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CONVERTING SENSOR DATA TO TACTICAL INFORMATION

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ABSTRACT

The U.S. military has made substantial progress in developing and fielding C4ISR systems that can collect and gather overwhelming amounts of valuable raw sensor data. A new challenge that has emerged with the deployment of numerous state-of-the-art ISR collection systems is the effective and timely use of the collected surveillance and reconnaissance information, or simply stated an architecture that pushes the timeliness and accessibility of this situational awareness data to the tactical edge – "the right data at the right time to the soldier." Delivery of real time key information to include situational awareness to a decision maker is what makes the difference between loss and victory on the battlefront. This paper is an extension of a GVSETS paper that was presented in the 2010 symposium. This paper discusses in more detail the integration of command and control (C2), video management, and collaboration capabilities, such as chat and telestration, with the sensor collection that enables more timely and efficient situational awareness.

INTRODUCTION

Delivery of real time key information to include situational awareness to a decision maker is what makes the difference between loss and victory on the battlefront. The challenge of getting "the right data at the right time to the soldier" is heightened by the lack of high bandwidth communication connectivity between platforms and the numerous stove-piped systems that are deficient in interoperability characteristics. The resultant vehicle architecture is a collection of stand-alone radios and systems, each requiring their own displays and input devices. This ad-hoc architecture results in two problems: the need for additional - more capable systems to produce and collect data that result in even more interoperability and weight/space problems and additional workload associated with the increased information and disparate user interfaces.

The objective of this paper is to present an architecture framework with the following characteristics:

- Scalable - so that the architecture supports a wide variety of equipment packages and mission variations
- Interoperable – provides an architecture that can accommodate *multiple* existing system packages and consolidates command and control for multiple mission profiles (i.e. surveillance, situational awareness, etc.)
- Usable – provides a logical, intuitive easy to use interface at all user levels (i.e. war-fighter, battalion commander, etc)
- Effective – increases utility and mission effectiveness of the systems on the platform by providing the necessary data, to the right place, at the right time, for a wide variety of missions, resulting in increased survivability.
- Provide the above features with reduced size, weight and power footprint on the platform

The Tactical Plug and Play framework provides a combination of hardware and software systems that are interconnected in order to allow centralized access to sensors, command/control, and situational awareness information, as well as system physical assets such as radios, and the distribution of real or near real-time video data to users. This integrated approach maintains or enhances operational capability and interoperability, and improves ergonomics while reducing size weight and power.

This paper will provide an overview of the previously presented framework and highlight the improvements enacted since the presentation. Furthermore, this paper discusses in more detail the integration of command and control (C2), video management, and collaboration capabilities, such as chat and telestration, with the sensor collection that enables more timely and efficient situational awareness.

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THE NEED

The transformation of the Army from heavy forces to lighter, faster forces increases the burden on today's video intensive C4ISR systems to maintain the lethality and survivability of the current forces. As depicted in Figure 1, the Intel community is part of the Army's architecture and strategy for getting situational awareness and relevant information to the tactical edge. Along with the distribution of Intel information, comes the need for better and timely collaboration. The latest generation of young soldiers is accustomed to the collaboration techniques associated with smart phones and expect to be able to collaborate through voice, chat, text, and electronic mail.

