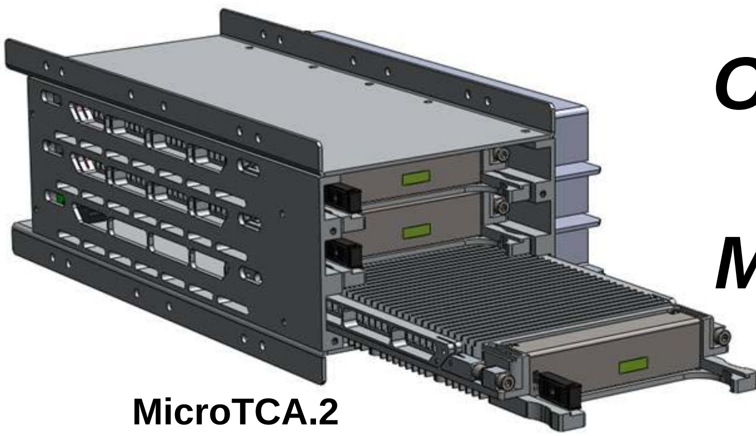
Hardened μTCA®

BAE SYSTEMS

MicroTCA Architecture Assures

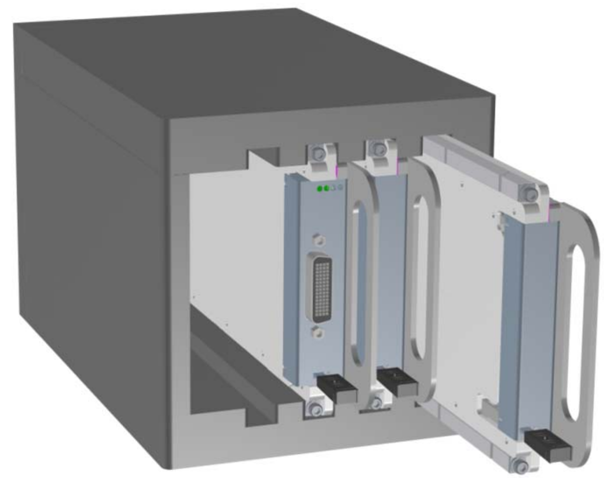
High Performance

Vendor Interoperability



MicroTCA.2

Open Standard
&
Military Ready!



MicroTCA.3

CERDEC Brief
March 5, 2014

Mark Leibowitz
Chief System Architect
BAE Systems

Rev. D

Agenda

- PICMG Overview
- Interoperability & Open standards
- MicroTCA Heritage
- MicroTCA Technical Details
- MicroTCA.3 Conduction Cooled Modules
- MicroTCA.2 Hybrid Cooled Modules
- Some MicroTCA & VPX Differences
- MicroTCA Systems

PICMG

Joe Pavlat, President & Chairman
Doug Sandy, VP of Technology
Jess Isquith, VP of Marketing
Michael Monroe, Secretary & Treasurer

PICMG® *

PCI Industrial Computer Manufacturer's Group

- **Founded 1994 as a non-profit consortium**
  - Focus on open standards for embedded computing
  - Over 250 members companies
- **Deep engineering expertise in member companies:**
  - Electronic, mechanical, packaging, and thermal design
  - High speed signaling and simulation
  - Software and High Availability skills
- **Rigorous Intellectual Property policies**
  - Patent landscape known to implementers
  - No PICMG standard requires a license to implement (so far)
- **45 standards released to date**
  - More than $10B in global revenue
  - Wide range of technologies including small form factor, networking, high-availability architectures, rugged computing and management

*Pronounced "Pick-M-G" or "Pick-Mig"

Special thanks to PICMG member companies Artesyn Embedded Technologies, Kontron, N.A.T, Pentair/Schroff and Radisys for providing photos used in this presentation

Value of Open Standards

PICMG®

Proprietary Solution

- Typically developed, built, and maintained by a single vendor – Little or no collaboration
- Generally expensive and rarely the latest technology
- Only the largest companies have all of the requisite skills to be experts on all elements
- Upgrades developed on vendor's timetable – the vendor "owns" you

Open Standard Solution

- Generally developed by non-profit consortia with many members that have a wide range of skills
- Multiple vendors provide price and feature competition
- If customers don't like their vendor(s) they can go someplace else
- Technology and improvements developed on industry timetable

Open Standards encourage innovation and differentiation amongst multiple vendors – interoperability is key

PICMG Technologies – CompactPCI®

- **CompactPCI Evolution**
  - First ratified in 1995
  - Switched fabric backplane in 2000
  - New versions have high speed serial interfaces
- **Popular and rugged Eurocard mechanics (3U and 6U)**
- **Used in a wide variety of industrial control telecommunications, transportation and automation applications**

CompactPCI®

PICMG Technologies – CompactPCI® Serial

- Latest version of CompactPCI replaces older parallel buses with modern, high speed serial interfaces
- Can be used with older CompactPCI cards if needed
- Ethernet mesh, PCI Express, SATA, USB interfaces
- Hot swappable and can be either convection or conduction cooled
- Builds on 20 years of CompactPCI experience and familiarity

PICMG Technologies - AdvancedTCA®

- The global standard for high end telecom equipment
- Modular, rugged, NEBS compliant
- Architected for High Availability
  - keeps running in the event of single item failures.
  - The only open architecture to offer this
- Global revenue greater than $2B USD/year
- AdvancedMC® and MicroTCA® spinoff specifications
  - customization and miniaturization
  - Rugged versions available
- VITA adopting ATCA & MicroTCA Platform Management architecture for VITA 46 (VPX) with PICMG's approval as of January 2014.

PICMG Technologies – COM Express®

- COM Express® : small single board computer "engines"
- Variety of sizes supported
- One of the most popular high performance Small Form Factor architectures
- Can be plugged into a customer-supplied carrier containing application specific I/O – customer does not have to be a high speed signaling expert – that is done on the COM Express engine
- Carrier Design Guide freely available from PICMG web site

COM Express® basic

COM Express® compact

COM Express® mini

Evolution and Revolution

- **PICMG has developed roadmaps for the future of key technologies:**
  - AdvancedTCA: add 100G backplane bandwidth, improved cooling, higher power capability, SDN and NFV, improved applicability for data centers (PICMG 3.7)
  - GEN4™ - a next generation platform with 10x system and module throughput, improved SWaP, reduced CAPEX & OPEX. Improved scalability and recognition of convergence of telecom central office and data center requirements.

Interoperability

&

Open Standards

Why Interoperability Is Important for Open Standards

- What do we mean by an open standard?
  - a succinct definition of everything a vendor needs to know to build equipment and write software that will work with compatible products offered by other vendors
  - These standards are usually defined at the plug-in board level
    - boards from Vendor "A" & "B" will plug into a chassis built by vendor "C" and everything will work together as intended

Why Interoperability Is Important for Open Standards (Cont.)

- While large ecosystems of products exist around popular standards
  - they are becoming more complex
- Plugging HW together obtained from multiple vendors and expecting it to work together "without interoperability" is difficult to achieve
  - Today's systems like ATCA & MicroTCA (xTCA) call for signaling rates up to 10 Gbps through boards, connectors and backplanes
  - ATCA's system management infrastructure was the industry's first open standard that allowed for the construction of High Availability systems that could continue to work in the presence of malfunctions or failures
  - A lot of complex software and hardware needs to work reliably to build these systems
    - "Plug-and-Play" is not automatically assured

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Why Interoperability Is Important for Open Standards (Cont.)

- So why not use proprietary products from a single vendor if you want everything to work out of the box?
  - Proprietary systems are usually expensive and often don't use the latest technology or offer particularly high performance
  - Upgrades are usually slow in coming and are also expensive because the vendor already owns you and can charge what they please
  - Obsolescence issues are harder to solve and become expensive to deal with when only one vendor is making the product
  - Only very large companies can be true experts at the myriad of technical disciplines necessary to build a complex, high performance system

Open Standards eliminate vendor lock in

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Why Interoperability Is Important for Open Standards (Cont.)

– Why industries are moving to open standards

  – Open standards are developed by standards organizations (like PICMG) that have hundreds of members with an extremely diverse technical talent base

  – When dozens of vendors compete for a customer’s business, there is price and performance competition, which is a good thing for the customer

  – If the customer doesn’t like their vendor(s) they can go someplace else

  – Open standards-based products tend to offer leading edge technology and improvements

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Why Interoperability Is Important for Open Standards (Cont.)

- So how do you achieve multi-vendor interoperability for standards-based equipment?
  - Module and backplane pin outs must be defined to keep independence from a single vendor
  - Conduct interoperability workshops that put vendors and their equipment in a secure environment and let them test everything with everything else
    - PICMG was a pioneer in doing this and has been conducting Interoperability Workshops on a regular basis since the mid 1990's with many technologies
    - 25 ATCA and MicroTCA Interoperability Workshops have been conducted and continue to be conducted
    - These events are held as needed, usually at least once a year or more often as necessary, which happens when a standard changes or adds significant new features for example, 40GigE ATCA

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Recipe for a Truly Open System

- A truly open system supports technology insertion without the need to change the backplane or chassis for a period of 15 to 25 years
- In order to achieve the open system requirement the specification must support a Modular Open Systems Approach (MOSA) with the following attributes
  - backplane interconnect must be limited to connectors carefully defined with options that are fully inter-changeable and inter-mateable
    - Alternative to above would require a backplane re-spin or limiting vendors
  - Specification must limit within reason the protocol formats used for data and control on the backplane or technology insertion becomes unmanageable
    - i.e., control plane transport limited to 1000base-BX to facilitate interconnect among all vendors
- I/O interconnect method is also a key to achieving a system that easily supports the open system requirement
  - I/O signaling on the backplane that is not defined in the spec limits technology insertion to the same vendor with additional NRE or a re-spin of the backplane will be required
  - Alternatively if I/O is limited to the module front panel you open up the vendor selection limiting cost for technology insertion
  - A trade off of chassis size vs. openness is required
- Governed by third party and well supported by industry

MicroTCA Heritage

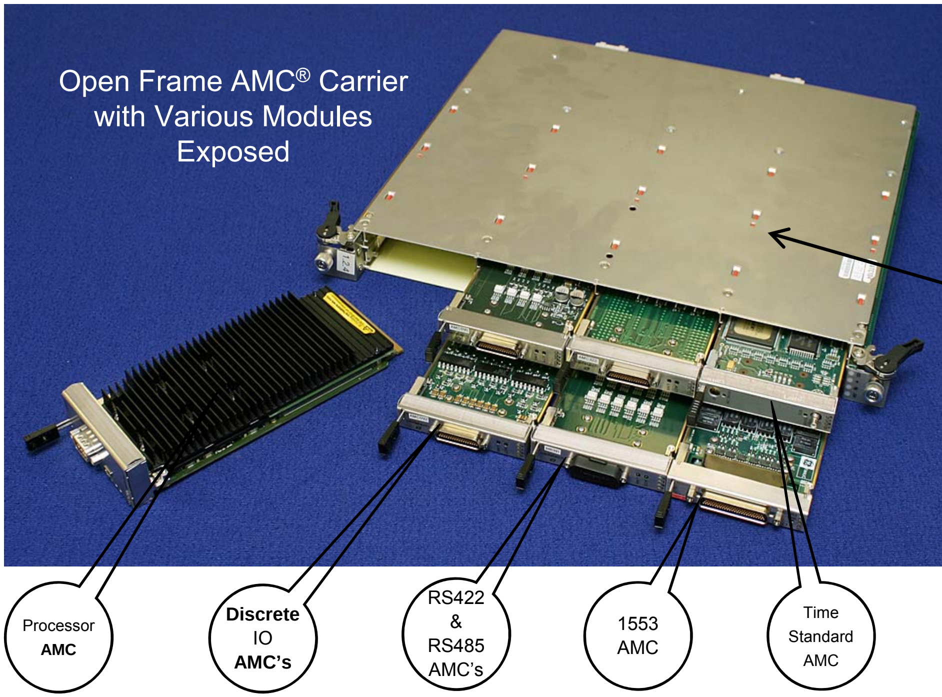
MicroTCA Heritage

- *MicroTCA is an off shoot of* ATCA® (Advanced Telecommunications Computing Architecture)
- ATCA® and MicroTCA® are fully open industry standards based on PICMG 3.X & MicroTCA.X specifications
  - State-of-the-art symmetric multiprocessing systems optimally packaged for performance, fault tolerance and high availability (0.99999)
  - Driven by needs of Telecommunication Industry
  - Provides capability to host numerous present and emerging processing engines with no change to the physical aspects of the chassis or backplane
  - Packet-based switched architecture, can be centralized or distributed
- $1B Industry with a healthy vendor eco-system supporting a consortium of over 100 participating members

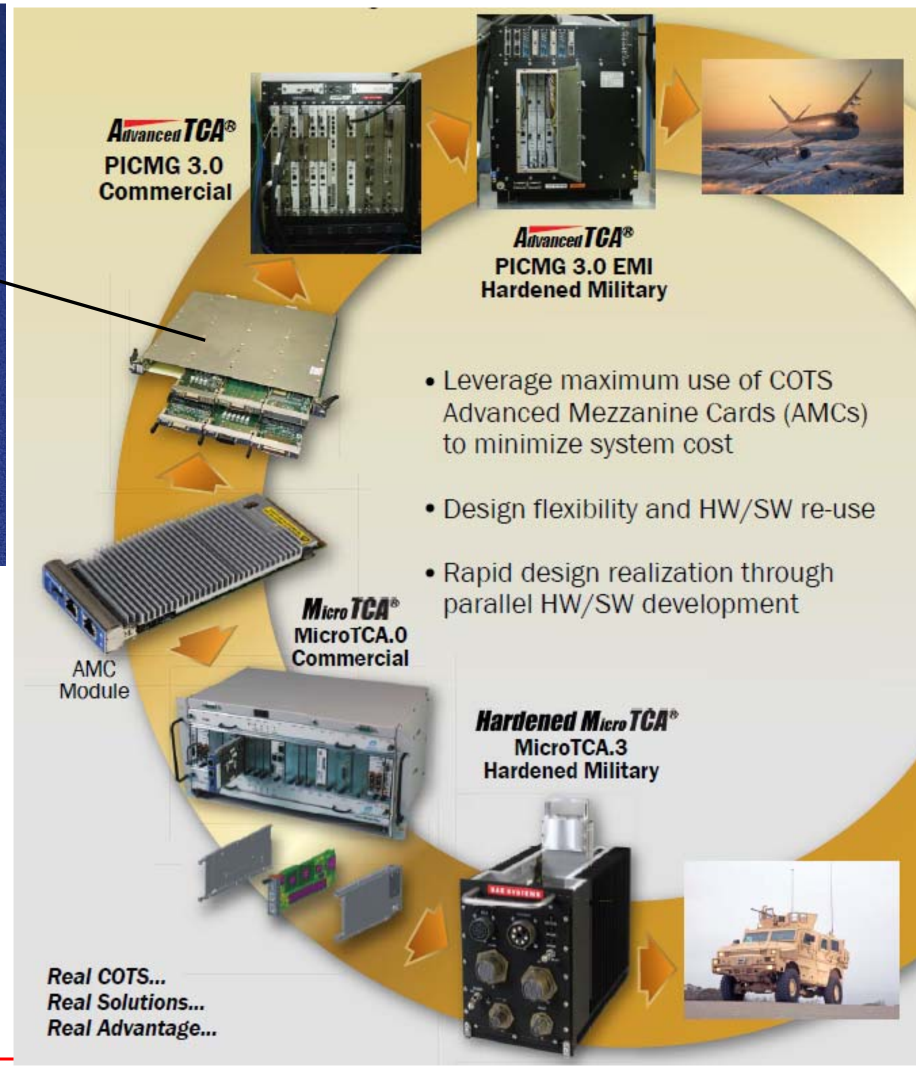
MicroTCA Heritage (continued)

