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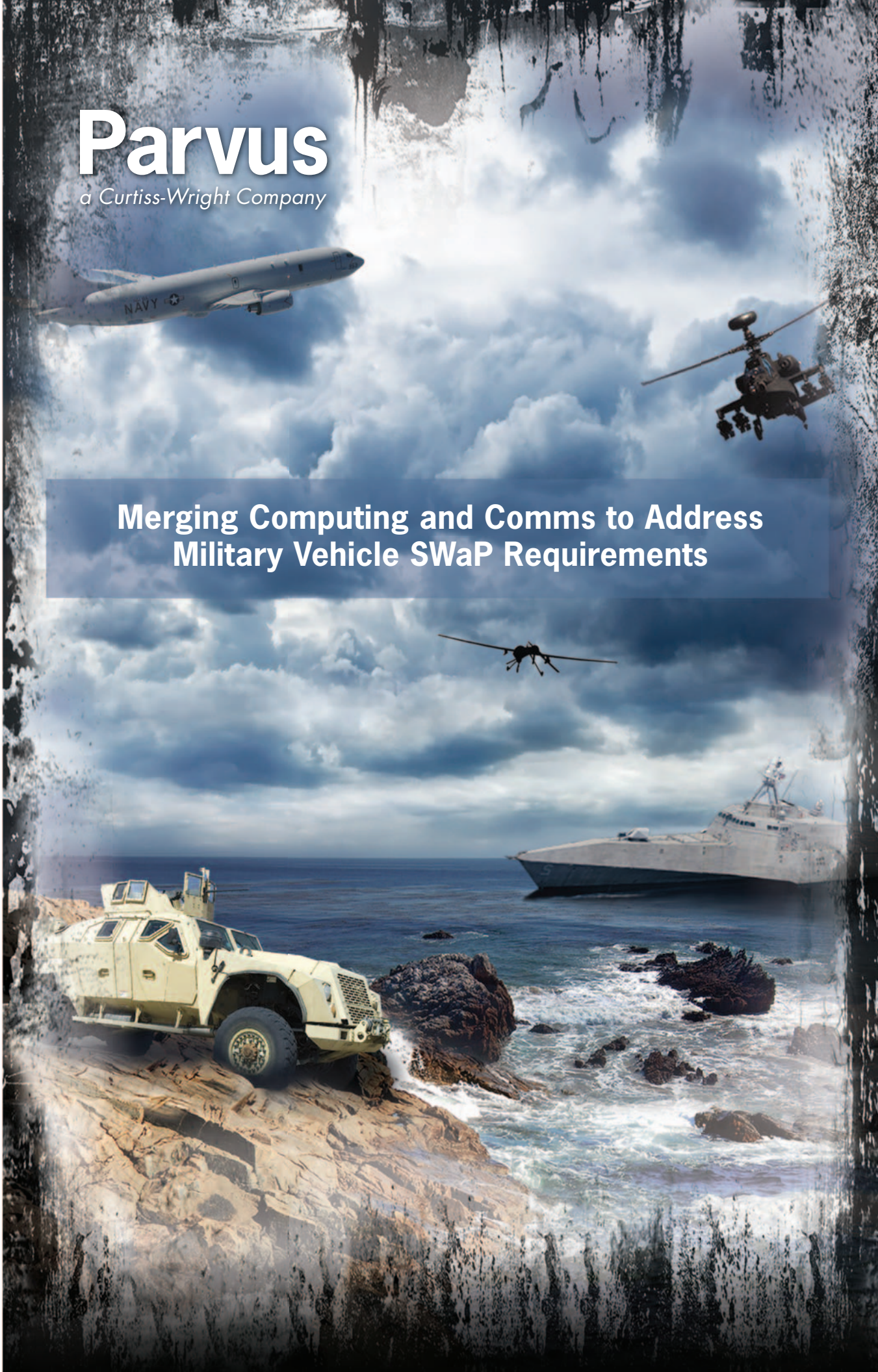
WHITE PAPER

Merging Computing and Comms to Address Military Vehicle SWaP Requirements



Merging Computing and Comms to Address Military Vehicle SWaP Requirements

Thanks to ever increasing semiconductor integration and creative engineering, more subsystems functionality can be squeezed into a single compact system than ever before. Military vehicles are taking advantage by combining modular systems. Some embedded subsystems can now support I/O expansion combined with network processing, Ethernet switching, and IP traffic routing in a single box.

Despite current budget challenges faced by the Department of Defense, the DoD continues to demand more performance and improved functionality from rugged computers and communications subsystems to fulfill its mission requirements.