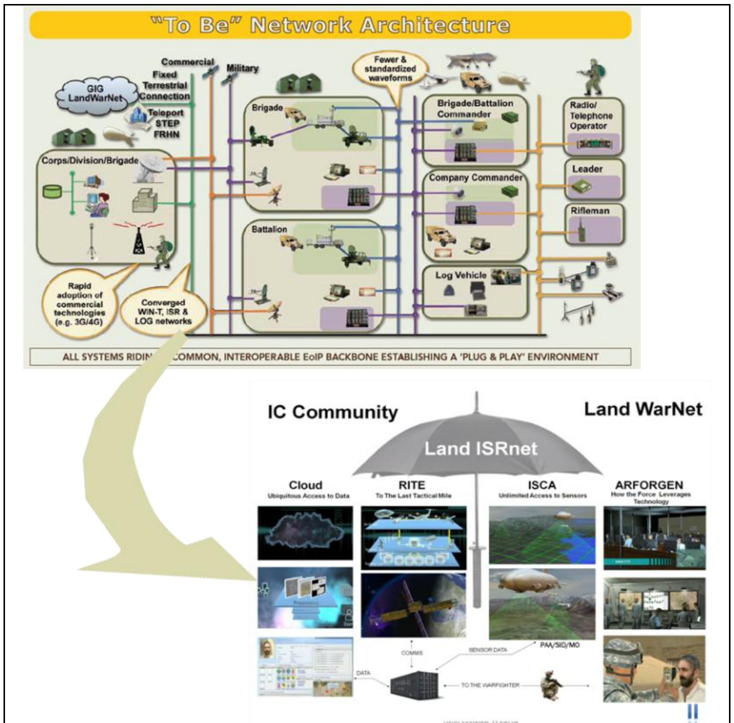

Figure 1: Army Strategy for Getting Relevant Data to the Tactical Edge

The objective of this effort is to develop a scalable architecture that integrates surveillance and reconnaissance, active protection, combat identification, and communication capabilities within the reduced space of platforms and dismounted soldiers. It is also to provide the same look and feel to the soldier regardless of whether the soldier is operating in a simple mechanized platform, a Reconnaissance, Surveillance, and Target Acquisition (RTSA) platform, or in a mobile command post. The framework expands the soldier's capabilities and increases the effectiveness to perform disparate missions, while reducing the mission execution timeline. Figure 2 illustrates the comparison of the capabilities of today compared to the efficiencies provided by the framework. The efficiencies are evidenced by the shorter mission times indicated by the shorter timelines to reach the End of Mission (EOM) criteria. The digitization of command and control functions, distribution of video data, and digital collaboration capabilities allows the soldier to reduce the amount of voice required during missions, which increases the survivability through decreased threat exposure. However, the network continues to support voice traffic along with the ability to digitize audio to be associated with the other collected situational awareness data and information.

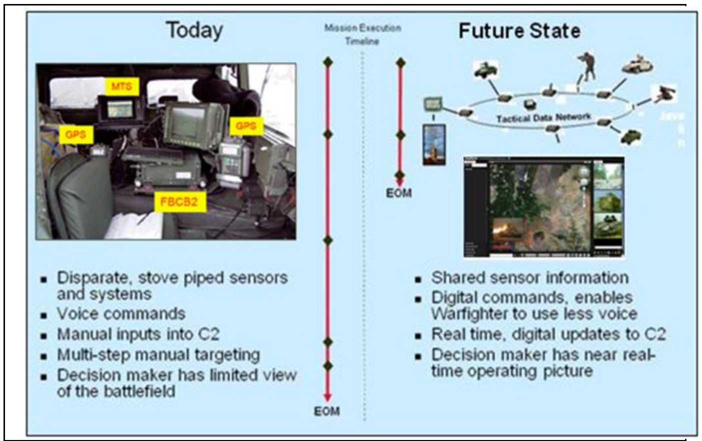

Figure 2: Capabilities to the Tactical Edge

Finally, the architecture has to be designed to enhance the tactical network and provide timely situational awareness information to the soldier. Currently, there is a gap of capabilities to provide timely situational awareness information and relevant Intel products all of the way to the tactical edge. There is a fairly well defined flow of information from the Company level to the Battalion, Brigade, and higher, but there is limited flow of information and knowledge, in a timely manner, to the mechanized platforms and below. Figure 3 delineates this gap of capabilities and information flow.

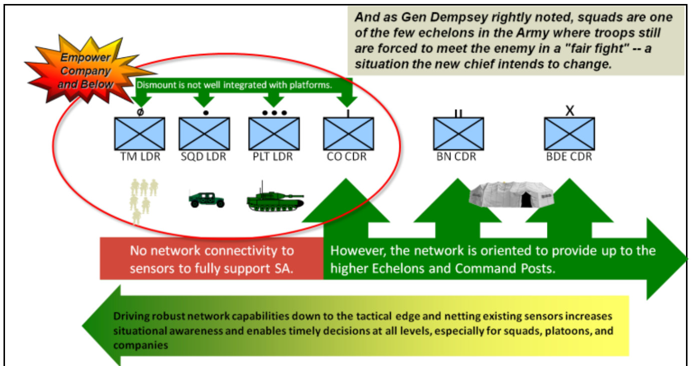

Figure 3: SA Down to the Tactical Edge

The resultant architecture has to integrate heretofore stove-piped, discrete systems into a common framework that enables sharing of information between users on the same platform and between platforms over a tactical network. One of the goals of the architecture is to provide a configurable, single-screen interface for the operator to monitor and control all systems integrated onto a vehicle, and provide a reduction in the space claim required for operation of these systems.

