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MODULAR VICTORY IMPLEMENTATION: 3 NETWORK ARCHITECTURE COMPARISONS

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ABSTRACT

As the Army invests in the integration of VICTORY (Vehicular Integration for C4ISR/EW Interoperability) into its ground vehicle platforms, it becomes clear there are multiple ways to achieve interoperable if not common implementation across the fleet. There are positive and negatives associated with each of the possible VICTORY configurations that ultimately achieve the same results. This paper will outline, compare, and evaluate the 3 most popular implementation configurations.

Both the Army and Marines are developing programs to implement VICTORY as a means of network improvement as well as more effective connectivity. A deeper understanding of the different architectures will reinforce what works well and achieves the goal, and provides insight into technical and operational areas that may be in need of some refinement or modification. The information provided by the analysis in all options can help guide the integration in a more successful direction by establishing a roadmap for technical and operational performance requirements. There are 3 main VICTORY architectures the paper will analyze.

INTRODUCTION

The U.S. Army has made a major step forward toward achieving its vision for commonality within its ground vehicle fleet through the development and implementation of the Vehicular Integration for C4ISR/EW Interoperability (VICTORY) standard.

Since the VICTORY standards do not define a full system or technical hardware configuration, the approaches to implementing VICTORY are limited only by the imagination. While VICTORY Standards do provide guidelines for messaging and control, there are no hardware implementation recommendations. This leaves it up to the individual platform managers and engineering teams to iron out the details required for each platform independently.

To move toward building commonality between the different defense vehicle platforms and to ensure that both the U.S. Army and U.S. Marine Corps benefit from VICTORY, the two services have worked closely during the VICTORY development stage.

Three dominant VICTORY system architectures have emerged during VICTORY development: the hub-spoke, the modular hub-spoke, and the modular architecture. The positive and negative attributes of each of these VICTORY implementations will be discussed in this paper. Each architecture's attributes will focus on Cost, Logistics, and Scalability.

This paper assumes a general knowledge of the VICTORY Architecture and Standards. Each of the VICTORY IVN implementations described are theoretical, yet well recognized approaches. The analysis uses the foundational infrastructure (Ethernet switch & SPU) to provide a basis for evaluation to assist in future engineered IVN's.

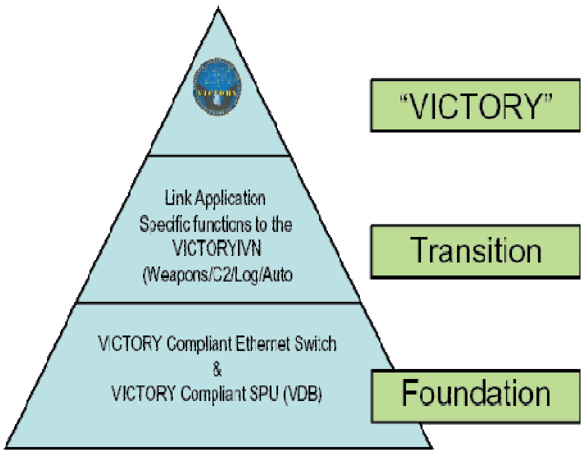

Figure 1 VICTORY Triangle

Each dominant VICTORY implementation architecture compares the approach for cost, logistics, and scalability.

The conclusion provides a simple comparison matrix that ranks the architectures. The rankings highlight the attributes that are best representative of each architecture in order to identify which architecture fit best in different platform scenarios. All three VICTORY implementations drive towards the same end point. Each configuration begins at the same starting point, thus interface control imperatives are preserved. Preference can only be positioned on the dominant attribute as defined by the platform manager and will be specific for each implementation.

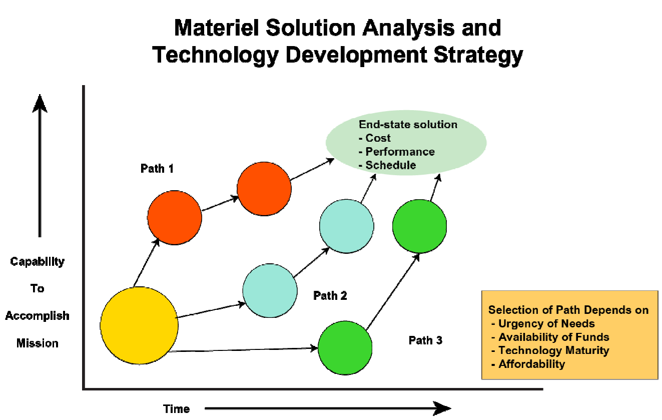

Figure 2 DoDI5000.02 Analysis of Alternatives

Undeniably VICTORY must achieve commonality across all platforms and maximize cost savings. This paper will aid platform managers in identifying the best configuration for their platform and in assist in selecting the best implementation method to achieve these goals.

