AGILE CAPABILITY DEVELOPMENT, ASSESSMENT AND TRANSITION IN SUPPORT OF THE GLOBAL WAR ON TERROR (GWOT)

Dr. R. Cherinka, J. Mathews, Dr. R. Miller, D. Pitcher, W. R. Sears and T. Semanchik
The MITRE Corporation

ABSTRACT

Net-Centric Solutions, as enabled through distributed service-oriented architectures, will have a significant effect on the way the DoD acquires capabilities, thereby requiring new ways to address the development and integration of complex enterprises. One approach, based on commercial best practices, entails establishing an environment and set of processes for users and developers to work together in the development and maturation of capabilities as they transform from innovation to fielded capability. In this paper, we discuss an approach that USSOCOM and MITRE are using to evaluate and mature capabilities that support the Global War on Terror. It is based on using a distributed innovation lab environment in conjunction with a series of warfighter workshops focused on themes and challenge problems identified by USSOCOM. The workshops are designed to provide hands-on warfighter immersion into emerging processes, concepts and capabilities combined with facilitated discussions to develop and/or refine CONOPS and Tactics, Techniques and Procedures. We highlight some of the capabilities provided, techniques used, challenges faced, and how this approach impacted the user. Finally, we discuss our future plans to extend this approach to other customers and locations in order to fully assess GWOT missions across a net-centric enterprise.

INTRODUCTION

Complex systems are characterized as having unpredictable behavior, fluid requirements, multiple competing stakeholders, and are susceptible to external pressures that can cause change across the entire system or enterprise [2]. Previous research has been accomplished to show that traditional systems engineering approaches do not work well when applied to complex systems [3, 10]. Instead, the notion of complex systems engineering has matured over the past few years as a way to address DoD enterprise engineering. Key principles of this approach that we seek to address include:

- More emphasis on capabilities, less emphasis on requirements
- Focus on early discovery and evolution of composite behavior, functionality, and performance.
- Emphasize design guidelines, such as the use of layered architecture and open standards
- Use of rapid development spirals and experimentation, supported by establishing a collaborative engineering & integration environment, developing best practices and providing incentives to collaborate

The US Department of Defense (DoD) Net Centric environment is a good example of a complex system, with many unpredictable external factors that often demand rapid response and flexibility to change. Net Centric Operations for the DoD represents a shift from traditional system-based interactions toward information-based web transactions, adding the requirement for highly secure, reliable, and dynamic "on-demand" capabilities [1, 9]. Using a distributed web-based data strategy, DoD net-centric Operations entails the networking of information producers (e.g., sensors), decision makers, and consumers to achieve shared awareness, increased speed and quality of decision making, and a higher tempo of dynamic operations [6].

This paper presents an approach that MITRE is helping the DoD and USSOCOM to use to adopt the use of agile development techniques as applied to capability assessment and transition in support of the Global War on Terror (GWOT) [5, 7]. The approach relies on using a distributed innovation lab (iLAb) environment in conjunction with a series of warfighter workshops focused on themes and challenge problems identified by USSOCOM. These workshops leverage FFRDC, Government, Industry and Academia resources and net-centric distributed capabilities to facilitate agile capability assessment and transition opportunities in end-to-end fashion. They are designed to provide hands-on warfighter immersion into emerging processes, concepts and capabilities combined with facilitated discussions to develop and/or refine CONOPS and Tactics, Techniques and Procedures (TTPs).

We discuss the results and lessons learned in conducting two USSOCOM warfighter workshops as a tool to assess capabilities and quickly integrate disparate netted sensor and Task, Post, Process and Use (TPPU) technologies related to the Global Sensor Network (GSN). The GSN is USSOCOM's emerging architecture to deploy, manage and exploit various sensors in support of GWOT missions. We highlight some of the capabilities assessed; the techniques used to quickly integrate them in a loosely-coupled fashion; the challenges we faced; and how the user was impacted. Finally, we discuss our future plans to extend this approach to other customers and locations in order to fully assess GWOT missions across a net-centric enterprise.

BACKGROUND

The GWOT represents a new form of warfare that includes many complex dimensions and challenges. Currently, USSOCOM manages global operations against terrorist networks [12].

