MicroTCA's role expands in modern battlefields

By David Pursley

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Even against military embedded mainstays CompactPCI and VME and the up-and-coming VPX, MicroTCA is proving itself a powerful design option in harsh environments with: high bandwidth in a small form factor and proven ruggedness, multicore support, and high availability. Additionally, standards development is fueling MicroTCA's rapid movement as a military design choice from command centers to shelters to the battlefield.

Standardization initiatives throughout the military are driving integrated battlefield management, moving designers and technology evolution well past legacy architectures and toward more powerful yet standard solutions that can be deployed quickly and cost effectively. Military designers tend to need something deployable within a very well-defined timeframe and budget: Time and costs to modernize must remain under control, especially when contractors are used for developing designs that are then funded for production.

At the same time, high-tech military programs supporting network-centric operations such as Future Combat Systems (FCS), Joint Tactical Radio Systems (JTRS), and Warfighter Information Network-Tactical (WIN-T) are heavily communication-centric, requiring orders of magnitude more bandwidth than previous generation programs. Couple this with a growing demand for improvements in issues of Size, Weight, and Power (SWaP), and the military is fast driving toward smaller form factors offering portability and very high performance. With military design expertise deeply rooted in VME and CompactPCI, designers face new challenges in learning about the functional differences between these options – along with the much-newer contender VPX – versus MicroTCA. Today's MicroTCA is proving that it can meet the demands of the front lines, with its SWaP-savvy high bandwidth, military-proven ruggedness, as well as its multicore support and High Availability (HA).

Bandwidth mingled with SWaP: In context

VME and CompactPCI are 6U and 3U architectures that provide communication via a shared data bus. They provide enough bandwidth between master and slave devices (320 MBps for VME64) for many onboard vetronic, navtronic, and avionics applications, but newer programs require more bandwidth. Switched fabric extensions to these architectures (VITA 31, VITA 41, and PICMG 2.16) offer additional interfaces such as dual GbE to improve overall bandwidth, but they are only available in a 6U form factor, which can be prohibitive to smaller designs. Moreover, many of today's communications-centric military applications require even more bandwidth.

However, the MicroTCA standard has risen to address the issue of meeting both SWaP and bandwidth requirements. MicroTCA was ratified in July 2006 as PICMG MTCA.0. (See sidebar on MicroTCA standards update.) MicroTCA is defined by the high processing capacity and extremely high communication bandwidth it brings to a small 2U form factor. When compared with 6U, MicroTCA achieves greater bandwidth in smaller spaces, meeting the growing need for SWaP considerations in high-end military designs. MicroTCA offers up to 21 high-speed serial connections on the backplane – versus the two generally found in VME and CompactPCI implementations – each giving up to 2.5 Gbps bandwidth.

Additionally, MicroTCA delivers more communication bandwidth and higher computational abilities using multiple processors on a single backplane. 6U VME or CompactPCI designs can deliver this too, but necessary form factor adjustments to 3U limit the bandwidth compared to MicroTCA. MicroTCA falls at the large end of the small form factor universe, but at 2U x 3-6HP x 183.5 mm, it is a smaller form factor than even 3U VME and Compact PCI.

The rugged decision: VPX or MicroTCA?

When considering MicroTCA, designers could also explore VITA 46, known as the *VPX* architecture. Mission-critical applications functioning in very rugged environments – such as conduction-cooled ground mobile installations – are ideal for the uniquely rugged processing power of VPX. Specifically targeted to high-end, ultra-rugged military applications, VPX technology tends to be expensive. As a result, MicroTCA meets the design cost parameters of a greater group of applications, and is well suited to moderately rugged applications.

Rugged MicroTCA standards update

Standard COTS MicroTCA systems are more than rugged enough for environments such as ground installations or on airborne platforms. MicroTCA boards and systems are designed to meet NEBS Level 3, which includes requirements such as thermal margins, fire suppression, emissions, and the ability to remain operational during a severe earthquake. But further ruggedization of MicroTCA holds significant interest for the mil/aero design community – and it's coming.

A working group of the PICMG standards body is driving standardized rugged implementations of MicroTCA, including rugged air-cooled MicroTCA (MTCA.1 and MTCA.2) and conduction-cooled MicroTCA (MTCA.3). These efforts are leveraging work done in the ANSI/VITA 47 specification to define the environments in which the boards will perform.

The first of these MicroTCA specifications, MTCA.1, is currently under draft review for ratification. MTCA.2 extends MTCA.1 into more rugged military environments such as those defined by ANSI/VITA 47's EAC6 environmental class and V2 vibration class. Meanwhile, the MTCA.3 specification defines a conduction-cooled interface that allows AdvancedMCs to meet the thermal, shock, and vibration profiles defined in ANSI/VITA 47: temperature ranges of -40 °C to +85 °C at the card edge, 40 *g*, 11 ms operational/operating shock, and random vibration profile suitable for rugged ground mobile applications.