FRAMEWORK AND UNDERSTANDING

The framework explained in the analysis is an architecture of implied VICTORY network implementations. The framework comes across as a simple network topology, but because the network itself is anticipated to be a mesh network topology with both client-server configurations and peer-to-peer configurations each architecture allows for similar functionality throughout. The spoke components refer to user/vehicle C4ISR/EW systems or Platform systems. These systems are understood to be user systems and will vary per mission and user group.

The Foundation described is a combination of the VICTORY Infrastructure and End Node component groups. It is the combination of End Node components and Infrastructure components that enables the VICTORY Data Bus to be shared by C4ISR/EW systems or Platform systems.

VICTORY requires Networked Attached Storage (NAS) under each of the described scenarios. The NAS is excluded from the analysis scenarios because it is required for each configuration and would be similar across each implemented architecture.

CYBERSECURITY

Cybersecurity must not be an afterthought as the In-Vehicle-Networks (INV's) are implemented. Developing the IVN's with cybersecurity as a support mechanism for each functional block of the IVN is essential.

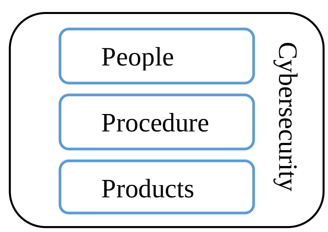

Figure 3 Encompassing Cybersecurity

Using products that have embedded cybersecurity are becoming more and more common. This embedded security is a needed feature that helps enhance the cybersecurity support structure. Each of the VICTORY implementations outlined must take in account the cybersecurity component. Authentication and authorization slows malicious attacks but cannot prevent them solely. Incorporating built in cybersecurity functions is a must and will add to securing the IVN's as they are implemented.

Much like NAS, cybersecurity is a function that will run across implementations. With that understanding, from an active implementation perspective cybersecurity is not included in the analysis. However, as industry progresses and products contain passive and active cybersecurity components the implementation architectures will adjust.

VICTORY ARCHITECTURE: HUB AND SPOKE

The Hub-spoke configuration consists of a central device to which all surrounding VICTORY and legacy components are connected. A single device provides an integrated shared processing unit to host the VICTORY services and manage the VICTORY In Vehicle Network (IVN).

This single Hub contains an Ethernet switch, a shared processing unit (SPU), and serial/comm interfaces. Spoke devices can be serial-based or Ethernet-based directly connected to a single device with no separation within the hardware. (Label a few notional spoke devices)

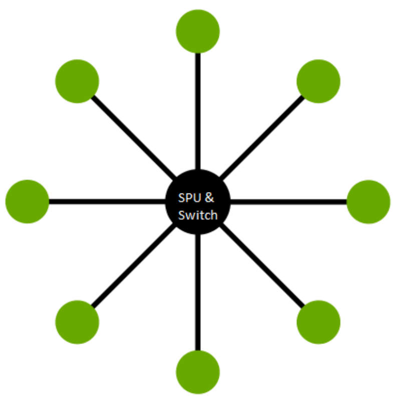

Figure 4 Conceptual Hub-Spoke

The HUB-Spoke architecture uses only a single device for the VICTORY infrastructure. This single device hosts the VICTORY Data Bus (VDB) and performs switching. This design lets services/legacy C4ISR/EW systems and Ethernet enabled systems plug directly into the hub unit.

Hub-Spoke is the easiest of the three architectures to implement and the benefits of this configuration are relatively straightforward.

- The solution allows all end-points/VICTORY components to terminate at the same location.
- There is a single power cable and a single management interface.
- Only one unit occupies a single mounting location.
- The minimalized hardware configuration can be complimented, when the there is a need to expand, by the addition of a secondary VICTORY compliant Ethernet switch.

