

## VME VPX AND BEYOND

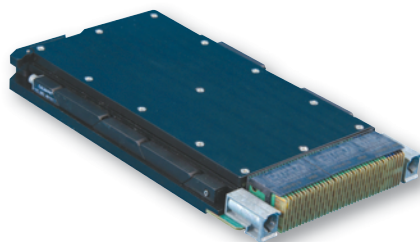
# 3U VPX: Rugged, High-Performance Small Form-Factor COTS Comes of Age

Filling the need for small form-factor, rugged modules with high compute performance and rich data transfer, 3U VPX appears to be ahead of the pack.

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Small form-factor COTS boards offer unique benefits for rugged applications, which frequently suffer from size, weight and power (SWaP) limitations. Now, with the 3U version of the VPX and VPX-REDI board standards, rugged, high-performance small form-factor (SFF) COTS has come of age. 3U VPX hits all of the “sweet spot” requirements, including quantity of user I/O pins, bandwidth, support for advanced cooling and protective metal covers to support line replaceable module (LRM) applications. For high-performance computing, the 3U VPX standards far exceed what has been available from alternative small form-factors (SFFs), such as 3U CompactPCI (cPCI), PICMG Express and the in-development Rugged MicroTCA. Until the availability of 3U VPX, military system designers have had to turn to non-COTS solutions to obtain all these features in a single board architecture.

Over the last several decades, the VME architecture reached its ascendancy as the most popular open standard embedded board architecture. During that time, vastly increased chip densities



**Figure 1** The VPX3-125 from Curtiss-Wright is a 3U VPX board with single or dual Power Architecture cores and two 4-lane PCI Express fabric ports.

and growing pressures to integrate more processing performance into smaller spaces, have driven the need for a rugged, high-performance small form-factor that directly addresses the unique needs of aerospace and defense (A&D) applications and their harsh environments. The 3U form-factor (100 x 160 mm) has proven popular as a satisfactory size and shape for embedded computing. The 3U size provides a modularity/capability trade-off, attractive for smaller platforms, and opens up a range of smaller systems such

as datalink equipment, mission computers and IFF units to the use of a standard open architecture module size. While the 6U VME form-factor rose to become the de facto board architecture for COTS computing, the complementary 3U version of VME never achieved significant adoption, primarily because of its lack of rear-panel I/O.

Finding themselves without a satisfactory SFF roadmap within the VME ecosystem, system integrators looking to meet the need for rugged, high-performance SFF computing that supports rear-panel I/O, previously had no option but to turn to non-VME solutions, derived primarily for benign (non-rugged) telecommunications and network-centric applications, such as the 3U CompactPCI, PICMG Express and, more recently, the AMC/MicroTCA form-factors. While each of these architectures has its own inherent benefits and ideal niche uses, for A&D applications, these alternate options



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	SFF Parallel Bus Architectures		SFF Serial Bus Architectures		
	VME	Compact PCI	PICMG Express	3U VPX	Rugged MicroTCA
Board Size	100x160mm	100x160mm	100x160mm	100x160mm	73x181mm
Board Area	24.8	24.8	24.8	24.8	20.5
User IO Pins	0	75 as "system" 105 as "peripheral"	30	72P2+32diff- P1+4P1=108	None Defined
Conn Contact	Dual Beam	Dual Beam	Dual Beam	Dual Beam	Single Beam
Bandwidth	A24/ D16=20MB/s	32/33=133MB/s	24 lanes PCIe=12 GB/s	16 lanes PCIe/ SRIO=8/10 GB/s	40 lanes Fabric sharing w/ user IO
Conduction Cool	Yes	Yes	No	Yes	In Development
Liquid Cool	No	No	No	Yes	No
LRM	No	No	No	Yes	No
Shock and Vibration Performance	Good	Good	Good	Excellent	In Development

Table 1 Small form-factor parallel bus architectures and small form-factor serial bus architectures.

have required designers to accept significant performance compromises.

In response to the growing need for high-performance SFF solutions, leading A&D COTS vendors and military contractors joined together under the auspices of the VSO to define the next-generation high-performance rugged board architecture. The resulting standards, VPX (VITA 46) and VPX-REDI (VITA 48), greatly increase I/O bandwidth and provide support for serial switched fabrics, such as Serial RapidIO and PCI Express. They provide the first open standard definition for the use of protective metal covers, enabling a COTS solution for the military's preferred LRM (line replaceable module) approach for in-the-field board-level repair and maintenance.

While employing a new, high-bandwidth connector type, the MultiGig RT2 and enhanced ruggedization, including built-in ESD (electro-static discharge) protection and the above mentioned protective covers, the VPX standards also retained many of the popular features of the legacy VME ecosystem, such as support for VME electrical signals (enabling hybrid VME/VPX systems to be

fielded), and the 1" pitch chassis standard. This approach eases the transition from legacy VME systems into the new VPX technology, while protecting existing investments in legacy hardware and software development.

To fully understand the significance of the technology advancements that 3U VPX brings to embedded COTS system integration, it's useful to compare and contrast the functionality of the various SFF options that it supersedes (Table 1).