- MicroTCA® is a natural offspring of ATCA® and is based on PICMG® Standards
  - Applicable for smaller platforms, mission payloads, vehicles, Unmanned Systems, small boats, and submarines
  - Supports AMC® & PMC/XMC modules (with carrier)
- Features include:
  - Robust, flexible, scalable, and rugged architecture
  - Multiple Operating Systems (Linux, Windows, etc)
  - Complete Health Management Systems
  - Redundancy, High availability
  - Input/Output Interfaces to virtually all Military system protocols
  - Hardened designs for Army ground and mobile based platforms

MicroTCA Heritage (continued)

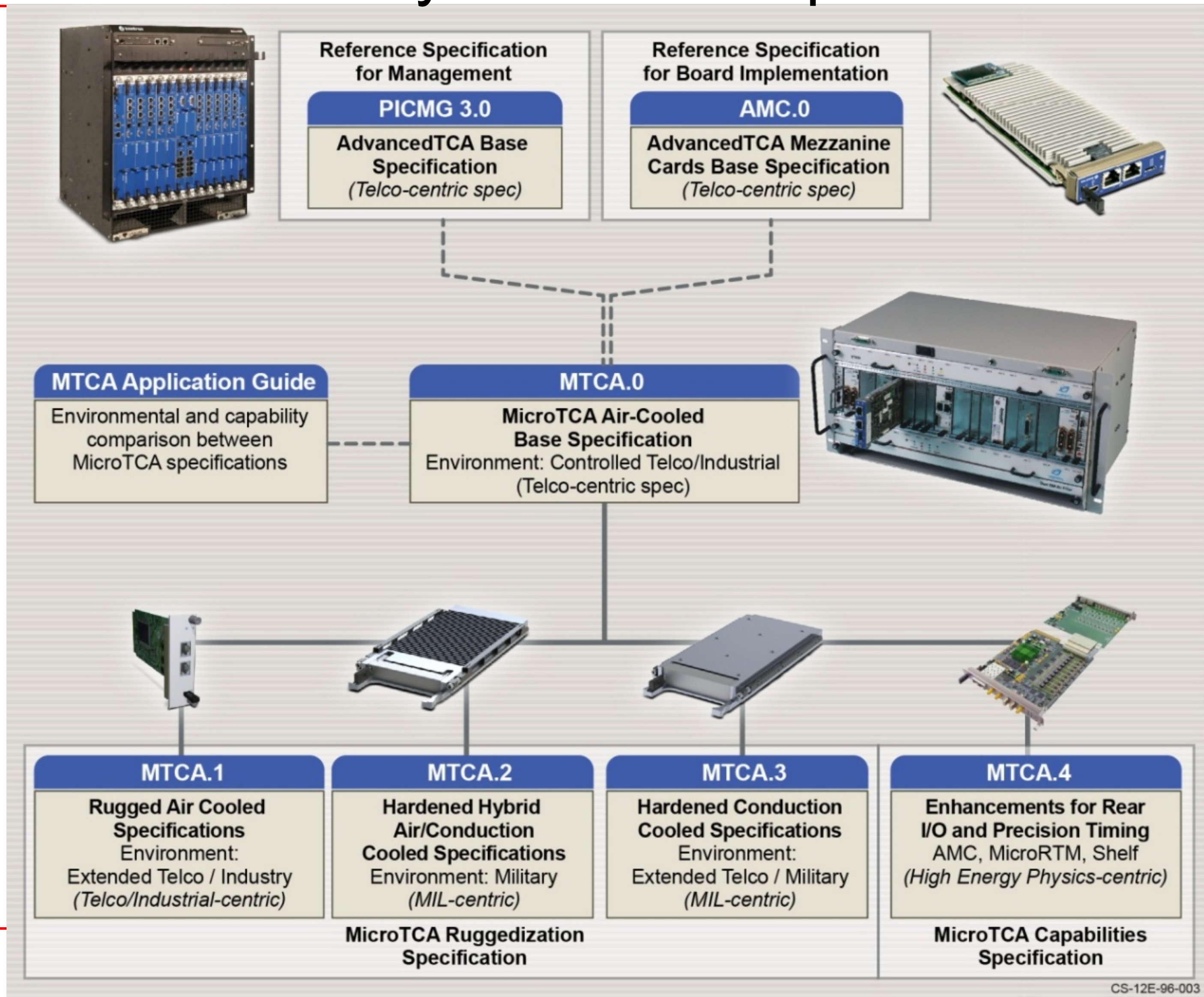


MicroTCA® leverages much of the ATCA® technology in a lower SWAP-C, scalable computer targeted for vehicle and small platform applications



MicroTCA
Technical Details

MicroTCA Family of PICMG Specifications



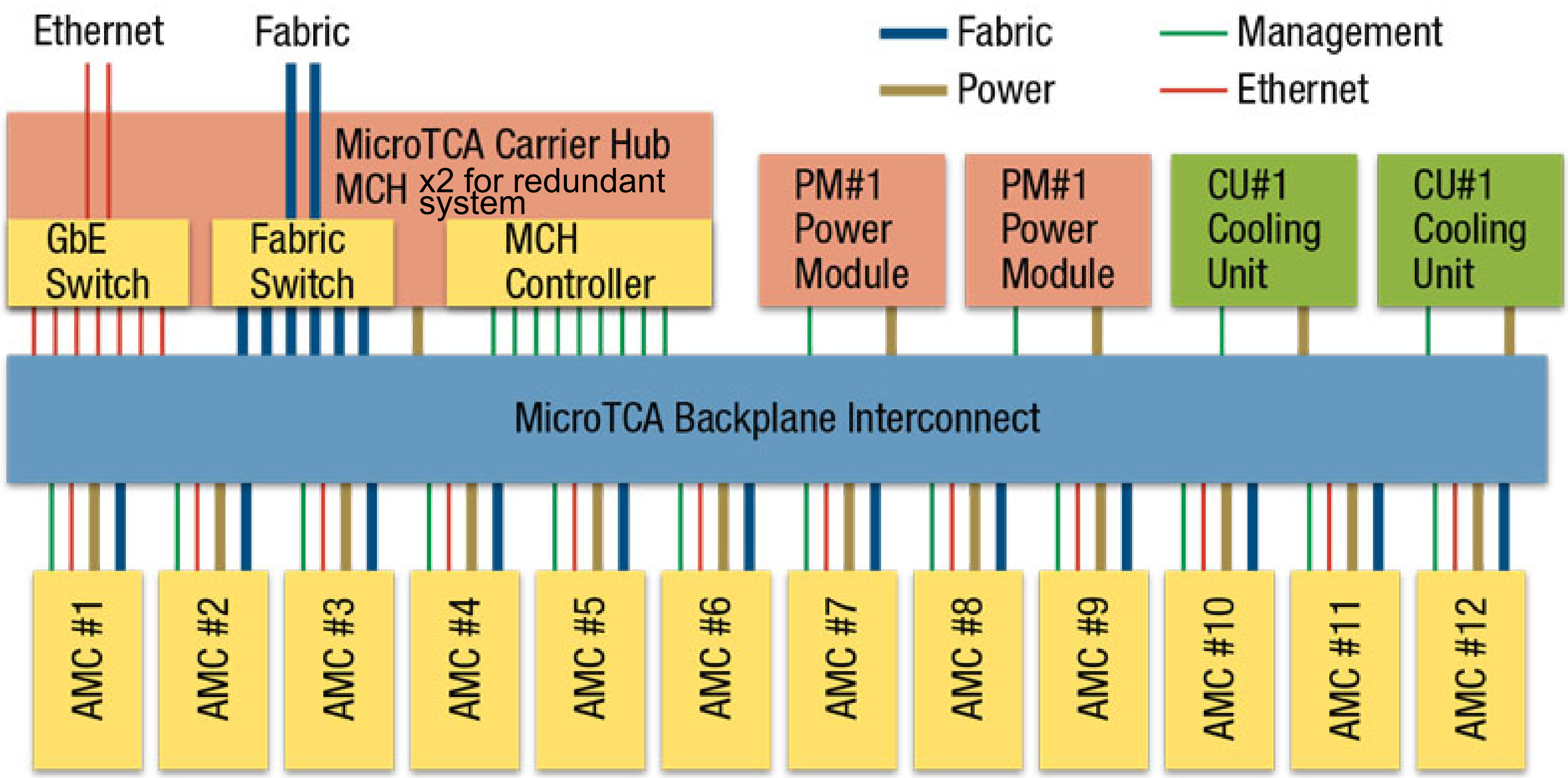
MicroTCA Family of PICMG Specifications

PICMG Specification	Name	Description
PICMG 3.0	AdvancedTCA Base Specification	The PICMG 3.0 “core” specification specifies board, backplane and shelf mechanicals; power distribution and the connectivity required for system management.
AMC.0	AdvancedMC Mezzanine Module	Defines a mezzanine building block approach for the addition of crucial functionality to a PICMG 3.0 carrier card available from a number of third-party suppliers.
MTCA.0	MicroTCA	Defines a system architecture that uses AdvancedMC Mezzanine Modules plugged directly into a backplane without modifications.
MTCA.1	Air Cooled Rugged MicroTCA	Defines hardened version of MicroTCA for exterior and mobile communications applications.
MTCA.2	Hardened Hybrid Air/Conduction Cooled MicroTCA	Defines hardened version of MicroTCA for rugged industrial and military applications with forced air flow over wedge-locked modules.
MTCA.3	Hardened Conduction Cooled MicroTCA	Defines ruggedized version of MicroTCA for rugged industrial and military applications with no air flow over the modules.
MTCA.4	MicroTCA Enhancements for Rear I/O and Precision Timing	Develops additional features and options for MicroTCA for use in particle physics research including data collection and accelerator control systems.

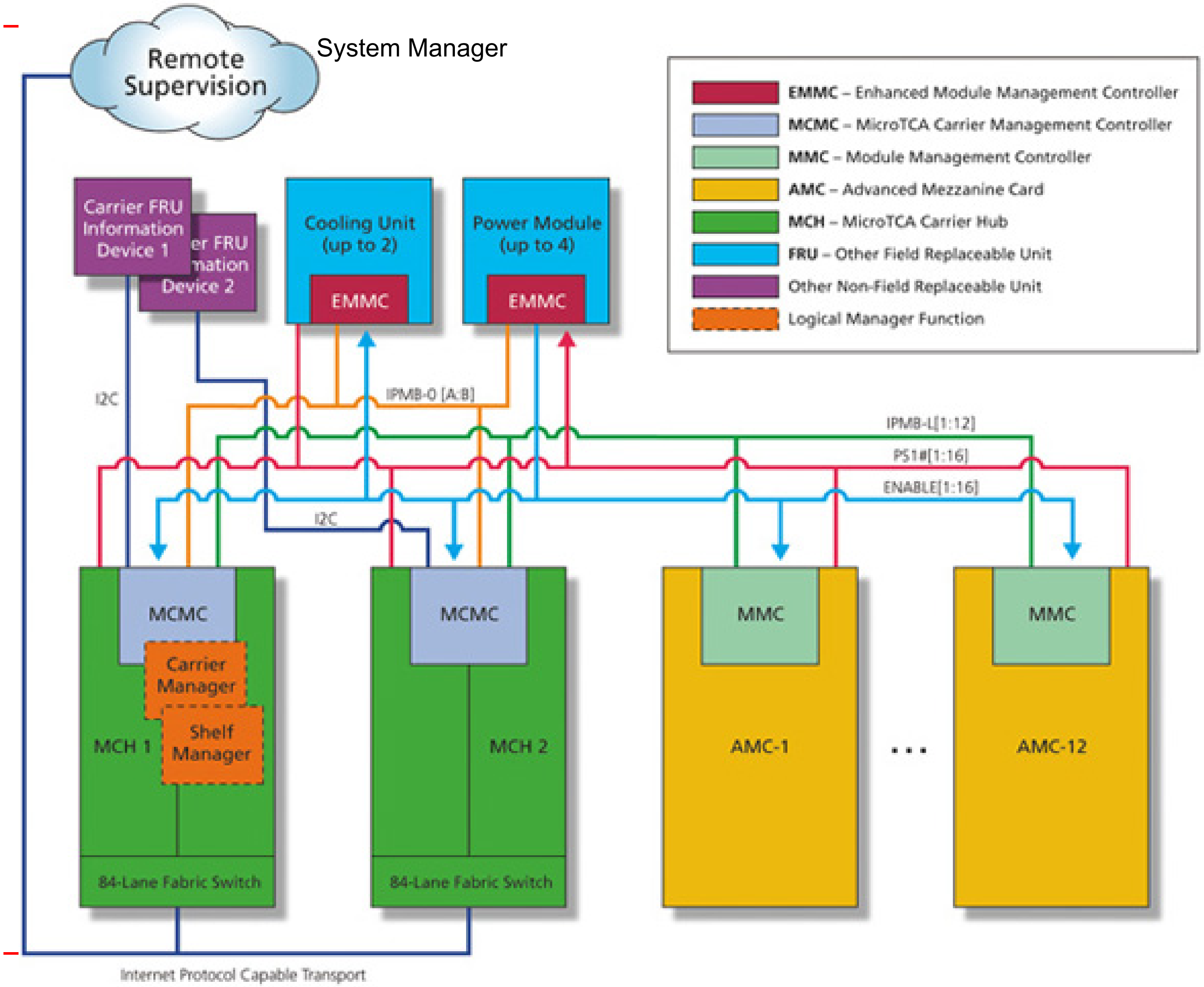
Excerpt from MicroTCA Application Guide, version 1.1, dated August 1, 2012, free copy @ www.picmg.com Resources area

