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ARCHITECTING FOR PERSISTENT MODERNIZATION

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ABSTRACT

The U.S. Army must adapt and upgrade ground platforms at the speed of technology advancement to maintain competitive advantages over adversaries. The Program Executive Office (PEO) Ground Combat Systems (GCS) Common Infrastructure Architecture (GCIA) is a new ground systems approach to enable persistent modernization of future platforms. For legacy platforms, Project Lead Capability Transition and Product Integration (PL CTPI) is developing plans to incrementally incorporate standards and portions of GCIA where feasible and affordable on legacy platforms. The GCIA will enable rapid integration of ground system capabilities, increasing the Army's ability to counter emergent threats on the battlefield.

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1. INTRODUCTION

The technology landscape and threat environments are rapidly evolving. The U.S. Army must adapt and upgrade ground platforms at the speed of technology advancement to maintain competitive advantage over adversaries. Historically, ground systems have lacked sufficient provisions for the adaptation, expansion, interoperability, or evolution of ground platform capabilities. As a result, the current fleet of ground systems requires significant time and cost to upgrade. A new approach is needed to increase the speed and reduce the cost of upgrading and enhancing ground platforms.

The Program Executive Office (PEO) Ground Combat Systems (GCS) Common Infrastructure Architecture (GCIA) is a new ground systems approach to enable rapid and continuous modernization of future platforms. GCIA takes a holistic view of ground systems, challenging the traditional subsystem paradigms. The new approach views a ground system as a platform outfitted with a suite of capability components that are integrated within a common infrastructure consisting of common hardware, software, safety, and cybersecurity governed by a data architecture as a common method of defining data, interface, and interoperability requirements of a ground system.

The GCIA is platform-agnostic and follows a common Modular Open Systems Approach (MOSA) applicable to all platforms in the PEO GCS portfolio. It ensures consistent MOSA implementation across future ground systems and supports both general-purpose and real-time safety-critical applications. The GCIA architecture fosters innovation and adaptability at the hardware and software component level by enabling their rapid integration on host platforms. It also allows commonality and portability of hardware and software components across platforms. Ultimately the GCIA will facilitate rapid integration of ground system capabilities, increasing the Army's ability to counter emergent threats on the battlefield.

2. OBJECTIVES

The objectives for defining and implementing GCIA are to:

- Ensure consistent MOSA implementation both within and across future ground platforms;
- Reduce the time and cost to add or upgrade capabilities on and across future platforms;
- Enable the development and integration of common infrastructure and capability solutions at the hardware/software component level versus entire subsystems;
- Reduce testing cost and time by eliminating the need to retest the entire system each time a new component is added or changed.

3. ARCHITECTURE

As technology continues to rapidly advance, capabilities have become increasingly software dependent versus defined predominately by hardware. In addition, integration constraints driven by size, weight, power, interoperability, and scalability limitations has resulted in significant time and cost to perform capability upgrades. The GCIA address these issues by providing a standardized approach for hardware and software infrastructure along with safety and cybersecurity for ground systems that will facilitate rapid development and integration of capability enhancements.

PEO GCS has made GCIA a requirement for all future vehicles. For legacy platforms, PL CTPI is incrementally incorporating GCIA where feasible and affordable. The intent is to move the legacy platforms toward GCIA over time and be ready to accept future hardware and software capabilities developed in accordance with GCIA.

3.1. Paradigm Shift

GCIA takes a new holistic view of ground systems, challenging the traditional subsystem paradigms. A comparison of an example current state versus future state is illustrated in Figure 1.

A traditional ground system consists of several standalone subsystems integrated on a host platform. The standalone subsystem construct makes data sharing difficult and leads to the unnecessary duplication of common functionalities like computing and displays. While new subsystems and subsystem capabilities may be added or upgraded, doing so typically requires multi-year integration efforts that are unique to each platform.

