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SMALL FORM FACTOR MISSION COMPUTER VICTORY & MOSA-COMPLIANT

Mark Leibowitz
Sr. System Architect
BAE Systems
Greenlawn, NY

Robert Saracino
Technical Director
BAE Systems
Greenlawn, NY

Jon Leach
Sr. Technical Writer
BAE Systems
Greenlawn, NY

ABSTRACT

Vehicle control, monitoring and C2/C4ISR capabilities have been delivered in the past by integrating disparate, stove-piped systems. Besides SWAP inefficiencies, stove-piped systems typically do not share critical data and are expensive to maintain and upgrade. The lack of interoperability and data sharing also adversely affects the integration of new capabilities.

Architectures under development by the government include the Joint Common Architecture (JCA), Mobile Distributed C4ISR Architecture (MDCA), and Vehicular Integration for C4ISR/EW Interoperability (VICTORY). Each embraces Modular Open Systems Approach (MOSA) principles to eliminate stove-piped systems. This paper examines the legacy and capabilities of MicroTCA®—a small form factor, MOSA-compliant hardware computing platform—in the context of the VICTORY architecture. MicroTCA® is revealed to be an excellent instantiation and enabler for VICTORY with significant advantages over competing architectures.

VICTORY ARCHITECTURE

The Vehicular Integration for C4ISR/EW Interoperability (VICTORY) Architecture provides a framework for integrating Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) and Electronic Warfare (EW) systems on military ground vehicles, and interfacing with the vehicle system. The scope of the VICTORY architecture is within the vehicle platform.

VICTORY Goals and Tenets

Several goals underpin development of the VICTORY architecture. In addition to eliminating, where possible, the practice of "bolt-on" systems, the government seeks to:

- Reduce SWaP and system cost significantly by using shared hardware computing resources, and by using shared displays rather than displays dedicated to each C4ISR/EW system
- Provide a framework for flexible introduction of new capabilities and reduction of overall life-cycle costs
- Maximize C4ISR/EW portability through use of open standards that define interfaces, data formats, and protocols for use by the C4ISR/EW and vehicle communities

- Support current and future Information Assurance (IA) requirements in U.S. Army ground vehicles. This includes documenting a set of shared IA hardware and software components, interfaces, and architectural patterns that enable system integrators to build "defense in depth" security designs appropriate to a wide array of requirements and levels.
- Provide an evolutionary approach towards network-centric C4ISR/EW that targets interoperability with current systems, while providing a pathway for insertion of new capabilities and technologies

Several fundamental principles, or *tenets*, form the core of the VICTORY architecture. Under these tenets, electronic system designs for vehicle platforms should:

- Use a data bus-centric design known as VICTORY Data Bus (VDB)
- Provide sharable hardware components so that software components can be deployed without additional hardware
- Use only open standard physical and logical interfaces between systems and between C4ISR/EW components
- Use a set of shared data bus services
- Provide shared hardware and software IA components that enable system integrators to build security designs that protect information

Without following these tenets, a design cannot be said to be compatible with the VICTORY architecture.

The VICTORY architecture is organized as shown in **Figure 1**. As the central structure, the VDB provides an Ethernet-based network infrastructure, IA facilities, shared hardware devices that can host software applications, and a set of shared services that includes network time synchronization as well as platform position, orientation, and direction of travel information. In addition, the VDB provides management interfaces that can be used to configure, control, report status, and manage faults on the VDB and the attached systems.

