TECHNOLOGY WHITE PAPER

Leveraging Modular Open System Architecture for Modified COTS

DEFENSE SOLUTIONS

Read About

Small form factor mission processors

Open Systems Architecture

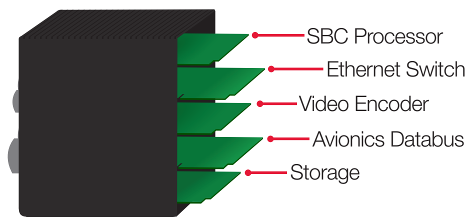
Modified Commercial Off the Shelf

Size weight and power optimization

COTS vs MCOTS Mission Computers

Introduction

Military and aerospace systems integrators face mounting pressure to reduce size, weight, power and cost (SWaP-C) for vehicle and aircraft electronics. They must also meet aggressive delivery schedules and integrate open architecture Commercial Off the Shelf (COTS) products to reduce or eliminate Non-Recurring Engineering (NRE) cost. Typically, military and civil ground vehicle and aircraft platforms also have unique technical and platform requirements that make finding a suitable COTS computing solution to meet 100% of their requirements very unlikely. This white paper discusses how leveraging Modular Open System Architecture (MOSA) design and Modified COTS (MCOTS) application engineering services for Small Form Factor (SFF) rugged mission systems can help integrators meet their cost, schedule, quality, and technical requirements, while reducing risk and eliminating traditional NRE fees.



MCOTS Solutions for Unique Requirements
Specialized Vehicle / Avionics Databuses
Network Connectivity / Ethernet Switching
Video Capture, Encoding, Streaming
FPGA / GPGPU Co-Processors
Additional Serial or GPIO Interfaces
Fixed / Removable High Capacity SSDs
RTOS / General Purpose Operating System

Figure 1: MCOTS helps system integrators to address diverse set of mission system requirements

Modular Open Systems Architecture

Motivated by budget constraints and the increased need for technology readiness, many defense leaders have pushed for supply chain acquisition reform, moving away from silo-based development and instead mandating the use of Modular COTS (as opposed to custom) based open systems architectures. In recent times, military services have been directed to seek out “80% solutions that can be produced on time, on budget and in significant numbers.” This is a shift away from the “99% exquisite” solution of yesteryear that cost too much, took too long to develop and was built in only small volumes.

To facilitate this COTS vision, various defense ministries and the U.S. Department of Defense (DoD) have directed their agencies to use open systems specifications and standards for the basis of their design strategies. The U.S. DoD’s Open System Architecture (OSA) initiative (formerly known as Modular Open Systems Architecture) has just such an objective—to leverage modular designs and widely supported and consensus-based standards for key interfaces to

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increase the chance that future systems changes will be integrated in a cost-effective manner. Some of the related initiatives include VICTORY (Vehicle Integration for C4ISR/EW Interoperability), GVA (Generic Vehicle Architecture), Future Airborne Compatibility Environment (FACE), and Better Buying Power 3.0. Ultimately, a common desired outcome from these programs is for program managers to design interoperability into future C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance) systems - without adding proprietary or duplicative devices that add undesired weight and cost to the system and make upgrades more challenging.

COTS Mission Processors

Modernization of tactical ground vehicle and airborne platforms routinely involves upgrading C4ISR equipment and related capabilities. Technology refresh initiatives of this sort usually have requirements for advanced computing devices that process and distribute network and sensor data. Aptly named mission processors, these systems enable tactical platforms to fulfill their particular mission objectives. As missions vary greatly between vehicle and air platforms, so do the form factors and technical capabilities of these mission computers.

