

**2014 NDIA GROUND VEHICLE SYSTEMS ENGINEERING AND TECHNOLOGY
SYMPOSIUM
VEHICLE ELECTRONICS AND ARCHITECTURE (VEA) TECHNICAL SESSION
AUGUST 12-14, 2014 - NOVI, MICHIGAN**

WHY SOME STANDARDS DON'T GUARANTEE INTEROPERABILITY

Jason Dirner

NetCentric Technology, LLC
Aberdeen Proving Ground, MD

Adam Melber

U.S. Army, RDECOM CERDEC I2WD
Aberdeen Proving Ground, MD

John A. Pankowski

NetCentric Technology, LLC
Aberdeen Proving Ground, MD

ABSTRACT

Leveraging an open standard may still not achieve the desired interoperability between systems. Addressing “lessons learned” from past implementations of open standards for various Department of Defense (DoD) acquisition programs is critical for future success. This paper discusses past issues which range from insufficient technical detail, when and how to apply a given specification, verification of an implementation’s compliance, to inconsistent and imprecise contractual language. This paper illustrates how the Vehicular Integration for C4ISR/EW Interoperability (VICTORY) initiative addresses these challenges to enable interoperability on Army ground vehicles, as well as facilitate rapid technology insertion and incorporation of new capabilities. VICTORY represents a leap ahead in solving interoperability challenges and defining open standards.

INTRODUCTION

Applying standards to hardware/software development is nothing new for the military. Many of us are familiar with MIL-STDs such as a MIL-STD-1679, which evolved to MIL-STD-2167, and then to DoD-STD-2167A. These specified how to develop software for the military (processes, milestone reviews, deliverables, etc.) and had ancillary MIL-STDs for associated documentation. They were very good for that period of time, where software languages, development strategies, and associated tools were relatively new. But, of course, software development methodology and technology have advanced. The same is true for hardware.

The concept of “open standards” has evolved to apply to software and hardware development in both commercial and DoD sectors. However, this term appears to be an oxymoron. Are they flexible as the word “open” suggests, or rigid as the term “standard” implies? One would think the term “Openly Accessible Standards” would have been a better, more descriptive term. (Don’t know of any programmers that have had second careers as novelists.) It needs to be clear that standards (i.e., rigidity and specificity) are good, while being open (i.e., letting people know about them, use them, and evaluate them) is also good, which leads us to our topic “Why Some Standards Don’t Guarantee Interoperability”.

The DoD has correctly followed the evolution of software and hardware development in using open standards, but has seen some setbacks in the learning curve. This paper will highlight some of the lessons learned from applying open standards to DoD acquisitions, and show that VICTORY has listened to and addressed these issues relative to the interoperability of systems. Furthermore, VICTORY has analyzed legacy C4ISR/EW capabilities, systems, and interfaces to define standard “component types” to facilitate System-of-System Engineering (SoSE) in Army ground vehicles.

TERMINOLOGY

The following terms are important to clarify before discussion of our topic.

“Architecture”: A conceptual framework defining overall concepts and terms, identifying elements to be standardized, including component types, their interfaces, design patterns, and common structures.

“Specifications”: A document containing specifications of varying maturity levels, which identify the technical details of system (application) and component interfaces.

“Standard”: A *specification* at a certain, high level of maturity.

“Reference Design”: Document describing how the *specifications* could be deployed.

LESSONS LEARNED FROM EARLIER DOD PROJECTS

In 2010, the Army’s Acquisition Executive asked for an after-action analysis of the Future Combat System (FCS) program in order to leverage its successes and learn from its problems. The source of the lessons learned quotations (regarding interoperability) related here is the RAND Corporation, Army Research Division’s research paper titled: *Lessons from the*

Army’s Future Combat Systems Program [1]. However, similar missteps and issues can be found elsewhere in other projects, both in the DoD and commercial sectors. This section proceeds with quotations from this analysis paper followed by explanations as to how VICTORY addresses the issues and lessons described.

