Knowledge Engineering for Command and Control Transformation at United States European Command (USEUCOM)

Authors:

Joanne Pester-DeWan
joanne@pacific-science.com
Pacific Science & Engineering Group, Inc.
9180 Brown Deer Road
San Diego, CA 92121
858-535-1661 – office
858-535-1665 – fax

Ronald A. Moore
ramoore@pacific-science.com
Pacific Science & Engineering Group, Inc.
9180 Brown Deer Road
San Diego, CA 92121
858-535-1661 – office
858-535-1665 – fax

Jeffrey G. Morrison
jmorriso@spawar.navy.mil
jeff.morrison@navy.mil
SPAWARSYSCEN
53560 Hull Street
San Diego, CA 92152-5000
619-553-9070 – office
619-553-9072 – fax

Point of Contact:

Joanne Pester-DeWan
joanne@pacific-science.com
Pacific Science & Engineering Group, Inc.
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San Diego, CA 92121
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Joanne Pester-DeWan
Ronald A. Moore
Pacific-Science & Engineering Group, Inc.
9180 Brown Deer Road
San Diego, CA 92121

Dr. Jeffrey G. Morrison
Space and Naval Warfare Systems Center, San Diego
53560 Hull Street, Bldg. Code D44210
San Diego, CA 92152-5001

Abstract

The Department of Defense (DOD) is seeking to transform the way it executes mission objectives to better take advantage of capabilities provided by modern technologies, as well as the best business practices currently being used in both DOD and industry. United States European Command (EUCOM) is taking a leadership role in this transformation. EUCOM is moving from a command organization focused on oversight and facilitation of communication and coordination among subordinate operational units to a *Standing Joint Force Headquarters* (SJFHQ) concept of operations focused on more direct command and control (C2) of forces and increased speed and flexibility of command, as well as more efficient use of limited staff manpower. Senior leaders at EUCOM recognize that a successful transformation is dependent on the effective and efficient management of information and knowledge. Accordingly, EUCOM leadership has devoted considerable effort towards optimizing facilities, tools and technologies. They are now focusing on assessing and improving their business processes. Towards this end, the authors were invited to conduct an independent, unbiased evaluation of their current information and knowledge management practices, identify strengths and weaknesses, and develop recommendations for improvement regarding information and knowledge management policies, practices, procedures, and their supporting technologies.

Introduction

This paper describes the processes and results associated with knowledge engineering and cognitive task analysis efforts conducted at United States European Command (EUCOM) in October, 2003 (Pester-DeWan, Moore, & Morrison, 2003). These efforts were conducted to assess the current state of information and knowledge management policies, practices, and supporting technologies at EUCOM, and to identify opportunities for improvement. The results of this effort are intended to be used as a basis for the strategic application of limited resources. Accordingly, specific options and recommendations were sought to facilitate EUCOM meeting its stated transformation objectives. It should be noted that *the issues and recommendations discussed in this paper are not unique to EUCOM*; most large, high-tempo, distributed, "high-tech" organizations – both military and civilian – report similar issues and conditions, and the results described in this report are likely be of value to any such organization.

Background and Problem

The adoption of the Standing Joint Force Headquarters (SJFHQ) concept of operations is the core driver in EUCOM's transformation effort. The most salient aspect of the SJFHQ concept of operations is the change in function of a joint headquarters from a traditional "communication and coordination center" to a theater-level agent responsible for mission- and unit-level command and control (C2). EUCOM's SJFHQ concept of operations focuses on enhanced theater and mission analysis and planning, and emphasizes mission monitoring and execution as the means to address multiple, simultaneous, dissimilar joint operations more quickly, effectively, and efficiently. EUCOM's European Plans and Operations Center (EPOC) - a physical instantiation of the SJFHQ concept of operations – is designed to provide a core, cross-functional staff to organize, plan, and execute both short- and long-term command and control of assigned forces and military operations in the EUCOM area of responsibility. The expectation is that this transformation will improve both the speed and effectiveness of EUCOM and its subordinate commands in responding rapidly to the diversity of threats anticipated in the near future. Command functions will need to be adaptable, and readily assignable within EUCOM area of operations as required to address an emerging crisis. EUCOM and its subordinate commands are expected to reflect this new philosophy of operations in order to allow the best use of all forces across command echelons as warranted by an emerging crisis. One consequence of the SJFHQ concept of operations is that EUCOM should be able to do more with less, specifically in terms of the number of senior staff required to manage complex operations; the ability to make major command decisions quickly; and improved information management within EUCOM and across its subordinate commands. However, the transition – in some ways a very radical transition – brings with it the potential to carry forward old ineffective business practices or introduce new ones. Additionally, with the new emphasis on direct C2 (vice communication and coordination), tried and true methods of using, managing, and exchanging information and knowledge may no longer be efficient or effective. Fortunately, transitioning from old to new also provides many opportunities for incorporating new or improved policies, practices, and procedures, as well as the technologies that support them.

