TECHNOLOGY WHITEPAPER

Ground Vehicle Modernization with VICTORY and GVA

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Ground vehicle modernization

Network integration evaluation and deployment

Achieving GVA and VICTORY goals through COTS solutions

Introduction

Historically, adding or enhancing command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) functionality in tactical ground vehicles has been a challenge. While advancements in technology have done much to improve vehicles' capability in the field, such upgrades have typically burdened vehicles with cumbersome "bolt-on" electronics equipped with proprietary, stove-piped communication interfaces and numerous independent Global Positioning System (GPS) and Human Machine Interface (HMI) peripheral devices.

As a result, modernizing ground vehicles to add new capabilities or feature the latest technology is unnecessarily complex. Upgrading technology with proprietary interfaces entails a costly and complicated migration process. As well, the lack of interoperability between in-vehicle systems results in redundant equipment, consuming excess power and taking up valuable real estate in an already constrained space that must accommodate people, ammunition and supplies. In this cramped environment, manually enabling communication between systems creates additional work for vehicle operators. Ultimately, these factors combine to create a poor, unsafe in-vehicle experience for warfighters, with reduced reliability and an increased chance of mission failure.

Modern efforts like VICTORY and GVA are simplifying system upgrades and modifications and while reducing complexity.

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Fortunately, modern efforts like the U.S. Army's VICTORY (Vehicle Integration for C4ISR/EW Interoperability) initiative and the United Kingdom's Ministry of Defence (MOD) Generic Vehicle Architecture (GVA) are paving the way for a modern battlefield where system upgrades and modifications are quicker and less expensive. This white paper will explore these two emerging and comparatively similar frameworks, highlighting key similarities and differences between these initiatives and discuss the benefits of using such frameworks in land vehicle upgrades and new builds.

Forces Driving Modernization

Siloed governmental acquisition processes have historically led to ground vehicles featuring a number of duplicative and proprietary C4ISR systems. 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 capability into a vehicle, the additional hardware usually comes with its own chassis, cables, keyboards, and other components. This results in unnecessary 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 independent GPS receivers, each with its own external GPS antenna, that draw from the same GPS source, but aren't yet integrated together.

A host of different strategic, operational and technological drivers are instigating change in modern vehicle electronics architectures. Budgetary pressures to reduce cost, requirements for specific networked technologies to improve situational awareness, governmental mandates for advanced GPS technologies, and the underlying size, weight, and power (SWaP) constraints of today's tactical vehicle platforms are all key factors influencing this shift. As well, 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 global push for improved practices. Since there are currently many legacy systems that are difficult to upgrade because they can't easily be pulled out and replaced, the goal of these initiatives is to ensure that new C4ISR systems or platforms don't suffer from the same legacy stovepipe challenges, and are instead easily modified and upgradable due to device interoperability. Additionally, the integration of open systems into vehicle designs will increase product availability and vendor competition, which will in turn "facilitate a more open market, improve procurement, enhance market competitiveness, and achieve smarter procurement and value-for money".[1]

With multiple different programs aiming to ease system integration and reduce complexity, it can be confusing to understand which framework should guide system architecture design. The obvious choice can be made if you are developing a ground vehicle for the U.S. (VICTORY) or the U.K. (GVA), but without the clear distinction, understanding the differences between VICTORY and GVA (as well as its global counterpart, NATO GVA) will give you a better understanding of which provides the right framework for your system architecture.

The VICTORY specification was officially kicked off in 2010 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." At its core, the VICTORY framework promotes the use of open standard physical and logical interfaces between LRU subsystems on C4ISR/EW combat vehicles. The open architecture standard is not intended to define how LRUs are built, but rather how these LRUs can intercommunicate and share data and resources, resulting in SWaP savings.

