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IMPLEMENTATION OF A GENERAL PURPOSE INTERFACE UNIT

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ABSTRACT

The Integrated Bridge currently fielded in the MRAP FoV is a capabilities insertion that provides data integration and visualization services to the vehicle crew. The Integrated Bridge combines displays, data buses, video sensors, switches/routers, radio interfaces, power management components, etc. to provide a unified view as well as a vehicle system control means to its crew members. The Integrated Bridge provides a flexible and modular architecture that can readily be adapted to the variety of Government Furnished Mission Equipment found in the MRAP FoV utilizing developmental hardware and software augmented with VICTORY technology to provide additional standardization and capabilities. This paper describes the continuation and capability extension of the VICTORY Radio Adapter, now called the Integrated Bridge GPIU (General Purpose Interface Unit). Details of the work leading to the fielding of a significantly enhanced version of the GPIU are discussed. GPIU software and hardware enhancements, VICTORY compliance improvements along with test event data results will be presented.

INTRODUCTION

The MRAP (*Mine-Resistant Ambush Protected*) MATV (*MRAP All-Terrain Vehicle)* is a useful and versatile platform for investigating possible fielding options for a wide variety of equipment essential to the Warfighter's mission. The MATV is a compact space constrained platform that presents challenges in fitting all required functionality into the space available As such, it is a good representation of typical Ground Vehicle space issues.

NIE 15.2, completed this month, and the upcoming NIE 16.1 and 16.2 test events will utilize the MATV as a demonstrator vehicle for the VICTORY (*Vehicular Integration for C4/ISR/EW interoperability*) data bus. These test events focus on data interchange between vehicles as well as data interchange between components within the vehicles and their crew. Tactical radios were among the vital vehicle components for inter-vehicle communication. They were dispersed throughout the crew cab and in an exterior armored compartment of the vehicle. In addition to demonstrating VICTORY capability, the MATV utilizes the core technology for internal data transport provided by the Integrated Bridge (IB).

The IB provides the direct interface to the vehicle components and the WMI (*Warfighter Machine Interface*) to the crew. The varied vehicle equipment sometimes presents distinct interface challenges that are not easily resolved by the standard data buses and interfaces. In such cases, adapters comprised of custom interface hardware and accompanying software must be provided. Such a proposed component was presented in [1]. An implementation of this adapter, the GPIU, was developed for fielding in NIE 15.2. Not surprisingly, the process of implementing and fielding a working GPIU resulted in some unforeseen problems that led to changes to improve the adapter's design and performance. This paper discusses the modifications and improvements made to the GPIU prototype implementation.

INTEGRATED BRIDGE OVERVIEW

The Integrated Bridge currently fielded in the MRAP FoV is a capabilities insertion that provides data integration and visualization services to the vehicle crew. The Integrated Bridge combines displays, data buses, video sensors, switches/routers, radio interfaces, power management components, *etc.* to provide a unified view and means of control of the vehicle system to its crew members. The Integrated Bridge provides a flexible and modular architecture that can readily be adapted to the variety of GFE found in the MRAP FoV. The Integrated Bridge augments its inherent capabilities by incorporating VICTORY technology to provide additional standardization and capabilities.

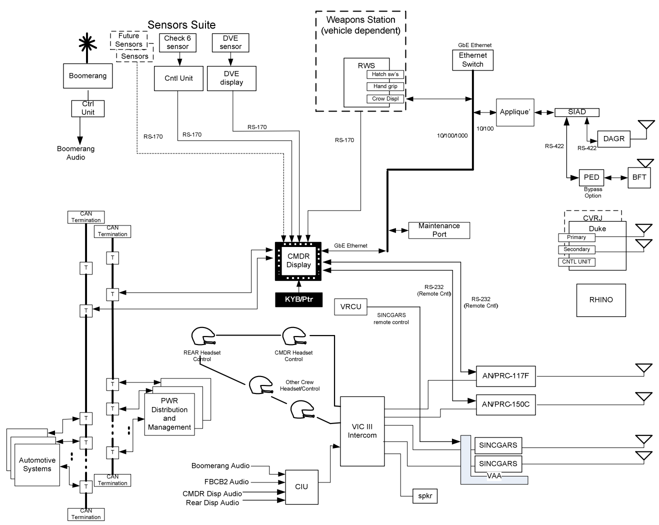

Figure 1: Typical Integrated Bridge Installation.

