TECHNOLOGY WHITE PAPER

Delivering VICTORY and PNT Hub Services for Tactical Ground Vehicle Architecture

DEFENSE SOLUTIONS

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- VICTORY
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Introduction

Historically, tactical ground vehicles have been burdened by large “bolt-on” Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) electronics packages equipped with proprietary, stove-piped communication interfaces, coupled with numerous independent Global Positioning System (GPS) and Human Machine Interface (HMI) peripheral devices. This has taxed not only the technology acquisition and upgrade cost for these vehicle programs and the interoperability of vetronics subsystems, but also impacted the physical space allotted for people, ammunition, and supplies.

Modern efforts like the U.S. Army’s VICTORY (Vehicle Integration for C4ISR/EW Interoperability) initiative and the United Kingdom’s Ministry of Defense Generic Vehicle Architecture (GVA) are posed to shift the current paradigm of system of systems engineering. This white paper will discuss some of the drivers and benefits of deploying an open, scalable vetronics system architecture as envisioned by these initiatives, and how modern Commercial off the Shelf (COTS) technologies are enabling network-enabled switching, shared processing, and assured military position navigation timing (PNT) services for Size, Weight, Power and Cost (SWaP-C)-constrained tactical ground vehicles. An overview to VICTORY services, Military Code (M-Code) GPS technology, as well as commercial shared network/processor line replaceable units (LRUs) optimized for tactical ground vehicle environments will be provided.

Figure 1: Tactical and combat ground vehicles, like the Stryker Infantry Carrier Vehicle, are seeking to modernize their approach to C4ISR systems integration.

Photo Credit: Murdock Online

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Forces Driving Modernization

A host of different strategic, operational and technological drivers are instigating change in modern vehicle electronics architectures. Some of these driving forces include budgetary pressures to reduce cost, situational awareness requirements specifying networked technologies, governmental mandates for advanced GPS technologies, and the underlying SWaP constraints of today's tactical vehicle platforms.

Stove-piped governmental acquisition process has historically led to duplicative and proprietary C4ISR systems taking over ground vehicles. Today's combat vehicles are typically deployed with multiple independent systems that have limited ability to share their functionalities or data. When a vehicle program office wants to put a new device into a vehicle, it comes with its own cables, keyboards and other components. The result is a lot of redundant hardware and software, which in turn increases cost and maintenance while taking up valuable space. Some vehicles, for instance, have multiple systems that all have a built-in GPS that draw from the same signal, but aren't yet integrated together.

Figure 2: U.S. Army VICTORY initiative pushes for modular open COTS C4ISR technologies.

High level fiscal pressures in the acquisition community are motivating governments to address these problems. Initiatives like Better Buying Power, VICTORY, GVA, and Modular Open Systems Approach (MOSA) are evidence of a push for improved practices. The hope is that when program managers design a future C4ISR system, they see that adding a proprietary or duplicative device like an additional GPS receiver only increases the weight and price of the system. Currently, there are many legacy systems that are difficult to upgrade because they can't easily be pulled out and replaced. Being able to easily remove such components is also important to lowering sustainment costs.

Given how critical GPS capabilities are for military services, next-generation PNT technologies are emerging to address vulnerabilities from emerging threats and field conditions. The U.S. Congress has directed military acquisition managers to buy only M-Code capable devices starting in fiscal year 2018. In addition to improved anti-jamming and security for military GPS signals, the need for scalable distribution of networked PNT data is driving this forward. Current Military GPS User Equipment (MGUE), including the Precision Lightweight GPS Receiver (PLGR) and Defense Advanced GPS Receiver (DAGR) cannot operate at the required PNT assurance levels, and these devices are not typically capable of being networked. This means that on one Stryker vehicle variant, for example, as many as nine separate DAGRs are incorporated, each with its own antenna; operating totally independently of the others.

