer before you ask the question. If you know exactly what you want, you get virtually an unlimited number of places to get information. But if you don't know, you need some oracle to get you there.

For the most part I rely on proven "gateways" to specific information areas that I've used in the past, or else I Google. I don't want to say that Google is my last resort because for very specific things it's unbeatable. That said, when I'm not sure of exactly what I want and I just want to research a concept, it really doesn't help me much other than to frustrate me. For me, Google for that kind of research is like a big bicycle wheel and I'm at the hub. I run down one spoke and page through a lot of things that don't interest me, then back to the hub and down another. Eventually, I either get lucky or I give up and find someone or something to help me either narrow or broaden my efforts.

Warren Andrews, RTC Group's Editorial Director, and I once again were provided the opportunity to go to Kennedy Space Center (KSC) and participate in the Press Room for the STS-117 Shuttle Launch. Visits like this along with trips to "Deliverables" conferences like AUSA, LandWarNet, MILCOM, ESC, and so on, enable us and our editorial team to determine the focus of not only *COTS Journal*, but also the other RTC Group publications: *RTC*, *PKG* and *Portable Design*.

At a place like KSC, our communication is not only with the contractors that are supplying systems to the Shuttle and the future Crew Exploration Vehicle. We also exchange knowledge with editors of other attending publications that focus on "Deliverables," tapping their insights on where they view the direction of embedded technology and its utilization. Knowing the thought processes of system integrators supplying NASA and the military is essential to our readers and their company's success in supporting these integrators.

*COTS Journal* has a limited number of pages per issue and only thirteen issues per year, and we need to focus our editorial on where it will do the most good for our industry and us. Over the last few years we've been getting an increase in interest from readers regarding not only flight hardware but also support and training hardware for space programs. But then we've been getting an increase in all the other severe environment areas as well.

Trying to decide where to focus *COTS Journal*'s attention—what technologies may win, what may loose—in some ways is like buying a car. You can read government reports, study the budget, even government predictions, and you can search the Web, but at the end you need to get out there and kick a lot of tires in order to have real info. The fact that every member of our editorial team has decades of experience only keeps us from falling into cyclical traps and avoiding smoke and mirrors. We still need to be in the face of not only the people in our end of the industry, but also in the face of the people responsible for the "Deliverables."

It wasn't until I started working on my part of the *COTS Journal* future direction plan here in my daughter's house, that I realized I have many different "gateways" that I subconsciously use to make finding what I want on the Web easier and useful. Key among those gateways are publications that focus on our industry's customers. Deliverables-focused publications like *Aviation Week*, *National Defense*, *Signal*, *Defense News* and dozens more focus on programs—their issues, hopes and problems. These publications are part of my gateway that point me to areas on the Web to investigate global issues that I need answers to, to do my job. Without them I'd just keep going down a multitude of "spokes" that don't help me. These publications provide me with analysis, and most of the editors to these pubs—like the ones we met at the STS-117 launch—are old pros, screening the information provided by suppliers and the government. But then, who needs to screen what suppliers say or put all over the Web? They wouldn't think of being subjective in their material, would they?

Well, have a great summer, what's left of it. I wish I had brought more reading material—I mean gateways.

**Pete Yeatman, Publisher**
*COTS Journal*

COTS JOURNAL

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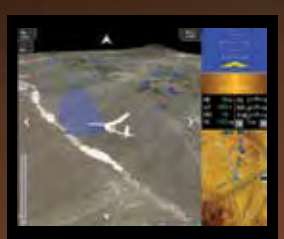

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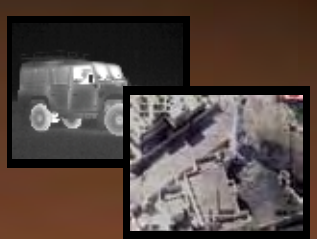

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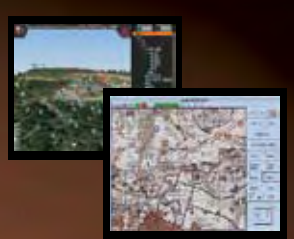

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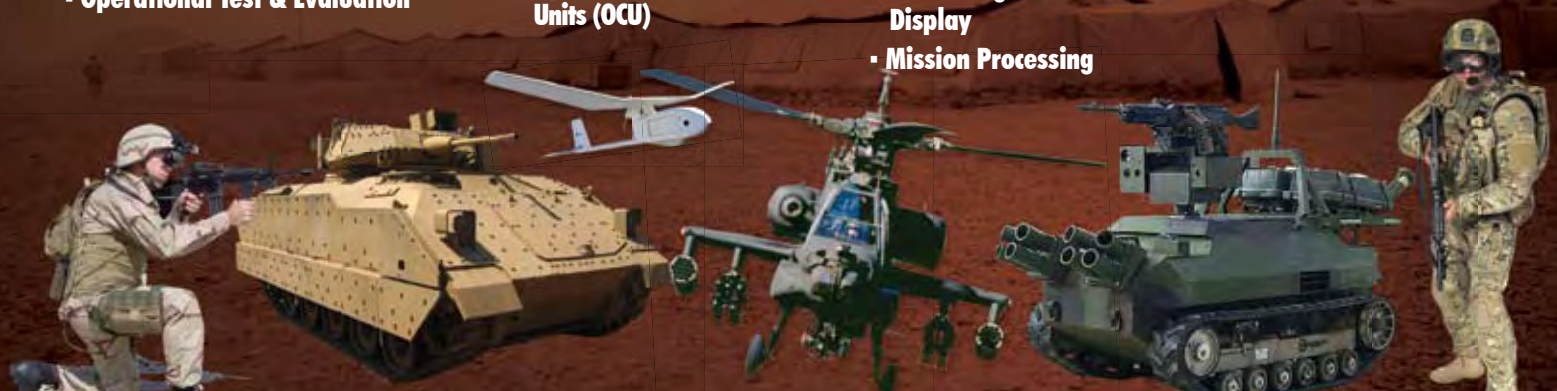

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# The Inside Track

## Raytheon Chooses GE Fanuc Embedded Systems SBCs for Zumwalt Destroyers

Raytheon Integrated Defense Systems (IDS) has selected GE Fanuc Embedded Systems to supply single board computers for the DDG 1000 destroyer. The DDG 1000 (Figure 1) is the lead ship in the Zumwalt class of next-generation, multi-mission surface combatants tailored for land attack and littoral dominance with capabilities designed to defeat current and projected threats as well as improve battle force defense. GE Fanuc Embedded Systems will supply PPC7A and PPC7D single board computers, and the PMCD3 multifunction PMC with up to three active Gigabit Ethernet ports.

The ship's network is called the Total Ship Computing Environment Infrastructure (TSCEI), and it implements the U.S. Navy's open architecture strategy. In January Raytheon announced the completion of a detailed design review of the TSCEI. The Zumwalt class ships rely on automation and networking to reduce the manpower that operates and supports the ship. The reduction is planned at 50% of the crew that is currently manning U.S. naval destroyers. Each ship has two 10 Gbit Ethernet backbones, with Ethernet switches to bridge the backbone to 1 Gbit Ethernet interfaces.

Figure 1

Zumwalt is the lead ship of a class of next-generation multi-mission surface combatants tailored for land attack and littoral dominance with capabilities that defeat current and projected threats and improve battle force defense. The ship will carry the designation and hull number DDG 1000. The image shown here is an artist's rendering of the DD(X) next-gen destroyer.

The TSCEI will use the PPC7A, PPC7D and PMCD3 boards to meet the network connectivity requirements for hardware, firmware and software of the Distributed Adaptation Processor (DAP), which bridges the VME64x-based embedded computing systems used for vertical launch of missiles, gun systems, radar, sonar, decoys, and to supply power to the TSCEI. Two ships are currently being built by separate contractors, with the potential for a joint effort to build a third. Eight ships are currently scheduled to be built.

GE Fanuc Embedded Systems
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[www.gefanucembedded.com].

## NASA Taps Tek Microsystems VXS Boards for TDRS System

TEK Microsystems has received an initial order from the NASA Glenn Research Center in Cleveland, OH for its first VXS-based satellite communications development system. The system will be used for Tracking and Data Relay Satellite System (TDRSS) compatibility test sets as part of the Space Communications and Navigation (SCaN) Program. NASA's SCaN Program is responsible for providing communications and navigation services to the Agency's flight missions and for supplying terrestrial communications needs. The initial order is part of a proof-of-concept system. Successful development may result in additional orders.

The delivered Tekmicro systems will include Callisto, Janus and Neptune 2 VXS boards. By providing a massive FPGA processing resource at the heart of the VXS communications fabric, Callisto achieves an optimal balance between processing power and I/O bandwidth; maximizing the value that can be extracted from the use of FPGAs for signal processing. Janus combines FPGA-based DSP processing technology with seven channels of 16-bit, 500 Msamples/s DAC. The Janus 6U VME/VXS payload card is the first to provide seven channels of output in one VXS slot with this resolution. It provides a highly flexible platform building block for a number of military signal processing applications. Neptune 2 combines FPGA technology with a dual channel, 2.2 Gsamples/s architecture.

TEK Microsystems
Chelmsford MA.
(978) 244-9200.
[www.tekmicro.com].

## X-49A VTDP Helicopter Demonstrator Achieves First Flight

Piasecki Aircraft Corp. (PiAC) has achieved first flight of its X-49A Vectored Thrust Ducted Propeller (VTDP) Compound Helicopter Technology demonstrator. The VTDP is a second generation of PiAC's "Ring-Tail" ducted fan compound helicopter technology that replaces the conventional helicopter's tail rotor. In addition to providing anti-torque and yaw control, the VTDP (Figure 2) also provides forward thrust and thrust vectoring control. In combination with a lifting wing and modification to the flight control, propulsion and other systems, PiAC believes the VTDP Compound offers significant improvement to helicopter speed, range, ceiling, survivability and life cycle costs.

This program is a U.S. Army Advanced Technology Demonstration (ATD) initiative being managed by the Aviation Applied Technology Directorate, Fort Eustis, VA. Successful flight demonstration of this technology will provide the Services a basis for assessing potential applica-

Figure 2

The VTDP is a second generation of PiAC's "Ring-Tail" ducted fan compound helicopter technology that replaces the conventional helicopter's tail rotor.

tion of this technology to upgrade existing helicopter platforms such as the H-60, AH-64 and Marine Corps H-1 helicopters, as well as expand the technology base for future potential platforms, such as the Joint Multi-Role rotorcraft.

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## NASA Tasks NI's LabVIEW FPGA for James Webb Space Telescope Test

The James Webb Space Telescope (JWST), NASA's next-generation successor to the Hubble, has passed a crucial milestone toward its 2013 launch using National Instrument's LabVIEW FPGA. An important element of the JWST (Figure 3) is the Near Infrared Spectrograph (NIRSpec), which is equipped with more than 250,000 microshutters designed to observe thousands of distant galaxies to better understand the origins of the universe. These microshutters are actually microelectromechanical system (MEMS) devices that physically open and close for light exposure, similar to shutters on a camera. Engineers at the NASA Goddard Space Flight Center have successfully tested the microshutters using LabVIEW FPGA to control the shutters in a test chamber.

NASA selected Mink Hollow Systems, a National Instruments Alliance Partner, to develop the

Figure 3

The James Webb Space Telescope (JWST) is NASA's next-generation successor to the Hubble. Shown here is a life-sized model of the JWST, which was on display at the AAS annual meeting in Seattle, WA. It stands two stories high and weighs several tons.

FPGA software required for a test application capable of not only actuating each of the nearly 62,000 microshutters that are tested at a time, but also providing design feedback and estimating the life of each unit. NASA engineers pulled the shutters open by sweeping a magnet, controlled with National Instruments PXI-7344 motion controllers, across the array of shutters. They controlled the individual shutters within each array through National Instruments PXI-7811R and PXI-7813R intelligent data acquisition (DAQ) modules.

National Instruments
Austin, TX.
(512) 683-0100.
[www.ni.com].

## Silvus Supports DARPA MIMO Project with Multi-Antenna Radio Solution

Silvus Communications Systems has announced a MIMO-capable radio platform, the SC 2000, as an optional IP solution for the military market. The device will support a variety of DARPA Projects, including the DARPA MNM (Mobile Networked MIMO) phase 2/3 program. Last fall Silvus was chosen as the only performer on the project.

Silvus provides Ready-to-Implement Radio Platform solutions based on Xilinx FPGA implementations and Nallatech hardware. For those customers that prefer to utilize their own internally designed Radio Platforms, Silvus provides a licensing model where the MIMO-capable PHY can be "dropped into" a Xilinx FPGA. The drop-in solution provides a mode-rich, packet-based OFDM-PHY that can deliver in excess of 300 modes ranging from 1.5 Mbits/s to 150 Mbits/s in non-line-of-sight and multipath rich environments. Many of these modes have been demonstrated and verified, by DARPA, including 60 Mph mobility and greater than 1 km coverage. Among the areas the technology is applicable to are Digital Battlefield/Network Centric Warfare, C4ISR, CIED, Urban Warfare, along with UAV, surface ship and ground vehicle electronics that require optimum performance and serviceability in range, transmit power and data rate.

Silvus Communication Systems
Los Angeles, CA.
(310) 479-3333.
[www.silvuscom.com].

## Air Force Validates Edgewater's Extended 1553 Technology

On board a U.S. Air Force F-16 at the Air National Guard (ANG) Air Force Reserve Command (AFRC) Test Center (AATC) in Tucson, AZ, Edgewater Computer Systems's Extended 1553 data bus technology successfully completed a flight test. The primary purpose of the test was to demonstrate an increase in network capacity roughly 100 times the legacy throughput with no interference to the legacy 1553 system.

During the flight test, the ANG Block 30 F-16 (Figure 4) performed typical mission flight and aircraft maneuvers including multiple-target tracking with radar and

Figure 4

During the flight test for the Extended 1553 technology, an F-16 performed typical mission flight and aircraft maneuvers including multiple-target tracking with radar and sensor systems and high-G turns. Extended 1553 operated with no interference or impact to the legacy 1553 operations before, during or after the flight test while high-speed video traffic was communicated bi-directionally across the E1553 network.

sensor systems and high-G turns. Extended 1553 operated concurrently with the legacy 1553 operation. There was no interference or impact to the legacy 1553 operations before, during or after the flight test while high-speed video traffic was communicated bi-directionally across the E1553 network. Two flight-certified line replaceable units (LRUs) were equipped with E1553 network interface cards—a programmable display generator (CPDG) and a commercial central interface unit (CCIU), both provided by advanced storage-management systems company EFW, color multi-function displays, display processors, digital moving maps and helmet-mounted cueing systems specifically for F-16 aircraft. This flight test is a significant milestone for the E1553 project and solidifies that the technology is at an advanced technical readiness level in support of operational flight.

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## DCVC Web Site Provides Commercial Vendors a Voice in Acquisition Reform

The Defense Commercial Vendors Coalition (DCVC) is an organization comprised of commercial vendors in the defense industry that champion acquisition reform and promote a free market of competing commercial products and technologies for use in DoD applications. The group was formed to elevate awareness and provide a voice for commercial products and other readily available capabilities that have been otherwise overlooked or reinvented in past DoD programs.


The DCVC's Web site gathers a wealth of resources that support their mission. There are success stories about officials, programs and contractors who have successfully used readily available capabilities from the marketplace to save cost, accelerate schedule and reduce risk. Visitors to the site can peruse articles, papers and other information that references the benefits of commercially available products/technologies and their use in the DoD. They can also review the hearings of those who have testified before Congress—including DCVC representatives—in regard to the issues with the DoD acquisition system. Registered members can also access the DCVC's ever growing "Reinvention List." This growing list cites DoD technologies that were built from scratch rather than bought off-the-shelf, when commercial products were available. Members may also submit additional citations that will be anonymously posted.

Defense Commercial Vendors Coalition,
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# Special Feature

Stand-Alone Rugged Boxes

# Rugged Box-Level Systems Move to Center Stage

The trend toward complete stand-alone rugged box-level systems continues to pick up steam. Mobile military applications are on the front ranks of the early adopters.

Jeff Child
Editor-in-Chief

A trend has been gathering momentum in the past couple years whereby traditional embedded board vendors are adding stand-alone rugged box-level systems to their military market offerings. These complete system boxes—which often support standard form-factor boards inside them—provide a complete, tested and enclosed computing solution that eliminates complex integration chores for customers.

The trend toward vendors in the embedded computer market offering ever more complete systems is nothing new. It's been steadily gaining steam for the past seven or so years. But within the last 18 months the concept has really become a fixture in this market. As a product category, stand-alone rugged boxes are somewhat difficult to define

Figure 1

New unmanned ground vehicles (UGVs) now in development are expected to rely heavily on stand-alone rugged box-level systems. Examples include the UGVs that are part of the FCS program: the Armed Robotic Vehicle (ARV), the Multifunction Utility/Logistics and Equipment Vehicle (MULE), and the Small Unmanned Ground Vehicle (SUGV). Shown here is a prototype demonstrator for those kinds of unmanned ground platforms. *(Photo courtesy of BEA Systems.)*

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Figure 2

Octagon Systems' XMB Mobile Server product blends the complete system approach with the ability to mix and match I/O and other functions via PC/104 add-in cards. The basic unit includes the processing power, power supply, memory and I/O for most applications. Additional I/O such as GPS, analog, GPRS and video camera can be readily added via PC/104, PC/104-Plus and XBLOK modules.

because they're available in a variety of shapes, sizes and capabilities. They typically comprise a set of modular embedded boards housed in a rugged enclosure that has its own power supply and interface ports to link to a variety of user terminals.

## Drive for Integrated Computing Muscle

Much of what's driving this trend toward rugged box-level systems comes from the current war effort. The push is to minimize size, weight and power, while cramming in more Gflops per watt to boost the processing muscle in smaller UAVs and unmanned ground vehicles (UGVs) (Figure 1), and on larger platforms such as JSTARS. Often the boards in the box are standards-based cards such as PC/104, PMC and 3U CompactPCI. But the enclosures by and large aren't in any industry standard footprint, although that may change as standards like MicroTCA and some box-level VITA standards gain acceptance in the military realm.

This new area of rugged boxes is outside the category of ATR enclosures—although those continue to be a main staple of many military and avionics systems. Rugged box-level systems in contrast are typically sold as a complete working system, often with some degree of environmental testing done beforehand by the vendor. The system is typically designed to work as stand-alone, plugged into whatever I/O and user interface scheme meets the application need.

The stand-alone rugged box trend also is separate from the strategy know as "appliqué,"—the term used by the DoD for its initiative under that name a couple years ago. Appliqué involves complete computer units—like rugged laptops—that are applied or woven onto existing weapons platforms and integrated with government-furnished software. In some sense, stand-alone rugged boxes are a competing trend to appliqué because they overlap somewhat as solutions.

## Widespread Product Offerings

At present, there are more than a dozen vendors that have some sort of stand-alone rugged box-level system in their offerings—many even have whole product lines in that category. Among these are Advantech, Aitech Computers, AP Labs, Curtiss-Wright, DRS Technologies, General Micro Systems, GE Fanuc Embedded Systems, Macrolink, MEN Micro, Octagon Systems, Parvus, Quantum 3D, Rave Computer, RTD Embedded Technologies, Tracewell Systems, VersaLogic and VMETRO.

Exemplifying the stand-alone rugged box trend is Octagon Systems' XMB Mobile Server product (Figure 2). The drawback to a complete all-in-one system has always been the lack of flexibility to customize to application requirements. With that in mind, Octagon Systems nullified that drawback by offering a product that marries the complete system approach with the ability to mix and match I/O and other functions via PC/104 add-in cards. The basic unit includes the processing power, power supply, memory and I/O for most applications.

