Future Directions in Chemical and Biological Detection

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ABSTRACT

The JPEO-CBD, in conjunction with other members of the defense community, is actively assessing future system architectures for Major Defense Acquisition Programs (MDAPs) such as the Future Combat Systems (FCS). Sensors, networks and information superiority are key elements of FCS, and the JPEO will provide the critical capability that enables complete situational awareness of CB hazards. After a brief overview of the JPEO-CBD program, this paper discusses early insight into how FCS operations and platforms affect CB sensors. Key challenges will be highlighted, such as sensor/platform integration, broad spectrum detection, and sensor performance.

Keywords: System architecture, system of systems, chemical sensors, biological sensors

1. ORGANIZATION OVERVIEW

The Joint Program Executive Office for Chemical and Biological Defense is responsible for research, development, acquisition, fielding, and life-cycle support of chemical, biological, radiological, and nuclear defense equipment, medical countermeasures, and installation and force protection supporting the national military strategy. The JPEO-CBD consists of eight Joint Project Managers (JPMs) from all the services, along with a number of internal JPEO-CBD directorates to manage high level business and strategic operations. The JPM list includes Information Systems, Collective Protection, Individual Protection, Contamination Avoidance, Biological Defense, Guardian (Installation Protection), Decontamination, and Medical Systems. With the true “Joint” Project Manager structure, there is no “service lead” in developing and procuring capabilities. Each Project Manager is responsible to all the services for delivering required capabilities. Building on the solid foundation of organizations that already existed in the individual services, the JPEO-CBD delivers joint chemical and biological defense capabilities to the warfighter, supporting the Global War on Terrorism, and transitioning capabilities supporting Homeland Defense and Homeland Security.

The Future Acquisition Directorate is one of the Directorates within the JPEO-CBD organization. The Future Acquisition Directorate has principal staff responsibility to the Joint Program Executive Officer to assure that material solutions are available to meet the articulated capability needs of existing acquisition programs and future acquisition programs. The Directorate executes this responsibility through analyses, experimentation, advocacy, alignment, and coordination.

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To provide this support, the Directorate executes a strategy targeted within and outside of the JPEO organizational structure. Within the JPEO structure, the Directorate assists the Joint Project Managers to effectively and efficiently execute their total life-cycle management responsibilities by coordinating and facilitating technology maturation and transition from all sources of technology including maximized leveraging of international developmental activities. We assure that JPEOCBD-managed programs are responsive to real operational needs through threat understanding and on-going analysis of architectural, concept and material alternatives. The Future Acquisition Directorate also shapes the role of the JPEO to provide acquisition in support of future capability needs and to major defense acquisition programs. The Directorate provides support to the development of enterprise architectures and CBRN defense capability portfolio definitions through representation on joint integrated concept teams. The outputs from these efforts are capability documents which drive material solutions for the joint forces in CBRN defense.

The Future Acquisition Directorate also provides the process framework for end-to-end capability development through leveraging network centric system of systems concepts, including modular/tailorable designs that are then integrated with the Services' Major Defense Acquisition Program strategies and adopted in internal material development strategies. The Directorate provides analytical support and organizational framework to achieve effective, suitable, and affordable capabilities. We emphasize front-end processes to identify new opportunities, create technology leverage through open architectures and commercial standards, balance resource capacity with system of system capabilities, and achieve strategic alignment across projects and products within the capability portfolio of CBRN defense. An important aspect of this is supporting focused experimentation to deliver new concepts of use supporting innovative technology application to capability needs. Early experimentation focuses material development and identifies trade spaces in resources and risks. Both are invaluable tools for the material developer.

The objective of the Directorate is to provide the framework for CDBP enterprise portfolios that are balanced, compatible, and aligned to create seamless warfighter solutions while leveraging external partners and protecting core aspects of the DoD material enterprise.