Figure 3: Military GPS technologies will migrate from DAGR/PLGR receivers to new M-code signal technologies in the near future. Photo Credit: Rockwell Collins

Vision of VICTORY Vetronics

C4ISR modernization initiatives like VICTORY and GVA aim to provide a common ground-vehicle infrastructure to ease the integration of new technologies, while improving SWaP through the elimination of redundant components. These initiatives use open network interfaces, open data formats, and open protocols to enable the integration and sharing of network, processing, PNT and display resources. Every device plugged into a VICTORY network backbone will be able to use a single GPS system, for example, so future acquisitions can be structured such that there is only one such device in a vehicle. If done correctly, VICTORY should be transparent to the soldier with a roomier vehicle cabin and more efficient data sharing while the overall life-cycle cost for maintaining the platform is reduced.

The VICTORY specification was officially kicked off in 2011 by the U.S. Army PEO C3T (Program Executive Office for Command, Control and Communications-Tactical) and a consortium of defense and industry participants, which included Curtiss-Wright. According to the VICTORY standards organization, the initiative "was started as a way to correct the problems created by the 'bolt-on' approach to fielding equipment on U.S. Army vehicles. Implementation of VICTORY enables tactical wheeled vehicles and ground-combat systems to recover lost space while reducing weight and saving power. Additionally, implementation allows platform systems to share information and provide an integrated picture to the crews. Finally, implementation provides an open architecture that will enable platforms to accept future technologies without the need for significant redesign."

VICTORY uses a data bus-centric design, which means that everything is connected together on the backbone of an Ethernet network. The design permits the information from each piece of hardware plugged into the data bus to be shared across the network. It also consolidates the number of interfaces, allowing users to do more without having to move to a different device. At its core, the VICTORY initiative is developing standards for interoperability between LRUs on combat vehicles. VICTORY defines the use of non-proprietary interfaces between heterogeneous LRU subsystems. The resulting open architecture standard is not intended to define how LRUs are built, but rather how these LRUs can intercommunicate and share data and resources.

As previously noted, one of the objectives of VICTORY is decreasing the size, weight and power consumption of the myriad C4ISR subsystems overcrowding the crew areas inside a vehicle. VICTORY integration also increases situational awareness and reduce users' operational burden. For example, the three major pieces of gear in a vehicle — the gun station on top of the vehicle, threat detection system and battle command system that tracks allies and adversaries — are currently independent from each other. When the threat detection system alerts troops that someone is shooting at the vehicle, the person at the battle command system must manually input the information. With VICTORY architecture, these systems are linked and can pass information to streamline operations.