Key Concepts: Rugged COTS, SWaP, Network Processing, Ethernet Switching, IP Routing, Modular Subsystems

Modern state-of-the-art equipment offers the DoD more than legacy products—one subsystem can now integrate the capabilities of multiple boxes. One way the DoD achieves savings is by purchasing rugged commercial-off-the-shelf (COTS) computing subsystems versus the custom MIL-spec alternatives of yesteryear. Open architecture, pre-integrated products featuring modularity (mix and match functionality) are most attractive to the DoD since they do not require significant engineering expertise for customization or integration.

Adaptable and Scalable

In recent years, rugged COTS subsystem architectures have become more scalable and flexible to adapt to the military's varying demands. Engineers are designing more open architecture, modular subsystems that can support I/O expansion and extend the life and usability of a system—a must for budget-conscious DoD programs.

In fact, many military programs have begun to request subsystems that combine mission processing, Ethernet LAN switching and IP traffic routing into a single box (Figure 1). Depending on the project, this may be motivated by Size, Weight & Power (SWaP) constraints or objectives to simplify systems integration. Some programs may want to reduce the number of power supplies or cables on board a vehicle, while others seek a solution with flexible mechanical installation options. The U.S. Army's VICTORY initiative is an excellent example of this trend, as ground vehicle architects aim to

trim unnecessary fat and yet leverage modern computing and networking architectures.

Challenges of a Combined Subsystem

Some box designers have tackled the "everything and a kitchen sink" request by simply putting computing and networking boxes together in a bigger enclosure. However, this solution may not fare well for SWaP, or vibration and thermal management. Nor does it help with power or cable management since the individual subsystems would still require separate power input cables. There are several challenges that rugged systems integrators must address when designing a combined subsystem, including a scalable electrical topography, heat dissipation, power management, electromagnetic interference (EMI), environmental protection, and shock and vibration considerations.

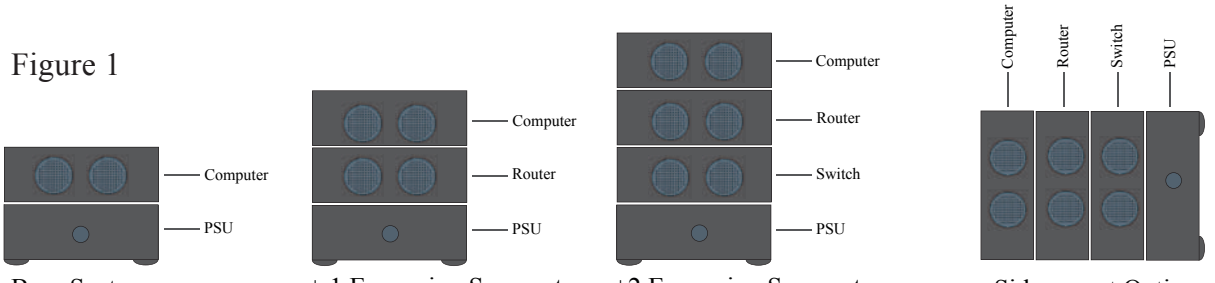
Designers must take into account the electrical topography of the individual components and consider how modules will integrate and communicate with each other. Each will have data and power lines and should connect to the outside world via rugged, military standard connectors. A stackable board architecture such as PCIe104 and a scalable internal connector breakout scheme are ideal in providing an interconnection between the varied modules. Reliable mating edge connectors and semi-rigid PCB flex cables can eliminate traditional "rats nest" wiring harnesses and allow the device to efficiently flow power and I/O signals through the system.

Handling EMI

As electromagnetic interference is also a concern, some parts of the system may need to be electrically isolated. To create an electrically sound design akin to a Faraday Cage and avoid electrical signals that may cause problems, designers may have to adhere some components with materials that are thermally conductive but electrically isolating. Special hardware may also be used to fasten parts down without being electrically attached.

Heat is a challenge as more and more electronics are aggregated into one box. Commercial heat pipes may not work adequately in a combined subsystem meant for military use since they are affected by gravity, vibration and extreme acceleration. Since designers have to account for stacking up several mechanical parts, the chassis must be designed to allow for tolerance stackup and dissipate heat very well, preferably with passive cooling devices within the system

Figure 1



Base System
Computer
Router
Switch

+ 1 Expansion Segment
Computer + Router
Router + Switch
Switch + Computer

+2 Expansion Segments
Computer, Router, Switch & Power

Side mount Option

to transfer heat out of the case efficiently and reliably. Thermal solutions such as flexible thermal links in the mechanical assembly using materials that conduct heat extremely well allow designers to dissipate heat in stacked subsystems.

Advanced Materials

Advanced materials such as annealed pyrolytic graphite are also becoming key in thermal management, as they can be several times more

conductive than copper. Combining parts and functionality can eliminate thermal interfaces and reduce thermal resistance. A well-designed enclosure can radiate the heat out to accommodate some interesting combinations of computing functionality without needing forced air or liquid cooling to keep temperatures at bay.