In addition to decreasing the size, weight, and power consumption of the myriad C4ISR subsystems overcrowding the crew area inside a vehicle, VICTORY integration also increases situational awareness and reduces users' operational burden. For example, the three major pieces of gear in a vehicle — the gun station on top of the vehicle, the threat detection system and the battle command system

VICTORY's Vision

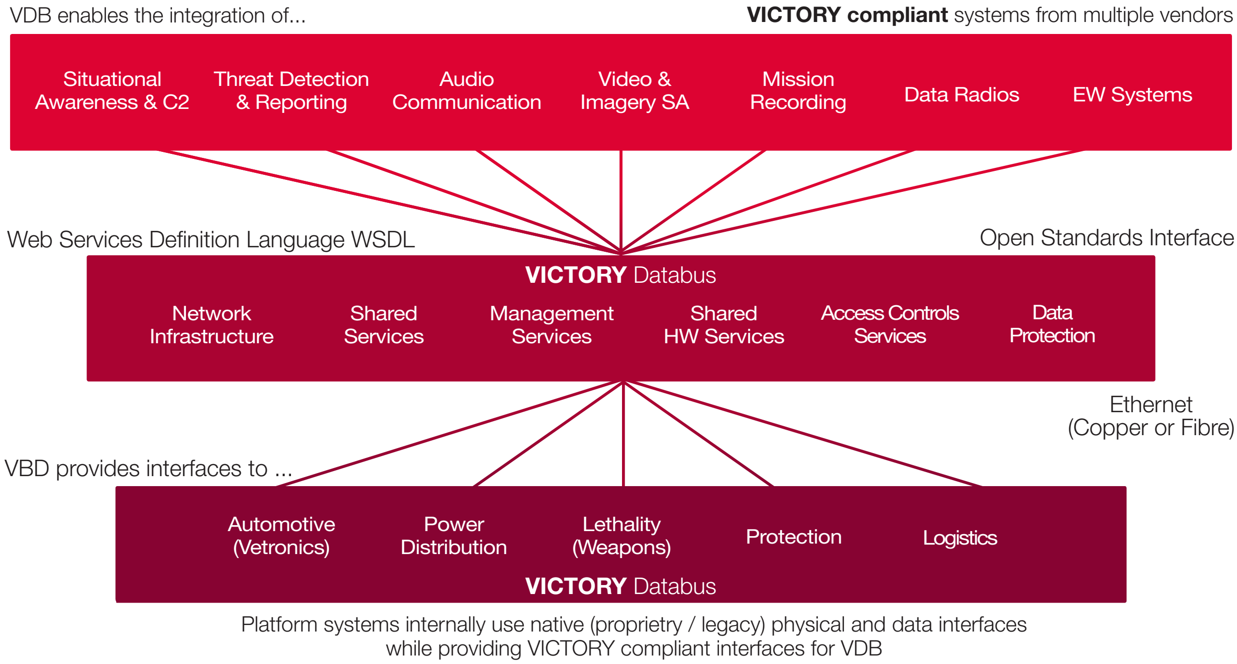

Figure 1: VICTORY Ethernet Architecture

that tracks allies and adversaries - operate independently in a non-VICTORY design. In this scenario, 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, simplify the in-vehicle experience, reducing the risk of human error, and ultimately saving lives.

To ensure that companies can create VICTORY compliant systems, the U.S. Army built its own mature open source libraries, and used standard Ethernet protocols. This enables the use of commercial off-the-shelf (COTS) switch and router products, with minimal change.

The GVA Approach

Similar to VICTORY, GVA is an approach introduced by the U.K.'s Ministry of Defence to mandate open, modular, and scalable architectures in the design of land vehicles. Its standards apply to electronic and power infrastructures, mechanical interfaces, Human Machine Interfaces (HMI) and Health and Usage Monitoring Systems (HUMS).