THE SOLUTION

The Tactical Plug and Play framework integrates cohesive, yet loosely coupled infrastructures for communications, C2 applications, and sensor suites along with providing a digital backbone. This electronics architecture is comprised of sensing capabilities, which are integrated into a platform-centric command and control infrastructure, along with a communications backbone providing the connectivity between warriors, platforms, and operation centers/command posts. This integrated architecture has to be flexible and configurable to support a variety of mission or operational tasks. The architecture has to support the appropriate capabilities required to enable the warrior to execute the various missions.

Missions are partitioned into a hierarchical set of tasks, where each set is associated with an Operational Domain. An Operational Domain is defined as one of the following: Net-Centric Communication, Mission Planning, Netted Lethality, Assured Mobility, Situational Awareness, Survivability, Sustainment, and Training, where the first six are collectively considered Combat Operations. This task structure:

- provides a logical division of sensor tasks that are used to support military missions;
- represents a top-down organization that transitions from general behavior to specific tasks;
- provides a basis for behavioral, functional, and performance analysis;
- provides a basis for construction of decision trees that guide employment of sensor assets in the field, and defines sensor fusion approaches;
- is platform-independent;
- is technology-neutral to the degree possible;

The architecture described in this document has to address the various mission scenarios and associated capabilities within each of the operational domains, while considering the capabilities needed from a mobile command post view, a mechanized platform view, and a dismounted warrior view.

Figure 4 shows the conceptual architecture for the Tactical Plug and Play Framework. The framework is a layered architecture with several integrated plug and play frameworks embedded in each of the layers. The embedded frameworks, facilitated through middleware, provide the flexibility and scalability attributes for the overall concept.

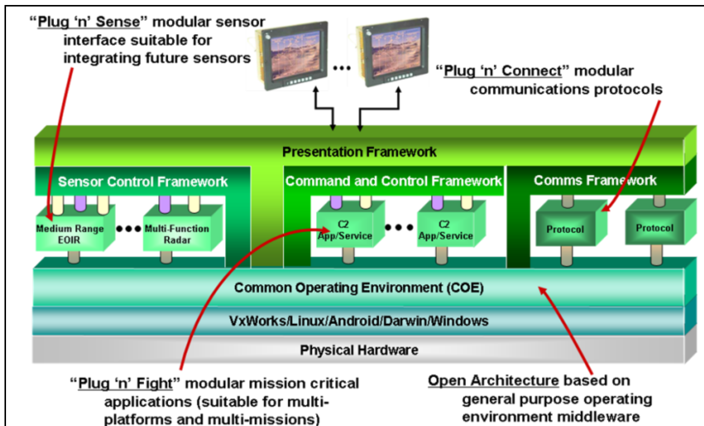

Figure 4: Architecture Concept

Commercial off-the-shelf (COTS) products and standards will be a heavy player moving forward. The architecture developed for the Tactical Plug and Play effort leverages open architecture concepts developed in the commercial environment. For example, the Google Android is a front runner for the small handheld, user-friendly device solutions space. Each one of the frameworks within the Tactical Plug and Play is architected with the same concept of the Android Application Framework in that the framework needs to provide capabilities that any application can leverage to implement its own functionality. The frameworks within the Tactical Plug and Play architecture are:

- Presentation Framework
- C2/Application Framework
- Sensor Framework
- Communications Framework

One of the main architectural patterns that comprise the Tactical Plug and Play Presentation Framework is the Model-View-Controller (MVC) pattern. The MVC pattern isolates "domain logic" (the application logic for the user) from input and presentation (GUI), permitting independent development, testing and maintenance of each. The model is used to manage information and notify observers when that information changes. The model is the domain-specific representation of the data upon which the application operates. The implementation of the model will reside in the Application Framework. The view renders the model into a form suitable for interaction, typically a user interface element. Multiple views can exist for a single model for different purposes. A viewport typically has a one to one correspondence with a display surface and knows how to render to it. The view portion of the MVC is the piece that resides within the Presentation Framework. The controller receives input and initiates a response by making calls on model objects. A controller accepts input from the user and instructs the model and viewport to perform actions based on that input. The actual interaction with the user will be part of the presentation framework, but the interpretation of the user's input, which is the primary function of the controller, will reside in the Application Framework and the Sensor Framework. The benefit of the MVC pattern is that the view and control components are independent from the model and each can be independently modified without impacting the other. For example, the control piece can change the type of input supported without impacting the view or model aspects. This approach also allows for multiple views to exist for a single model, which supports different user interface devices.

