

COM Express and PC/104 meet the needs of rugged SFF systems

[Dave Barker, X-ES](#) — September 5, 2012

Many small form factors, including PC/104 and COM Express, are currently used to build SFF systems, though the industry is working to expand the catalog of SFF standards. However, existing form factors meet the needs of rugged SFF system applications and may be preferable over new, unestablished form factors.



There is an increasing demand for Small Form Factor (SFF) systems in rugged military applications. Customers are asking for systems with reduced Size, Weight, and Power (SWaP) for many applications, for instance, to pack more capability into vehicles, produce smaller [UAVs](#), and help the military “go green.” On the supply side, the consequences of Moore’s Law – the doubling of the number of transistors on integrated circuits every two years – enable the industry to continue reducing the SWaP of systems.

Several efforts are underway to develop new standards for rugged SFF systems, including [VITA 73/74/75](#), and the recently formed European SGET organization’s Qseven-based effort. Despite the efforts to create more SFF standards, they may not be needed – it is possible today to create low-end to very high-performance, small, [rugged systems](#) based on existing standards.

Defining “small”

The terms “small form factor” and “small form factor system” are often used in the [embedded computing](#) industry but lack standard definitions. Numerous “SFF boards” are available on the market, but they are all different. In some cases, it isn’t even clear if “SFF” refers to a board or a system.

There are no true system standards for rugged, [embedded systems](#). The [ARINC Specification 404A](#), which defines Air Transport [Rack](#) (ATR) enclosures, is the closest there is to a true system standard, but is more of a guideline for ATR system dimensions and [mounting](#). System designs are driven by the requirements of each application, such as the type of [cooling](#) (forced air, conduction, convection, and so on), SWaP constraints, input power, physical dimensions, weight, type of [connectors](#), and environmental and EMI requirements; one size does not fit all.

For the purposes of this discussion, SFF encompasses board-level industry standards smaller than 3U form factors (a “U” is a 1.75" unit for measuring the height of equipment intended for use in a 19" or 23" system rack), such as 3U [CPCI](#) and 3U [VPX](#), with a market of COTS products available from multiple vendors. A number of SFFs fit these criteria, including PrPMC, PC/104, EBX, [COM Express](#), and Qseven. SFF systems are simply defined as systems that utilize SFF boards.

Options for building SFF systems today

Two viable SFF standards for rugged systems that stand out among the pack are PC/104 and COM Express. While both present [rugged system](#) designers with many advantages, they are suited for different applications.

PC/104 is small (3.6" x 3.8"), self-stacking, and provides a level of inherent ruggedization. PC/104 has been a standard for 20 years, with a well-established ecosystem of available SBCs, I/O boards, and system-level components. Supporting

primarily lower-end embedded processors such as the Intel Atom processor, PC/104 is suited for low- to mid-level military control applications.

The COM Express specification defines processor subsystems and their associated I/O. A COM Express module includes a processor, memory and flash, and the I/O that is provided by the processor and any associated chipset. There are four defined sizes of COM Express modules – Mini (84 mm x 55 mm), Compact (95 mm x 95 mm), Basic (125 mm x 95 mm), and Extended (110 mm x 155 mm).

COM Express modules are processor mezzanines; therefore, they must be mounted on a carrier card. In addition to hosting a COM Express module, a carrier can provide other functionality, such as providing application-specific I/O. A typical COM Express module includes Ethernet, serial, USB, SATA, video, and audio, depending on the I/O capabilities of the processor. With a carrier card that provides both COM Express and PMC/[XMC](#) sites, an SFF system can be built with a COTS COM Express module for the processing power and a COTS PMC or XMC module for the application-specific I/O.

Choosing the right tool for the job

For SFF systems that need to function in harsh environments (including extreme temperature, shock, vibration, airborne contaminants/dust, humidity, altitude, EMI) a ruggedized, [conduction-cooled](#) COM Express module may be required. Even though the COM Express specification only defines modules for use in [air-cooled](#), benign environments, conduction cooling and ruggedization can easily be supported with features such as soldered memory, designing and testing for extended solder joint reliability, additional mounting holes, Class III PCB fabrication and assembly, lead-based solder, and conformal coating, without violating the specification.

COM Express has characteristics that are important for deployed military SFF

applications: superior thermal properties, support for high-performance Freescale QorIQ and Intel Core i7 processors (in large part because of the thermal properties), support for ruggedization and conduction cooling, and easy integration of application-specific I/O.

A determining factor of system performance is the amount of [heat](#) that can be removed from the system's processor. In general, the higher a processor's performance the more power it consumes, creating more heat that needs to be removed from the system.

In PC/104 systems, the processor is sandwiched between modules, making it more difficult to get the heat out of the processor, especially in conduction-cooled applications where the heat has to be conducted to the walls of the [chassis](#) and then to a cold plate (Figure 1). PC/104 has done very well in low- to mid-level control applications supporting low- to mid-level processors and even some higher end processors in air-cooled applications. However, there is little, if any, PC/104 ecosystem for conduction-cooled SBCs utilizing the highest performance embedded computing processors, such as the Freescale QorIQ or the Intel Core i7 processors that are deployed in high-end Command, Control, Compute, Communication, Intelligence, Surveillance, and Reconnaissance (C4ISR) and Electronic [Warfare](#) (EW) applications.