2. THE CBRN DEFENSE CHALLENGE

CBRN weapons are proliferating because of their value in asymmetric warfare. The future vision goes beyond providing traditional CBRN defense and force protection capabilities to the elimination of the operational value of these weapons thereby deterring their use on the battlefield. Future CBRN defense capabilities must support operations in a CBRN environment without impacting the mission or force survivability. They must be an integrated part of the overall System of Systems (SOS) that enables mission accomplishment.

CBRN defense capabilities must transform to support future joint operational concepts. CBRN defense concepts must be based on an integrated systems-of-systems view and a modular view where CBRN defense packages can be tailored to the mission, threat, environment, or situation. The objective is to provide commanders the flexibility to operate in a CBRN environment without degrading operating tempo or survivability.

The common operating picture should include CBRN considerations based on data fused from multiple CBRN and non-CBRN sensor sources. These sensors should be modular and plug-and-play in a network environment. Analysis and decision tools which integrate CBRN and non-CBRN information should enable rapid decision making at the strategic, tactical, and unit level to protect the force. The goal is for a CBRN environment to become just another operating environment to adapt to and overcome. Key transformational concepts for CBRN defense include:

- Fuse information from numerous sources (CBRN and non-CBRN) to rapidly understand the CBRN operating environment as part of the common operating picture to support rapid tactical decision making
- Eliminate the physical constraints on the force posed by CBRN protective equipment to prevent degradation in capability without sacrificing force protection.
- Prevent CBRN effects on equipment and minimize their impact on the logistics system

The CBDP will develop a family of systems (FOS) to integrate into SoS to provide Chemical Biological Radiological and Nuclear (CBRN) defense capabilities to the current and future forces.

The threat against the future forces is a departure from the traditional threat and therefore requires a different approach to counter it. The Services are undertaking a transformation to deal with this change, which require the forces to be more mobile and adaptable. Developing a modular force will allow the commander to make adjustments to an evolving threat.

3. FUTURE COMBAT SYSTEMS (FCS)

Each military service has Major Defense Acquisition Programs (MDAPs) designed to support transformation. The JPEO CBD has established a team to lead efforts to provide CBRN equipment for integration into the MDAPs (figure 1). One of the initial programs task to this integration team was Future Combat Systems.

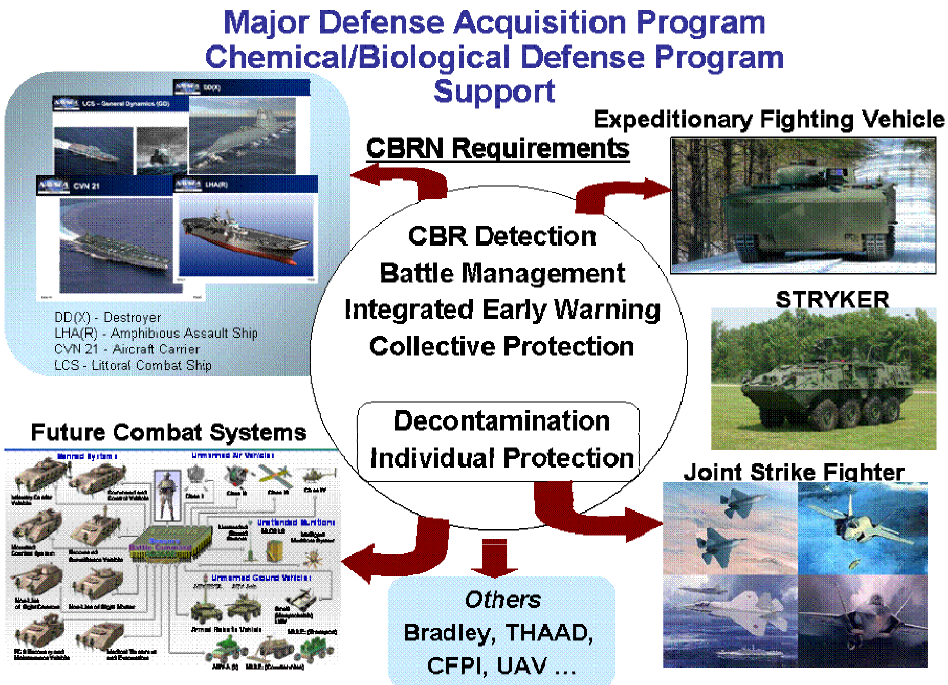

Figure 1. Chemical Biological Defense Program Support to Major Defense Acquisition Programs