MicroTCA System Architecture

– MicroTCA.0 defines the system architecture that scales up to 12 AMC (payloads) & defines fabric, management & power interconnect
  – Full redundancy is defined with two each MCHs, PM's & CU's



MicroTCA Management Architecture



- All modules are intelligent and communicate to the carrier manager over I2C buses
- IPMB (Intelligent Platform Management Bus) uses addition IPMB protocols for communication
  - Defined in PICMG3.0 ATCA spec
- Carrier management on MCMC (MCH) performs the local management of the payloads
- Shelf management can be on the MCH or PrAMC and can control its local carrier & remote carriers that are connected on the local internet
- Remote Supervision (System manager) can remotely oversee all carriers and can declare when & where FAULTS are occurring

MicroTCA (AMC) Module Form Factors

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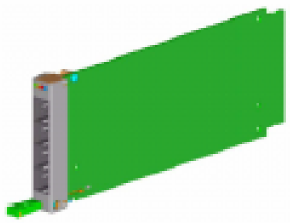
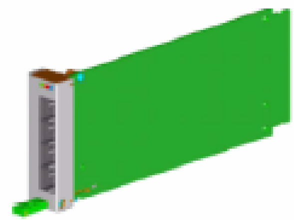
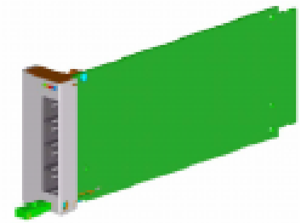
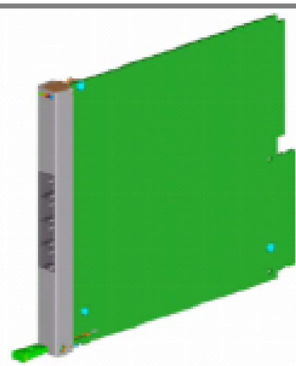
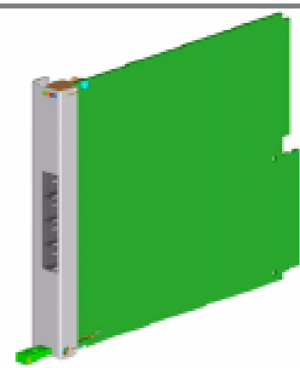
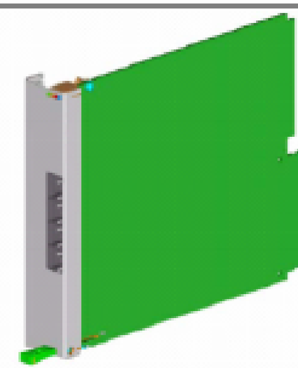
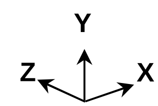
	Compact-Size **(Z)** (3HP) **(0.55”)**	Mid-Size **(Z)** (4HP) **(0.75”)**	Full-Size **(Z)** (6HP) **(1.14”)**
Single modules **(2.91”)** **(Y)** **(3U equiv.)**	 73.8x13.88x181.5mm	 73.8x18.96x181.5mm	 73.8x28.95x181.5mm
Double modules **(5.86”)** **(Y)** **(6U equiv.)**	 148.8x13.88x181.5mm	 148. 8x18.96x181.5mm	 148. 8x28.95x181.5mm



All modules are 7.15” (X) long

AMC Connector Signaling

BAE SYSTEMS

- AMC Connector (Tongues 1 thru 4)
  - Tongue 1 defined for minimum required signaling and power (payload & Management)
    - Standard port mapping, see next slide
  - Signaling rate defined as a maximum differential pair at 6.25 GBAUD, with 12.5 GBAUD recommended
    - Working group underway to require 40GigE, as 4 lanes of 10Gbps each
  - Tongues 2 thru 4 available for extending port mapping & user defined rear I/O
  - 170 contacts per tongue, Single module (3U equivalent)

Tongue 1		Tongues 2 - 4	
40 signal pairs 5 clock pairs 5 JTAG 9 System management	8 power 56 ground 2 reserved	Up to 53 signal pairs per tongue (106 contacts) {159 signal pairs max for 3 tongues}	8 power 56 ground

AMC Port Mapping, Tongue 1

BAE SYSTEMS

<table>
<tr><th>Non-Redundant MCH Fabric #</th><th>Redundant MCH # Fabric #</th><th>Port #</th><th>AMC Std Port Mapping</th><th colspan="3">Port Use</th></tr>
<tr><td>A</td><td>1A</td><td>0</td><td rowspan="4">Common Options Region</td><td colspan="3">Gigabit Ethernet</td></tr>
<tr><td></td><td>2A</td><td>1</td><td colspan="3">Gigabit Ethernet</td></tr>
<tr><td>B</td><td>1B</td><td>2</td><td colspan="3">SATA/SAS</td></tr>
<tr><td>C</td><td>2B</td><td>3</td><td colspan="3">SATA/SAS</td></tr>
<tr><td>D</td><td>1D</td><td>4</td><td rowspan="4">Fat Pipes Region</td><td rowspan="4">x4 PCI-E, SRIO, 10-40GiGE</td><td rowspan="8">x8 PCI-E</td><td rowspan="17">x16 PCI-E</td></tr>
<tr><td>E</td><td>1E</td><td>5</td></tr>
<tr><td>F</td><td>1F</td><td>6</td></tr>
<tr><td>G</td><td>1G</td><td>7</td></tr>
<tr><td></td><td>2D</td><td>8</td><td rowspan="4">Extended Fat Pipes Region</td><td rowspan="4">x4 PCI-E, SRIO, 10-40GigE</td></tr>
<tr><td></td><td>2E</td><td>9</td></tr>
<tr><td></td><td>2F</td><td>10</td></tr>
<tr><td></td><td>2G</td><td>11</td></tr>
<tr><td></td><td></td><td>12</td><td rowspan="9">Extended Options Region</td><td rowspan="9">10-40GigE, Display Port, USB, Audio, GPIO, … etc.</td><td rowspan="9">x8 PCI-E</td></tr>
<tr><td></td><td></td><td>13</td></tr>
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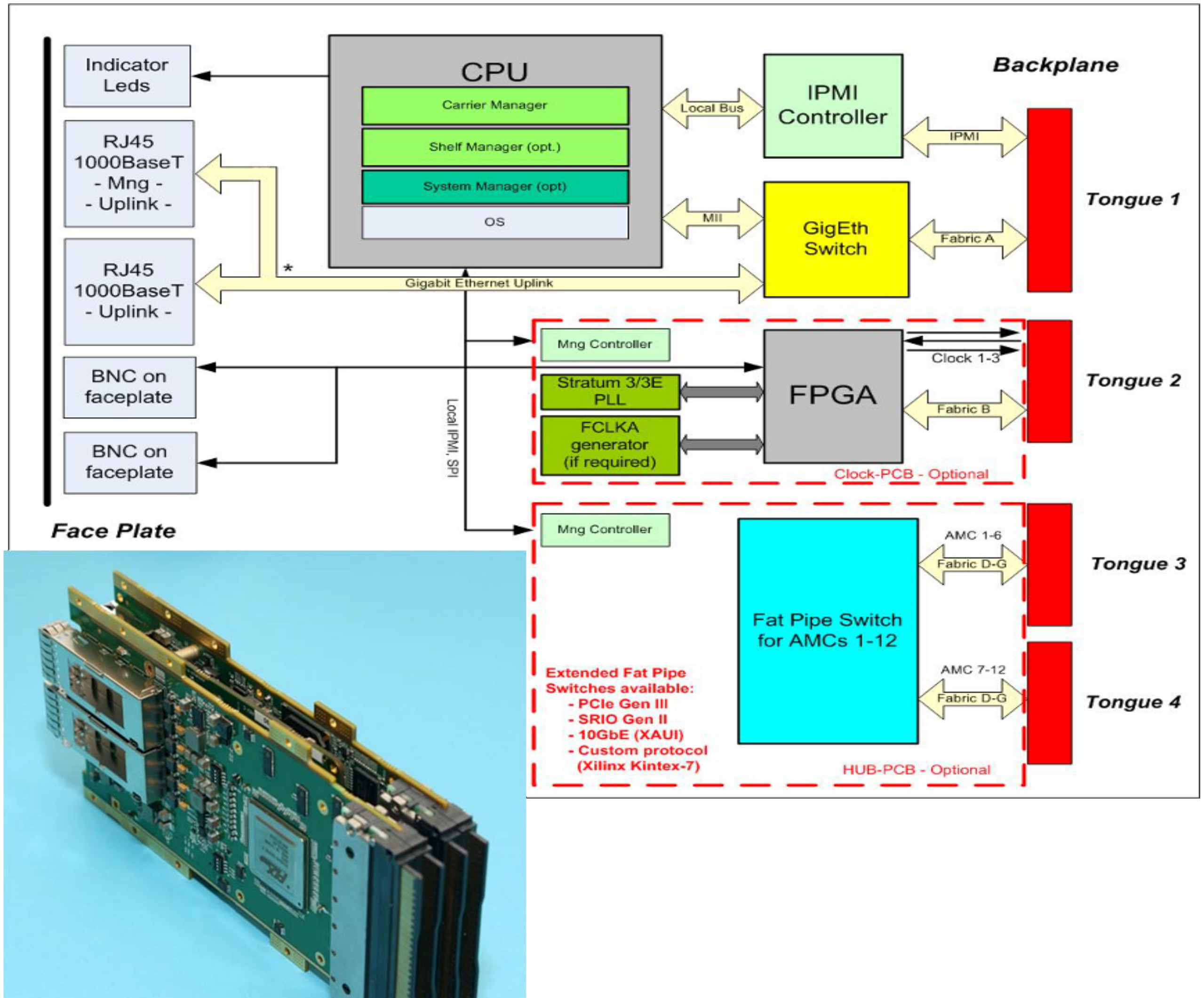
<tr><td></td><td></td><td>20</td></tr>
<tr><td></td><td></td><td>TCLK A-D</td><td>Telecom Clocks</td><td colspan="3">Telecom (User Defined) clks to/From MCH/AMC</td></tr>
<tr><td></td><td></td><td>FCLK</td><td>FCLK</td><td colspan="3">PCI-Express 100MHz Clock to/from MCH/PrAMC</td></tr>
</table>

Additional PICMG specifications define mapping for various protocols:

- AMC.1: PCIe (Gen2, 3) & Advanced Switching
- AMC.2: 1 – 10GigE
  - 40GigE in process
- AMC.3: SATA/SAS (3 & 6Gbps), Fibre Channel
- AMC.4: SRIO

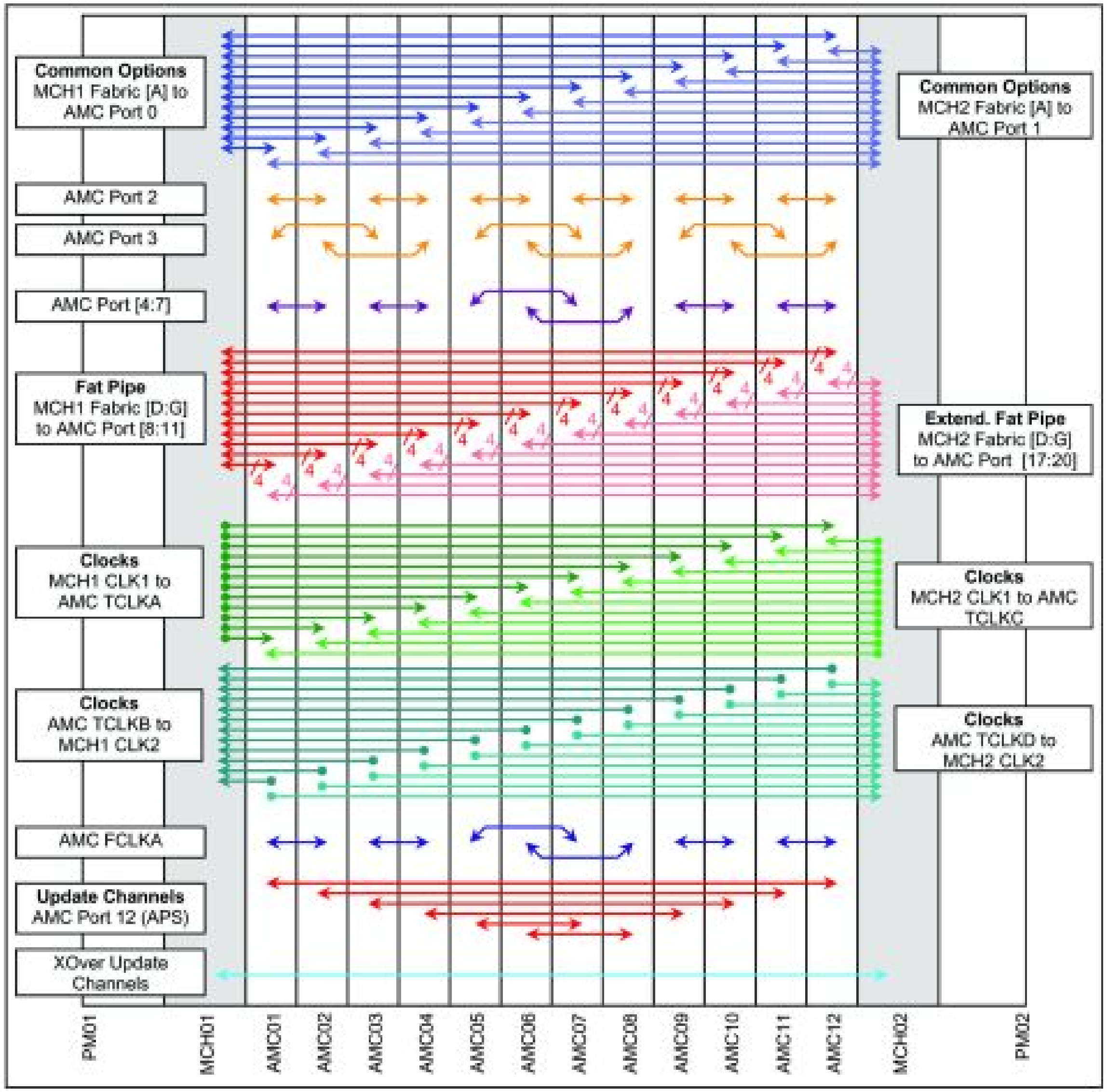
MCH Backplane Interconnect



MCH
Full size, single module shown

- MCH with full fabric (20 ports) requires 4 tongues (edge connectors)
- Tongue 1 supports
  - IPMI & Fabric A
- Tongue 2 supports
  - Clocks & Fabric B
- Tongue 3 supports
  - Fabric D – G for AMC 1 – 6
  - Update channels
- Tongue 4 supports
  - Fabric D – G for AMC 7 – 12
  - Update channels