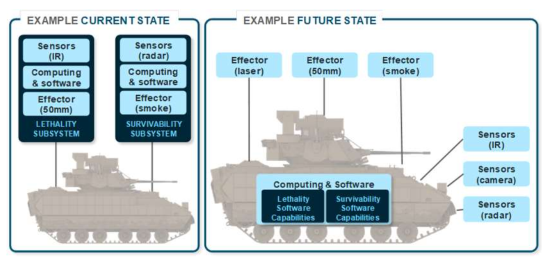

Figure 1: Current vs. Future State

The GCIA approach views a ground system as a platform outfitted with a suite of capability components that are integrated utilizing a shared common infrastructure. Rather than components being dedicated to standalone subsystems, the GCIA views hardware such as sensors, computers, displays, and effectors as shared resources.

The GCIA common infrastructure also allows hardware and software components to be independently developed and easily added and upgraded on platforms to increase capabilities. In addition, the architecture allows software developers to innovate and conceive new capabilities by utilizing implemented platform sensors, effectors, and data in new ways.

3.2. GCIA v2.0

The second and latest version of GCIA, GCIA v2.0, is the culmination of a year-long collaborative effort between architecture experts from across the Army, working with industry through a Community of Interest to define a common infrastructure architecture for future ground vehicles. The effort leveraged previous work done with GCIA v1.0 along with many other relevant architecture efforts from across the Army, including: Vehicle Integration for C4ISR/EW Interoperability (VICTORY), Modular Active Protection System Framework (MAF), Next Generation Intelligent Fire Control (NGIFC), Autonomous Ground Vehicle Reference Architecture (AGVRA), Future Airborne Capability Environment (FACE), Standardize A-Kit Vehicle Envelope (SAVE), C5ISR/EW Modular Suite of Standards (CMOSS), Sensor Open Systems Architecture (SOSA), and others.

The GCIA follows a Modular Open Systems Approach (MOSA) and is applicable to all ground systems, both manned and unmanned. This architecture supports both general-purpose applications and real-time safety-critical applications.

The GCIA is first an architecture, developed based on drivers and requirements that fulfill the architecture goals. A description of standards that support the anticipated system requirements and qualities clarifies the architecture and implementation. This approach allows standards to change and evolve without affecting the system's overall architecture.

The GCIA defines a set of common behaviors and infrastructure components for standard software infrastructure functions (e.g., data sharing, cybersecurity, and fault handling), in-vehicle network (IVN) computing resources, and infrastructure services. The definitions consider the logical, physical, and software interfaces between the GCIA-integrated subsystem capability components and the GCIA common infrastructure.

The architecture by which capability components interface with the network is within the purview of the GCIA, however, the architectures for capability components themselves is not. Therefore, the GCIA does not include the definition of mechanical, hydraulic, pneumatic, or environmental functions or interfaces.

3.3. GCIA Community of Interest

The GCIA was developed in collaboration with industry through a National Advanced Mobility Consortium (NAMC) Community of Interest (COI).

The key architecture artifacts available through the COI include: SysML Models, Architecture Description Document, Data Architecture Definition Document, and Reference Implementation Guide.

NAMC membership is required to join the COI and access the architecture artifacts. Joining the COI involves a separate application process, signing a COI agreement, and appointing a point of contact.

PEO GCS anticipates that the GCIA will continue to evolve as opportunities for improvement surface during implementation and as technology evolves. PL CTPI will be the managing authority for GCIA to maintain version control, change management, and approved distribution.

4. Approach for Legacy Platforms

PL CTPI is looking across the PEO GCS portfolio and developing plans to incrementally incorporate standards and portions of GCIA where feasible and affordable. The intent is to move the legacy platforms toward GCIA over time and be ready to accept the future hardware and software capabilities developed in accordance with GCIA.

The initial standards PL CTPI is working to incorporate are: SAVE, CMOSS, VICTORY, and GCIA FACE. These standards are referenced within GCIA and can be implemented independently to evolve incrementally toward full GCIA compliance.

4.1. SAVE

The Standardized A-Kit / Vehicle Envelope, or "SAVE" [2] standard describes the size and shape of a standard mounting location and set of physical interfaces for integration of Command, Control, Computers, Communications, Cyber, Intelligence, Surveillance, and Reconnaissance (C5ISR) systems into Army ground vehicles. SAVE is one of the physical portions of system integration within GCIA. It is intended to provide long term predictability and stability in terms of physical parameters for vehicle and systems development.

