

CompactPCI's versatility fuels strong growth in military applications

BY DAVID PURSLEY

David discusses the characteristics of CompactPCI that make it suitable for mil and aero applications, using real world examples, and explores considerations for implementation of systems based on these architectures.

Limitations of 3U VME in terms of bus width, bandwidth, and rear I/O pins make it impossible to use for many applications. Instead, designers choose 3U CompactPCI for these applications, as it supports a much higher bandwidth with plenty of rear I/O. Similarly, for high-performance applications that require multiple CPUs processing data across a single backplane, 6U CompactPCI's derivative PICMG 2.16 is a logical choice, as it is more reliable and supports more rear I/O than VITA 31 or VITA 41.

CompactPCI's roots in PCI also make it more desirable than VME for many design groups. For example, new software designers already know and understand the development challenges for PCI applications, while developing VME applications provides some unique challenges. Millions of software applications are CompactPCI compatible. These "comfort zone" factors that made CompactPCI quite successful in nondefense embedded applications are now helping to keep it as a prevalent architecture in defense applications.

Rear I/O in military applications

The requirement for rear I/O (routing board I/O signals to the backplane instead of, or in addition to, routing them to the front panel) in deployed military and aerospace applications is almost universal, as it greatly simplifies the replacement of Line-Replaceable Units (LRUs).

When all I/O is done through the backplane, a failing board can be simply unplugged from the backplane and replaced. No other reconnections are necessary, making replacement faster and less error-prone. PICMG 2.16's hot swap capabilities allow the board to be replaced without powering down the system. These advantages minimize system downtime and the time to repair each incident, reducing the deployed system's Total Cost of Ownership (TCO).

As shown in Figure 1, rugged military systems differ from "standard" 3U CompactPCI and PICMG 2.16 systems because they usually do not use standard Rear-Transition Modules (RTMs), instead using a custom backplane for inter-board

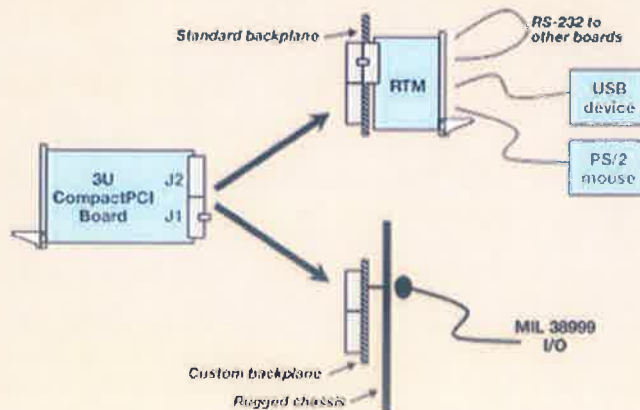


Figure 1

APPLICATION

COMPACTPCI IS BEING USED FOR A WIDE VARIETY OF MILITARY AND AEROSPACE APPLICATIONS, INCLUDING SUBMARINES, NAVAL SHIPS, AIRBORNE APPLICATIONS, AND GROUND VEHICLES, NOT TO MENTION IN MORE BENIGN ENVIRONMENTS SUCH AS SHELTERS, DEPOTS, BASES, AND OFFICE ENVIRONMENTS.

communication and to route the I/O for the system. MIL-style connectors for the system are typically connected to the custom backplane through an application-specific I/O module.

Rear I/O provides different capabilities for different applications. In non-rugged applications, rear I/O signals pass through the standard backplane to a board-specific RTM that provides I/O connectors, such as the RS-232, USB, and PS/2 connectors that are shown in Figure 1. In rugged applications, rear I/O pins connect to a custom backplane that provides rugged connectivity between boards and to ruggedized connectors.

When a system requires both rear I/O and a 3U form factor (as detailed in Table 1), CompactPCI is the only available option. If a larger form factor (6U) is sufficient, CompactPCI, VME, and their derivatives (PICMG 2.16, VITA 31, and VITA 41) all allow for rear I/O. PICMG 2.16 provides the most rear I/O functionality, with 295 connector pins available (Table 2).

As Table 1 illustrates CompactPCI can be used to overcome many of the limitations of 3U VME, including the low bandwidth and lack of rear I/O. Also note that a 64-bit bus is not possible with the 3U VME form factor.

CompactPCI as a rugged multiprocessor computer

Today's highly integrated military electronics systems typically must process multiple data streams independently. For example, Unmanned Ground Vehicles (UGV) and avionics systems require real-time feedback based on the concurrent processing of dozens of sensor streams. Similarly, during the early stages of large-scale defense programs, emulators simulate entire networks of deployed systems. Each of these applications requires multiple processor blades to operate independently, while at the same time communicating heavily with the rest of the system.