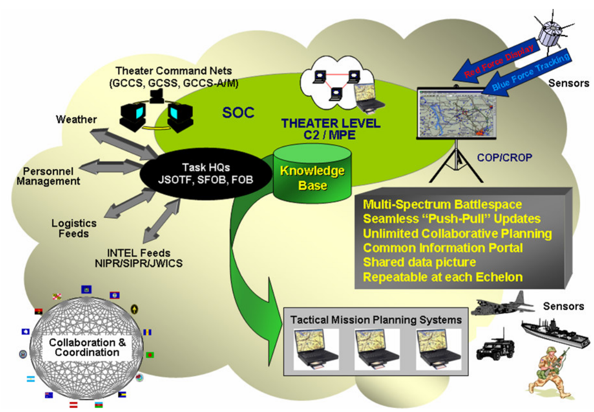

Figure 1. Overarching GWOT Concepts

Figure 1 depicts the GWOT conceptual architecture integrates many capabilities, such as global and tactical situational awareness, multi-agency/nation collaboration & coordination; enhanced joint operations among conventional and special operations forces; knowledge sharing and management; and enhanced sensor technologies.

The methodology and lessons learned described in this paper are based on our experiences in helping USSOCOM to quickly assess and transition capabilities pertaining to sensor technologies that support GWOT missions. These GSN capabilities are fundamentally based on emerging sensor web enabling (SWE) standards being matured and reviewed by the Open Geospatial Consortium (OGC) [4]. A Sensor Web refers to web accessible sensor networks and archived sensor data that can be discovered and accessed using standard protocols and application program interfaces (APIs). The goal of SWE is to enable all types of Web and/or Internet-accessible sensors, instruments, and imaging devices to be accessible and, where applicable, controllable via the Web. The vision is to define and approve the standards foundation for "plug-and-play" Web-based sensor networks. Our goal is to assess these standards for use in realistic environments.

AGILE CAPABILITY DEVELOPMENT & ASSESSMENT

As discussed above, Net Centric Operations as a complex system has challenged the DoD acquisition process. To that end, we are experimenting across the DoD with a shift of emphasis toward creating a process and environment (rather than a product) to help in the development and maturation of capabilities as they transform from innovation to fielded capability. The core objectives of this approach are to:

- ***Promote*** application of emerging technology to key sponsor & mission areas
- ***Provide*** technical path finding capability via rapid prototyping & experimentation, integration and assessment
- ***Demonstrate*** reuse of technology & solutions across customer programs
- ***Facilitate*** collaboration among Government and Industry

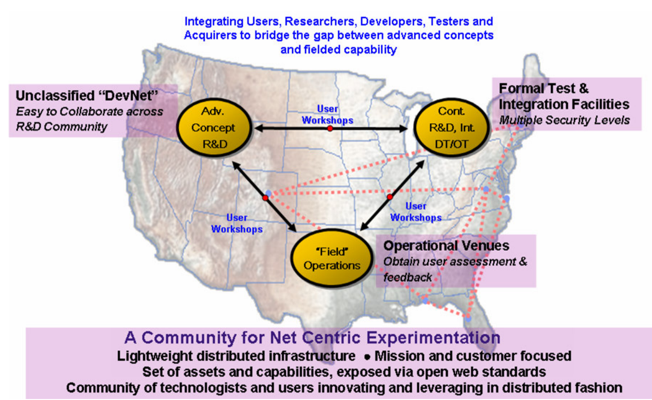

Figure 2. A Distributed Innovation Environment

As depicted in Figure 2, the intent is to create an environment where researchers, developers, testers, and users can work together and exchange their ideas, code, and expertise as they experiment and mature new capabilities. This carries through from advanced concept research & development through controlled test & integration through operational test & assessment.