“Immature technologies and insufficient understanding of requirements can lead to instability and significant changes later”. [2]

Engineering changes become increasingly expensive as a program progresses. Changes made late in the game can significantly impact a program’s cost and schedule. It is imperative that a specification is mature before it is employed to avoid incurring unneeded change later on. Anyone that has been involved in the development of a specification knows that writing and implementing are two very different things. It’s typically not until you implement a specification that you discover issues regarding clarity and completeness. The resultant ambiguity will open the door for discrepancies in interpretation and implementation, thus jeopardizing the ultimate goal of achieving interoperability.

The VICTORY standards development process addresses this concern by conducting an initial validation experiment to prove that a specification is reasonable and effective before proposing it as a standard. Validation experiments include the development of lab prototypes to verify functionality, performance, and resource requirements. The validation team is intentionally firewalled from the standards body to ensure that their implementation is based solely on the specification document and is not influenced by prior discussions. Results of the validation experiment are incorporated into the specification before it is approved

and released. Validation artifacts resulting from this initial implementation are provided in a reference software library that can be leveraged by the community to jumpstart development.

“Designing smaller integrated units could facilitate the development of requirements for large systems of systems.” [3]

Complexity increases exponentially with the number of systems integrated. Attempting to take a top-down approach by specifying requirements for the system of systems as a whole will increase the probability that details will be overlooked until the integration phase. A more manageable approach is to define standard components with well-defined functions and interfaces. This approach affords the system integrator with increased flexibility to combine components as needed to achieve the desired capabilities. Changes in scope are limited to a subset of components versus the entire system of systems, which in turn minimizes impact on cost, schedule and performance of the program.

The VICTORY architecture is based on a bottom-up approach in order to provide an evolutionary integration of electronic systems on Army ground vehicles. Component types represent common functions of both current and emerging C4ISR and EW systems. By clearly defining the functionality of each component type, along with the interfaces to integrate components over a network-based data bus, VICTORY allows material developers to independently implement each component. Required functionality and associated interfaces are identified (usually in contract verbiage) by referring to one or more component types in the VICTORY standard specifications.

This component-based architecture approach ensures that vendors implement the appropriate aspects of what are most times vast and complex standards. Use of a VICTORY-provided Compliance Test Suite helps vendors make accurate claims regarding VICTORY compliance. The Compliance Test Suite reduces vendor burden by providing configurations and methodologies for conducting verification tests, tools to automate or provide guidance for each test, and templates for documenting test results. This robust and standardized verification process provides high confidence that acquisition activities will deliver the necessary interfaces, which in turn should decrease the number of issues encountered during final integration. Figure 1 illustrates the interfaces associated with the Position Service in the VICTORY architecture.

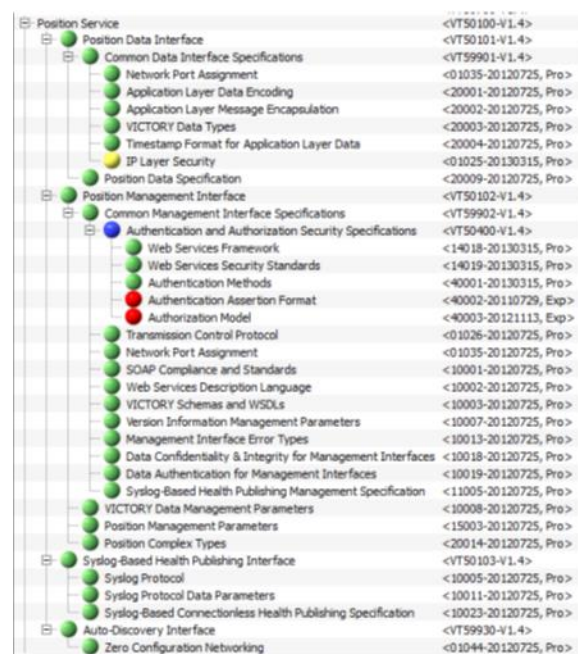


Figure 1. VICTORY Position Service Interfaces [4]

“The implementation of formal Interface Control Documents (ICDs) was an attempt to align FCS with outside programs’ cost, schedule, and performance ... For such

programs, an ICD could be written only as a result of negotiation between the controlling parties.” [5]

Establishing ICDs between programs can be a challenging and time consuming process. ICDs have to be mutually beneficial to all parties while taking into consideration each organization’s funding and schedule constraints. For these reasons and many more, standards that are unilaterally developed will encounter heavy resistance to adoption which will ultimately lead to their failure. VICTORY addresses this concern by developing all specifications within a standards body that is open to Government, industry, and academia. Use of a standards body fosters communications within the community while ensuring that the resulting specifications support each organization’s requirements.