Table 1	CompactPCI (3U)		VME (3U)	
Data Bus Width	32	64	32	64
Theoretical BW (MBps)	264	528	40	N/A
Rear I/O	75 or 105	0	0	N/A

Table 1

Table 2	PICMG 2.16 (6U)	VITA 31 (6U)	VITA 41 (6U)
Backplane fabric	Gigabit Ethernet	Gigabit Ethernet	PCI Express, InfiniBand, StarFabric, Serial RapidIO
Rear I/O	295	205	110
System management	IPMI	Limited	Limited
System protected from single board failures	Yes	No	No

Table 2

For small footprint applications, 3U CompactPCI is the logical choice. Some of the rear I/O pins will typically be used to communicate between 3U processor blades, usually via Gigabit Ethernet (GbE). Other rear I/O pins communicate to peripheral cards or to the I/O modules, as explained earlier.

When a 6U form factor is acceptable, PICMG 2.16, VITA 31, and VITA 41 all natively support a switched or mesh fabric on the backplane, and Table 2 compares these architectures. PICMG 2.16 is the obvious choice for applications requiring a significant number of Rear I/O pins, but designs with modest rear I/O requirements will find that any of these architectures will meet their rear I/O needs. PICMG 2.16, VITA 31, and VITA 41 all offer a switched fabric backplane for high bandwidth connectivity. Additionally, PICMG 2.16 provides the advantages of IPMI-based system management and prevention of a single board from bringing down the entire system.

In such a case, the designer has to look more carefully at other system considerations. For example, if the application requires legacy custom VME boards, the system designer must choose VITA 31 or VITA 41. However, if that is not the case, the designer may select PICMG 2.16 for its improved reliability.

PICMG 2.16 improves reliability over VITA 31 or VITA 41. The PICMG 2.16 architecture provides Intelligent Platform Management Interface (IPMI) on the boards and backplane via an I2C bus allowing the system to be monitored. Failing boards can be identified and swapped with a replacement board. Also, PICMG 2.16 does not have a data bus shared among the cards. Therefore, no single card can go haywire and completely prevent all communication in the system. On the other hand, VITA 31 and VITA 41 include legacy VME64x support, which means that a single bus is shared among the boards, giving the opportunity for a single board to fail the system. In the most pathological case, an electronic failure on a single board could damage all cards in the system.

Combined, these features of PICMG 2.16 provide the ability to create a rugged multiblade supercomputer with reliability benefits that reduce the total lifetime cost of a deployed system as compared to VMEbus-based architectures.

Full range of military applications

CompactPCI is being used for a wide variety of military and aerospace applications, including submarines, naval ships, airborne applications, and ground vehicles, not to mention in more benign environments such as shelters, depots, bases, and office environments.

CompactPCI's ruggedness and the ability for both 3U and 6U form factors to meet connectivity and rear I/O requirements make CompactPCI versatile. For example, CPU blades can allow a CompactPCI solution with the same processor and chipset to be deployed in rugged air- or conduction-cooled systems, via either a 3U or 6U processor blade. Both blades can provide similar capabilities and connectivity, which maximizes flexibility for the system engineer. Kontron's CP307 (left side, Figure 2) is a 3U air-cooled solution, while the Kontron CP6001 (right side, Figure 2) is a 6U conduction-cooled version. Both form factors provide high computational power by way of dual-core CPUs.

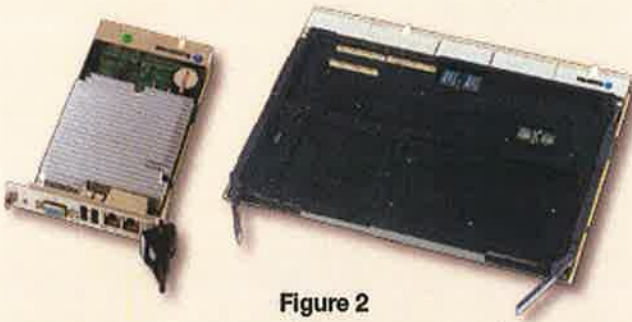


Figure 2


Systems based on the board-level building blocks as seen in Figure 2 have been used to create nearly identical architectures for completely different applications.

A radar processing application deployed 3U CompactPCI to create an array of networked dual-core processor computers. Some 3U blades also communicated with peripheral cards over the PCI bus to implement additional I/O for the system. When using 3U CompactPCI, the peripheral cards are additional 3U boards plugged into the backplane.

Similarly, 6U PICMG 2.16-based solutions with very similar architectures have been deployed in ground combat vehicles and in avionics applications. In each case, a number of 6U dual-core single board computers communicated to each other via GbE. Many boards also had a peripheral I/O card that it talked to over the PCI bus. The peripheral cards were PMCs attached as a mezzanine on the 6U boards.

A common and familiar view

Although the three applications just described had vastly different system form factors and cooling requirements, CompactPCI presented a common view of the system to the software developers. To the software, these three architectures would appear to be identical (assuming identical I/O cards) making software development very straightforward. Better yet, the CompactPCI architecture reuses the desktop computers' familiar PCI architecture, something even green software designers are comfortable with, so no special training is needed.

CompactPCI processor boards are identical to PCs from the software's point of view, so most existing PC application software will run unmodified on CompactPCI boards. While commercial application software is not as widely used in military applications as in other markets, there are still advantages. For example, commercial and open source operating systems and drivers can be used on CompactPCI boards with little or no customization. This fully supports the directive to use COTS components, including both hardware and software. 

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