MicroTCA Sample Backplane Mapping

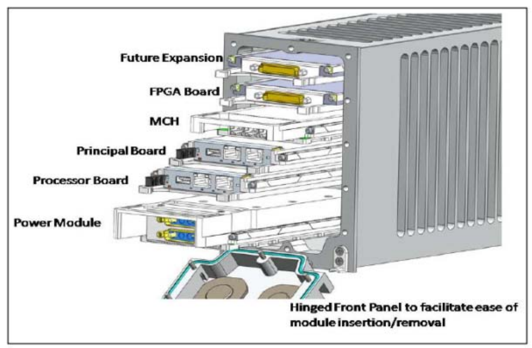


Backplane Mapping depends upon

- Intended use
- Number of slots
- Number of MCH's
  - Redundant or Non-redundant
- Required clocks
- Protocols required
  - Number of lanes per protocol

MicroTCA Form Factors

- MicroTCA® overall form factor, a.k.a. chassis is not defined
  - Standards define the backplane and standard electronic modules
- Chassis can be tailored to meet platform requirements
  - Various form factors exist
    - 1U – 4U Rack mount and desktop systems
    - Commercial to rugged
    - Various size ATR chassis



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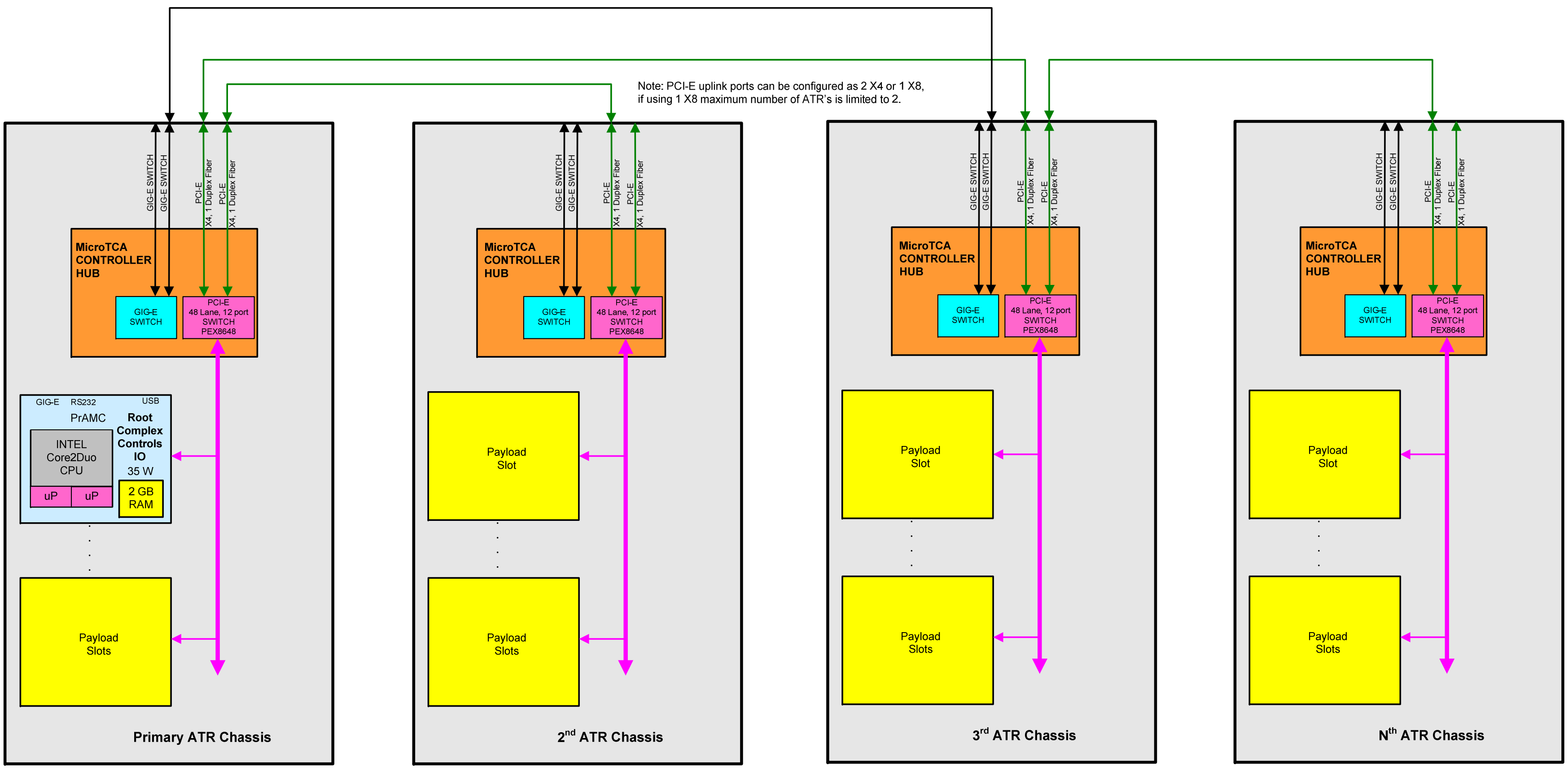
Scalability

- MicroTCA chassis can be linked via Fiber PCI-Express or Gigabit Ethernet uplink ports from MCH to a 2nd Chassis
- 3rd chassis would be linked either thru 2nd chassis or from primary chassis
- PrAMC (root complex) can be limited to primary ATR chassis and drive thru primary MCH PCI-E switch to 2nd or 3rd chassis MCH PCI-E switch
  - PCI-E uplink ports can be configured as two X4 or one X8, if using one X8 maximum scalability is limited to 2 ATR's
  - PCI-E transaction rate is 5Gbps (Gen 2) or 8Gbps (Gen 3) and requires fiber interconnect
    - or very special copper cabling and connectors for high speed signaling and a limitation on cable length would be required

Scalability (continued)

MicroTCA ATR Chassis Scalability

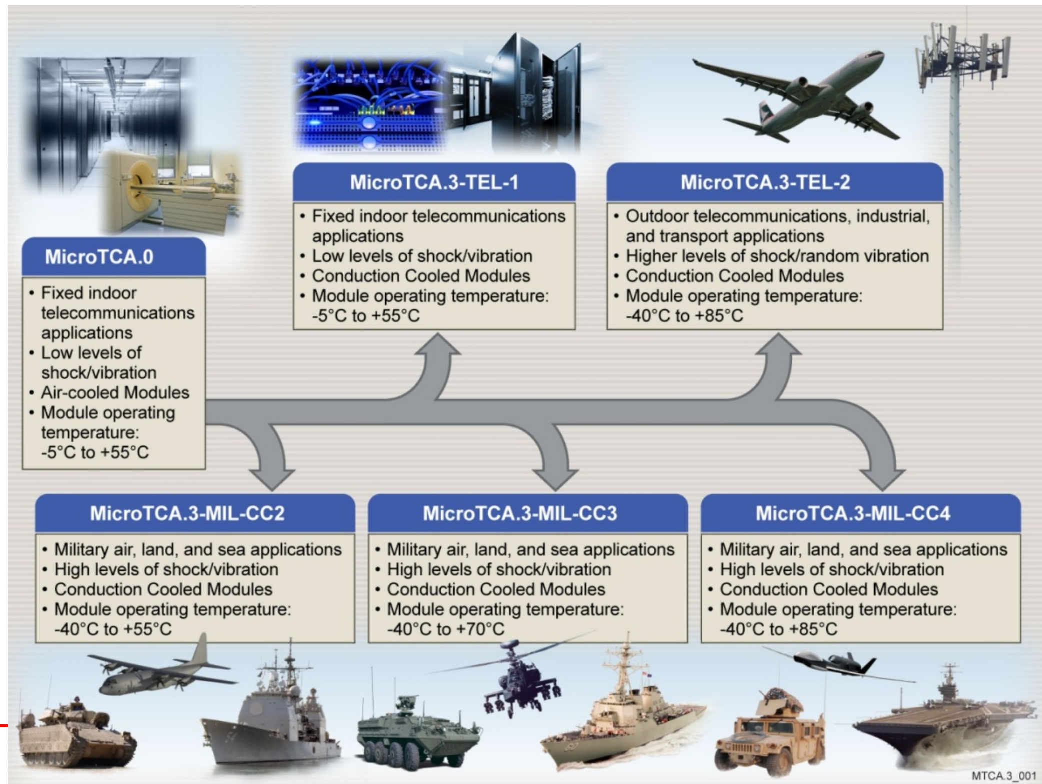


Note: PCI-Expansion is limited to the maximum enumeration of the Root Complex
PrAMC BIOS and the host OS. Practical limits is around 24 to 32 PCI-E devices

MicroTCA.3
Conduction Cooled
Modules

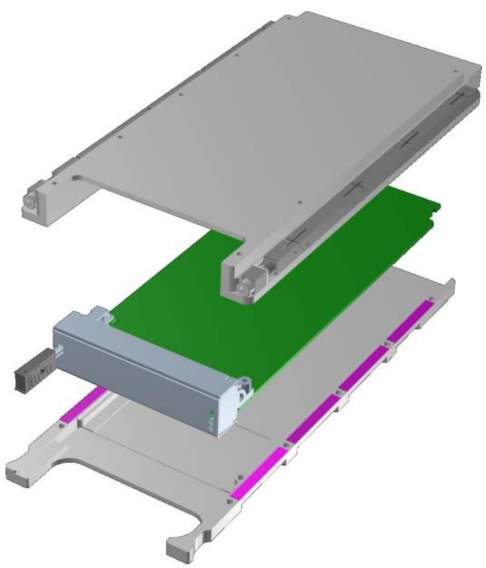
MicroTCA.3 Specification Overview

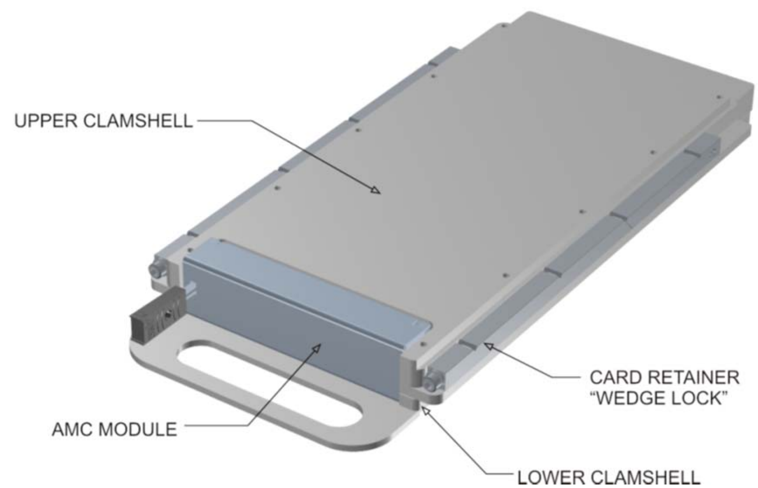
– MicroTCA.3 Hardened Conduction Cooled specification in conjunction with MicroTCA.0 and .1, provides the requirements necessary for a system to meet the system & rugged requirements of
  – outside plant telecom, machine and transport industry
  – military airborne, shipboard and ground mobile equipment environments



MicroTCA.3 Mechanical

- Typical Conduction Cooled AMC
  - Mandated that AMC.0 modules are used as is to leverage large eco-system
  - There are ten types of Modules sizes defined. They are the Compact, Mid-Size, Full Size, Power, and MCH in Single & Double module configurations
  - Clamshell designed to support
    - Thermal interface to the chassis sidewall
    - Mechanical rigidity
    - 15KV ESD capability for 2 level maintenance
  - Single size module shown below

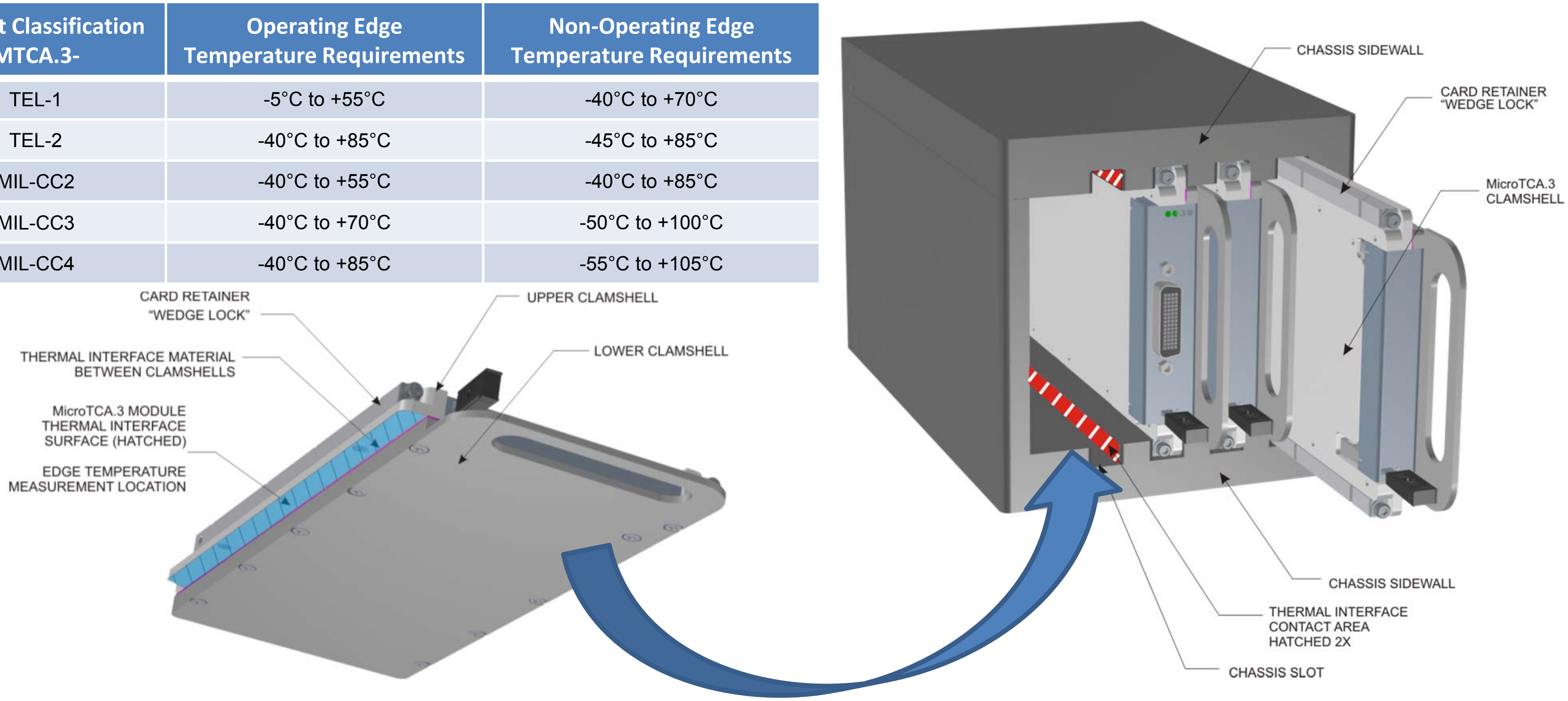




MicroTCA.3 Thermal

- The Thermal Interface surface
  - is the area of the Upper Clamshell (blue cross hatch) that contacts the Chassis Slot (red cross hatch)
  - is the location where the Module Edge Temperature is specified/measured
- The temperature specification does not include the associated temperature rise of the interface boundary layer between the MicroTCA.3 Module Thermal Interface surface and the Thermal Interface contact area on the Chassis Slot