Outlined in Ministry of Defence Standard (Def Stan) 23-09, the goal of the GVA approach is to realize operational, technical, and cost benefits by promoting open standards for software and hardware interfaces to enable simple and rapid replacements or upgrades of equipment as needed. Intended to be applied not only on new land vehicle designs, but also "whenever practicable by amendment to those already in existence"[2], the GVA infrastructure encourages the use of adapters or gateways to enable interoperability with legacy equipment. Similar to VICTORY, GVA does not mandate specific solutions but specifies a generic architecture that is platform and vendor agnostic, which can be tailored to design requirements. Interoperability is enabled by the Data Distribution Service (DDS) middleware system, a generic software interface that allows the exchange of data between equipment of different manufacturers.

Comparing GVA and VICTORY

GVA and VICTORY have very similar goals and their approach is fundamentally different. Where VICTORY specifically aims to provide an architecture for C4ISR/EW systems, GVA has a wider remit across the entire land vehicle platform (Tony White, 2018). Additionally, both standards are based on global open standards and make use of technology such as Ethernet but while GVA is freely available on the public U.K. MOD website, VICTORY is limited to U.S. citizens working on U.S. programs.

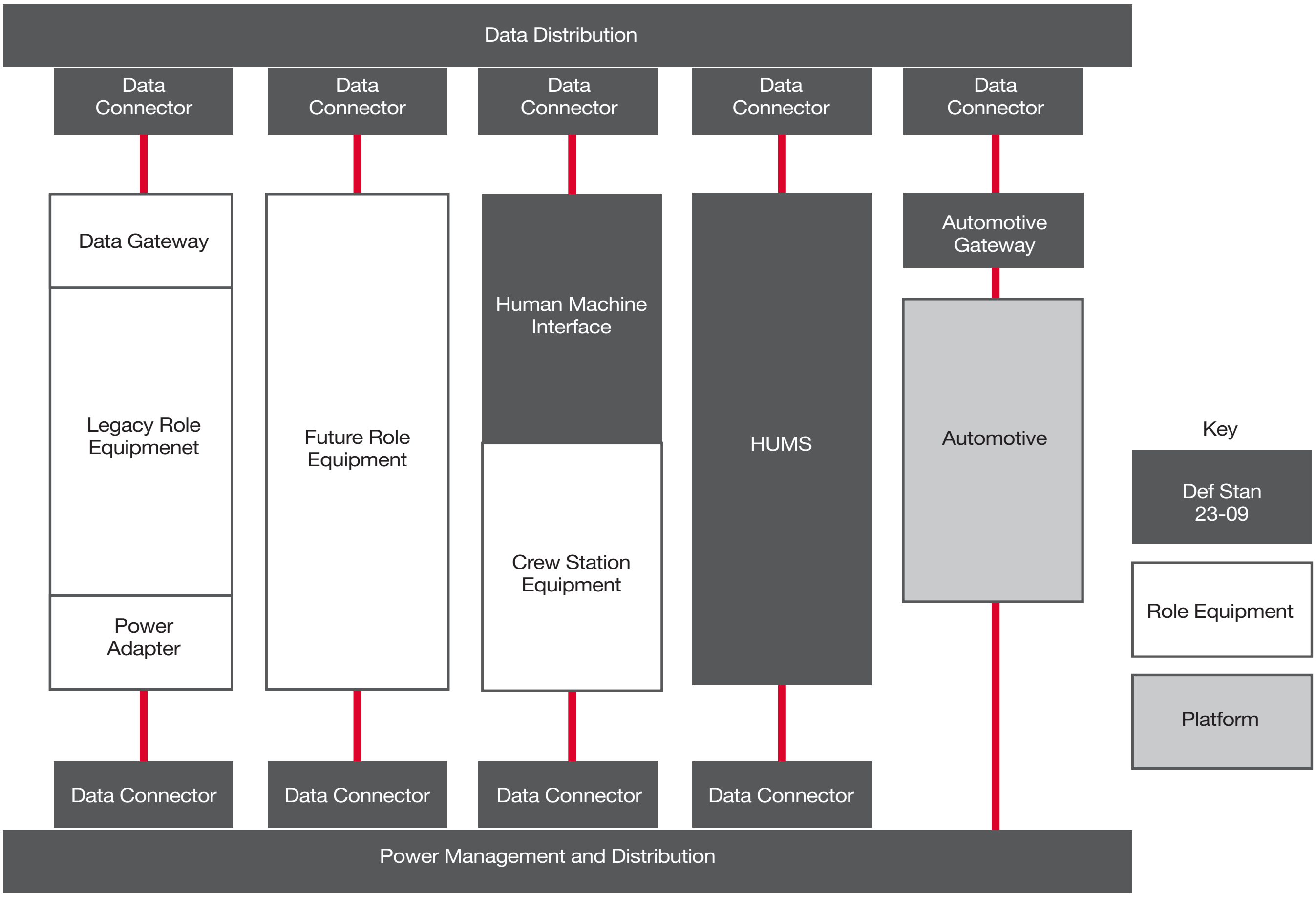

Figure 2: GVA Data Distribution Model

