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System Integration Laboratory (SIL) is a Key Tool for Establishing and Testing Systems Engineering Discipline

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ABSTRACT

The Integrated Survivability System Integration Laboratory (ISSIL) developed at the U.S. Army Tank-Automotive Research, Development, and Engineering Command (TARDEC) is a tool which enables and enhances the integration of Soldier survivability technology suites. TARDEC utilized the ISSIL to bridge the gap between concept and realization of the survivability demonstrator vehicle built on MTV 1083 A1P2 platform. The ISSIL was a critical tool for enabling the integration of mechanical, electrical, data, and networking components as well as for validating the system integration through Soldier usability trials. This paper describes how the ISSIL advanced the RDECOMs comprehensive systems engineering process throughout the modeling, analysis, design, development and testing of the demonstrator vehicle.

INTRODUCTION

In 2006, Program Executive Office Combat Support and Combat Service Support (PEO CS&CSS) noticed that TWVs were underequipped for current contingency operations. Along with TARDEC, PEO CS&CSS identified an opportunity to combine efforts on what would become the TWVS ATO. Partnering with government organizations that included the U.S. Army Research Laboratory (ARL) and Engineer Research Development Center (ERDC), and collaborating with academia and industry, PEO CS&CSS and TARDEC joined forces to develop a truck survivability approach that could adapt to changing missions, threats and technologies. The ATO's objective was to demonstrate holistic survivability through the integration of cutting-edge technology solutions for warfighters' current and future needs. The demonstrator truck would be a versatile vehicle with plug-and-play capabilities. The overarching mission requirement was broad - provide protection to the entire TWV fleet [1].

The broad comprehensive mission required selection of 50 technologies through a rigorous gap analysis process. Three Demonstrators, two ballistic demonstrators and the Integrated Survivability Demonstrator (ISD) (Figure 1) were built on onto a standard FMTV platform. The development of these demonstrators followed an Integrated Survivability Approach so that they can a) sustain and defeat multiple threats without compromising on the three P's (Payload, protection & Performance), b) all the layers of survivability are available to the user by integrating suites of technologies that provide the functionality for the layers. The Physical, Power & Data Platforms that were developed and integrated on these vehicles accepted all the 50 survivability technologies. This Integrated Survivability Demonstrator (ISD) does not show the final production integration of a single vehicle. Rather, it focuses on showing the art of the possible in configuring a large number of protection technologies to meet all identified potential threats.

Figure 1: Integrated Survivability Demonstrator (ISD)

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Integrated Systems Engineering Approach

TARDEC studied each potential technology's impact with respect to payload, performance and protection, while keeping cost in mind. In addition, the TWVS ATO team as a whole worked with the U.S. Army Training and Doctrine Command (TRADOC) and other government agencies to conduct requirements analysis, technology assessment and concept development.

Following the analysis process, the TWVS ATO team developed an ISD plan to addresses technical integration challenges. A key tool for implementing the integration is the development and usage of the ISSIL (Integrated Survivability System Integration Laboratory) ISSIL was crucial in bringing the ISD from concept on paper to steel.

The ISSIL focused on enhancing the FMTV capability at a rapid pace in a low risk environment. The main objective was to design, develop, install, and manage a TWV ISSIL that is modular and flexible for evaluating the effectiveness of new survivability technologies and assess the impact of the system integration on mobility, payload, networking, transportability, and sustainability.

This required the development of a system design that is modular and flexible for integrating and performing system evaluations of current and advanced communication, survivability, and vehicle technologies. In short, the ISSIL developed a plug-and-play system that:

a. Maximized the ease of use by eliminating redundancies and simplifying user interfaces.
b. Maximized the capability by developing interoperability and eliminating single points of failure.
c. Minimized life cycle costs through an open architecture to ease integration and enable technology advancement.

ISSIL System Overview

The ISSIL defined the system architecture and provided the ability to exercise component interoperability. It also demonstrated the capability to optimize data and power management, while managing the physical interfaces.

The TWVS ATO utilized the ISSIL as a tool to bridge the gap from concept to development of the ISD, thus accelerating the process of fielding the operational vehicle. The ISSIL evolved from being a Power Systems Lab with emulated loads to a complete system (physical, data & power) integration lab with actual Sub Systems (Figure 2).

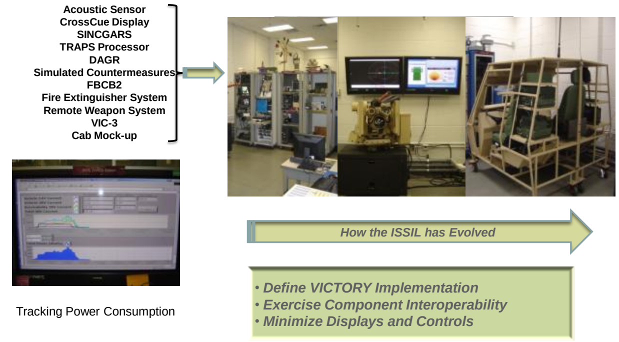

Figure 2: Development & Evolution of ISSIL

The ISSIL developed the ISD system architecture, which was comprised of power components (power control units, inverters, and converters), and the VICTORY (Vehicular Integration for C4/EW interoperability) Data Bus (VDB) components (switches, routers, firewalls, video gateways, and common processors) as well as the physical component packaging on the vehicle. The architectural framework developed supported all the survivability functions of the vehicle (Figure 3). The survivability technologies are tied together via the VDB and are accessed through a common GUI that runs on smart displays. The smart displays run multiple applications, reducing the need for additional processing hardware and the associated burdens for size, weight, and power.