A key enabler for such an environment is an iLab that spans across several locations to provide a common set of Service-Oriented distributed computing resources modeling the DoD Net-Centric data strategy. This helps integrate the user and developer through knowledge sharing; providing a process for evaluation; a mechanism of reward; a common understanding of services and constraints; and rules for cooperation and competition. Typical functions include:

- Providing access to existing DoD and Commercial systems to support R&D efforts
- Providing core services and infrastructure (e.g., service registries, brokering technologies, security) to enable rapid deployment, discovery, and usage
- Publishing guidelines for information service creation and usage based on accepted industry and government standards
- Enabling user and provider discussion and feedback channels for collaboration (e.g. forums)
- Ensuring usage and testing in operational context

In our work described in this paper, the iLab is used for addressing common enterprise challenges and net-centric C2 and horizontal integration initiatives across several DoD customers. Individual site iLabs leverage their site customer relationships and their understanding of mission and customer requirements in addressing local sponsor mission needs through technology solutions. This provides a foundation to work cross-cutting mission-critical enterprise problems at large.

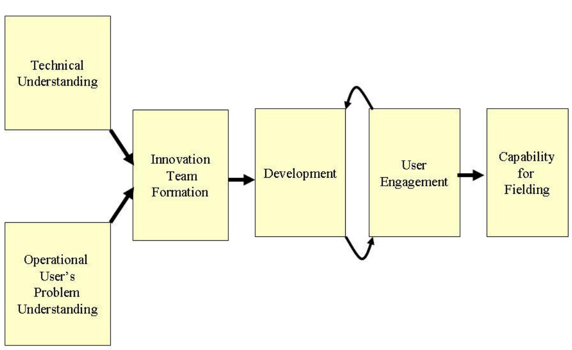

Figure 3. Agile Capability Assessment Process

In addition to having a distributed capability such as the ilab, it is equally important to have a light-weight process for addressing those cross-cutting problems. In our work, we have adapted agile development techniques to provide such a light-weight process. Figure 3 represents the specific process that we are employing across several customer communities within the DoD. The formal steps are highlighted as such:

- Engage customers to identify critical, tangible, focused sponsor needs, use cases, scenarios and assessment criteria
- Identify cross-customer common problems
- Leverage cross-customer investments and corporate initiatives
- Put out a "Call for Solutions"
- Evaluate and select solutions (full or partial) and integrate them
- Validate via a realistic enough "workshop"
- Analyze & produce "Hotwash"
- Feed back results to sponsors to drive CONOPs, TTPs, Requirements and Transition opportunities

The key to this process is the use of a series of user workshops focused on customer identified themes and challenge problems to drive integration spirals and limited objective evaluations that provide value in two important areas:

- hands-on user immersion into emerging processes, concepts and capabilities
- facilitated discussion to drive concepts, requirements and transition opportunities

To support this process, we have established a repository of important user problems, gaps and priorities. We use this repository when we engage with users to look for common challenges, establish workshop objectives, as well as the scenarios and criteria to measure the success of each workshop. We have developed a number of templates for capturing this information in a way that facilitates the experimentation and "hot wash" process to assess capabilities in terms of operational utility, technical readiness and to transition/influence progress.

APPLYING AGILE TECHNIQUES TO ASSESS GWOT CAPABILITIES

In this section, we highlight the application of the agile techniques discussed above through two warfighter workshops conducted at USSOCOM in Tampa, FL. The main objectives of the warfighter workshops were to evaluate Net-Centric approaches, technologies and capabilities to drive business processes, TTPs, CONOPs, and capability/technology transition opportunities for GWOT operations.

The first workshop was conducted June 2006 with a focused theme on Joint Intelligence Operations Center (JIOC) and other similar knowledge Centers. It showcased initiatives highlighting emerging capabilities in Multi-INT analysis, exploitation, archival and forensics, collaboration & information sharing, tactical edge mobile computing & sensor networks, and command center & decision support.

The second workshop was conducted October 2006 with a focus on netted sensor capabilities/limitations and sensor data processing/analysis for experimentation of a global sensor network. This workshop highlighted capabilities of current and emerging sensors, processing/visualization systems, and web-enabled services.

For both workshops, USSOCOM established the objectives based on a need to gain a better understanding of emerging GWOT capabilities in the above areas, and helped to construct the realistic scenarios to stress test key concepts. The results of these workshops were used to directly influence the acquisition products necessary to guide future investments. In addition, several of the capabilities were determined ready for "field testing" and were promoted to the next level of assessment by the users.

LESSONS LEARNED

In this section, we attempt to highlight some very specific lessons learned associated with the application of agile techniques to quickly "assemble" and assess capabilities, as well as the workshop process itself.