In the VICTORY architecture in Figure 1, all systems communicate over Ethernet, enabling shared use of data, signals and peripherals, such as a keyboard, across multiple pieces of equipment. To achieve this, system integrators create VICTORY software using open source libraries based on SOAP (Simple Object Access Protocol) to allow communication between devices over Ethernet and ensure interoperability. This service-based network (referred to as the VICTORY Data bus or VDB) is similar to GVA's middleware approach based on the Data Distribution Service (DDS) messaging protocol and DDS wire protocol (DDS is an open standard released by the Object Management Group, a systems software standards organization), that enables inter-device communication across any common data bus. Similar to VICTORY, GVA's middleware approach decouples applications and enables "plug-in" integration, and does so through a real time publish/subscribe method of communication (Figure 2).

Though VICTORY and GVA are similar in defining open standards software to increase technical flexibility and scalability of C4ISR/EW systems, GVA takes it a step further by including guidance on physical interfaces, HMI, and video distribution standardization across all the electronic systems on a ground vehicle.

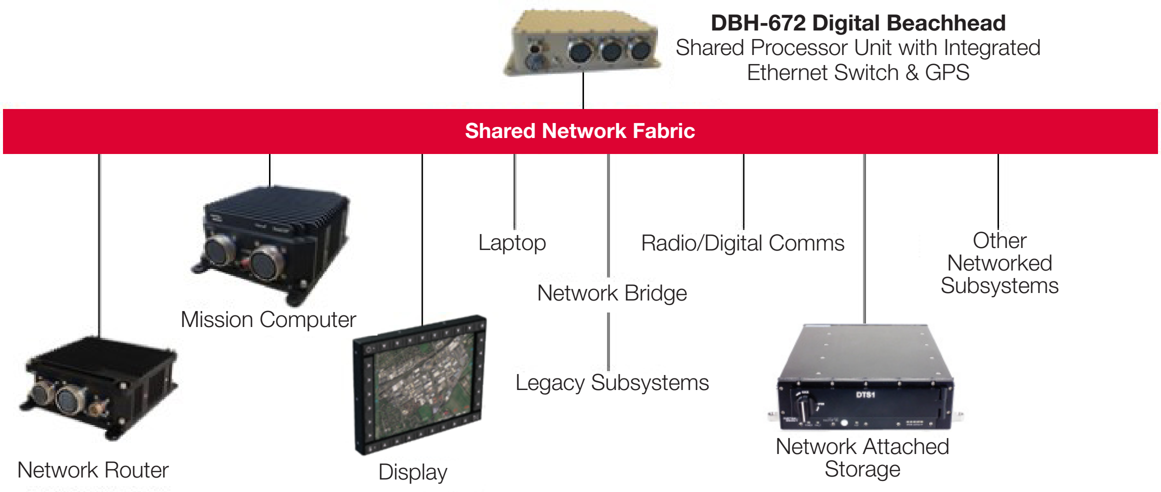

Figure 3: VICTORY - Data-bus centric design

Scalable, Modular, Open System Technology

Ease of integration of both new and legacy systems is streamlined through the use of scalable, modular, open systems technology. For this reason, both GVA and VICTORY emphasize the use of modular COTS systems.