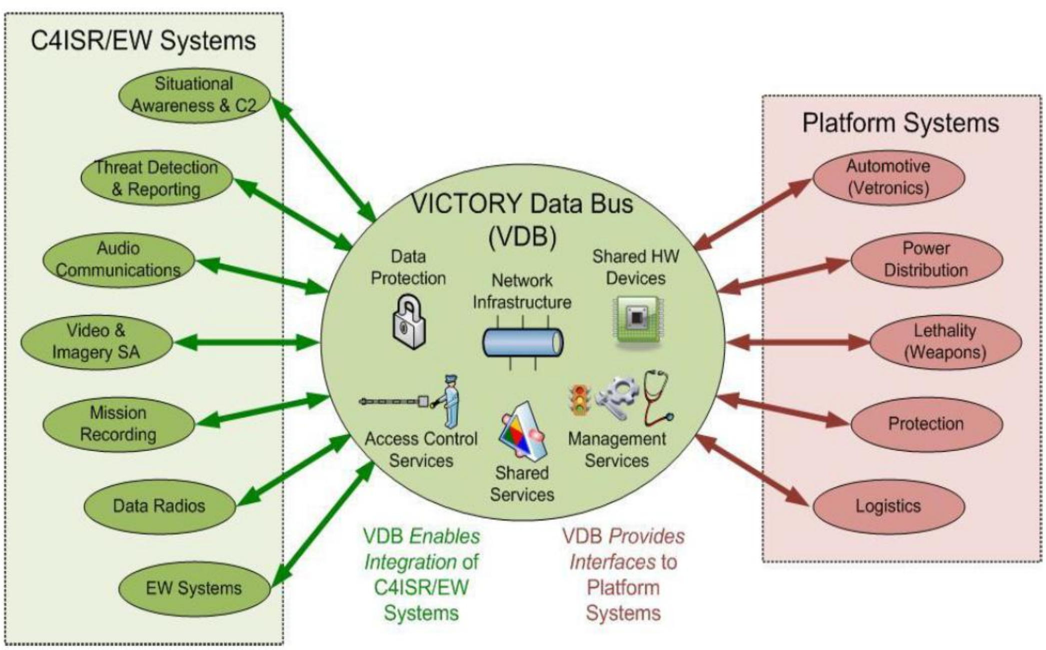

Figure 1: *The VICTORY Data Bus (VDB) is the core of the VICTORY architecture.*

VICTORY Compatibility and Compliance

A C4ISR/EW system design that follows the philosophy and concepts of the VICTORY architecture is said to be VICTORY *compatible* or compatible with the VICTORY architecture. A system that is VICTORY compatible and which follows the VICTORY standard specifications is said to be VICTORY *compliant* or compliant with the VICTORY standard specifications.

For the U.S. Army to gain the maximum benefit, systems must be specified to be compliant with VICTORY standard specifications, which implies compatibility with the VICTORY architecture. The MicroTCA® architecture is both compatible and compliant with VICTORY based on its capability to support all of the required tenets of the architecture and interfaces of the specification. **Figure 2** shows how MicroTCA® addresses each of the goals defined for the VICTORY architecture. Additional details of the advantages of MicroTCA® follow in this paper. The MicroTCA architecture envisioned is depicted in Figure 3. It supports all the tenets of the victory architecture such as shared hardware and software components communicating on a VICTORY data bus using a set of shared data bus services, such as TCP-IP. Additionally, the MicroTCA architecture supports hardware and software based IA components utilizing COTS hardware and software. All of the hardware and software defined herein support the MOSA doctrine by virtue of the open specifications which are controlled by PICMG®, a third-party industry consortium supported by many companies.

Goals of VICTORY Architecture	How MicroTCA® Addresses these Goals
Reduce SWaP and System Cost by using shared HW computing resources and shared displays	• Flexibility to be implemented in a centralized or distributed architecture • Extremely scalable • Economy of scales resulting from telecom-based ecosystem • Technology investment driven by industry and not paid by government
Provide framework for flexible introduction of new capabilities	• Extremely scalable • Controlled by 3rd-party industry consortium (PICMG®) • Use of open source constructs
Maximize portability through use of open standards	• Controlled by 3rd-party industry consortium (PICMG®) • Use of open source constructs • Supports virtualization, which facilitates maximum portability
Support Current and future Information Assurance requirements	• MicroTCA® ecosystem is supported by many Intel-based processing modules • Intel-based products provide many of the features required to support High Assurance Platform (HAP) and Multi-level Security (MLS) capabilities
Evolutionary approach toward net-centric C4ISR/EW that targets interoperability with current systems while providing a path for insertion of new capabilities	• Supports currently used standard interfaces • Switched fabric infrastructure supports higher speed interfaces needed for the future • Extremely scalable • Databus Centric - supports shared databus services

Figure 2*: A MicroTCA® - based hardware computing platform supports the goals of the VICTORY architecture*