On the negative side, this architecture may pose a critical security problem. Having the SPU and Switch combined in a single device could increase the risk of malicious internal or external attacks on the network. Information Assurance must be closely managed to ensure this risk is adequately mitigated. Additionally, a single unit limits the capability for growth. It also reduces ad-hoc capabilities by restricting cable and hardwired infrastructure. Finally, it sub-optimizes to a single point failure due to reliability faults or catastrophic damage during combat.

Attribute Outline**:**
Cost:$3.5-$5k (Estimated Cost of a single unit device that contains a VICTORY compliant Ethernet Switch and SPU).

Logistics: Having a single device creates a logistic issue. A single vendor solution would leave the government open to limited supply and possibly unmitigated price increases.

Scalability: Scaling is inefficient. As a single all in one device adding additional units creates excessive oversupply of components that may not be needed as the system scales upward. This would be an unnecessary system cost driver.

VICTORY ARCHITECTURE: MODULAR HUB-SPOKE

The modular Hub-Spoke provides a separate SPU and Ethernet switch contained inside a single unit. Envisioned as a two-slot 3U VPX device, this architecture leverages two key factors that the Army/Marines are emphasizing. The first is Standard-Off-The-Shelf (COTS) Computing and the second is standard-size hardware implementation.

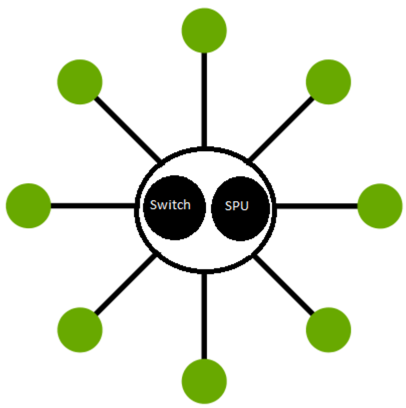

Figure 5 Conceptual Modular Hub-Spoke

The modular hub-spoke architecture separates foundational functions; thus it's important as a precursor to integrating critical user systems. By separating the foundational components, the design increases the robustness of the VICTORY IVN. A stand-out positive aspect of this implementation is its ability to remove foundation components as LRM's. Open the single chassis remove, replace, close, complete. This LRM feature provides ease of maintenance and ease of upgrading for future processing or switching upgrades. The benefits of this configuration are again straightforward:

- LRM based cards
- Increased industry competition for the LRM cards for both SPU and Ethernet Switch
- Single chassis for cabling
- Single chassis for management interfacing
- Easy upgradability for each LRM
- Easy user/operator replacement of components
- Commonality in LRM's with existing Army programs (RF Hardware/Software Convergence)

The Hub-Spoke Modular design's negative issues are similar to those of the Hub-Spoke. This architecture offers limited scalability because of its reduced footprint. Ad-hoc bolt on capabilities are also difficult. The cost of this architecture is higher than the other architectures as there are separate costs for the chassis, SPU card, and Ethernet switch card.

Attribute Outline

Cost: Chassis- $2k SPU- $4-$10k Ethernet Switch- $2-$4k

Logistics: This configuration allows commonality with other Department of Defense programs. Using an industry standard format would make it easy for competition to drive down cost to the government.

Scalability: Scaling is inefficient. By using a specified form factor for the LRM components technology limits the amount of features that may be required and would reduce possible growth for changing mission sets.

VICTORY ARCHITECTURE: FUNCTIONAL MODULAR NETWORK DESIGN

The third implementation that is a strong candidate for the VICTORY IVN is a completely modular design based on function. This Modular Network design exploits the use of an Ethernet switch for the backbone for the IVN and a separate processing unit for the SPU. Each function is considered a module. This separation allows functions to modified, modernized, or changed by adjusting the component for that functional module. By separating the two units, this architecture provides the ultimate flexibility in achieving commonality across the disparate combat vehicles and increasing network survivability. It also increases industry competition by forcing industry to specialize and provide a best of breed product for the function to the market.