Figure 2: Many UAS platforms require mission processors to manage ISR sensor payloads

Rugged COTS mission computer Line Replaceable Units (LRUs) are now available on the market from many suppliers, but as-is, they tend to be general-purpose computers and require some level of customization to meet military platform requirements. The CPU performance, memory architecture, and high speed peripheral interfaces of modern PC architectures are generally more than adequate for today's tactical requirements, but vehicles and aircraft platforms tend to also require support for legacy devices and/or specialized functionality. Naturally older interfaces aren't part of standard Intel chipsets and yet they must still be supported on many platforms. For example, while Gigabit Ethernet is quickly being adopted on vehicles and airborne platforms and is well supported by most mission computers, wiring and sensors for the venerable MIL-STD-1553, ARINC 429, and CAN data buses still have widespread deployment on today's ground vehicles and aircraft. In addition, many platforms have specialized discrete I/O, network switching, and/or video interface requirements not standard for a traditional PC. In these cases, customization of mission processors has often required considerable development expense and time to bridge the functional gap.

Modified COTS (MCOTS)

In recent times, a new breed of adaptable mission processor has emerged expressly designed to minimize (even eliminate) non-recurring expense (NRE) for customization. Customers can now have a tailored COTS-based mission computer solution that meets platform-specific requirements without paying for extensive developmental expense. These modular rugged computing platforms feature built-in scalability and I/O expansion characteristics that make the prospect of taking a general-purpose device and transforming it into a tailor-made solution a palatable reality.

Figure 3: MCOTS mission computers are adaptable to meet program needs

Through MCOTS subsystem integration services, customers have their unique technical requirements addressed by skilled application engineers who identify and integrate appropriate SFF rugged COTS I/O functionality into MCOTS mission processor systems, which are delivered, tested and turnkey. Generally, no developmental NRE fees are required, and systems can be delivered within a matter of weeks. Instead, a modest recurring per unit integration fee is added to cover the add-on hardware and assembly cost for a new variant of the standard product. This quick-turn, cost-competitive approach is made possible because of modular COTS-based system design decisions coupled with an ever expanding ecosystem of rugged SFF module suppliers that are providing support for legacy and specialized I/O interfaces commonly used by military and aerospace programs. Ultimately, MCOTS is changing the paradigm for how COTS-based solutions can be quickly and affordably delivered to military and aerospace system integrators. Customers can now procure well-crafted solutions that meet their technical requirements without traditional NRE, nor significant impact to schedule.

MCOTS Design Approach

As COTS system suppliers gain experience and a pedigree of designing SFF rugged COTS mission processors, some common proven best practices tend to guide each successive product. The use of modular open system architecture has become a foundational principal, along with specialized ruggedization and validation techniques, as well as inclusion of system functional expandability.

In the case of Curtiss-Wright Defense Solutions and its Parvus DuraCOR mission processor line, each system is mechanically optimized for SWaP-C, as well as ingress protection (typically dust & waterproof), thermal management (fanless, passive natural convection) and reliable operation under extreme environmental, power and EMI conditions. In fact, each system goes through extensive MIL-STD-810 and MIL-STD-461 compliance testing to validate the design, providing tremendous risk and cost reduction for system integrators seeking pre-qualified products. Newer models also undergo RTCA/DO-160 testing for commercial aerospace deployment.

To address special functionality, built-in spare I/O card slots compatible with multiple, standards-based SFF I/O modules (i.e. Mini-PCIe or PCIe104) and a modular mechanical / electrical design have become a hallmark to enable creation of customer-specific variants that fill in the functional I/O gaps.

Part of making MCOTS a reality is the supplier partnerships between systems and module providers. System suppliers have learned that it isn't always practical to design and manufacture every possible I/O card that a customer wants. Thanks to an ever growing ecosystem of third-party embedded system partners, mission system architects can draw upon the best that industry has to offer: rugged COTS modules, such as Mini-PCI Express (see figure 4) or PCIe104 (see figure 5), which are increasingly popular given their small size and affordability.

Figure 4: Mini-PCIe module for MIL-STD-1553

Figure 5: Stackable PCIe104 I/O cards

Modules for MIL-STD-1553, ARINC 429/717, isolated serial communications, CANbus interfaces, H.264 video encoders, video capture cards, Gigabit Ethernet NICs, Wireless 802.11 LAN adapers, high-precision GPS receivers, analog/digital I/O interfaces, video controllers, and a host of other functions are currently available.