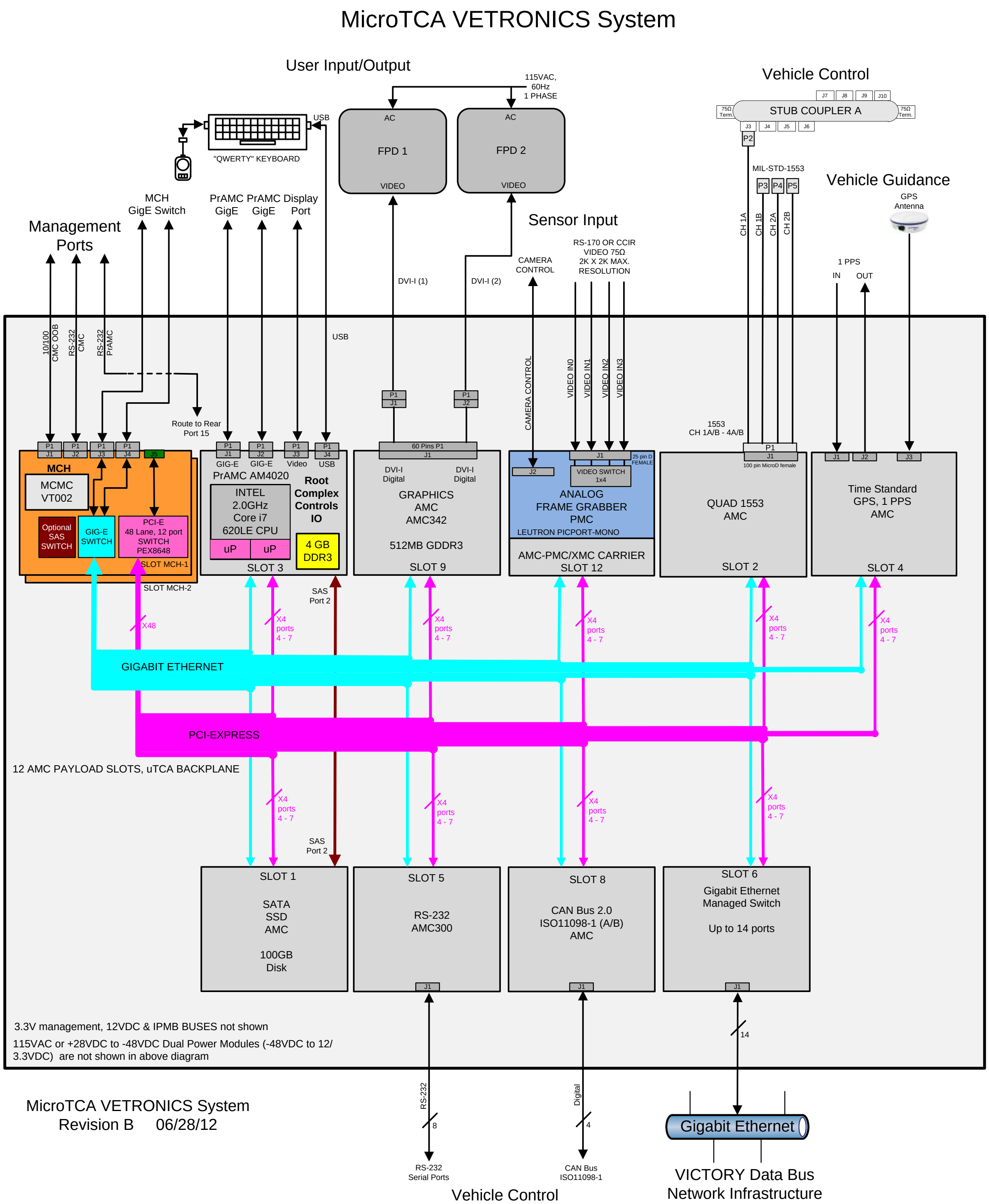

Figure 3: *Because the MicroTCA® architecture supports all of the required tenets of the architecture and interfaces of the specification, it is considered to be both compatible and compliant with VICTORY.*

ORIGINS OF ATCA® / MICROTCA®

PICMG®'s Advanced Telecommunications Computing Architecture (ATCA®) has grown to become a billion-dollar market.

As a stable, mature standard grounded in a modular, open systems approach, ATCA® has expanded beyond its telecommunications origins and has established a footprint in other industries, including SATCOM, process control and high-energy fusion physics. ATCA®'s compliance to Network Equipment Building Standards (NEBS) requirements, high availability (99.999%) and substantial system throughput (2 Tbit/s) are features that also make this standard highly desirable for demanding, mission-critical military computing applications.

The U.S. Navy, for example, uses ATCA®-based mission computers and operator consoles on the P-8A Poseidon platform. The Navy has also embraced ATCA® for programs such as Consolidated Afloat Networks and Enterprise Services (CANES). ATCA is also found within Shadow UAS Ground Control Stations.

ATCA® is supported by an extremely healthy vendor ecosystem offering highly interoperable products. The PICMG® 3.0 standard, which covers all aspects of the electrical, mechanical, cooling and power subsystem properties, governs this interoperability.

ATCA® has also spawned a series of standards for small form factor rugged computing components called MicroTCA®. In its AMC.0 standard, PICMG defines a mezzanine building block approach for the addition of crucial functionality in the form of Advanced Mezzanine Cards (AMC®) to an ATCA® carrier card. The MicroTCA® base specification, or MicroTCA.0, is complementary to ATCA® and defines a system where these AMC®s can be used outside of an ATCA® carrier—that is, within its own chassis and backplane. MicroTCA® thereby enables the creation of systems with many of the ATCA® advantages in a smaller, more energy-efficient size.

The ability of MicroTCA® to draw from the ATCA® ecosystem means that a large number of AMC® modules are already available for use in rugged MicroTCA® applications without modification, except for screening, staking and conformal coating as required.

Figure 4 illustrates how COTS AMC modules can be leveraged to afford considerable design flexibility while minimizing system cost.