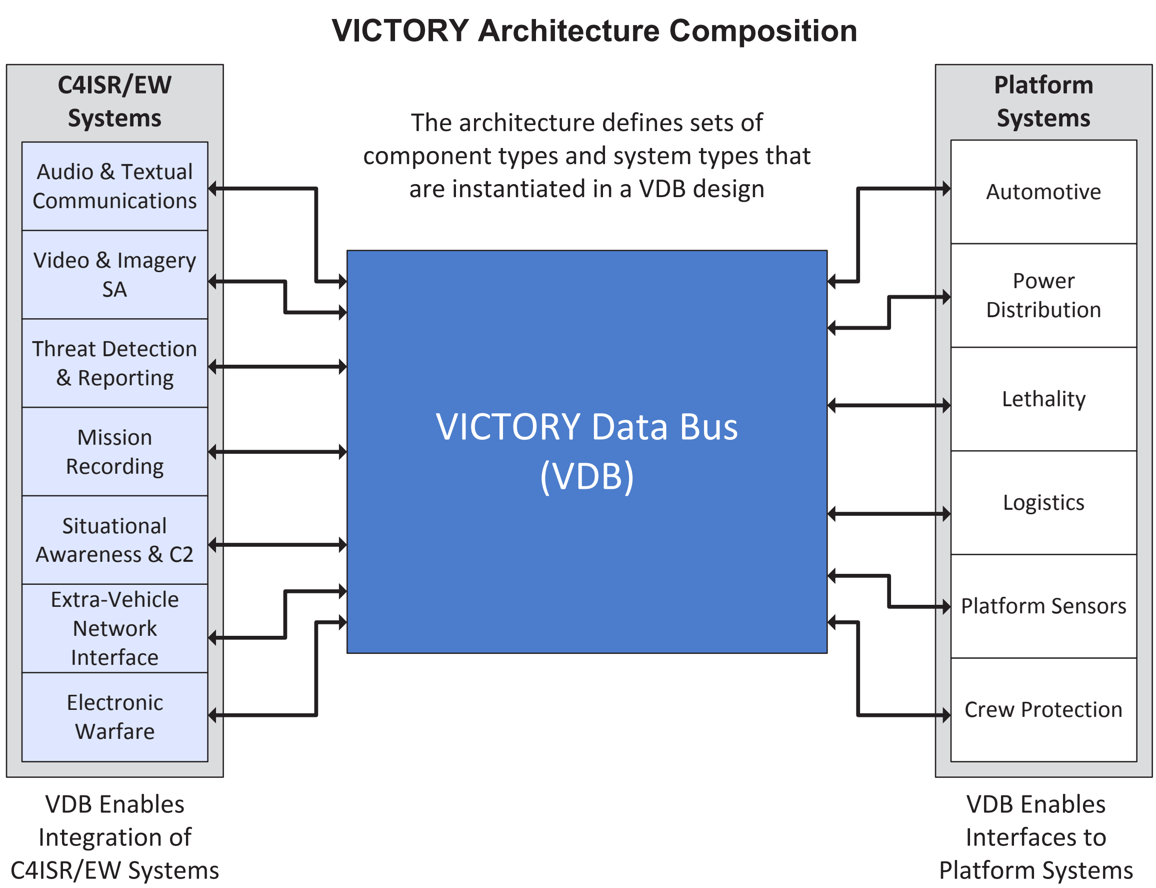


Figure 4: VICTORY Architecture is founded on an Ethernet databus and shared services for on-board electronics.

Battle Command Use Case Example

To provide a clear sense of how today's combat vehicles are overburdened, and how the VICTORY architecture will mitigate this challenge and related performance limitations, consider the example of a tactical vehicle's Battle Command (BC) application. The BC application informs the vehicle commander where the enemy and friendly forces are located in the relevant area of operation. Today's BC applications rely on a GPS receiver to provide the warfighter's location and mapping resources. The vehicle platform may also include a Remote Weapon Station (RWS) and an acoustic shot detection system that can locate the direction of incoming fire. On today's combat vehicles, these three subsystem types are standalone and do not interoperate with each other.

Figure 5: Vehicle remote weapons stations can be networked to a digital backbone under VICTORY architecture. Photo Credit: BAE Systems

A useful metaphor for today's stove-piped combat vehicle LRUs is to consider what desktop computing would be like if a user required a separate, non-interfaced computer system, mouse, keyboard, and display for word processing, another for spreadsheets and yet another for presentation software—each supplied by different vendors. Essentially, this is the operating environment in today's combat vehicles, where there is limited interoperability, heaps of equipment, and almost no sharing of data or resources. This is precisely the problem that VICTORY can eliminate.

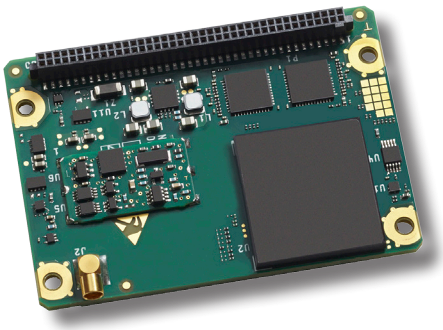
In the BC use case, after the shot detection system identifies a location, the vehicle commander must take that data and physically move to another console to enter that data into the BC application. Next, the RWS must be aimed toward the target. With VICTORY architecture, on the other hand, the BC application can run on a shared processing resource, reducing the onboard electronics. Using VICTORY standard network messages, the threat detection system communicates with both the BC application and RWS through the VICTORY databus (Gigabit Ethernet). The shot detection system is then able to deliver a standard message type, with an accurate timestamp and GPS location data that is used by the BC application and enables the RWS to instantaneously "slew to cue" to target the imminent threat automatically. This level of interoperability delivered by the VICTORY architecture can significantly increase combat effectiveness.