Product Classification MTCA.3-	Operating Edge Temperature Requirements	Non-Operating Edge Temperature Requirements
TEL-1	-5°C to +55°C	-40°C to +70°C
TEL-2	-40°C to +85°C	-45°C to +85°C
MIL-CC2	-40°C to +55°C	-40°C to +85°C
MIL-CC3	-40°C to +70°C	-50°C to +100°C
MIL-CC4	-40°C to +85°C	-55°C to +105°C

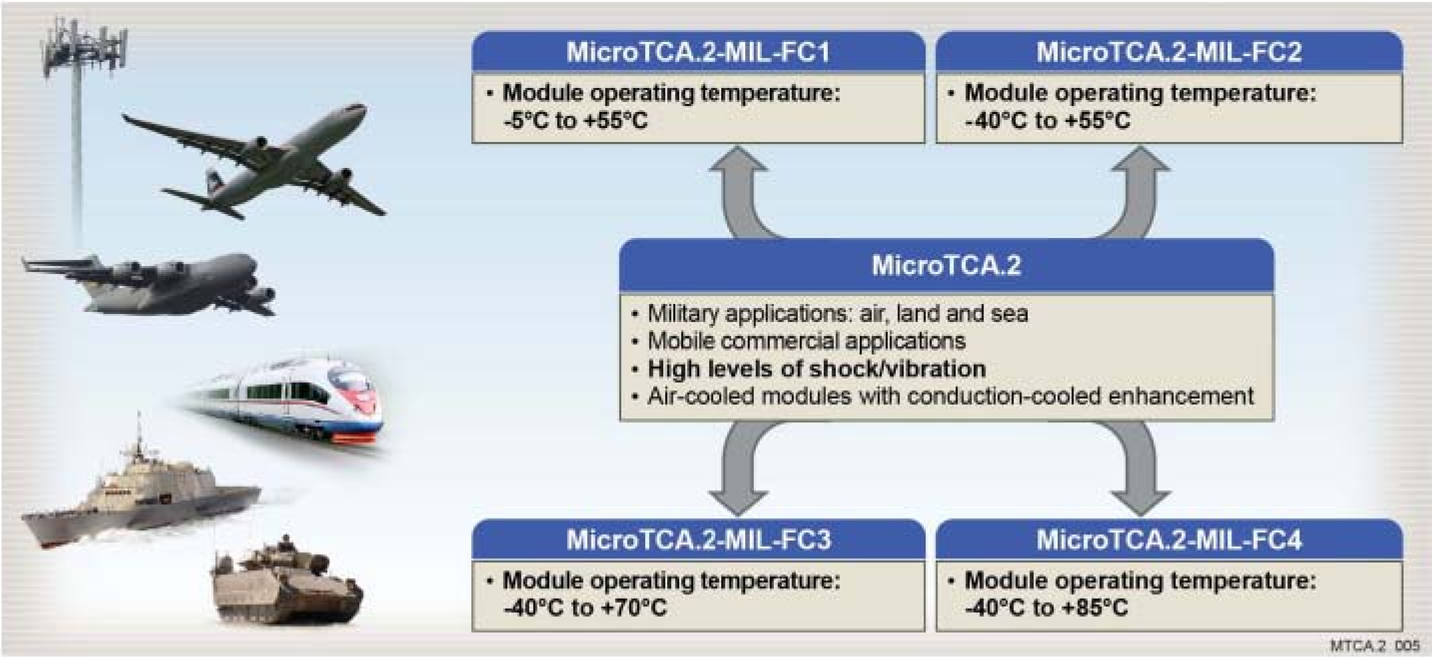


BAE SYSTEMS

MicroTCA.2 Hybrid Cooled Modules

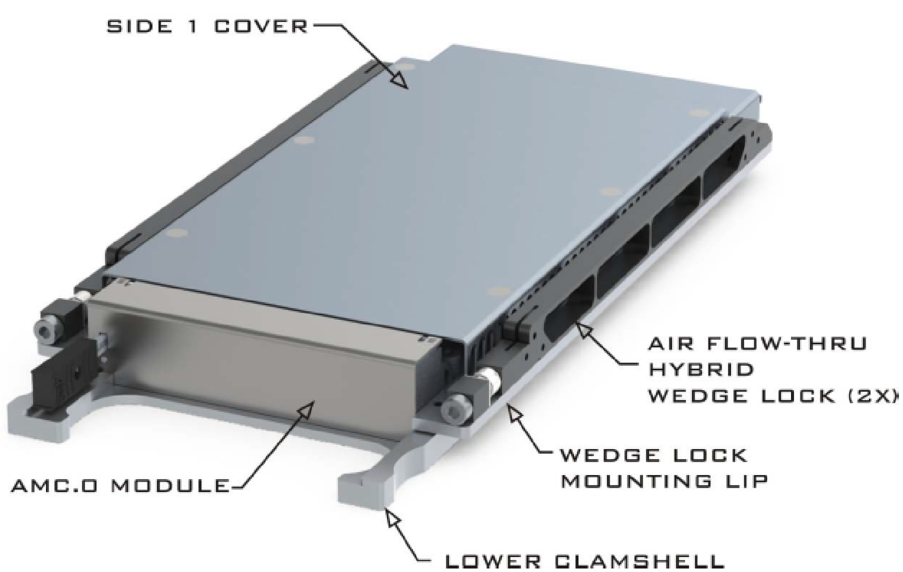
MicroTCA.2 Specification Overview

- MicroTCA.2 Hybrid Air/Conduction cooled specification in conjunction with MicroTCA.0, .1, .3, .4 provides the requirements necessary for a system to meet the system & rugged requirements of
  - Outside plant telecom, machine and transport industry
  - military airborne, shipboard and ground mobile equipment environments

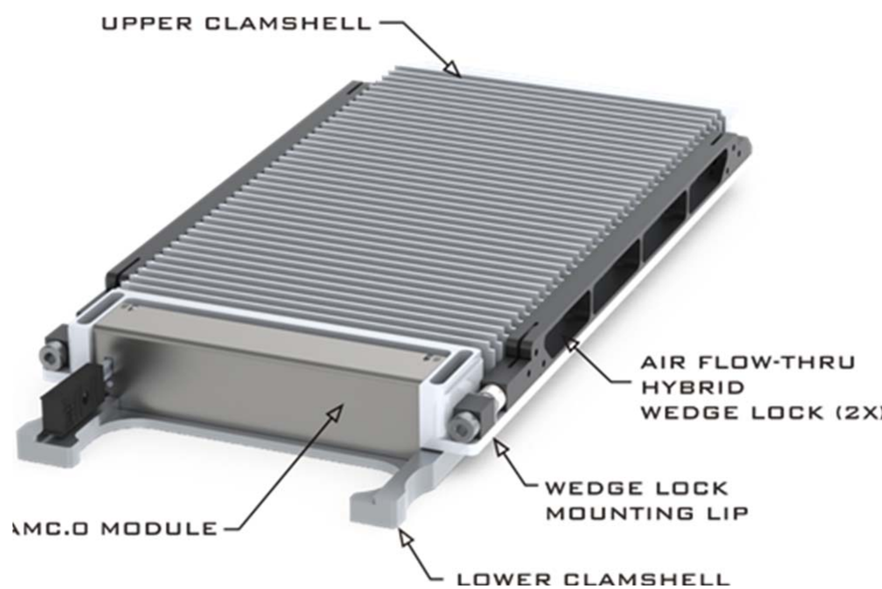


MicroTCA.2 Mechanical

- Hybrid Air/Conduction Cooled AMC
  - There are ten types of Module sizes defined. They are the Compact, Mid-Size, Full Size, Power, and MCH in both Single and Double module configurations
  - Clamshell designed to support
    - Air cooled over/through clam shell
    - Thermal interface to the chassis sidewall
    - Mechanical rigidity
    - 15KV ESD capability for 2 level maintenance



Low Power MicroTCA.2 Module
Open Frame Configuration



High Power MicroTCA.2 Module
Closed Frame Configuration

MicroTCA.2 Hybrid Cooling

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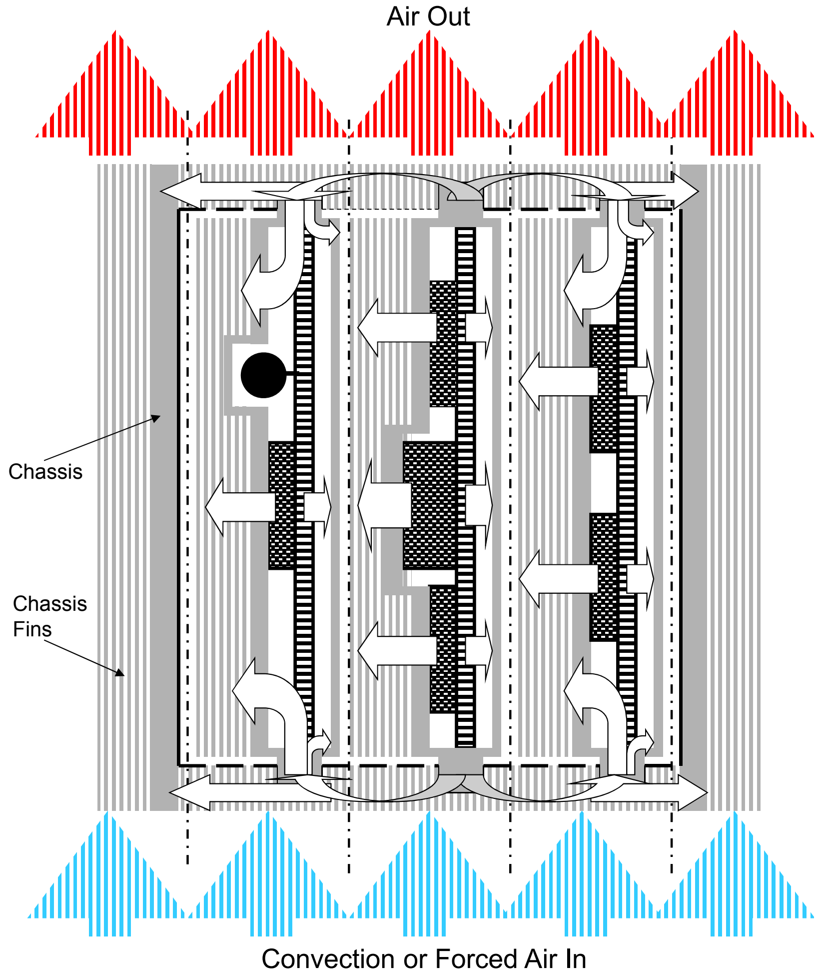
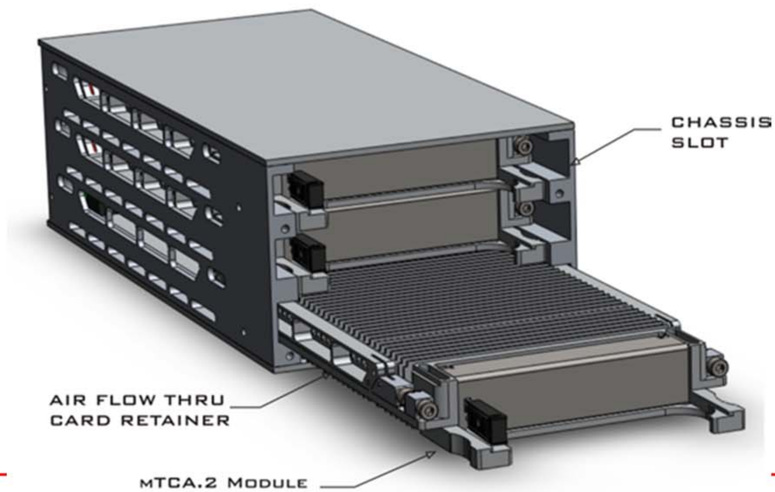
- MicroTCA.2 “hybrid” thermal design provides the benefits of both forced-air convection cooling (dominant effect) and conduction cooling (secondary effect)
- Cooling is achieved primarily through forced-air convection by directing the flow of air over and through the Modules
- The structural design of these Modules and the heat transfer achieved through physical contact between the Modules and Chassis Sidewall provide a conduction cooling path that augments the dominant forced-air convection cooling effect.