Standard I/O includes dual Ethernet, quad USB 2.0, dual serial, CRT and LCD video and digital I/O. Because the XMB-1 is fully functional out-of-the-box, additional I/O such as GPS, analog, GPRS and video camera can be readily added via PC/104, PC/104-Plus and XBLOK modules. An option panel can be easily removed and punched for custom annunciators, connectors and controls. Generated heat is efficiently channeled directly to the case to help prevent internal hot spots. The XMB Mobile Server operates in ambient temperatures from -40° to 75°C, depending upon the processor speed, user options and mass storage devices.

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Figure 3

Quantum3D has added three new small form-factor computers—Models 6300, 3500 and TL—to its Thermite TVC-2.0 family of multi-role, real-time, 2D/3D COTS Tactical Visual Computers (TVCs).

Taking a specific focus toward applications such as UAVs and ground combat vehicles as well as portable computing units for troop field use is GE Fanuc's Rugged Operational Computer (ROC) (Figure 3). Weighing less than six pounds and measuring less than 100 cubic inches, the ROC fits well into the tight spaces usually found in military vehicle applications. The ROC can be configured with an Intel or PowerPC processor PMC.

## Stacked PMC Architecture

The ROC chassis has a modular stacked PMC architecture, an integrated 100W power supply and EMI filter, and a solid-state fast Compact Flash disk with up to 128 Gbytes of memory mounted on a PMC carrier module. A one-ROC System Enclosure includes one system chassis, one power supply and one single board computer. A two-ROC System Enclosure includes two system chassis, one power supply, one single board computer, one 8-channel high-speed serial PMC and one dual redundant MIL-STD 1553 PMC.

Serving the need for low-power, fanless operation, WIN Enterprises offers an enclosed computer designed for the embedded OEMs designing applications for harsh environments. The PL-06058 is powered by a 34W Intel Celeron M ULV or Pentium M processor with low power requirements. The fanless unit provides silent operation where ambient noise is unwanted. Internal heat pipes conduct heat to the aggressive heat-sink design of the rugged aluminum enclosure.

The PL-06058 is an enclosed version of WIN's popular IP-06058 single board computer (SBC). The PL-06058 is suited for scientific, military and aerospace applications. The compact unit supports a CompactFlash socket, Mini-PCI slot and up to 1 Gbyte of DDR RAM. Also featured are: one 10/100 Ethernet port, four serial ports, one parallel port, an IDE interface, three USB 2.0 ports and a FDD interface packaged into an industrial grade enclosure of 12.3 (width) x 5.5 (depth) x 2.6 (height) inches.

## MIL-STD-810F Testing

One of the major advantages of the stand-alone rugged box is the pre-testing for shock and vibration specs often done by the vendor. An example along those lines is Parvus's DuraCOR 810, a rugged military-grade processor system designed for high-reliability applications requiring MIL-STD-810F environmental compliance with extreme temperatures, shock/vibration and ingress. Mechanically designed with considerations for dust exposure, water immersion, EMI/EMC, corrosion resistance, power protection and system mobility, this field-ready computer integrates a low-power 1.4 GHz Pentium M processor (equivalent to a 2.8 GHz Pentium 4) together with a MIL-STD-704/1275-compliant power supply securely mounted in an aluminum PC/104 card cage. Up to six spare slots are available for PC/104-Plus expansion cards. To enable rapid deployment, a solid-state disk comes pre-loaded with a Linux or Windows XP Embedded operating system image.

Locking MIL-DTL-38999 circular connectors bring out a rugged RJ-45 Ethernet connection, four USB ports, two RS-232 ports, VGA Video, Keyboard, Mouse and Audio signals, as well as an expansion connector for up to 79 signals from optional add-on cards. A cable-less internal interconnect scheme is used to ensure high reliability, signal integrity and ease of customization.

## Battle-Ready cPCI Chassis

Representing a blend of traditional ATRs and the rugged box trend is the battle-ready Modular Tactical Computer (MTC) from Curtiss-Wright Controls Embedded Computing (CWCEC). The MTC is a complete subsystem containing a 5-slot CompactPCI backplane. Designed for the harshest environments, it's fully configured and ready for immediate integration into applications such as fire control, mission computing or network-centric communications.

The core of the MTC is a single board computer running the low-power 800 MHz IBM 750FX PowerPC (1856 Dhrystone Mips). There are 256 Mbytes of ECC DRAM, Ethernet, nine serial channels and three dual-redundant MIL-STD-1553 buses. Also, the MTC can be ordered with a Gigabit Ethernet switch or a 50 ms power holdup (handy in military platforms). Finally, there are 20 digital/analog input channels. Designed around the PICMG 2.16 (switched Ethernet) standard, the MTC is ideal for high-speed interboard connectivity applications such as radar processing.

## From a Different Direction

Most rugged-box vendors are traditional board-level product vendors who expanded up the food chain by adding box-level products to their offerings. In contrast, Quantum3D began in the small, wearable computing space and expanded into rugged box-level systems for larger form-factor applications. In March, Quantum3D added three new small form-factor computers—Models 6300, 3500 and TL—to its Thermite TVC-2.0 family (Figure 4). These multi-role, real-time, 2D/3D COTS Tactical Visual Computers (TVCs) have been specifically designed to support real-time visual computing applications in both vehicle-based and man-wearable deployed environments.

The Model 6300 operates in conjunction with a companion Vehicle Mounting Dock (VMD), which features an integral, rugged blind-mate connector and a host of available vehicle-specific I/O capabilities, including MIL-STD-1553A/B and CANbus, and a range of rotating and solid-state drive options. The Thermite TVC-2.0 3500 is optimized for vehicle-based visual computing applications where fixed mounting options are permissible and mounting space, power and weight are at a premium. ■■

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# Special Feature

Stand-Alone Rugged Boxes

# Rugged Boxes Entrench into Military Embedded Computing

As complex computing functions increase their role in large defense programs, the demand is rising for pre-integrated rugged box-level solutions.

Ken Armitage, Director, Systems Applications Integration, GE Fanuc Embedded Systems

In an ideal marketplace, there is an exact fit between what customers want to buy and what manufacturers want to sell. That's becoming increasingly the case in the military and aerospace market, driven by two key factors. On the one hand, military programs are becoming increasingly sophisticated and complex. Take, for example, the U.S. Army's Future Combat Systems (FCS) (Figure 1), a program designed to reflect the very different kind of warfare in which today's armed forces are involved. It is envisioned as a "system of systems," in which several different technology and application initiatives will combine to deliver a unified computing strategy. The result of this first major modernization initiative in decades will be a family of manned and unmanned systems, connected via a network, and planned to deliver the overwhelming technology superiority demanded by the armed forces.

FCS may be the largest and highest profile defense technology program, but it is representative of the challenges faced by the industry's prime contractors. Where smaller, more bounded programs enabled prime contractors to take responsibility for even the smallest details, these larger programs mean they no longer have that "luxury." They are largely unanimous in declaring their need for help with lower-level minutiae—and they're calling on their traditional suppliers to deliver that help.

## Price a Factor

The supply-side factor is the need for manufacturers to maintain and improve

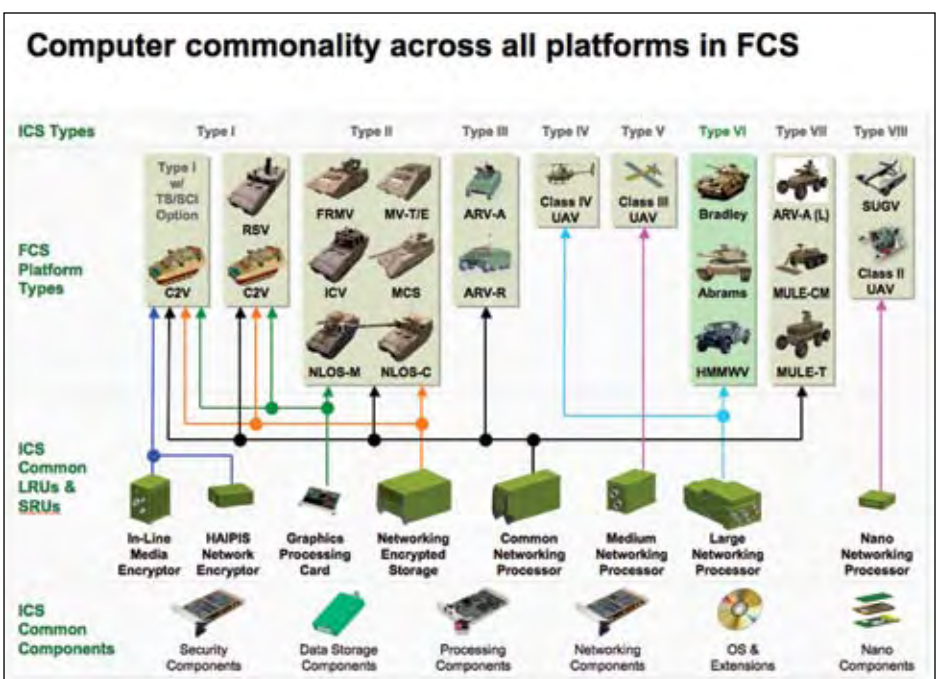


Figure 1

The U.S. Army's Future Combat Systems (FCS) program is designed to be a "system of systems," in which several different technology and application initiatives will combine to deliver a unified computing strategy. Large programs like FCS are largely unanimous in their help with lower-level minutiae—and they're calling on subsystem suppliers to deliver that help.

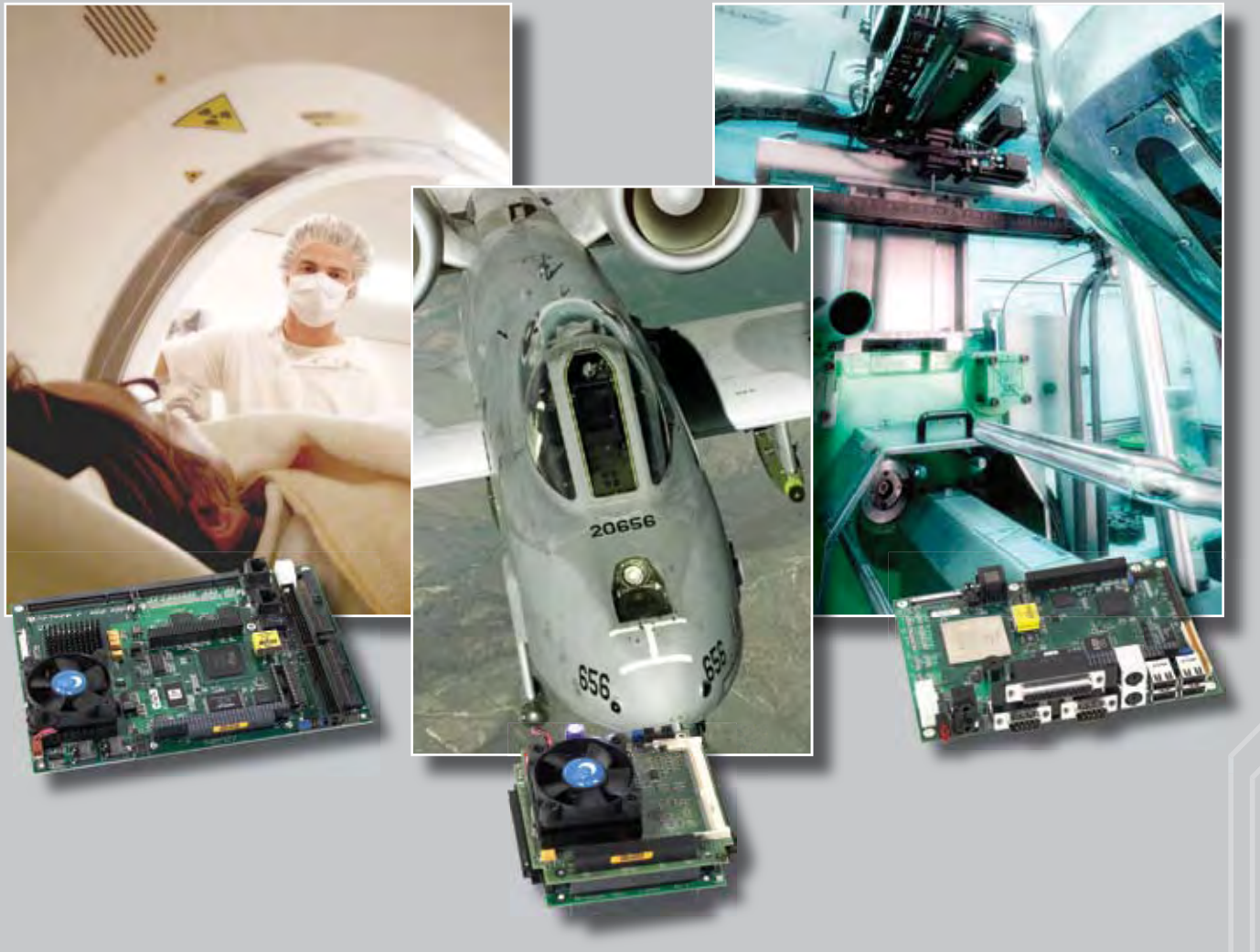


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Figure 2

In the category of "vertical" rugged box is GE Fanuc Embedded Systems' 3U VPX MAGIC1 rugged display computer. The unit is configured with processor card, graphics processor and all necessary I/O within an appropriate enclosure. It brings a desktop gaming graphics processing capability and a 16-lane PCI Express fabric.

profitability in a market that is, almost by definition, price-driven. The military and aerospace market is a highly price-sensitive one—differences of a few dollars at a component or board level multiplied throughout a program can become differences of hundreds of thousands or even millions of dollars. And each dollar of expenditure is funded by an increasingly inquisitive taxpayer.

The pressure is on manufacturers to find new profit streams by adding more value, and low level integration of functional subsystems, in response to prime contractor requirements, is attracting increasing attention. But what are these subsystems? By definition, being developed for military applications, they are rugged. And they are, to all intents and purposes, "plug and play"—coming preconfigured with the appropriate hardware and software to allow them, with the addition of application software, to become productive out of the box.

## Plug and Play Generation

Interestingly, the move toward plug and play may also be a function of the changing nature of the engineers working on the military programs of the future. There is unquestionably truth in a remark made by an engineering manager: "Tomorrow's systems are being designed by today's engineers—who were yesterday's graduates." The implication is, of course, that tomorrow's engineers will be very accustomed to the concept of plug and play. In fact, their skill set may be a very different one from that of their predecessors, such that working in any other way is simply not intuitive.

Of course, that's something of an over-simplification, but it illustrates the fundamental concept that the ideal subsystem needs no further integration, validation or testing by the customer. The prime contractor has not had to concern himself with identifying an appropriate enclosure or chassis, with ensuring the interoperability of the chosen boards, or with devising appropriate cooling strategies. That has all been done, allowing him to focus on how this subsystem fits within the broader program landscape.

The challenge for suppliers to the prime contractors is to identify the opportunity to add value—to design and develop complete, integrated, plug and play rugged subsystems that fulfil the requirement for a "black box" that performs a mathematically classical "transfer function"—taking data, processing it and outputting information. The prime contractor's responsibility for the subsystem ends, in effect, with getting an input into the box, and begins again as the information comes out of the box.

The difficulty for manufacturers is how to identify the "silver bullet" applications where the design, development and manufacture of a rugged box would add real value for the prime contractor. It is a fact of life that, generally, traditional board manufacturers are at least one step removed from the final application—giving them minimal visibility into the final application.

## Three Approaches

All that said, progress is certainly being made. The approaches being taken can perhaps be defined as custom-to-generic, horizontal and vertical (Table 1). Perhaps the best guide to likely future re-

quirements is the one-off, bespoke boxes that have been developed in response to specific customer requirements, and that have the potential—once customer-proprietary elements have been eliminated—to become off-the-shelf solutions. An example of this approach would be a subsystem recently developed for a UAV program.

The original requirement was customer-driven: a complete, self-contained subsystem into which a customer-proprietary image processing board needed to be installed. From the customer's point of view, subcontracting the entire system allowed a third party—in this case, GE Fanuc Embedded Systems—to take responsibility not only for the design and manufacture of the subsystem, but also for its integration and testing. The complete "box" could then be delivered to the customer and placed in stock, ready for final deployment within the UAV.

While the requirements of the system dictated the provision of five slots, analysis of the available space and weight indicated that a six-slot system was possible. This allowed the potential for the insertion of an additional board; the provision of additional functionality; and the opportunity to reuse the same, proven architecture for other applications. A subsystem started life as a custom program, but taking the rugged box approach at the design stage saw the potential of creating a generic solution. It's a question of mindset—a mindset that would see, for example, the development of a custom fire control system into an off the shelf fire control system, capable of being deployed in a range of platforms much broader than the original intention.

| Application Type | Application Target |
|---|---|
| Custom-to-generic | From single customer to multi customers |
| Horizontal | Broadly applicable solution |
| Vertical | Application-specific solution |

Table 1

Rugged box development is typically initiated in one of these three ways.

## Horizontal Applications

The horizontal approach sees the identification of an application that is common across multiple environments. Here, the industry has thus far reacted primarily with "'development systems:" hardware and software preconfigured, integrated and tested as a single plug and play package, designed to make developers immediately productive. Invariably, such systems are scalable, allowing for larger, powerful systems for development and smaller, compatible systems for deployment. Similarly, they are typically available for use in either benign or harsh environments.

The current predominance of horizontal rugged boxes is perhaps explained by the fact that specific domain expertise—which, as noted earlier, traditional board vendors typically do not have—is less of a requirement in the development of the solution, which can be said to be a "generic" application. That said, a fundamental appreciation of the end application is, of course, imperative—and that appreciation can be derived from extensive experience in working closely with customers.

An example of the horizontal development system would be a hardware platform configured with both general-purpose processors and FPGA processors for the development of sophisticated signal processing applications, together with a sophisticated software development tool such as the AXIS Advanced Multiprocessor Integrated Software environment from GE Fanuc Embedded Systems. The design rationale behind this kind of rugged box would take on board a number of factors. It would be pre-configured,

pre-integrated and pre-tested—saving the end customer valuable implementation and validation time. The inclusion of a development software environment—itself pre-installed, and the hardware/software combination fully validated—would ensure not only reliable operation out of the box, but also improved developer productivity.

## Vertical Applications

The most recent, and perhaps most exciting developments in rugged boxes for military applications, however, see board vendors gaining more insight into end applications—and with this insight comes rugged boxes designed to address specific vertical applications. These applications arise as a result of two key vectors in military embedded computing. On the one hand, applications are becoming increasingly diverse as the military looks to leverage available technology in new ways—and on the other, the advent of serial switched fabrics—notably via the VPX specification—is enabling the creation of multiple interconnected, but discrete, functional subsystems. It is also true, as noted previously, that major programs such as FCS encompass the principle of multiple distributed small subsystems, rather than the monolithic architectures that have characterized military computing in the past.

A possible example of a vertical rugged box—"possible" because there is an extent to which graphics is a horizontal application, if less horizontal than development or signal processing—might be a complete graphics subsystem like the GE Fanuc Embedded Systems 3U VPX MAGIC1 rugged display computer (Figure 2), configured with processor card, graphics processor and all necessary I/O within an appropriate enclosure. Here, the design rationale recognizes the increasingly sophisticated imaging requirements of modern military applications in simulation and situational awareness for example, and the solution provides a desktop gaming graphics processing capability that would more usually be associated with games like Call of Duty, Battlefield or Counter-Strike: Source. 16-lane PCI Express allows for the highest performance communications between the NVIDIA GPU and a processor based on Intel's Core Duo processing technology. By definition, given its target market, it is both rugged and small/lightweight.