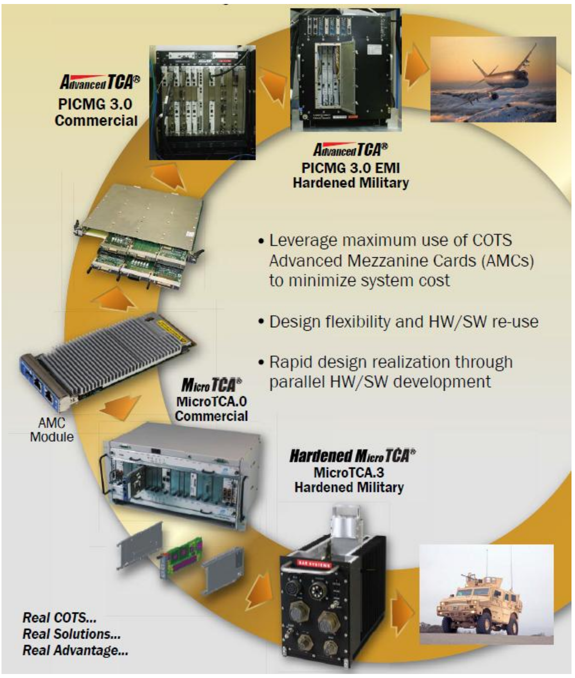

Figure 4: *A large number of AMC® modules are currently available for use in rugged MicroTCA® applications.*

The MicroTCA® architecture is well suited for high-performance computing and networking functions. It defines switched fabrics, including requirements for 1GigE, 10GigE, PCIe (Gen 2), SRIO and SATA/SAS fabrics. It also incorporates redundancy of both power and MicroTCA® carrier hub (MCH) modules.

Moreover, it offers inherent hardware platform management (HPM) functions that use the same software tree as ATCA®. The architecture has been ruggedized for military applications.

ADVANTAGES OF MICROTCA®

Mark Lowdermilk, President and CEO of Embedded Planet, was asked about MicroTCA® in an article for Military and Aerospace Electronics.

"That MicroTCA® packs a lot of punch in a small form factor is undeniable. The primary selling points for MicroTCA® are impressive: an affordable next-generation computing architecture, high communications bandwidth, the latest multi-core processors, support for redundancy, and high availability—in a small system footprint that is extremely scalable."

These and the many other selling points described below support MicroTCA® as an ideal candidate for use as a ground vehicle hardware computing platform.

MOSA Compliance

MOSA compliance is the most compelling reason for using ATCA® and MicroTCA®. The Open Systems Joint Task Force, or OSJTF was chartered in 1994 by the Under Secretary of Defense for Acquisition, Technology, and Logistics to champion the establishment of a Modular Open Systems Approach and ensure implementation by all DOD acquisition programs. The OSJTF:

- Makes MOSA an integral part of the acquisition process
- Provides expert help to ensure all acquisition programs apply MOSA
- Collaborates with industry to ensure a viable open standards base

The benefits for using a MOSA are:

- Lower life-cycle cost (LCC) for electronic systems
- Better-performing systems with greater interoperability
- Technology transparency for rapid upgrades
- Multiple sources of supply at component and system levels to ensure the government is not tied to one source of supply
- Improved interoperability for joint warfighting
- Closer cooperation between commercial and military electronics industries
- Improved international competitiveness of U.S. electronics industry
- Ease of integration of new capabilities, functions and features

A Modular Open System design is based on open architecture and open source constructs that ensure reduced development expense, design cycle time and manufacturing cost at a time when product complexity and reliability demands are increasing. Open architecture and open source are hardware or software architectures based on specifications that are:

- Available to the public and generated, approved and controlled by various standards and trade associations (e.g., VITA, PICMG® and IEEE), or

- Uniquely generated provided they are made public by their owners (e.g., Peripheral Component Interconnect, or PCI).

Open architecture system specifications must be controlled by an objective third-party industry organization to ensure that no single developer or vendor has control over their use.

A truly open architecture has multiple vendors producing products to its standard. This creates competition in industry, thereby forcing recurring costs to trend downward. ATCA® and MicroTCA® systems, which are controlled by a third-party industry consortium (PICMG®) and supported by over 200 companies, are truly MOSA compliant.

Scalability and Commonality of xTCA™

The large and diverse ecosystem for the xTCA™ (ATCA® and MicroTCA®) environment drives the need for multiple chassis sizes and types. ATCA® is used in telecom data centers, central offices, outdoor communication shacks, and military platforms such as P8-A, DCGS-N and CANES. In the ATCA® arena there currently exists a multitude of chassis configurations such as 16-slot, 14-slot, 6/5-slot and 2-slot enclosures with both AC and DC power inputs. These chassis have been designed to support industrial (NEBS) environments and are adaptable to support military (MIL-STD-810) environments.

For other platforms such as ground vehicles, rotary wing upgrades, and smaller surface and air ships, MicroTCA® provides a solution path for smaller SWaP-C mission computers. The smaller MicroTCA® chassis allows the AMC® module used in the ATCA® system to be used directly. This commonality in modules drives competition among vendors and aids in the affordability and logistics of large programs.

MicroTCA® is also scalable with chassis available in various sizes and form factors. MicroTCA® can be scaled for different vehicle platform demands while maintaining open industry standards and interoperability and minimizing life-cycle cost.
Processing can be centralized or distributed based upon specific platform needs. AMC® processors available today include the latest in multicore processing technology. The Kontron 4020, for example, offers the new Intel® Mobile Core™ i7 processor with integrated graphics.

