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TARDEC'S VICTORY SYSTEMS INTEGRATION LABORATORY (SIL) IS A KEY TOOL FOR ADVANCING STANDARDIZED GROUND VEHICLE ELECTRONIC ARCHITECTURE

Nikia Williams
Venu Siddapureddy
Leonard Elliott
Nathan Ellis
Patrick Griffin
US Army RDECOM-TARDEC VEA
Warren, MI

Steve Reddmann
Heather Berry
DCS Corporation
Warren, MI

Mark Russell
UBT Technologies, Inc.
Troy, MI

ABSTRACT

The Vehicular Integration for C4ISR/EW Interoperability (VICTORY) Systems Integration Lab (SIL) is established and developed at the U.S. Army Tank-Automotive Research, Development, and Engineering Command (TARDEC). The VICTORY SIL will be utilized for the development and integration of the extensive set of C4ISR/EW technologies that are to be systematically down selected to provide the comprehensive VICTORY services & infrastructure required in the development of mission capabilities of the Army's tactical and combat vehicles. A fully functioning VICTORY SIL will be utilized for validation and independent verification of the Army's and the vendor provided C4ISR/EW sub-systems. The lab will emphasize the importance of testing the data, power & physical interface strategy of the sub-systems in a low-cost laboratory environment before integration onto a vehicle. This paper describes how the VICTORY SIL will advance the RDECOM's vision for a standardized electronic architecture for ground vehicles as well as the strategy and process for the design, development and testing of the infrastructure and the VICTORY core services.

INTRODUCTION

The TARDEC Vehicle Electronics and Architecture (VEA) team started developing the VICTORY SIL in April 2011. The SIL was developed to be an environment to demonstrate, develop and validate the VICTORY 1.0 standards and future implementation of the standards. VICTORY is an initiative that is developing a framework for the integration of Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance / Electronic Warfare (C4ISR/EW) and other electronics equipment on U.S. Army ground vehicles. VICTORY 1.0 is the first version of the standards document and it is intended to be used by the system acquisition and science and technology communities as a citable reference in new procurements, modernization activities, and engineering change proposals. [1] It focuses on key network, information assurance and C4ISR application interface capabilities.

The TARDEC VICTORY SIL was created to support the following objectives:

- Create a lab environment that represents a government owned independent implementation of the VICTORY 1.0 standards
- Provide validation and verification of the VICTORY 1.0 proposed standards to evaluate suitability of the technology solutions specified by VICTORY 1.0 standards
- Provide additional validation testing to take the VICTORY standards from "proposed" to "draft"
- Identify and clarify issues with the language and implementation of the VICTORY 1.0 proposed standards to ensure that the specification provides interoperability and to provide feedback into future versions of the specification
- Provide independent verification of the vendors components to VICTORY 1.0 standard via test service agreements
- Develop testing tools to support the continued testing of the VICTORY standards

- Utilize a representative vehicle cabin to demonstrate the VICTORY1.X standards in a system level vehicle environment
- Build in-house environment and knowledge base to support future R&D capability regarding vehicle electronics and architecture

The TARDEC VICTORY SIL accelerated the development in December 2011 so that it would be ready to support the Engineering Change Proposals (ECP) for both the Abrams and Bradley family of vehicles. The SIL reached Initial Operating Capability (IOC) in June 2012 and is heading towards Fully Mission Capability (FMC) by September 2012.