But if graphics is somewhere between a horizontal and a vertical application, a possible application of the MAGIC1 would see it moving from a generic graphics application box to become an embedded training box, designed to fit in a wide variety of vehicles to allow troop training during periods of down time. Embedded training sees, in effect, the use of sophisticated simulation—using virtual synthetic environments—running on subsystems embedded within operational equipment, and which may or may not be integrated with the onboard graphics/imaging capability. In either event, it is a complete, discreet subsystem that lends itself well to the rugged box principle.

## Rugged Boxes and the Future

Rugged boxes are nothing new. What is new, however, is the accelerating rate at which they are coming to the military market, driven by the needs of the prime contractors to focus on their key value added and eliminate time and effort spent on lower level tasks. They do so by the increasing sophistication of military applications, and the network-centric nature of the battlefields of the future; by the need of vendors to add value in a marketplace that, by definition, is often a price-driven marketplace. They also depend on rapid advances in embedded computing technology, which are enabling higher degrees of functional integration at the board level. That's enabling flexible, high performance yet small and lightweight rugged subsystems to be integrated in a way that was inconceivable only a few years ago. For this industry it looks like rugged boxes are the future. ▮▮

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# Application Needs Drive Rugged System Choices

Standard modular computing solutions abound for military system designers. Cost, level of ruggedization and I/O flexibility all must factor into the architecture choice.

Steve Cooper, President
One Stop Systems

Quickly deploying low-cost, state-of-the art technology remains a challenge for military system developers. Designers have found that most military applications can be solved using various off-the-shelf modules based on standard architectures. Choosing the right architecture depends on the level of modularity and ruggedness required for the application. In military applications where extreme ruggedness is required, special enclosures can be used to protect the embedded computing electronics from the harsh environments.

Choosing the right bus architecture for the right application is the key to optimizing the cost and technology timeliness of the system. Figure 1 illustrates several bus structure choices and their applicability based on cost and modular flexibility. Applications that require a low level of modularity and ruggedness can use existing PCs and laptops. These have become increasingly robust over the past few years and you can't beat the cost-effectiveness and timeliness of the included technology. In particular, rackmount ATX-based motherboard systems are deployed in a number of airborne-, shipborne- and submarine-based applications. The modularity limitations of these systems are related to the relatively small number of I/O slots available for expansion.

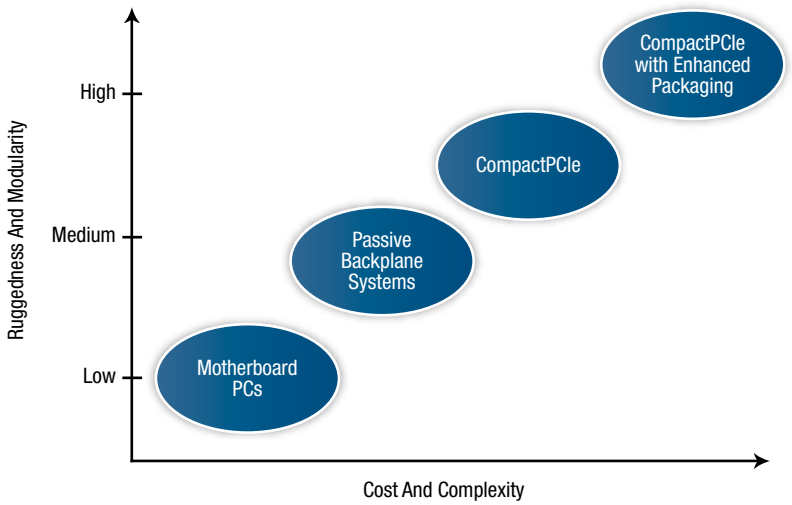


Figure 1

Different bus structures are appropriate for applications with different levels of modularity and ruggedness needs.

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Figure 2

Passive backplane systems provide more I/O slots and higher power.

## Ruggedizing Issues

For rugged systems the problems tend to occur in higher vibration environments where the DRAM DIMMs may pop out, internal cards and cables may come off or the cards with card edge connectors become intermittent due to dirty connectors. The long rectangular shape of the PC I/O cards compounds vibration issues, with only the card edge connector and faceplate to hold them in place. Hard disk drives, which historically have had a lot of problems with shock and vibration, are much more rugged now, and can typically be replaced with fully solid-state flash disks if needed.

In applications that require a medium level of modularity and ruggedness, designers often upgrade to passive backplane systems, where the CPU functions are provided on an add-in board, and thus the backplane is relatively passive. A wide variety of backplanes are available, and semi-custom backplane variations are easy to create.

With the passive backplane architecture, it is straightforward to add up to 20 slots in a chassis, or to have multiple CPU boards per chassis. These chassis typically have larger, higher-performance and redundant power supplies. Due to the large slot count and robust power supplies, passive backplane systems are often referred to as the "lots of slots and watts" solution. Passive backplane systems such as the one shown in Figure 2 provide tremendous flexibility, but still have the ruggedness limitations of the card edge connector and rectangular physical shape of the I/O boards.

## VME, cPCI and cPCIe

For applications that need a high level of modularity and ruggedness, VMEbus, CompactPCI and most recently CompactPCIe—cPCI with PCI Express—come into play. These structures define up to 21 slots and have a much larger board area per slot. This allows a great deal of electronics to be housed in a single chassis. The connectors, board shape and mounting provisions for CompactPCIe are particularly well suited for harsh environments.

Figure 3

3U boards measuring 6 x 4 inches, with all four sides held in place, offer a shape and mounting that's very rugged and increasingly popular in military applications.

The 6U board is approximately 6 x 9 inches with all four sides held in place. The 3U boards, as shown in Figure 3, measure 6 x 4 inches, again with all four sides held in place. This shape and mounting make these boards very rugged and increasingly popular in military applications. The connectors use the contamination-resistant pin-and-socket style. Airflow

is also improved as the air is channeled from bottom to top of the board by the faceplate on one side and the backplane on the other.

Many military applications use CompactPCIe modules and chassis as is, but for those applications that demand more ruggedness, additional features can be added to improve shock and vibration resistance, extend the operating temperature, reduce EMI radiation and provide independent system monitoring and alarming. The system shown in Figure 4 is based on the chassis within a chassis concept, where a normal CompactPCIe chassis is shock mounted within a larger rugged enclosure. This provides exceptional shock, vibration and EMI suppression, and is often the technique used to allow off-the-shelf boards to be used and still meet MIL-SPEC-810B requirements.

***Improved Shock and Vibration Resistance:*** Shock and vibration resistance is key to keeping a system running in many environments. One technique for extending the shock and vibration characteristics of CompactPCIe systems is to use steel cable rope isolators to suspend the CompactPCIe card cage within a larger enclosure. The rope isolator size and locations can be chosen such that even under the most extreme shock, the inner chassis never touches the outer chassis. These isolators dramatically attenuate the high-frequency component of the shock, allowing the electronics to survive shocks that would otherwise have ripped the electronics to pieces.

***Extended Temperature Range:*** Temperature range is often dictated by start-up situations where a vehicle has been sitting idle without its normal heating and cooling systems operating. In these cases the start-up temperatures can be much colder or warmer than the normal board-level products are specified to. Fortunately many manufactures provide extended temperature versions of their board-level products. Providing additional chassis airflow can also extend the top end of these products. The type of insulation used in the wiring is also key to extended temperature operation. Teflon

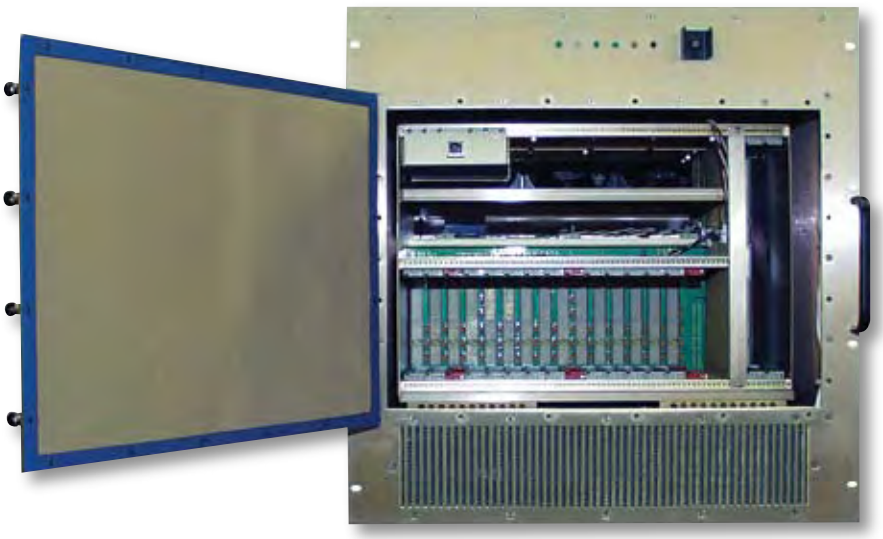

Figure 4

This chassis inside a chassis design extends the environmental robustness of CompactPCIe systems.


Figure 5

In harsh environments it is often essential to have an independent controller monitoring the internal chassis operation. Shown here is an independent system monitoring and alarming board.

insulation is the best, and allows a much greater temperature range.

***Reduced EMI radiations:*** Radiated emissions are a concern for their ability to interfere with other electronic devices. If implemented correctly, the chassis within a chassis technique with CompactPCIe can virtually eliminate radiated emissions. One key is to produce the inner chassis with full shielding such that there are only slight emissions coming out from the inner chassis. A good test for this is to operate the inner chassis separately. When fully loaded with electronics, this inner chassis should still pass the FCC class A EMI requirements for emissions. If properly designed, the outer chassis will further attenuate the EMI. The outer chassis should be manufactured with fully welded seams to avoid any leakage. Front and rear access doors should contain screws every 1.5 to 2 inches apart and include EMI gasketing. Air intake and exits should include honeycomb EMI filters. To avoid EMI radiating out the chassis through the power cord, internal AC wiring should all contain ground shields.

***Independent system monitoring and alarming:*** In harsh environments it is often essential to have an independent controller monitoring the internal chassis operation, reporting the results externally, and if need be turning the main system off to protect the electronics. An independent system monitoring and alarming board is shown in Figure 5. This extended temperature microcontroller-based board operates from the power supply's 5V aux power so that it remains powered up even though the main system power may be turned off. Upon system start-up, the system monitor board will check that the system fans are operating and that the temperatures within the chassis are within operating range, and if everything is operating properly, then enable the main power to the CompactPCIe electronics.

## Unmodified Solutions

Using unmodified off-the-shelf computing elements can solve a wide variety of military applications. For applications with low modularity and ruggedness needs, standard motherboard-based systems are the lowest cost and simplest solution. The passive backplane architecture provides additional slots and configurations. CompactPCIe has the best native modularity and ruggedness. Combining CompactPCIe with extended ruggedness packaging allows off-the-shelf electronics to be used in some of the harshest military environments. ▮▮

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# Tech Recon

Cooling Solutions

# Embedded Modules Wrestle with Cooling Challenges

As heat dissipation of microprocessors continues to rise, module-level cooling solutions are racing to keep pace.

Ivan Straznicky, Senior Staff Mechanical Engineer
Curtiss-Wright Controls Embedded Computing

Military vehicle system integrators continue to make use of embedded processors and other devices in order to increase processing capability and density for such applications as sensor data processing. That brings the benefits of Moore's Law to those demanding applications, but the drawbacks of using commercial parts in harsh environments—cooling in particular—must be addressed.

Processor fabricators such as Intel, Freescale and AMD continue to increase functional density by integrating ever smaller transistors, which are then switched at increasingly higher frequencies. Both of these trends increase power dissipation in the form of heat. A phenomenon that further increases processor heat is current/power leakage. Leakage was always present in the total power calculation, but has recently become a major concern due to the miniscule geometries of the ever smaller transistors.

Different forms of leakage, such as gate oxide tunneling, have combined to vastly increase heat dissipation. This is mainly due to the exponential dependence of leakage power on both decreasing transistor size and increasing junction temperature. The junction temperature dependence is a particular concern due to the high temperatures experienced by military electronic systems.

Figure 1

Some systems rely on a combination of conduction- and air-cooling. An example is this avionics chassis with forced air-cooled sidewalls that cool conduction modules inside the chassis.

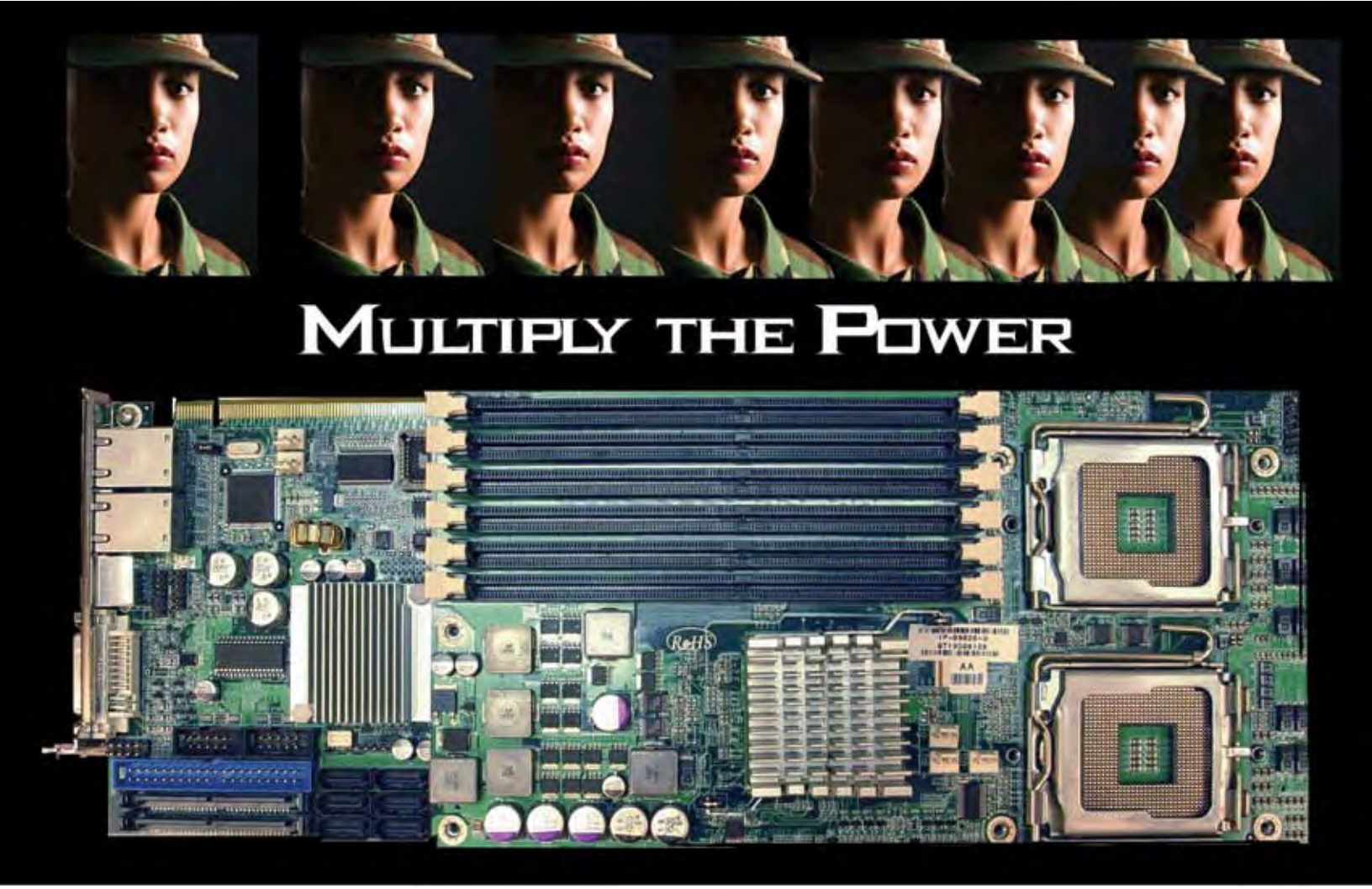
## Counter Balancing Trends

As somewhat of a counterbalance, lower core voltages and the recent trend to multiple processing cores reduce heat and heat density, respectively. Also, Intel has announced the use of new transistor materials on their next-generation processors that promise to substantially reduce leakage power. Finally, power management techniques are being architected into processors for even further power decreases. It remains to be seen whether these power reduction approaches will be enough to alleviate the traditional power increases seen to date.

At the plug-in module level, trends show increasing power and heat loads, particularly for high processing density DSP modules, which have seen an exponential increase in power over the last decade. Power increases are likely to continue with the introduction of new high-speed serial technologies via the new VPX specification (VITA 46). VITA 46 allows up to 768 watts of power to be brought onto a 6U x 160 mm module. This is a huge increase over the 90 watts allowed on VME cards, and poses a substantial cooling challenge to thermal engineers. In addition, the new VPX-REDI specification (VITA 48) allows a 1.0-inch pitch with increased space available for taller, and typically hotter, components.

## Cooling Solutions at the Module Level

The cooling of military embedded electronics has typically been done through the use of conduction or air, or a combination of both. An example is an

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avionics chassis with forced air-cooled sidewalls that cool conduction modules inside the chassis (Figure 1). While airflow over electronic components is frequently used for cooling, air-cooled modules are not as rugged under harsh military conditions—like high shock and vibration—as conduction-cooled modules.

For air-cooled modules, the simple convection equation (Newton's law of cooling) can be used to determine where effort should be focused for improvements in cooling:

$$Q = h \cdot A \cdot \Delta T$$

where Q is heat load in watts, h is the heat transfer coefficient in W/m$^2$ degrees K, A is the area exposed to the airflow, and $\Delta T$ is the temperature difference between ambient and the surface being cooled.

In most cases, $\Delta T$ is fixed because there is a maximum component junction temperature and a maximum ambient temperature. To increase the amount of heat that can be cooled, either h or A (or both), need to be increased. Increases in A usually take the form of finned heat sinks placed in contact with hot components. This introduces conduction heat transfer as a factor between the die and the heat sink surfaces.

The various resistances in this conduction path need to be accurately determined and modeled for the computational fluid dynamics (CFD) thermal analysis. In particular, any thermal interface materials (TIMs) need to be characterized because datasheet thermal conductivity or resistance values have been found to be as much as an order of magnitude too optimistic compared to independently measured values.

Increasing the heat transfer coefficient can be done in several ways. The most straightforward approach has been to increase air velocity over the surfaces being cooled. This can be done with higher flow/pressure fans and blowers, or by channeling existing airflow to hot components. Other approaches to increasing "h" include offset fins, which reintroduce airflow boundary layers, and dimpled fins, which introduce boundary layer disturbances.



## Conduction-Cooled Modules

For conduction-cooling, the simplest form of Fourier's law of conduction can be used to highlight cooling improvements:

$$Q = k \cdot A \cdot \left(\Delta T / \Delta x\right)$$

where k is thermal conductivity in W/m degrees K, A is the cross-sectional area perpendicular to heat flow, and $\Delta x$ is the heat path length. Increases in A and decreases in $\Delta x$ are limited by form-factor envelopes, component layout and component density. The new VPX-REDI specification (VITA 48) helps here by introducing a 1.0-inch pitch and allowing card edge retainers on the secondary side of the module.

Thermal conductivity increases can be achieved with different materials, such as copper instead of aluminum, although other material property differences may offset the thermal improvement, like density increase. Composite materials hold promise in being able to increase thermal conductivity without excessive, or in some cases any, increase in weight.

One issue with some of these materials, such as aluminum-graphites, is their very low "through thickness" conductivities as compared to "in plane" (very high). In some applications, this may be acceptable and still result in overall cooling improvement, while in others no cooling benefit is obtained. An accurate finite element thermal analysis is

required to determine this. In addition, characterization of material properties is highly recommended to ensure you get what you pay for.