Typical MTCA.2 design – front view internal cross section

MicroTCA.2 Hybrid Cooling Thermal Testing

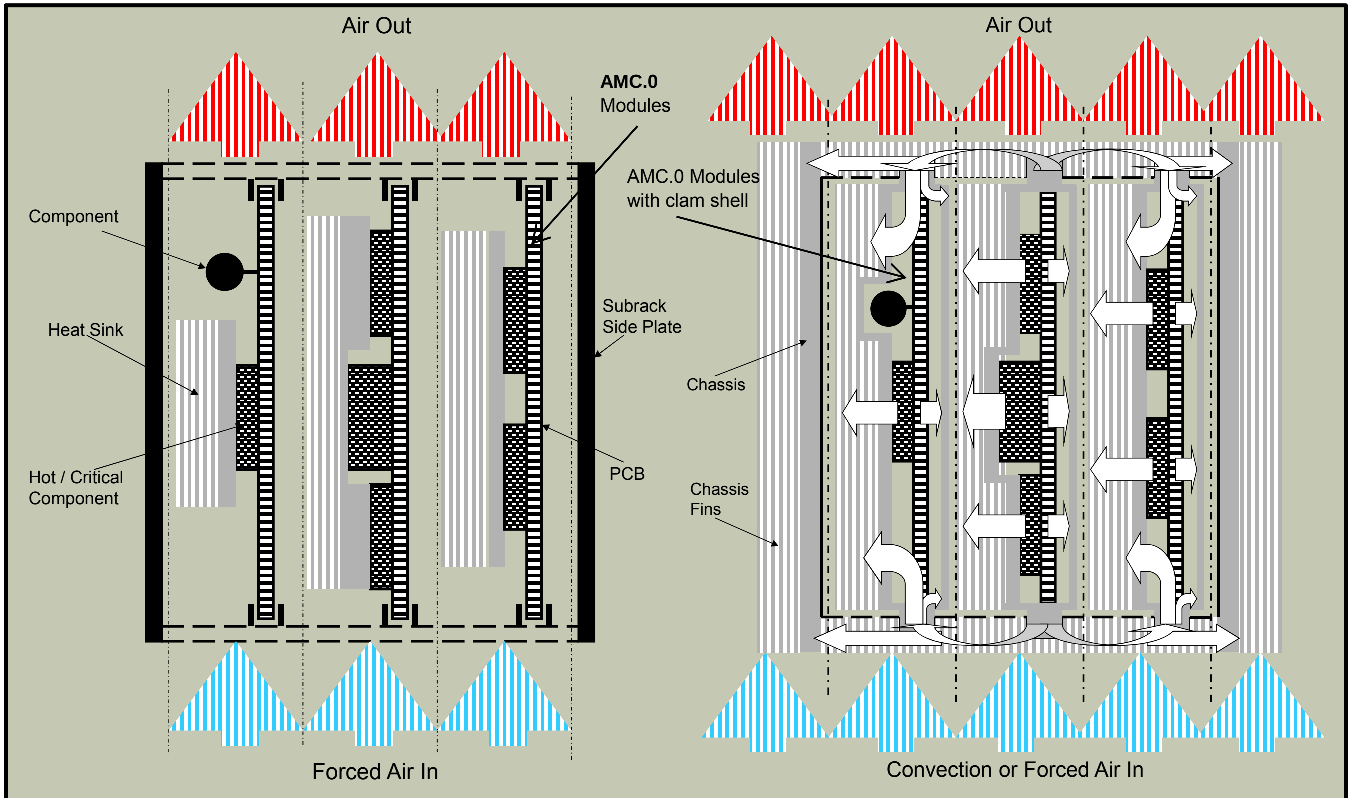
- The purpose of the testing was to identify and characterize the primary (forced-air) and the secondary (conduction) thermal performance contributions inherent in the proposed Hybrid Air/Conduction Cooled MicroTCA.2 specification
- Thermal testing was conducted using two versions of a reference design chassis
  - Non-heat conductive sidewalls (Forced Convection only)
  - Traditional aluminum sidewalls (Hybrid: Conduction + Convection)
- The testing characterized multiple combinations of low-power and high-power AMC thermal load modules (TLMs)
- Various system configurations generated an extensive data set, capturing chassis inlet airflow velocity, module slot airflow velocity, inlet ambient air temperatures, and module onboard sensor temperatures. Link to PICMG test report #209623D: http://www.picmg.org



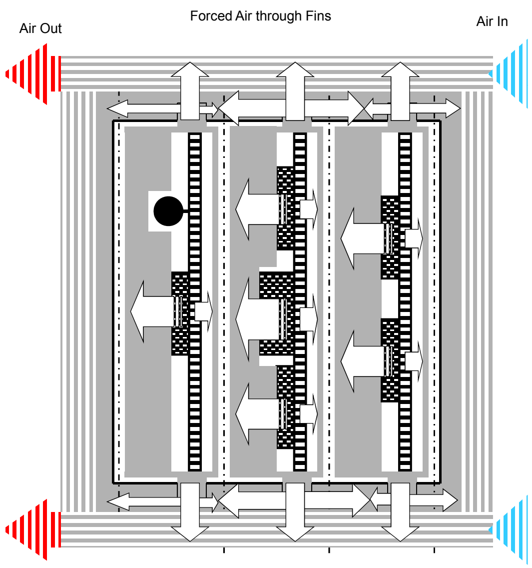
3-Slot Thermal Test Chassis with both non-conductive & conductive side wall versions

MicroTCA.2 Hybrid Cooling Test Results

– Thermal test results confirms that a significant thermal dissipation benefit is provided by the secondary (conduction) heat sharing of MicroTCA.2 Hybrid cooling
– Testing documented a contribution of up top 33% in component temperature[1] reduction as compared to standard MicroTCA.0 & MicroTCA.1 forced air solutions



Typical MTCA.0 / MTCA.1design – front view internal cross section
Typical MTCA.2 design – front view internal cross section

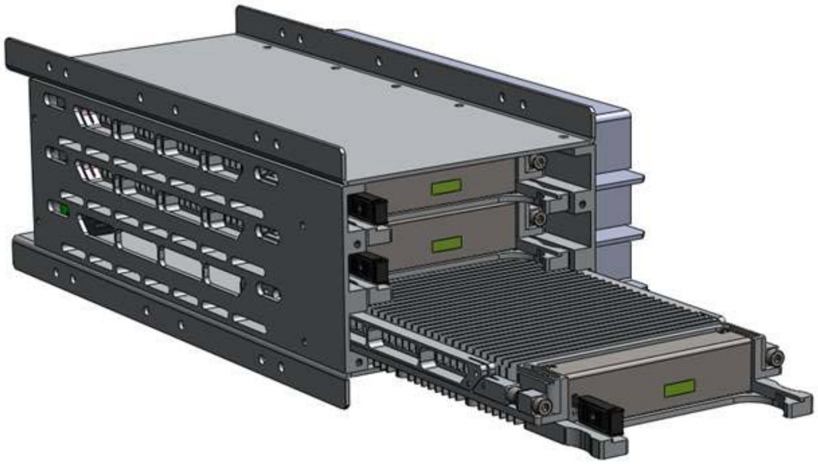


Typical MTCA.3 design – front view internal cross section

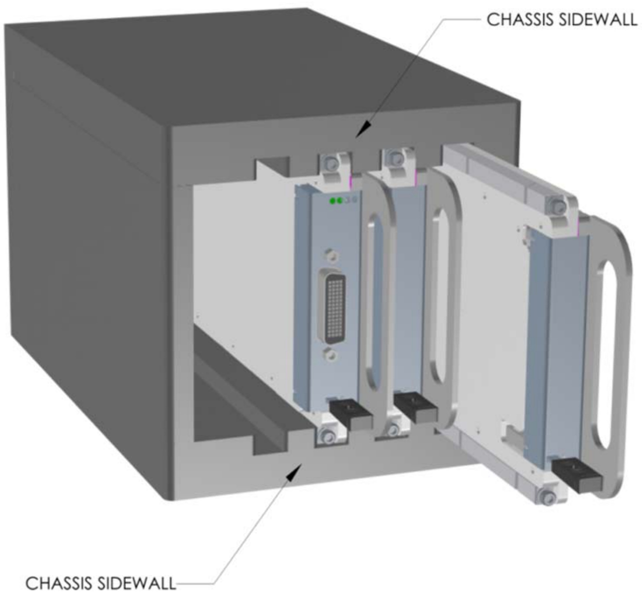
1: At a flow condition of 6.7 CFM per slot, a Single Module dissipating 51.6 watts of power recorded a 6.6°C reduction in component temperature

MicroTCA.2 vs. MicroTCA.3

- MicroTCA.2 Hybrid Air/Conduction Cooled chassis



- MicroTCA.3 Conduction Cooled chassis



Product Classification			Requirements (Operating)		
MicroTCA.0	MicroTCA.2	MicroTCA.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 0S2) / 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		

MicroTCA.2/3 Environmentals

Environmental category	Requirements per MicroTCA.3 product class				
	MTCA.3-TEL-1	MTCA.3-TEL-2	MTCA.3-MIL-CC2	MTCA.3-MIL-CC3	MTCA.3-MIL-CC4
Shock	IEC 61587-1, DL1, 15g	ANSI/VITA 47 OS1, 20g*	ANSI/VITA 47 - OS2, 40g; MIL-STD-810, Method 516, Procedure I*		
Vibration	IEC 61587-1, DL1 (1g) sinusoidal	VITA 47 - V2 (8g) random*	ANSI/VITA 47 - V3 (12g) random; MIL-STD-810, Method 514, Procedure I*		
Bench handling	Sect 2.9.3.2	Sect 2.9.3.2**	MIL-STD-810, Method 516, Procedure VI*		
Earthquake (Seismic)	ANSI T1.329	ANSI T1.329**	Not applicable		
ESD resistance	GR-1089-CORE; EN 61000-4-2	GR-1089-CORE; EN 61000-4-2**	EN 61000-4-2		
Two-level maintenance	Not applicable		See ESD Requirement		
Corrosion resistance	GR-1089; ETS 300 019-1-3, Section 5.3, Table 3a	GR-1089; ETS 300 019-1-3 Section 5.3, Table 3a**	ASTM G85, Annex A4, Cycle A4.4.4.1*		
Fungus resistance	ETS EN 300 019-1-3, Class 3.1, Section 5.1, Table 2; GR-63-CORE	ETS EN 300 019-1-3, Class 3.1, Section 5.1, Table 2; GR-63-CORE**	MIL-STD-810, Method 508*		
Humidity	Operating Normal 5-85% non-condensing Op. Short Term 5-90% non-condensing	Operating Normal 5-85% non-condensing Op. Short Term 5-90% non-condensing**	95% RH (5x48h); MIL-STD-810 Method 507*		
Explosive atmosphere	Not applicable		MIL-STD-810 (60,000 feet maximum) Method 511.4 Procedure 1		
Mixed flow gas	GR-63-CORE Section 4.5	GR-63-CORE Section 4.5**	Not applicable		
Altitude	-60m / 4,000m, EN 300-19-2-A1563; GR-63-CORE, Section 4.1.3	-60m / 4,000m, EN 300-19-2-A1563; GR-63-CORE, Section 4.1.3**	-460m to 18,300m; MIL-STD-810, Method 500, Procedure II*		
Rapid decompression	Not applicable		MIL-STD-810, Method 500, Procedure III*		
Attitude	Module shall meet all requirements in all orientations.				
Acoustic	Not applicable		≤24dBA (Sound Pressure)*		
Thermal	MicroTCA.3, Section 5				
Laser (module/system)	FDA/CDRH 21 CFR 1040.10, 140.11	FDA/CDRH 21 CFR 1040.10, 140.11***	Not applicable		
Flammability			FAR-25, subpart D, section 869		

Non-thermal requirements

- MicroTCA.3 product classes different environmental requirements are defined for Telco & Military
  - TEL-1 & TEL-2 are based upon IEC & EN & ANSI requirements
  - MIL-CC2, MIL-CC3 & Mil-CC4 are based upon ANSI/VITA47, MIL-STD-810 requirements

– MicroTCA.2 product classes same environments as MicroTCA.3
  - MIL-FC1 thru Mil-FC4

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MicroTCA Environmental Comparison

- MicroTCA.0 defines the base level of ruggedization, mainly intended for central office controlled environments
- MicroTCA.1, .2, and .3 define additional enhancements to allow MicroTCA to be deployed in more rugged environments

Requirement	**Maximum Operating Shock**	15g	25g	40g
	Maximum Operating Vibration	1g sinusoidal	8g random	12g random
Implementation	**Required Retention Mechanism**	Hot swap handle	Enhanced retention screw	Wedge locks
	MicroTCA Ruggedization Specification	**MTCA.0**	**MTCA.1**	**MTCA.2 or MTCA.3**

Ruggedized specification compliance enable use of MicroTCA in applications requiring high levels of shock & vibration capability

MicroTCA Environmental Comparison

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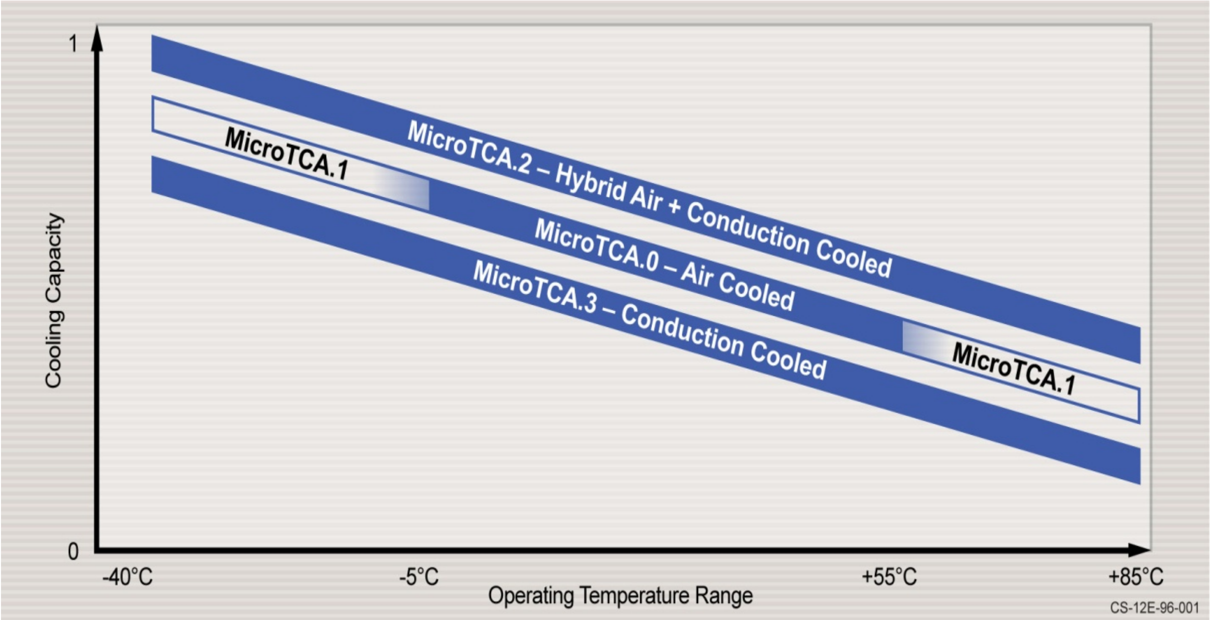
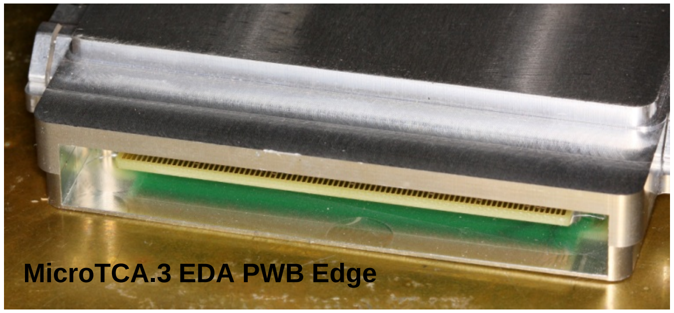
- All ruggedization specifications allow for operation over an extended temperature range
- The amount of power that can effectively be thermally dissipated relies on the underlying cooling mechanism
- As a rule of thumb, air-cooled boards can dissipate more heat than conduction-cooled boards
- MicroTCA.2's hybrid air and conduction cooling allows the greatest amount of heat to be dissipated