Additionally, MTCA.3 will address systems that are conduction cooled with no airflow in sealed environments. MCTA.3 is underway with PICMG, and designers can anticipate that this will pit VPX against MicroTCA as competing design options. Initial testing has been promising, and rugged MicroTCA options are already available and being deployed in advance of these standards.

Accordingly, when considering whether a new project should utilize VPX or MicroTCA, architectural choice is vital (Table 1). At a very basic level, MicroTCA and VPX are targeting the same problem for the military but from two completely different perspectives: VPX is extremely rugged and currently has no real path to a less costly, more widely applicable solution. MicroTCA by contrast is starting out as a less-rugged, lower-cost solution, but is now specializing its rugged features through follow-on specs designed for specific rugged elements. However, both form factors have their place.

If development time is slightly less of a factor – say, for an application being deployed sometime next year – and if the application is running in a ground vehicle rather than an aircraft, VPX could be an excellent design choice for its ruggedness. If the application in question is running on a jet or fighter plane, a platform such as MicroTCA – proven both in terms of communication bandwidth and ruggedness – could be the best design choice.

Hence, MicroTCA is being used in more rugged applications these days. In fact, BAE Systems has conducted tests that reveal that MicroTCA is rugged enough for even ground mobile applications (Figure 1). In this testing, they found that the MicroTCA edge connector was sufficient for vibration profiles necessary for the WIN-T JC4ISR radio. Specifically, testing showed that there were no discontinuities and that the contacts did not abrade after the equivalent of a 25-year life cycle.

	CompactPCI	VME	PICMG 2.16	VPX	MicroTCA
Form factor	3U x 160 mm	6U x 160 mm	6U x 160 mm	3U x 160 mm	73.5 mm x 181.5 mm
CPU to CPU communication	1 CPU board typical	VMEbus	GbE	GbE, 10 GbE	GbE, 10 GbE
Peripheral communication	PCI Bus	VMEbus	PCI Bus	PCI Express, Serial Rapid IO	PCI Express, Serial RapidIO
Hot swap of line cards	Peripherals only	No	Yes	No	Yes
Rugged	Yes	Yes	Yes	Yes	Underway
Widely applicable	Yes	Yes	Yes	Military-centric	Yes

TABLE 1: When considering whether a new project should utilize VPX, MicroTCA, or another form factor, architectural choice is vital.

FIGURE 1: MicroTCA is proven rugged enough for even ground mobile applications.

Multicore and high availability: Mission critical

MicroTCA's high bandwidth for both communications and computing can accommodate 12 compute blades on a single backplane. Now imagine that same 2U system, but with those 12 blades each utilizing a multicore processor. If that becomes a 3U or even 4U system, it could have as many as 24 cores today. That would be achieved in a very small footprint, which is perhaps the most unique advantage of MicroTCA. In addition, communication bandwidth capabilities range from 40 Gbps to >1 Tbps. This wide range is realistic because actual bandwidth will depend on the implementation. Meanwhile, typical PICMG 2.16 or VITA 31 applications offer 2 Gbps.

In addition to its expansive multicore computing capabilities, MicroTCA also provides high-availability capabilities. High availability was not always a requirement for earlier military systems, but that is changing as integrated battlefield management demands maximum system uptime. Monitoring the health of a system and then "healing" it in the field is a plus with MicroTCA. (MicroTCA and AdvancedTCA were built with HA in mind, which means that HA doesn't add much to the cost because the infrastructure already supports it.) Through an Intelligent Platform Management Interface (IPMI), users can be notified when the system is not running at peak performance. Fans can be turned on and off automatically as temperature thresholds change, and if a board fails, it can be removed and replaced with the system up and running. IPMI-based health monitoring, along with full redundancy with fail-over, prevents any single point of failure in the system.

MicroTCA in today's battlefield

Modern military systems require high computing and communications bandwidth to link soldiers to vehicles, aircraft, ships, and command centers. These complex systems also require greater communication bandwidth and smaller footprints, which means that high-end processing in small form factors is a key design element moving forward. Designers of modern warfare systems must consider choices beyond traditional VME and CompactPCI architectures, recognizing where these legacy platforms fit and where other newer form factors such as VPX or MicroTCA hold the most promise for their rugged military system design. Multicore support and high availability are also important considerations when planning for today's battlefield technology.

David Pursley *is a field applications engineer with Kontron. He is responsible for business development of Kontron's MicroTCA, AdvancedTCA, CompactPCI, and ThinkIO product lines in North America and is based in Pittsburgh, PA. Previously, he held various positions as a field applications engineer, technical marketing engineer, and marketing manager. David holds a Bachelor of Science in Computer Science and Engineering from Bucknell University and a Master's degree in Electrical and Computer Engineering from Carnegie Mellon University. He can be contacted at david.pursley@us.kontron.com.*

Kontron
888-294-4558
www.kontron.com