Very high effective thermal conductivities may be obtained through the use of heat pipes due to their use of liquid to vapor phase change. The increased conductivity is only in the axial direction of the heat pipe, and they are orientation-dependent due to body force effects—such as gravity, acceleration—on the condensate. Nevertheless, innovative embedded heat pipe designs have been proven to increase cooling and operate in harsh military environments (Figure 2).

A perceived drawback to conduction-cooled modules is the thermal contact resistance that arises between the module's card edges and the chassis rails that they contact. Values between 0.3 to 0.5 degrees C/W have been used for 160 mm deep cards (per card edge), meaning that temperature deltas of 15°- 25°C for a 100W module are lost at this interface. Experimental characterization of various surface finishes and properties has shown that contact resistance values can be reduced substantially from the above values.

For both air-cooled and conduction-cooled modules, continuous innovation as described above has resulted in sustained increases to the amount of heat that can be cooled from military embedded modules with given boundary conditions. For 6U air-cooled modules at 70°C inlet air temperature and conduction modules at 85°C card edge, 200W was previously considered virtually unobtainable. Now that target is in sight, with 160+W already achieved. The price being paid, however, is a dramatic increase in the time and resources required for thermal design, analysis and testing.

Figure 2

Embedded heat pipe designs have been proven to increase cooling and are suited for operation in harsh military environments.

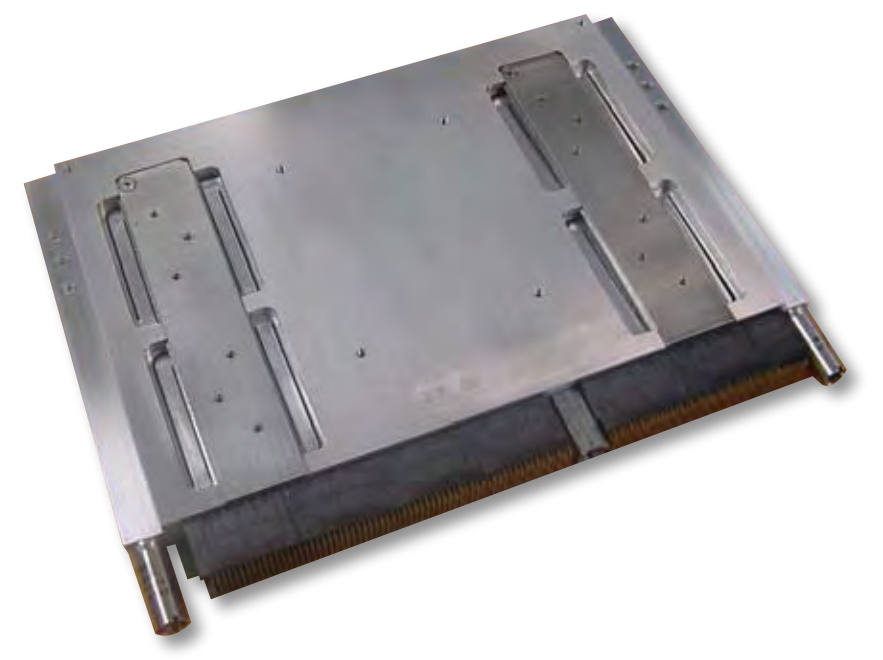

Figure 3

Liquid flow through cooling has been proven to be able to cool at least 650W four 100-150W heat loads on this 0.85-inch pitch, VITA 48.3 module shown.

## What's Next in Cooling?

Incremental gains in air-cooling and conduction-cooling will continue, however, new high-power module designs and/or the need to decrease component temperatures will eventually require a different cooling method. Liquid flow through (LFT) cooling has been proven to be able to cool at least 650W—PAO coolant, 55°C inlet, less than 15 psi drop across module—with four 100-150W heat loads on a 0.85-inch pitch, VITA 48.3 module (Figure. 3). This kind of performance, along with its history of use in custom modules in military systems, qualifies LFT as the next step in cooling for military embedded modules. ■■

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| Bus | AT Expansion Bus | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | PCI Universal Expansion Bus | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ |
| | PCI Bus Masters | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | | | 4 |
| | APIC (add'l PCI interrupts) | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | | | |
| CPU and BIOS | CPU Max Clock Rate (MHz) | 1000 | 1400 | 1400 | 1400 | 400 | 650 | 400 | 650 | 400 | 650 | 333 | 333 | 333 |
| | L2 Cache | 512KB | 2MB | 2MB | 2MB | 256k | 256k | 256k | 256k | 256k | 256k | 16K | 16k | 16k |
| | Intel SpeedStep Technology | ✓ | ✓ | ✓ | ✓ | | | | | | | | | |
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| | Quick Boot Option Installed | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | USB Boot | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | |
| Peripherals | Watchdog Timer & RTC | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
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| | AT Keyboard/Utility Port | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | PS/2 Mouse | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | USB Mouse/Keyboard | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| I/O | RS-232/422/485 Ports | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | USB 2.0 Ports | 4 | 4 | 2 | 4 | | | | | | | | | |
| | USB Ports | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | 10/100Base-T Ethernet | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 |
| | ECP Parallel Port | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | aDIO(Advanced Digital I/O) | 14 | 14 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| | multiPort(aDIO, ECP, FDC) | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
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| | McBSP Serial Ports | ✓ | ✓ | | | | ✓ | | | | | | | | |
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| | Differential Inputs | 8 | 8 | | 8 | 8 | 8 | | | | | | | | |
| | Max Throughput (kHz) | 1250 | 1250 | 40 | 500 | 100 | 1250 | | | | | | | | |
| | Max Resolution (bits) | 12 | 12 | 12 | 12 | 16 | 12 | | | | | | | | |
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| | *Autonomous* SmartCal | ✓ | ✓ | | | | | | | | | | | | |
| | Data Marker Inputs | 3 | 3 | | 3 | | 3 | | | | | | | | |
| Conversions | Channel-Gain Table | 8k | 8k | | 8k | 8k | 8k | | | | | | | | |
| | Scan/Burst/Multi-Burst | ✓ | ✓ | | ✓ | ✓ | ✓ | | | | | | | | |
| | A/D FIFO Buffer | 8k | 8k | | 8k | 8k | 8k | | | | | | | | |
| | Sample Counter | ✓ | ✓ | | ✓ | ✓ | ✓ | | | | | | | | |
| | DMA or PCI Bus Master | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | | | | | ✓ | |
| | SyncBus | ✓ | ✓ | | | | ✓ | | | | | | | | |
| Digital I/O | Total Digital I/O | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 48 | 18/9 | 32 | 64 | 32 | 48 | 48 |
| | Bit Programmable I/O | 8 | 8 | | 8 | 8 | 8 | 8 | 24 | 6/0 | | | | 48 | ✓‡ |
| | Advanced Interrupts | 2 | 2 | | 2 | 2 | 2 | 2 | 2 | | | | | 2 | |
| | Input FIFO Buffer | 8k | 8k | | 8k | 8k | 8k | | | | | | | 4M | 8M |
| | Opto-Isolated Inputs | | | | | | | | | | 16 | 48 | 16 | | |
| | Opto-Isolated Outputs | | | | | | | | | | 16 | 16 | | | |
| | User Timer/Counters | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | | | | 10 | 6 |
| | External Trigger | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | ✓ | |
| | Incr. Encoder/PWM | | | | | | | | | 3/9 | | | | | ✓‡ |
| | Relay Outputs | | | | | | | | | | | | 16 | | |
| Analog Out | Analog Outputs | 2 | 2 | | 2 | 2 | 2 | 4 | | | | | | | |
| | Max Throughput (kHz) | 200 | 200 | | 200 | 100 | 200 | 200 | | | | | | | |
| | Resolution (bits) | 12 | 12 | | 12 | 16 | 12 | 12 | | | | | | | |
| | Output Ranges | 4 | 4 | | 3 | 1 | 4 | 4 | | | | | | | |
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# Tech Recon

Cooling Solutions

# PC/104 Faces Unique Cooling Trade-offs and Challenges

Because of its small size, PC/104 isn't the easiest form-factor to deal with when it comes to heat dissipation. Clever mechanical schemes and processor choices help ease the way.

Alexander Buravlev, Marketing Director
Fastwel

The PC/104 form-factor is well entrenched as a solution for applications such as unmanned aircraft control, onboard vehicle control and navigation systems. According to the Electronics Trend Publications data, the global PC/104 boards market amounts to around $170 million per year, with defense systems enjoying 20 percent of that. Defense customers' demand for functionality and reliability of PC/104 systems very often requires additional efforts from board developers and specific engineering solutions for their realization.

Many applications require PC/104 systems to operate within a wide temperature range that often exceeds the operating range of the individual components provided by their manufacturers. To increase reliability and to widen operating temperature range, designers can choose a more robust version of a certain component type—a tantalum capacitor instead of an electrolytic for example. Such options don't apply to certain key components, such as high-performance CPUs, chipsets and memory. Therefore, when developing a board for harsh operating conditions, the key issues are thermal effects analysis and building the board in such a way as to provide its operation even in the worst working conditions, and finally, thoroughly and comprehensively testing the product within the whole operating temperature range at the outgoing inspection stage.

Figure 1

Fastwel's approach to conduction-cooling is to design boards to be either the top or the bottom boards in the stack of PC/104-Plus cards. The CPU itself is placed on the side opposite of the PC/104-Plus connector, thus the task of heat sinking is significantly simplified. Fastwel's boards like this CPC1600 card have a highly engineered, integrated heat sink installed on the CPU and GMCH chip.

## Thermal Challenge for Small Sizes

Because of PC/104's small size and the far from ideal heat dissipation conditions inside the enclosure, special attention must be paid to the thermal stability and functionality especially at high ambient temperatures. Forced air-cooling is not always an acceptable solution in these systems because of their very compact size and hence the ineffectiveness of air-cooling; additionally, due to the com-


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| Processors / Chipsets | Max. Frequency, MHz | Thermal Design Power (TDP), W | Frequency to TDP Ratio, MHz/W |
|---|---|---|---|
| Pentium M 760 | 2000 | 27 | 74 |
| Pentium M 745 | 1800 | 21 | 85 |
| Pentium M 1.6 | 1600 | 24.5 | 65 |
| Celeron M 370 | 1500 | 21 | 71 |
| LV Pentium M 738 | 1400 | 10 | 140 |
| LV Pentium M 1.1 | 1100 | 12 | 92 |
| ULV Celeron M 373 | 1000 | 5, 5 | 182 |
| 855 GM/ICH4M | FSB 400 MHz | 4.3 + 2.2 | |
| 915 GM/ICH6M | FSB533/400 MHz | 6 + 2.3 | |

Table 1

Shown here is the frequency and Thermal Design Power (TDP) data for standard processors, their low voltage versions for embedded applications, and the associated chipsets. Note that relative thermal efficiencies—measured in MHz per W—of Low Voltage Pentium M 738 and Ultra Low Voltage Celeron M 373 processors are several times higher than that of the Pentium M 1.6 GHz.

parative reliability of cooling fans—when compared to the life cycle needs within a system —the fan becomes a point of failure. For instance, mean time between failure (MTBF) of an average fan does not exceed 20,000 hours, but the PC/104 processor board itself should have MTBF well exceeding 100,000 hours.

To cope with the low heat dissipation capability of PC/104 systems, many processor board manufacturers use lower-power, lower-performance CPUs such as a Pentium III operating at lower clock speeds—300, 600 MHz and so on—to reduce power consumption. Such processors have relatively low performance compared to what is needed for modern applications. Moreover, when those classes of processors get phased out—as Intel announced recently with its ultra low voltage Pentium III processors—the risk of relying on them increases.

A more reasonable strategy is to use low voltage versions of Intel's Pentium M family of processors. These CPUs are

manufactured using special technology and have almost double the advantage, defined in the frequency-to-TDP (Thermal Design Power) ratio, compared to their predecessors. Table 1 presents frequency and TDP data for standard processors, their low voltage versions for embedded applications, and the associated chipsets. Relative thermal efficiencies—measured in MHz per W—of Low Voltage Pentium M 738 and Ultra Low Voltage Celeron M 373 are several times higher than that of Pentium M 1.6 GHz.

Even though developers selected a low thermal power processor for their application, they still have to solve the task of heat dissipation from CPU and Graphics and Memory Controller Hub (GMCH). Only a select few vendors offer PC/104-Plus processor boards with CPUs greater than 1 GHz. They use various solutions for heat dissipation like heat pipes, low profile fans and so on. The common practice used by PC/104 processor board manufacturers is to locate the CPU on the PCI and ISA connectors' side of the SBC. These connectors and any expansion boards placed in them prevent effective heat dissipation from the CPU.

## Simplifying Heat Sinking

For its part, Fastwel uses a different conduction-cooling solution on its computing boards. The boards are designed to be either the top or the bottom boards in the stack of PC/104-Plus cards. The CPU itself is placed on the side opposite of the PC/104-Plus connector, thus the task of heat sinking is significantly simplified; additionally the Fastwel board has a highly engineered, integrated heat sink installed on the CPU and GMCH chip. System designers can take advantage of this design to draw heat from the CPU and GMCH chip via the unique heat conductive plate to the PC/104 cabinet. In this case the contact area is much greater and the overall heat transmission resistance is much lower than in those boards where heat pipes are used to bring the dissipated heat along the board surface to the sides of the PC/104 enclosure.

Using a low heat-resistance thermal bridge between CPU and system chassis allows the use of the whole PC/104 cabinet as a large heat sink (Figure 1). This solution gives advantages in size, weight, price and overall system design. In addition, for the most demanding computing applications it allows the use of high-performance Pentium M processors operating at frequencies of up to 2 GHz with 533 MHz front side bus. For applications with high data exchange rates between the CPU, memory and I/O, the limitation in the system bus speed can be crucial; that is why the increase of system bus frequency from 400 to 533 MHz can give a 30 percent benefit in certain system performance parameters. ■■

Fastwel
Brooklyn, NY.
(718) 554.3686.
[www.fastwel.com].

# Space Systems Exploit the Commonality Benefits of Modular Computing

Using a common set of space electronics modules in a common enclosure across many space system applications, space system designers are reaping the rewards of modular and plug-and-play standard architectures.

Anthony Lai, Vice President, Space Systems
Aitech Defense Systems

The ever-increasing demand for more powerful computing platforms with mission-critical capabilities for future space exploration is a recurring theme for many recently started space programs. And the effort to meet these demands is worldwide. Over the past two years, NASA has made significant progress in formulating future space systems to enable further human exploration throughout the universe. This not only includes the moon and the familiar destinations currently explored by the International Space Station (ISS), but also brings us closer to a new frontier of previously unexplored regions, with Mars first on the list.

## Efforts Span the Globe

Four new NASA vehicles specifically developed for human exploration include the Orion crew exploration vehicle (CEV) (Figure 1) for human transport as well as ARES first stage, ARES I and ARES V launch vehicles. NASA's unique solution in the development of these vehicles combined the traditional approach of selecting prime contractors to build and demonstrate these four systems, coupled with the funding of two private companies under the Commercial Or-

Figure 1

This artist rendering shows an Orion Exploration Crew Vehicle taking off aboard an Ares 1 launch vehicle.


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bital Transportation Systems program. The combination proved a cost-effective space transport alternative for both humans and cargos to the ISS. When the Space Shuttle retires in the early 2010s, the systems derived from this program are expected to continue to sustain the ISS for years to come.

Meanwhile, the European Space Agency (ESA) is also planning to launch the new Autonomous Transfer Vehicle (ATV) to provide similar transport capabilities in support of the ESA Columbus module as part of the ISS operations. Other countries such as China, Russia and Japan are also pursuing next-generation space transport development.

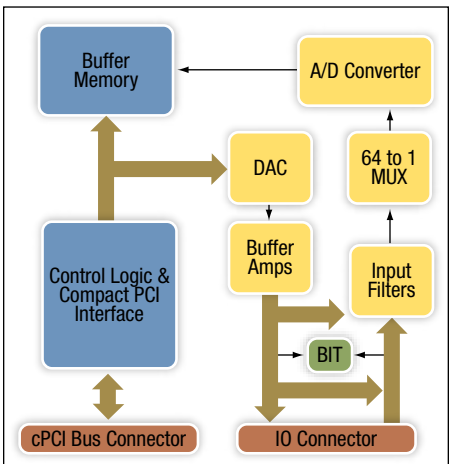


Figure 2

A sample FPGA implementation of an analog I/O CompactPCI card.

## Computing Advances Lead to Progress

Additional new space or near-space programs are requiring reliable high-performance computing. One of the most recent successes is the Orbital Express program. For the first time in human history, this program demonstrates that two satellites (ASTRO and NextSat) can dock with each other in full autonomy, with no human involvement or intervention during the process. The onboard computers provide real-time processing of thousands of sensor inputs that allows immediate decision-making, enabling the independent spacecraft to dock with each other from a distance of over four miles (seven kilometers).

Other examples include hypersonic vehicle programs like the FALCON program, space-borne weapons such as the Kinetic Energy Interceptor, next-generation GPS, commercial tourism including the SpaceShip Two, responsive space platforms such as TacSat, and Internet in space with software-defined radios from the NASA CONNECT program.

Even though the choice of embedded computing products with higher performance is greater today than a few years ago, the challenge to operate a high-performance and reliable computer system

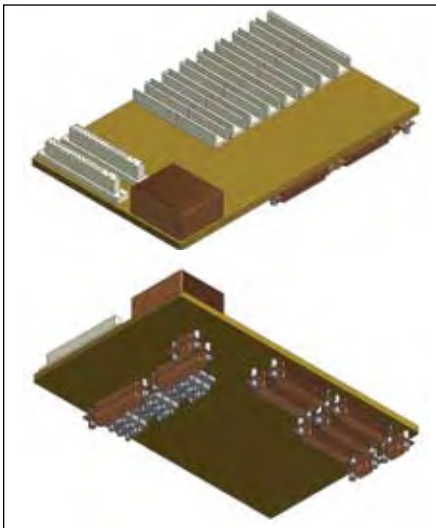

Figure 3

The CompactPCI (a) view of a reconfigurable backplane, and the bottom view (b).

| Function | Requirement |
|---|---|
| Docking | Use of additional vision and ranging payloads to control the movement of one object toward another – demanding complex software and uninterruptible operation. |
| Autonomy | Unparalleled computing capabilities used to handle multi-tasking software with artificial intelligence. |
| Precision Movement | Active control of mechanisms in real time requires high-data-rate sensor inputs. |
| Coordination | Multiple instances of objects with reconfigurable software and hardware to execute a task. |
| Servicing | Processor module must be able to operate reliably during critical service segments to ensure completion of each pre-defined service step for an overall successful repair sequence. |

Table 1

Key functional tasks and derived hardware requirements.

in space requires a unique combination of design techniques.

## Other Space Mission Successes

The twin NASA rovers, Spirit and Opportunity, represent some groundbreaking developments in recent space missions. Both rovers have been working around the clock for months to provide invaluable information to ground-based teams studying the geology on Mars in preparation for future human exploration. Another new plan for the intermediate lunar exploration is to deploy multiple mini-rovers on the lunar surface to investigate and map out resources available around the potential landing sites before human arrival. All these ideas are becoming reality via advanced robotics controlled by high-performance computer systems.

Some of the recent demanding space operations demonstrated in robotics include :

- Docking between two space-borne objects, such as a transfer vehicle or capsule and another space platform like the ISS. (Docking is one of the primary robotic capabilities needed for various exploration tasks.)
- Autonomous maneuvering of multiple spacecraft and rovers with LIDAR instruments.
- Precision pointing or tracking of space-borne laser communication systems.
- Teaming of multiple spacecraft, as in the Orbital Express mission.
- Remote servicing of one spacecraft by another spacecraft, as in the Hubble Robotic Service mission (demonstrated in a simulated space environment).