The schematic presented in Figure 1 shows some of the components and vehicle interface elements of a typical IB implementation. Some of the major components are Power Controllers, Radio interfaces, Ethernet switches and display heads. Interfacing vehicle equipment includes radios, weapon systems, video sources, intercom, *etc.* A detailed description of the IB can be found in [2, 3].

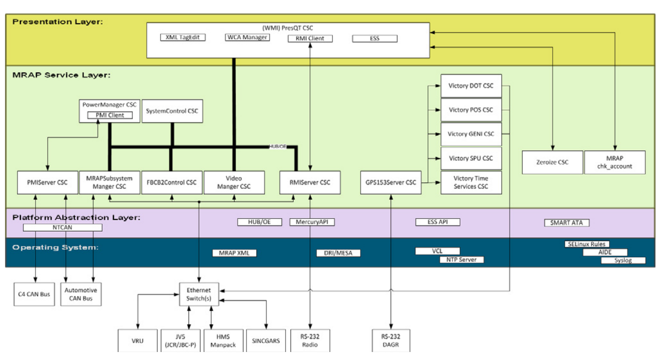

Figure 2: Integrated Bridge Software Structure.

As shown in Figure 1 and Figure 2, it is evident that the IB is replete with multiple interconnections reflecting the need to provide control of many vehicle components and subsystems from user stations. The quantity of components puts pressure on the space claim requirements. The IB provides Smart Displays at crew stations to consolidate control and monitoring functions in a single device eliminating other MEP (*Mission Equipment Package*) displays like JBP-P, WIN-T MDA and RWS.

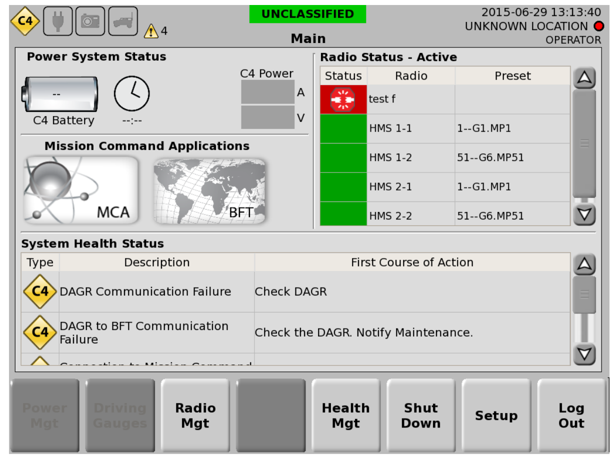

Figure 3: Integrated Bridge Main Display.

The heart of the IB is the display head that is available at each of the crew stations. The touch panel screen shows current vehicle status and provides function to control, configure and monitor the status of several vehicle components and subsystems. A representative WMI display on the Smart Display is shown in Figure 3.

These components and subsystems consist of some devices that are specifically built for the IB. However, most IB components are chosen from the existing military stock. A majority of these components support a data interface to allow monitoring and control. These interfaces are typically CAN, Ethernet or serial. And often these interfaces employ custom message protocols.

The VICTORY initiative provides a standardization methodology to alleviate issues with multiple data communication protocols. VICTORY provides a standardized messaging architecture that enables compliant equipment to share information and perform management (control) functions over standard interfaces. This can result in the elimination of redundant equipment. The IB is incorporating VICTORY components in the MATV demonstration vehicles to provide a number of functions. VICTORY goals, methods and its implementation approach can be found in [4, 5, 6].

One of the primary uses for the IB is to allow the crew to make changes to the settings of the various radios in the vehicle. Each display head at each crew station has the capability to monitor and change radio settings per preset configurations. Usually, these control interfaces make use of Ethernet or serial (RS-232, typically) for command and data communications. But, some radios, particularly legacy radios, can require custom hardware interfaces. So, either remote control is not provided for these radios or custom interface hardware is required. As the integration of a vehicle proceeds, other requirements for custom hardware functions often present themselves. Power conditioning, multiple serial interfaces, video connections and elimination of all KDU's (*Keypad/Display Unit*) and VRCU's (*Vehicle Remote Control Unit*) are examples that emerged in the integration of the NIE 15.2 vehicle. Requirements for custom interfaces arise from time to time as well. Therefore, a configurable, *general purpose interface unit* (GPIU) can be utilized in a vehicle similar to the VICTORY Radio Adapter, as originally proposed in [1].

