Board and Box-Level Integration Strategies

Many Approaches Vie for Board and Box Integration Success

Today's performance hungry military applications require a variety of board and system solutions for success. Technologies such as COM Express, VPX and PCI Express form a spectrum of solutions feeding those needs.

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According to the U.S. Army Training and Doctrine Command, "military power in the 21st century will be defined by our ability to adapt." Compute-intensive applications such as high performance surveillance and situational awareness systems illustrate the support of this ideal and are among the most urgent requests from the field, including full-motion video (FMV) in unmanned vehicles covering both ground and air deployments. Part of the arsenal to adapt are unmanned systems, which have become a new essential, helping military forces face hybrid threats such as organized militias, or uncertainty about location, context and duration of contact with adversaries.

By working with modular, plug-and-play payloads, developers are maximizing combat capability, flexibility and efficiency in the face of these evolving threats. At the same time, developers are increasing focus on compute-intensive performance—maintaining attention on the network and payload as an integrated system, rather than centering on the particular field platform such as a truck or other vehicle. It's a new and high-value approach, supported by a broad expanse of standards-based, high performance design options, whether the designer is integrating systems onboard

Figure 1
Smaller UAVs have less available space to integrate system equipment. Flexible, low power performance processing available in both x86 and ARM COM architectures are improving SWaP considerations in these platforms.

a vehicle or enabling related applications from offsite command and control centers.

The embedded computing industry offers a variety of board and box-level solutions that system developers can use to integrate the compute-heavy platforms needed for today's military. Computer-on-Modules (COMs) and VPX-based platforms illustrate two ends of this high performance spectrum – both proven to perform in their respective arenas, and readily enabling competitive designs that blend price and performance in secure, highly scalable systems. Most importantly for designers, embedded computing solutions that support both standards have advanced with pre-integrated options, simplifying Proof of Concept (PoC), meeting Agile Acquisition demands, and enabling the next generation of high performance computing.

Figure 2
VXFabric software simplifies and accelerates application development of inter-CPU communication in VPX system architectures. VXFabric also enabled migration to emerging hardware communication solutions in the embedded domain, such as 10G and 40G Ethernet.

COMs in Tight Quarters

Literally hundreds of systems may be fitted onto a single aircraft or ground vehicle—creating a significant OEM opportunity even with defense cutbacks. Air Force resources have shifted, for example, focusing procurement on the MQ-9 airframe based on its 600 percent greater payload capability than the MQ-1. When combined with the versatile and powerful Wide Area Airborne Surveillance (WAAS) sensor, the MQ-9 Reaper initially increases the effectiveness of individual Combat Air Patrols (CAPs) by more than 1,200 percent. Future expectations peg this at a 6,000 percent improvement over today's MQ-1 Predator.

Designers must consider initiatives like Future Airborne Capability Environment (FACE), in light of these performance expectations. Developed to define an open avionics environment for all military airborne platforms, FACE provides a forum to standardize best practices, guidance documents and business models for aircraft system design. To optimize systems, OEMs should follow the use of standard interfaces that not only reduce long-term costs, but also easily enable the reuse of capabilities across various aircraft and applications.

Practicality dictates that more equipment cannot simply be added onto an unmanned vehicle, yet demand continues for more sensor capability, or flexibility to change or update sensor arrays based on specific mission profiles. This elevates the role of proven small form factor COMs platforms, and increases the usefulness of compact and modular open-standard high-performance modules or systems. Low power advancements further improve design options, enabling developers to work with x86 or ARM-based processors (Figure 1). By leveraging a module-based system solution (rather than a too-large traditional backplane solution), systems can achieve a smaller overall footprint suitable for placement in more compact areas of the vehicle.

Using smaller and more powerful processor modules, compact systems can integrate both sensor and I/O capabilities. For example, today's modules provide GbE ports for network connections, USB2.0 and USB3.0 ports, GPIO, serial, display, and more. Tightly coupled systems can be architected by routing PCIe lanes, SATA, and some of the USB lanes and other features to onboard connections on the carrier board. Appropriate processing modules can be selected from a large ecosystem of options, best supporting the requirements for system level processing, exploitation and dissemination (PED) of the sensor data collected. Depending on the processor selected, or how it might be coupled with an application specific FPGA, these small but powerful systems can handle real-time analysis send data immediately back out over the secure defense network.