The main concept embodied in the Sensor Framework is that there are several types of interconnects that have to be supported due to varying interface requirements; such as high bandwidth video, low-latency command and control, and high-level command and control interactions. The Sensor Framework will interface directly with the Presentation Manager for the low latency and display video interconnects and it will interface with the Sensor Manager within the Application Framework for the high-level command and control and video storage interconnects.

One of the main concepts exploited within the Tactical Plug and Play architecture is that of an Integration Architecture. An Integration Architecture covers the communication technologies and the interaction between different systems and the applications, processes, or threads, within a system. There are two main types of communication architectures employed in the Tactical Plug and Play architecture; namely, the Publish-Subscribe Messaging paradigm, and the Service-Oriented Architecture (SOA) paradigm. The real-time control portions of the architecture, such as the Sensor Framework, will exploit current and future communication technologies to make communication between components/capabilities flexible and scalable, while simultaneously making the system more usable to the war-fighter. The Application Framework and Presentation Framework will exploit the SOA capabilities, such as Web Services and an application server. The Application Framework provides the infrastructure for enabling collaboration capabilities and the bi-directional flow of Intel information between platforms, and reachback capabilities. The layered architecture in each framework demonstrates the importance of the middleware and infrastructure required to support the plug-in architecture, and provides the ability to easily extend and modify the functionality of each framework independent of the other frameworks.

The Tactical Plug & Play system, in practical terms, embodies sensors and the ability to present data captured by the sensors. In a tactical environment, the data must be usable, or in other words near-instantaneous, to enable operator intervention in rapidly changing or battlefield conditions. In contrast to the real-time tactical environment, ISR Data Management and Exploitation implies analysis and capture of information of the data and subsequent usage of the information. Finally, standards – standards for subsystem interfaces, APIs, controls, data distribution, and standards that allow incorporation of selected COTS products represent the plug & play aspect and rounds out the concepts embodied by this project. Note also that rapid integration is a goal of using the right standards and a driving factor of the plug & play concept. Tactical plug and play architecture principles may be implemented for a combat vehicle, or may be implemented for other sensor platforms as well. Figure 5 illustrates the concepts and components embodied in the Tactical Plug and Play architecture.

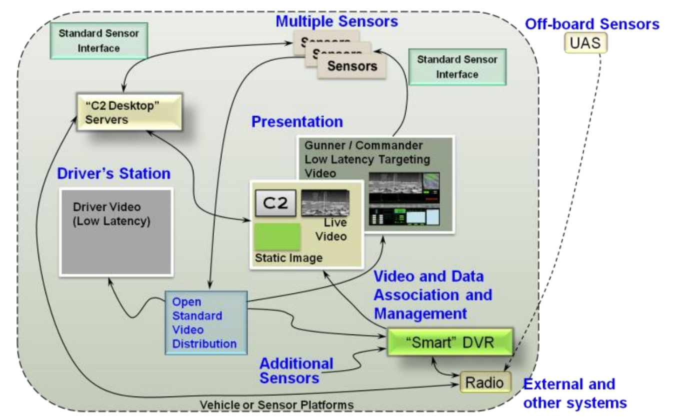

Figure 5: Platform Scalable Architecture Concept

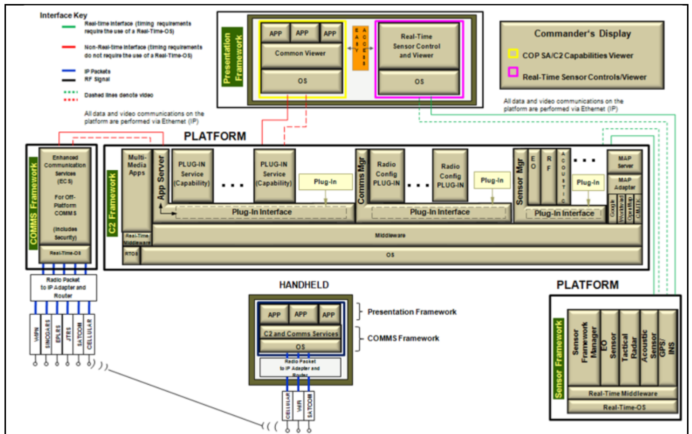

Figure 6: Frameworks

As delineated in Figure 5, this architecture addresses elements of the following:

- Sensor Collaboration
- Common Scalable Command and Control
- C4I Integrated ISR Data Management & Exploitation
- Combined C2 Visual Experience

Some of the main objectives of this architecture are as follows:

1. Provide Real-Time Sensor coordination capability integrated with commercial plug-and-play
2. Provide platform level video management capabilities
3. Provide core collaboration capabilities and gateway to VMF tactical messages (VMF or similarly, JVMF is Joint Variable Message Format)
4. Provide radio and network configuration management capability

Application Framework

The Application Framework, as depicted in Figure 6, is comprised of several plug-in architectures; namely, the Communication Manager, the C2 Server, the Sensor Manager, and the Map Server. These plug-in architectures provide the needed infrastructure to enable the C2 capabilities, such as collaboration, tactical messaging, and provide the path for establishing a connection for the flow of Intel information.

The Communication Manager, C2 Server, and Sensor Manager plug-in architectures are similar in that they all provide an application server infrastructure while the applications are the plug-ins that provides the functionality and APIs for external consumption. This is somewhat similar to the Android environment referenced above where the applications are fairly independent of each other but they all reside, and coexist within the application infrastructure. The benefit of this type of architecture is that the applications can be developed and deployed independent of each other and the applications can be deployed based on mission parameters and objectives. However, the Map Server plug-in architecture differs from these in that it provides the infrastructure for the plug-ins that deal with the formats and protocols particular to various map servers, such as Google and World Wind. The benefit of this approach is that the map implementation is hidden from the presentation framework and the different map implementations can be chosen based on performance and esthetics. This approach enables the three frameworks to evolve independently in order to focus the Presentation Framework on the ease of use aspects while providing an infrastructure within the C2 environment that enables ease of modification and the addition of new capabilities.

Figure 7 depicts the importance of the infrastructure and middleware layers for the Application Framework. The middleware isolates the applications from the hardware and operating system specifics and details while providing an environment that enables easy deployment to one or more processors. The communication between the applications relies on middleware capabilities, such as publish/subscribe messages, which facilitate the delivery of information independently of the hardware and network topology. The diagram illustrates the ability to separate the different plug-in implementations from each other and deploy them on separate processors, or as separate processes on the same processor.

This approach illustrates how legacy systems can interoperate with the Application framework through the use of the middleware capabilities. The messaging capabilities of the middleware facilitate the use of an adaptor to translate from one message set, and associated protocol, to another – (making two disparate systems common from a C2 point of view). In addition, the Presentation Manager provides the capability to access the legacy system through either a remote desktop type of window, or as an application that provides a stream of data to a view portal.

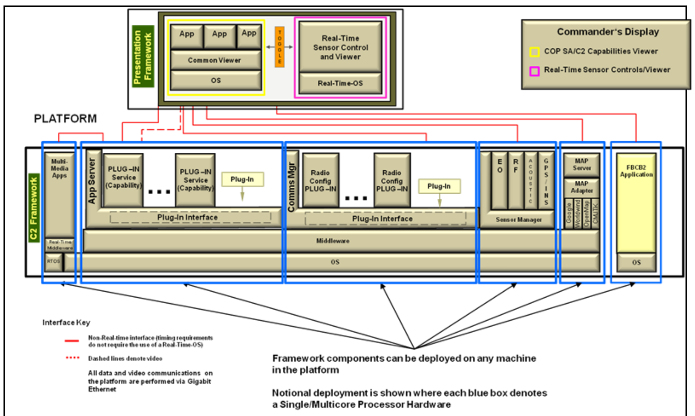

Figure 7: Application Framework and Middleware Role

The interface between the Application Framework and the Sensor Control framework facilitates capabilities such as configuring the sensors, initiating search operations, and initiating cross-cueing between sensor types (such as RF to EOIR). The video connection between the Sensor Control Framework and the Application Framework supports both the fusion processing and the ability to store/archive video for playback and radio transmission.

A big part of the functionality provided by the Application Framework is the management of the information from various sources, such as friendly force location, enemy force locations, environmental information (such as weather and terrain), orders and plan information, and resource management. The totality of this information is managed and presented to the user, through the Presentation Framework, to provide something like a Common Operating Picture. This information is generally provided through a map interface to provide context.