With VICTORY, information can now be published on the network databus and immediately pushed out to the vehicle's subsystems. This architectural approach makes it easier to share information between personnel in a vehicle or in a formation. That means that someone sitting at the battle command system will automatically see the coordinates of where a threat was detected. If a gunner at a remote weapons station isn't sure whether to shoot a target, he can send still imagery to his commander. At the same time, that commander can take the still images and give them back to his formation or up his chain of command.

Networked, Modernized PNT

Complimentary and in parallel to the VICTORY effort, the U.S. Army is advancing an Assured PNT program that will enable warfighters to transition from using legacy PLGR and DAGR SASSM (Selective Availability Anti-Spoofing Module) based GPS devices to new networkable devices based on a new military signal called M-code. A major component of the GPS modernization process, M-code will give users access to a higher-power signal (more resistant to jamming) and interference along with improved message formats and signal modulation techniques that make it both faster and more accurate. M-code receivers will also have advanced security features aimed at preventing unauthorized access or exploitation by adversaries.

Figure 6: Embedded GB-GRAM-M (M-code) GPS receiver module. Photo Credit: Rockwell Collins



As part of M-code technology migration efforts, the Army's Aberdeen Proving Ground is working to reduce the amount of weight a warfighter needs to carry by integrating a hub capable of providing PNT information to multiple devices. With a networked, assured PNT hub distributing M-code signals to all devices connected on the vehicle's VICTORY backbone, the warfighter would avail of enhanced capabilities and do so with a much smaller price tag. This Assured PNT program is focusing on upgrading to future technologies at a lower cost than the current architecture of GPS user equipment (UE) together with platform distribution of PNT data and scalable PNT architectures. This is expected to deliver improved capabilities for accurate and reliable PNT service where current receiver performance might be compromised or unavailable. And if these advanced PNT services are integrated within a multi-function LRU capable of additional computing/communications functions (as opposed to a standalone PNT device like current devices), SWaP-C can be further improved.

Implementing VICTORY together with assured PNT services can also help drive standardization of operator data and increase cyber security (since there will be one system to protect, verses multiple systems). Today's combat vehicles display geospatial terrain data to operators in multiple different ways, depending on which system/platform is used. VICTORY compliance would unify the operator picture and give warfighters in their vehicles or aircraft and those back at headquarters the same real-time operating picture. In turn, having the same operational view will boost mission command effectiveness.

Network Integration Evaluation and Deployment

To validate the effectiveness of next-generation C4ISR vehicle architectures, armed services have taken VICTORY for a "test drive" and are developing fleet-based approaches for VICTORY integration into both emerging and legacy vehicle platforms. As part of a recent U.S. Army Network Integration Evaluation (NIE), the Army demonstrated a VICTORY-outfitted Mine-Resistant Ambush Protected (MRAP) Terrain Vehicle (M-ATV). The VICTORY databus was connected to the Common Remotely Operated Weapons System (CROWS), Mounted Family of Computing Systems (MFCS), AN/VIC-5 enhanced vehicular intercommunication system, PNT and vision devices (Check-6, DVE), Boomerang gunfire locator, and a collection of tactical radios, including SINCGARS (Single Channel Ground and Airborne Radio System), HMS (Helmet Mounted Sight), and WIN-T (Warfighter Information Network-Tactical) equipment.

Figure 7: M-ATV vehicles participated in U.S. Army NIE exercise with VICTORY compliant digital backbone interfaced to on-board LRUs. Photo Credit: US Army Cpl. Kyle McNally

The Army says that these demonstrations illustrate how implementing the VICTORY standard increases situational awareness within vehicles and across unit formations. The effort gives soldiers a more common set of tools and capabilities, allowing the Army to reduce soldiers' operational burden and providing better insight into logistics and maintenance needs through the Army's Condition-Based Maintenance (CBM) enterprise. The NIE demos also show how VICTORY better manages space, power, and cooling demands for vehicle occupants, and how it could provide acquisition and life cycle management cost savings by reducing equipment duplication and associated training.