VPX Capitalizes on PCI 3.0 Simplicity

Breakthrough technology is also being seen in VPX systems used for unmanned applications. Developers are stepping into an entirely new and unparalleled class of signal processing applications, based on using PCI 3.0 with microprocessor-based VPX systems. Where an existing distributed application might exchange information on gigabit Ethernet, a process illustrated by most VME or CompactPCI platforms, VPX platforms can now implement TCP/IP protocol over the PCIe 3.0 infrastructure.

This method relies on high-speed PCIe 3.0 bandwidth for data transfers, simply selecting a different IP address to connect to other boards; developers can achieve this using VXFabric, Kontron's open infrastructure which implements efficient inter-board communication at hardware speed. Development resources are protected – no software coding changes are required, safeguarding applications from obsolescence while keeping systems free from managing the complex, low-level details of the current generation of PCIe silicon management.

With the full data plane bandwidth no longer shared between boards, systems can readily access high speed data processing. Through its connectors and backplanes, the VPX platform can capitalize on multi-gigahertz signals to enable the capability of one or more dedicated 10 Gigabit connections via Ethernet or PCIe. VXFabric software acts as the bridge between this disruptive technology and applications that exchange data via gigabit Ethernet; peer-to-peer transfer is enabled, eliminating the need for a switch to achieve greater than 10GBit speeds (Figure 2).

Pre-Validated Systems

Surveillance applications such as full-motion video require high speed I/O, along with ever-present demands to meet SWaP, performance, communication bandwidth, low power, efficient cooling, standards compliance, rugged operation, interoperability and scalability. Working with the DoD's Agile Acquisition Process, instituted to keep costs in check, requires developers to provide proof-of-concept (PoC) prototypes in order to compete for contract awards. Both COMs and VPX platforms offer pre-validated platforms as a means of simplifying the PoC process, eliminating design steps and reducing development resources.

Kontron's COBALT (Computer Brick ALTernative) provides an example of a pre-validated COMs-based embedded computer in a small footprint (Figure 3). Weighing in at less than six pounds and an 8.5 (W) x 5.5 (D) x 3.9 (H)-inch form factor, COBALT's COM processor board forms the heart of the platform; the complete solution includes a rugged carrier board, power module, housing and appropriate I/O connectors in a fully-enclosed, fanless system.

COBALT's advanced features ensure rugged reliability, including shock and vibration profiles that are pre-validated to the diverse range of UAV, tracked vehicle, shipboard and avionics environments. Unique features include a special Rapid Shutdown circuit design on the RXT modules; the system can quickly shutdown and survive a high energy pulse such as a nuclear event or high energy electromagnetic pulse (EMP).

Preserving Base-board Designs

Designers can further integrate mezzanine options with COMs-based systems such as COBALT, creating new systems without significant modification to the original base design. This method capitalizes on COM Express Type 6 pin-outs, which enable future design options by reallocating legacy PCI pins for digital display interfaces and additional PCI Express lanes. Extra PCI Express lanes can be routed to serial-based mezzanine card slots such as mPCIe (mini PCIe) and XMC. Non-standard options are also handled more easily, for example designs can readily incorporate a SATCOM modem when standard XMC or Mini PCIe do not offer sufficient features or performance. This design method creates expansion slots, enabling a performance jump compared to earlier pin-out options, as well as an enhanced fourth generation graphics architecture essential to high definition surveillance and imaging applications.

In addition to FACE, the COTS or common operating environment in military aircraft, the Army's VICTORY (Vehicle Integration for C4ISR/EW Interoperability) initiative is another example of the type of military computing environment that would benefit from using a pre-integrated, small form factor system such as COBALT. Implementation of VICTORY allows tactical wheeled vehicles and ground combat systems to recover lost space while reducing weight and saving power; platform systems also share information and provide an integrated picture to the crews operating the machinery. Most importantly, VICTORY is based on an open architecture that will allow platforms to accept future technologies without the need for significant re-design.