A fundamental aspect of C2 and the SJFHQ concept is the efficient and effective use, management, and exchange of information and the facilitating of knowledge sharing across command decision-makers. Therefore, EUCOM senior commanders and staff are interested in better understanding how current and emerging information and knowledge management concepts, practices, and technologies might be adapted to meet their specific efforts. The objective of the effort reported here was to identify issues relevant to information and knowledge management at EUCOM, and where appropriate, to recommend changes to information and knowledge management policies, practices, procedures, and supporting technologies.

As part of this transformation, EUCOM has already implemented significant changes to their command facilities, introduced a number of state-of-the-art supporting technologies, and has begun the process of redesigning their organizational structure, and developing new internal processes to support the SJFHQ concept of operations. These efforts have met with varying degrees of success.

Method

A multi-disciplinary Knowledge Management[1] team was invited to conduct semi-structured interviews with personnel assigned to, or directly in support of, the EUCOM Plans and Operations Center (EPOC). The EPOC is a central part of the transformation to a SJFHQ concept of operations and serves as the main command center at EUCOM. The EPOC collocates representatives from all of the traditional directorates or "J Codes" to facilitate improved communication and coordination during the planning and execution of operations.

Interviews with EPOC staff at EUCOM relied on tools and techniques described below. Any or all of these techniques – and many others not listed – can be considered within the domain of "Knowledge Engineering." As appropriate to the situation, scientists and technologists must apply these methods to ensure that a system or process has been engineered to facilitate the acquisition, use, and sharing of knowledge for the benefit of the system's users. The application of knowledge engineering is based on the premise that system users must be considered as the center of the person-machine system– not as a component of the system, but rather *the reason that the system exists at all*[2].

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[1] Knowledge Management – broadly defined – is a "discipline for identifying, capturing, retrieving, sharing and evaluating an organization's information assets" (p. 1; Bair, 2000). At EUCOM, there are many kinds of information assets including implicit and explicit expertise and experience resident in staff members, tools / systems that pull or push information, information products, lessons learned, business rules, practices, and procedures.

[2] When system design, development, and acquisition efforts fail to take system users into consideration, the resulting system is often difficult or impossible to use, and technology tends to be much less effective. Technology is often not the limiting factor in modern systems. People are. Knowledge engineering, therefore, views human performance as an integral element to achieving total system performance that satisfies personnel's work task and mission requirements.

Knowledge Engineering (KE) defined. Knowledge Engineering is a specialized field of engineering and analysis involving a variety of techniques and practices to develop effective and efficient tools, technologies, policies, practices, and procedures supporting improved task performance and enhanced decision support. In other words, "Knowledge Engineering" is a high-level, umbrella term that actually encompasses a variety of purposes, methods, and goals. For example, Knowledge Engineering often includes efforts such as:

- **Conducting focused interviews and Cognitive Task Analyses (CTAs) to:**
  - Identify information requirements for specific cognitive tasks as well as user preferences related to the use of that information in performing those tasks
  - Identify and document factors that affect cognitive task performance and decision making for various decision-making tasks
  - Develop recommendations for hardware, software, training, and business rules and practices

- **Applying Specialized knowledge of:**
  - Relevant literature and efforts
  - Accepted "Best Practices"
  - Relevant standards, specifications, and guidelines
  - Relevant Systems Engineering and technical issues

- **Developing storyboards / rapid prototyping to iteratively develop, test, and validate solutions to user needs**
  - Develop storyboards / conceptual interface designs / drawings
  - Create semi- or fully-functional concept demonstrations / software
  - Develop and implement experiment / data collection stimuli

- **Conducting assessment / validation / verification / analysis**
  - Conduct data collection and reduction
  - Perform detailed analysis and reporting
  - Develop change recommendations

- **Providing documentation**
  - Establish and document functional requirements
  - Create hardware / software specifications
  - Recommend business rules
  - Develop / Publish training materials

Results

Twenty EUCOM personnel from a variety of services, backgrounds, and organizational affiliations across several echelons of command were interviewed (see Appendix A for

demographics). The interviewers encouraged discussion of a wide range of topics, including job roles and responsibilities; common tasks; standard operating procedures; technologies used (and a subjective assessment regarding the utility and usability of each); and general organizational, information, and knowledge management issues – in each case, the emphasis of the discussion was focused on the cognitive aspects of the various tasks performed, decisions made, actions taken, etc.