The Army fleet of Humvees and Family of Medium Tactical Vehicles (FMTV) are expected to follow with demonstrations of VICTORY services. Bradley, Abrams, and Stryker will also incorporate selected VICTORY requirements as part of planned upgrades with additional requirements to be implemented as future efforts are approved. New vehicles coming online in the next few years will also leverage the architecture. The Army and Marine Corps' Joint Light Tactical Vehicle (JLTV) will roll off the assembly line with a minimum set of VICTORY components. The Armored Multi-Purpose Vehicle (AMPV) also contains some VICTORY requirements.

Scalable Modular Open System Technology

The defense community's commitment to Modular Open System Architecture (MOSA) is driving the use of open system approaches for ground vehicles both from the technical and the procurement perspectives. VICTORY, a prime example of MOSA policy implementation, explicitly encourages the use of COTS open standards. VICTORY LRUs communicate using ubiquitous Ethernet over distributed Internet Protocol (IP)-based networks, exploiting cutting-edge commercial networking technology such as Web Services, SOAP and XML. As an added benefit, this approach eliminates redundant system components such as displays, keyboards and GPS receivers; now a single keyboard and video display are all that is required for the user to control all the subsystems.

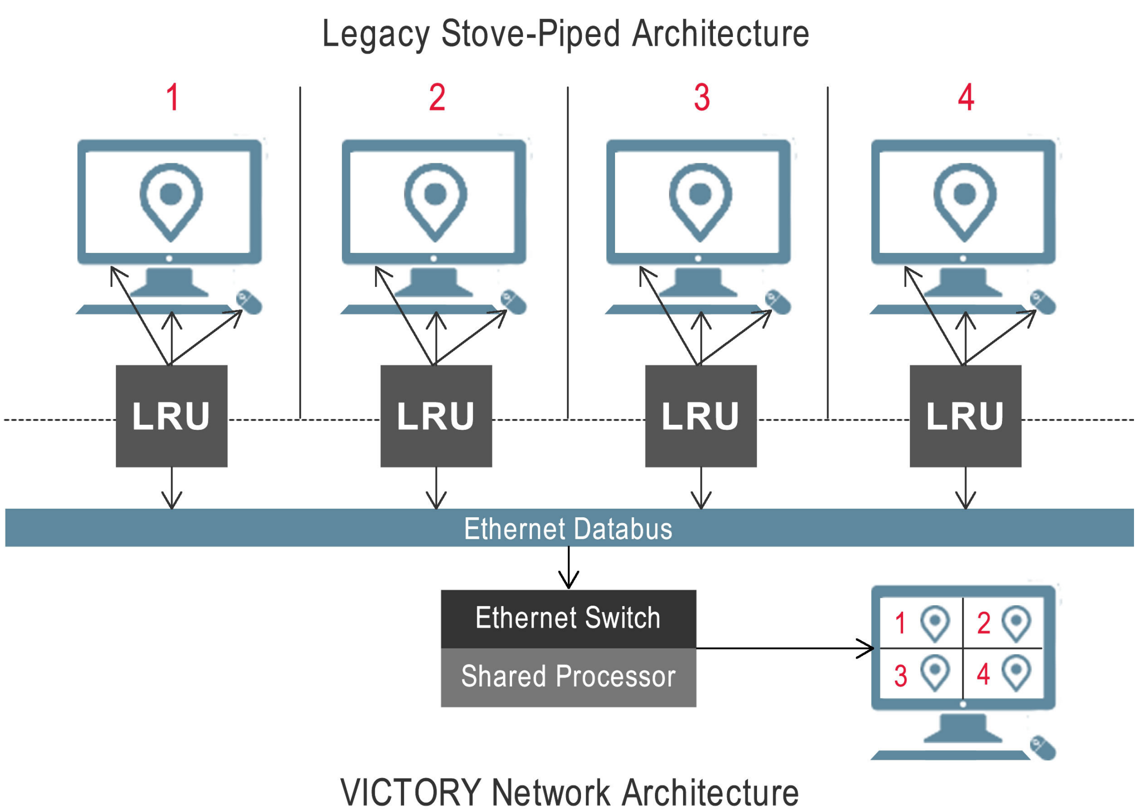


Figure 8: Modular open system architecture enabling reduction in peripherals to interface with vehicle LRUs.