This trend is empowering system engineers to turn away from proprietary and single-vendor solutions, instead sourcing from multiple suppliers the various and heterogeneous modules they require for integration into their specific solution. This hybrid open architecture approach enables designers to better leverage a wider range of open standard solutions being offered from a greater number of industry suppliers.

Since the integration of COTS technology in mission subsystems involves careful "integration" of add-on functionality, as opposed to traditional engineering "development," COTS becomes a significant enabler for the quick-turn and low-cost integration paradigm that application engineering services offer.

When architecting MCOTS systems, application engineers begin by reviewing the technical requirements and then identifying suitable COTS industrial-grade I/O modules to meet those requirements. They then perform the subsystem integration, acceptance test the units, and deliver them turnkey - in rapid fashion, compared to a truly customer design. Where needed, delta qual testing is performed or similarity analysis reports are prepared. In many cases, proven I/O modules are used that have already gone through environmental qual testing as part of the original COTS systems development effort, which qual data can then be leveraged for follow-on customer-specific projects without having to re-qual.

x86-based MCOTS Mission Computers

Prime examples of modular open architecture-based SFF COTS modular mission computers built around an x86 (Intel®) architecture are the Parvus DuraCOR 8041 (4th Gen Core i7) and the DuraCOR 8042 (5th gen Core i7), which use a hybrid open architecture approach, combining multiple SFF standards in a single system.

Figure 6: Parvus DuraCOR 8041/ 8042 SFF modular Core i7 mission processor

Delivering new capabilities for C4ISR command and control, image processing and surveillance requirements, these DuraCOR computers offer a high performance quad-core computer with built-in graphics processor unit (GPU) together with advanced I/O interfaces (video, GbE, USB, serial, audio, GPIO, eSATA) and flexible I/O expansion capabilities for mission-specific payload interfaces.

In the case of the DuraCOR 8041, the system architecture incorporates a rugged COM-Express Compact form factor processor mezzanine card hosted on a specialized carrier board (see figure 7) with I/O card slots to support PCI Express® Mini Cards (aka Mini-PCIe modules), as well as an interface to the PCIe104 bus for more I/O expansion possibilities.

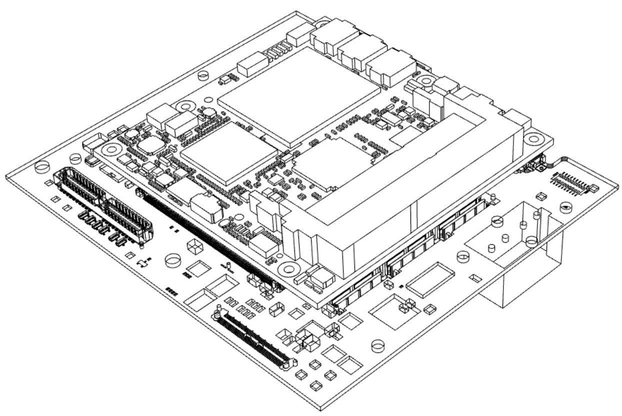

Figure 7: Modular CPU and I/O architecture of DuraCOR 8041

Add-on cards in the form of PCI/104-Express, PCIe104 or Mini-PCIe are added to the bottom of the carrier board for application-specific functionality beyond the Intel chipset. On the top of the carrier, for the COM-Express CPU module itself, there is a standardized mating connector for COM-Express into which the mezzanine CPU plugs. This approach is ideal for system upgrades since it easily facilitates pin-for-pin replacement to migrated to future COMe modules, such as from a 4th gen Core i7 (Haswell) of the DuraCOR 8041 to the 5th gen Core i7 (Broadwell) of the DuraCOR 8042 with just minor mechanical tweaks to the enclosure to optimize thermal management. While the base systems support two Mini-PCIe I/O slots in their SWaP-optimized base chassis, additional interlocking modular chassis segments with additional MIL circular connector interfaces can be coupled to the base system and support further integration possibilities using stacking PCIe104 I/O cards. These lego-like cards support a host of even more complex I/O and peripheral requirements (i.e. DSP modules, HD-SDI video streamers, Ethernet switches, GPGPUs, multi-port serial, multi-function 1553/429/avionics discrete I/O, etc.).