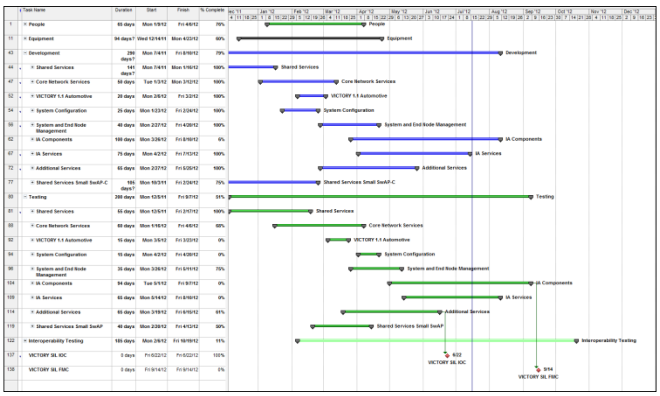

Figure 1: VICTORY SIL Timing Plan

VICTORY SIL DEVELOPMENT

The VICTORY SIL is being developed based on VICTORY 1.0 Standard Specification that was released on 29 July, 2011. Once completed, this facility will be a fully capable lab within TARDEC that houses an implementation of the VICTORY 1.0 standards at a bench level. This lab will create a knowledge base to support future electronics and architecture development. It will also expand TARDEC's involvement and influence towards achieving standardization of the VICTORY standards. It will be used for independent verification testing of the VICTORY 1.0 standards specification and it will help in bringing the specifications to maturity. This lab will be capable of acting as a test bed to allow for VICTORY independent verification of vendors components and products via test agreements.

The VICTORY SIL utilized much of the space and hardware that was used in the development of the Tactical Wheeled Vehicle Survivability (TWVS) Army Technology Objective (ATO) SIL. The TWVS ATO SIL was used as the foundation in the development of the VICTORY SIL. As mentioned, the inherited lab space in TARDEC has hardware and also a surrogate Tactical Wheeled Vehicle cab that will be utilized for implementing the VICTROY Architecture in a surrogate army ground vehicle. In addition, the cab is networked into a Simulation Environment that can create realistic missions for testing with users in the loop.

The VICTORY SIL is being developed in three phases. The first phase consisted of Shared Services, Threat Detection and Reporting, and the Remote Weapon Station (RWS) build up and validation. The second phase consisted of developing VICTORY Data Bus (VDB) Data Transport Interfaces, Management Interfaces, VDB Component Interfaces, C4ISR System Interfaces, VICTORY Configuration Language, and Automotive Services build up and validation. The third phase consists of Security and Information Awareness build up and validation.

The first phase consisted of the development of the shared services or core services that are required by many C4ISR/EW systems. The shared services include: time synchronization, position, direction of travel, and orientation. Time synchronization is important so that the system clocks of hardware components can all have the same notion of time. Developing a standard interface for position, direction of travel and orientation helps to reduce the number of global position system (GPS) antennas and devices and allows you to get vehicle latitude, longitude, altitude from one source, the VICTORY Data Bus.

The threat detection and reporting components are the ones that detect and report active threats to the vehicle platform to the Warfighter. VICTORY allows for the information from these systems to be shared on the VDB so that information can be used by anything on the VDB. It will transport information that may include azimuth, elevation, and distance of a detected threat with relation to the vehicle. One type device that might make use of this type of information is a remote weapons station.

The Remote Weapon Station interface was developed mostly by the Naval Surface Warfare Center (NSWC) Dahlgren with some minor modifications by the VICTORY SIL team. NSWC Dahlgren was asked to develop the VICTORY RWS Data and Management Interfaces along with the Target Messages and integrate that with the CROWS II RWS. Implementing a RWS interface allows for managing configuration, control, status reporting, and fault management interfaces to all be standardized and shared on the VDB.

The second phase of development focused more on the core development of VICTORY and some of its additional services such as the Video, Audio, Radio Controls, and Automotive Services build up and validation. The heart of VICTORY can be found in the VDB. It is based upon the Internet Protocol and Ethernet. Configuration, control, status reporting, and fault management interfaces must be shared and accessed on the VDB. It enables the integration of C4ISR/EW systems on the vehicle. The VDB is what transports data between the C4ISR/EW systems and also between the components of those systems. The additional services help to enhance VICTORY and make it more useful for vehicle programs to use. It includes some of the key functionality of C4ISR/EW systems and allows those systems to use shared service interfaces that are found on the VDB.

The last phase of development is focused on Information Assurance (IA). The Information Assurance portion provides shared hardware and software IA components to enable system integrators to build secure designs that protect information. By developing a set of interfaces and architectures, system integrators can design to varied requirements and constraints. The final portion of our development consisted of tools developed that help track the data and the management of the data on the VDB.

VERIFICATION AND VALIDATION

The **i**mplementation of VICTORY Architecture and Services at the VICTORY SIL is utilized for maturing and standardizing ground vehicle electronic architecture, sub-system interfaces and compliance testing. To support the purpose of the SIL, testing of the VICTORY 1.0 Architecture core services and data bus standards were planned and performed at the SIL. The testing implied that when implemented correctly with the standards format specified by the VICTORY 1.0 the core services are available and manageable on the VDB (VICTORY Data Bus) as shown in Figure 2.