Figure 3
COBALT is a highly scalable embedded computer system, sealed and validated IP67, available with a wide selection of processor, storage, power and interface options. Flexible I/O combinations can be established via the application-specific customization on its carrier board.

HPEC Performance Using VPX

Pre-validated VPX platforms enable designers to tap into their own extensive experience working with all the familiar technology utilized by these systems. Standards-based deployments that are better protected against obsolescence—and by integrating mainstream IT technology such as x86, Linux, TCP/IP and PCIe, costly proprietary designs are eliminated from the competitive landscape. For developers in contract competition, PoC can be completed on mainstream IT servers and the system can deploy without further modification. OEMs have a significant competitive advantage, capitalizing on the platform's massive I/O bandwidth and available IP sockets for sigh speed signaling applications such as next-generation radar, sensor processing and high definition, full-motion video surveillance. This design approach also reduces the need for OEM technical specialists, by integrating an HPEC system that can deliver the required lightning performance on the backplane in a much smaller footprint.

Kontron's StarVX illustrates the ability to support multiple prototypes or system solutions with a single pre-validated platform. StarVX has been designed to scale to any size; its modular approach accelerates HPEC designs including a range of prototype profiles, for instance sensor signal and data processing, or high speed recording and 3D reconstruction applications (Figure 4). StarVX can be used to demonstrate application feasibility in a contract process; developers can implement just a portion of the application being evaluated for contract. Initial prototyping investments are cost protected, even while the system offers the option to upgrade to any number of processors based on the final application requirements. Standards-based flexibility adds value; for example StarVX runs Linux, reducing development time, allowing for growth and portability, and reducing early software expenditures.

Figure 4
StarVX is a pre-qualified Proof of Concept (PoC) platform for mil/aero system developers. StarVX enables prototyping and demonstrations, but it provides the capability to expand as application requirements and functionality needs evolve.

Building Block Design Strategies

The military need for high speed signaling is well-established; using COTS-based platforms for military design is a well-proven and even encouraged design strategy. The next evolution in meeting the need – and competing as an OEM—is delivering performance while minimizing the cost and timeline associated with creating PoC prototypes. Using pre-validated VPX platforms keeps defense OEMs in sync with Agile Acquisition requirements; datacenter-like parallel servers offer extreme I/O and computing power, while designers avoid specialized code or the need to assign resources to FPGA development.

A full range of standards-based building block components adds even more flexibility—boards, development systems, rugged enclosures, integration and board support packages and operating system support are essentially manufacturer-supported tools that enable systems to be quickly lab tested and proven prior to application deployment. COMs-based systems, coupling mezzanine modules with carrier boards, also enable military designers to readily use and reuse low power, reliable designs to develop smaller high performance systems. Maximizing flexibility with upgradable processors and perfect fit design by virtue of carrier board and mezzanine card options, developers have a fully tested, cost-effective design path that meets mil/aero requirements and gets to market quickly.

Demanding Applications

Military reliance on data gathering and sharing continues to grow and evolve. High speed signaling provides the foundation for leadership decisions, and comprehensive situational awareness that helps to ensure safety and security of military personnel. Unmanned systems are getting more and more assignments, handling surveillance and reconnaissance in a range of field settings, and increasing the importance of high compute performance for both onboard systems and their related command centers.

By leveraging pre-integrated systems as generic building block solutions, military embedded designers increase functionality and performance for the long-term; this optimizes solutions for broad military initiatives such as FACE and VICTORY—highlighting the design imperative of using open architectures that enable long-term reuse of technology. By more easily integrating powerful features into robotic devices, long-range UAVs or small airframes such as Wasp III, RQ-11 Raven, or Scan Eagle, military developers are answering these initiatives, competing effectively and readily bringing high-value, real-time data processing and analysis into the field.

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