Interviewees shared their insights and experiences, lessons learned, opinions regarding various organizational issues, and their views on the strengths and weaknesses of current information and current knowledge management practices at EUCOM. Twelve common themes were identified across organizational groups and command echelons that are relevant to EUCOM's SJFHQ transformation process. The twelve themes are briefly described below:

1. **Organizational / personnel strengths**
    - Interviews revealed EUCOM personnel are generally highly motivated, maintain a positive attitude, and believe that what they do is important and necessary. Despite a very demanding pace of operations, morale was generally high. Staff personnel recognize the need for change and are willing to embrace change initiatives, *if change is perceived as improving the overall organizational process*.
    - Senior leaders are perceived as taking significant steps to support the organizational shift to the SJFHQ concept of operations (CONOP), and the shift in CONOPS provides EUCOM with an opportune time to facilitate and manage change.
2. **Lack of formal assessments / metrics for current and evolving tools / procedures**
    - Because work tempo, performance requirements, command expectations, policies, procedures, and supporting technologies are constantly changing to meet mission / situation conditions, participants indicated there are no standardized, well-understood performance-based measures that signify if and when they are performing at an acceptable level, and there are no baseline measures of performance to reference. This is significant given the importance of the perception of change for sustained personnel support for change.
3. **Insufficient training**
    - Work tempo and personnel turnover are high. As a result, an almost universal issue was that on-the-job training (OJT) or "trial by fire" is the typical method of training. It is generally assumed that new staff members have requisite training before they are assigned to EUCOM, however with the current tempo of operations, this is often not the case. Additionally, personnel stated that both formal training and training necessary for coordinating agencies is not being made available as it would not accommodate the current pace of operations. OJT is perceived as even less effective because it is also hampered or ineffective due to negligible opportunities for hand-offs between out-going and incoming staff. Further,

rapid turnover of temporary staff precludes building of adequate knowledge before the next duty rotation. The move to an SJFHQ suggests that the use of temporary personnel to deal with emerging crises will be an on-going issue that merits the development of an effective long term strategy for "just-in-time," as-needed training tailored to both current operational requirements as well as the needs of individual warfighters as they report to the command or take on a new assignment.

- Participants reported that a reduction in permanent staff positions has resulted in an increase in augmenting / temporary staff (reservists and temporary assigned duty personnel), who initially lack the experience and knowledge, skills, and abilities (KSA) required to perform critical tasks. Likewise, personnel who are considered to be corporate knowledge holders or knowledge experts in a particular field are frequently moved from their area of expertise to other areas of the command (where they are for all intents and purposes novices) in order to accommodate / resolve manning shortages.

4. **Inadequate data and information management procedures**
    - Participants revealed that data and information, most often stored on a shared network drive, are not consistently organized. There were no generally established business rules addressing such issues as naming conventions or use of command-, topic-, or operation-specific folders. Consequently, personnel reported routine difficulty in locating and accessing needed information – particularly if it did not originate from them or their immediate work group. In addition there may be a significant amount of redundant and obsolete data that is not recognized as such.
    - Reportedly, access/permission issues that extend from network drives to web spaces are also problematic, i.e., some areas can not be accessed by their intended users due to permission issues.
    - Participants reported difficulty dealing with and managing an overwhelming volume of e-mail traffic.
5. **Lack of common business rules / standard operating procedures**
    - A consistent theme running through all interviews was that best practices have yet to be identified and common business rules have not been adopted or are obsolete, unknown, non-existent, or insufficient.
6. **Difficult-to-use or unreliable tools / technologies**
    - Many personnel noted issues with usability and inadequacy of official messaging tools, the common operational picture (COP), and other supporting technologies. In particular, some systems were being updated or replaced faster than users could master them.
    - Participants reported various problems or issues with hardware / systems (particularly new systems), software changes to old systems, stove-piped databases, and general connectivity. These issues suggest that a more systematic software / hardware release protocol, with clear notification procedures and policies regarding changes and upgrades could improve the overall effectiveness of the command as they conduct operations. Information technologies should identify which users are likely to be

impacted by upgrades / changes and make sure mechanisms are put in place to ensure that IT maintenance does not impact operations.