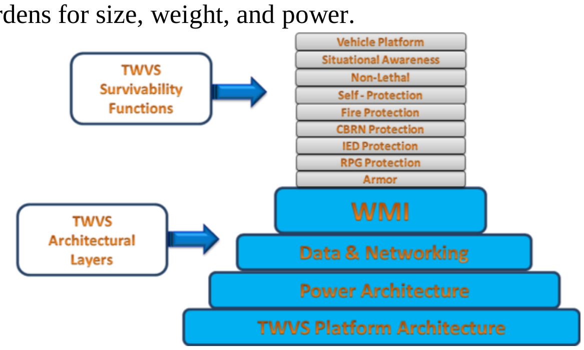

Figure 3: TWVS System Architectural Layers

TWVS Power Control System Layout

The TWVS system integrated a suite of subsystems and technologies which have varying power needs and communicate across various data buses. The TWVS system can be tailored based on mission (Figure 4). In order to develop this functionality, each subsystem is connected through a Remote Power Control (RPC). The RPCs are point of load power switching components that have embedded microcontrollers that are Control Area Network (CAN) and Ethernet based. These PRCs are used for switching the power to the load sources, giving feedback on the current, voltage and temperature at the point of load. They are capable of performing pulse width modulation for advance power management. Other advantages of using the RPCs are:

a. Balancing and distributing power consumption
b. Supporting smart power switching
c. Supporting fault management and isolation
d. Supporting reconfigurable power generation output
e. Supporting component or distributed system architectures and designs
f. Supporting energy storage, power generation, power distribution and control

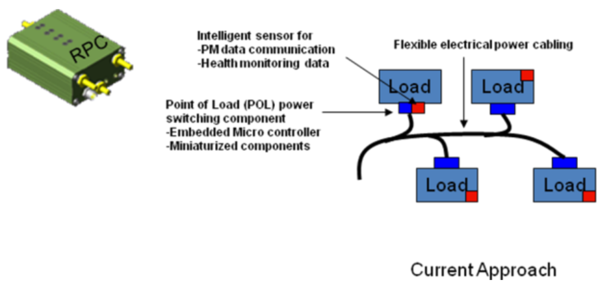

Figure 4: TWVS System Power Control

ISD Data & Network

As the primary focus of the TWVS ISD was to demonstrate systems which enhance survivability, the TWVS ATO adapted and the VICTORY architecture [2] for integrating the electronic systems in its ISD due to the benefits it provided. A VDB (VICTORY Data Bus) was designed and integrated with many systems, including survivability, protection, vehicle, and power control systems. The VDB, as implemented on the TWVS ISD, provided core capabilities to vehicle subsystems (Figure 5). These core capabilities included common time distribution, common position and orientation (with greater accuracy due to the availability of an INS), access to health and status information, and shared computing resources with the possibility for multiple security enclaves using a MILS-based IA solution with a colorless core.

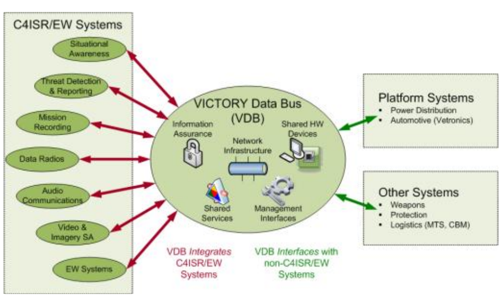

Figure 5: ISD Data & Network Architecture Schematic

Integrated Survivability Demonstrator Platform

The purpose of the FMTV platform based ISD was to integrate suites of survivability technologies which are applicable across the TWV fleet. It was never the intent of the program to promote the ISD as a ready to be fielded solution. Constraints such as transportability, power, payload, optimization of technology integration, crew visibility, Heating, Ventilation and Air Conditioning (HVAC), and maintainability were all considered, and several design concepts were evaluated and refined as large number of technologies that were packaged and integrated onto the platform.

ISSIL built a physical mockup of the FMTV cab and was used for refining the final design of integrating technologies within the physical constrains of the MTV platform. The placement of the components as well as the cable routing was finalized with foam core models of the technologies in the FMTV mockup before the physical buildup of the ISD (Figure 6).