The adaptive and unpredictable nature of future adversaries, combined with other geopolitical and geo-strategic realities, mandates that the Army have a rapid, decisive capability to respond across the full spectrum of operations. The Army's current capabilities exhibit a near-term strategic capabilities gap that impacts its ability to provide the National Command Authority (NCA) and Combatant Commanders the full range of land power options necessary to operate in this dynamic security environment. In order to close the gap, the Secretary of the Army and the Chief of Staff of the Army articulated a vision of how the Army will transform to meet the demands of the 21st Century. The former Army Chief of Staff's White Paper[1], a published articulation of the vision, provides the foundation of the vision. The FCS Organizational and Operational Concept (O&O), Operational Requirements Document (ORD), and the FCS design concept embody the Army's strategy.

The FCS Program[2] is the greatest technology and integration challenge the Army has ever undertaken, providing unprecedented military capability. General Eric Shinseki, former Chief of Staff of the Army, said "FCS will be a unified effort across the Army and across science and industry that proceeds along a broad axis of advance. It's going to break down walls between organizations – in the Army, between science, technology, and engineering communities, and among members of industry." The dramatically reduced program schedule introduces an unprecedented level of concurrency, where all stakeholders must act in concert together as one organization. The user community, the materiel developers and our industry partners must work as one towards the common goal of developing, producing, fielding and sustaining the full complement of safe, reliable, suitable, survivable, and effective materiel envisioned by the Brigade Combat Team (BCT) Operational and Organizational Plan.

The revolutionary changes required to achieve the Objective Force (OF) transcend all Doctrine, Organization, Training, Materiel, Leader, Personnel, and Facilities (DOTMLPF) (formerly

DTLOMS) domains. However, DOTLPF (minus materiel) changes alone, although critical to success, cannot achieve full OF capabilities. Results of the FCS Mission Needs Analysis (MNA) reveal that the FCS BCT represents a new way to organize, train, and fight. The BCT will require the synergistic application of new and existing materiel technologies, plus changes in doctrine, training methods, and organizational designs, resulting in fully trained and adaptive leaders and multi-functional soldiers. Deficiencies identified by the MNA that require materiel solutions include but are not limited to strategic deployment, Reception, Staging, Onward Movement and Integration (RSOI), sustainment, tactical effectiveness, survivability and lethality.

To facilitate using greater shared situational awareness to understand when and where to attack, the BCT is designed to allow greater horizontal and vertical collaboration. Embedded in the FCS System of Systems is an en-route mission planning and rehearsal capability. Soldiers and leaders can receive and disseminate information as well as collaboratively plan and virtually rehearse en-route regardless if they are moving by land, sea, or air, mounted or dismounted. This information includes near real time enemy information and digital maps. The same systems we use in training, transitions to the Battle Command systems leaders use in combat to collaboratively plan, rehearse and execute operations on the move from vehicles or dismounted.

4. OPERATIONS IN A CBRN ENVIRONMENT

Maneuver support imperatives provide the BCT the means to conduct operations in a CBRN environment through embedded capabilities and augmentation from attachments and Joint forces. The basic maneuver support operational approach is applied in CBRN operations through the processes of Shape-Sense-Shield-Sustain. BCT personnel and leaders are trained and equipped to conduct operations in a CBRN environment. CBRN defense personnel integrated in the Maneuver and Support Staff Cells at Brigade and Chemical/CBRN defense staff personnel at Battalion coordinate external CBRN support and perform battle management functions. The BCT identifies and locates delivery systems and hazard areas, and predicts potential hazard areas that could impact BCT operations. It uses dispersion, information superiority, protective posture, and mobility to reduce its vulnerability to CBRN targeting. It attacks delivery systems to prevent potential hazards.