### 3U CompactPCI

3U CompactPCI (cPCI) has found increasing popularity in space- and weight-constrained defense and aerospace applications in recent years. But for the higher-end applications, such as radar and signal processing, 3U cPCI's bandwidth is not well suited to support serial switched fabrics such as Serial RapidIO and PCI Express. It is also unable to take full advantage of the high-speed interconnects prevalent on new multicore processors such as Freescale's 8641, with dual 8 lane PCI Express ports (or Serial RapidIO), and P.A. Semi's 1682 with 24 flexible SERDES engines. cPCI's 32-bit PCI

bus can run at 33 MHz for a 7-slot system (66 MHz for a 5-slot system), providing a maximum transfer rate of 264 Mbytes/s but cannot provide the intercard bandwidth required in higher-performance systems. Also, cPCI's connectors provide a maximum bandwidth of 1 to 1.5 Gbits/s, which is insufficient for many high-speed signaling requirements.

3U VPX is a superior alternative to 3U cPCI for high-end, bandwidth-intensive applications. The 3U version of VPX is compatible with many existing COTS enclosures and chassis because it preserves the PICMG 2.0 Rev. 3 air-cooled O&I envelope and follows the VITA 30.1 standard for conduction-cooled designs. Even better, VPX supports significantly greater bandwidth than cPCI. It uses the Tyco MultiGig 7-row RT2 connector, which is rated to support signaling up to 6.25 Gbits/s and higher with advanced SERDES technologies. Each 3U VPX card is equipped with two 16-column 7-row RT2 connectors along with an 8-column 7-row RT2 utility connector. The two 16 column connectors provide 64 high-speed differential pairs and 16 signal-ended signals. Additionally, a new VPX "dot-spec," VITA 46.9, defines mapping for PMC and XMC differential I/O.

### PICMG Express

PICMG Express was designed to bring serial technology to the cPCI form-factor. Its initial use is in the instrumentation industry. It uses a new connector and defines several backplane topologies. The PICMG Express SFF board architecture retains the 3U form-factor, like cPCI and VPX, but it lacks support for conduction cooling, which is available with both cPCI and VPX, frequently a critical requirement for the harsh temperature extremes, from desert tarmac to high atmosphere flight, commonly demanded of A&D COTS boards.

PICMG Express does not have support for advanced cooling techniques, such as liquid cooling, supported by VPX-REDI. Unlike cPCI though, PICMG Express does provide support for high-speed serial switched fabrics, with 24 lanes of PCI Express (12 Gbytes/s). PICMG Ex-

press also suffers when it comes to user I/O pin counts. Its 30 user I/O pins are much less than 3U cPCI's 75 user I/O pins (for system card: 105 when peripheral) and significantly fewer than the 108 user pins provided by VPX.

### Rugged MicroTCA

Rugged MicroTCA is currently in the specification development stage. It leverages AMC boards, bringing the 73 x 181 mm form-factor mezzanine cards used in ATCA into the backplane environment. There are no user I/O pins defined on this SFF, but user I/O may be available at a later date to be shared on the 40 lanes of serial fabric that they support. Rugged MicroTCA is defined to work in several disparate environments, from outdoor telephone pole environments to rugged conduction cooled environments. It remains to be seen how well the single beam connector performs in rugged applications as this specification is in development and test data is not yet available.

Again, like PICMG Express, MicroTCA does not currently support either conduction cooling or liquid cooling. And this SFF also lacks support for the protective metal covers that enable the safe in-the-field removal and replacement required for LRM maintenance.

### VPX: Designed for Military Duty

The VPX standard was developed to directly address the special requirements of high-performance military and aerospace embedded applications. To survive in the harsh environments typical of these programs, and to ease in-the-field maintenance and repair, VPX includes integrated electro-static discharge (ESD) protection and support for metal covers. Today the cost of repairs comprises a large part of the sustaining cost of deployed systems. By enabling technicians to remove and replace system modules, such as pluggable processing and I/O boards, without special training or tools directly at the platform, VPX embraces the military's preferred Line Replaceable Module (LRM) model, which eliminates the cost and logistics associated with replacing and sparing complete subsystems.

To address the ESD protection requirement, the 7-row RT2 connectors used in VPX have a unique ground-strip element that acts as a miniature lightning rod for any ESD sources, ensuring that any signal contacts are not struck by ESD directly. To address the need for mechanical protection as well as providing ESD protection for exposed component leads and board traces, an LRM-capable module needs to conform to the VPX-REDI

(VITA 48) specification, which defines extended mechanical formats applied to the overall board outline and connector system of VPX. These extended mechanical formats include versions with full top and bottom covers that provide the handling capabilities required to support the LRM maintenance concept.

3U VPX is enabling MIL COTS vendors such as Curtiss-Wright to design powerful processing solutions. These small form-factor single board computers (SBCs), such as Curtiss-Wright's new VPX3-125 (Figure 1), can deliver 2x the processing power and 12x the interconnect bandwidth (with only 2/3 the power dissipation) of 3U SBCs released as recently as a year ago. For space/weight-constrained applications with high-speed signaling and bandwidth requirements in harsh deployed environments the trend is VPX. ▲

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