This commonality is not just relevant to hardware; it also exists in software, enabling existing ATCA® shelf management software to be used directly (or ported) on the MicroTCA® Management Controller Hub (MCH).

All xTCA™ systems are controlled by open industry specifications; PICMG® 3.0 controls ATCA® and PICMG® MTCA.0, MTCA.1, MTCA.3 and MTCA.4 (with MTCA.2 soon to be released) control MicroTCA®.

Key advantages of using MicroTCA®

- MOSA-compliant
- Scalable to meet platform-specific processing and IO needs
- Latest Multicore processors
- Designed for redundancy/high availability
- Significant re-use of AMC® modules
- Technology investment and refresh by industry, not the government

Availability

BAE Systems' xTCA™ solutions fully comply with failover and high availability requirements for critical services. Use of high-availability hardware based on the xTCA™ architecture provides the foundation of a MicroTCA® solution.

The xTCA™ architecture and hardware provides inherent redundancy and fault tolerance with:

- Redundant data paths
- Dual shelf managers
- Separate fabric and base networks for data and control planes
- Automatic internal error checking and handling
- Health Management
- Error reporting through IPMI
- Shelf management control of hardware resources
- Redundant power
- High-reliability hardware
- No single-point hardware failures

High-availability software included with the MicroTCA® equipment allows management and monitoring of various services such as cluster management and node management.

SWaP-C

As discussed in the scalability section, MicroTCA® provides the ability to scale the computing host to meet the performance needs and the size constraints of the platform while maintaining a common standard. MicroTCA®-based mission computers can take the form of 1U to 4U rack-mount chassis for commercial versions and ½ ATR, ¾ ATR or any shape or size required for rugged military grade versions. Processing can be centralized or distributed providing even more flexibility in the platform implementation. By centralizing processing needs, the system eliminates redundant hardware resulting in significant SWaP-C reductions while facilitating sharing of critical data.

Maturity

The building blocks for MicroTCA® are mature. Ruggedized AMC® modules and military qualified ATCA® chassis are at a TRL9, while MicroTCA® military qualified chassis are between a TRL6 and TRL7. A strong infrastructure already exists due to the momentum of ATCA® in the telecom industry, and now in the military market.

MicroTCA® Development System

The AMC® module is the basic building block for a MicroTCA®-based system. The COTS AMC® module and the AMC® module that is eventually ruggedized and qualified for military use are functionally identical. This offers the potential of delivering a commercial MicroTCA® development system extremely early in a program. An early development system is a significant risk mitigation tool for SW development, including the porting of existing applications and development of new ones. A commercial development system would be used for the initial computing hardware platform.

Information Assurance

Current vehicle architectures do not support modern Information Assurance (IA) needs. Systems typically support only a single security domain, forcing the entire vehicle to be classified at the highest level. The MicroTCA® ecosystem is supported by many Intel-based processing modules that provide many of the features required to support High Assurance Platform (HAP) and Multi-level Security (MLS) capabilities.

The scalability and flexibility of MicroTCA®, along with the MLS features it can support are additional appealing features of the architecture.

MICROTCA® RUGGEDIZATION

To expand its reach into more rugged, demanding environments, MicroTCA® working groups have defined a number of specialized MicroTCA® implementations with a common goal–reuse of the same AMC® printed circuit boards and as much of the MicroTCA® base specification infrastructure as possible.

Figure 5 shows the five specifications that govern MicroTCA® systems. MicroTCA.3 and MicroTCA.2 specifically target the military market. The MicroTCA.3 specification was released in February 2011; MicroTCA.2 release is expected in 2012.