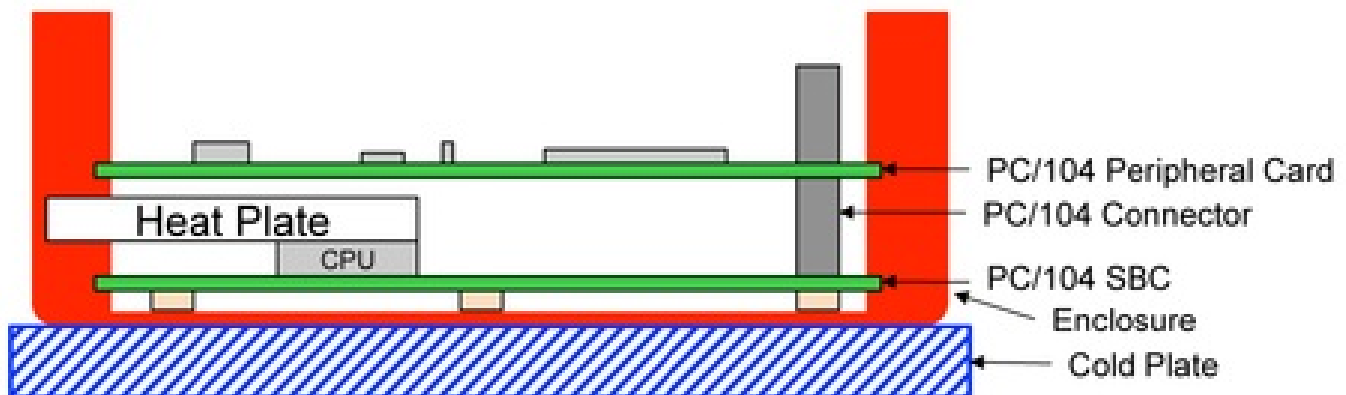


Figure 1: In a stack of PC/104 modules with the PC/104 [SBC](#) at the bottom of the stack, the heat from the processor must travel through the heat frame to the side

wall of the chassis.

(click graphic to zoom by 1.9x)

Processors in COM Express-based systems, however, can interface directly to the interior wall of the chassis. This provides a better thermal path and makes it easier to cool the processors, especially in conduction-cooled applications (Figure 2).

Consequently, COM Express supports high-performance C4ISR and EW applications due to its ability to support the highest performance embedded processors.

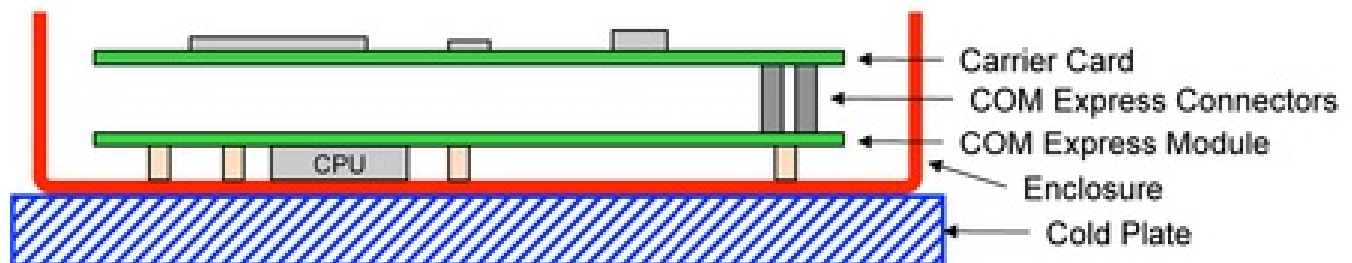


Figure 2: A COM Express module and carrier stack have the processor in direct contact with the chassis wall, which acts as a large heat sink.

(click graphic to zoom by 1.9x)

Applying COM Express on the battlefield

SFF systems that are based on COTS COM Express and PMC/XMC modules can be integrated for rapid deployment in a variety of military [vehicle](#) and aircraft systems.

Utilizing an Intel Core i7 processor COM Express module and a PMC router, an integrated network appliance and router can be deployed in ground vehicles to create Mobile Ad hoc Networks (MANETs). A Freescale QorIQ P4080 COM Express module and an [ADC/DAC XMC](#) module can create a [Software Defined Radio \(SDR\)](#) for deployment in aircraft. A system used to pinpoint enemy fire in an [Unmanned Aerial Vehicle \(UAV\)](#) can house a Freescale QorIQ P5020 COM Express module and an XMC module that interfaces to an infrared camera.

The XPand6000 Series from Extreme Engineering Solutions (X-ES) is an example of a

COM Express-based SFF system with support for conduction or natural convection cooling. The horizontal, conduction-cooled XPand6002 [model](#) (Figure 3) supports a COM Express module, one PMC or XMC for application I/O, and a 1.8" [SSD](#) for application storage. The processor on the COM Express module is positioned inside the system against the chassis wall, which is a large heat sink that enables support of high-performance embedded processors.



Figure 3: The XPand6002 Small Form Factor [enclosure](#) supports a rugged, conduction-cooled COM Express module, a PMC or XMC for I/O, and a 1.8" SSD.

(click graphic to zoom by 1.9x)

Because of its ability to run multiple [avionics](#) applications simultaneously, an XPand6000 system with a Freescale QorIQ P4080-based COM Express module and a graphics XMC module will be deployed as an avionics glass cockpit system. There is also an effort to utilize an XPand6000 system with an Intel Core i7 processor COM Express module and an XMC that provides [CANbus](#) and GPIO interfaces to control an autonomous ground vehicle.

The right tools are available now

Today there are plenty of existing standards to design SFF systems around utilizing existing COTS products. Together, PC/104 and COM Express can support low- to high-performance SFF system applications. The existing SFFs provide choices to designers and ensure that they will not get locked into a single vendor's proprietary solution.

Creating a new SFF standard and building the ecosystem takes a lot of work and time, and any SFF system standard will only satisfy a fraction of the SFF application needs. Designers will be better served by having the industry focus on designing SFF systems around existing industry standard COTS products.

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