Using a distributed environment and repeatable process as described in this paper has its challenges with coordinating resources including people across the geographic boundaries. However, it has the benefit of cost reduction for hardware, etc. and avoids the need of one location knowing/having all data and systems in-house. Such use of distributed resources allows the experts of those systems and the systems themselves to be shared across the distributed community in realistic fashion. Using our ilab, we realized the following:

- Connectivity issues can be solved once and not lost to network and system teardown.
- Applications can be made available through standardized web service interfaces, mitigating system interface issues.
- Web service architectures can be set up, expanded, and exercised.
- Subject Matter Experts and operational personnel can participate from their base location, reducing travel costs and increasing participation.
- Systems can be employed that otherwise would not be available, e.g., through lack of necessary hardware.

In order to fully appreciate the application of agile assessment techniques to a complex set of problems, we discuss some of the key challenges addressed in the USSOCOM warfighter workshops mentioned above. From an interoperability standpoint, one of the key lessons we learned was that one of the first activities to be accomplished is deciding upon a common information standard to share information across the various participating systems. A light weight extensible XML meta-language to support the Net Centric capabilities allowing rapid reconfiguration and extensions as needed was required and several markup languages were evaluated (e.g. CoT, SML, TML, XML-MTF) [8]. The Cursor-On-Target (CoT) standard was chosen primarily for the low cost of entry to implement and the high-level of support in the selected DoD end-user systems. Systems were not forced to communicate CoT internally, but all inter-system exchanges were required to be in CoT. Converting information to and from CoT (e.g. to KML for Google Earth) turned out to be trivial in each case. CoT has been used successfully by over 90 systems to exchange time sensitive information that spans the gamut from prototype and proof of concept applications to fielded DoD systems of record [11].

CoT achieves a loose coupling between systems with a simple exchange of time sensitive information that each system understands. CoT defines the "What, When, Where" information that enables DoD systems to communicate. A producer can produce as much CoT-enhanced details as appropriate (e.g., geometric shapes, inline imagery, track/target info, classification, tasking, etc.) or as little being the few required core attributes to define the what, when, and where of a given event. This facilitated agile development with producers refining the CoT message content with adding/removing/restructuring the detailed metadata in a number of iterations prior to the workshop. Clients processed whatever they understood in the message received. For example, the final sensor update message included an energy level and sensing mode, which the basic client ignored but an advanced client could utilize.

With the base messaging infrastructure in place, there must be a design for the taxonomy of message types and concrete attributes to use (e.g., energy level, representation for sensor field of view/coverage, sensor types, position error, imagery, estimated target course/speed, confidence, probability, etc.). With the various sensor systems available, the messages included the following types:

- Sensor status/updates including position, sensor status, and field of view of sensor to include radar, acoustic and motion-trigged camera sensors
- Tracks reported by tracking/fusion engine including position, and error in position
- Detections including error estimation with geometric shape appropriate to the sensor type
- Ground truth including position of ground truth vehicles (real or simulated)

These message types provided the data to feed our tactical displays illustrated below.

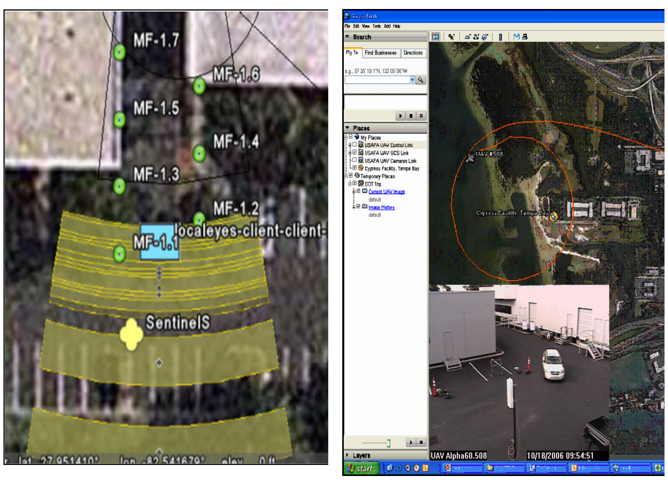

Figure A. Figure B.