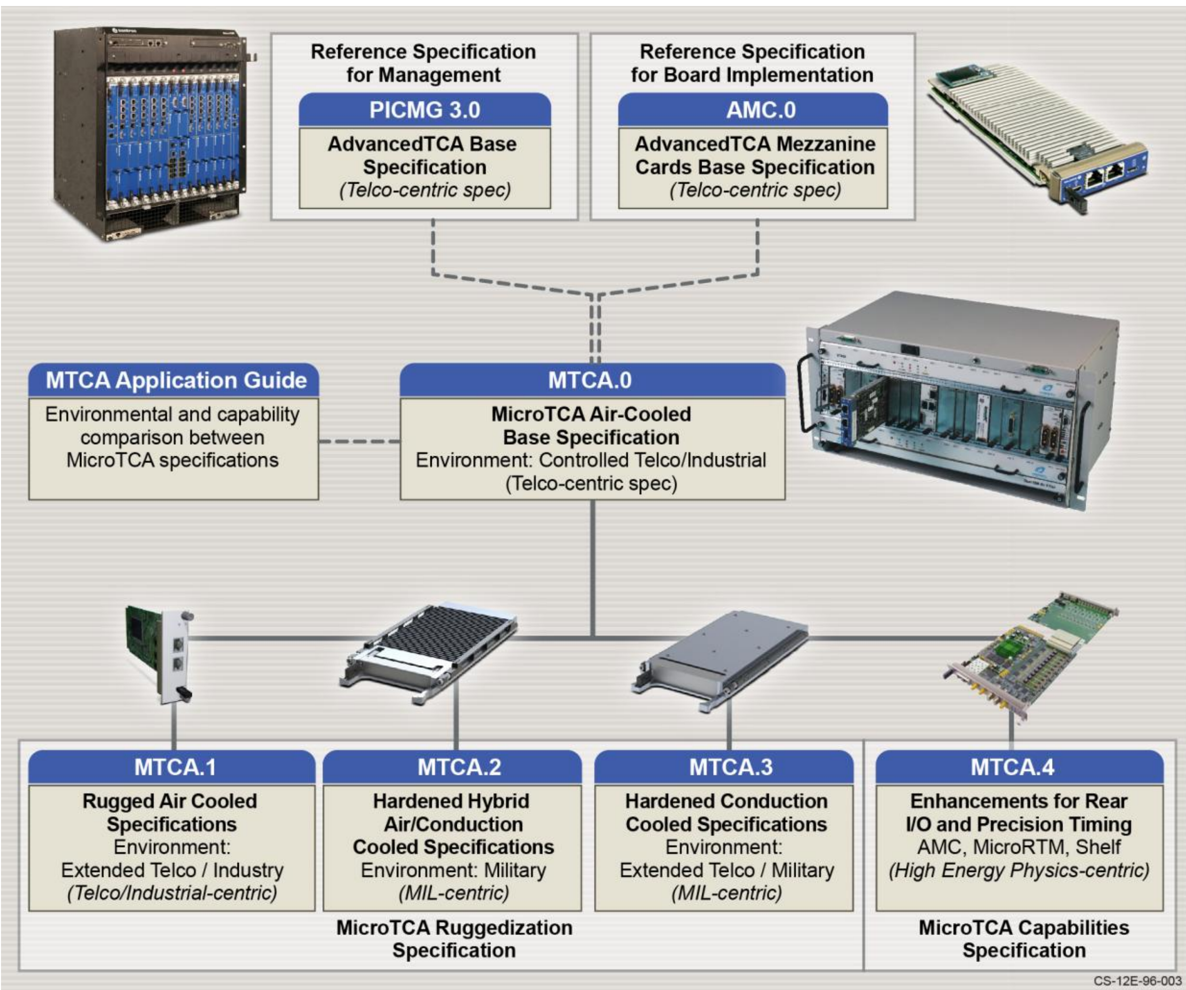

Figure 5: *The MicroTCA® family of standards offers varying levels of ruggedization to meet commercial, industrial, and military environments.*

Military Use of Hardened MicroTCA®

MicroTCA® addresses the severe shock and vibration environments typical of many military air, land and sea applications with the MicroTCA.3 and MicroTCA.2 specifications, which define a hardened design approach for conduction and hybrid-air cooled systems, respectively. Each benefits from key input from military vendors, such as BAE Systems and Boeing, and include well-defined test procedures for a consistent reading of vendor compliance.

The MicroTCA.3 Hardened Conduction Cooled specification provides the requirements necessary for a system to meet the rugged requirements of outside plant telecom, machine and transport industry, and military airborne, shipboard and ground mobile equipment environments. Released in early 2011, the specification defines five ruggedization levels, or product classes—two telecommunications grade and three military grade—intended for applications where air flow over the modules is not available.

Closely related to MicroTCA.3 is the MicroTCA.2 Hybrid Air/Conduction Cooled specification, which defines four military grade ruggedization levels of its own. With an expected release in late 2012, it defines a forced-air cooled system that targets rugged industrial and military applications. **Figure 6** compares Hardened MicroTCA®'s VITA 47-based key environmental requirements to those of the MicroTCA® base specification.

Product Classification			Requirements (Operating)		
MTCA.0	MTCA.2	MTCA.3	Temperature	Shock	Vibration
Basic		TEL-1	-5°C to +55°C	15g	1g sinusoidal
-	-	TEL-2	-40°C to +85°C	25g	8g random (VITA 47 V2)
	MIL-FC1		-5°C to +55°C	40g (VITA 47 OS2) / 11 ms	12g random (VITA 47 V3)
-	MIL-FC2	MIL-CC2	-40°C to +55°C		
-	MIL-FC3	MIL-CC3	-40°C to +70°C		
-	MIL-FC4	MIL-CC4	-40°C to +85°C		

Figure 6: *Development of hardened, air and conduction-cooled standards aligned to VITA 47-based environmental requirements makes MicroTCA® a worthy candidate for a wider range of rugged military applications.*

As depicted in **Figure 7**, hardened MicroTCA® encloses AMC® PCBs, MCHs modules and power modules in electrically conductive heat frames (clamshells), which are fitted with card retainers to harden the circuit boards, protect electrical connections from shock and vibration, and provide a thermal conduction path to the chassis.

