THE IMPACT OF AUTOMATED COGNITIVE ASSISTANTS ON SITUATIONAL

AWARENESS IN THE BRIGADE COMBAT TEAM

By:

Carl E. Fischer
B.A., University of Maine, 1981
MMAS, Command and General Staff College, 1997
M.P.A, University Of Oklahoma, 1998

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Submitted to the Department of Curriculum and Teaching and the Faculty of the Graduate School of the University of Kansas in partial fulfillment of the requirements for the degree of Doctor of Philosophy

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## DEDICATION

This work is dedicated to my wife, Carol, without whose help and encouragement this would never have come to pass.

**ACKNOWLEDGEMENTS**

# ABSTRACT

This research investigated the impact of automated cognitive assistants, specifically, the Personalized Assistant that Learns (PAL), on situational awareness, efficiency and effectiveness of decision making in the brigade combat team.  PAL was recently commissioned by Defense Advanced Research Projects Agency (DARPA) to enhance decision making with the Command Post of the Future (CPOF). This is the first study to investigate PAL's effectiveness.

Previous literature has indicated that automated cognitive assistants can reduce cognitive load and improve the efficiency and effectiveness of decision-making. This is consistent with constructivist theories that assume that relegating repetitive tasks to an assistant allows decision makers to focus on the most critical issues.  This is particularly true in those conditions where the environment is in continuous flux and the decision makers must remain cognizant of changing situations.

To investigate PAL'S influence on situational awareness, two groups of military officers comprising a convenience sample were placed into two groups representing brigade combat teams.  Before tests were administered, each team was trained on the cognitive assistants and given a hands-on examination to measure competency in PAL and CPOF.  All subjects participated in one trial with PAL-enhanced CPOF and one trial with CPOF alone. Self-assessments of situational awareness were administered which included sub-scales on: task management, information management, decision support, and appreciation of the environment, visualization and trust.  Speed and quality of decision-making were also measured.  Repeated measures analysis of variance was used to compare PAL and CPOF only on situational awareness.

In the repeated measures ANOVA, the overall difference on self-report of situational awareness approachedthe .05 level with PAL ($M = 1.85$, $SD = 0.46$) and CPOF ($M = 2.06$, $SD = 0.57$; $F(1,10) = 4.61$, $p = .057$), with the lower score indicating higher approval.  There was a significant difference on the decision support category of situational awareness in the second trial using both PAL and CPOF ($M = 2.21$, $SD = 0.59$; rated higher than the first trial ($M = 2.53$, $SD = 0.49$; $F(1,10) = 5.06$, $p = .048$). The following differences were not significant but the means all favored PAL over CPOF:  quality of decision making products PAL ($M = 2.89$, $SD = 0.75$); CPOF ($M = 2.53$, $SD = 0.83$), speed of submission in minutes PAL ($M = 9:13$, $SD = 3:15$); CPOF ($M = 10:00$, $SD = 5:53$), and Situational Awareness quizzes PAL ($M = 67.03$, $SD = 7.15$); CPOF ($M = 59.24$, $SD = 8.23$).

While comparisons of PAL and CPOF were not significant, results indicate that the PAL automated cognitive assistant has promise in improving the situational awareness and efficiency of military leaders in complex decision making. The findings demonstrate that as military officers grow more accustomed to using these analytical systems, both PAL and CPOF, they rate their support in decision making higher.  This initial study of PAL was conducted with a convenience sample of 12 military officers.  Further studies are warranted to investigate the benefits of automated cognitive assistant on an array of factors that influence decision-making across conditions and audiences.

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## DISCLAIMER

The views, opinions, and findings contained in this study are solely those of the author and should not be construed as an official Department of the Army or Department of Defense position, policy, or decision, unless so designated by other documentation.

## CHAPTER ONE
## THE RESEARCH PROBLEM

*Situation Awareness: the perception of the elements in the environment within a volume of space and time, the comprehension of their meaning, the projection of their status into the near future, and the prediction of how various actions will affect the fulfillment of one's goals.*

- Mica Endsley

### Introduction

Developing and maintaining situation awareness (sometimes called "situational" awareness) is both the most difficult and most pressing job of military commanders and staffs. Without this appreciation for their environment, commanders and staffs can be overwhelmed by the sheer volume of information, and decisions suffer. Tools and procedures that make Army leaders more efficient, particularly in their quest for good situation awareness, are among the most sought-after technologies in current research and development activities. Moreover, lessons learned to increase the efficiency of leaders in a military setting are likely to have implications to leaders in other settings, including education.

Limits to short-term memory (Miller, 1956) and cognitive loading (Sweller, 1988, 1994) require commanders and staffs to "chunk" information into usable schemas to mitigate the overwhelming volume of information thrust upon them in the modern command center. A schema is a "cognitive construct that organizes the elements of information according to the manner with which they will be dealt." (Sweller, 1994). This information is available from sources as varied as satellite imagery, real-time video feeds from unmanned aerial systems and tips provided by local residents. It takes all forms from intercepted phone conversations to extensive Department of State country studies. Collecting, sorting and managing information inundates commanders and staffs.

The Army introduced a composable collaborative and visualization tool called the Command Post of the Future, or CPOF (pronounced "SEE-pof") in 2004 as fielded forces faced increasingly complex threats and mountains of data in full spectrum operations in Iraq and Afghanistan. CPOF enabled soldiers to configure workstations with the specific goals of establishing, maintaining and sharing situation analysis.  Because CPOF is configurable by each individual user, it allows users to chunk information into more usable schema, off-loading the short-term, or working, memory.  Miller's work and considerable further study bear out that short-term memory is limited by the number of items ("bits") of information it can handle, not by the size of those bits, in fact, "The span of immediate memory seems to be almost independent of the number of bits per chunk…" (Miller, 1956).  CPOF has allowed division (and, later, brigade) staffs to chunk information in order to be able to visualize and share three of the four parts of the above definition – perceive the current, comprehend its meaning and project (through schedules and animation) into the near future – leaving only that highest level of situation analysis, prediction, in the minds of the staff and commander.  PAL intends to build on this, to automate and manage tasks and manage and share information.
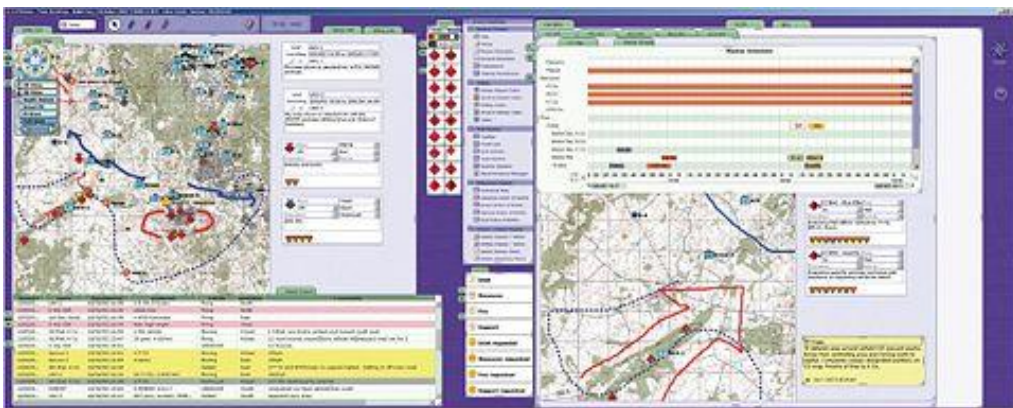


**Figure 1-1, Command Post of the Future Display Screens**

CPOF is a software and hardware solution that serves as a command and control system. Command and control is the exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of a mission. Command and control is exercised through "mission command."  Mission Command is defined as: the conduct of military operations through decentralized execution based on mission orders (Field Manual (FM) 3-0, Operations, 2008).  Mission command requires timely decisions, initiative of subordinates and mutual understanding among all levels of command.  CPOF, with its visualization and collaborative capabilities, helps provide the environment for leaders to succeed in chaotic situations, particularly when in conflict, or other time-compressed environment.

Command and control in "full-spectrum" operations (FM 3-0) requires split-second decisions as well as identification of changes in adversaries' methods and patterns.  CPOF, with its suite of collaborative and visualization tools, facilitates both types of problem sets.  To make these decisions – both immediate and longer term, situation analysis is imperative.

CPOF consists of a networked Windows-based processor linked to three screens – one each used as three-dimensional workspace, a two-dimensional shared workspace, and an additional two-dimensional workspace that can be used for sharing or local product creation. Technical specifications are addressed in Appendix A.

CPOF has been well-received by the military community as a great improvement to previous command and control systems (Lawlor, 2007).  It is the current state-of-the-art command and control tool suite, on the historical heels of such technological breakthroughs as the telegraph, frequency-hopping radios, satellite communications and electronic graphical displays of terrain, imagery and units.  It accommodates inputs from various military systems – blue force tracker (a device that reports the position of friendly units and individuals), the Global

Command and Control System and others - but it is not without its shortcomings largely in data sharing and ease of use: CPOF does not use standard imagery or map products provided by the National Geospatial-Intelligence Agency, nor does it incorporate data from fire support coordination measures or airspace control measures (Globalsecurity.org). CPOF has been updated continuously throughout its relatively short life to address these and other issues.

Originally a Defense Acquisition and Research Project Agency (DARPA) technology demonstration, CPOF is the first command and control suite to view the graphic interface – and its capacity to allow users to visualize and share – as the most important aspect. (DARPA STO) Other projects are underway to improve features and interfaces, as well as add functions. The Personalized Assistant that Learns, or PAL, is one such project that adds capability to the CPOF.
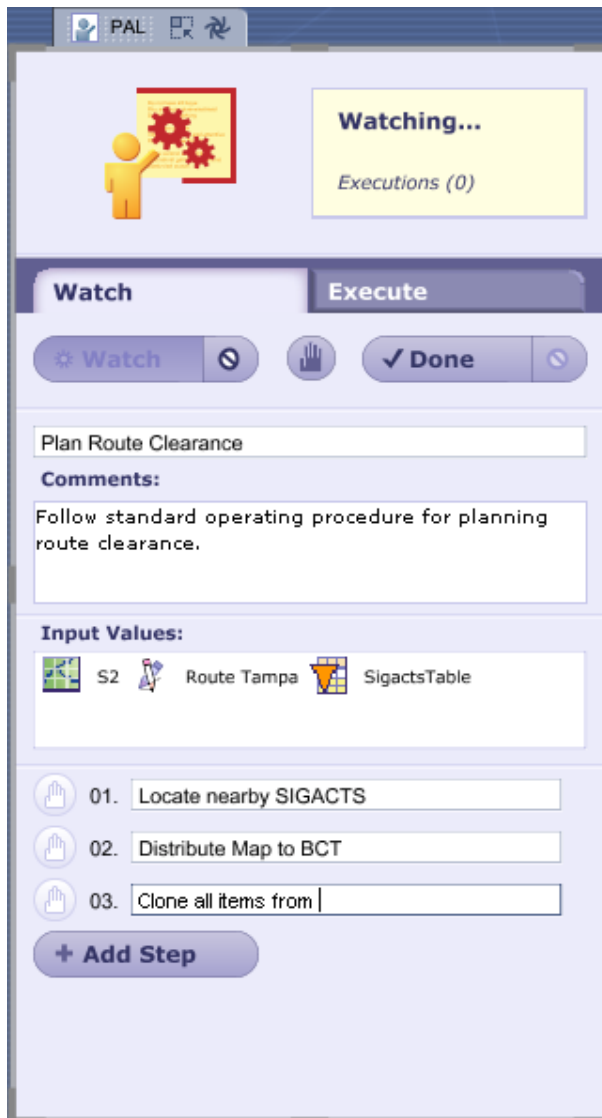
**Figure 1-2, Personalized Assistant that Learns Screen Capture**

The PAL software adds applications that seek to provide staffs and commanders with

more time to think about the complex problems facing them by automating routine and

redundant tasks.  To accomplish this, users can teach PAL to follow specific steps, and, when

coupled with CPOF's "information liquidity" (General Dynamics, Program Details) allows the

user to establish a template that will always find the most current information available within

the CPOF repository.