The GVA Def Stan 23-09 breaks down the definition of scalability to describe both horizontal and vertical capability expansion. It describes horizontal scalability (or "scaling out") as the ability to scale system performance with the addition or subtraction of system elements, whereas vertical scalability ("scaling up") "addresses how the existing architecture can be extended to provide additional performance (bandwidth, processing power, etc.) by exploiting existing spare capacity, simple replacement, or minor modification"[3]. As well, it posits that a modular architecture is "designed in such a way as to allow the replacement or addition of subsystems and upgrades as required without any undesirable emerging properties."[4] Both vertical and horizontal scalability is achievable by enabling communication between devices via the open source data distribution model, using software and connectors. Using modular, upgradable, COTS, open standards based systems or electronics increases system scalability with the ability to quickly add (or subtract) functionality.

In the U.S., the Department of Defense (DoD) Modular Open System Architecture (MOSA) initiative is similarly driving the use of open system approaches for ground vehicles both from the technical and the procurement perspectives. VICTORY is a prime example of MOSA policy implementation and explicitly encourages the use of COTS open standards. VICTORY LRUs exploit cutting-edge commercial networking technology such as Web Services, SOAP, and XML through VICTORY open source libraries. This ensures system interoperability and encourages VICTORY complaint COTS development resulting in modular, open COTS systems that are inherently scalable in a VICTORY Ethernet architecture.

Leveraging a modular system architecture gives 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 or GVA component types, as needed.

Choosing Between GVA and VICTORY

While both are network-centric architectures that support equipment or service publishers and subscribers at an application software level, VICTORY provides the architecture to support C4ISR/EW systems and GVA includes direction on physical cables, connectors and electrical interfaces as well as common HMIs. Modern frameworks, both GVA and VICTORY architectures are based on a common Ethernet data-bus and rely on the concept of network adaptors or connectors; VICTORY uses SOAP and XML to publish data or provide access to networked systems and GVA uses the DDS to do the same. In theory, GVA and VICTORY are interoperable with the addition of software that supports both frameworks and converts messages from one to the other. While full interoperability between the frameworks will require years of development and convergence, today, the use of middleware can enable a VICTORY compliant system to work in GVA architecture.

Upgrading versus New Build

One of the key reasons for moving to either standard is to enable quicker integration or upgrade of components. Both standards are driven by the need to easily change out a vehicle's role/capability by simply disconnecting network cables and connecting the new device to the system. Ideally, adding and removing software wouldn't be necessary, nor would modifications to cabling. Though this is the long-term goal, it isn't immediately achievable to update an existing system to either architecture. When updating existing systems, significant software configuration is required to enable communication when plugged into the system. If all new systems are GVA or VICTORY compliant, future generations of land vehicles will reap the interoperability benefits of GVA or VICTORY architectures implemented today.

Compliance

Though it is easy to use these standards as design guidelines, being fully compliant to either is very costly and time consuming for system developers. GVA does not have a third-party certification house that can determine if your product is compliant. Instead, it is left with system developers to determine their own compliance given the available documentation on GVA. VICTORY, on the other hand, supplies developers with a test suite that enables companies to self-test compliance. Passing the test enables you to call your system compliant and ensures interoperability with other systems in a VICTORY architecture.

Compliance to either standard can be a lengthy process with much room for error and, due to lack of industry knowledge of either standards, compliance might still leave customers confused. For example, you can develop a mission computer that has Ethernet and the ability to run VICTORY software, but it is up to the customer to develop, install and manage the software to get their system to be VICTORY compliant. Similarly, a product may claim to be GVA compliant but that could just mean that, given the correct software, it could communicate with the GVA data model.