SAVE was initially developed for radios but also applies to computers and emerging systems such as the Integrated Visual Augmentation System (IVAS) vehicle integration kit and its Tactical Cloud Package (TCP), the CMOSS Mounted Form Factor (CMFF) the first instantiation of the C5ISR Modular Open Suite of Standards (CMOSS), Electronic Warfare (EW) kits, etc. SAVE can also be applied to PEO CS&CSS and other platforms that independently of GCIA.

The SAVE Interface Description Document (IDD) specifies the outer dimensions, mounting bolt locations, physical connector types, and environmental requirements for systems to be mounted in ground combat vehicles. It also serves as guidance to developers of new vehicles with respect to the space they must provide to accommodate C5ISR equipment.

Ground vehicle Program Management offices (PMs) and C5ISR system PMs have agreed that adopting SAVE will significantly reduce both cost and schedule when integrating new C5ISR system technology into ground platforms. Using SAVE, platform PMs will provide a standardized integration space with connections for C5ISR systems, and system PMs will acquire C5ISR devices that fit within the space and utilize the connections either natively or via adapters (mounting trays, cables, etc.).

By specifying only the outer envelope (maximum dimensions) and by providing for a range of possible connection configurations within this envelope, significant flexibility is retained for competitive acquisition. By incorporating SAVE into legacy platforms, the platforms will have space claims and connections ready to receive future C5ISR systems along with being ready to receive future GCIA common infrastructure components. PL CTPI will be the authoritative source of SAVE and maintain configuration control.

4.2. CMOSS

PEO GCS is collaborating with PEO C3T in the development of the next generation of C5ISR systems. CMOSS standards allow capabilities such as radios and computers to be added to Army ground platforms as cards in a chassis rather than individual stove-piped boxes for each capability.

Initial CMOSS Mounted Form Factor (CMFF) chassis-based systems are currently under development, and will be SAVE compliant, allowing vehicle developers to design new systems such as the OMFV around fixed numbers of SAVE slots to accommodate the CMFF chasses when available.

The CMFF chassis-based solution aligns with shared computing elements specified in the GCIA. By incorporating CMFF on the legacy platforms, it will not only reduce the size, weight, and power consumed by all the individual boxes, but also provides the option to serve as a GCIA shared computing resource.

4.3. VICTORY

The Vehicular Integration for C4ISR/EW Interoperability (VICTORY) standard provides a framework for integrating C4ISR (EW) systems on military ground vehicles, and interfacing with the vehicle systems. VICTORY defines standards for an in-vehicle network framework along with network messaging frameworks [3]. Many platforms and systems have already incorporated VICTORY in some form.

The GCIA utilizes VICTORY standards for data sharing, but also goes beyond VICTORY to accommodate safety-critical systems. By continuing to incorporate VICTORY interface and messaging standards in legacy platforms and systems, the platforms will continue moving toward being fully GCIA-enabled.

4.4. GCIA FACE

The Future Airborne Capability Environment (FACE) is a technical standard developed through an Open Group consortium for software developed by Government, Industry, and Academia. FACE specifies a layered software architecture with standard Application Programming Interfaces (API) that allows layers and applications within the layers to be individually replaced or reused across systems. The FACE defined interfaces, data architecture, and data modeling language allows the software to modular, portable, and agnostic to the platform [3].

The GCIA Software Portability and Modularity Framework (SPMF) enables portable, modular, and reusable software through a set of standardized APIs based on FACE and an optional standardized software container systems. A given operating system can support elements of the SPMF for the development and deployment of new software and the sandboxing of legacy software. The FACE standard includes aspects that extend beyond what is envisioned for the GCIA design space, so the GCIA also references tailoring mechanisms provided by FACE.

Incorporating the GCIA SPMF into new software development paths will allow future software to be available and ready for integration on and across future GCIA-enabled vehicles.

5. CONCLUSION

PEO GCS is architecting future vehicles to be agile and adaptive, ready to be continually upgraded at the speed technology to counter emergent threats on the battlefield. PEO GCS plans to implement GCIA on all new platforms moving forward, and incrementally evolve the legacy platforms toward the GCIA architecture over time incorporating standards and portions of GCIA where feasible and affordable.

We encourage industry and other stakeholders to participate in the GCIA Community of Interest to access the artifacts and provide feedback as we continue to evolve the architectures and standards.

6. REFERENCES

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