INITIAL VRA CONCEPT

The VRA concept was a standalone LRU that was designed to facilitate remote control of the various tactical radios operated/controlled by the Integrated Bridge using VICTORY compliant messages. The VRA, as presented, provided a custom interface to legacy radios, serial and Ethernet interfaces for other radios as well as software to implement a VICTORY compliant interface for crew member remote control of vehicle radios.

Figure 4: VRA/GPIU LRU.

Figure 4 depicts the VRA prototype external form factor. With minor modifications, this is the external form factor of the GPIU as well. These differences will be discussed in the sections that follow. Figure 5 shows the software structure of the VRA with an emphasis on the VICTORY-related components for remote software-based control of the vehicle radios.

Contrary to initial design beliefs and understanding, the original software concept, discussed in [1], proved to be unrealizable and resulted in a new software architecture and implementation. The resulting software implementation, which is significantly different, is shown in Figure 7.

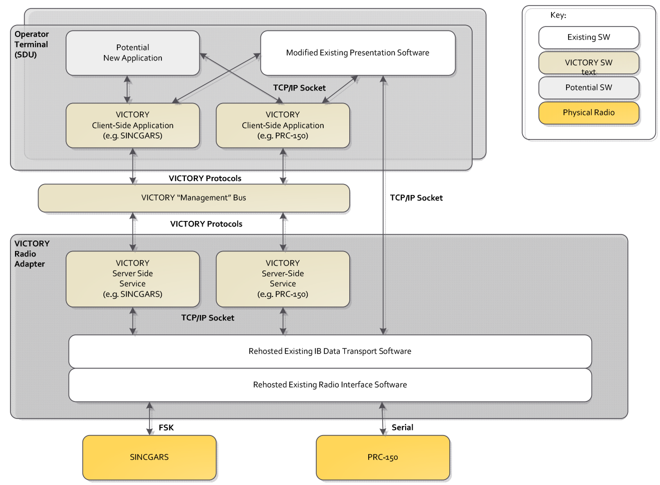

Figure 5: Initial VRA Software Concept.

ISSUES

Integration is a key task when transitioning a concept to a functioning component in an actual vehicle. This task, usually performed under intense schedule pressure, inevitably presents mistakes and pitfalls in the concept and/or design implementation.

The VICTORY demonstration vehicle incorporated a number of functions that were not previously supported by the IB. These were developed from the set of operational vignettes developed as part of the initial planning for the NIE. Some of these functions used existing GFE or COTS, but in some cases, requirements for newly developed hardware were present. Developing a new hardware LRU imposes space claim requirements and introduces cost and schedule risk, so it often makes more sense to incorporate functionality into already planned new developmental items. Since the VRA was already planned for inclusion into the NIE 15.2 VICTORY demonstration vehicle, a number of these functions were incorporated. These functions included:

1. ***Video Capture and Transmission -***
   Three video sources are integral to the MATV and incorporated into the IB. However, the IB uses an analog RS-170 video interface to incorporate and

distribute the video internally even though the requirement was to transmit captured images across a radio link to other vehicles. This implied digitization of the video that was easily implemented with individual Video Encoder Units (VEU), which required a Power-over-Ethernet (PoE) data link. The Ethernet switches of the IB do not provide this capability so incorporating a PoE switch into the GPIU provided a cost effective, low risk approach.

2. ***Network Verification Tool* -**
The health and status of the inter-vehicle radio network is important to the vehicle commander and crew. This function is one of the key VICTORY demonstration items. Therefore, an existing application was modified to poll the status of the connected radios and the networks to which they were connected, consolidate the information, and present it to the user. However, this application expected to communicate with the radios by use of a web service that followed closely the SNMP protocol used by some of the radios. Also, it was not practical to implement the VICTORY interface to the other radios. Therefore the software structure, both internal to the GPIU and external, required serious redesign.

3. ***Orientation and Navigation Management* -**
Vehicle orientation and direction of travel were to be computed by the Orientation Management Unit (OMU), using attitude (*pitch/roll*) and heading (*yaw*) information that is based on inertial measurement data. However, this LRU required conditioned power that was MIL-STD-1275 compliant and not easily available on the vehicle. Since the GPIU would need a conditioning power supply anyway, it was effective in terms of time, cost and space to incorporate a MIL-STD-1275 power supply in the GPIU that would provide power for itself as well as distributing power to the OMU.