Similar Frameworks around the World

Adoption outside of the U.S. and U.K. is also seen, with approaches like NATO GVA (NGVA) and Australian Generic Vehicle Architecture (AS GVA). These variants widen GVA's reach and promote interoperability and standardization between systems from allied nations.

Similar to GVA, NGVA is "an open standards-based approach to the design and integration of multiple electronic subsystems onto a military vehicle, which are controllable from a multifunction crew display and control unit. It has been based on the U.K. [Ministry of Defence] GVA approach but NGVA strives to enhance and expand it."[5] The NATO GVA enhancements to GVA include coverage for a wider range of platforms such as unmanned vehicles and additional requirements on, for example, the Crew Terminal Software Architecture. Like GVA, NATO GVA uses the DDS and Land Data Model.

Also derived from GVA, AS GVA is defining a Land Data Model and DDS for seamless information exchange across a common communication network. An example of AS GVA's success can be seen in General Dynamics' Ajax armored vehicle, touted as the most advanced armored fighting vehicle available.[6] Its digital architecture featuring GVA allows common interfaces for all the sensor systems, communications and extra screens to be plugged in without requiring re-engineering of the vehicle every time it's upgraded.

Conclusion

In today's budget climate, VICTORY and GVA ready solutions are well positioned for use in enhancement upgrade packages, as well as new designs, to help reduce the number of boxes that are needed to add capabilities into a particular ground vehicle over time. VICTORY and GVA also help combat obsolescence, since their core principles mandate interoperability and enable an upgrade path that speeds and eases the addition of new capabilities to vehicles in the future.

The promise of both VICTORY and GVA standards is that its wide adoption will help to increase interoperability, eliminate redundant functionality and hardware, and ultimately reduce vehicle acquisition and upgrade costs. By all indications, the VICTORY and GVA standards have passed the "tipping point," and have now become a de facto requirement, and common line-item, in many requests for proposal (RFP) issued by the DoD, MOD and system integrators. Government Program Executive Offices (PEOs) are now commonly stipulating these standards as a requirement for upgrades. Commercial vendors, including Curtiss-Wright's Defense Solutions, are already beginning to see VICTORY and GVA compliance as a requirement for new light tactical vehicle subsystems, as well as in the emerging modernization requirements for combat vehicle platforms.

Functionally, both VICTORY and GVA address the same needs for lower cost system development, reduced redundancy, and higher communication and cooperation between stove-piped systems. Both standards achieve this but with different languages. Choosing which framework, if any, is best for you depends on a number of factors, including where the system or subsystem will be fielded (VICTORY for U.S., or GVA for U.K.), the type of system being developed, and if it is an upgrade or new build.

At the frontline of bringing the VICTORY and GVA architecture into ground vehicles, rugged COTS technologies from Curtiss-Wright are helping to showcase the benefits of adopting a common communications architecture and consolidating modern computing and networking architectures for SWaP optimization. Leveraging over 80 years of experience and expertise developing rugged, field-proven defense technology, Curtiss-Wright has engineered its GVA and VICTORY ready solutions to not only optimize SWaP, flexibility and modularity in ground vehicle systems, but also ensure scalability and interoperability with legacy systems. Beyond providing these benefits to ground vehicle designers and the armies they provide for, these open standards-based solutions improve the in-vehicle experience for today's warfighters. By reducing system complexity and clutter while enhancing situational awareness, Curtiss-Wright solutions like the DBH-670 and DBH-672 switch router and GVDU Mission Display provide the performance and reliability ground vehicle operators can trust to protect them as they protect our nations.

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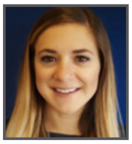

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Vehicle Integration for C4ISR/EW Interoperability (VICTORY)