Successful execution of these tasks depends upon unique software and hardware capabilities designed to accommodate the demands of specific functions (Table 1).

## Functional Hardware Elements

Meeting the performance elements noted in Table 1 requires specific hardware capabilities in a uniform, integrated design. To achieve the cost, compatibility and lead-time advantages of an off-the-shelf approach, these capabilities must be contained within industry-standard form-factors. For example, to provide superior performance under demanding conditions while surviving a hostile space environment, a system designed with one or more processors and a set of I/O cards in a conduction-cooled 3U CompactPCI (cPCI) form-factor might include some or all of the features outlined in Table 2.

## Modular System Design

The ability to use a common set of space electronics modules in a common enclosure for various space system applications creates the foundation for a modular and plug-and-play architecture. Multiple subsystems can also operate concurrently to offer capabilities that are

| Hardware Feature | Capability |
|---|---|
| Microprocessor | Available PowerPC processors with inherent radiation-tolerant capabilities provide superior performance and low power consumption for space applications.<br><br>ECC and parity-protected on-die L1 and L2 cache to provide mitigation to Single Event Effects. |
| Volatile Memory | SDRAM arranged in a triple-redundant configuration with zero-wait state when executing CPU memory read or write requests. |
| Non-Volatile Boot Memory | Dual-redundant boot memory to minimize any single-point failure when a system starts up or it is being reset. |
| Non-Volatile User Memory | ECC-corrected user flash memory provides real-time correction and detection to data corrupted by Single Event Effects. |
| Data Buffers | Triple voting takes place on a memory buffer when a read request is made to a specific input or output data buffer in order to minimize bit flips rooted in any Single Event Upset event. |
| Redundant Channels | Each mission-critical data channel can be designed to provide redundant data paths with anti-fuse FPGA implementations. |
| I/O Expansion | Conduction-cooled PCI Mezzanine Card (ccPMC) slot on the processor module or on an alternate carrier card delivers flexible and modular I/O expansion and increases density of additional functions. |
| Bus Interface | Incorporating a standard bus interface ensures capabilities for additional redundancy and for integrating signals from outside the enclosure, including future capability enhancements through backward and forward technology insertion. |

Table 2

Embedded modules and their associated capabilities.

more complex as well as redundant or coordinated mission operations. To achieve rapid and cost-effective space system integration with the "plug-and-play" methodology, there are three key elements to consider: a widely accepted open bus architecture (such as CompactPCI), a radiation-tolerant FPGA implementation of bus interface and the use of a common enclosure design.

A mature and well-defined open architecture, a primary element in achieving a modular, flexible space system, allows the modules to seamlessly operate together with a common protocol and a physical bus interface. In contemporary spacecraft design, some popular open architectures include VMEbus and CompactPCI (cPCI). In particular, CompactPCI has recently gained significant notoriety due to the small, rugged form-factor of modules, plenty of available user-defined backplane I/O pins and the extensive knowledge base across various industries such as telecom, military and space applications.

The use of open architecture also permits various parties to develop modules that can work together properly in a single bus interface within the same enclosure. A customer typically procures most of the modules required for a specific spacecraft avionics solution, then develops one or two custom I/O cards with the same bus interface to provide unique or proprietary capabilities not offered otherwise. Open architecture helps minimize this time-consuming and costly effort.

Other benefits include using space-proven hardware, further reducing costs associated with continually re-inventing and re-architecting the spacecraft mission computer. Time-to-market and the pressures of platform qualification prior to launch decrease. Typical features in a cPCI system solution could include:

- A PowerPC processor module as the system controller;
- Redundant processor modules or additional modules for increasing performance and reliability;
- Coordinated reset signals on a cPCI backplane;
- A backplane with no wire harness, increasing reliability in launch conditions or hypersonic cruising environments;
- A custom reset to allow each individual processor module to reset itself or the whole cPCI backplane bus and;
- Local and cPCI bridges on processor modules to separate high-speed traffic and increase overall system throughput.

## FPGA Implementation

To enable a flexible architecture for space applications, the common bus interface must be implemented in a radiation-tolerant silicon solution. In the case of cPCI, radiation-hardened FPGAs can be used for this implementation on each module to communicate across a cPCI bus. In addition to offering a bus interface, the same FPGA can also control operations for onboard interfaces to minimize real-time interactions or relax timing constraints from software to complete specific tasks.

An example of such a design is an analog I/O card. As shown in Figure 2, the front-end of the FPGA implemented on the card is a cPCI interface. The

back-end of the FPGA provides full control of the analog-to-digital conversion sequence, the digital-to-analog outputs and the in-flight loop-back, built-in testing capability. This configuration limits software interaction command relays that start or stop conversion, initiate a test or designate a specific digital output value for analog conversion. Also, the cPCI bus provides four independent interrupts for the FPGA to define four unique events, resulting in more flexible software coordination.

## Common Enclosure Design

One of the most time-consuming activities when creating a spacecraft avionics subsystem is the development of a unique I/O harness that offers the front-panel I/O through various connectors. Also, unique test setups—test cables, test equipment and test procedures—required for each new application tend to add complexity.

A reconfigurable backplane used in a 3U small form-factor cPCI bus architecture could be implemented through multiple space-qualified switching circuits that allow any specific card slot to be configured to host a unique I/O card. This feature is crucial for future exploration to outer planets, where each mission has only a limited weight allocation for spare components onboard the spacecraft.

A common enclosure and modular card design can help reduce the number of card and enclosure types needed to maintain high levels of capabilities for any unforeseen situation by allowing shared resources. Figure 3 depicts this reconfigurable backplane that eliminates the I/O harness between the backplane bus interface and the enclosure's front-panel connectors for modules or cards. As many satellite and spacecraft programs have determined in the past, wire harnesses do not hold up well in harsh, rugged environments. In fact, they can significantly impact the launch vehicle system's reliability. Several of the newer Microsat programs have mandated the use of "wireless" harnesses to increase system reliability during launch, docking and orbit insertion, all of which are associated with severe shock and vibration.

Space exploration is continuing to evolve, paving the way for a deeper understanding of the universe around us. Within these newer space vehicles lie powerful computing systems that continue to clear the path for each subsequent mission. The road has been long, but the advancing technologies incorporated into off-the-shelf components, combined with the flexibility afforded by these components, have proven to be a worthwhile pairing that is leading us toward new discoveries. Next stop, the Red Planet.

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# Technology Focus

Ethernet Switch Boards

# Ethernet Switch Boards Muster for Fabric and IP Duties

As the selection of rugged Ethernet switch boards grows, defense programs are relying on them for critical fabric interconnect and networking roles.

Jeff Child
Editor-in-Chief

Long popular in military command and control systems, Ethernet is now gaining traction in numerous military applications. As a result, Ethernet switch boards are emerging as a critical building block for a variety of programs. On one hand they're being deployed as multi-layer switches with dual IPv4 and IPv6 forwarding to support the DoD's sweeping plans to leverage the benefits of IPv6 (Internet Protocol version 6). Indeed, the DoD has a set a deadline for all of its networks to support IPv6 by 2008. And on the other hand, switched Ethernet is being used as an interconnect fabric in compute-intensive applications like sonar, radar or any application that networks sensor arrays together.

Switched Ethernet is being used, for example, as an interconnect for the upgraded electronics on BAE Systems' Bradley Fighting Vehicle Program (Figure 1). In June BAE awarded LaBarge a contract to continue to produce the Ethernet Switch Unit (ESU) for its A3 Bradley Combat Systems vehicles. The ESU functions as a router and a switch, making local forwarding decisions to devices operated in the vehicle's LAN (local area network).

The A3 upgrade version of the Bradley features an advanced digital architecture that integrates communications equipment, digital sensors, battle management systems, embedded diagnostic and training systems. The Bradley fulfills critical infantry, cavalry, fire support, battle command and engineer roles for the Army's heavy brigades.

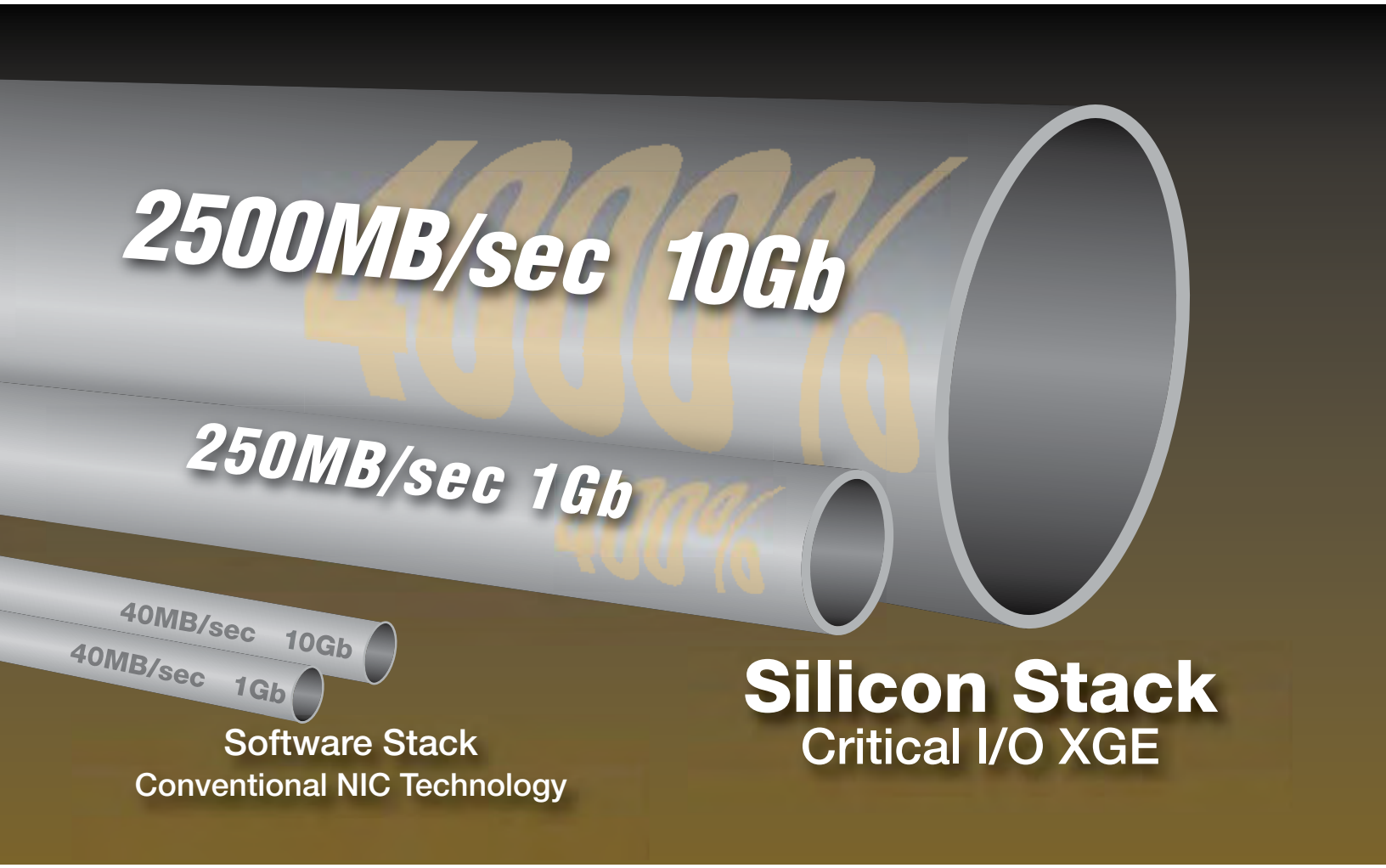
A GE Fanuc Embedded Systems' switched Ethernet product, along with other subsystems, was selected by Lockheed Martin's Littoral Ships & Systems business for the control system in the Non-Line-Of-Sight Launch System (NLOS-LS) platform commissioned by the U.S. Army. NLOS-LS is scheduled to be part of "spin-out one" within the U.S. Department of Defense's Future Combat Systems (FCS) initiative. The GE Fanuc processing subsystem selected by Lockheed Martin comprises an adapted version of one of the company's standard rugged enclosures; together with a Compact PCI 6U CP1A single board computer fitted with an I/O daughter card PMC; a CPX24 rugged managed Gigabit Ethernet switch; and a Radstone MFIO (Multi Function I/O) board.

Figure 1

Switched Ethernet is used in BAE Systems' Bradley Fighting Vehicle Program to link the vehicle's advanced digital architecture that integrates communications equipment, digital sensors, battle management systems, embedded diagnostic and training systems.

NLOS-LS is being developed for the U.S. Army by Netfires LLC, a joint venture between Lockheed Martin and Raytheon. It uses a common vertical launch Container Launch Unit (CLU) comprising 15 missile launch chambers. It also has integrated command and control equipment to support the deployment of the Precision Attack Missile (PAM). The CLU is platform-independent and is transportable by truck, plane, helicopter or ship. The CLU can be fired from a platform or the ground, and can operate in an autonomous mode. ▮▮

# Which Way do You Want Your 10Gb Ethernet?




## Silicon Stack Technology from Critical I/O. 10Gb Ethernet at Wire Speed.

[**Problem**] You're expecting 10Gb Ethernet to deliver a whole lot more performance to your embedded system. But what if you invest in it and get no gain at all? The performance of nearly all existing 1Gb applications are limited by the software overhead associated with the TCP/IP protocol stack. This bottleneck is in the software stack, not the network hardware. So, simply upgrading to 10Gb pipes will not improve your system's performance.

[**Solution**] Unlike conventional Ethernet interfaces or processor-based "offload" products, Critical I/O's Silicon Stack technology eliminates this inherent bottleneck by offloading protocol processing to silicon; thereby achieving sustained line-rate performance, microsecond latency, and rock-solid deterministic behavior. And, Silicon Stack is 100% compliant with Ethernet standards, allowing you to leverage existing applications and hardware.

**XGE Silicon Stack Ethernet**
vs. Software-based Stack

| | Software Stack | | Silicon Stack | |
|---|---|---|---|---|
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| **Host Overhead** | Very High | | Very Low | |
| **Latency** | 125 µsec | | 12 µsec | 5 µsec |
| **Determinism** max sustained rate | Horrible ± 200 µsec | | Rock Solid ± 1 µsec | |
| **Reliability** | Poor when under heavy load | | Excellent under all load conditions, no dropped data | |

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# Technology Focus:

# Ethernet Switch Boards Roundup

## 3U cPCI Card Brings Full Switch Management to Rugged Apps

Embedded network switching applications including ground mobile, shipboard, airborne and homeland security all demand the right mix of networking functionality and physical ruggedness. ACT/Technico, a leading supplier of embedded products and systems solutions,

offers a rugged, 3U cPCI Gigabit Ethernet switch that enables full management via an on-board processor. Designed with ultra low power and thermal monitoring, the non-blocking, full wire speed switches offer nine auto-sensing ports including Quality of Service (QoS) with four traffic classes, IPv4 and IPv6 Layer 2/3 protocols. The 3U cPCI 661x series also provides seamless network management that can be accessed from a browser, PC, local console or SNMP.

The switches feature port monitoring, multicast, VLAN control and MAC-based authentication as well as management software that provides a range of configuration options such as user controllable Built-in-Test, transmission speed/mode, VLAN, STP parameters and port mirroring. The 661x switches are available in three temperature grades, including conduction-cooled for harsh environments. A rear transition module is also available for rear I/O options. Pricing for the 3U cPCI switches starts at $2,700 in low quantities.

ACT/Technico
Ivyland, PA.
(215) 956-1200.
[www.acttechnico.com].

## 24-Port Gbit Ethernet Board Targets PICMG 2.16 or VITA 31.1

Gbit Ethernet, while always there during the so-called "fabric wars," was seldom listed as a contender as the dominant switched fabric. Today it's emerged as among the most attractive switched fabric interconnect technologies for military systems. Concurrent Technologies' latest Gbit Ethernet switched fabric board is the FP 110/019. The FP 110/019 is an "unmanaged" embedded Ethernet switching platform that provides a low-cost, low-power switching solution for system integrators. Typically consuming less than 20W, it offers twenty-four 10/100/1000 Mbit/s auto-negotiating Ethernet ports, nineteen accessible via a PICMG 2.16 or a VITA 31.1 packet switched backplane. The switch core contains a wire-speed, Layer 2, Quality of Service (QoS) switch fabric. Also provided is PICMG 2.9 IPMI system monitoring and hot insertion/removal to the backplane. Extended temperature variants are also available.

Using the FP 110/019 Switched Fabric board within a CompactPCI PICMG 2.16 or a VME64x VITA 31.1 system enables a tried and tested method of implementing a LAN-based multiprocessor architecture by leveraging readily available Ethernet hardware, TCP/IP software, clustering and other network management tools. PICMG 2.16 (or VITA 31.1) can also be used as a method of offloading tasks from the standard CompactPCI (or VME64x) backplane, thereby improving overall application efficiency. The FP 110/019 enables up to nineteen computing node boards to interconnect in a chassis that supports a packet switched backplane (PICMG 2.16 or VITA 31). A second FP 110/019 could be added to the chassis for redundancy or increasing the number of 10/100/1000 Mbit/s ports.

Concurrent Technologies
Woburn, MA.
(781) 933 5900.
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## ATCA System Manages Packet Traffic and Security

The AdvancedTCA architecture is slowly starting to gain some traction in defense applications, particularly those focused on hefty communications challenges. Continuous Computing offers a new ATCA system capable

of supporting deep packet inspection at 10 Gbit/s line rates to deliver application-aware traffic management and aggregation. The bladed solution provides enhanced security capabilities to detect and prevent unauthorized access, protect against denial of service attacks and facilitate virus scanning.

This ATCA traffic management and security system provides system developers a platform that enables them to expedite the rollout of new "content-aware" network elements considered essential to deliver high-quality and secure IP networks. Continuous Computing's new traffic management and security platform provides a carrier-grade solution for deep packet inspection in edge and core network equipment. The system includes up to 10 advanced deep packet inspection blades as well as two redundant 10 Gbit Ethernet switches, all housed in a robust carrier-grade ATCA chassis. Each packet processing blade, known as FlexPacket ATCA-PP50, incorporates two XLR732 multicore MIPS devices from Raza Microelectronics that deliver packet processing and security at line rates up to 20 Gbits/s.

FlexPacket supports a dual redundant 10GbE backplane fabric with a range of 10 Gbit Ethernet and 1 Gbit Ethernet ports to the front and rear depending on a customer's specific cabling requirements. Each XLR732 multicore MIPS64 processor supports up to 8 Gbytes of memory (16 Gbytes per blade) and can connect to mezzanine sites for supporting TCAM and dedicated content processors via the on-chip HyperTransport interface.