VICTORY’s mantra is “ADOPT as much as we can, ADAPT if necessary, and AUTHOR only if we absolutely have to”. By adopting existing standards whenever possible, VICTORY leverages the collective expertise and prior investments of the community. Vendors are incentivized to propose their internal (potentially proprietary) specifications as open standards in hopes that this gives them a competitive advantage in terms of time to market. A regimented development and maturation process ensures that all parties have equal opportunity to provide input, evaluate proposals, agree in principal, and review documentation.

IMPLEMENTATION GUIDANCE

Standards must have a “*sufficient level*” of detail to ensure independent implementations are interoperable. This *sufficient level* is achieved when there is not any ambiguity regarding: which messages accomplish a particular function, the exact meaning and

format of individual fields, and what fields are mandatory versus optional. The following examples illustrate how VICTORY provides amplifying language regarding how commercial standards are applied in order to achieve a *sufficient level* of detail.

Web services are based on Hypertext Transfer Protocol (HTTP), Simple Object Access Protocol (SOAP), and eXtensible Markup Language (XML). In and of itself, these standards do not provide any information regarding the functionality that is offered by a web service. This information is contained in a Web Service Definition Language (WSDL) file that identifies the associated web methods, parameters, and returned data structures. One could specify that a vendor use HTTP, SOAP, and XML for communications and still end up with a stovepipe solution that is not interoperable with other systems. VICTORY goes an extra step to provide the *sufficient level* of detail by defining the WSDL for each component type. For example, the WSDL for the Position Service specifies how to retrieve data such as the current platform position, as well as the specific format of the XML structure that’s returned.

Access control for network resources can be implemented using Security Assertion Markup Language (SAML) and Extensible Access Control Markup Language (XACML). Although these standards define the structure of principal assertions and policies, additional guidance is required to describe how to combine these standards to implement an access control framework. Again, VICTORY goes an extra step to provide the *sufficient level* of detail by defining an Attributed-Based Access Control (ABAC) framework that is consistent with best business practices. This access control framework specifies how SAML and

XACML are used to pass information between associated services including a Policy Enforcement Service, Policy Decision Services, Attribute Store Service, and Policy Store Service.

CERDEC I2WD OPEN ARCHITECTURE EFFORTS

Communications-Electronics Research, Development and Engineering Center (CERDEC) Intelligence and Information Warfare Directorate (I2WD) is leveraging VICTORY to perform rapid integration of Electronic Warfare (EW) capabilities. I2WD is developing VICTORY Adapters for legacy EW systems to translate between proprietary vendor messaging and VICTORY standard interfaces. Use of standard interfaces enables a common user interface to provide Command and Control (C2) and Situational Awareness (SA) for all EW systems on a platform. Integration of a gateway to translate between VICTORY and extra-vehicle protocols also enables remote management of EW assets from a Tactical Operations Center (TOC).

I2WD is conducting research into interoperability between EW systems that is now achievable with VICTORY. One research area is the ability to use VICTORY to coordinate between systems to share the electromagnetic spectrum. Coordinated spectrum access is one of many techniques being explored to improve compatibility on ground vehicles. Other research areas include sharing of EW assets to reduce the hardware footprint on the platform, as well as automated tipping and cueing based on messages published over the network. Open architectures including VICTORY will enable technology insertion to address emerging threats, as well as facilitate coordination between systems to deliver precise and targeted electronic warfare effects.