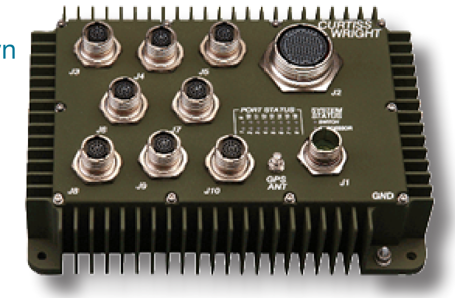
The initial version of the VICTORY specification defined 54 VICTORY component types that provide a variety of functional elements, such as direction of travel, time services, and shared storage. More recently, the U.S. government identified a subset of 17 core components needed to implement useful in-vehicle VICTORY architecture. This has enabled COTS vendors like Curtiss-Wright to focus on these essential required services. Additional component sets beyond the core 17 can be added based on the usage profile of a particular vehicle.

Leveraging modular system architecture supporting VICTORY databus services gives C4ISR system of systems architects a great degree of freedom to scale and optimize vetronics to their platform mission requirements. As standards are leveraged for in-vehicle LRU subsystems, platform architects can implement multi-vendor solutions (which by definition should be interoperable) and phase-in support for relevant VICTORY component types, as needed. At the same time, platforms can leverage either a distributed or consolidated LRU approach for network switches, processors, storage devices and PNT hub electronics, adding in LRUs as needed or starting with bundled functionality that reduces SWaP aspects.

VICTORY Leadership with COTS Solutions

In September 2012, the Curtiss-Wright Defense Solutions division introduced the first integrated COTS VICTORY system solution. This rugged "Digital Beachhead" system featured a GigE switch combined with a tightly integrated vehicle management computer, delivering a VICTORY databus, management and shared services. This product represented a low-cost rugged ground vehicle "appliance" for modernizing ground vehicles to comply with the VICTORY standard. Since its debut, it has generated significant interest in the ground vehicle community, multiple U.S. Army System Integration Labs (SILs), and other government contractors, for evaluation. Recognizing the rapidly proliferating demand for VICTORY-compliant solutions in program requirements, the company has expanded VICTORY product development efforts and introduced several new products, including rugged line-replaceable modules (LRMs) and LRUs, including network switches and router systems, and mission computing resources.

Figure 9: First generation Digital Beachhead, known as the DBH-670, featured VICTORY-recommend connector pinout for Ethernet ports.



A notable example of the latest in VICTORY subsystem technology is the recently introduced DuraDBH-672 Digital Beachhead, a second-generation rugged COTS GbE switch and vetronics computer system. This LRU extends many of the capabilities introduced in the original VICTORY system but in a smaller form factor even more optimized for SWaP-C and more flexible in terms of I/O expansion scalability. The unit features 16 ports of fully managed Layer 2 GbE switching and static Layer 3 routing together with a low-power quad-core ARM-based Freescale i.MX6 processor that can handle general-purpose processing requirements or optional VICTORY Data Bus Management and Shared Processor Services. It can also support the U.S. Army TARDEC's libVICTORY API to serve as a VICTORY Infrastructure Switch and Shared Processing Unit, and optionally host an embedded SASSM GB-GRAM or M-code GPS receiver. By consolidating what have traditionally been standalone LRUs, each dedicated to processing and network switching, into a single multifunction system solution, VICTORY subsystems like the DuraDBH-672 enable ground-vehicle-system architects to significantly reduce integration SWaP and complexity.

Figure 10: Second generation Digital Beachhead, known as the DuraDBH-672, reduced size and weight, while adding I/O expansion capabilities.

Standalone network switch and processor LRUs, including the Parvus® DuraNET 20-10 and DuraNET 20-11, make available the same VICTORY network infrastructure switching capabilities as integrated into the Digital Beachhead, while the modular Parvus DuraCOR 80-40 and DuraCOR 80-41 processor subsystems deliver high-performance multi-core Intel® x86-based computing alternatives.