PAL is being designed to improve human-computer interaction by serving as an assistant to users. Ultimately, PAL would displace human staff officers with "cognitive assistants" (DARPA IPTO) by learning to adapt to changing situations. As fielded for this research, PAL was taught specific procedures, and told when, how or under what circumstances to execute them. For example, PAL was taught to recognize significant activities and to create a synopsis (story board) of each event to provide to higher headquarters. By teaching, then automating, this set of tasks, staff officers and commanders were able to focus more consistently on the "big picture" rather than a recurring requirement.

For this research, PAL and CPOF were linked to an analytical database that had been created for the test. The database was introduced into a vast data management system known as Combined Information Data Network Exchange, CIDNE (pronounced "Sidney") (ISS, CIDNE). CIDNE maintains myriad sources of information within its database. These data represent all and all forms of information, including telephone or radio intercepts, media articles or other publications, intelligence reports and analytic assessments. The CPOF interface with CIDNE is called the Web-based, Temporal Analysis System or "WebTAS" (ISS, WebTAS). WebTAS is used to "harvest" information from CIDNE, and has capabilities to allow users to visualize and integrate that information. However, without PAL, the system is slow and mechanical – all queries consist of one data element (variable) and return scores, sometimes hundreds of raw responses, depending on the frequency the individual search term appears in the database. The PAL interface allows multi-parameter queries that routinely result in manageable returns of linked data.

These four basic systems – CPOF, PAL, WebTAS and CIDNE – comprised the suite of command and control tools used during the research. In both cases, CPOF was the base

command and control system and all users had access to the CIDNE database through WebTAS.

PAL became the dependent variable in order to demonstrate any advantage it might provide.

Two groups of users replicated brigade-level staffs and at any given time, only one had PAL

running on their systems. The "non-PAL" team served as the control group, essentially

replicating fielded command and control systems.

**Scenario**

The study focused on staff operations and commander decision making during full

spectrum operations set in the current time in Azerbaijan. "Full spectrum" implies a wide variety

of potential operations, including offensive, defensive and stability (FM 3-0, 2008). In the

scenario, combat operations had concluded 30 days prior, the attacking (fictional) Ahurastani

army has been repulsed, and U.S., coalition (from Great Britain and Turkey) and local forces

have begun to restore order near the city of Pushkino. This specific scenario was chosen for

several reasons. First, in order to determine whether or not a role player had good SA, a

thorough knowledge of a detail-rich environment is essential. Because this scenario is used as

part of the curriculum for the U.S. Army Command and General Staff Officers Course at Fort

Leavenworth, Kansas, it was familiar to the participants. Additionally, the fictitious nature of the

scenario allowed the study to be conducted in an unclassified forum. This facilitated the input

and observation of non-military participants, i.e. the technology experts representing the various

software suites.

Finally, a repository of pertinent reports, key personnel (friendly, enemy, and "fence-

sitters"), unit statuses, critical infrastructure, terrain, strategic goals, communications intercepts,

and a host of other data, provided the role players with the complexity and diversity of mission

sets likely to be faced in contemporary full spectrum operations. The scenario, rich with detailed information, enabled linking of seemingly disparate bits of information. This allowed measurements to be taken regarding situation analysis and understanding. The setting allowed for great latitude in the types of missions and tasks confronting the staffs. The operational tempo of events was set at a level comparable to busy days akin to current deployments. While combat actions were required in certain circumstances, the bulk of activities centered on stability operations. Absent high fidelity data on adversaries, host nation infrastructure and friendly forces, these measurements would not have been possible.

### Significance of the Study

Determining if PAL can provide better shared situation analysis to representative brigade staffs and commanders could significantly benefit the Army. Additionally, if cognitive loading is reduced, staffs and commanders could build schema that would assist them solving more and more complex problems over long deployments. This study tests hypotheses that incorporating PAL into brigade CPOF command and control systems will improve situation analysis, by improving task management, information management, decision support and visual awareness, as well as the user's perception of situation analysis. The study suggests these benefits derive from reducing cognitive load by automating routine tasks, thus freeing users to concentrate on the remaining tasks at hand.

### Research Questions

RQ1:   Does the Personalized Assistant that Learns (PAL) improve situational awareness when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

RQ1.1: Does the Personalized Assistant that Learns (PAL) improve task management when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

RQ1.2: Does the Personalized Assistant that Learns (PAL) improve information management when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

RQ1.3: Does the Personalized Assistant that Learns (PAL) improve decision support when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

RQ1.4: Does the Personalized Assistant that Learns (PAL) improve visualization when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

RQ1.5: Does the Personalized Assistant that Learns (PAL) improve environment appreciation when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

## Operational Definitions

- PAL is a Defense Advanced Research Project Agency (DARPA) Information Processing techniques Office initiative system that provides a software application that incorporates machine learning with current and future Department of Defense (DoD) command and control systems to assist the warfighter during all aspects of the Military Decision

Making Process.  For thorough description of CPOF, PAL and other technologies used in this experiment, see Appendix A.

- Situational Awareness – Knowledge and understanding of the current situation which promotes timely, relevant and accurate assessment of friendly, enemy, and other operations within the battle space in order to facilitate decision making.  An informational perspective and skill that foster an ability to determine quickly the context and relevance of unfolding events.  Situational awareness is knowledge of the immediate present environment, including knowledge of the factors of mission, enemy, terrain and weather, troops and support available, time available and civil considerations (METT-TC) (FM 3-0, 2008).  In its most basic level, situation awareness is the perception of the situation (Endsley, et al, 1998).  Second level situational awareness requires comprehension of the situation in context.  Third level situational awareness, projection, is analogous to situational understanding.  In this paper, "situational" and "situation" awareness are used interchangeably.

- Situational Understanding – By Endsley's definition, this is the third and highest level of situational awareness.  It is the product of applying analysis and judgment to relevant information to determine the relationships of the factors of METT-TC to facilitate decision making.  This knowledge and understanding of the current situation promotes timely, relevant and accurate assessment of friendly, enemy, and other operations within the operational environment to facilitate decision making (FM 3-0, 2008).  Situational understanding implies that a decision maker can project or predict knowledge into the future to direct actions.  This paper will treat situational understanding as the highest

level of situational awareness throughout, and therefore the term "situation awareness" will be used to describe either phenomenon.

- Full Spectrum Operations – Army forces combine offensive, defensive, and stability or civil support operations simultaneously as part of an interdependent joint force to seize, retain, and exploit the initiative, accepting prudent risk to create opportunities to achieve decisive results. They employ synchronized action—lethal and nonlethal—proportional to the mission and informed by a thorough understanding of all variables of the operational environment.  Mission command that conveys intent and an appreciation of all aspects of the situation guides the adaptive use of Army forces.

## Summary

At the heart of command and controlling forces in full spectrum operations is visualizing the operational environment and collaborating with others in the environment to attain, maintain and share situational awareness.  It remains important for our military to continue to seek out technological solutions that can make these tasks simpler or faster.  As the Prussian theorist Carl von Clausewitz has said, "Everything in war is very simple, but the simplest thing is difficult. (Clausewitz, translated by Howard and Paret, 1989, p. 119)  Command and control systems attempt to remove some of the fog and friction of war that creates difficulty in the simple.

By automating tasks that would otherwise require soldiers' working memory, PAL technologies free human memory for the most important information, improving appreciation of the environment and ultimately, decision making.

## CHAPTER TWO
## LITERATURE REVIEW

A review of contemporary literature indicates few studies have been conducted on the effects of PAL on staff situational awareness or cognitive load. Since PAL is a project under development, this should not be surprising. Numerous studies have been undertaken regarding situational awareness, and the results of these studies offer insights regarding how PAL could improve situation analysis, and the importance of those capabilities in modern warfare command and control. This chapter will also discuss current Army doctrine and service literature on the subjects of command and control systems and situation analysis. The intent is only to inform this discussion within the scope of this study. Cognitive loading literature will start with Miller's seminal work in 1956, as well as the expansion of his ideas in Sweller and Bruner. Additionally, some technical reports on the software suite are reviewed, but the author does not intend to explain fully the specific technical capabilities of PAL. Rather, this discussion will contain in layman's terms any advantages PAL brings to command and control. In this chapter, the research on situation analysis, Army doctrine and policy, cognitive loading and technologic reports have been discussed separately.

All this literature points toward the genesis of a system like PAL – one that might find a way to streamline information management or afford commanders and staffs more time to consider the information facing them.

### Situation Awareness and Shared Situation Awareness – Constructivist Concepts

Situation awareness is a critical commodity not only for commanders and staffs, but in any number of commercial applications. Research for this experiment spans not only military research, but investigations into other, comparable, complex decision-making environs.

The first step in determining how PAL impacts situation analysis is to define the concept. Strater, et al. (2001) provide perhaps the simplest definition: knowing what is going on in the situation around you. The definition derives from the one that Endsley (1995a) formulated several years prior: the perception of the elements in the environment within a volume of space and time, the comprehension of their meaning, the projection of their status into the near future, and the prediction of how various actions will affect the fulfillment of one's goals. One can assess the "amount" of situation analysis in steps: perception of the elements (what), comprehension of their meaning in context (so what), and projection or prediction into the future (now what).

Nofi (2000) suggests that the nature of situational awareness is not always known, but significant agreement can be found in defining it: the result of a dynamic process of perceiving and comprehending events in one's environment, leading to reasonable projections as to possible ways that environment may change, and permitting predictions as to what the outcomes will be (p. 1).

Hjelmfelt and Pokrant (1998) describe situational awareness as a "volatile mental state (p. 7)." To them, situation analysis is not strictly an understanding of doctrine or procedures (although it presumes competence in those), rather it is an understanding of the current situation, some understanding of context, and it can clearly decay over time.

Additionally, Hjelmfelt and Pokrant identified the dynamic nature of situation analysis by stressing monitoring and integration of information from various sources, a need for participants to evaluate information "to avoid overload," and that there was also a requirement for participants to identify issues or problems while maintaining sight of the "big picture (p. 5)." These are important considerations for measuring situation analysis: its dynamic – and perhaps

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fleeting – nature, constant input from multiple sources, and a requirement to evaluate information streams throughout, to avoid inundation.

Thus situation awareness is constructivist in nature. Constructivism is a broad field with many applications that apply to this research. Constructivism has several associated factors including cognitive flexibility, collaborative learning, situated learning, (Ross, 1999). Staffs and commanders must piece together disparate bits of information and create an appreciation of what is going on around them. Bruner, 1966, states that learners must construct new hypotheses or ideas based on their current and historical knowledge. The learner relies on a schema or mental model to frame new information. Information is selected and transformed, allowing the learner to appreciate the meaning of the situation through hypotheses rooted in these models. Ultimately, the learner – or in this case the staff or commander – makes a decision based on the new appreciation of the situation. It is this structure, in the form of a mental model or schema that enables individuals to "go beyond the information given" (Bruner, 1957).

The primary influences of Bruner's theory can be further described by Piaget's (1969) theory of intellectual growth. Piaget specifically stressed that processes underpinning conceptual change as interactions between new experiences and existing cognitive structures.

According to Ross (1999), constructivism not only supports the exploitation of "authentic" learning environments (as replicated in the scenario-based demonstration), but also emphasizes higher order cognitive skill acquisition including knowledge management, information management and what they term "hypothesis," which can be equated to the "therefore" or third level of situation awareness. To explore the limits of constructivism, one must delve into the concepts of cognitive loading.

To measure situation analysis, Endsley developed the Situation Awareness Global Assessment Technique (SAGAT) (Endsley et al 2000).  It is based on Endsley's three levels: perception, comprehension and projection, for which she has adopted the shorthand:  "What?" "So what?" and "Now what?"  It is an objective scale that uses probing questions at certain times throughout the data gathering period. The questions require knowledge of the current situation in context.  Levels of situation analysis can be determined by responses.