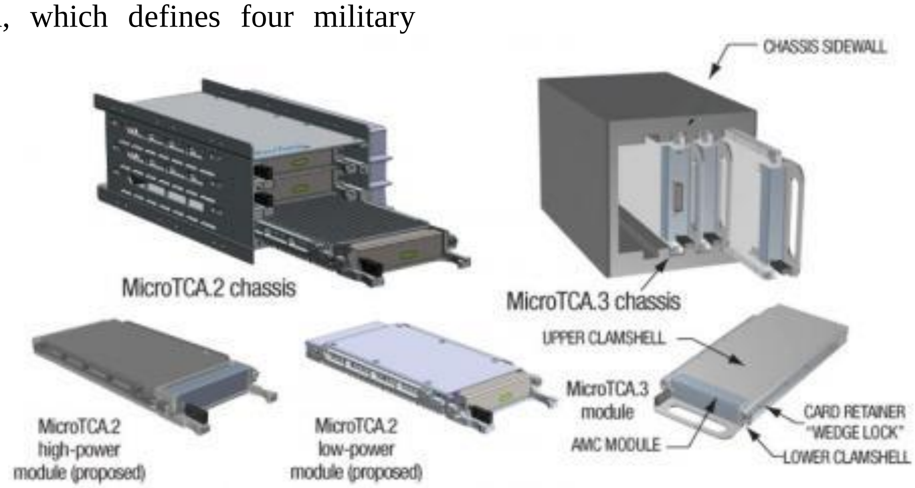

Figure 7: *Hardened MicroTCA® module clamshell design allows for the logistical and cost benefits of a two-level maintenance approach.*

For MicroTCA.2 systems, this conduction path is a beneficial by-product of the hardened design, and serves to augment the dominant forced-air cooling effect—thus its "hybrid" cooling designation.

MicroTCA® and OpenVPX—Different Legacies, Common Goals

While MicroTCA® and VPX have much in common, their different origins may influence opinions as to which best applies to the demands of high-performance military embedded computing systems. For some, the fact that VPX technology succeeded VME with rugged military applications specifically in mind affords it a certain incumbency—a status only strengthened by the interoperability advances of OpenVPX. However, hardened MicroTCA® is a strong competitor. As shown in **Figure 8**, MicroTCA® meets the same environmental requirements as VPX, is less expensive, and is more "open" than OpenVPX. Additionally, MicroTCA® has performance advantages in the areas of both backplane fabric technology and the inherent hardware platform management (HPM) available to MicroTCA® systems.

AdvancedTCA® has long leveraged its widespread acceptance in commercial network-centric applications to gain solid ground in many benign-environment communications-centric military applications. Since MicroTCA® derives from ATCA®, these applications are easily scaled for small form factor applications. MicroTCA®'s commercial roots, unlike those of military-centric VPX, broaden the range of solutions available to the developer. Moreover, MicroTCA®'s recent VITA 47-based rugged implementations—and hardened variants in particular—are attractive for these applications because they combine net-centric performance and low cost with the ability to overcome severe temperature, shock and vibration challenges.

Parameter	MicroTCA.2/MicroTCA.3	OpenVPX (ANSI/VITA65) VITA 47/48 (EAC6 and ECC4 Environment)
Serial topology (fabrics) on backplane	Gigabit Ethernet (GigE); PCI-Express Gen 2; 10GigE; SRIO; ***SAS/SATA—with simultaneous support for two or more fabrics***	Gigabit Ethernet; PCI-Express Gen 2; 10GigE; SRIO—***no support for SAS/SATA***
Redundancy	Power modules; Fabrics (GigE, 10GigE, SAS, SRIO)	Redundancy supported
Bandwidth (PCI-Express)	8 Gen 2 lanes per slot, 40 Gbps	8 Gen 2 lanes per slot, 40 Gbps
I/O	Front panel support; backplane support via tongue 2	Front panel support; backplane support via P2
Hardware platform management (HPM)	***Mature HPM based on ATCA***	***Under development; not mandatory per VITA 46-11 specification (not approved)***
Board size	Six sizes defined (inches): Single/Double modules 2.9/5.9 x 7.2 Compact/Mid/Full: 0.6/0.8/1.2 pitch	Six sizes defined (inches): 3U/6U modules: 3.9/7.9 x 6.3 0.8 pitch (optional 0.85/1.0 VITA 48)
Connector system	Multi-tongue edge finger BP connector: 50 micro-inches Au Edge pad: 50 micro-inches hard Au over 100 micro-inch Ni; hardness: 130-180 knoops; roughness: 0.2 Ra max. ***Multi-vendor, open-source connector***	Multi-wafer dual edge finger BP connector: 50 micro-inches Au Edge pad: 50 micro-inches hard Au over 150 micro-inch Ni; hardness: 130 knoops; roughness not specified ***Single-vendor (patent pending) connector***
Temperature, operating	Same as VPX	VITA 47 AC1 – AC4
Temperature, non-op	Same as VPX	VITA 47 CC1 – CC4
Shock and vibration	Same as VPX	VITA 47 OS1/OS2 and V2/V3 levels
Two-level maintenance	Yes, uses clamshell; ESD to 15 kV human model	Yes, w/optional metal covers; ESD to 15 kV human model
Cost	***1 (cost normalized to MicroTCA)***	***Approx 1.5 – 2x, higher with HPM***

Figure 8: *Among the key advantages that MicroTCA® holds over VPX is a mature HPM capability leveraged from ATCA®, advanced backplane fabric technology, and lower cost.*

Additional Advantages

It is worth noting that as shown in **Figure 9**, both MicroTCA® and VPX use PWB edge pads with very similar characteristics for high-speed interconnect.

