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Pre-Integrated System Innovations

Pre-Integrated Systems Evolve to Satisfy New Expectations

Increasing demands for more "finished" systems are driving technology supplies to craft embedded computing solutions that are pre-integrated to greater degrees.

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The age of the pre-integrated embedded system has arrived. Whether those systems are general computing systems, network communications centric, surveillance (C4ISR) or data storage centric, end users and defense primes are increasingly looking to lower tier suppliers to provide complete sub-systems with a high TRL (Technology Readiness Level).

With this emerging shift in the landscape comes a learning curve for suppliers, especially as they strive to meet defense industry expectations for fast delivery and near deployment-ready operation. Demand for off-the-shelf systems to put on the table or in the field for testing before program commitment is increasing. Risk reduction and accelerated time to deployment are key drivers of this trend. The dilemma faced by system suppliers is how to be ready with the right product, at the right time, in a market that lacks widely accepted industry standards, which would describe the baseline requirements of form, fit, function and connectivity at the box system level.

Leaving the 19" Comfort Zone

For years, embedded system suppliers have been developing 3U and 6U slot card based systems housed either in 19 inch wide chassis defined in height in "U" increments of 1.75 inches or in any one of the myriad of ATR box sizes. These standardized sizes allowed end users to define, and suppliers to build, systems conforming to the directives in the standard, thus eliminating the question of physical size. Connectivity to the outside world in 19 inch chassis is often in the form of discrete single purpose cables with predefined connectors. Mounting for 19 inch and ATR chassis is also well defined by standards.

The movement towards SFF systems is driven by two factors: Higher levels of chip integration that allow increased functionality in ever smaller packages; and the need to pack more overall functionality into high performance, smaller and lighter defense assets. For many applications, however, miniaturization has reduced, or even eliminated, the need for these larger chassis. The new wave of pre-integrated systems involves small form factor (SFF) CPU boards such as COM Express, PCI/104 and sometimes 3U slot cards, where the external dimensions and connec-

Figure 1
Pre-integrated small form factor systems are critical for use across a range of demanding defense applications.

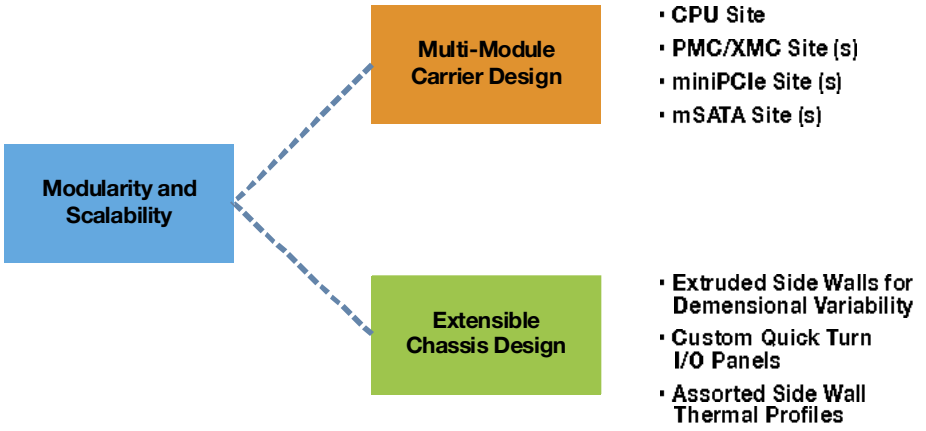

Figure 2
Modularity in baseline system elements enables configuration flexibility and shorter lead times.

tivity requirements of such systems are determined more by the specifics of the application and, unlike 19 inch and ATR chassis, not much at all by an open industry standard.

ATR and 19 inch systems have mainly been developed as projects targeting specific requirements and then sold into a program as a defined system. In this case, system development is often a joint effort between supplier and customer. The integration of these puzzle pieces is at the heart of slot card based systems. Buying expectations are now shifting from an engagement that starts out more like a project and, over time, ends in the final solution to one where the solution is expected to be on the shelf and ready to go.

Demand for off-the-shelf, pre-integrated SFF systems with a high TRL did not really exist in defense applications until recently, but it's here so stay. So the question becomes how to satisfy that demand. Intelligent system design practices in the form of modular and scalable system design can help bridge that gap between the needs of the supplier and the expectations of the customer (Figure 1).

Modularity and Extensibility

A building block approach to systems design can help reduce this gap in expectations, and applies to both the mechanical and electrical designs. Scalability in just about every design aspect is key to shortening lead time and delivering a system within the time required. Regarding mechanics, chassis designs that can grow and shrink for a tailored fit to meet a specific space requirement can streamline the design effort. Despite the wide selection of pre-defined systems now being introduced by suppliers, customer engagements often begin with interest in a particular system only to be followed up with, "That's exactly what I need, however…".