 Seet et al developed the Constructible Assessment for Situation Awareness, or CASA based on SAGAT (Seet, et al., 2004).  CASA attempts to avoid some of the issues that arise when administering the SAGAT, specifically interrupting the participants to administer the instrument and using questions prepared in advance (free-flow scenarios might "miss" certain actions or events, resulting in wasted questions).  Despite using this CASA-like approach in question preparation for the PAL investigation, some questions still preceded actions during the experiment.  As will be explained in depth in the next chapter, situational awareness quizzes were administered twice daily to all participants.

 Perla, et al (2000), adopted Endsley's three-part approach to situational awareness: perception, comprehension, projection and prediction (p. 11).  They also suggest three steps very reminiscent of constructivism for individuals to share their situation analysis:  Build individual awareness, share this individual awareness and develop the group's shared awareness (p.18). This shared awareness is critical to staffs and commanders as they prosecute operations.  It provides the "common operational picture" (FM 6-0, 2003) required for decisions to be made based on shared understanding of the problem set.

 Another theory of note, forwarded by Salmon, et al (2008), is that it is important to move beyond what could be termed "individual" situation analysis, into what Nofi and others have

called "shared situation awareness" when examining collaborative or distributed systems. Salmon, et al, found that when assessing systems, it is useful to view the situation analysis of the system rather than the sum of individual situation analysis. Their research was conducted in the energy distribution community, and built off Endsley (1995a, 1995b and 2000), but does not accept all Endley's premises, finding that group situation analysis cannot be derived simply by adding individual member situation analysis (p. 368).

Similarly, team situation awareness (Artman & Garbis, 1998) is defined as a mental model of the situation, shared and distributed among team members, and that these models are integrated and coordinated to anticipate events likely to occur in the near future.

Although there is a lack of agreed upon model of exactly what shared or team situation analysis is, there has been some agreement that it consists of three major components: the individual team member situation analysis, the situation analysis that is shared among the team and the sum of all the individual situation analysis that results in a "common picture." (Salas, et al., 1992) Salas used the following definition for a team in this regard:

- Two or more people

- Who interact dynamically and interdependently

- Share a common, valued goal or mission

- Have specific roles or functions, and

- Have a limited lifespan of membership

All these criteria apply to the brigade combat team staff.

But others view shared awareness as a system – distributed situation awareness (DSA). This approach, favored by Ottino (2003) among others, argues that to assess situation awareness in a complex system, it would be better to focus on the interactions off the parts –and the

resultant behavior – than to study the parts themselves. Hollnagel and Woods termed these "joint cognitive systems" (2005) and a brigade staff could surely be viewed in this light. The staff and commander develop cognitive processes and only achieve situation awareness (cognition) by coordinating and collaborating between and among each other. Distributed situation awareness, then, is the combined awareness of the entire system (staff) (Artman & Garbis, 1998). Artman further developed this theme, contending that distributed situation awareness is neither the sum of individual situation analysis nor the group's appreciation of the environment, but a snapshot "actively communicated" within the team (Artman, 2000). Stanton, et al (2006) described DSA in a command and control environment "as a product of the coordination between a system's elements and suggest that *the **system** collectively holds the situation analysis required for task performance*. situation analysis -related information is held by and distributed between the agents and artifacts (*both human and non-human*) comprising the system." (Salmon, et al, p. 369, emphasis added) This model differs from Endsley who proposed that shared situation analysis is "the degree to which every team member possesses the situation analysis required for his or her responsibilities" (1988). This research relies on the broader view, that situation analysis is transient and consists of agents and artifacts.

## Cognitive Load Literature

Seminal work in cognitive load theory has been provided us by George A. Miller. In 1956, Miller explored the shortcomings of short-term memory. His paper, "The Magical Number Seven, Plus or Minus Two," describes in detail some limits on the human ability to process information. He hypothesizes that humans are capable of processing about seven "bits" of information at a time, the "span of immediate memory." But people are also able to "chunk" bits of information into ever more complex pieces that can then be used in working memory as a

single bit.  Working memory is now the more common term, as it tends to better describe a process rather than a storage location. (Baddeley and Hitch, 1974)  This expands the ability for a person to discriminate among complex choices in immediate memory.  Level of expertise is often reflected in the complexity of the chunks.  A good command and control system, then, would facilitate chunking of information by allowing experts to assemble large amounts of complex data into rich representations.

Sweller used Miller's work and developed the concept of "schema" which can be defined as cognitive structures comprised of combinations of bits.  Sweller's theory suggests that learning takes place optimally when conditions are aligned best with our human systems of cognition.  Miller proposed that short-term memory has definite limits to the number of bits of information it can process at one time, but that individual bits could be themselves, very complex. Sweller offers that our long-term memory contains many of these complex or sophisticated cognitive structures – schemas – and that result from experience and expertise.  In fact, they are the cognitive structures that comprise our base of knowledge (Sweller, 1988). Experts have much more extensive and complex schema than novices.  Development of these schema allow individuals to maintain in long-term memory increasingly complex structures that allow one's performance to progress from  awkward and error-riddled to smooth and efficient.

Essentially, an individual's performance improves because his or her cognitive structures encompass more and more of the possible variables associated with decisions. As suggested by Miller, use of these mental models allows us to treat multiple bits of information as a single bit in our short-term memory.  In CPOF, a map icon can represent multiple bits of information, which can be gleaned with a glance.

Sweller, Van Morriboer and Pass (1998) define three types of cognitive load: intrinsic, germane and extraneous. Intrinsic load reflects the complexity (difficulty) of the new information. This load differs based on existing knowledge or experience. Germane load are those tasks that contribute directly to learning. Extraneous loads do not contribute to learning or understanding, but occupy working memory, limiting the amount of useful information that can be processed. These concepts are important since an effective cognitive assistant should be able to assist in the easy access of intrinsic loads, provide germane loads and eliminate extraneous loads.

Sweller's (1988) research was based largely on creating instructional materials for challenging material. There are clear parallels with learning and developing situation analysis. Just as a classroom student needs a limited cognitive load to add to his or her schema, so a staff officer or commander needs to control cognitive load to better appreciate his or her environment. Among Sweller's recommended design elements in instructional materials are three that are particularly pertinent to this discussion: First, the physical integration of several sources of information can preclude the cognitive load in working memory of having to do it oneself. Command and control systems integrate chat, video, and audio into complex two- and three-dimensional representations of reality, alleviating strain on working memory.

A second element regards the elimination of redundancy. There is considerable working memory load involved with repeatedly processing information. One of PAL's primary intentions is to reduce the amount of recurring tasks a user must initiate, or remember, by executing those tasks as directed or scheduled by the user. The third principle suggests using both audio and visual information to provide different information, to avoid overloading of either input capacity. While receiving redundant information through multiple sources can overload working memory,

providing different information through those sources can increase substantially the amount of information short-term memory can process.

The Constructivist perspective offers two primary underlying theories that support the idea of gaining and understanding situation awareness with regard to the limits of cognitive load; Situated Cognition and Cognitive Flexibility.


**Situated Cognition Theory**

Lave & Wenger (1990, 1991) contend that learning depends on the situation ("situated learning"); essentially that classroom learning involves abstract knowledge without, or out of, context.  According to Lave (1988), learning normally occurs as a function of the activity, context, and culture that it occurs in (situated). Lave & Wenger propose that in order to develop knowledge in context, social interaction is a critical component of the learning process: learners must become involved with a "community of practice" that shares common goals and beliefs as the learner.  This collaboration, or social interaction, is crucial to learning. These concepts are found readily in a command center.  A staff is a community of practice, developing and sharing information developed in defined functions (intelligence, operations, logistics, etc.) in context. Novices have a place in the discussion, and over time, as expertise is developed, the participation moves inward from the initial, peripheral role.

John Seely Brown believes that learning takes place best in context. "Situations might be said to co-produce knowledge through activity." (Brown, et al, 1989, p. 2).  He further states that without the "situated nature of cognition," the knowledge gained will be neither helpful nor deep. Thus situation awareness is essential for staff officers to appreciate what it is they are confronted

with in terms of new information.  Without the context – a shared appreciation of the environment – true learning will be impeded.

## Cognitive Flexibility Theory

Spiro & Jehng (1990) apply this constructivist concept in a theory they call "cognitive flexibility."  Cognitive flexibility theory focuses on how people learn in complex and ill-structured environments. "By cognitive flexibility, we mean the ability to spontaneously restructure one's knowledge, in many ways, in adaptive response to radically changing situational demands...This is a function of both the way knowledge is represented (e.g., along multiple rather single conceptual dimensions) and the processes that operate on those mental representations (e.g., processes of schema assembly rather than intact schema retrieval)." (Spiro & Jehng, 1990, p. 165)

This theory is pertinent because it is applied largely beyond initial, school learning situations.  Spiro and Jehng, as Bruner before them, emphasize presenting information in many different ways to avoid over stimulating short-term memory. Spiro and Jehng use case studies for varied examples, but in practice, the staffs and commanders have multiple stimuli – tactical radio nets, two- and three-dimensional displays of text and graphics, animations and real-time video. The cognitive flexibility theory suggests that effective learning is context-dependent, which is why such care has been taken to make the simulation a faithful representation of operations under duress.  Cognitive flexibility stresses constructed knowledge, which is to say that learners (staffs) need to work on individual schema to learn from personal depictions.  Inasmuch as CPOF and PAL allow composability – each operator creates his or her own display – the subjects were able to develop their own palette and were able to develop appreciation independently as

well as in collaboration. This theory appears particularly appropriate while using interactive technology (Spiro, et al., 1992).

Spiro's work complements the "dual-coding" work of Allan Paivio (Paivio, 1986). Dual-Coding theory suggests that verbal and visual information are coded and represented differently – the former with symbols and the latter with analogue codes. Each type of code travels along a separate channel and is processed differently by the receiver. Despite the distinct channels, the human mind uses the visual and verbal codes to organize incoming information, and turn it into knowledge that can be acted upon, placed in storage, and/or retrieved for later use.

There are limitations with this system. Spiro, et al, have highlighted the difficulty humans have dealing with multiple clues in either of the channels. Additionally, Sweller (1988) has posited that the ability to handle large volumes of disparate information depends largely on experience. Thus the multiple sources of input CPOF affords the user (the same sources PAL helps organize) – audio, still and motion video, rich icons that represent units or events – coupled with a user's experience in operations, should attenuate the difficulty humans have with processing large volumes of information through task and information management and effective visualization.

McGuinness and Ebbage (2002) identified human factors involved in commanders making decisions faster than an adversary could react, and that these decisions are often impeded by less than optimal information, or as Clausewitz described it, "friction" of war (Clausewitz, p.119). Clausewitz identifies these points of friction as those things that arise during actual combat actions that did not occur to planners as they envisioned the battle. These writers recognized the value of accurate, timely information and, it could be extrapolated, good mental models, to decision making.

In summary, developing, maintaining and sharing situation analysis is critical to the success of a military commander and his or her organization. Situational awareness consists of perception of the current situation, placing that information in context, then projecting or predicting what best to do next. Various tests can be used to gauge situation analysis among participants including the Situation Awareness Global Assessment Technique (SAGAT) (Endsley, 1995a) and the Constructible Assessment for Situation Awareness (CASA) (Seet, et al., 2004). To place the concept of situation analysis into the military perspective, the next part of the literature review will investigate pertinent Army doctrine. The transient nature of situation analysis suggested by Artman (1998), and the idea that shared situation analysis is held and distributed by both human and non-human parts of the system are key parts of the military definition, which describes situation analysis as "immediate knowledge" (FM 3-0, 2008), and the importance of command and control systems for collaboration and sharing information.