Figure 8: Modular add-on chassis segments scale mission computer I/O card integration

MCOTS Case Example: ISR Video Mission Processor

A system integrator for military, security force, and governmental-agency aircraft required a flight-worthy rugged small form-factor mission processor as part of a common mission system architecture being proposed for civil and military platform upgrades. This processor would interface with and be integral to a mission system package that includes various intelligence, surveillance, and reconnaissance (ISR) sensors, including an EO/IR FLIR camera turret, AESA maritime radar, Flash sonar, pilot and copilot situational awareness/navigation displays, along with a mesh network data link.

Figure 9: MCOTS ISR video mission computer

The mission computer would need to support multiple high definition HD-SDI camera inputs with capabilities to compress and encode video to H.264 standards and stream video across an Internet Protocol (IP) network as well as optionally store locally on high capacity disks, as well as support real-time frame grabbing of uncompressed video over HD-SDI. Since size, weight, and power (SWaP) are at a premium onboard aircraft and the platform system integrator desired the same mission package for multiple civil and military programs, the mission processor LRU would also need to integrate a managed Gigabit Ethernet switch and serial communications controllers for control/monitoring of interfaced sensor and communications devices.

The rugged, compact and modular design of the DuraCOR 8041 mission computer system made it an ideal solution for this customer's aircraft mission system upgrade initiative. An MCOTS variant of this modular processor subsystem was successfully and affordably integrated using rugged off-the-shelf Mini-PCIe and PCIe104 modules (see figure 10) to meet any specialized interface requirements not already delivered by the standard processor chipset. Taking advantage of Curtiss-Wright's cost competitive and quick-turn application engineering services, the customer received a system fitted with two H.264 video encoder/network streamer cards (capable of taking in HD-SDI video and distributed it over Ethernet), an HD-SDI video frame grabber (for monitoring video feed), digital I/O and serial cards (for control of EO/IR sensors, radar, sonar), as well as an 8-port Gigabit Ethernet switch card (the Parvus SWI-22-10) to connect the video encoders and CPU together and provide five additional Gigabit Ethernet ports for other on-board LRUs interfacing with the mission processor. Thanks to the modularity of the DuraCOR system architecture, the required I/O was integrated using Mini-PCIe slots on the processor carrier board together with two PC/104 I/O expansion segments that attached to the base chassis. A 2-slot removable 2.5" disk add-on segment, capable of hosting multiple 1 TB 2.5" capacity disks, was also integrated along with special MIL-DTL-38999 coaxial connector inserts for HD-SDI video for optimal signal integrity of the high definition video inputs.

The aircraft system integrator now has a common mission processor system ready for integration into both civil and military mission system architectures. The MCOTS variant of the DuraCOR 8041 included all required I/O and network interfaces in a single LRU device that minimized SWaP as well as recurring and non-recurring costs. Thanks to the modularity of the subsystem architecture, the LRU integrates stands ready to support various ISR/situational awareness upgrade programs that require a multi-core rugged mission processor capable of supporting HD networked video compression, encoding, and streaming, as well as local storage and real-time video capture.

ARM-based MCOTS Mission Computers

Low-power ARM architectures are also now entering the MCOTS arena with the introduction of the Parvus DuraDBH-672 Digital Beachhead.