When subsystems are combined, there must be enough power to support each component. Rather than having multiple DC/DC power converters kluged together, the power supply for the primary single board computer module can be designed with sufficiently spare power output to also feed the other subsystem components through the PCI bus, PCI Express bus, or auxiliary power connections.

Lastly and key for any military project, is shock and vibration robustness. When designing a combined system, eliminating weak components and connections and minimizing stress on boards will make the system more robust and versatile for installation. Mounting holes can be placed to allow for vertical or horizontal mounting, and board-to-board I/O signal connections can be used as a more reliable solution than ribbon cables that can have potential for chafing or coming loose.

Network Processing and Routing

Military customers today are looking for an elegant solution that carefully considers how best to mechanically and electrically integrate multiple functions into a single functional appliance without sacrificing SWaP or performance. When engineers take modularity into account from initial concept, this objective can be met successfully.

Salt Lake City-based Parvus Corp. has designed many modular-type systems. Recently it rolled out the DuraMAR 5915 mobile router and the DuraCOR 80-40 mission computer, which can be combined into a single solution to provide computer/router/switch and other I/O requirements in a single appliance (Figure 2 and 3). Both the underlying computer and the router technologies are based on rugged stackable PC/104 architecture, and both utilize a common fully sealed yet passively cooled enclosure that is thermally optimized to dissipate heat and minimize failure, even in extreme environments. Each standalone system leverages similar design best practices and goes through rigorous MIL-STD-810G environmental and MIL-STD-461F

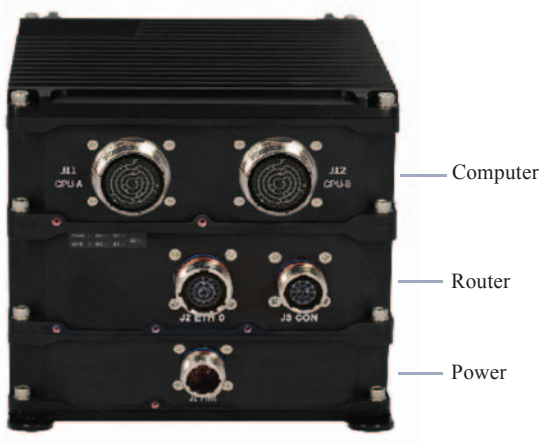
qualification testing to minimize risk when mixing and matching functional segments into a single housing.

There are several obvious advantages of this combined computing and routing approach. The first is versatility, as a uniform and simplified mechanical approach enables scalability on military platforms. Specific functions can be combined to meet mission requirements. Further, installation is simpler for subsystems similar to these Parvus products, as they may be mounted horizontally or vertically. Instead of needing a cabinet with shock mounts, customers can bolt the box anywhere they can find a place for it. Further, a single power connection and robust power supply in a multi-function device makes the unit simpler to install and integrate into system of system solutions. Designing a combined computing and routing subsystem requires extra power to account for the high-performance processor, router, high-density Ethernet Switch, and any additional customer-specific I/O payloads. Having a sufficiently high output supply capable of delivering the needed voltages to internal electronics and protecting them with inline EMI filtering and power conditioning, enables such appliances to operate in a wide range of extreme environments.

Combined Subsystems

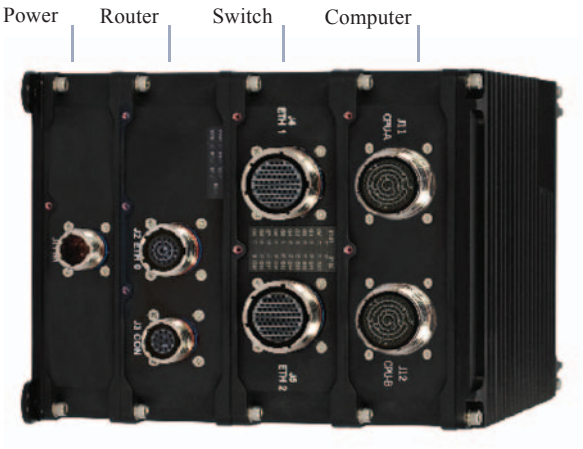
As technology evolves, more powerful processors can be used in combination subsystems. Thermal management will likely remain a significant challenge. To date, Parvus has successfully leveraged advanced thermal management techniques to deploy multicore Intel Core i7 processors to operate in wide, extended temperatures. A combined system can go anywhere—on a vehicle, unmanned or manned aircraft, or ship. Video processing and IP networking are in great demand for situational awareness reasons, and combined systems can help military programs do this while achieving a smaller footprint.

Figure 2



The Parvus DuraCOR 80-40 and DuraMAR 5915 router employs modular interlocking chassis segments to enable multifunction subsystems

Figure 3



Sidemounting Option with GigE Switch