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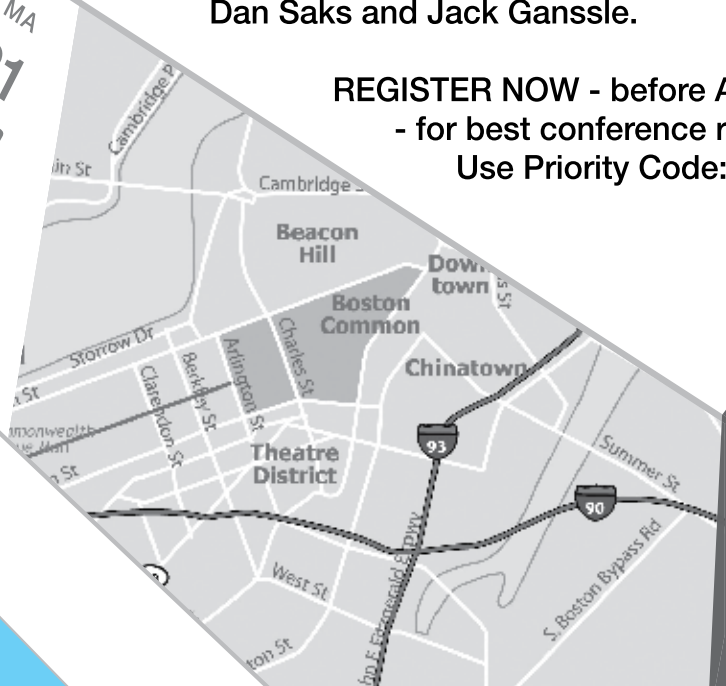



Is this a must-attend event? Let's just file that under no-brainer.

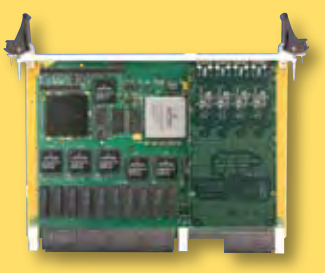
CMP
United Business Media

## Gbit Ethernet Switch/Router Climbs Aboard 6U VPX

VPX, the fabric-based next-gen VME form-factor, is gaining more and more momentum every month. A variety of SBC products have emerged, and now special function boards like Ethernet switch boards are adding to the VPX ecosystem. For its part, Curtiss-Wright Controls Embedded Computing has announced the first high-density 6U VPX Gbit Ethernet multilayer switch/router board designed for rugged embedded aerospace and defense applications.

The new VPX6-684 FireBlade II, available with 12, 20 or 24 Gbit Ethernet ports and up to 4x10 Gbit Ethernet ports, is ideal for system integrators architecting secure high-performance IPv4/v6 Intra-Platform Networks (IPNs). The board, which operates as either a fully managed or an unmanaged switch/router, provides significant performance and configuration advantages to developers building Layer 2 or Layer 2/3+ networks. Additional feature enhancements include support for routing up to 4x10 Gbit Ethernet to the FireBlade's P1 connector, and support for copper interfaces to the backplane for all of the board's 12, 20 or 24 Gbit Ethernet ports.

The VPX6-684 FireBlade II is ideal for use in applications that require high levels of security. When used as a Unified Threat Management (UTM) router the VPX6-684 FireBlade II provides strong perimeter defense via an ICSA certified firewall. Additional security



features supported by the board include Access Control List (ACL) filtering, Network Address Translation (NAT), Virtual Private Network (VPN) with tunneling support (IPSec/L2TP), IPv6 ESP/AH payloads, and Encryption/ Decryption/ Authentication support.

Curtiss-Wright Controls
Embedded Computing
Leesburg, VA.
(703) 779-7800.
[www.cwcembedded.com].

## IPv6 Managed GbE Switch Platforms Target Mil Apps

A core requirement for network-centric warfare is the support of IPv6. The first members in a family of fully managed layer 2/3+ Gigabit Ethernet switches have debuted as three products from GE Fanuc. The Neternity family is designed to handle the demanding requirements of a broad range of applications including military, telecommunications and commercial. The three new products feature the OpenWare switch management environment. OpenWare is portable across switch fabrics and

processor environments, is easy to customize using the familiar Linux command line interface and is designed to make switches easy to deploy and easy to manage.

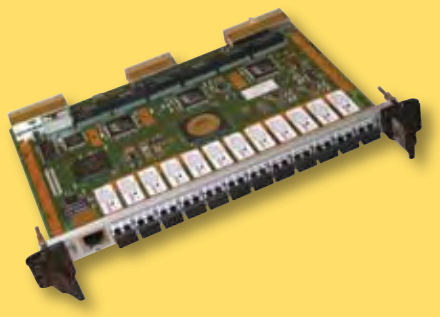
The Neternity RM921 is an IPv6-enabled 6U VME Gigabit Ethernet switch with either 12 front I/O (single-slot solution) or 24 front I/O ports (dual-slot solution). It also offers support of IPv4. Port configuration can be all copper, all fiber or combinations of both. Also optionally available are 100BaseFX ports so that both 100BaseFX and Gigabit Ethernet interfaces can be supported on the same Network Interface Card. The Neternity RM922RC is an RoHS-compliant IPv6-enabled 6U VME fully managed layer 2/3 Gigabit Ethernet switch with 24 copper ports (single-slot solution) via rear I/O. The Neternity CP921RC is an RoHS-compliant PICMG 2.16 6U CompactPCI fully managed layer 2/3 Gigabit Ethernet switch with 24 copper ports, and is hot-swappable, minimizing potential system downtime. It is also compliant with PICMG 2.1 and PICMG 2.9.

GE Fanuc Embedded Systems
Charlottesville, VA.
(800) 368-2738.
[www.gefanucembedded.com].

## GbE Switch Complies with PICMG 2.16 and VITA 31.1

Ethernet's popularity among military decision makers continues to grow. No other networking technology can boast Ethernet's longevity and wide adoption. Fueling that trend, Interface Concept has announced the ComEth4020a, a line of 6U cPCI/VME full Giga Ethernet Switches that are PICMG 2.16 and VITA 31.1 compliant, for embedded applications. ComEth4020a is built on the latest generation of Gigabit switch engine and PHY transceiver. ComEth4020a supports full-wire speed L2 bridging and L3 forwarding with L2-L4 advanced traffic classification, filtering and prioritization.

ComEth4020a switches are full managed and can easily be monitored from a browser, a remote application, a console or SNMP. The Switchware software provides layer 3 functions, allowing local IP forwarding (IPv4



/ IPv6), static and dynamic protocols (RIP, OSPF) routing, proxy-ARP and DHCP-relay. These L3 functions are managed through a CLI interface. The IP routing and the L3 protocols are carried out by the processor and the forwarding is carried out by a full-wire speed L3 router. These switches can be used in all types of environments with operating ranges from standard, extended, rugged and conduction-cooled grades—operating in extended-temperature ranges of -40° to +75°C. Prices start at $6,700.

Interface Concept
Briec de l'Odet, France.
+33 (0) 298 577 176.
[www.interfaceconcept.com].

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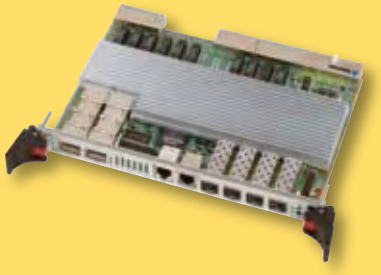
## cPCI Ethernet Switch Boasts Integrated IP Router

The concept of EOIP (Everything Over IP) is catching on strong in the military. Voice-over-IP networks aboard aircraft carriers, for example, is one step in that direction. Cost is a factor in such network implementations. With that in mind, Kontron's CP6923 board provides built-in switching capabilities for cPCI installations at an unmatched price-to-performance ratio by implementing the latest technologies including the highly compact Broadcom BCM56502 Gigabit Ethernet switch chip. The Kontron CP6923 is a 6U hot-swappable cPCI switch with 24 Gbit Ethernet ports and two high-capacity uplinks (10GbE), which make systems cascadable. It supports all relevant standards in carrier-grade L2 and L3 switching, routing, VLANs and QoS (Diffserv) developed by Kontron.



The Kontron CP6923 Flexi-Switch is a PICMG 2.16-compliant 6U cPCI Gigabit Ethernet switch with 24 channels. It provides leading-edge technology to cPCI installations, thus maximizing their usage and longevity. The board provides a fully managed software environment and comprehensive firmware package with seamless integration into the shelf and its shelf management by IPMI V1.5. It supports hot-swap capabilities, the reset of basic fabric and reliable field upgrades for all software components. An IP router is integrated into the base fabric.

Kontron America
Poway, CA.
(858) 677-0877.
[www.us.kontron.com].

## Platform Blends cPCI PSB and Switched Ethernet

The communications and IP networking segment of military technology can draw on a rich universe of hardware developed for comms infrastructure applications. Exemplifying that trend is One Stop Systems' OSS-HW400c/2 core-processing platform. It features two PCI Telecom Mezzanine Card (PTMC) sites for CT Bus-enabled I/O interfaces that are interconnected through a high-speed Layer 2 Gigabit Ethernet switch to the dual node CompactPCI Packet Switched Backplane (cPSB). The HighWire core architecture provides a powerful computing environment for addressing a wide range of military communications applications.

For processing, the HW400c/2 boasts a Freescale 1 GHz MPC7447A PowerPC processor with Marvell MV64462 System Controller The system offers front panel management via 10/100/1000 Ethernet and System Management per IPMI/IPMB (PICMG 2.9). The system sports front and rear I/O support, up to 1 Gbyte of DDR333 SDRAM and a 128 Mbyte flash file system. The PTMC site onboard supports 3.3V signaling and PICMG 2.3 Rear I/O mapping. The two 0/100/1000 Ethernet cPSB sites comply with PICMG 2.16 single or dual node. Two 10/100/1000 Ethernet ports are provided per PT5MC site, with an

additional Front Panel RJ45 Ethernet port. The 32/64-bit, 33/66 MHz PCI 2.2 CompactPCI interface supports full and basic CompactPCI Hot Swap (PICMG 2.1) in a cPCI 6U x 4HP (single slot) form-factor. Maximum power requirements for the board are 20W at 5 VDC and 5.3W and 3.3 VDC.

One Stop Systems
Escondido, CA.
(760) 745-9883.
[www.onestopsystems.com].

## Five-Port PC/104 Fast Ethernet Switch Supports Port-Based VLAN

When developing space-constrained, high-reliability aviation and military systems for net-centric operations in extreme temperature/high-shock/vibration environments, military engineers are turning to virtual LAN technology. In particular, port-based VLAN functionality support enables any combination of ports to be connected together in subnets for use in a small secure or non-secure network. To meet this need, Parvus has introduced the PRV-1059 VLAN-enabled five-port PC/104 Ethernet switch, designed and tested to MIL-STD-810F, and featuring very low power consumption of 1.5W and highly reliable extended-temperature operation up to +85°C. Its five transceiver ports are fully IEEE 802.3 and IEEE 802.3u compliant and designed so any port can serve as an uplink.

Supporting auto-MDI-MDIX network installation, the board is designed for simple plug-and-play operation, enabling up to five embedded computing devices to be networked together using 10BaseT or 100BaseTX LAN connections. It integrates fully independent media access controllers (MACs), an embedded frame buffer memory and a high-speed address look-up engine, along with support for auto-crossover, auto-polarity, auto-negotiation and bridge loop prevention. The compact, 90 x 96 mm PRV-1059 switch is available in non-RoHS and RoHS-compliant (lead-free) versions. Pricing is $199 for base models and $249 for models with VLAN support.

Parvus
Salt Lake City, UT.
(801) 483-1533.
[www.parvus.com].

## PICMG 2.16 Board Sports Dual 10 Gbit Ethernet Uplinks

Applications like airborne or shipborne communications systems demand a mix of high bandwidths and the resilience of high availability. Feeding such needs, Performance Technologies offers the CPC6620, an advanced PICMG 2.16 embedded Ethernet switch featuring 24 10/100/1000 Mbit switch ports, two 10 Gbit uplink ports and support for IPv6 routing. Available in ruggedized and conformal-coated versions with fiber-optic 10 Gbit uplinks, the CPC6620 can be configured to monitor network status and to continuously check its own health through real-time integrity tests. In the event of system or network failure, data can be automatically rerouted to an alternate path.

Performance Technologies' line of high-availability Advanced Managed Platforms is available in configurations including 1 Gbit or 10/100 Ethernet switches, comprehensive remote shelf management, high-performance x86 and PowerPC compute elements accommodating Linux, SolarisT or Windows operating systems, and HA middleware. Options include applications processors, a wide range of networking I/O products and communications protocols, and NexusWare, the Company's CGL 3.2-registered and POSIX-compliant Linux distribution and development environment. These configurations provide a complete, integrated base platform for system designers looking to develop a wide range of applications, and are designed to reduce integration time and lower development costs.

Performance Technologies
Rochester, NY.
(585) 256-0200.
[www.pt.com].

## Ethernet I/O Server Configures without Programming

As embedded computing nodes get more integrated, the myriad I/O connections in military systems tend to remain the same. What's needed is a way to manage and aggregate all those I/O channels. Along such lines, a new I/O server that uses the Ethernet and IP networks to extend the distance between digital inputs and digital outputs has been introduced by Moxa Technologies. The ioMirror E3210 uses an existing Ethernet and IP network infrastructure, a wide range of applications such as multiple intrusion detection, fluid level sensors and alarm signals, can be extended to multiple locations without the need to lay additional transmission lines.

The transmission speed between a DI and DO can be as high as 20 ms over an Ethernet network. Configuration can be carried out with a browser over the network, and with only 4 steps required, all signal mappings can be set up in under 5 minutes. In fact, the process is made even easier since no programming is required. The ioMirror E3210 features I/O status updates within 20 ms and direct input-to-output signal communication over IP. The unit offers local alarm and remote alarm messaging and supports Modbus/TCP for remote monitoring.

Moxa Technologies, Brea, CA. 714) 528-6777. [www.moxa.com].

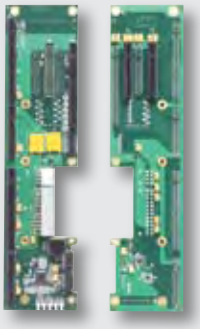
## Battery Management System Supports Li-Ion

Portable battery-powered devices represent one of the most dynamic areas of military system design these days. OceanServer Technology has introduced a patented, fully engineered battery and power system that lets designers add smart, rechargeable Li-ion battery back-up power as an OEM component to virtually any type of electronic and electromechanical equipment. The Intelligent Battery and Power System serves as a complete AC/DC power supply and provides clean, regulated DC, sourced from Li-ion battery packs, an AC wall outlet or any external DC source including solar and wind power. Seamlessly taking over if the external power is interrupted, it recharges automatically when the power is restored and provides status feedback such as charge and discharge rate, time to empty and number of active batteries.

Modular, fully scalable and SMB compliant, the Intelligent Battery and Power System lets designers speed the development cycle of integrating up to 48 VDC battery power into an OEM product. A variety of battery management modules and DC converters are offered that can manage up to eight packs each, to provide up to 760 watt-hours of high-density Li-ion power. The Intelligent Battery and Power System is priced starting at $299, depending upon power requirements.

OceanServer Technology, Fall River, MA. (508) 678-0550. [www.ocean-server.com].

## PICMG 1.3 Backplanes Targets 2U Computing



Small, compute-dense military applications are hungry for tighter form-factors. That's brought the 2U form-factor into the sites of lots of designers. Trenton Technology is feeding this need with two new PICMG 1.3, butterfly form-factor backplanes. These new backplanes support SHB Express system host boards and a variety of PCI Express (PCIe) option cards. The BPG6741 and BPX6736 are optimized for use in 2U chassis systems that operate in graphics-class or server-class embedded computing applications.

The two sides of this 2U backplane are identified as Side A and Side B. Side A of the BPG6741 graphics-class backplane supports one PICMG 1.3 SHB and one x16 PCI Express option card slot. This slot is driven by a x16 PCIe link from a graphics-class system host board and is designed to support x16 PCI Express option cards such as those used in video, graphics and vision inspection systems. Side A also includes the USB Audio interface. Side B includes two x8 PCIe slots driven with x1 links from an SHB like a Trenton MCG-series system host board. Like the BPG6741, the two sides of the BPX6736 are also identified as Side A and Side B. Side A of the BPX6736 server-class backplane supports one PICMG 1.3 SHB, one x16 and one x8 PCI Express option card slot. The backplanes are available now and typical BPG6741 and BPX6736 pricing starts at $316.

Trenton Technology, Atlanta, GA. (770) 287-3100. [www.trentontechnology.com].

## 2.8 GHz Mini-ITX Board Sports Six Serial Ports

Today's level of computer integration allows a tremendous amount of computing power to fit in a stand-alone board. That's driven some military applications to consider form-factors like the Mini-ITX motherboard form-factor. Serving that need, the eAutomation Group of Advantech introduces the AIMB-240, a Mini-ITX motherboard with 2.8 GHz processing power and six serial communication ports. It's equipped with a 82852GME chipset, supports Pentium 4 and Celeron processors, and has 400/533 MHz FSB and 1 Gbyte of DDR 266/333 SDRAM. With Intel's integrated Extreme Graphics 2 controller, the AIMB-240 delivers integrated 3D graphics and video capability without adding expensive graphic cards. There are multiple display interfaces such as LVDS, DVI, TV-out and CRT as well as multimedia features including 5.1 multi-channel audio and DVI transmission of 135 mega-pixels per second.

The AIMB-240 uses the Intel ICH 4 to enable expandability. There's one 32-bit/33 MHz PCI slot and one 32-bit/33 MHz mini-PCI slot that enables flexible expansion. The six serial communication ports and six USB 2.0 ports offer superb connectivity for keyboards, mice and other peripherals. The motherboard also supports dual 10/100Base-Tx Ethernet. Pricing for the AIMB-240 starts at $219.

Advantech, eAutomation Group, Cincinnati, OH. (513) 742-8895. [www.eAutomationPro.com].

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## VME Board Boasts 256 Gbytes of Flash Memory

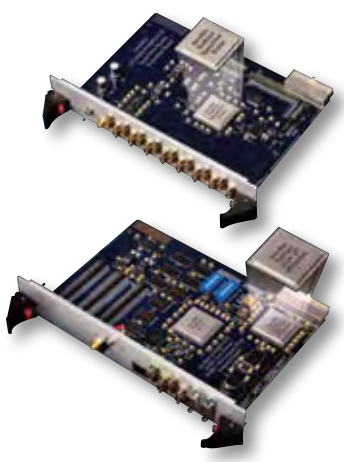
Flash memory has been a staple onboard VME cards for decades now as a limited non-volatile code storage medium. As density climbs, flash now can serve as a complete onboard mass storage solution. Along those lines, Aitech Defense Systems has upgraded the memory capacity of its C212 high-capacity, non-volatile memory VMEbus board that uses NAND Flash memory supported by software drivers to provide full hard-disk emulation for up to 256 Gbytes of cost-effective, solid-state mass storage in embedded military applications. Coupled with the board's exceptionally low power consumption of less than 5W, the board is ideal for a storage of detailed maps, large databases, radar or sonar images, software programmable radio ELINT data or other graphics.

The C212 uses no moving parts, enabling its low power requirements and significantly increased board reliability. Available in forced air-cooled and standard ANSI/IEEE 1101.2 conduction-cooled mechanical formats, the C212 is a single-slot 6U module that connects to, and takes all of its power from, a standard VMEbus backplane. Pricing for lower capacity versions of the upgraded C212 starts at $2,805 in OEM quantities.

Aitech Defense Systems, Chatsworth, CA. (888) 248-3248. [www.rugged.com].

## Boards Support Rad-Hard SPARC and FPGA Eval

Radiation-hardened components aren't the kind of devices that get stuck onto a board and shipped out the door. Rigorous testing and verification are required to ensure their capabilities. Easing that process, Aeroflex has added to their RadHard portfolio two new evaluation boards: the UT699FP-EVB LEON3 Fault Tolerant SPARCTM V8 Processor FPGA Evaluation Board and the UT200SpW16RTR-EVB SpaceWire Router Evaluation Board.