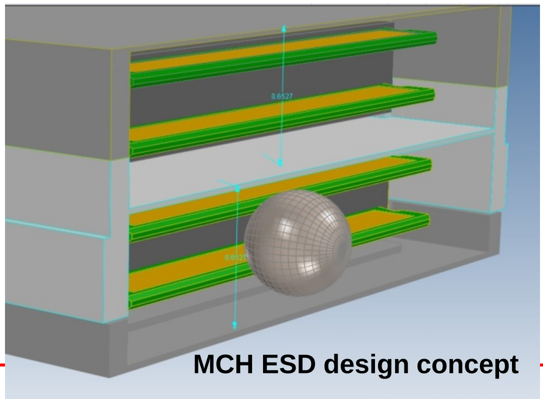


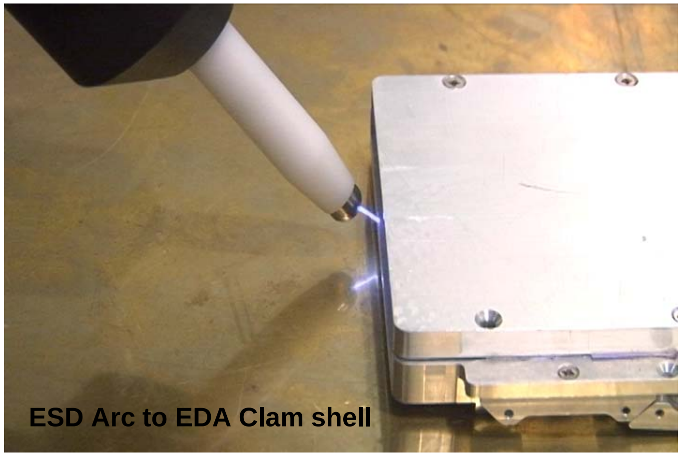
Relative performance of MicroTCA cooling mechanisms across the operating temperature range

MicroTCA.2/.3 ESD Testing

- ESD Design
  - The Clamshell encases the functional AMC Module in an electrically conductive shell which extends beyond the tabs of the connector area sufficiently to provide ESD protection for a 15 kV half-inch ball test
  - The Clamshell itself is electrically conductive and will provide a path to Chassis Ground when installed within the Chassis
  - An ESD test was performed as part of the test phase and is supplied as an appendix to the test report written by Contech Research

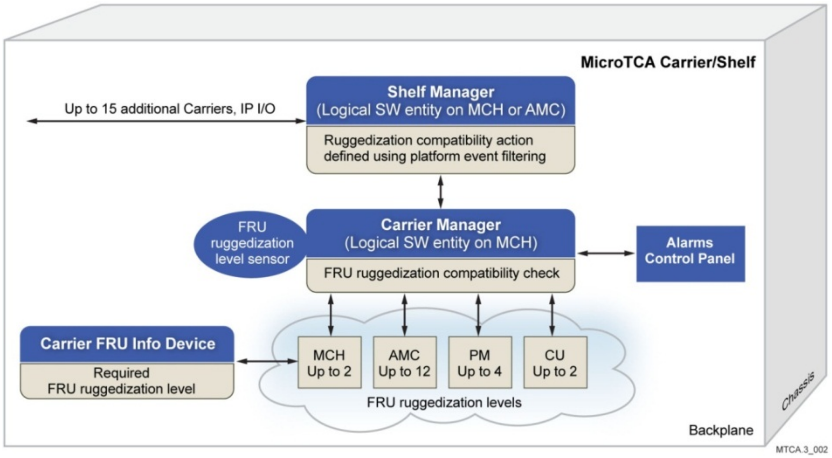

MicroTCA.3 EDA PWB Edge


MCH ESD design concept


ESD Arc to EDA Clam shell

Hardware Platform Management (HPM)

- MicroTCA.2 & .3 HPM supplement to base specification
  - All FRUs (Field Replaceable Units) have their ruggedization level defined in its FRU information record
  - Carrier FRU info device contains required ruggedization level of the FRU’s defined by system integrator or chassis design authority
  - Carrier manager has a FRU ruggedization level sensor that reports the compatibility between all the FRUs and the carrier to determine if the system is configured correctly
  - Shelf manager can use the carrier ruggedization compatibility event to determine action to be taken
    - The action is user defined by the system integrator using Platform Event Filtering



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Some
MicroTCA & VPX
Differences

Product Interoperability

- Why define module pin out vs. profile definition?
  - As discussed earlier in this presentation defining module & backplane pin out is essential to providing
    - Multi-vendor interoperability
    - Otherwise one does not have a truly open standard
- Multi-vendor interoperability leads to
  - Independence from a single vendor
  - Easier obsolescence resolution
  - Competition that leads to reduced cost & greater innovation
- On the flip side OpenVPX is more of a development philosophy with a collection of profiles rather than a true open standard!

Remember Future Bus, a VITA specification?

  - No, that is due to its use of profiles vs. pin out definition
  - There was no interoperability so vendor modules could not be exchanged!

Product Interoperability (Cont.)

- MicroTCA defines standard signaling & protocols by pin number to ensure Module Vendor Interoperability (MVI)
- VPX only defines the number of signal pairs, not pin numbers
  - No Module Vendor Interoperability
- OpenVPX is the same as VPX, but profiles (rules) where added defining signal assignment methodology not pin number
  - No Module Vendor Interoperability

MicroTCA AMC Single Module		VPX 3U Module	Open VPX
Tongue 1 40 signal pairs 5 clock pairs 5 JTAG 9 system management 8 power 56 ground 2 reserved *Standard signal pin number assignment per Spec*	Optional Tongues 2 – 4 159 signal pairs (53/tongue) 24 power 168 ground *User defined signal assignment*	P0 49 power & ground P1 56 signal pairs Optional P2 56 signal pairs *User defined signal assignment*	Same as VPX *User defined signal assignment with profiles or rules that dictate signal assignment methodology not pin number*

MicroTCA.3 Environmental Testing

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- ***MicroTCA.3 backplane connector system has successfully passed all Military and Telcordia grade testing for mechanical, environmental and ESD requirements***
  - Prior to releasing MicroTCA.3 specification, chassis level testing was performed to ensure a robust backplane to Advanced Mezzanine Card (AMC) connector system
  - Testing was sponsored by the PICMG MicroTCA.3 working group and consisted of 8 full life test groups plus a separate ESD test
    - MicroTCA.3 working group test sponsors: BAE Systems, Hybricon, Cisco Systems, Cypress Point Research, Elma Electronics, Emerson Network Power, Extrusion Technology, GE Intelligent Platforms, Harting, Inc., Kontron, VadaTech, Wavetherm
    - Qualification test summary, see http://www.picmg.org/v2internal/resourcepage2.cfm?id=14 for test plan & final test report

Mechanical shock (50 G),	Insulation Resistance
Random Vibration (12 Grms, 50 – 2 KHz)	Dielectric Withstanding Voltage
Thermal shock (-55°C to +85°C)	Durability @ **extreme environments**
Thermal Cycling with Humidity **(500 hrs)**	Engaging/Separating Force
Temperature life **(500 hrs)**	Salt Fog/SO_2 (2 days)
Mixed Flowing Gas (10 days)	Sand
	15KV ESD

  - Contech Research, Attleboro MA an independent testing & research company performed the testing for MicroTCA.3 & VPX

MicroTCA.3 testing was more comprehensive, tested over a longer life duration and tested against more failure mechanisms than VPX

500 hours for MicroTCA.3 vs. 240 hours for VPX

VPX Environmental Testing

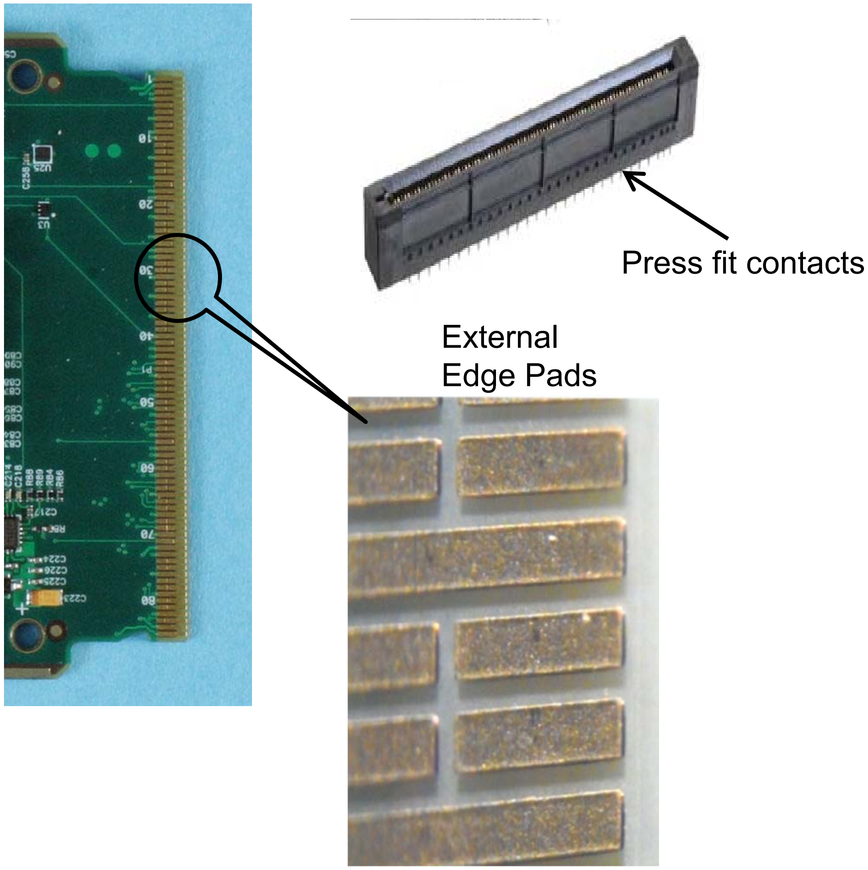
- ***VPX backplane connector system has successfully passed all Military grade testing for mechanical, environmental and ESD requirements***
  - Prior to releasing VITA 46 (VPX) specification, holding fixture testing was performed to ensure a robust backplane to VPX module connector system
  - Testing was sponsored by the VPX working group and consisted of the 7 test groups
    - VPX working group test sponsors: CWC embedded computing, Mercury Computer & Radstone
    - Qualification test summary, see http://www.vita.com/vpx.html for final test report, test plan not available

Mechanical shock (50 G),	Insulation Resistance
Random Vibration/HALT (12 Grms, 50 – 2 KHz)	Dielectric Withstanding Voltage
Bench Handling/Vibration over Temperature	Durability @ **std environment**
	Engaging/Separating Force
Thermal Cycling with Humidity **(240 hrs)**	Salt Fog/SO_2 (2 days), Salt Fog
	Sand & Dust
	15KV ESD

  - Contech Research, Attleboro MA an independent testing & research company performed the testing

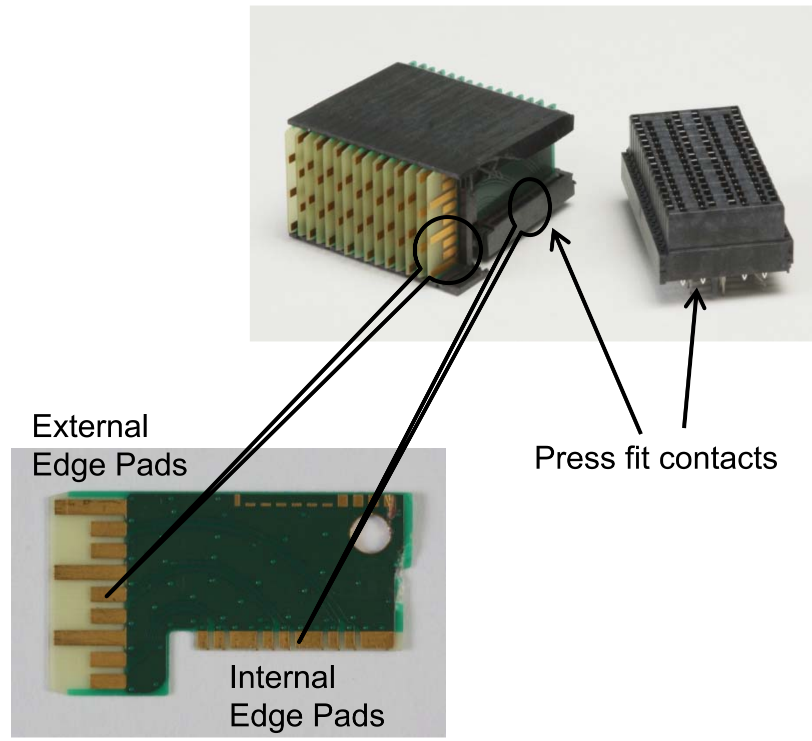
Backplane Interconnect

MicroTCA PWB Edge Pads



Multi-vendor interoperability for MicroTCA connector

VPX MultiGig RT Connector Wafer Dual PWB Edge Pads



No Multi-vendor interoperability for VPX connector
Two suppliers that do not inter-mate