Figure 4. Example Sensor Visualizations

Figure 4-A shows a visualization of the target ground vehicle entering the sensor grid with multiple radar detections being reported. Figure 4-B shows the simulated UAV being rerouted into the area of interest in response to the triggered event with inline frames from a live streaming video source. Figure 5 shows the larger area with sensor field of view, sensor placements, and target path.

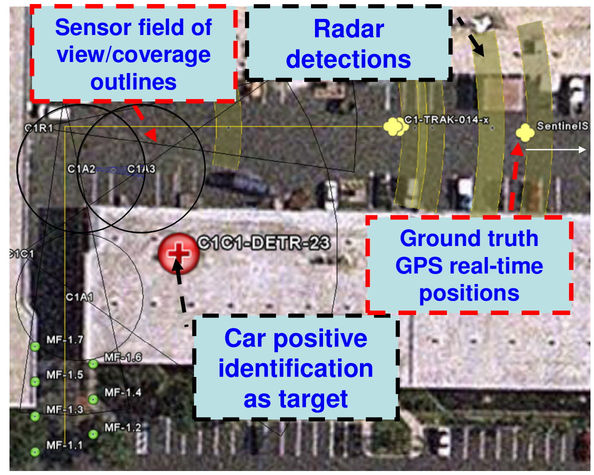

Figure 5. Google Earth Visualization of Sensor Data

One significant lesson learned from this type of display, which showed large amounts of complex information, was information overload. Further research and close attention to user feedback from the workshops led to implementing custom visualizations with varied levels of detail. In Figure 6, , a display tool has the ability to turn layers on/off as needed with a "semantic lens" showing, for example, the sensor field of view (or any other layer) in the upper left white box which can be hidden, enlarged, and moved around the screen by the user [13]. Also, rather than show individual sensor detections, a grid-based exfiltration region (shown with green and red boxes) shows the probability of a target in that sensor cluster (green=low probability, yellow=medium, red=high; solid=high confidence, transparent=low confidence). There are also other states encoded into this display (e.g. sensing modality, energy level, etc.) and many other layers or message types hidden (e.g. communication and status messages). This shows the overall situational awareness in a large area while allowing a fine level of detail and drill down.

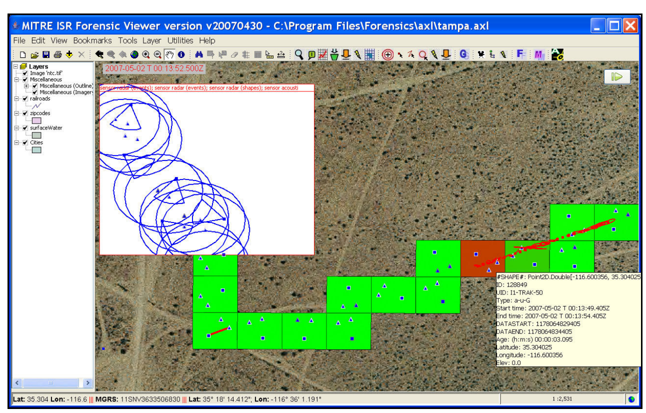

Figure 6. Forensics Real-Time Display

Other challenges included incorporating several different sensor systems and normalizing the network for disparate sensor systems from government research projects, commercial packages, and industry partners to communicate with each other. Most communicated over 802.11 wireless networks, some over a UHF radio network, and another required a shared broadband connection and getting messages sent via a commercial cellular phone provider. IP address de-confliction was a major theme of bringing all of the disparate sensor systems together. Many projects evolve their network systems with no prior knowledge or thought of combining their network with another. Most of these systems were embedded systems that were very hard and unlikely to have their IPs changed dynamically, which was typical for some sensor devices.

Bottlenecks were another network problem. Since our entire network resided at layer 2 all systems were propagating ARP packets across the full network, to include over wireless bridges. This caused a major bandwidth issue at our UHF long haul bottleneck. Many times the UHF connection would go down or become unresponsive because of the ARPs flooding the outbound UHF connection. A workaround for the experiment was found by bridging the local resource manager with the external sensor using 802.11b. This task should never be under estimated or postponed to the last minute.