The UT699FP-EVB LEON3 Fault Tolerant SPARC V8 Processor FPGA Evaluation Board is a compact PCI-based board containing an FPGA version of the UT699RH RadHard pipelined monolithic, high-performance, fault-tolerant LEON 3FT SPARC processor with four dual SpaceWire ports, Ethernet and CAN ports. The UT200SpW16RTR-EVB SpaceWire Router Evaluation Board's router is designed to provide 16-port SpaceWire connectivity at 120 Mbits/s. Aeroflex currently offers a SpaceWire Physical Layer Transceiver and SpaceWire IP for the RadHard Eclipse FPGA; the 16-Port Router Evaluation Board and Router solutions are next. The UT699FP-EVB LEON3 Fault Tolerant SPARC V8 Processor FPGA Evaluation Board and the UT200SpW16RTR-EVB SpaceWire Router Evaluation Board are $20,000 each.

Aeroflex, Colorado Springs, CO. (719) 594-8035. [www.aeroflex.com].

## Compact Data Recorder Offers 480 Mbyte/s Rates

High-speed, high-capacity data recording may be a mature discipline. But it's no easy trick to implement recording systems that meet the shock, vibration, temperature, humidity and atmospheric pressure requirements of demanding military applications. Conduant's newest offering is its Big River LTX2 data recorder. The new recorder provides over 480 Mbytes/s (3.8 Gbits/s) recording and playback performance. The unit can operate as a stand-alone system with network control or can be directly connected to a host computer via its Star Fabric PCI bridge interface. The 1U (1.75-inch) high chassis, which is less than 16 inches in width and depth, accepts sixteen 2-1/2-inch disk drives for up to 3.2 Terabytes of storage capacity.

The user may choose lower-cost, high-performance rotating disk storage or solid-state drives for more environmental tolerance such as shock, vibration, temperature, humidity and atmospheric pressure, depending on the user application. The architecture supports a wide variety of external, interchangeable interface mezzanine cards including FPDP, FPDP2, LVDS, Serial FPDP and Camera Link. Base pricing for the Big River LTX2 starts at around $28,000 for a 1.6 Terabyte system. Solid-state options are also available.

Conduant, Longmont, CO. (303) 485-2721. [www.conduant.com].

## VME/ATR Supply Powers 28V Avionics and Vetronics

The military power supply realm remains a high barrier of entry market space. That's because a select set of vendors has earned the trust of military system designers over decades of working with them. Designed to satisfy the needs of many of today's 28V input military applications, Rantec's new line of power supplies is available in conduction-cooled 6U x 160 mm single slot and convection-cooled 6U x 160 mm two-slot models. Rated for up to 250W, output voltages of 3.3, 5.0 and +/- 12 VDC are provided. In addition, there are two electrical configurations in order to serve cost-sensitive applications and a wide-input ANSI VME64-compliant version for performance driven requirements.

All of the power supplies meet MIL-STD- 461 EMI, MIL-STD-810F environments and MIL-STD-901C shock. The device is compliant to MIL-STD-704A-F steady state, normal and abnormal conditions. Operating temperatures are -55° to +85°C for single-slot conduction models and -55° to +65°C for double-slot convection models. The supplies support thermal protection with auto-recovery as well as overcurrent and overvoltage output protection.

Rantec Power Systems, Los Osos, CA. (805) 596-6000. [www.rantec.com].

## Four-Channel Video Frame Grabber Rides PC/104-Plus

Full motion video capture was once only possible using a whole backplane full of boards. Now multiple channels of video can be captured using a single PC/104-Plus card. Doing exactly that, Digital Logic developed the video frame grabber Microspace MSMG104+. The PC/104-Plus extension card is based on a BT878 frame grabber with 4-channel video multiplexer. Three video cameras (CVBS) and one S-Video camera can be connected to the product. The compact video frame grabber supports common image formats like PAL and NTSC. Software supports toggling between both formats. The bandwidth for PAL resolution is 30 frames/s.

The 32-bit/33 MHz PCI bus permits simultaneous operation of two video streams in PAL resolution. More cameras (3-4) are possible with a reduced number of frames or lower resolution or by using multiple MSMG104+ cards respectively. Drivers for Windows and Linux are available. The card is connected to the 32-bit PCI bus and requires only one PCI resource. The MSMG104+ requires a 5V power supply and operates within the standard temperature range of -25° to +70°C. On request it is also available for an extended operating temperature range from -40° to +85°C.

Digital Logic, Luterbach, Switzerland. +41 (0)32 681 58 40. [www.digitallogic.ch].

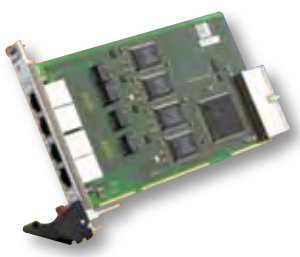
## Dual 19-inch Flat Panel KVM Mounts Vertically

Military control stations face requirements for even more sophisticated graphics and video display. Serving that need, Neuro Logic Systems, provides the first vertical "over-under" Dual 19-inch Flat Panel display and keyboard drawer (KVM) unit that mounts into a 2U (3.50-inch) space. Called the RFT2-19-L2, the unit was originally designed for piloting Unmanned UAVs and features a sealed, backlit, full-travel keyboard and sealed 38 mm 3-button trackball for use in harsh battlefield environments. When closed, the lightweight, aluminum alloy RFT2-19-L2 stows into a single, 24-inch deep 2U space in a transport case or standard RETMA equipment rack.

The two high-quality, wide view angle 19-inch LCDs, with 1280x1024 native resolution, are protected by strengthened, anti-reflective glass filters. The RFT2-19-L2 also comes equipped with a backlit, sealed, full-travel keyboard and large 3-button trackball. Video connections are HD-15 and keyboard connections are PS/2 while options exist for DVI, NTSC and RS-170 video and keyboard options for USB. Single piece pricing is $5,775 and quantity discounts are available.

Neuro Logic Systems, Camarillo, CA. (805) 389-5435. [www.NLSdisplays.com].

## cPCI Card Features Quad Fast Ethernet Links



Drawn to its longevity and ubiquity, the military has warmed to Ethernet for even the harshest of deployed systems. MEN Micro now offers a single-slot, 3U CompactPCI (cPCI) network controller with Quad Fast Ethernet (QFE) for expanded control of multiple network configurations. The new 32-bit, 33 MHz F211 is qualified for an extended temperature range of -40° to +85°C, making it ideal for harsh and mobile applications.

The IEEE 802.3u-compliant network controller features four full-duplex/half-duplex channels that support 10Base-T and 100Base-TX physical layers and provide auto-negotiation, collision and link detection with a maximum data transfer of 200 Mbits/s per channel. Each of the four channels has a unique MAC/IP address, enabling the F211 to function in a redundant mode when the lines are used in parallel, especially useful for high-availability systems. The F211 has a high isolation voltage of 1,500V and a low power consumption of 3.3V. The front panel features four standard 8-pin RJ45 connectors. Optional conformal coating further ensures the controller's resistance against rugged conditions. Pricing for the F211 is $544.

MEN Micro, Ambler, PA. (215) 542-9575. [www.menmicro.com].

## Time-to-Digital Converter Has Six Stopwatch Functions

Applications such as laser detection and ranging (LIDAR) for 3D mapping, navigation and mass spectrometry all have something in common. They depend on precise timing subsystems to get the job done. Agilent Technologies introduced the first time-to-digital converter (TDC) from its Acqiris product line that features six independent stopwatches for precise timing measurements from a common start event to multiple stop events at a high resolution.

The TC890 records multiple events or hits on each of its six input channels, with a timing resolution of 50 ps and a mean dead time between sequential pulses on the same input (double pulse resolution) of less than 15 ns. Running at full speed, the instrument offers a massive 25 million events-per-second data-throughput rate. The module operates in a multi-start, multi-stop acquisition mode with the timing information of stop events on all independent channels encoded relative to the most recent start event on the common channel. Digitized data is fed directly to the onboard FPGA-based data processing unit. This handles the data and subsequent fast readout with a direct memory access (DMA) mode for increased data throughput to the PC. Pricing for the TC890 multi-start, multi-stop time-to-digital converter starts at $13,700.

Agilent Technologies, Monroe, NY. (845) 782-6544. [www.acqiris.com].

## 500W DC/DC Converter Suited for High-Reliability Chores

Harsh environment military systems can't skimp when it comes to power converters. A level of reliability is called for where failure is not an option. Along such lines, Century Electronics has announced a new family of extra high power DC/DC converters, providing up to 560 watts of output power with 90% efficiency. The new Model DC500 Series Converter operates at 28V input in accordance with MIL-STD-704 Magnetic Isolation.

The power supply is unaffected by time, temperature or radiation, as the feedback circuit does not use optocouplers. A primary current sense transformer and a secondary output current sense resistor are used for output short-circuit and current-limit protection creating higher reliability. Soldering is not required for interface connection with the module, as D-type input and output connectors are utilized. The input connector is an integral part of the six-side shielded EMI input filters. Input In-Rush current is limited to less than 50A. A power On/Off remote-control input pin is available. Unit size is 6 x 5 x 1 inches and weighs 1.85 lbs.

Century Electronics, Westlake Village, CA. (818) 706-8224. [www.centuryele.com].

## EPIC SBC Serves Up 1.8 GHz Pentium M

As the long awaited follow on to the popular PC/104 form-factor, the EPIC form-factor is—like PC/105—gaining fans among military systems designers. Fastwel's latest EPIC offering is the CPC800, an SBC based on an embedded Intel Pentium M processor up to 1.8 GHz and 1 Gbyte of DDR SDRAM. All components including CPU, SDRAM and 32 Mbyte solid-state disk are soldered on board thus providing superior shock/vibration resistance. For challenging applications there is a CompactFlash socket for cards of up to 8 Gbytes.

Two Gbit Ethernet ports make CPC800 an ideal platform for robust redundant systems. A new modification, the CPC800-02 will provide an additional LVDS interface for flat panels and allow capability to deliver two independent graphical streams for VGA and LVDS interfaces. The board sports a PC/104-Plus connector with PCI and ISA interfaces, which allows Fastwel CPC800 and PC/104 modules to work together as an integral system. The board can withstand shock up to 50g and vibration up to 5g in three directions with operating temperature range from -40° to +85°C. EPIC with a Pentium M processor is now shipping in volume with pricing starting from about $1,500.

Fastwel, Brooklyn, NY. (718) 554.3686. [www.fastwel.com].

## Multifunction VME Card Blends Five Functions in One

As military programs—including airborne, shipboard, ground mobile and C3I applications—go into upgrade mode, the desire is always to do in one slot what used to take several. Satisfying just such needs, North Atlantic Industries (NAI) has announced the availability of a second-generation 5-module, multi-function, single-slot VME card. This universal and highly flexible card eliminates the complexity and size constraints of using multiple, independent, single-function cards.

The 64CS4 VME card can accommodate up to five independent function modules. Modules can be selected from a library that includes D/S (2-channels), D/LVDT (2-channels), S/D (4-channels), LVDT/D (4-channels), A/D (10-channels), D/A (10-channels), AC Synchro Reference Generator, Function Generator (4-channels), Discrete I/O (16-channels), TTL I/O (16-channels), Transceiver I/O (11-channels) and RTD (6-channels). The 64CS4 also incorporates a Gbit Ethernet interface that can be used to transfer data to and from the board, without using the VME backplane bus. The 64CS4 is available with operating temperature ranges of -40° to +85°C and 0° to +70°C. Conduction-cooled versions with wedgelocks are also available. Pricing for 100 pieces of the 64CS4 starts at $3,500 each.

North Atlantic Industries, Bohemia, NY. (631) 567-1100. [www.naii.com].

## PICMG 1.0 SBC Sports Core 2 Duo, 1033 MHz FSB

Not long ago the Pentium M seemed to dominate the new product announcements for embedded SBCs. Now the Intel Core 2 Duo is stepping into that role, offering military systems designers the boost in computer density they crave. NEXCOM has rolled out its first PICMG 1.0 SBC to support the Intel Core 2 Duo processor up to 1033 MHz Front Side Bus, and to provide backward support of ISA peripherals.

Since all components of the PEAK 765VL2 are designed to mount only on one side of the board, the PEAK 765VL2 board requires less manufacturing and components. As a result, the PEAK 765VL2 has a much lower failure rate due to the component failure. Since many existing peripherals in the military embedded computing market are connected through a legacy ISA expansion port, and all NEXCOM industrial computing products come with five years shelf-life support, the PEAK 765VL2 provides a great opportunity to upgrade your system's performance without giving up the legacy peripherals and applications for many years to come.

NEXCOM, Fremont, CA. (510) 656-2248. [www.nexcom.com].

## Ethernet Media Converter Adds SFP Option

The jury is in. The military market has accepted Ethernet for numerous networking and fabric interconnect chores. Aaxeon Technologies has released of its Optolinx FCU-3002SFP 1000BaseT Ethernet to 1000BaseSX/LX Ethernet Media Converter with SFP (Small Form-Factor Pluggable) interface. The FCU-3002SFP is exactly like its FCU-3002 counterparts except that it has the luxury of having an SFP Slot. Users now have the option to use either Single-Mode or Multi-Mode by simply changing SFP modules. They can also easily change wavelengths and reach by doing a simple SFP swap.

Since the SFP modules are hot-swappable, changing to the desired mode is a breeze. The FCU-3002SFP will work with any MSA (Multi-Source Agreement)-compliant transceiver. The FCU-3002SFP is fully compliant with IEEE 802.3z and IEEE 802.3ab standards. With supports to Link Alarm, Jumbo Frame (64-9216 byte) and Voltage Monitoring, users should have no problem implementing the FCU-3002SFP into their application. Installation and operation procedures of the FCU3002SFP are simple and very straightforward.

Aaxeon Technologies, Brea, CA. (714) 671-9000. [www.aaxeon.com].

## Repeater Does Safe CAN-Data Transmission via Fiber

Already a fixture in automotive electronic systems, the CANbus continues to gain mindshare among military vetronics (vehicle electronics) system designers. CANbus expert IXXAT has rolled out its new CAN-CR210/FO, a line-up version of its approved FO-Repeater. Several CAN-CR210/FO can be connected via the integrated backbone bus, which allows the set-up of a star-coupler with an almost unlimited number of channels.

The main operational area for the FO-Repeater is the transmission of CAN messages in an environment with high electromagnetic influences as well as the dependable galvanic isolation of subassemblies. As with all IXXAT repeaters, the CAN-CR210/FO allows the automatic recognition and separation of a defective segment from the rest of the network, so that the remaining network can continue working. After elimination of the defect, the segment is automatically switched into the network again. The CAN-CR210/FO has one high-speed CAN interface (ISO/IS 11898-2), an integrated backbone-bus and a fiber-optic interface (50/125 micrometer duplex). For the fiber-optic version F-SMA or ST-Socket is available. The repeater is delivered in a small plastic case for DIN rail mounting. The power supply can be provided in a wide range from 9 to 35 VDC.

IXXAT, Bedford, NH. (603) 471-0800. [www.ixxat.com].

## MicroTCA Backplane Features Cube Format

MicroTCA is starting to gain traction in the military market, as the ecosystem of boards, backplanes and chassis products continues to flesh out. Offering a twist on the traditional MicroTCA backplane configuration, Elma Bustronic has crafted a new MicroTCA backplane in the Cube style format. The backplane features six AdvancedMC, one MicroTCA Carrier Hub and a Power Module slot. The Bustronic backplane has a Star topology and fits in a 4U wide Cube-style MicroTCA portable enclosure. The backplane also features a JSM (J-Tag Switch Module) slot, and connections at the bottom for a Cooling Unit and at the top for temperature sensors. The 12-layer routing includes twelve ports, including Fat Pipe lanes and allocations for PCI Express traffic.

The pinout of Connector 2 of the MCH is the first alternative pinout defined in the MicroTCA Spec. This pinout contains half a fabric (fabric B) and three clock networks. The fabric on this connector is not used at all. Instead the according Ports 2 and 3 of the AMCs are connected directly between the cards. Bustronic also offers MicroTCA backplanes in both Star and Dual Star topologies and in Pico and Subrack formats. Pricing for the Cube MicroTCA backplane is under $1,000 depending on volume and configuration requirements.

Elma Electronic, Fremont, CA. (510) 656-3400. [www.elma.com].

## Digital Transceiver Embeds Interpolation Filter IP Cores

Applications like SIGINT, military communications systems and radar have big appetites when it comes to transceiver bandwidth and range. Feeding those needs, Pentek has released its Model 7140-420 Dual Digital Transceiver with Wideband Digital Downconverter (DDC) Core and Interpolation Filter. This is a complete software radio system in a PMC/XMC module. It includes two A/D and two D/A converters for connection to HF and IF ports.

This module is also available in a variety of form-factors including PCI, 3U and 6U cPCI, as well as a PMC/XMC conduction-cooled version. The Model 7140-420 Dual Digital Transceiver with Wideband DDC Core and Interpolation Filter handles a range of input and output signal bandwidths from 4.8 kHz to 40 MHz—highly extraordinary for a single product. The GateFlow Core 420 includes a two-channel, wideband DDC IP core that complements the multiband Texas Instruments GC4016 ASIC. This DDC can be driven directly from the A/D converters to achieve decimations from 2 to 64 for signal bandwidths up to 40 MHz. The Model 7140-420 PMC/XMC module's prices start at $11,995.

Pentek, Saddle River, NJ. (201) 818-5900. [www.pentek.com].

## Touch Panel Computer Features PC/104 Expansion

PC/104 ranks high in the list of popular military embedded form-factors. The eAutomation Group of Advantech has introduced the TPC-660G, an AMD LX800 6.4" VGA TFT Touch Panel Computer designed for small-sized operator interface applications. The integration of a fanless kernel, touchscreen and non-volatile storage makes this machine a reliable solution for rugged environments. The TPC-660G has a 16-bit PC/104 expansion slot that provides a dependable and convenient way to add on functions. Common PC/104 cards for a variety of applications can fit in the TPC-660G.

The display's backlight life is rated at 20,000 hours and has a 180:1 contrast ratio and a luminance (cd/m2) of 150. Maximum colors is 263k, with a maximum resolution of 640 x 480. I/O functions include one PS/2 port, a 10/100Base-T Ethernet LAN port, a RS-232 and RS-232/RS-422/RS-485 serial port, two USB 2.0 ports and an optional CompactFlash card slot. The TPC-660G is super slim with a compact design, plastic housing and a front panel that is NEMA4/IP65-compliant. Also, it supports Windows XP/CE and WinXPe. The TPC-660G is priced starting at $1,090.

Advantech, eAutomation Group, Cincinnati, OH. (513) 742-8895. [www.eAutomationPro.com].

## UPS Family Is Designed for Critical Military Use

When it comes to back-up power for mission-critical military systems, a unique set of Uninterruptible Power Supplies (UPS) requirements come into play. Right up that alley, Falcon Electric has launched its FN Series UPS Plus family of parallel or N+1 redundant UPSs. Designed to meet the demands of military network infrastructures with a scalable platform and N+1 redundancy, the new double-conversion on-line UPSs achieve many technical milestones including a faster processor utilizing DSP.

The new hardwired FN Series UPS will be available in various model configurations. All models support a hardwire connection to any 208-240 VAC single-phase, 2-wire plus ground power source. In contrast to the current parallel UPS solutions offered in the marketplace, Falcon's innovative UPSs are stand-alone units that may be connected in parallel, providing low-cost, scalable solutions from 3 kVA up to 24 kVA. This approach eliminates the added expense of buying cabinets to house power and battery modules. When the FN models are configured in parallel, with the addition of one extra UPS, true N+1 redundancy can be achieved. Available now, the FN Series UPS Plus models are designed to UL and cUL standards and meet FCC Class A requirements. List pricing starts at $3,889.

Falcon Electric, Irwindale, CA. (800) 842-6940. [www.falconups.com].