**Military Manuals**

Army Field Manual (FM) 3-0, <u>Operations</u> (2008) defines situational awareness as "immediate knowledge of the conditions of the operation, constrained geographically and in time" (Glossary, 13). FM 3-0 is considered the proponent of this definition, thus all Army doctrine defers to this publication regarding situation analysis. Note that this definition is not as inclusive as Endsley's. The manual splits Endsley's construct of three levels of awareness in half, calling the perception and context levels "situational awareness" and the prediction and projection steps "situational understanding." FM 3-0 also addresses command and control systems and how the common operational picture helps improve situation analysis by integrating myriad data sources and making that information available and understandable quickly (4-3).

FM 3-0 introduces an additional concept, that of situational understanding, which it defines as "the product of applying analysis and judgment to relevant information to determine the relationships among the mission variables to facilitate decision making" (Glossary, 13). This is a handy construct for assessment, in that a participant with awareness might, for any number of reasons, fail to achieve understanding. Commanders improve their situational understanding through collaboration with other commanders and adjacent organizations (5-5). Ultimately, commanders must use their experience, judgment, and command and control systems to develop and maintain situational understanding (1-96). It requires continuous assessment and updating – time to focus on the operational picture, and project friendly and enemy next moves. These concepts are consistent with Bruner and Spiro regarding the constructivist nature of learning.

According to the Army's primary command and control manual, Field Manual 6-0, Mission Command: Command and Control of Army Forces, (2003) "the essential task of commanders is applying the art and science of war to the command and control of Army forces. … Using his command and control system, the commander directs the actions of his forces and imposes his will on the enemy" (FM 6-0, 1-1). It is this command and control system that enables a commander to accomplish his mission, which requires the commander and staff to manage all the information arriving in the headquarters. This information management leads to a common operational picture, or "COP" that reflects the status of friendly units, enemy and environmental factors. This COP is then shared throughout the command – not as shared situation analysis itself, but as a means for individuals and groups to develop that awareness (1-2). Remember, though, that CPOF and PAL are composable – individuals can generate unique representations of reality on individual command and control systems.

At the top of the list of criteria for effective command and control systems is the need for information management (1-6). Getting the right information, to the right person, in a format that enables that person to use it, when it is needed is essential for situation analysis and decision making (3-4). The CPOF command and control system, with its ability to allow users to collaborate and share visualization, manages information. Users in combat situations, however, faced with redundant tasks and reporting requirements have, at times, struggled to keep pace with the high volume of data available.

Whereas command is the human or "art" side of military operations, control is largely the science. Control "the regulation of forces … to accomplish the mission" (3-1), then, is where technology can be introduced to assist in managing information. In fact, control includes "collecting, processing, displaying, storing and disseminating relevant information for creating the common operational picture" (3-1). Taken together with experience and judgment, these activities help commanders and staffs develop situation analysis at all levels, perception through projection (3-4).

In summary, Army commanders and staffs rely on accurate, timely and contextual information to develop thorough situation analysis. This information is managed by the command and control systems that provide users a common picture of the disposition of friendly assets, adversaries and the environment. Using the situation analysis gleaned through command and control systems, commanders make better and / or faster decisions than enemies. PAL has been introduced as an option to improve users' situation analysis by providing time to think about, thus improve, decisions.

**Technical Studies (CALO/SRI)**

In this section, literature about the technical aspects of PAL will be discussed. This section of the review draws significantly from information gleaned from the website for PAL hosted by SRI, the primary developer. This discussion is limited to the integration of PAL with military command and control systems, specifically, the Command Post of the Future (CPOF).

*PAL Background*

The Personalized Assistant that Learns, PAL, is part of a Defense Advanced Research Projects Agency (DARPA) undertaking of the SRI International Corporation in Menlo Park, California. PAL is a product of DARPA research intending to make contributions to cognitive systems by developing prototypes with integrated cognitive assistants. PAL derives from A DARPA project known as CALO (or the Cognitive Assistant that Learns and Organizes) that has been called the "most ambitious artificial intelligence project in U.S. history" (VisWiki.com, 2010).

The concept behind PAL is that while software can be programmed for myriad contingencies, it could never be programmed for all contingencies, thus there is a need for systems that learn. PAL is offered as part of a command and control system that does not require reprogramming, rather, it learns or adapts by observing a user's actions. It is an integrated machine learning technology that permits the software to learn to assist users.

The PAL program mission is to "radically improve the way that computers support humans by enabling systems that are cognitive, that is, computer systems that can reason, learn from experience, be told what to do, explain their actions and respond robustly to surprise" (DARPA website). The expectation is that PAL technologies will speed decision making at all levels of command by enabling "cognitive assistants" that could reduce staffing requirements, and improve the efficiency and effectiveness of staffs and commanders. The integration with

CPOF is one such use of PAL technologies (DARPA 2). DARPA claims three aims of PAL: reducing staff workload – by performing tasks for a busy user, managing information – directing information to those who need it, and raising situational understanding – by allowing time for analysis.

PAL itself emanates from work including the Rao & Georgeff "Belief – Desire – Intention agent (Rao & Georgeff, 1991, 1995) studies that attempt to design systems that perform management and control tasks in complex environments (Rao & Georgeff, 1995, p. 312). Myers and Yorke-Smith (2005) describe this model as "delegative" in that the user assigns tasks to the cognitive assistant that the assistant completes, generally autonomously. The model allows for interactions that would insert a human decision maker to preclude automatic engagement of planned actions. For example, were PAL to identify an enemy position, ample safeguards are in place to disallow artillery engagement prior to approval by a person in authority.

For PAL to be successful in this application, a mix of user-based and agent-based autonomy was required to preclude decisions made without humans in the loop. An important question regarding this research is the determination of whether and when PAL should conduct an action without human interaction. A user must trust the cognitive assistant to do what it is told (and only what it is told). Within the software code for the assistant, policies must balance making competent and timely decisions without venturing into areas where the user wants to be in the loop for decision making (Maheswaran, Tambe, Varakantham and Myers, 2004). That PAL allows both "automatic" and "controlled" actions is essential. There are any number of reasons a commander would be required to make a decision, especially regarding the use of force in a built up area, or a commitment of a reserve force based on pre-determined conditions.

PAL "persists, collaborates, and learns over an extended period of time" (Myers and Yorke-Smith, 2005).  This requires up-front work on the part of the user to teach PAL procedures required of his position or area of expertise.  Although networked, each individual user creates specific procedures he or she requires that run only on that user's machine. But this feature also allows users to set parameters for PAL to conduct a procedure based on future events – teaching PAL to conduct an action upon certain circumstances occurring.  Thus the agent is flexible enough to retain what it learns as long as the tasking is still active.  This assists users in that PAL can be taught to monitor a great number of activities (variables) that the user could not possibly monitor him or herself.  When the designated condition(s) are identified (target is at a certain location, convoy reaches a checkpoint, etc.), PAL provides the user notification.

Summarizing, PAL is a cognitive assistant that automates tasks taught to it by a user. These can be mundane, recurring tasks (generate a report, monitor stocks of a commodity, etc.) or tasks requiring complex or voluminous data (notify me upon receipt of information that a specific enemy action has occurred (improvised explosive device attack), given certain parameters (command-detonated, 155 mm or larger, in our unit area of operations), with measurable outcomes (casualties, damage to infrastructure, etc.).

In each case, PAL frees the user from conducting these tasks personally, allowing him or her to focus on those aspects of his/her position requiring attention or thought.  Because of these capabilities, PAL should help users to get more tasks done and stay ahead of the adversary's decision making cycle; maintain accurate perception of status, comprehend and manage ongoing operations and project future requirements; and focus on and understand key information and maintain situation analysis of the battle space.

**Summary**

Current literature supports the idea that a cognitive assistant could reduce the load of a user and make him more productive. By affording the user the ability to shift repetitive tasks to an automated assistant, the user could become more flexible and better able to process the new information bombarding him from multiple stimuli. PAL accounts for the requirement to learn in a specific situation, allowing rapid assimilation of new information, while avoiding the overloading of short-term memory.

The PAL project aims to increase situational awareness – including the highest levels, also known as situational understanding – and efficiency and effectiveness of decision making by freeing staffs and commanders from routine or burdensome tasks that dilute focus from the most pressing issues. PAL is delegative in nature (Myers and Yorke-Smith, 2005), to allow continued interaction with the user at a level specified by the user. Initial literature review indicates there are expectations that PAL will reduce task loading, and in fact, even reduce manpower requirements (DARPA 2).

Military operations require a high level of situation analysis and understanding to control operations in dangerous, complex environments (FM 3-0, 2008). Much of this situational understanding is based on information managed by, represented on, and shared through command and control systems (FM 6-0, 2003).

**Contribution to the Body of Knowledge**

The overall objective of this study was to identify if interventions using two different types of command and control systems – the Command Post of the Future (CPOF) and an enhanced CPOF with the Personalized Assistant that Learns (PAL) – improve a staff's shared situational awareness during simulated full spectrum operations. By providing this automated

cognitive assistant, we can improve the situational awareness of staffs and commanders in complex environments.

Clearly this tool is applicable more broadly than the military – any occupation that consists of redundant tasks would benefit from this intervention. For the Army, PAL offers the promise of leaders who make better, quicker, and more informed decisions in critical, time sensitive situations. This research focused on the situational awareness aspect of decision making and leaves the question of what comprises a good decision to later studies.

No other studies specifically address the ability of a cognitive assistant to improve situational awareness in simulated combat operations, or any other time-sensitive situations. This study has taken a first step to discover the application of such assistants on shared situational awareness on complex problems requiring timely collaboration, solutions and reporting.

It seems important to conduct further studies to assess these interactions, as well as skill sets, personality traits, and techniques required to maximize the utility of a cognitive assistant. Training on these new command and control tools must be researched as well, to ensure end users get to appreciate the benefits of the assistant quickly and efficiently. This research contributes to the existing body of literature by adding insights and observations into the continued improvement of cognitive assistants.

**CHAPTER THREE**

**METHODOLOGY**

In this chapter, the research design methods used for assessing the shared situation awareness within two teams portraying brigade combat steam staffs using the Personalized Assistant that Learns (PAL) (including its various tools) are presented to answer the following research questions (Additional information on PAL and the other tools in Appendix A):

RQ1:   Does the Personalized Assistant that Learns (PAL) improve situational awareness when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

RQ1.1: Does the Personalized Assistant that Learns (PAL) improve task management when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

RQ1.2: Does the Personalized Assistant that Learns (PAL) improve information management when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

RQ1.3: Does the Personalized Assistant that Learns (PAL) improve decision support when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

RQ1.4: Does the Personalized Assistant that Learns (PAL) improve environment appreciation when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

RQ1.5: Does the Personalized Assistant that Learns (PAL) improve visualization when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

RQ1.6: Do users of the Personalized Assistant that Learns (PAL) trust the cognitive assistant's autonomy when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

This research examines the effect on situation awareness while staffs use two command and control collaboration suites. In each experimental trial (there are two), staff officers used a different command and control toolset to visualize the battle space, synchronize activities, create decision-making products and make decisions. In the first trial, one representative staff, nominally the control group, used the current system – Command Post of the Future (CPoF) – while a similar team used the CPoF system enhanced with the Personalized Assistant that Learns (PAL), the treatment group. (For simplicity, we will call the teams "the CPoF team" and "the PAL team.") In the second trial, the two teams switch and the CPoF team became the PAL team and vice versa. The focus is on whether or not the PAL system improved situation analysis, and whether or not differences among the subscales: task management, information management, decision support, environment appreciation, visualization and trust.

Specifics about each trial follow. Prior to the actual trials, significant training was conducted over the course of several months to familiarize all the participants with the scenario and the command and control systems, as well as develop competence in the command and control tools. This training included three separate week-long training events conducted by PAL's developers. Additionally, a "dry run" pilot of the trials took place approximately one month prior to the trials to

assure that all role players had achieved competence in the systems. The intervening month provided an opportunity to provide focused training to any role player who was not able to develop competence before the pilot. Each role player was administered and passed a competency test prior to the trials. This test was designed by the CPOF and PAL experts who understood precisely what capabilities all the role players needed for the trials. The pilot also provided an opportunity to vet the tool assessment surveys (detailed later) by administering and assessing the validity and reliability of the instruments under trial conditions.