7. **Unclear or conflicting tasking**
    - Personnel reported that it is often difficult to determine which people / groups across the organization have been assigned which tasks, who is actually performing any given task, and what the status of those tasks are. As a result, sometimes tasks are initially not performed by anyone, or tasks are performed redundantly and the redundant tasking is only discovered after the fact.
8. **Organizational / personnel issues**
    - Current manning levels are only "one layer deep" and do not allow room for expansion to handle additional crises / multiple missions or additional tasks. In other words, the current staff are fully tasked (sometimes over tasked) and might not be able to maintain current performance levels should additional tasking be placed upon them.
9. **Briefings and other information products**
    - Participants revealed that the development of the daily morning brief is extremely labor intensive, yet the purpose and end-use of the brief is unclear.
10. **Reliability and accuracy of some data / information**
    - Reliability of data is sometimes negatively impacted by old or incomplete information. As a result, personnel spend a large portion of their time requesting, clarifying, and tracking down information.
11. **General attitudes and morale**
    - Personnel expressed that morale is sometimes negatively impacted as a result of long hours, unequal workload distributions, work and task uncertainty, and a perceived lack of command support for long-term career development.
12. **Situation awareness (both mission / tactical and organizational)**
    - Personnel stated that overall situation awareness (SA) is difficult to maintain due to limitations in the common operational picture (COP) technologies used and difficulty in obtaining up-to-date status of operations, available forces, actual and potential implications, etc.

It should be noted that this initial effort to identify knowledge and information management issues related to the SJFHQ transformation was limited in scope and therefore represents a relatively narrow view into the command's information and knowledge management environment (e.g., a small number of participants, relatively short semi-focused / structured interviews, all participants were from a new organizational construct – the SJFHQ EPOC – that was still evolving, interviews took place over the course of just a few days, etc.). Still, given the number and wide variety of personnel participating in the interviews, and the relatively consistent responses that were obtained, it is likely that these results were highly representative of the larger information and knowledge management environment at EUCOM.

Recommendations

Based on lessons learned from research and development supporting similar command centers, and established best practices in the fields of organizational psychology, human factors, and information and knowledge management, it was possible to develop a number of specific recommendations to address the 12 themes identified by the interviews. This paper provides such recommendations along with supporting information to facilitate improved information and knowledge management at EUCOM. These recommendations are only an initial step towards achieving the transformation implied by the SJFHQ concept of operations. As specific recommendations are implemented, it was recommended that additional knowledge engineering and assessments be conducted to better understand the issues impacted by that intervention. Successful implementation will address technologies as well as the processes and business rules that make them work. Best practices for these interventions must be developed, captured and formalized into a living document that becomes the basis for standard operation procedures. Lessons learned by individual staff members while instituting change should be captured and shared so as to maximize the value across the command as well as for future staff members. Specific metrics for change should be developed as an integral part of the transformation process that assesses the impact the changes have on organizational effectiveness. Metrics such as man-hours required to complete specific critical tasks, rate and extensiveness of information dissemination, staff redundancy and conflicts, etc. would prove most useful and pervasive in assessing progress. Further, we recommend that change be facilitated using the best systems engineering principles, with a multi-disciplinary team of engineers and subject matter experts.

Recommendation Summary:

> **Issue:** Organizational / personnel strengths
> **Recommended Solution:** Given that personnel are motivated and open to change initiatives, we recommend a significant focus be placed on engaging the subject matter experts to solicit input with regard to development of business rules, policies, and training area requirements. If corporate knowledge holders are leveraged, staff personnel will take pride and ownership in the change process and dramatically increase its chances for success. EUCOM should create a climate that encourages and rewards change / transformation efforts, and is reasonably tolerant to failure. This might include the establishment of an experimentation / prototyping capability that can be engaged independently of, but parallel to the current capability so that staff can “try out” new tools and processes at minimal risk to the daily operations of the command. Officially adopt new tools and procedures only after they have been vetted in the prototyping environment. Establish formal procedures and entry / exit criteria for change / transformation, and make these criteria known to all those staff impacted by the process of change. Consider mechanisms by which new tools and procedures can be prototyped in parallel to existing tools / procedures so as to create fail-safes until new tools and procedures are sufficiently mature for wide-scale adoption.