It's that "however" moment that enables design innovations. When the system size does not meet the need, an extruded box design will step up to the challenge. Sturdy, lightweight extruded aluminum side panels can be cut to length and offer infinite variation in the height, width and depth of a chassis. Extrusion profile options, with or without cooling fins, allow fast adaptation to meet thermal needs. Depending on the magnitude of the change, incremental thermal analysis may be required to fine-tune the new size. Integrated system suppliers who have long histories of proven chassis design capability can quickly support this end-to-end set of tasks.

Flexible I/O and Connectivity

Critical to any application are the external connectivity requirements that drive the I/O connector type and arrangement. A wide range of shapes and sizes of MIL-STD-38999, Mighty Mouse, M12 or discrete connector styles is generally needed. While most defense systems require MIL-STD 38999 connectors, hundreds of variations exist, even within that subset and the I/O location can be specific – whether front or rear placement, for example.

Signal breakout requirements also cause variations in connector sizes, just as pin

counts drive the size of each connector. Suppliers can maintain a library of common panel designs for a given set of I/O exiting the box. These I/O panel designs can be quickly substituted, mixed and matched to meet the specific requirement. Even in situations where no existing design is suitable, a custom solution is easily fabricated from stock (Figure 2).

Assembling the Puzzle Pieces

Central to most pre-integrated SFF mission computers is the CPU module, which is typically either a COM Express (type 10 or type 6) or PCI/104 board. Both form factors and their respective derivatives are COTS-based and defined by the PICMG standards organization. Both have established track records of performance and are supported by a worldwide ecosystem of suppliers with rugged versions available.

COM Express CPU modules require a carrier board for I/O breakout, which are typically supplied by the end user or integrator. In contrast, PCI/104 CPU modules are used in a stackable architecture intended for direct connection to additional modules and are designed with a wide array of I/O breakout options. Modularity in the I/O set is achieved using existing COTS form factor boards. XMC and PMC mezzanine modules are long established in the 3U and 6U Eurocard world and enable a modular, scalable, easily replaceable and low cost way to upgrade system I/O, while preserving the investment in the more expensive host card – typically an SBC.

Both mezzanines types are increasingly being used in SFF systems used in SWaP avionics and ground mobile applications. Additionally, and newer to the scene, miniPCIe and mSATA modules offer credit card-sized I/O options for converting typical I/O signal types into PCIe, thus making use of the growing number of PCIe ports available on the CPU. These modules enable add-on support for Ethernet, audio, video, CANbus, WiFi, digital and analog, SATA, and USB plus a variety of mobile service standards such as LTE (4G) and derivatives or even additional on-board storage. This combination forms a powerful basis for quick adaptation of a baseline system to meet the needs of a wide array of applications (Figure 3).

The Critical Carrier Card

CPU choices, plus an extensive set of I/O options, provide the ingredients for a wide range of pre-integrated systems. However, the glue that brings these discrete pieces together in a system is the all-important carrier card.

COM Express carrier cards typically provide the connectors and headers necessary to support the I/O native to the CPU. In many cases, they are barely larger than the CPU module itself. As this standard finds its way into the defense market, suppliers have developed carrier cards featuring mezzanine sites designed to support multiple XMC/PMCs, as well as multiple miniPCIe and mSATA modules in addition to the CPU module site.

Reliable carrier design is critical, especially where high speed and densely packed

Figure 3
The NetSys-5303 features both mechanical and functional modular concepts for scalability.

signals are common. PCIe Gen 3 signals at 8 Gbps require skilled board designers and the latest signal integrity analysis tools to ensure every piece of data makes its way through intact. Taking it one step further, carrier designs can support both COM Express and PCI/104 cards to leverage the best options available, irrespective of the board form factor. Last but not least, modularity in power supply options enable multiple choices in power levels as well as power filtering and conditioning. Many defense applications require MIL-STD 1275 and 704 capable power supplies, so this is a valuable option in terms of modularization.

Re-configuration an Added Bonus

It's clear that pre-integrated systems, based on modular designs, can resolve many pre-sale demands, but an additional benefit addresses post-sale issues that can arise. Pre-integrated systems are modular and configurable, by definition, and that inherently enables efficient re-configuration after the system is deployed. This becomes useful when mission evolution requires a CPU upgrade or a new I/O recipe and as COTS modules reach end of life. Programs can then preserve the lion's share of their equipment investment by replacing only the effected obsolete compute and I/O modules, while leaving the remaining system intact, inclusive of the carrier card, connectors, balance of the I/O cards, power supplies and chassis mechanics.

Modularity and scalability in both the electrical and mechanical designs of pre-integrated systems enable baseline designs to be quickly adapted to meet specific compute level, I/O and mechanical requirements for the end application. This approach reduces time to deployment in critical defense programs and enables efficient system upgrades post-deployment.

With proper attention to system design and a seasoned team with an eye towards emerging defense requirements, experienced embedded system suppliers can address the growing demand for pre-integrated systems which are delivered against ever shortening lead time expectations. This capability allows primes and end users to realize cost savings as they concentrate their efforts towards higher level system integration.

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