Each team replicated essential functions of a brigade combat team (BCT) and consisted of a commander, operations officer, battle captain, intelligence officer, intelligence analyst, sustainment officer and effects officer. (Functions for each position are contained in Appendix B.) Each team was controlled by a combination higher command/lower command (HICON/LOCON) that provided higher level guidance and subordinate execution. Events injected from the HICON/LOCON were synchronized to the maximum extent possible, so that both teams received the same inject at the same time. The format allowed for some flexibility if the planned number and variety of events did not adequately stimulate (or overwhelmed) the role players.

Each team had one day to plan with PAL, one day to plan without PAL, one day to execute plans and operations with PAL and one day to execute plans and operations without PAL. Each team followed the basic schedule: PLAN-EXECUTE. PLAN-EXECUTE. One iteration was conducted with PAL and the other was conducted without the PAL technologies. On each of the two planning days, each team received precisely the same planning requirements – dictated from higher headquarters in the form of Fragmentary Orders (FRAGOs). Each team got five hours to plan two related missions that would be executed the following day. Planning within each trial could have an

impact on the success on the execution portion of the trial, but the two trials were distinct: second trial performance was not dependent on first iteration planning or execution.

On the day following each planning session, teams executed their plans while dealing with other, typical battlefield events. These ranged from threats from adversaries to issues with governance, humanitarian assistance and civil control and security. The plan was to inject an event every four minutes and a significant activity (SIGACT) every 10 minutes. The two HICON/LOCON teams had the flexibility to increase or decrease the pace of event injection, but were required to synchronize their actions so the test was comparable to both groups. Throughout the event, the administrating HICON/LOCON remained on the "four-minute/10-minute" schedule. It proved challenging and at times, overwhelming, but not demoralizing.

Both the role-playing staffs received individual training on the tools and collective training as a staff. Different skill levels were accounted for two ways. First, qualitative and quantitative assessments across teams can be compared to determine if, indeed, one team consistently outperformed the other. Secondly, and more important, intra-team assessments of each team with and without PAL discounts any skill variation between the teams.

### Participants

The participants for this study were six role players in each of two similarly staffed brigade combat teams (n=12) participating in an experiment focusing on stability operations set in the current time in Azerbaijan. In the scenario, major combat operations have concluded 30 days prior, the attacking (fictional) Ahurastani army has been repulsed, and US and local forces have begun to restore order near the city of Pushkino. The trials took place entirely on Fort Leavenworth, Kansas. All participants were active duty Army officers, government service civilians or government contractors. Specific demographics were surveyed. Ages ranged from

25 - 65 but all participants had knowledge of the systems and had training on them prior to the experiment trials, although there was variance in skills among the role players.

Eleven of the 14 participants were retired army – 10 of them field grade officers and the eleventh, a retired senior non-commissioned officer. All 11 had 22 years or more of service – the two brigade combat team commanders were both 30-year veterans who had previously commanded at the brigade level. A twelfth participant was an active duty Army major with 12 years of service, and had just completed a combat tour in Iraq using CPOF in a division headquarters.

Military experience was a common characteristic among the participants. For this study, a convenience sample of two groups was designated, based on staff experience and experience with the collaborative tools. The subjects were assigned to positions on the staff for which they had training, in positions of command, operations, intelligence, logistics and effects.

Access to the subjects involved in the study was obtained through cooperation with the Battle Command Battle Lab (BCBL) at Fort Leavenworth. Subjects were informed of the process and of the confidentiality of the process and results, as well as the voluntary status of their participation in the survey collection. Subjects were informed that code numbers or role playing positions rather than names would appear on all the data and that all data would be kept in the researcher's locked files. Students signed a consent form that follows the guidelines of appropriate Army regulations and the University of Kansas. KU Human Subjects Participation permission was approved prior to start of any evaluations.

**Procedures**

RQ1:   Does the Personalized Assistant that Learns (PAL) improve situational awareness when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

Good situational awareness (Nofi, 2000) relies on a focus on relevant versus irrelevant cues and the ability to focus on important information.  Using Bloom's Taxonomy as a guide, basic situation analysis would be at the knowledge level, an answer to the question, "What?" Endsley, 1995b, provides a common situation analysis framework that defines this first level of awareness as perception.  Each of these definitions recognizes that situation analysis is the building block for higher levels of awareness or understanding.

To Endsley, this extends to level 2 situational awareness – Comprehension, or "so what?" Bloom would define this as synthesis or analysis of input.  However defined, Endsley and others see the knowledge-level situation analysis as the means to build mental models that allow users to process the large amounts of data available.  In this experiment, we understand mental models to consist of relevant or irrelevant cues in relation to any number of patterns and meanings of those cues.  The tests for this higher level of situation analysis are not markedly different from level 1 situation analysis, but require the role player to analyze or synthesize available data.  The expectation is that the PAL technologies will improve level 2 situation analysis as well – individual and shared – by automating simple, routine tasks, thus affording users more time to analyze available information.

The scenario used for the experiment focuses on insurgent-type operations rather than major combat operations.  To determine patterns, it is expected that the role players will need to rely on each other, rather than simply what each person sees on his or her visualization interface.

PAL's ability to find information in disparate sources and share it across the staff is expected to improve overall situational awareness.

This awareness must be spread throughout the staff so that all members of the team share critical information and a similar appreciation of the problem. Two senior Army officers once defined this shared situational awareness to the Senate Armed Services Committee in 1998 in this way:

> Shared situational awareness . . . translates to a clear and accurate,
>
> common relevant picture of the battlespace for leaders at all levels and
>
> a reduction in the potential for fratricide. *Situational awareness*
>
> *answers three fundamental battlefield questions: Where am I? Where*
>
> *are my friends'? Where is the enemy*? ..." (Nofi, 2000)

Role players are inundated with information – orders, imagery, significant activity reports, intelligence, requests from higher headquarters and subordinates. The amount of disparate information threads and sources is so great, that at times a staff officer or commander could "misplace" information while attending to other, often routine functions. By automating some of these routine functions, PAL could keep individuals focused on the most important or time sensitive information. Four separate quantitative activities were used to determine the level of situation awareness within each staff. First, to determine how well staff officers and commanders achieve and retain situation analysis, role players received "quizzes" a total of three times during each trial to determine how closely their picture of the situation resembles ground truth. These quizzes were created considering the lessons learned by Seet, et al, 2004, in their CASA concept, generating specific questions based on experiment context. (A sample situational Awareness/Understanding Test is at Appendix D.) (A total of seven quizzes were administered,

but only five were considered valid.  The quizzes had been designed prior to the start of the trials, and actions during the execution phase of the trial invalidated – either because key scenario injects had been changed, or free play with the scenario resulted in correct answers that were not on the quiz – both quizzes on day two of the first trial.)  We expected to observe higher situation analysis scores with the PAL Enhanced suite of command and control tools.

A "tools assessment survey" (Appendix E) was administered twice each day, and among the questions were several querying self-assessments of situation analysis throughout the session. There are three tools surveys – one for the CPoF team, one for the PAL team and the third as a post-hoc survey given both teams to enable them to compare the two systems directly.  This survey provided the bulk of quantitative data for this study.

The survey contained several subscales to identify differences in key aspects of situational awareness, specifically, task management, information management, decision support, environment appreciation, visualization and trust in the tools, both to do what they are instructed, and NOT to do things not instructed.

The nature of shared situation awareness as discussed in Chapter 2 infers that these self-assessment surveys be aggregated by team to reflect the team's awareness – one member of the staff's individual situation awareness is important only if shared through collaboration across the team.  Analyzed numbers in Chapter 4 are team aggregate numbers.

We expected to observe greater situation analysis with the PAL Enhanced suite of command and control tools.

The third objective measure used to determine situation awareness was to calculate the time it took each staff to submit a report required with every significant activity (SIGACT). These times were collected by a computer-run timing system. The system tracked the time of the

"inject" (the event), the time it was identified by each staff as a "SIGACT" (an event requiring a report), and the time the report – in the form of a "storyboard" – was submitted.  This timing system allowed the analysis of these two separate bits of information: the amount of time it took to elevate an event to a SIGACT and the time to complete the required storyboard.
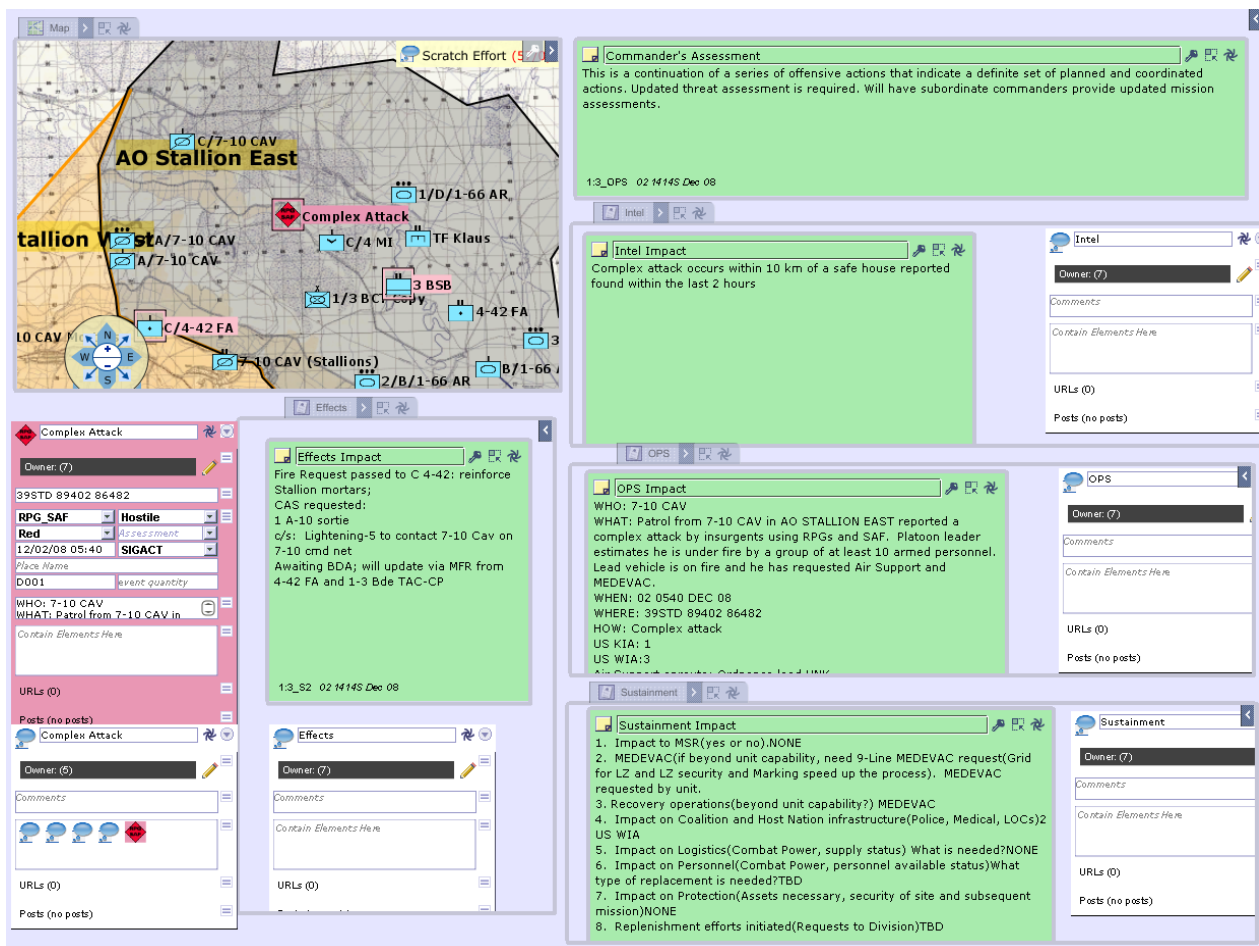