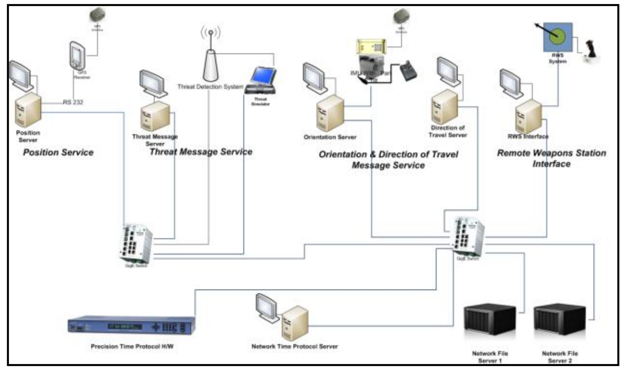

Figure 2: VICTORY Services network as implemented in the VICTORY SIL

The experiments conducted evaluated the interface specifications by integrating software clients and services developed using the specifications, and evaluating the resulting functional behavior and performance.

The following sequence of steps was utilized for testing at the SIL for the core services,

- Specification 1.0 Verification - Message content & Format
- Functional Testing - VICTORY Service Functional Performance
- Management Interface Testing
- VICTORY Service(s) Resource Usage Testing

Additional testing was also conducted on the SIL's VICTORY implementation to validate the interoperability with SwRI's implementation. Also, the implementation was tested with a small SWAP system that hosted all the VICTORY services.

Validation Process

The procedure for designing a Test Plan consisted of the following phases:

1. Review of the documentation provided for the VICTORY standard specifications.
2. Develop experimental procedures for validating the documented specifications. The procedures target each specification being evaluated.
3. Create a logical and physical design for executing the experiment. This phase designs the hardware and software configurations necessary to perform the experiment.

After developing the experiment plan and reference component implementations, the VICTORY SIL is configured in accordance with the logical and physical designs outlined in the experiment plan. As mentioned in the previous section, two test tools were developed and used for managing and monitoring the VDM's:

1. Wireshark VDB plug-in:

A custom dissector plug-in for Wireshark version 1.2.8 was developed for the VICTORY SIL and is used as a tool for testing and monitoring VDM's. This dissector captures UDP VICTORY Data Messages (VDMs) and breaks them down into their specific header and data fields. It also provides a filter to look for VDM messages and the ability to log captured VDMs to a formatted text file.

2. Terminal & GUI Client's for DoT & Orientation VDM Management:

Two clients were developed to manage the VDM's: One is a command line client and the other is a GUI based client. Both of these clients perform the same VDM control functionality, i.e. to enable/disable, set data rates, set update period, etc.

Small SWAP Implementation of VICTORY Services

Reducing the SWAP-C (Size, Weight, Power and Cost) is highly desirable to the Army Ground Vehicles. The VICTORY services that were developed in the SIL were ported to a commercially available low cost small SWAP computer, the Small-SWAP Board, which was tested in the SIL environment. The experiments evaluated the memory, CPU and power consumption of the Small-SWAP Board that interfaces with the sensors and executes software for generating the VDM's using the sensor data.

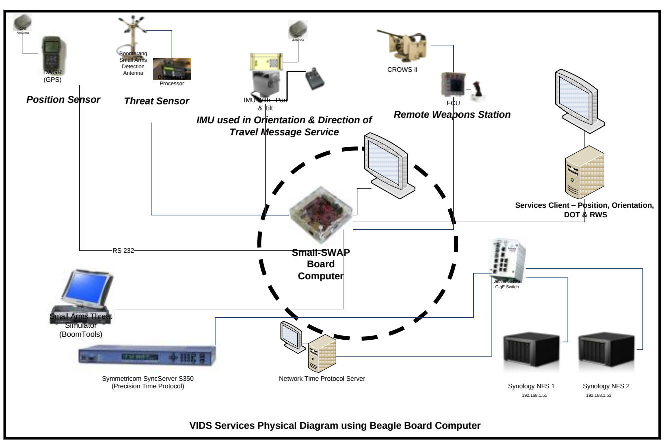

Figure 3 - VICTORY network with Services implemented on the Small-SWAP Board

As shown in Figure 3 multiple VICTORY services were implemented on the Small-SWAP Board within the network that included sensors that provided raw data for Position, Orientation, Timing, Threat and Remote Weapons Station. The results were very encouraging with very low power consumption (3.15 Watts), less than 1% system memory and CPU utilization and very low heat dissipation. Overall, developing and executing services on a Small-SWAP Board type computer on a vehicle platform with tight SWAP requirements is achievable with hardening the system to MIL standards.