DuraBDH-672: Scalable Rugged COTS Solution

For many reasons, the DuraDBH-672 Digital Beachhead is the ideal digital backbone for today's combat vehicles:

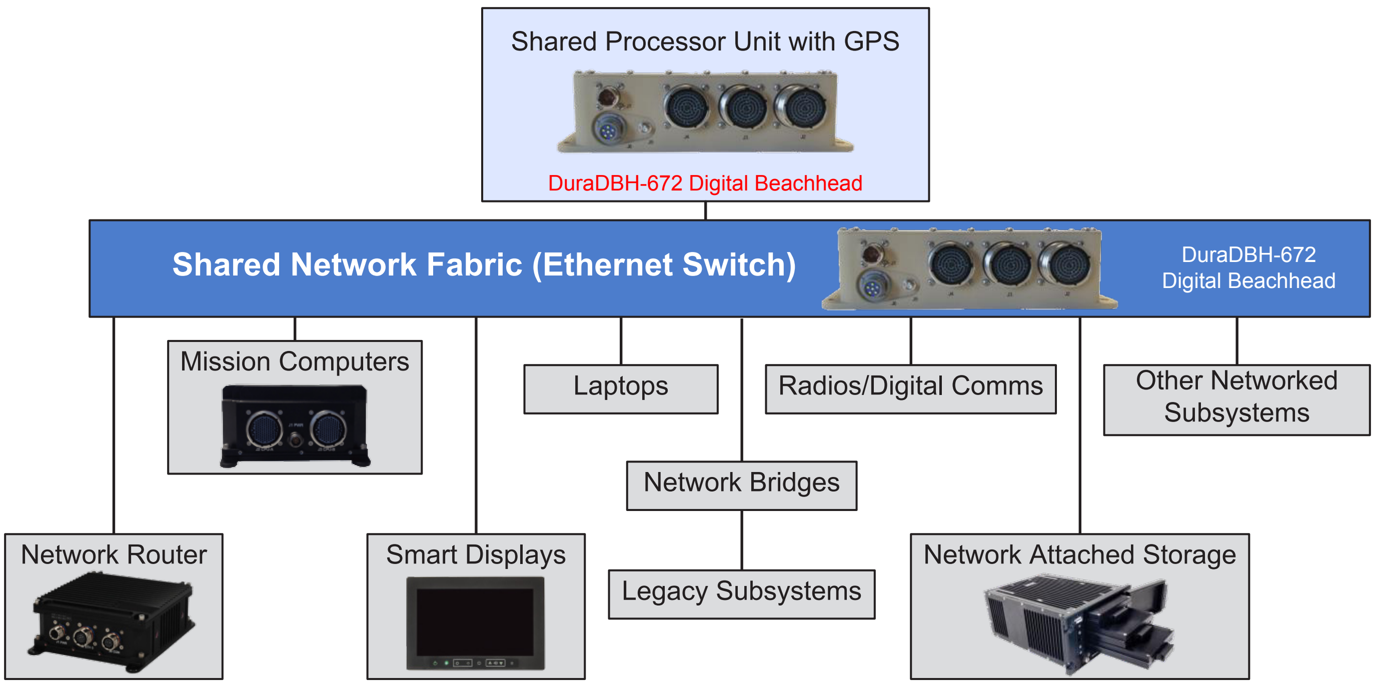


Figure 11: DuraDBH-672 provide shared network fabric for VICTORY services architecture

Robust, fully managed Gigabit Ethernet switching

Using an open standards approach and Ethernet network technology in a SWaP-optimized chassis, the Beachhead supports up to 16 network-enabled devices—including other computers, displays and situational awareness (SA) sensors—at any given time. Not to mention, this Ethernet connectivity device comes equipped with the latest network management and power savings technology.

Consolidated mission controls

Beachhead's powerful quad-core ARM-based vetronics computer can deliver a number of essential data services for tactical vehicle platforms while reducing their total equipment footprint thanks to its integrated 16-port GbE switch and GPS capabilities. The system supports flexible vetronics interfaces over a host of standard serial, CANbus, Ethernet, video, and digital inputs/outputs, along with optional add-on Mini-PCIe I/O module expansion for additional specialized interfaces (i.e. MIL-STD-1553, etc.). This is topped off with support for an internal or external military GPS receiver, including hosting a government-furnished equipment (GFE) GPS device, such as embedded GB-GRAM / M-Code GPS receiver modules.