**Figure 3-1, Sample Storyboard Significant Activity report**

The final quantitative measure for situation awareness was a subject matter expert rating of the quality of the submitted storyboards reflecting the scenario-based cognitive assessment tool (Prevou, 2006) and the Behaviorally Anchored Rating Scale (BARS) (Muchinsky, 2003, Riggio, 2000).   These scales are posted in Appendix G.  This objective assessment provided the ability

for subject matter experts who were not role players to corroborate the role players' self-assessments.
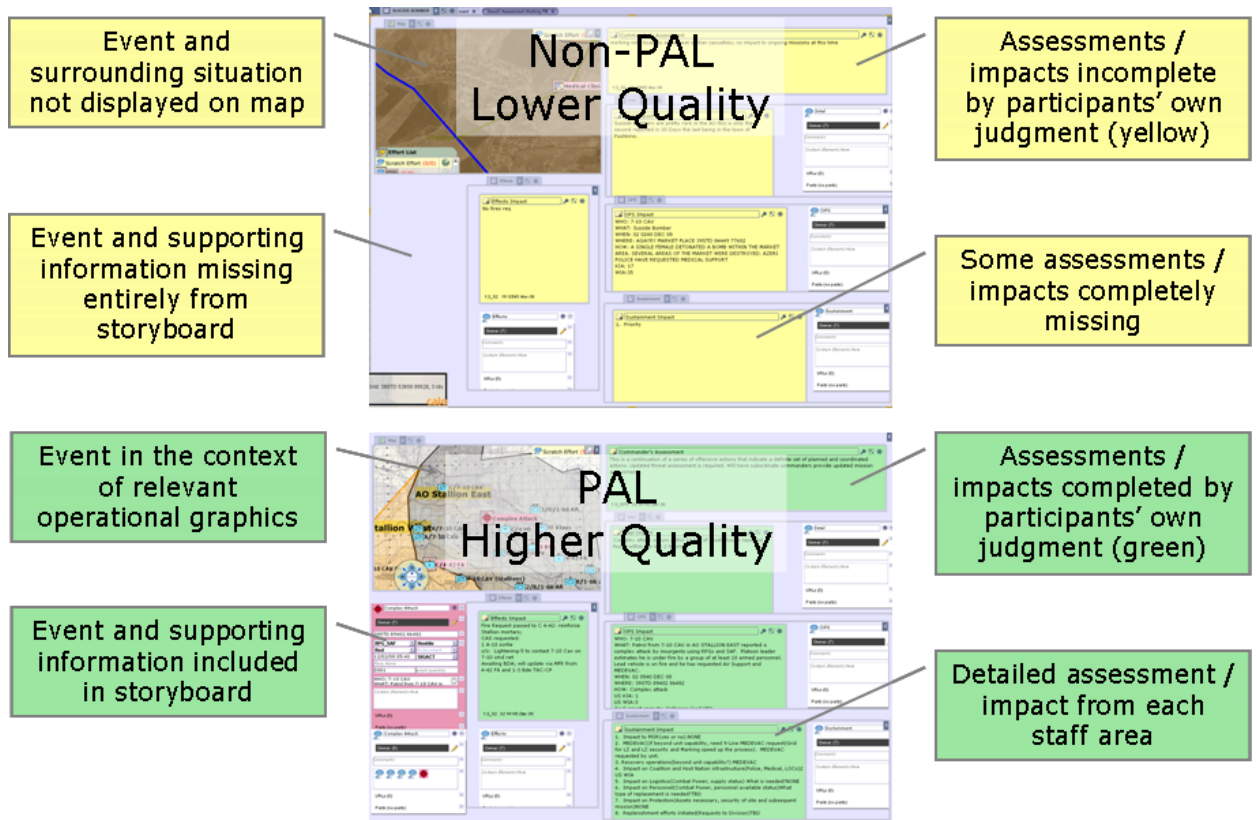


**Figure 3-2, Sample Qualitative Assessment of PAL and non-PAL Storyboards**

In addition to the quantitative measures, trained observers, with significant military experience, watched over each staff team throughout the trials. While not the focus of this study, these qualitative observations were recorded to compare players self-assessments with objective observations and to provide richness to the data specific for the software developers. These observers were forewarned of impending significant actions and provided a list of "expected outcomes" of these significant events. Additionally, the observers facilitated interviews of the subjects (as a group) after each session. Further study is required to correlate this qualitative data with the quantitative.

RQ1.1: Does the Personalized Assistant that Learns (PAL) improve task management when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

Six questions on the self-assessment survey related to task management. Specific issues regarding organization, anticipation, quantity and quality of tasks individuals could handle depending on the command and control system.

RQ1.2: Does the Personalized Assistant that Learns (PAL) improve information management when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

Five questions on the self-assessment survey related to information management. Questions asked about getting information rapidly, effectively and to the right people as well as whether or not the command and control system facilitated obtaining information from varied sources. One question regarded the C2 system's role in focusing and understanding key information.

PAL technologies automate many routine tasks of information management, providing notification upon data satisfying a pre-defined "trigger," and assembling related information from disparate sources. These capabilities create an expectation that the task load for each staff member would decrease while using PAL

RQ1.3: Does the Personalized Assistant that Learns (PAL) improve decision support when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

Four questions on the self-assessment survey related to decision support. These questions asked participants to assess their recommendations to the commander and if their own decisions

were affected by the C2 system, and the quality of the products they generated to assist in decision making.

Speed of decision making is a command imperative. But to make decisions quickly without complete information, or with incorrect information, is risky indeed. In this experiment, each team was confronted with one full day of planning (approximately five hours) followed by one full day of executing not only the plans developed the day prior, but also significant activities and events that happen while executing those plans. (For example, Day 1 requires each team to plan a mission that will be executed on Day 2. While executing the mission on Day 2, each team will be presented with numerous challenges. Some were "events" requiring some simple staff work to complete. But approximately every third one (about every 10 minutes) each team received notification of a "significant activity" (or SIGACT) that requires a report to higher headquarters. While not the sole requirement a higher headquarters would levy on its subordinates, reporting significant activities is a measurable, realistic, representative task the 7-person teams could reasonably be expected to submit to higher headquarters, and will constitute the basis for evaluation.

It is through these SIGACTs that we measure speed of execution. Each team was required to submit a "story board" to division headquarters for each SIGACT and for any other event so designated by the evaluation control team. The BCT commander had 15 minutes to submit a story board from the time of receipt/acknowledgement of a SIGACT. Each story board required specific minimum information and analysis from each staff position and commander. For example, the Sustainment Officer was required to provide a roll-up of personnel and equipment issues, based on the specifics of the SIGACT, as well as make an assessment of whether or not the decrement to personnel and/or equipment would impact current or near-term future operations.

The expectation is that the automatic features PAL offers would enable the PAL team to complete the story board requirement faster than the CPoF team.

Another critical component of decision making is the quality of information being shared to make decisions. Quality of decisions in this context potentially has life or death consequences. As discussed previously, speed and quality are the two primary determinants of decision-making and decision-making products. During the planning sessions, each team developed "battle boards" from which they would execute the operations the following day. The Military Decision Making Process (MDMP), long a staple in military planning, provided the metrics for qualitative assessment. (See Appendix F for a synopsis of the Military Decision Making Process.) Each team was required to plan operations including an air assault, downed aircrew recovery, high value target (cordon and search), and security of a holy site during a religious holiday. The former two and latter two would be linked together to create two five-hour planning sessions.

Using the command and control tools available and the Military Decision Making Process, the teams developed plans, producing numerous decision support products during the process. These products were crafted on virtual "pasteboards" that were harvested from the CPoF data repository at the end of each planning day. The qualitative judgment of these products was conducted by a subject matter expert (SME) review of the pasteboards using a behaviorally anchored rating scale (Appendix G). This 1-5 scale provided SMEs tested guidelines to assess the quality of the submitted products. Since PAL technologies can reduce the requirement for a user to conduct redundant actions, reduce or eliminate routine tasks, and link information from disparate databases, the expectation is that the PAL team will produce qualitatively superior products, because of improved situational awareness.

RQ1.4: Does the Personalized Assistant that Learns (PAL) improve environment appreciation when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

Four questions on the self-assessment survey asked participants to gauge their appreciation of the environment around them, including whether or not they were able to anticipate threat actions (the highest level of situation awareness) and whether or not the C2 system affected the role player's situation awareness.

RQ1.5: Does the Personalized Assistant that Learns (PAL) improve visualization when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

Four questions on the self-assessment survey related to visualization. CPOF is a collaborative and visualization tool and these questions focused on differences in setting up displays and boards.

RQ1.6: Do users of the Personalized Assistant that Learns (PAL) trust the cognitive assistant's autonomy when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

Two questions focused on the matter of trust of the system – whether or not PAL performed any functions not commanded and if that resulted in having to "undo" any actions. The "tools assessment survey" was administered twice each day, and among the questions were several querying self-assessments of speed of work throughout the session.

### The Scheme for Testing Situational Awareness, while on the CPOF Team

The CPoF team faced the stimuli detailed above. On the first day, the team was given five hours to create two fragmentary orders (FRAGOs). After each of two 2.5-hour sessions,

subjects received a situational awareness/understanding quiz and a tools assessment survey.

Following the survey period, subjects participated in a group facilitated discussion, focusing on

specific questions designed to add detail to the quantitative measures (these comments have been

captured but are not analyzed in this study). The pasteboards the team created during the

planning efforts were captured from the CPoF repository for post hoc study by subject matter

experts using the Behaviorally Anchored Rating Scale. On the second day, three hours of

executing operations were followed by the same battery of surveys and facilitated discussions,

then by 2.5 more hours of execution and a repeat of the survey – discussion protocol. After these

two days using the CPOF without PAL, the team switched to command and control systems

enhanced with PAL for the latter two days. Again, each half-day session includes a situation

awareness quiz, post hoc interviews, and a SME review of products submitted.

### The Scheme for Testing Situational Awareness while on the PAL Team

As detailed above, the PAL team faced precisely the same stimuli as the CPoF team. The

only difference with the PAL team was the change in the tool assessment survey that geared it

toward the PAL technologies. Additionally, flexibility was built in to increase the frequency and

complexity of injected events to the PAL team in case the original planned events did not

adequately challenge the PAL team. This did not prove to be required. The pasteboards the team

created during the planning efforts were captured from the PAL/CPoF repository for post hoc

study by subject matter experts using the Behaviorally Anchored Rating Scale. After these two

days using the CPOF enhanced with PAL, the team switched to command and control systems

without PAL for the latter two days.

Table 3.1 outlines the research design to answer RQ1: Does the Personalized Assistant

that Learns (PAL) improve situational awareness when compared to the "Command Post of the

Future" (CPoF) suite of collaborative and visualization tools? The treatment group will be compared to the control group throughout the different phases of the trials.

Table 3.2 outlines the research design to answer RQ1.1: Does the Personalized Assistant that Learns (PAL) improve task management when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools? The treatment group will be compared to the control group across the task management questions to determine if task management performance is affected by any of the particular attributes.

Table 3.3 outlines the research design to answer RQ1.2: Does the Personalized Assistant that Learns (PAL) improve information management when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools? The treatment group will be compared to the control group across the information management questions to determine if information management performance is affected by any of the particular attributes.

Table 3.4 outlines the research design to answer RQ1.3: Does the Personalized Assistant that Learns (PAL) improve decision support when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools? The treatment group will be compared to the control group across the decision support questions to determine if decision support performance is affected by any of the particular attributes.

Table 3.5 outlines the research design to answer RQ1.4: Does the Personalized Assistant that Learns (PAL) improve environment appreciation when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools? The treatment group will be compared to the control group across the environment appreciation questions to determine if environment appreciation performance is affected by any of the particular attributes.