The BCT uses non-CBRN ISR (termed collateral sensors) such as radar to identify munitions and aircraft that are delivering CBRN, to initiate the warning and reporting system, and to cue CBRN sensors. It uses CBRN standoff detectors, unattended ground sensors (UGS), unmanned aerial vehicles (UAVs), unmanned ground vehicles (UGVs), and point detectors embedded on manned platforms to provide the layering of detection capabilities needed for a dispersed force to confirm hazards and their extent, avoid hazards, and warn personnel to assume protective posture; notably against downwind hazards whose impact can change rapidly due to changes in weather and the effects of terrain. It neutralizes hazards that cannot be avoided. The BCT maintains combat effectiveness even in a hazardous environment through the use of collective protection for manned systems, allowing crews to perform their duties without assuming mission oriented protective posture (MOPP). Personnel are vaccinated, medically monitored, and have ready access personal protective equipment, decontamination supplies, and immediate treatment measures for expected hazards. If contaminated, the BCT will conduct contamination reduction using organic decontamination systems, request augmentation from higher echelons if needed, and rapidly return to a pre-attack state.

5. DEVELOPMENT APPROACH

In order to maintain technological superiority and support the tenets of transformation, the CBDP is changing the way it does business. The materiel developer must be integrated with the combat developer from the beginning as they analyze and assess the capabilities required.