Key to an ISR capability is identification of artifacts and potential targets, and immediate dissemination to multiple users, or annotation, indexing, and storage of the artifacts for subsequent recall and viewing. Ideally, much of this should be automated to assist the user in processing vast amounts of available surveillance information.

The major components implemented in the Application Framework that enable these key capabilities in the Tactical Plug and Play Architecture include:

- Tactical C2 Capabilities. Subsystems integrated to provide C2 are:
    - A visualization capability which presents ISR information to the User.
    - JVMF capability for Tactical Messaging
    - Collaboration
        - Whiteboard
        - Chat
        - E-Mail
    - Maps with Mil Standard 2525 Symbology
- Video Management Subsystem that may receive low latency video or imagery in a number of formats, and encodes and disseminate it in MPEG-4, H.264, or other formats
    - Archives sensor video, metadata, track and point of interest, images, video tags, events, observations, and comments, and related documents.
    - Disseminates video at a per-feed rate; allows slower off-board radio transfers
    - Handles annotation, indexing, and storage of the artifacts for subsequent recall and viewing.
    - Data retrieval that may be based on geospatial, temporal, or keyword queries
- VNC clients, allowing remote-desktop type of access of select applications
- Web browser access of select applications
- Virtual Machine operation of designated applications in partitioned workspaces

LESSONS LEARNED

The following are key artifacts of this vehicle architecture that have been either learned from feedback or integration of the frameworks.

The first artifact derived from this effort is that the user interfaces need to stay consistent, simple and intuitive between various capabilities and vehicle systems. There is a need to minimize the number of displays, but there is also a need to maintain consistency with the look and feel of operating the integrated system, regardless of the number of systems integrated behind the display.

There needs to be a separation of real-time management from the desktop capabilities from an architectural standpoint. The architecture should avoid trying to integrate the desktop capabilities with the real-time sensor control within the same infrastructure. The real-time environment typically does not provide all of the interfaces and capabilities needed for the desktop environment, and the desktop infrastructures generally do not meet the latency requirements needed for the sensor control, especially for the engagement scenarios.

Collaboration capabilities, including chat and telestration, are key to situational awareness at the lower echelon levels. The ability to convey information through graphical representation between end-users provides real-time situational understanding and awareness.

Finally, the ability to archive, playback, disseminate, and add tagging to video, image clips, and pictures provides a means for conveying a lot of information in context, along with the support for forensics.

CONCLUSION

A plug and fight architecture for existing and future Army platforms has been presented. It achieves the objectives of scalability, interoperability, effectiveness, and usability while providing a reduced SWaP footprint relative to today's video intensive C4ISR systems. The architecture is comprised of four frameworks (C2, Sensor Control, Presentation, and Communication) that provide application server infrastructure while the applications are the plug-ins that provide functionality and APIs for external consumers of data. This approach, facilitated by middleware, allows independent evolution of the frameworks as well as the applications that give the system its capabilities. Another important benefit of this architecture is it is a digital framework that helps eliminate manual steps, which reduce mission timelines. Finally, this digital architecture provides the ability to accommodate legacy systems as well as the current and future generation capabilities which increases effectiveness by providing the necessary data to the right place and the right time for a wide variety of missions. Figure 8 captures the capabilities provided by the vehicle digital backbone structure along with the C2 desktop capabilities.

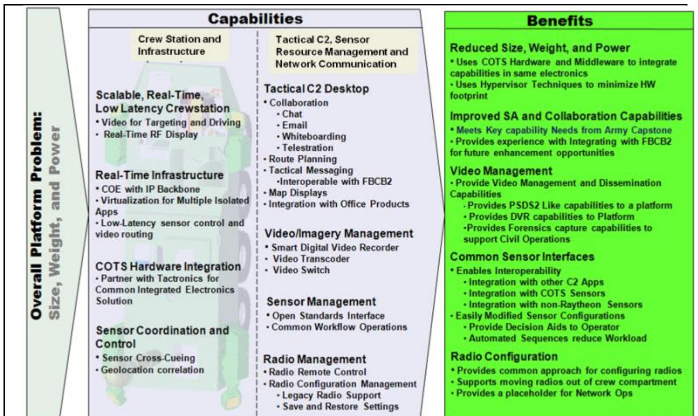

Figure 8: Framework Capabilities and Benefits