Table 3.6 outlines the research design to answer RQ1.5: Does the Personalized Assistant that Learns (PAL) improve visualization when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?  The treatment group will be compared to the control group across the visualization questions to determine if visualization performance is affected by any of the particular attributes.

Table 3.7 outlines the research design to answer RQ1.6: Does the Personalized Assistant that Learns (PAL) improve trust when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?  The treatment group will be compared to the control group across the trust questions to determine if trust performance is affected by any of the particular attributes.

*Table 3-1*
Research design for Research Question 1

RQ1:   Does the Personalized Assistant that Learns (PAL) improve **situational awareness** when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

Research question 1, 1.1, 1.2, 1.3, 1.4 and 1.5 will be analyzed by comparing the means of each team's scores while in planning and execution across both conditions (CPOF (control) and PAL (treatment)), then by a repeated measures analysis of variance.

| (Dependent Variable) | Team 1 | Team 2 | Overall |
|---|---|---|---|
| CPoF (Control) | _<br>x | _<br>x | _<br>x |
| PAL (Treatment) | _<br>x | _<br>x | _<br>x |
|  | _<br>x | _<br>x | _<br>x |

*Table 3-2:*
Research design for Research Question 1.1

RQ1.1:  Does the Personalized Assistant that Learns (PAL) improve task management when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

| (Dependent Variable) | Team 1 | Team 2 | Overall |
|---|---|---|---|
| CPoF (Control) | _<br>x | _<br>x | _<br>x |
| PAL (Treatment) | _<br>x | _<br>x | _<br>x |
|  | _<br>x | _<br>x | _<br>x |

*Table 3-3*
Research design for Research Question 1.2

RQ1.2: Does the Personalized Assistant that Learns (PAL) improve information management when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

| (Dependent Variable) | Team 1 | Team 2 | Overall |
|---|---|---|---|
| CPoF (Control) | $\overline{x}$ | $\overline{x}$ | $\overline{x}$ |
| PAL (Treatment) | $\overline{x}$ | $\overline{x}$ | $\overline{x}$ |
|  | $\overline{x}$ | $\overline{x}$ | $\overline{x}$ |

*Table 3-4*
Research design for Research Question 1.3

RQ1.3: Does the Personalized Assistant that Learns (PAL) improve decision support when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

| (Dependent Variable) | Team 1 | Team 2 | Overall |
|---|---|---|---|
| CPoF (Control) | $\overline{x}$ | $\overline{x}$ | $\overline{x}$ |
| PAL (Treatment) | $\overline{x}$ | $\overline{x}$ | $\overline{x}$ |
|  | $\overline{x}$ | $\overline{x}$ | $\overline{x}$ |

*Table 3-5*
Research design for Research Question 1.4

RQ1.4: Does the Personalized Assistant that Learns (PAL) improve environment appreciation when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

| (Dependent Variable) | Team 1 | Team 2 | Overall |
|---|---|---|---|
| CPoF (Control) | _<br>x | _<br>x | _<br>x |
| PAL (Treatment) | _<br>x | _<br>x | _<br>x |
| | _<br>x | _<br>x | _<br>x |

*Table 3-6*
Research design for Research Question 1.5

RQ1.5: Does the Personalized Assistant that Learns (PAL) improve visualization when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

| (Dependent Variable) | Team 1 | Team 2 | Overall |
|---|---|---|---|
| CPoF (Control) | _<br>x | _<br>x | _<br>x |
| PAL (Treatment) | _<br>x | _<br>x | _<br>x |
| | _<br>x | _<br>x | _<br>x |

*Table 3-7*
Research design for Research Question 1.6

RQ1.6: Does the Personalized Assistant that Learns (PAL) improve trust when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?

| (Dependent Variable) | Team 1 | Team 2 | Overall |
|---|---|---|---|
| CPoF (Control) | _<br>x | _<br>x | _<br>x |
| PAL (Treatment) | _<br>x | _<br>x | _<br>x |
| | _<br>x | _<br>x | _<br>x |

*Table 3-8*
Research design for Situational Awareness Quizzes, Speed of Product Submission and Quality of

Submitted Products  (RQ 1)

| (Dependent Variable) | SA Quiz 1 | Speed 1 | Quality 1 | SA Quiz 2 | Speed 2 | Quality 2 |
|---|---|---|---|---|---|---|
| CPoF (Control) | _<br>x | _<br>x | _<br>x | _<br>x | _<br>x | _<br>x |
| PAL (Treatment) | _<br>x | _<br>x | _<br>x | _<br>x | _<br>x | _<br>x |
| | _<br>x | _<br>x | _<br>x | _<br>x | _<br>x | _<br>x |

Comparison of means of the situation awareness quizzes, speed of product submission and the quality of submitted products will determine the remainder of the overall situation awareness assessment.

## The Testing Order

Both groups were trained on the command and control suites and the scenario prior to the

start of the experiment.  The groups practiced together as staff-command teams.  Team 1 served

as the first CPoF team, while Team 2 was the first PAL team.  They served in these roles

Monday and Tuesday.  They switched rooms Wednesday, and Team 1 became the PAL team,

while Team 2 became the CPoF team.  See Figure 3-3, Testing Sequence.

PAL "Challenge" 1 – 5 Dec 08

| | Monday | Tuesday | Wednesday | Thursday | Friday |
|---|---|---|---|---|---|
| 0800-0830 | Arrival/Sys Check | Arrival/Sys Check | Arrival/Sys Check | Arrival/Sys Check | AAR Build |
| 0830-0900 | Div Update to BCTs | BCT Prep for Execution | Div Update to BCTs | BCT Prep for Execution | |
| 0900-0930 | BCT Plan Prep | Execute FRAGO 1010/CONPLAN 1004 Injected Events | BCT Plan Prep | Execute FRAGO 1006 /CONPLAN 1001(HVT ) | AAR (0900-1000) |
| 0930-1200 | Planning FRAGO 1010/CONPLAN 1004 (Co Air Assault/Aircrew Recovery) | | Planning FRAGO 1006 (Religious Holiday) | | Way Ahead |
| 1200-1230 | CL and SA Surveys Pasteboard Capture Hotwash (CA) | CL and SA Surveys Pasteboard Capture Hotwash (CA) | CL and SA Surveys Pasteboard Capture Hotwash (CA) | CL and SA Surveys Pasteboard Capture Hotwash (CA) | |
| 1230-1330 | Lunch | Lunch | Lunch | Lunch | Lunch |
| 1330-1600 | Planning FRAGO 1010/CONPLAN 1004 (Co Air Assault/Aircrew Recovery) | Execute FRAGO 1010/CONPLAN 1004 Injected Events | Planning CONPLAN 1001 (HVT) | Execute FRAGO 1006 /CONPLAN 1001(HVT ) Injected Events | Way ahead Required training assessment |
| 1600-1630 | CL, SA, TA, SQ Surveys Pasteboard Capture | CL, SA, TA, SQ Surveys Pasteboard Capture | CL, SA, TA, SQ Surveys Pasteboard Capture | CL, SA, TA, SQ Surveys Pasteboard Capture | |
| 1630-1700 | Hotwash (CA, SQ) | Hotwash (CA, SQ) | Hotwash (CA, SQ) | Hotwash (CA, SQ) | |
| 1700-UTC | EXCON Meeting | EXCON Meeting | EXCON Meeting | EXCON Meeting | |

Color Legend:
Green = Planning Event // Rose = Execution // Orange = Assessment //Gray = Admin

Survey Legend:
CA = Cdr's Assessment // CL = Cognitive Load
SA = Situational Awareness // TA = Tools Assessment
SQ = Speed/Quality Self Assessment
Post hoc: Pasteboard Subjective Evaluations by SME Board

**Figure 3-3, Testing Sequence**

**Technology Control**

To help control for the factor of utilizing a new technology, each subject was given a thorough introduction to the PAL software and applications over the course of several months, beginning in July preceding the December experiment. Other commitments in the Battle Lab precluded focused training on this scenario in August and September, but three weeks in October and two additional weeks in November reinforced the training. Training was provided and overseen by technical experts from the software creators. Much of the training was one-on-one. During the experiment, help desks were established to replicate similar services currently offered to deployed forces.

**Validity and Reliability**

All surveys were objectively scored and recorded by the researcher during the week of December 1-4.  All surveys had been administered during the week of October 20-24 during a pilot for the experiment, and questions that proved not applicable were expunged or reworded. The qualitative scoring rubric for the planning pasteboards and significant activities storyboards was developed and implemented for recent situational awareness and understanding research at the School of Command Preparation at Fort Leavenworth.  It had been expertly vetted.  A team of three disinterested, experienced subject matter experts from the Battle Lab reviewed the scales and recommended several minor changes, and content and face validity were tested on the role players in October to ensure it was measuring the variables of interest.  To ensure that the interpretation of the results followed from the study, countermeasures to threats to internal validity consisted of multiple control groups and convenience assignment of subjects to groups.

Threats to external validity were addressed only in that the homogeneous nature of the subjects (all U.S. Army or former army) was controlled for by collecting data through various methods.  Reliability was determined during this study by using a test-retest method during the experiments.  Each instrument was administered multiple times to control for reliability.  Inter-rater reliability between the three subject matter experts who conducted the qualitative assessment of the planning pasteboards and the four observers was established by a set of behaviorally anchored rating scales and instruction on those scales.  Observers were given a "heads-up" notification prior to significant events, and were provided with expected actions upon receipt of those events.  Additionally, the observers were provided specific questions for the focused discussions following each session.  To calibrate the scoring procedures a training session on the meaning of each level and identification of indicators to the criterion was conducted.  The three research SMEs rated pasteboards from the pilot run in an attempt to

establish an 80% or better agreement of criterion for calibration. The 80% was achieved after review of six pasteboards, at which time greater than 95% of the scores of each attribute were compared and fell within a 1 point spread. Random assignment of the role players to each experimental group and random assignment of the observers/evaluators to individual subjects also assisted in reliability of the evaluation.

## Observation

Observers recorded interactions and discussions for each planning and execution session. The observers used the scenario-based cognitive assessment tool described previously. The objective was to assess whether there was variation in the level of situation analysis dependent on the tool suite being used. Observers remained with the same team throughout the experiment to be able to detect differences in situation analysis as the teams used the different command and control suites. Observers narratives serve as reinforcement and corroboration to the quantitative data.

## Student Proficiency with the PAL Technologies

An issue that could have been a factor was the use of the PAL Technologies by newly trained users. The Battle Lab and PAL software developers worked extensively to ensure the role players were competent with the technology. To mitigate this variable, trained technicians worked closely with the role players during the many training sessions to facilitate maximum use of the PAL efficiencies. During the experiment, when the collected data was used for evaluation, the technicians remained available only through the help desk service, and all such interactions were recorded by the observers.

This training included introductions to all the technologies comprising the PAL evaluation: CPOF, WebTAS, Meeting Assistant and PAL itself. It was imperative that each role

player knew not only his job and his system, but the capabilities across the staff.  Qualified and

experienced WebTAS technicians linked the role players to the information database.  All role

players participated in the pilot event that served to familiarize the staffs with the general

elements of the scenario as well as improve proficiency on the command and control systems.

## Instruments

### Demographic Questionnaire

Participants completed a demographic questionnaire as part of their pre-experiment

requirements to collect information on military background, education level and command and

control suite experience.  The demographic questionnaire is shown in Appendix I.

### Tools Assessment Surveys

Each trial consisted of four four-hour sessions. Participants completed tool assessment

surveys after the first three four-hour sessions of each trial.  These surveys are at Appendix E.