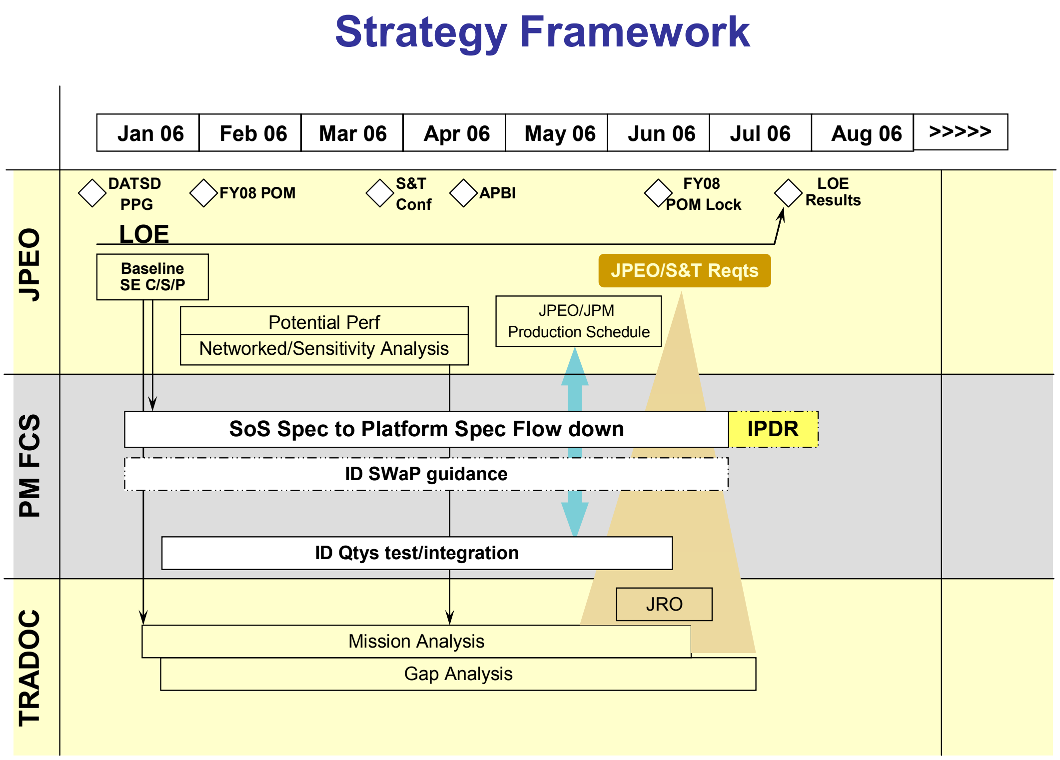

Figure 2. Organizational and Strategy Framework for FCS Analysis

Keeping in mind CBRN survivability is not the mission, but is key in providing the commander situation awareness and flexibility, the integrated team is conducting a thorough analysis to understand the problem, determine the capabilities required, translate those required capabilities into technical requirements and develop a SoS technology solution that will provide those capabilities. This starts with a good understanding of the threat. As part of the FCS efforts, a study team was established to study and document the CBRN threat. Their process and unclassified results are illustrated in the "Threat Prioritization Process" diagram below.

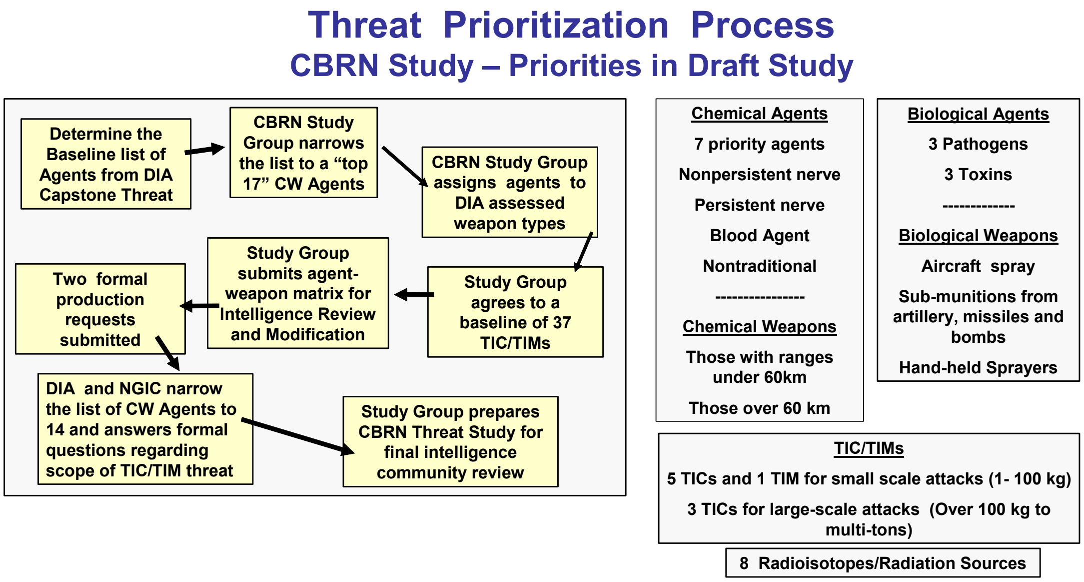

Figure 3. Threat Prioritization Process

Once the threat was understood, an analysis team was formed to dissect the FCS Operational and Organizational (O&O) Plan and operational scenarios to develop CBRN operational vignettes, to analyze the actions and reactions of the forces and understand when and where CBRN threats may be used and what hazards they provide to the BCT. The threats and vignettes are currently being modeled as a tool to aid us in this understanding.