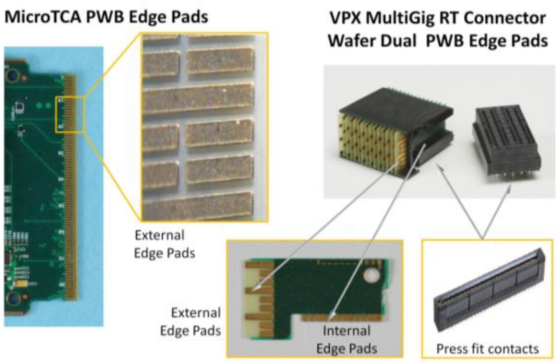

Figure 9: *The efficacy of the PWB edge pad design concept common to MicroTCA® and VPX for rugged applications was one driver of extensive connector system testing.*

To ensure a robust backplane-to-AMC® connector system in rugged environments, the PICMG® MicroTCA.3 working group sponsored chassis-level testing prior to releasing the MicroTCA.3 specification. Testing consisted of eight full-life test groups plus a separate ESD test.

Similarly, prior to releasing the VITA 46 (VPX) specification, the VPX working group sponsored holding-fixture testing to validate its own backplane-to-VPX module connector system. Testing consisted of seven test groups. In each case, Contech Research of Attleboro, MA, an independent testing and research company, performed the testing. **Figure 10** highlights the results—and differences in duration and severity—of the test regimens.

In terms of architecture software, MicroTCA® supports open, free operating systems and drivers natively. While this support extends primarily to Linux and Windows, support for other operating systems is available. Free or minimal-cost operating systems and all associated PCI-E hardware drivers allow for low-cost solutions. In contrast, VPX and OpenVPX support mainly operating systems such as VXworks, which carry a high cost for the software and drivers.

Test Cycle	MicroTCA.3/.2	VPX
Mechanical Shock	Passed (50 G)	
Random Vibration	Passed (12 Grms, 50 – 2 kHz)	
Bench Handling	*Not performed*	***Passed***
Thermal Shock	***-55 °C to +85 °C***	*Not performed*
Thermal Cycling with Humidity	***500-hour duration***	*240-hour duration*
Temperature Life	***500-hour duration***	*Not performed*
Mixed Flowing Gas	***Passed (10 days)***	*Not performed*
Durability	***Passed (extreme environments)***	*Passed (standard environments)*
Insulation Resistance	Passed	
Dielectric Withstanding Voltage	Passed	
Engaging/Separating Force	Passed	
Electrostatic Discharge (15 kV)	Passed	
Sand	Passed	
Salt Fog/SO_2	Passed (2 days)	

Figure 10: *Testing for MicroTCA.3 was more comprehensive than for VPX, with testing performed over a longer life duration and against more failure mechanisms using VITA 47-defined environments—including 500 hours thermal cycling for MicroTCA.3 versus 240 hours for VPX.*

Further, MicroTCA® uses multi-vendor, open-source connectors, whereas VPX and OpenVPX use a single vendor's patent-pending connector system

An energized, expanded vendor ecosystem willing to invest in competing technologies is good news for military and other users of high-performing, network-centric embedded computing products, as it stimulates competition to develop the low-cost, high-performance solutions needed for demanding military environments. Robust vendor support has been a key driver of the evolution of ATCA® into the rugged air- and conduction-cooled variants of MicroTCA®.

At present, MicroTCA® costs less than VPX products. When considering the cost of developing a HPM capability, VPX cost may exceed that of comparable MicroTCA® implementations by as much as 50 to 100%. MicroTCA®'s lower cost and open source advantages, coupled with its ability to meet the same environmental requirements as VPX and its performance edge in backplane fabric technology and HPM, make it an appealing choice in the small form factor military embedded systems domain.

SUMMARY

BAE Systems believes that MicroTCA® is a technology that is ideally suited for a VICTORY-compliant small form factor hardware computing platform. Its scalability and flexibility in form factor, cost relative to VPX, data throughput, and robust ecosystem make it an ideal solution for today's SWaP-constrained military platforms.

REFERENCES

[1] "Micro Telecommunications Computing Architecture Base Specification", PCI Industrial Computer Manufacturing Group, July 2006.

[2] "Vehicular Integration for C4ISR/EW Interoperability (VICTORY) Architecture", Version A, PEO C3T SE&I Futures, Ft. Monmouth, NJ, April 2011