This new capability resulted in additional power consumption. The initial design proved to be incapable of handling this power increase due to thermal complications. As a result, alternatives were proposed. The initial attempt was to provide a louvered cover to allow the heat to escape more efficiently. This is not acceptable since the unit must be sealed. As a result, a sealed unit solution needed to be developed. Along with this modification, a number of software issues also emerged during the development process. There were the usual integration problems associated with rehosting the operating system and application. The most significant issue was that it was not practical to utilize VICTORY elements directly in the GPIU as originally planned. As discussed in [1], the VICTORY Radio Control Component Types (CT) were found to be inadequate for monitoring and controlling the modern data radios and had serious issues in regard to controlling the legacy radios, such as the SINCGARS. Therefore, the software design related to radio control had to be restructured. This is described in the following section.

RESULTING DESIGN

The resulting GPIU hardware architecture was required to be modular, scalable and capable of utilizing a wide selection of COTS products. A PC-104 form-factor and bus standard was chosen as the core of this architecture. The GPIU can accommodate a PC-104 stack of three modules plus additional hardware. The internal layout is shown in Figure 6. The space at the side of the stack contains a custom FSK generating module used to control with the legacy SINCGARS radios. The microprocessor used by the GPIU is not currently part of the PC-104 stack. The microprocessor card generates the most heat and is, therefore, mounted to a thermal plate with thermal compound to the cover of the GPIU. The cover has vanes to help dissipate the heat.

Interestingly, the software also contributed to solving the thermal problem. The unit generally worked as expected but occasionally would drop its Ethernet connection for a short period of time. The source of the problem was found to be the power-saving module in the microprocessor's BIOS. This module would run periodically and occasionally interfere with the functioning of the Ethernet driver causing lost packets. The solution was to disable the power saving module. An unexpected side benefit was that the microprocessor board ran significantly cooler with the power saving module disabled. The rationale for this obvious contradiction is still unknown. The microprocessor is connected to the other components in the initial version using a wire harness. In the future, this will be replaced with a *rigid-flex printed circuit board* design.

The GPIU incorporates multiple PoE ports and video encoder interfaces to support enhanced Situational Awareness capability, additional power conditioning and multiple serial ports for GPS (*Global Positioning System*) data along with radio control features. The video and GPS functions require no software support as they are hardware-based data conversion of transfer modules. Software provides support for legacy and PRC-155, commonly referred to as the HMS (*Handheld, Manpack & Small Form Fit*) radios. Using a web service, GPIU software supports updates and enhancements of existing interface modules.

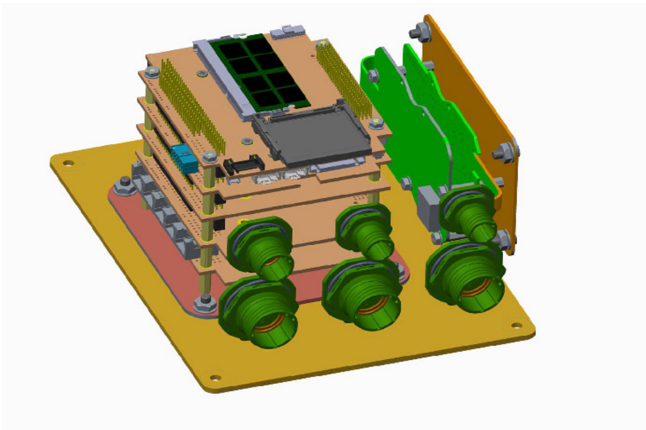

Figure 6: Internal physical structure of GPIU.

Figure 6 shows the general internal layout of the GPIU hardware. The PC-104 stack is on the left, the microprocessor module is located at the top, where it is mounted to the cover with a thermally conductive interface. Lastly, the FSK module is to the right.

Figure 7 shows the change in software structure. The original VRA concept included significant VICTORY modules in the VRA itself. However, that design would have required that the control data partially pass through the VICTORY interface and partially pass through the existing TCP/IP point-to-point interface. Also, the existing VICTORY CTs, at that time, did not support data radios that were controlled using SMTP. So this was not a practical approach.