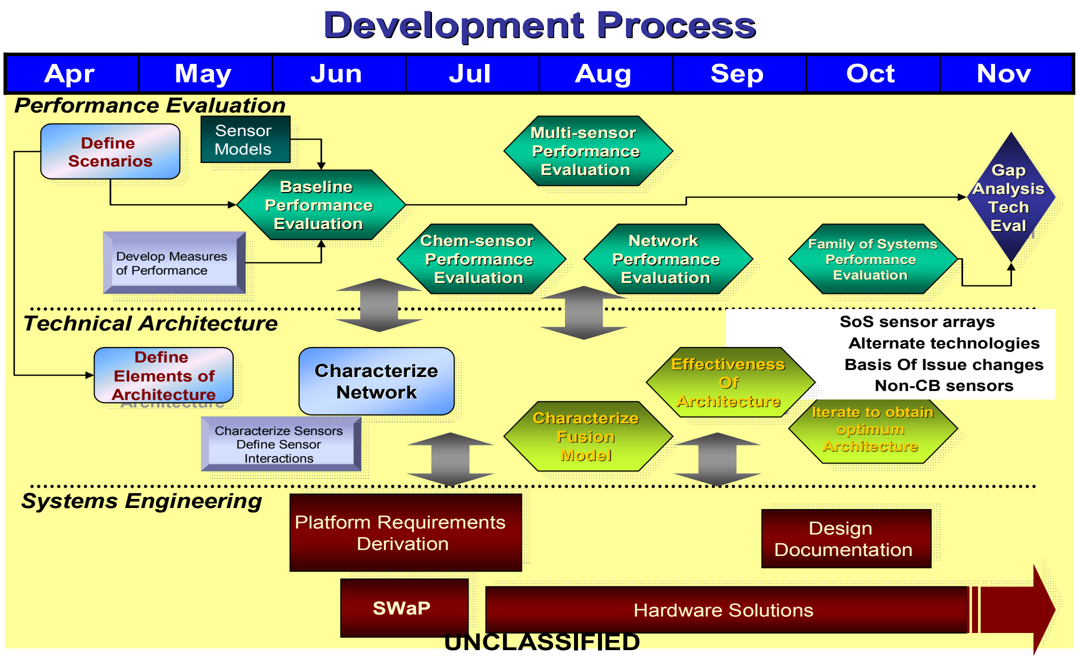

Figure 4. FCS/CBRN Development Process

The modeling output will be detailed information on the hazards presented to the elements and platforms of the BCT, providing us the information necessary to develop an effective SoS solution. As described earlier, the SoS solution (see Technical Architecture example below) will comprise of CBRN and non-CBRN components using data fusion algorithms and the network to inform the commander with the most accurate reliable situation awareness information available.