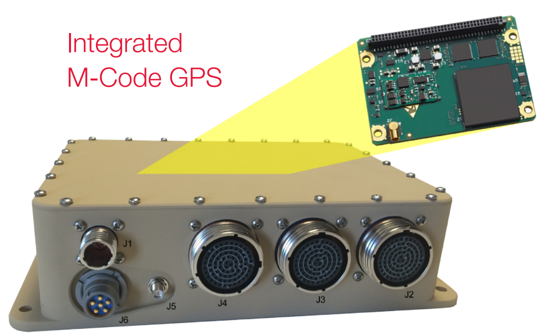


Figure 12: DuraDBH-672 Digital Beachhead can host embedded GB-GRAM Receivers (MPE-S, M-Code, SPS C/A Type I/II)

VICTORY compatible

The DuraDBH-672 is the ideal starter kit for implementing the U.S. Army's VICTORY standard. It can serve as a specified infrastructure switch component type, shared processing unit component type, and with optional software supports a host of VICTORY data bus services.

High-powered network management software

The DuraDBH-672 provides a powerful set of capabilities for multicast traffic, VLAN, port control, Quality of Service (QoS), Link Aggregation, SNMP management, secure authentication, redundancy, precision timing (IEEE-1588 PTP) and data zeroization.

SWaP-optimized

The Parvus DuraDBH-672 fits all the before mentioned functionality into a shockingly small package. At 2.5 inches tall and four pounds in weight, it takes up no more space than a letter-sized piece of paper and operates at just twenty watts on average.

Rugged design

Designed to meet MIL-STD certifications for MIL-STD-810G and MIL-STD-461F, the DuraDBH-672 can withstand extreme temperatures (-40 to +71°C), shock, vibration, humidity, high altitude, humidity, dust, water, and conducted and radiated emissions. Systems designers can depend on its reliable performance in virtually any setting.

Low cost

The Beachhead is significantly more affordable than comparable offerings, especially given its combined functionality traditionally provided by multiple separate LRUs. Rather than deploy independent switching, processing, and GPS devices, the DuraDBH-672 delivers it all in one.

Conclusion

At the frontline of bringing the VICTORY architecture into ground vehicles, rugged COTS technologies from Curtis-Wright are helping to showcase the benefits of adopting a common network fabric for C4ISR architecture and consolidating modern computing and networking architectures for SWaP optimization.

The promise of VICTORY is that its wide adoption will help to increase interoperability, enable the elimination of redundant functionality and hardware, and ultimately reduce vehicle acquisition and upgrade costs. By all indications, the VICTORY standard has passed the "tipping point," and has now become a de facto requirement and a common line-item in many requests for proposal (RFP) issued today by the DoD and system integrators. Government Program Executive Offices (PEOs) are now commonly stipulating VICTORY as a requirement for upgrades.

In today's budget climate, with fewer new platform designs getting started, VICTORY compliant solutions are well-positioned for use in enhancement upgrade packages to help reduce the number of boxes that are needed to add capabilities into a particular ground vehicle. VICTORY also helps combat obsolescence, since its core architecture fosters interoperability and provides an upgrade path that speeds and eases the addition of new capabilities to vehicles in the future.

Figure 13: New and legacy ground vehicle platforms poised to modernize C4ISR systems leveraging VICTORY architecture. Photo Credit: OshKosh Defense

Commercial vendors, including the Curtiss-Wright Defense Solutions division, are already beginning to see VICTORY compliance as a requirement for new light tactical vehicle subsystems as well as in the emerging modernization requirements for combat vehicle platforms. Open standard-based rugged subsystems can address critical programs such as Abrams, Bradley, Stryker Modernization, and the Joint Light Tactical Vehicle with technology and packaging leadership, delivering standard-compliant products and their resulting flexibility, modularity, compatibility, and reduced cost.

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Learn More

- DuraDBH-672 Digital Beachhead
- DBH-670 Digital Beachhead
- DuraCOR 80-41 Mission Computer
- DuraNET 20-11 8-port Ethernet Switch
- DuraNET 20-10 20-port Ethernet Switch
- Vehicle Integration for C4ISR/EW Interoperability (VICTORY)