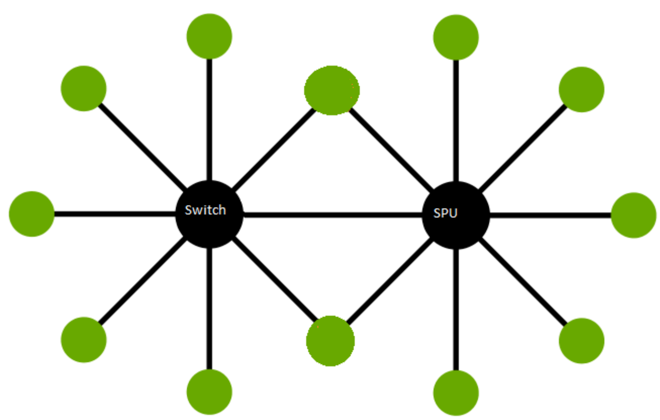

Figure 6 Conceptual Modular Implementation

This modularity retains the basic tenet of the VICTORY standards which is to provide a structured control and messaging structure for all products and C4ISR/EW systems integrated into the combat vehicle regardless of application. This architecture is best employed by using a building block foundation. The first block would reuse existing SPU's in the combat vehicle. The second block would integrate a VICTORY Compliant Ethernet Switch. Benefits of this architecture include:

- Capable of scaling up to meet demand
- Extremely competitive market-availability of hardware
- Separate foundation structures for independent security architectures
- Allows easy bolt in ad-hoc upgrade capability
- Re-use of existing processing hardware
- Segmentation of critical system functions for a reduced security risk

On the negative side is the requirement for a slightly higher density octopus cable as well as the need for additional power and management cables for each separate foundational component (SPU and Switch).

Attribute Outline
Cost: $4k-$8k for each Ethernet Switch. SPU reuses existing SPU (No Additional Cost)

Logistics: Each functional component would allow for multiple sources increasing availability. This would reduce bottlenecks from single suppliers or single manufactures.

Scalability: Scaling is efficient. As mission or capacity requirements increase the capabilities needed can be efficiently connected. Capabilities required can be added in to the IVN without system redesigns or custom pieces.

CONCLUSION

The forcing function for VICTORY is the establishment of a baseline into which all bolt-on packages can gracefully plug and play, achieve resource sharing, and to reduce the chance of any new incompatibilities. Now that the VICTORY standards have been established and program architecture development has begun, it is more important that the Army identify specific weighted-criteria for the IVNs and specify its architectural priorities.

Each of the three VICTORY Architectures outlined herein have both positive and negative attributes. The individual platform managers must ultimately decide which attribute is most important to them and their fleet. To assist them, the table below lists the strengths of each architecture.

Table 1 Attribute Conclusion

	Hub-Spoke	Mod-Hub-Spoke	Function Modular
Cost	☆		
Supportability		☆	☆
Scalability			☆

The Hub-Spoke architecture is an efficient and cost effective VICTORY architecture. It is easy to implement and maintain. The Modular Hub-Spoke creates logistical overlap with similar technology being used in military programs across the Defense Department. The Functional Modular VICTORY Architecture is the most secure by having separate management/control for the foundational components and is the most easily scaled implementation enabling modules to be swapped for higher density or increased capacity pieces.

The generic foundation of the VICTORY standards enables each VICTORY IVN installation to be completely different and to still achieve the same goal. Ultimately, all choices eventually lead to the same goal, VICTORY.

REFERENCES

[1] Defense Acquisition Guidebook. (https://acc.dau.mil/CommunityBrowser.aspx?id=488336#3.3.2)
[2] Defense Acquisition Program Manager Handbook. (https://dap.dau.mil/aap/Answer%20References/Program%20Management/102878%20AoA-Handbook.pdf)
[3] 2016 PEO LS Advanced Technology Investment Plan (p. 79-85)
[4] Analysis of Alternatives (AoA) Handbook, A Practical Guide to Analyses of Alternatives, July 2008
[5] VICTORY STANDARDS (http://victory-standards.org/index.php/component/content/featured)
[6] How To Implement the VICTORY Architecture on Platforms and Subsystems (www.curtisswrightds.com%2Funsecure%2Fcontent%2Fdocuments%2FHow-to-Implement-VICTORY-Architecture.pdf&usg=AFQjCNHMsQTdckvRvPSlHCYB2ltOlZHJ8A)
[7] CNSSAM TEMPEST/01-13