I2WD is defining a Modular Open RF Architecture (MORA) based on VICTORY standards and methodologies. MORA decomposes monolithic radio systems into modular components including Software Defined Radios (SDRs), Radioheads, and RF Distribution Devices (RFDDs). An SDR implements all of the signal processing for the radio system, while a Radiohead includes the signal conditioning (e.g., power amplifier) and antenna. Each SDR is connected to one or more Radioheads using RF cables and an RFDD. Configuration, control, and health monitoring of each device occurs over the VICTORY Data Bus (VDB). The MORA High Speed Bus (MHSB) supports low latency, highly deterministic messaging for real-time communications between components. A power bus completes the architecture by providing standard vehicle power to each device. The MORA architecture is illustrated in Figure 2.

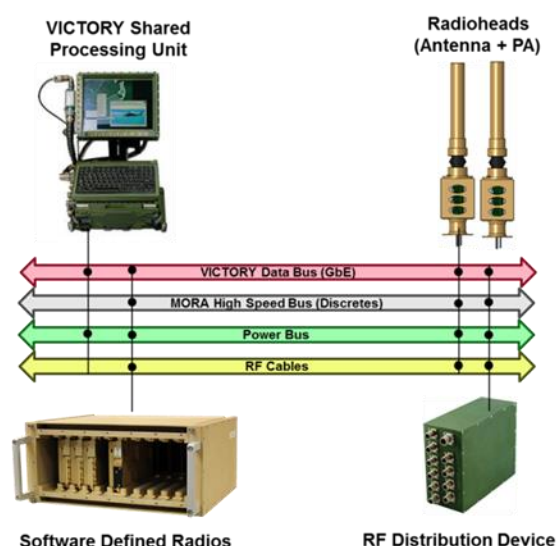


Figure 2. MORA Architecture Composition

MORA enables sharing of hardware components such as power amplifiers and antennas. MORA's functional decomposition also exposes new points in the architecture

that were previously not accessible. This in turn provides system integrators with the flexibility to insert third-party capabilities to address technical challenges and emerging requirements.

Because most RF applications have the same underlying hardware requirements, a radio's personality can be changed simply by provisioning it with new software. Although the concept of a SDR is not new, the standardized interfaces that MORA defines enable monitoring and management of SDRs via common user interfaces and platform automation. By moving from dedicated hardware supporting a single mission to general hardware capable of supporting any mission, MORA makes hardware a *commodity* - a commodity that can be dynamically configured based on mission objectives. Further, system integrators can now establish *pooled resources* that provide varied levels of availability. For example, a dedicated spare could be included to provide 1xN redundancy (to tolerate the failure of a single component without any loss of capability). On platforms where redundancy is not an option, MORA allows the warfighter to select which capability is lost by preempting a lower priority mission.

SUMMARY

VICTORY embraces new technologies and development methodologies based on a bottom-up SoSE approach with a keen eye on lessons learned from previous acquisition efforts. VICTORY addresses a major lesson learned by employing a manageable architecture consisting of well-defined component types and associated interfaces. VICTORY also has in place rigorously defined processes for specification development, along with a standards body to oversee their maturation and consistent application. Independent and consistent evaluation of an implementation's

compliance to standards is critical to ensure interoperability between systems.

The VICTORY initiative addresses past challenges to enable interoperability on Army ground vehicles, as well as facilitate rapid technology insertion and incorporation of new capabilities. VICTORY represents a leap ahead in solving interoperability issues and defining open standards.

REFERENCES

- [1] Christopher G. Pernin, Elliot Axelband, Jeffrey A. Drezner, Brian B. Dille, John Gordon IV, Bruce J. Held, K. Scott McMahon, Walter L. Perry, Christopher Rizzi, Akhil R. Shah, Peter A. Wilson, and Jerry M. Sollinger, *Lessons from the Army's Future Combat Systems Program* (Santa Monica, California: RAND Corporation, Army Research Division, 2012)
- [2] Ibid., 161.
- [3] Ibid., 24.
- [4] *VICTORY Training Material*, 27 June 2013.
- [5] Pernin et al., *Lessons from the Army's Future Combat Systems Program*, 156