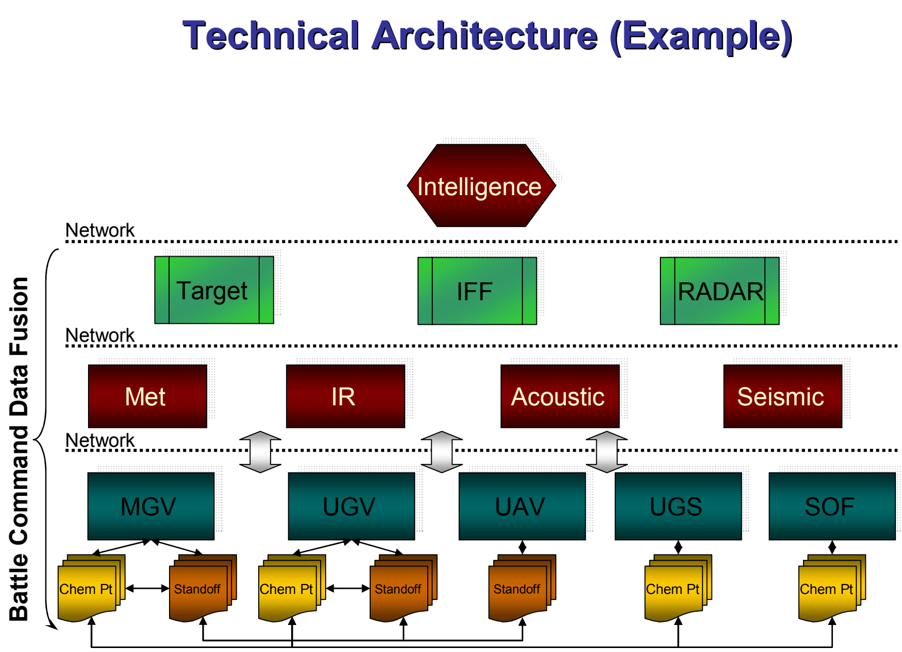

Figure 5. Example CBRN Technical Architecture

6. FUTURE CBRN DEFENSE CAPABILITIES

In addition to meeting the CBRN defense requirements of the major defense acquisition programs, our forces are being required to provide full spectrum CBRNE detection AND identification. This capability must be met using equipment systems that fit and operate within the restrictive space and weight requirements of the mobile platforms. This comprehensive sensing capacity is also sought for missions requiring handheld sensing capability. These emerging requirements present the major challenge of incorporating the capability of many commercially available and developmental systems into easily integrated CBRNE defense solutions.

The JPEO-CBD has approached this challenge by proposing a sensor focused architecture that employs enabling technologies and standardized sensor hardware and software interfaces. Enabling technologies such as plug-n-play architecture, power standardization, and wireless communication, coupled with standardized connection designs and data formats will provide the warfighter with modular sensor packages, deployable across the many mission scenarios anticipated. This modular concept will allow for interchangeable sensors systems that, in the near term, can be tailored in the field to the desired mission. As a result, the size, weight, and power burden on the users can be significantly reduced. This modular concept will also help lay the foundation for next generation sensor designs and concepts of operation where full spectrum capability is achieved in one small sensor package. These modular or small, all-inclusive sensor packages would be easily integrated into mobile or handheld applications.

To realize this concept of modularity, the JPEO-CBD will utilize a Limited Objective Experiment (LOE) in the Fall of 2006 to seek feedback from the user community. LOEs allow mature and prototyped equipment packages, along with the associated concepts of operation, to be assessed and evaluated by the users through live experimentation in simulated battlefield scenarios. As an experiment, the methods, procedures, and equipment can be changed or modified during the trials to help determine the best possible solution for the given problem.

For the modular sensor concept LOE, functional prototypes will be developed in cooperation with industry and provided to the user community for evaluation in the live experiment. The functional prototypes will be various sensors with distinct sensing capabilities, repackaged to share common physical interface connections and data formats. Plug-n-play functionality, net-centric architectures, and wireless communication will all be incorporated. The repackaged sensors will be integrated into a military vehicle using a docking station design and will be capable of both mounted and dismounted (via wireless communication) operation where appropriate. The warfighter personnel will conduct a number of mock sensitive site assessment (SSA) missions to demonstrate and evaluate the concepts. The SSA missions will include chemical, biological, radiological, and explosive detection and identification in open field and building hazard areas.

This LOE will deliver user comments on the equipment's military utility and will assess, refine, and validate concepts of operation and techniques, tactics, and procedures (TTPs) for the provided equipment capability. The information gathered will then be used to help develop requirements documents for acquisition program planning and execution. The LOE will also provide information to help drive interface standards for industry to follow when designing military CBR sensors. From the macro view, this LOE provides another step towards achieving the ultimate goal of embedded full spectrum sensor capability throughout the battle space.

7. SUMMARY

The JPEO-CBD continues to develop, procure and field the most advanced chemical and biological defense equipment that allow our warfighters to succeed in their missions. We are developing integrated systems-of-systems for our Major Defense Acquisition Programs that are optimized for their needs. Important results are emerging from our FCS analysis.

The nature of the FCS BCT, including the platforms and communications network, requires the chemical and biological equipment to be embedded, lightweight, and network ready. Non-CB sensors will be used to cue and supplement CB sensors to provide more complete situational awareness. The proliferation of these sensors on the battlefield requires intelligent data aggregation and fusion so that soldiers are not overloaded with data. Successful development and deployment of these capabilities will allow the FCS BCT to complete its mission unencumbered by CBR hazards.

8. REFERENCES

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