Issue: Lack of formal assessments / metrics for current and evolving tools / procedures
Recommended Solution: We recommend that a detailed Cognitive Task Analyses be conducted to develop specific, relevant objectives and metrics for each significant problem to be addressed. Such analyses are essential for measuring whether changes are having the desired effect, as well as assessing the overall transformation of the SJFHQ ConOps [3]. Development of performance-based metrics can also be used for evaluating, measuring, and influencing staff's attributes, behaviors, and outcomes.

Issue: Inadequate training
Recommended Solution: Develop and provide "EUCOM Basics" and "Core Competency" training courses / mentoring programs that can be provided on-site as quick-study courses compatible with watch schedules. The Core Competency course should address general policy and guidance associated with EUCOM's mission as a Joint Command. The EUCOM basics course would review Standard Operating Procedures, protocol issues in working with outside commands, Points of Contact, and general policies and practices for working within the EUCOM command. We recommend this course make extensive use of on-line materials, accessible from anywhere in the command, and that resources be dedicated to maintaining these materials as evolving, "living documents." As feasible, these individual training resources should be supplemented with appropriate, regularly scheduled classes.

Issue: Inadequate data and information management procedures
Recommended Solution: Adopt a network centric information management strategy that supports a new and more effective way to rapidly collect, manage, display, and utilize time critical and commonly used information. Look at developing best practices guides, Frequently Asked Questions (FAQ) archives, on-line communities of interest collaboration systems, etc.

Issue: Inconsistent business rules / standard operating procedures
Recommended Solution: Develop Business Rules and Establish Best Practices that provide personnel with direction and guidance for using technology and accomplishing work activities. Identify "expert" staff to serve as resources and mentors to reservists & detailees.

Issue: Difficult-to-use or unreliable tools / technologies
Recommended Solution: 1) Develop easy-to-use, template-based tools such as an order management system, a document management system, and an operational status tracking system. 2) Additionally, develop a prototyping capability for new systems, and track, identify impacts of, and offer solutions for software changes to old systems. 3) Establish a formal usability assessment

[3] It is important to note the iterative nature involved in measuring organizational transformations.

process that is responsible for assessing and documenting changes from the perspective of those users who will be impacted by system changes.

Issue: Unclear or conflicting tasking
Recommended Solution: Develop a web-based tasking management system that allows personnel to easily access, manage, and monitor task responsibilities, status, timelines, interdependencies, and implications. Make explicit areas of responsibility and procedures for resolving ambiguities in authority / responsibility before it becomes a problem. Develop explicit policies that empower working level staff to detect and deconflict tasking to eliminate redundancy / inefficiencies as they may arise, and make resulting tasking assignments available to all interested parties.

Issue: Organizational / personnel issues
Recommended Solution: Avoid movement for administrative reasons of personnel trained in specific elements of the command without assessing potential impacts to overall command effectiveness and morale. When appropriate, engage affected personnel to identify optimal assignments. Avoid assigning people based purely on their current clearance status. Ensure personnel have the needed training (e.g., "EUCOM Basics and Core Competency" courses), clearances, and computer skills prior to filling their billets. Capitalize on Military Occupational Specialty (MOS), if possible. Attempt to identify "shortcuts", e.g. training, innovative administrative procedures, etc. to get the appropriate people the necessary training and qualifications prior to their arrival at EUCOM. Make a point of considering the opportunities for staff that will enhance their careers as well as meeting immediate EUCOM needs. Such efforts should dramatically impact morale, quality of life, and ultimately command effectiveness.

Issue: Briefings and other information products
Recommended Solution: Revise briefing culture to a less formal, web-based approach to maintaining status information. Disseminate Commander's intent, priorities, information requirements, as well as senior staff feedback through web tools. Such an approach will allow more rapid speed of command, as current knowledge products will no longer be tied to the briefing cycle, and will allow increased efficiency as critical information is available to a wider audience, when they need and/or are better equipped to assimilate it, rather than forcing all work to stop among a majority of the staff during the daily briefing. Denote critical information with uniform change as well as criticality indicators.