In summary, the workshops achieved the following milestones:

- Increased awareness of agile development techniques and showed how iLab-like resources can be leveraged to evaluate emerging warfighter concepts and requirements
- Successfully integrated netted senor systems covering air and ground picture
- Demonstrated cue & slew with several sensor systems
- Identified key GSN capability requirements
- Demonstrated emerging capabilities in sensor web enablement and machine-to-machine communications using the SWE standards
- Captured data from workshop to support forensics analysis and playback for future experiments

FUTURE PLANS

Our plans are to extend the Warfighter Workshop scenarios to include participants, mission threads and data services that span distributed locations. The goal is to fully assess GWoT missions across a net-centric enterprise. This would involve both government and contractor laboratories and functionality. There are numerous advantages to distributed workshops. Too often, demonstrations and experiments involve a week or more of set up by a cadre of technicians and systems developers. A great deal of time and money is lost to load software, trouble-shoot network connectivity and system interfaces, and get systems operational. Often, the demonstration infrastructure is barely executing just prior to the start of the activity.

Future workshops intend to leverage the Global Cyberspace Integration Center's (GCIC) Constellation Development Environment (CDE), a distributed testing and experimentation capability being developed at the GCIC Transformation Center (TC). The CDE:

- Provides a venue for cross-platform prototyping, integration, standardization, concept exploration and demonstration for the various C2 experimental platforms.
- Provides a development environment for industry and service partners to access standard Command and Control (C2), Intelligence, Surveillance, and Reconnaissance (ISR), Air Force (AFFOR) data, services and infrastructure.
- Consists of standard Distributed Common Ground Station Integration Backbone (DIB) based infrastructure with clients accessing databases from all C2, ISR, and AFFOR communities of interest.
- Provides access through the NIPRNET, and Commercial Internet networks to live, virtual, and constructive capabilities (CDE, DCGS, and Combat Support).

The MITRE iLAb at Langley AFB recently executed an MOA with the GCIC TC to operate with the CDE. Connectivity is obtained via standalone workstations connected via the internet. Security is provided by point-to-point router connections (IP filtering). The intent is to provide MITRE researchers with unclassified access to joint systems and capabilities.

We are currently reviewing plans to use this CDE connectivity in a future warfighter workshop, contingent on available funding. The plan is to setup a JIOC (Tampa), DCGS AOC (Langley) and sensor field (Tampa and Bedford) to evaluate and stress test, through experimentation, the CONOPS/TTPs associated with conventional AOC/DGCS forces supporting a USSCOCOM-led GWOT mission against high value targets. Linkage through the CDE will provide the secure critical sensor information needed to track high value targets and integrate that information into the DCGS/AOC backbone for exploitation to support GWOT and TST missions. Lessons learned will influence current and emerging requirement specifications, e.g., DCGS-SOF CDD, GSN architecture, conventional DCGS/AOC future GWOT requirements, and the Tactical Edge ICD. It will also demonstrate the potential of a distributed network linkage between military and MITRE laboratories by putting MITRE in the position of addressing overlapping sponsor's problems and needs. Finally we intend to document the workshop outcomes and lessons learned to provide guidance for implementing a distributed GCTN and other service/joint information architectures and acquisition programs.

CONCLUSIONS

Complex systems theory and extensive experience demonstrate that sufficiently complex systems need evolutionary engineering strategies. Like many DoD customers, USSOCOM is focused on agile capability assessment and transition. The model of distributed prototyping via resources such as the iLab, utilized through frequent warfighter focused workshops, will play an important part in supporting their rapid acquisition cycle and their migration toward net-centric operations. Based on our experience thus far, we have shown that frequent, "light-weight" warfighter workshops can facilitate agile capability assessment and transition by

- Keeping customer focus throughout entire capability lifecycle
- Providing strong ties to Academic and Industry R&D
- Focusing on Holistic/Enterprise view … Keeps eye on bigger picture
- Supporting quick evaluation of capability alternatives
- Helping in risk mitigation
- Verifying/influencing CONOPS
- Identifying/Refining requirements and facilitates prioritization
- Linking strategy and needs to capabilities and technologies … Maximizes Return on investments
- Minimizing gap between mission need and fielded capability … agility

We believe the methodology discussed in this paper is very promising, and does allow for an organization to begin thinking about their complex environment in new ways. It also allows for organizations to guide hands-on capability spiral development, assessment and transition across the enterprise.

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