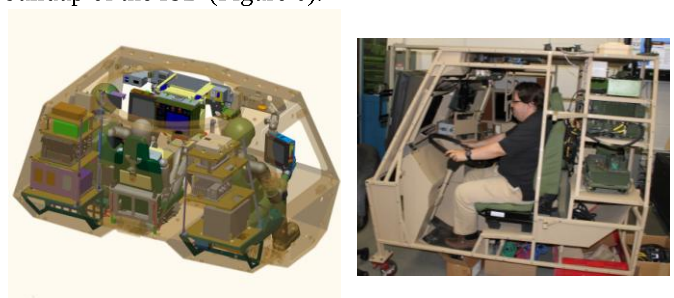

Figure 6: ISD Physical Platform Technology Integration

ISD Warfighter Machine Interface (WMI)

The ATO team designed and developed the WMI that provided the vehicle Commander access to the various survivability systems through Common Display Units. In addition to the data being available on the ISD vehicle through the WMI, all of the health and status feeds were also available to the static Tactical Operations Center (TOC). Using the WMI and the VDB, the Vehicle Commander was able access over 11 camera feeds, including front and rear DVE, four side-blind-spot cameras, the camera of the CROWS weapons system, and a 360° SA camera with both IR and visible optics. The layout of the screens for accessing the data is shown in Figure 7 and an example (the 360° video layout) is also shown in Figure 8.

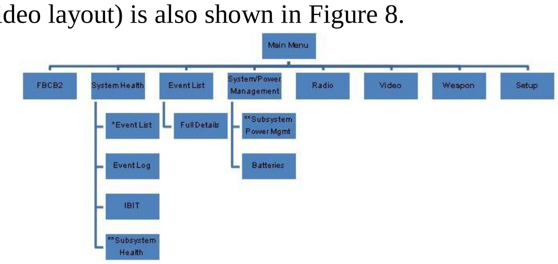

Figure 7: ISD WMI Layout

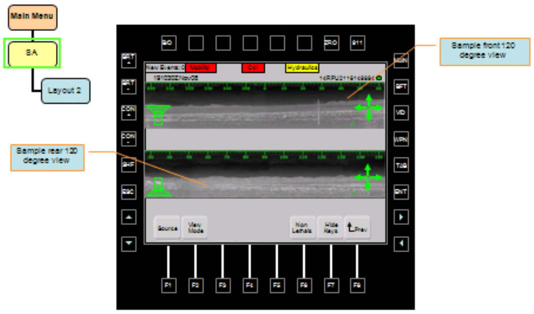

Figure 8: IR Video Interface on the ISD

ISSIL Testing Goals

ISSIL testing validated and matured the major functions of the non-armor survivability suites prior to incorporation on the Integrated Survivability Demonstrator (ISD).

The high level goals (Figure 9) of the ISSIL testing are as follows:

a. Modify all selected components to meet TWV needs
b. Develop operational scenarios with user that tax system electronics (power, data, etc.).
c. Standardize interface for future TWV electronic components
d. Determine future TWV power generation needs
e. Demonstrate ability to be reconfigured with “plug and play”
f. Demonstrate “system” operation

Tests were performed on survivability subsystems, communications subsystems, performance subsystems, electronic and data architectures. When issues were

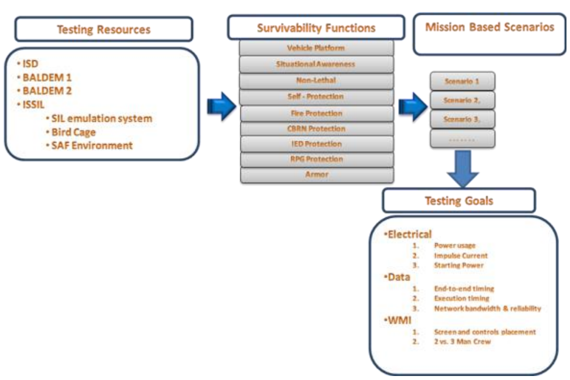

Figure 9: ISSIL Test Development Framework

identified during testing, repeatability was designed and built into the ISSIL so that trouble-shooting and lessons-learned were immediately available. The final result was subsystem functionality, followed by seamless integration of survivability subsystems onto the demonstrator vehicle.

Conclusion

In conclusion, ISSIL developed into a key System Engineering tool that was used to bridge “paper” to “steel,” i.e. concepts to physical prototypes. The laboratory developed the capabilities and tools to integrate and test C4ISR, Situational Awareness, and Survivability technologies through VICTORY data backbone and develop common Power Distribution and Control. This was demonstrated in early integration and testing the 50 sub-systems used in the Integrated Survivability Demonstrator (ISD) in the laboratory environment before they were migrated to the ISD.

In addition, the simulation environment in the ISSIL can successfully develop Mission Profiles to test network architecture, track power demands, human factors, Warfighter Machine Interface using Soldier-in-the-Loop user trails.

REFERENCES

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

[1] Matthew Sablan, “Encounter Avoidance – Protecting and Sustaining the Tactical Wheeled Vehicle [TWV] Fleet”, Accelerate, TARDEC, Warren, MI, Summer 2010 Edition.