As part of the NIE effort, a Network Verification Tool was also developed. This tool incorporated a web service to talk to the PRC-155 HMS radio to determine the status of the vehicular radio network. It proved much easier to develop a web client to directly interface with this service for purposes of control and monitoring of the PRC-155 HMS radio. VICTORY was still an integral part of the system but not in the radio control area. Once the data radio Component Types are fully specified then it may be possible to integrate them into the GPIU.

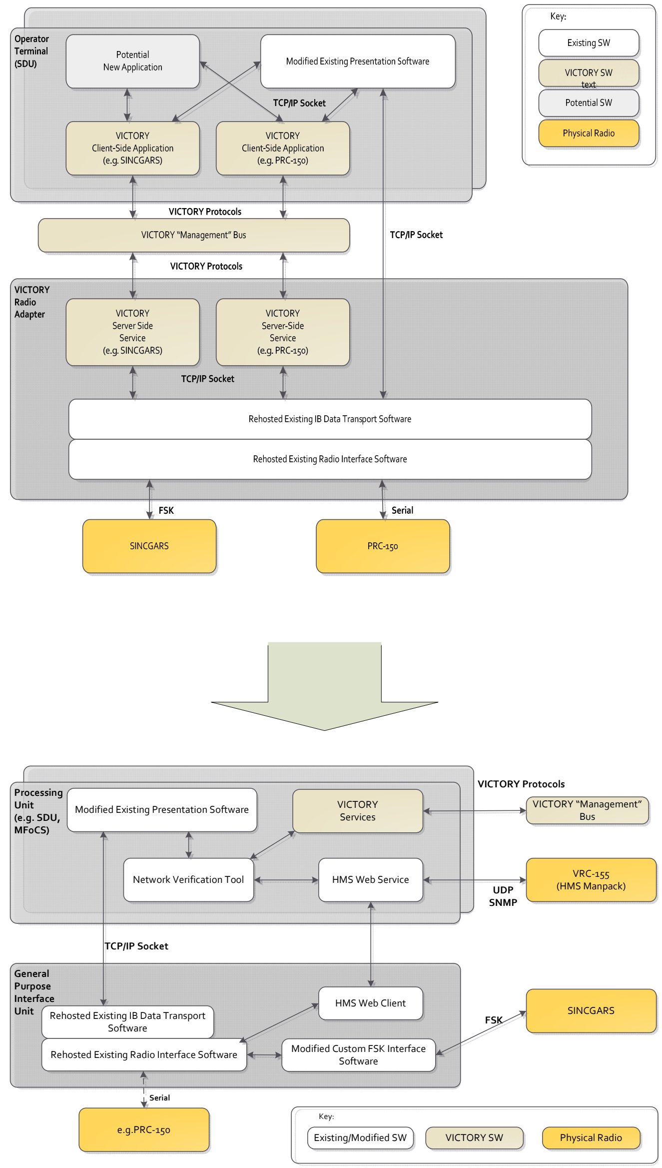

Figure 7: Development of New SW Structure.

FUTURE WORK

The GPIU is proving to be a useful addition to the suite of IB developmental components. Improvements will continue to take place to minimize thermal design deficiencies and to increase the GPIU capability. One significant modification will consist of the redesign of the FSK module to support the control of up to six *receiver/transmitter* units as well as its incorporation into the PC-104 stack. Additional I/O modules providing digital and analog signals will also be developed. The mechanical design will also be improved to facilitate an economical and streamlined manufacturing process. The computational power and memory capacity will be increased to support enhanced software functions.

CONCLUSIONS

The GPIU is a modular, scalable unit that can be easily customized to support many applications within the Integrated Bridge. The GPIU is an extension of the original VRA unit discussed in [1]. The GPIU, not only performs the functions of its VRA predecessor but it offers assistance and interface support to the vehicle electronics architecture and infrastructure by providing processing, power resources and I/O support for *video capture and transmission*, *network verification tools* as well as *orientation and navigation management*. Due to the GPIU's design flexibility and modularity it could easily be utilized in other vehicle architectural frameworks as well. This paper has described some of the issues and pitfalls encountered during the GPIU's concept and subsequent prototype to its fieldable unit realization. In addition, solutions to these pitfalls were discussed as well as future improvements to the GPIU design and capability.

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