MicroTCA & VPX both use PWB Edge Pads for High speed interconnect

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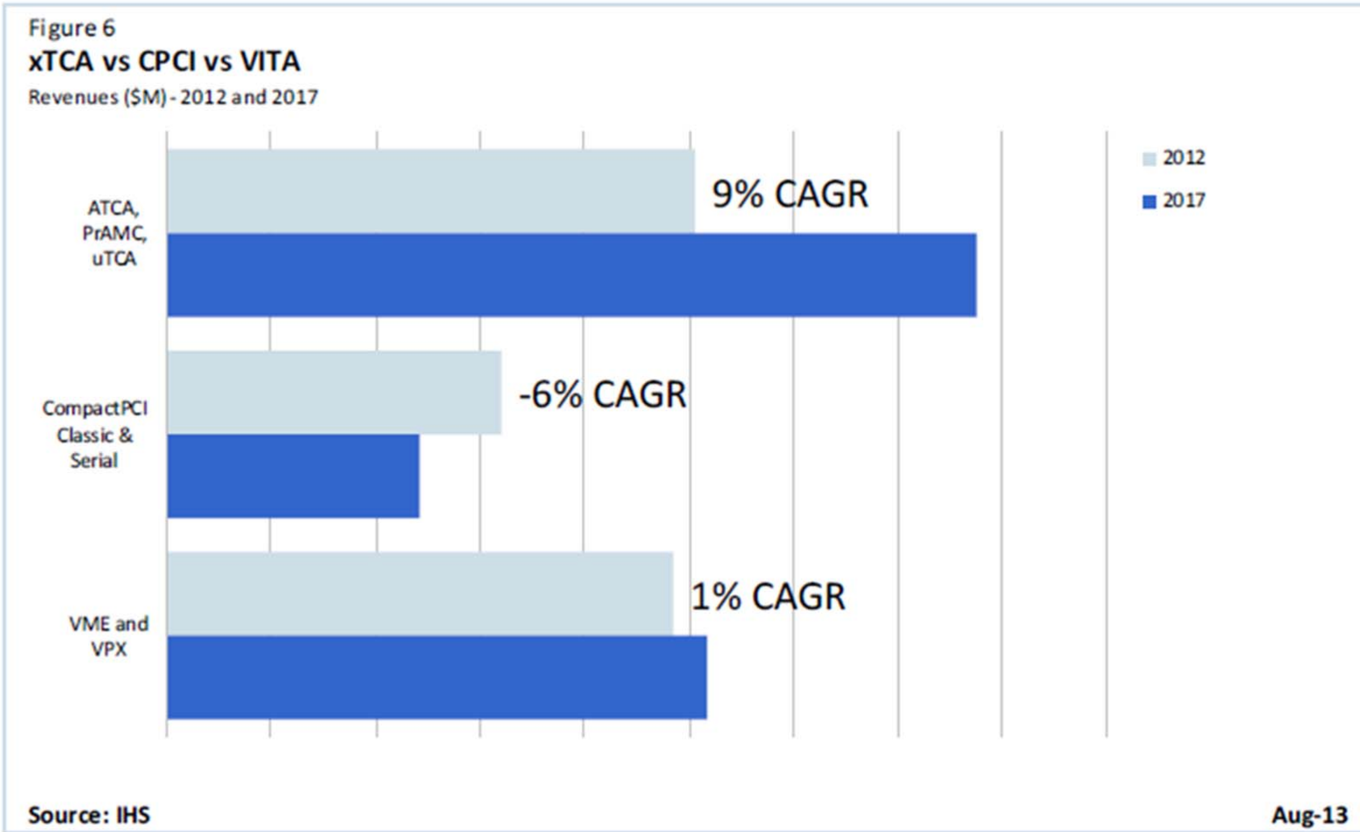
Architecture Software

- MicroTCA
  - Supports open, free OS’s & Drivers natively
    - Linux & Windows primarily
    - Support for other OS’s available
    - This allows for low cost open solutions
      - Free or minimal OS’s & all associated PCI-E HW drivers
- VPX/OpenVPX
  - Supports primarily OS’s such as VXworks that has a high cost for the software & drivers
  - Other OS’s such as Linux & Windows may also be supported depending upon module type and what the user of the product previously required.

MicroTCA Market Projections

– MicroTCA shows a larger market gain over competing standards



CAGR: Compound Annual Growth Rate

Cost Differences

- MicroTCA
  - Priced to support a multi-vendor eco-system originating from a Telecom mind set
- VPX/OpenVPX
  - Priced to support a single vendor, targeted for the military only
- With MicroTCA normalized to 1, VPX/OpenVPX is 1.5 to 2.0 times the cost depending upon implementation of HPM
  - VITA HPM specification V46DOT11-VDSU at this time is still at draft level and utilizes HPM code from xTCA
    - Use of PICMG IP for HPM was granted on January 2014

Line	Qty	Item Number	Name	Description	Price Per Unit	Extended Price
1	1 10			Processor AMC Module, 1.5GHz Core 2 Duo,Full-size, 2GB DDR2 Mem, FH Heat Sink,PCI-Expr. (AMC.1),GbE (AMC.2),SATA (AMC.3)FP-IO: 1x GbE, 1x RS232, 1x USB, LEDs,Order seperately:FLASH-USB-xxx-.	$2,155.00	Includes HPM
2	1 10			3U Single slot VPX SBC / Intel® Core2 Duo (L7400) SBC / 1,5GHz, 4MB L2 CPU / 2GB DDR2-SDRAM with ECC / USB Flash Disk / PCI-Express x4 VPX interface / I/O: 2xGbE, 2xUSB, 2xSATA / VGA Graphics connector on front / Air-Cooled VITA 47 Class AC1 (0°C to +55°C) build	$3,919.00	No HPM

MicroTCA – VPX Highlights!

- MicroTCA Vendor Interoperability is achieved thru open standards that defined all relevant details for any vendor to produce product to
  - OpenVPX is not so open
- Hardened conduction cooled MicroTCA.3 testing was more comprehensive, tested over a longer life duration (500 vs. 250 hrs) and tested against more failure mechanisms than VPX using VITA 47 defined environments
- Advantages of MicroTCA over VPX
  - MicroTCA supports additional fabrics & capability to run two or more fabrics simultaneously
  - Built in redundancy for power and fabrics
  - Full system and health management capabilities leveraged from mature proven ATCA system
  - Connector available from multiple sources
  - MicroTCA is approximately half the cost of present VPX products
- MicroTCA brings an economy of scale advantage to the end user
  - Large number of AMC modules already available for use in MicroTCA leveraging ATCA ecosystem
  - Cost advantages associated with shorter system integration time, software reuse, training, … etc
- Leverage existing AMC Modules for rugged harsh environments without modification except for screening, staking & conformal coating as required

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MicroTCA Systems

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MicroTCA use in the Military

- P-8A: All I/O & graphics utilize ruggedized AMC in an convection cooled environment
- European RADAR platform
- Satellite system via national Laboratory

- Projects underway:
  - Situational Awareness system for land vehicles
  - VICTORY compliant SPU & network switch

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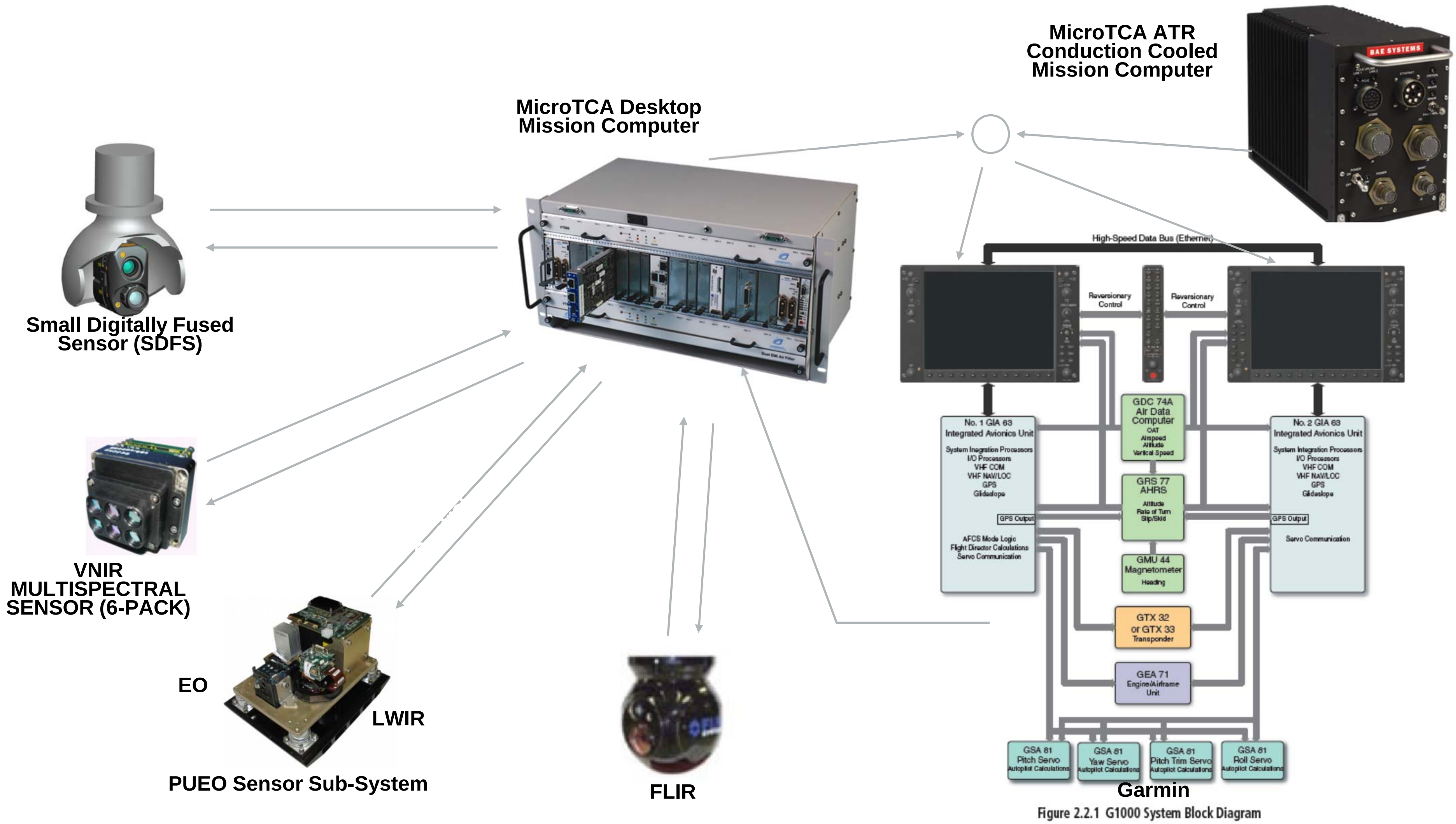
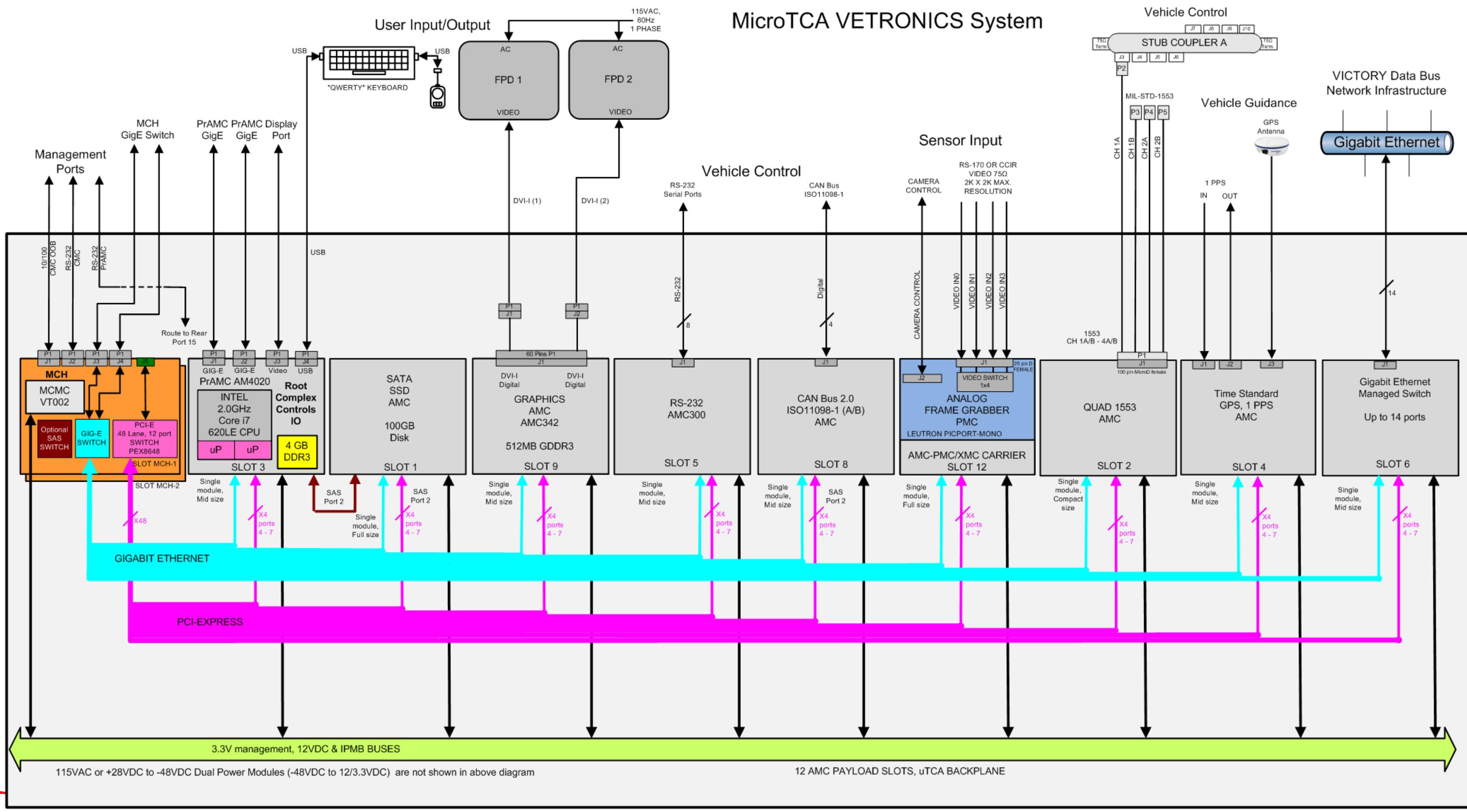
MicroTCA Interface Possibilities



MicroTCA VICTORY Example



Some Take Aways!

- MicroTCA® is an excellent candidate for a SFF, MOSA-Compliant hardware computing platform such as VICTORY
- MicroTCA® is supported by a healthy telecom-based ecosystem
- MicroTCA® has both technical and cost advantages over VPX-based systems
- MicroTCA.2 has an excellent thermal advantage with a 33% margin in the thermal design
- MicroTCA systems serves many markets
  - Communications & Network Infrastructure
  - Industrial Automation Control
  - Medical
  - Transportation/Infotainment
  - Energy/Power
  - Physics Research Centers
  - Military & Aerospace

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