Interoperability Testing Between Independent VICTORY Implementations

The focus of this experimentation is to gain confidence in the interoperability of independent implementations of the VICTORY services and make sure that they are compliant with the 1.0 standards. Interoperability should allow you to make use of each other's services and clients interchangeably without having to change the underlying implementation details (code, configuration, etc.).

The Physical/Logical block diagram for testing the services and the clients for SwRI implementations is shown in Figure 4.

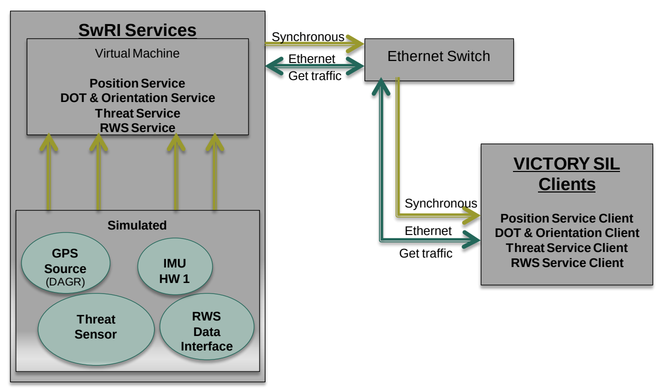

Figure 4 – Block Diagram for SwRI Services testing using VICTORY SIL clients

Similar to the diagram above VICTORY services utilized SwRI provided clients. The clients, on both implementations are used for sinking the VDM's and managing the interfaces. The implementations collected all the sensor data created and transmitted the VDM's.

An Interoperability Testing Matrix was used to methodically test for interoperability between the VICTORY SIL and SwRI services and clients. The VICTORY SIL clients (GUI, Terminal & Wireshark) as described above and the SwRI client provided with the SwRI virtual machine were used in testing and capturing the results. The testing included the VICTORY core services (Position, Timing, Orientation, Direction of Travel, Threat and RWS) controlled and managed by clients from the other implementation.

The VICTORY Service VDM's were tested individually prior to interoperability testing for validity of the data. The interoperability testing involved communicating and setting a set of static and dynamic parameters; this would verify that the management interfaces of the VDM's were implemented correctly and responded to calls with the right data from any of the management clients.

In addition, the 'Direction of Travel' as derived from the 'Position' and 'Orientation' makes use of the data from either of the implementations to create the Orientation service, which confirms that, not only the management and control of the services but the underlying data can be utilized interchangeably with any VICTORY implementation that conforms to the VICTORY 1.0 standards.

Independent Verification of Hardware and Software Utilized in VICTORY Implementations

In addition to standards development, verification and validation, the VICTORY SIL in the near future will be also be utilized for independent verification testing of vendor provided hardware and software that implement VICTORY services and management interfaces. A test agreement will be provided by TARDEC and a test plan will be prepared based on the vendor specified capabilities. The testing will be performed in the VICTORY SIL that will have a fully networked surrogate vehicle cab that represents an actual implementation of VICTORY architecture based network.

In addition, a commercially available comprehensive Network Test and Network Visibility tool is used for network testing and analysis such as Benchmarking for Network Interconnect Devices, LAN Switching Devices, Firewalls, and detailed Quality of Service Testing.

SUMMARY

In summary, the development of the VICTORY SIL at TARDEC has proven not only to be a required capability for advancing open and standardizing Army's ground vehicle architectures but also as a key tool for capturing knowledge and supporting R&D projects that reduce SWAP-C and promote interoperability. In addition, the lab also has the capability to test and verify vendor provided VICTORY capable components and subsystems that support the Army's vision for standardized and interoperable ground systems.

REFERENCES

[1] Vehicular Integration for C4ISR/EW Interoperability (VICTORY) Standard Specifications, Version 1.0, July 29, 2011

[2] http://www.victory-standards.org/