## Backlit LCD Solution Targets Night Vision Apps

Night vision displays play a critical role in a wide range of applications, including displays in military aircraft cockpits, tanks, trucks, ground mobile applications and communications gear. Apollo Display Technologies has developed a more efficient and more cost-effective way to make LED-backlit TFT LCDs compatible with Night Vision Imaging Systems (NVIS). Apollo can furnish VGA and XGA resolution TFT LCDs backlit by LED rails that are addressable via the company's standard PRISMA II industrial controller board to switch back and forth between day and night mode. Eliminated are the cumbersome and expensive filters—large glass overlays bonded to the outside of the display—that have been previously used.


A key to Apollo's approach is its addressable LED rails. Coated CCFL lamps have been tried but, according to McKay, they negatively impact the appearance of the display in daytime mode. Apollo's LED rails have separate day and night mode functions built into them. Two versions are available: NVIS A for upper echelon applications and NVIS B for applications with less stringent requirements. Apollo has produced an 8.4-inch diagonal NVIS-compatible LCD, which will be scalable up to 15-inch diagonal. All LCDs are fully RoHS-compliant.

Apollo Display Technologies, Ronkonkoma, NY. (631) 580-4360. [www.apollodisplays.com].

## 1.8 GHz Pentium M EBX SBC Runs at -40° to +70°C

Compute density seems to be the watchword these days in all manor of embedded autonomous military computing applications. The EBX form-factor has a lot to offer for such applications. WinSystems has launched their EBX-compatible Intel 1.8 GHz Pentium M single board computer. The EBC-855-G-1.8-1 is a RoHS-compliant, processor- and I/O-intensive board offering -40° to +70°C temperature operation. Based on Intel's 855GME chipset with the ICH 4 communications controller and integrated Extreme Graphics 2 video 3D controller, the EBC-855-G-1.8-1 offers long-term product availability and full x86-Pentium compatibility. It supports up to 1 Gbyte of industry-standard PC2700 SDRAM and up to 8 Gbytes of CompactFlash. It also supports rotational floppy and hard disk drives.

The EBC-855-G-1.8-1's I/O interface features include a 10/100BaseT Ethernet port (with remote boot capability), VGA and dual channel LVDS flat panel video, a miniPCI connector for an 802.11 wireless networking module, four USB 2.0 ports, four serial COM ports, AC97 audio (5.1 codec), LPT and a PS/2 port for keyboard and mouse. A software programmable 48-line digital I/O controller provides input, output or output with readback for each I/O line. More I/O expansion is possible by self-stacking modules plugged onto the PC/104 and PC/104-Plus connectors. The EBC-855-G-1.8-1 is priced at $895.

WinSystems, Arlington, TX. (817) 274-7553. [www.winsystems.com].

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# COTS View

# Modular Strategy Eases Airborne Motor Control Woes

By avoiding the need for complex embedded code development, an integrated module approach moves variable motor drive systems faster to market.

Michael Toland, Aerospace and Defense Marketing Manager
International Rectifier

Today's manufacturers of manned and unmanned military aircraft are under pressure to achieve improved performance while at the same time lower operating costs. In those efforts, aircraft designers face the challenge of developing increasingly complex avionics systems that require more power. Liquid-cooling systems with electrically operated pumps and chillers, for example, are replacing traditional bleed air-cooling of the environmental control system (ECS).

Meanwhile, variable speed Permanent Magnet (PM) electric motors, pumps, fans and compressors for More Electric Aircraft (MEA) are preferred over induction motor-driven, hydraulically actuated mechanical gearboxes to significantly reduce the weight of the aircraft and provide a greater level of reliability. The F-117 fighter, B-2 bomber, F-22 fighter and F-35 Joint Strike Fighter (Figure 1) represent the latest generation of aircraft whose maneuverability and flight characteristics could not have been achieved without this shift toward MEA and electrically controlled digital fly-by-wire designs.

The transition from gear-driven to electronic-driven subsystems requires several new motors on each aircraft. Developing and testing a number of drives for each vehicle is a time-consuming and costly task. However, a new approach utilizing a high-reliability motor control platform featuring sensorless vector control of a PM motor is now available to help meet these challenges.

## Traditional Motor Controllers

Digital motor control is typically software-based in a DSP, microcontroller or FPGA device. The power silicon and gate drive are supplied co-packaged in an off-the-shelf module. The controller is mounted on a separate printed circuit board that must be encoded by the drive manufacturer. Programming the device for a specific application requires a team of software engineers to write and debug the code. In safety-critical applications, these software programs must be certified. This certification process is complex and expensive, particularly where a design reiteration is required.

Figure 1

Advanced aircraft like the F-35 represent the latest generation of planes whose maneuverability and flight characteristics could not have been achieved without this shift to electrically controlled digital fly-by-wire designs. The F-35 Lightning II is shown here completing a successful inaugural flight in Fort Worth, Texas last December.

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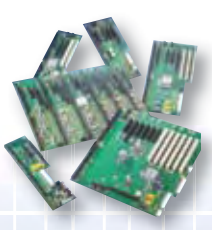

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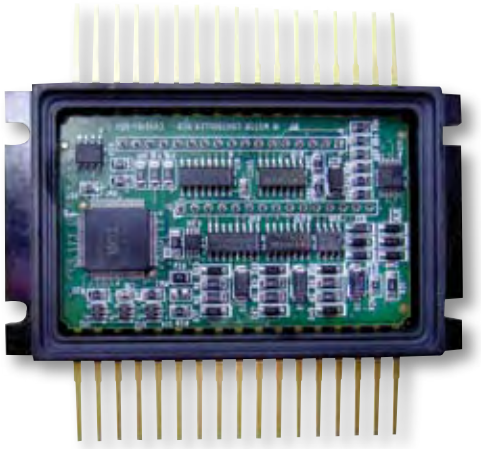


Figure 2

International Rectifier's IRMCT3UF1is a MIL-STD-883-certified integrated module for high-reliability variable-speed motor control. The module features sensorless field-oriented control for 500 VA or less motors.

An alternative approach developed by International Rectifier is a MIL-STD-883-certified off-the-shelf integrated module that provides a quick and easily implemented solution for variable-speed motor control. The IRMCT3UF1 (Figure 2) module features sensorless field-oriented control for 500 VA or less motors. In addition to the digital IC, the module features power MOSFETs mounted on an insulated metal substrate (IMS) and gate drivers mounted close to the power silicon to achieve the lowest possible parasitic inductance. The module has control and protection circuitry mounted on a PCB mezzanine and is co-packaged with the IMS in an encapsulated plastic frame.

## Improved Reliability

Sensorless control is the key to high reliability. The IRMCT3UF1 features a unique Motion Control Engine (MCE) controller IC. The MCE consists of configurable control blocks—Proportional plus Integral, Vector rotator, Clark Transformation, and so on—necessary to perform closed loop controls and motion hardware peripherals.

Unique flow control logic is used to structure the control blocks into a configurable control loop that enables parallel execution and multiloop control. Therefore no multitasking operating system is required. Synchronous execution mechanism of closed loop velocity control and closed loop current control can be included in the control structure. Flexibility is retained by the implementation of configurable parameters in the control blocks and peripherals. The parameters are accessed through a real-time host register interface that can be read or written by a host controller or companion microcontroller.

One significant advantage of the MCE over a traditional DSP or FPGA device is the very short computation time to complete a closed loop control algorithm with deterministic timing. Fast computation directly influences the dynamic performance of torque and speed of a motor system. The faster the update rate of closed loop current control, the higher the bandwidth of torque control. This will in turn affect system turnaround time or cycle time of the machine.

A significant boost to reliability is the sensorless operation of the device. The sensorless algorithm operates over a continuous speed range of 10 percent to 100 percent of full speed without overload. The goal is to maintain an orthogonal relationship of the stator and rotor windings. In order to provide the maximum torque and maintain speed, the rotor angle in relation to the stator is estimated every 11 microseconds.

The rotor position is calculated and the signal fed to the space vector PWM modulator, and the appropriate gate signals applied to the MOSFET. In addition, inverter leg shunt current sensors are used to feed back phase current to the digital controller IC. Without the use of Hall sensors, the motor size and cost are reduced, while the reliability is improved. Figure 3 shows a block diagram of a sensorless digital controller.

The IRMCT3UF1 is equipped with many protection features including shutdown during over-current, over-temperature and under-voltage events. The chipset, including the control, gate drive and power MOSFETS leverages IR's proven devices used in factory automation, white goods and automotive controls. IR has combined this technology with rugged packaging to meet vibration profiles in a small lightweight footprint ready to mount on a cold plate or heatsink.

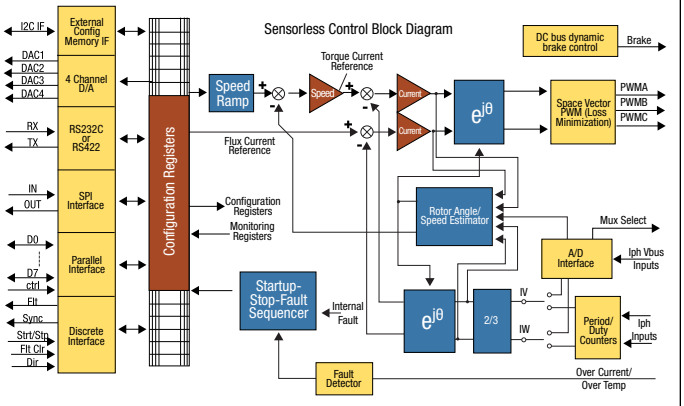



Figure 3

Shown here is a block diagram of a sensorless digital motor controller.

Figure 4

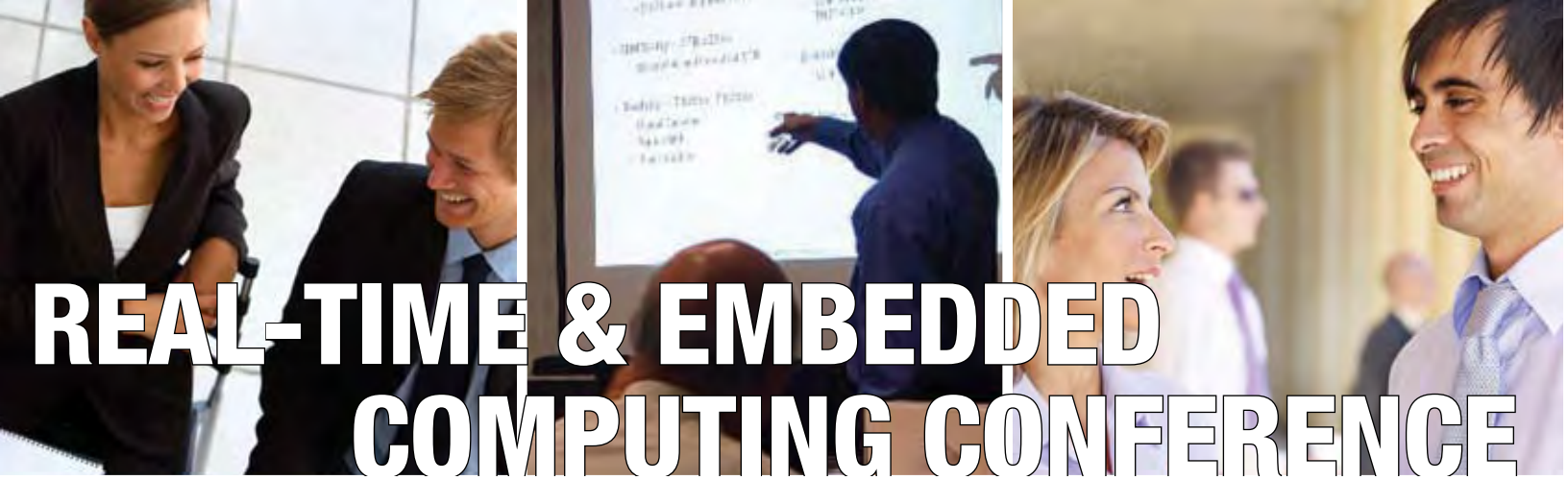
ServoDesigner is a Windows-based configuration tool that maps the internal registers to configure motor type, motion peripherals, control mode, tune control parameters, and monitor and diagnose internal signal waveforms.

## Design Tools

To optimize all of the control loop parameters and evaluate the performance of the whole system, ServoDesigner (Figure 4), a Windows-based configuration tool, maps the internal registers to configure motor type, motion peripherals, control mode, tune control parameters, and monitor and diagnose internal signal waveforms. Once motor and user-defined parameters are entered and the command initiated, the tool translates the parameters into an internal format and transfers them to the configuration registers within the digital control IC's memory. Based on the selected parameters, the proprietary algorithm within the digital controller device controls the integrated gate driver and switching of the power semiconductors commutation. Using this approach, the designer can spin the motor and optimize its control within hours rather than weeks or months.

An off-the-shelf module for electronic motor drive control in military aircraft offers a compelling argument to manufacturers to adopt variable-speed motor control systems as a higher-performing and viable cost-effective alternative to existing electromechanical techniques. From the designer's perspective, the integrated approach blends the best silicon, packaging, processes and software to optimize performance while simplifying the design task, to increase performance and reliability and bringing military applications to market faster. ■■

International Rectifier
El Segundo, CA.
(310) 726-8512.
[www.irf.com].



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# Coming Next Month

COTS JOURNAL

- *Nano- and High-Density Computers.* Many of today's advanced military programs—in particular unmanned air and ground vehicles—are hungry for high-density embedded computing. The more processing of data and decision making that can be performed onboard the UAV itself rather than performed via a communication link with the ground, the more efficiently the craft can be used. Meanwhile highly integrated "nano-computing" solutions will enable a whole new level of autonomy and mission flexibility for mini-UAV and ground robots. This section examines today's high-density and nano-computing embedded computer products and their application in military programs.
- *Graphics & Imaging in Situational Awareness.* Embedded military computing plays a vital role in the development of advanced situational awareness systems. Such systems must gather and present a mix of data gathered externally, data stored internally and data generated on the fly. This section examines the processing techniques and technologies involved in bringing diverse forms of image data together in a timely manner, and technologies in VPX, cPCI and graphics PMC are helping system developers craft next-gen situational awareness systems.
- *The PC as a Military Test Platform.* Fading fast are the days when complex military electronics systems required large racks on boards to implement test platforms for them. Now the same test functions can be done on the PC using USB, PCI Express data acquisition and test modules. This section looks at the boards and software solutions driving this trend.
- *Conduction-Cooled CompactPCI.* The CompactPCI embedded form-factor—now well into its second decade of existence, has achieved the maturity and broad product range that military system designers so crave. The 3U flavor of cPCI is particularly attractive to space/weight-constrained applications like avionics. This Tech Focus section updates readers on cPCI trends, and provides a product album of representative conduction-cooled 6U and 3U cPCI boards.

# Editorial

Jeff Child, Editor-in-Chief

# Wheel Invented, Reinvented

Like most New Englanders—who must suffer through our ice-cold, snowy winters—summer is when I take most of my vacation time. In theory that should rank it as the most relaxing time of year for me, and it is to some extent. But the flip side is that I have to work twice as long and hard to make up for time away from my desk. Publishing is a fun business, but it's unforgiving when it comes to the ticking clock.

Certainly, the industry we cover—the defense electronics and embedded computing industry—does slow down somewhat in the summer, which only makes getting information out of people trickier for us journalist types. But I have no cause for complaint—a little planning ahead is enough to neutralize those issues. All that said, summer isn't the first thing that pops into my head when I hear the term "slow pace." For me, nothing deserves the term "slow pace" more than Defense Acquisition Policy reform.

For anyone who's been involved in the defense industry for any length of time, it's hard not to get a bit jaded when hearing of more attempts at acquisition reform. How many panels and committees have studied the acquisition process in the past 20 years, without generating much improvement? A recent go-around was in 2005 with the Defense Acquisition Performance Assessment (DAPA) committee. Over the course of that year it undertook a full assessment of every aspect of acquisition—including requirements, organization, legal foundations, decision methodology, oversight, checks and balances.

More recently, in its 2007 Defense Authorization Act, Congress mandated that the DoD produce biannual reports on acquisition reform. The first Defense Acquisition Transformation Report (DATR) was submitted to Congress in February, and the second in July. It's great that the matter of acquisition reform continues to be a matter of vigorous debate and the lines of communication are strengthening between Congress and the DoD. Why is it then, that very little changes? Seems like these kinds of reform discussions and policy revamps have been going on since 1986 and the David Packard commission under the Reagan Administration.

I got some interesting insights on that question from a recent talk I had with Dr. Sally Baron of the Defense Commercial Vendors Coalition (DCVC). The DCVC is an organization formed to elevate awareness and a provide a voice for commercial products and other readily available capabilities that have been otherwise overlooked or reinvented in past DoD programs. It's made up of commercial vendors in the defense industry that champion acquisition reform and promote a free market of competing commercial products and technologies for use in DoD applications.

"One of the main reasons," said Baron, "that acquisition reform is slow to happen is the upside down reward system in defense procurement. It's a system that's fundamentally not friendly to commercial outsourced subsystems." She gave this example in an IT situation, although it applies to the embedded market too. Let's say an Air Force Major goes into an office where there's 200 people and $200 million dollars worth of computer equipment. In order for him to make promotion to Lt. Colonel he needs to supervise a certain number of people and a certain dollar amount to make him competitive. What is the likelihood that he would say: "We only need three people and three Pentium PCs. Let's cut this office down." It's not going to happen, because the reward system doesn't favor it.

Another problem, Baron said, is that the required "market searches" just aren't being done. Federal acquisition regulations require that a market search be performed prior to award of any contract. That means a search for the relevant systems and subsystem vendors that could contribute to the program. The DCVC did some research recently that concluded that in the last 200 acquisitions of over $1 million, only around 1 in 200 actually did a market search. "By that I don't mean an exhaustive market search," says Baron. "Only 1 in 200 did ANY market search." That's a pretty astounding statistic in this day and age when searches can be done pretty effectively with a search engine like Google.

Among the interesting initiatives that the DCVC recently started maintaining is a "Reinvention List." This growing list tracks DoD technologies that were built from scratch rather than bought off-the-shelf, despite the fact that equivalent commercial products were available. DCVC members are permitted to submit additional citations that are posted anonymously. "To compile the list, we asked every company we talked to—many of which we found in *COTS Journal*—to come to us with any product that they know for a fact has been reinvented using government funding," says Baron. "You would not believe how fast the list is growing."

The DCVC is a relatively new organization, but I applaud its efforts to tackle the acquisition reform problem from a "bottom up" point of view—in other words from the perspective of the commercial product vendors. History has shown that the "top down" attempts—however well intentioned and vigorous—have failed to achieve the lower costs and shorter development cycles long sought after in today's military programs. ▮▮

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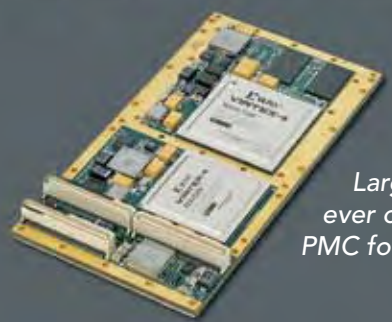

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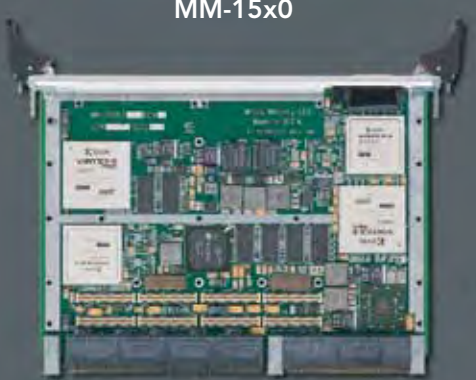

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