Figure 11: Modular ARM-based vehicle computer + GbE switch

This rugged SFF system features not only a quad-core NXP (formerly Freescale) i.MX6 ARM CPU, but also a 16-port GbE network switch, modular I/O expansion for Mini-PCIe modules and an optional embedded military GPS receiver. Complimentary to the vision of the U.S. Army VICTORY initiative, the DuraDBH-672 supports network-enabled shared computing and position navigation timing (PNT) services. And like the DuraCOR 8041 / 8042, the DuraDBDH-672 has a modular architecture based around a standards-based computer on module (COM) along with support for MCOTS variants based on standard Mini-PCIe cards for application-specific I/O requirements (i.e. MIL-STD-1553/ARINC429/COM/DIO/GPS).

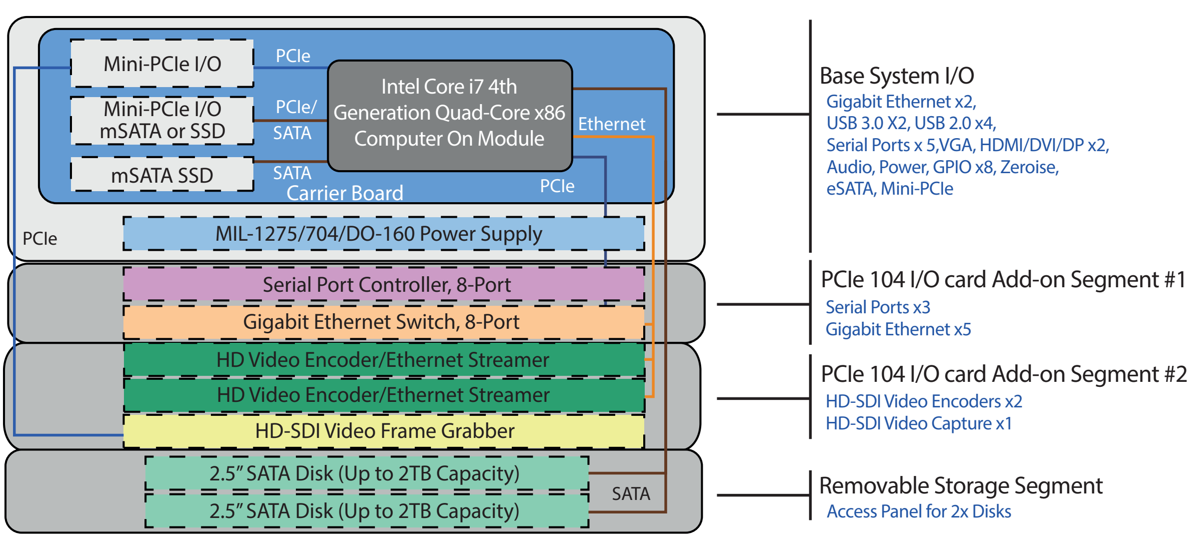

Figure 10: Mini-PCIe and PCIe104 modules integrated into MCOTS system

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Conclusion

Military and aerospace contractors are indeed discovering the advantages of open architecture MCOTS solutions for vetronics and avionics upgrades, as they address SWaP reduction, compressed deployment schedules, and shrinking government budgets. For its part, Curtiss-Wright continues to provide innovative, cost-effective and qualified small form factor mission processors based on open standards that are today being deployed broadly in ground vehicles, aircraft of all types, and maritime vessels. Proven modular system architectures together with seasoned MCOTS subsystem integration services and a growing base for embedded SFF COTS I/O modules will continue to reduce risk, save money, shorten schedules, and ensure mission success for customers.

Learn More

Products:

- Curtiss-Wright DuraCOR 8041 Mission Computer
- Curtiss-Wright DuraWORX 8041 Mission Computer + Router
- Curtiss-Wright DuraCOR 8042 Mission Computer
- Curtiss-Wright Digital Beachhead DuraDBH-672 Vehicle Computer + Switch

Case Studies:

- Graphics/Payload Mission Management Processor for ISR Aircraft
- Common ISR Video Mission Processor for Civil and Military Aircraft