Issue: Reliability and accuracy of some data / information
Recommended Solution: Develop and enforce information management policies to ensure information is appropriately accurate, time-stamped, timely, updated, and complete. Develop a mechanism to reassess information criticality based on on-going mission requirements. Formally flag information elements that are considered critical for the on-going mission(s). Additionally, provide templates

and examples to guide information providers when developing and producing information content and structure.

Issue: General attitudes and morale
Recommended Solution: Sufficient training, guidance, and business rules should allow for more evenly distributed workload. Develop and implement onsite, condensed training options to fulfill career development requirements in lieu of sending staff to off-site classes. Work with the training authorities to gain accreditation for alternative training, such as on-site classes, so that staff are not penalized by their being at EUCOM (instead of elsewhere where more traditional training and advancement opportunities exist). Identify those staff positions where there is a linear relationship between tasking and time required, and focus on those positions first in seeking improved efficiencies. NOTE: These positions also appear to be the limiting factors in the overall speed of command.

Issue: Situation Awareness (both mission / tactical & organizational)
Recommended Solution: Acquire or build an SA tool, which permits information producers to create interactive tactical pictures that provide value added information and hyperlinks to other documents. Additionally, identify where numerous information products must be used concurrently by staff position. Consider the adoption of multi-display workstations, and / or build web pages and business rules around a situation report page and watch turnover pages for these positions first.

Summary

EUCOM is currently undergoing a significant transformation from a command organization focused on oversight, to providing more direct, real-time, C2 that is faster, more flexible, and built upon network-centric foundations. For this transformation to be successful, EUCOM is implementing changes to their command facilities, supporting technologies, organizational structure, and internal processes. As discussed in this paper, the application of knowledge engineering identified a number of specific opportunities to aid the senior EUCOM staff in developing a comprehensive strategy for implementing this transformation. The preliminary knowledge engineering was done with minimal cost and impact to on-going EUCOM operations. Based on interviews with 20 EUCOM staff members, 12 themes related to Knowledge Management were identified as significant to the SJFHQ transformation. These areas included a wide range of issues, such as developing formal transformation metrics, developing training tailored to the new operational environment, developing new business rules for how the staff works in a web-centric operating environment, addressing deficiencies in current information systems user interfaces, and addressing quality of life factors that impact staff morale. Recommendations were made for improving these areas derived from various human factors, systems engineering, and knowledge management interventions.

Future efforts could include studies that use structured knowledge management exercises to collect qualitative and quantitative human performance data. These data could serve as

the basis for evaluating interventions designed to increase the effectiveness and efficiency of knowledge management tasks in the SJFHQ. Specifically, the authors suggested the following:

Step 1: Consider and select high payoff solutions / targets for change implementation.

Step 2: Consider CTAs and quantify Information Requirements to develop baselines and customize solutions.

Step 3: Select and customize metrics to measure and validate selected solutions.

Step 4: Obtain senior staff “buy-in” and then direct coordinated, unified change across EUCOM.

Step 5: Measure effects of change and refine as necessary.

Step 6: Conduct assessments to measure effectiveness of change implementations.

Step 7: Refine processes and metrics as necessary and re-measure iteratively.

References

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Appendix A. Participants

The data collection team interviewed a total of 20 individuals. Eligible participants were solicited from personnel assigned to, or directly in support of the EUCOM Plans and Operations Center (EPOC). All eligible personnel voluntarily participated in separate Knowledge Engineering sessions lasting 1-2 hours, with the exception of one session in which two participants attended. Participants were from a variety of services, backgrounds, and organizational affiliations across several echelons of command, as shown in Table 1. Additionally, the majority of participants were Joint Staff officers and NCOs (Non-Commissioned Officers), as shown in Table 2. Twelve of twenty participants shared a broad range of experience that related to most key roles in the JOC, while others had varying amounts of experience in areas of IS/KM, J2, J4, J5, and J6.

Table 1. Number of Participants by Command Type

Command Type	Number of Participants
J3 Operations	13
J2 Intel	3
J4 Logistics	1
J5 Strategic Planning and Policy	1
IS / KM	1
J6 Command, Control, Communications and Computer Systems	1

Table 2. Number of Participants by Rank

Rank	Number of Participants
General	1
Captains / Colonels	2 / 1
Commanders / Lieutenant Colonels	1 / 8
Majors	4
Staff Sergeants	2
Civilian (prior military)	1