After the last of the four sessions for each trial, a "hotwash" was conducted to discuss how the

team felt about the previous two days of evaluation.  Three different surveys were used: CPoF

(Non-PAL), PAL and post hoc comparison.  The CPoF survey was administered to the CPoF

team following each session (morning, afternoon, morning) for a total of six administrations

(after the last of the eight sessions, the post-hoc survey was administered).  Likewise, the PAL

survey was administered to the PAL team following each session (morning, afternoon, morning)

for a total of six administrations.  These surveys focused on self assessment in the areas of:  Task

Management, Information Management, Decision Support, Environmental Appreciation,

Visualization, and Trust.  They used a 5-point Likert scale for the majority of the questions

(Agree = 1 − Disagree = 5).  They both provided space for narrative comments.  The post hoc

comparison survey was administered only once − following the last session Thursday afternoon −

to allow the subjects to offer insights on the technologies in a comparative format using a 5-point

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Likert scale.  The post-hoc survey served to assess the how the participants felt about the trials, and, after using each command and control system, their opinions on the value and effectiveness of each in a head-to-head comparison.

These surveys were tested during an experiment rehearsal October 20-24.

*Situational Awareness Quizzes*

Situational awareness quizzes were administered at the end of each of the sessions.  Each quiz focused on critical information the staffs and commander would have been exposed to during that specific session, or contextual information provided earlier that might have led to understanding.  Questions were true/false or multiple choice.  As detailed previously, these quizzes were modeled on, the CASA model developed by Seet, et al, (2004) and the SAGAT instruments developed by Endsley (1995a).

*Speed/Quantitative Product Assessment*

On the two days set aside for conducting operations, teams were faced with a significant activity (SIGACT) approximately every 10 minutes.  Each of these events required the teams to generate a "storyboard" synopsizing the event and its impact on the unit (by function, then an overall assessment by the commander).  A computer-based tracking system calculated the time the incident first appeared to the teams, the time each team identified it as a significant activity and the time the required report was submitted to higher headquarters in the form of a storyboard (Figure 3-1 is a sample storyboard).  Each submitted storyboard was evaluated by a three person SME panel according to the BARS and the Scenario-based Cognitive Assessment tools.

*Directed questions/Facilitated Discussions*

Each session was followed by surveying, then facilitated discussions, routinely called "hot washes."  Each hot wash consisted of directed questions asked by the observers.  These questions focused on critical aspects of the technologies (How did using a specific part of the command and control system affect your staff work and/or decision?), workload (It appeared that

at one point you became overwhelmed by the injects and your requirements - explain what

happened?), or decision-making (Commander, you seemed very confident in the air assault plan

- how did the technologies contribute?). Other questions were focused on other aspects,

technologies or other hypotheses-related (Situational Awareness, task management, information

management, trust, etc.) topics. These comments were recorded but require further study to fully

assess the implications.

*Analyst Observations*

A pair of observers accompanied each team through the four days, collecting notes and

rating the teams on Situational Awareness/Situational Understanding using the Scenario-based

Cognitive Assessment scales. These behaviorally anchored rating scale (BARS) have been

calibrated and standardized across the raters with training and practice as previously detailed.

*Scenario-Based Cognitive Assessment*

The focus of the Scenario-based Cognitive Assessment tool, shown in Appendix G, is to

assess level of while conducting planning and operations with CPoF and PAL. This assessment

tool builds on behaviorally anchored rating scales (BARS) (Muchinsky, 2003, Riggio, 2000) and

later used by Prevou, 2006, among others**.**

The scale provided a range of responses from novice to expert for each of the four

dimensions of tactical thinking being evaluated. The range of responses was divided into five

levels and each level was assigned a numeric value: 1 novice (lacks situation analysis), 2

Advanced Beginner (has level 1 situational awareness, but not situational understanding), 3

competent (has level 2 situational awareness), 4 proficient (has level 3 situational awareness), 5

expert, based on work by Baxter et al. (2004). The observer was instructed to select the category

that most closely matched the team's level of situation analysis at a given point in time.

This was the primary assessment methodology for the planning days, drawn by capturing the planning pasteboards from both teams at the end of Monday and Wednesday for post hoc review.

*Role Player Comments*

While necessarily subjective, the researcher captured narrative comments, both on surveys and through the hot wash process. This data would provide richness to the numbers collected elsewhere.

*Informed Consent*

All participants signed a consent form (Appendix I) that follows the guidelines of the University of Kansas.

## Data Analysis

*Quantitative Analysis*

There were four separate methods used to capture quantitative data during this study: situation awareness quizzes, tool self-assessments, speed of storyboard submission and the quality of the submissions. The situation awareness quizzes provided an objective measure of how much the role players appreciated about their environment. Questions included level 1 ("What?") and level 2 ("So what?") situation awareness questions. Quizzes were graded for correct answers. A total of six quizzes were assessed as valid. Two were eliminated as actions in the scenario did not align with the pre-established questions for that day. Means for each team were recorded and compared.

Role players used a five-point Likert Scale to assess satisfaction with the command and control systems on 27 questions spanning six subscales. Means of these scores were compared across teams, based on the C2 system used. All the results of the self-assessment surveys were then analyzed using a repeated measure analysis of variance design. Each of the subscales was compared separately as well as in aggregate.

The length of time taken for each storyboard to be submitted was captured by a computer system established to track this activity. Additionally, time required to identify the incident and declare it a significant activity were also recorded.

Across the two trials, all efforts were made to make the incidents faced by each team as similar as possible, but because each team handled each event differently, there was a slight difference in the total number of incidents each team received. A total of 43 story boards were analyzed by the group of subject matter experts (16 during the first trial and 27 during the second trial). This assessment was independent from the quality assessment and measured only the time from "flash" (the event) to "bang" (in this case, the report to higher headquarters). Again, means were compared to determine differences across the conditions.

The fourth quantitative assessment was the determination of quality of each product submitted using the Scenario-based cognitive assessment tools and the behaviorally anchored rating scale (BARS). The intent was for the team of subject matter experts to assess the quality of the products submitted to provide a post hoc, objective evaluation of the storyboards. Scores ranged from 1 (poor situation awareness) to 5 (expert situation awareness). Means were compared to determine differences across the conditions.

Also captured, but not a focus of this study, were independent variables of rank, experience in stability operations and familiarity with the command and control systems used. Demographics and role player surveys provided insights into these variables that may be used to guide further study. While observer comments were collected and interviews were conducted throughout the trials, data from these sources serves only to highlight the quantitative data.

*Assumptions*

Several assumptions must be made regarding this study. First, subjects were assumed to participate in the experiment as a normal part of their jobs and made their decisions based on the

information that the tools, scenario and experience provide.  Second, the subjects all had

knowledge of United States Army tactics as they were all either active duty, or retired from the

Army, thus creating an equivalent population with which to sample.  It was assumed that no

participants would rate as tactical novices due to their experience and time in service.  The

groups were randomly organized and balanced to ensure an equal mix of branches and specialties

in each team.  Another assumption was that the role playing subjects were competent enough on

the technologies to preclude questions regarding the validity of the results due to shortfalls in

that regard.  All subjects participated in extensive training and were evaluated informally by

PAL technicians.  While skill levels varied among the participants, all maintained minimum

competence levels.  The research design addressed the limitations of the study – small samples,

group dynamics, team skill level differences – and in doing so, provided an effective framework

for investigating the effectiveness of these technologies.

### Limitations of the Study

Generalization – given the nature of this experiment, questions regarding generalization

of this data are considered limitations.  Participants were all military and the test measured skills

limited largely to military operations.  However, the constructivist nature of situation awareness

would suggest that testing in other disciplines would yield similar results.  Second, the scenario

and most of the survey instruments were built from scratch and internally tested for reliability

and validity.  The cognitive assessment tools – a critical measure of situation analysis and

understanding – had only been tested in one previous (known) study (Prevou, 2006).  Further

refinement of these tools used in follow-on research might prove beneficial and / or yield clearer

findings.  The limited number of personnel involved with the research could limit its general

application.  Even though all attempts were taken to replicate the functions of brigade combat

team staffs, the teams represented only a fraction of the hundreds of officers and enlisted personnel that would normally man a brigade headquarters.  However, this is a variable routinely addressed in Battle Lab experimentation, and this event was scaled to accommodate the smaller staffs, but focusing on the most pertinent activities of a staff function.

Technical limitations – CPOFs in actual brigade combat teams in Iraq and Afghanistan are routinely in different locations throughout the BCT headquarters, not adjacent to one another as in the trials.  Juxtaposition allowed role players to communicate face-to-face in situations that actual deployed staffs would not.  Further testing should include a full BCT staff and the ability to move the staff sections into separate rooms.  This would better replicate a current operating Command Post.

The volume of signals intelligence (SIGINT) traffic in the trials was limited.  For instance, in Iraq and Afghanistan, intelligence analysts have a much larger and more complex database to data mine.  However, some of the complexity had to be reduced to focus the scope of this trial on the available role players, which account for a small fraction of a typical BCT staff.  Experimenting with a more realistic database should be considered to incorporate additional and conflicting intelligence sources and a high volume of continuous.  The expectation is that PAL enhanced CPOF would prove even more valuable in such an environment, given that PAL is expected to link disparate items, and an intelligent search through a more cluttered database using WebTAS (as improved by PAL) would improve results.

Products that were required and analyzed were limited in scope by design.  Only a few representative products – storyboard and planning pasteboards – were evaluated.  In the future, a wider range of products should be created by the role players to stress the PAL software.  This would enhance further testing in that the role players would be stressed in more

areas. This would lead to further analysis of the ability of PAL to conduct routine tasks for the staff officer.

The level of familiarity with the command and control tools among the staffs was inconsistent. Despite multiple weeks of training and the administration of a competence test, a few participants were still marginally capable users of the automated tools. While this is, perhaps, a valid reflection of a new staff or a staff recently introduced to the tool suite, a more thoroughly and consistently competent staff might have yielded different results. As discussed in the "future research" section, replicating this test on a competent staff at authorized strength could provide additional insights to the body of knowledge captured herein.

The scenario, while rich in many ways, was executed by observers who ensured each team received the same event at essentially the same time. Thus, this event was not entirely "free-play," so the activities of the adversaries were limited by the imagination of the scenario designers. The real world was caricaturized to allow the small teams to focus on specific objectives of the experiment. While the scenario did not reflect faithfully all the nuances of the real world, it provided challenging stimuli that were the same across the teams. The lower volume of information available within the scenario database was offset by the limited size of the staffs.

Although the participants were all steeped in military experience as well as both civilian and military education, there was limited experience among the role players in the specific roles while conducting stability operations. It is suspected that this shortcoming would have a similar effect with or without the cognitive assistant, by requiring the less-familiar role-players to use more working memory from the outset. It could be argued, however, that a novice team member

would be a particular liability without PAL, or, conversely, that PAL compensates for novices on the team.

Although these potential limitations existed, the researcher took several measures to avoid any bias of the data. These will be highlighted more fully in Chapter 5, but discussed briefly here. First, participants were randomly assigned to a team by the Battle Command Battle Lab. Secondly, wording and definitions used in the survey instruments were edited to avoid strict application within the military. Additionally, all instruments were tested during a pilot and adjusted after that event, prior to the trials. This included the participants as well as subject matter experts. Any time constraints or limitations are placed on a study, especially those that result in an altered or less preferred research design, results could be distorted. But this methodology addressed limits as thoroughly and systematically as possible.

# CHAPTER FOUR
# RESULTS AND DISCUSSION

## Chapter Overview

The purpose of this study was to determine through test and assessment if a specific automated cognitive assistant improved situational awareness in representative brigade combat team headquarters that were conducting full spectrum operations. This chapter describes the research findings and is divided into three overarching sections. The first section addresses the demographics of the participants. The second section addresses quantitative research including both the comparison of means and the subsequent analysis of variance using the repeated measures test. Each of the research questions is addressed separately in both the means and repeated measures portions of the chapters. The final section, Additional Findings, addresses results of a post hoc survey of the subjects, narrative comments from surveys and post-trial interviews and discussions.

## Demographics

Discussion of findings will start with a demographic examination of the participants. The twelve individuals involved in the hands-on portion of the event consisted exclusively of active duty or retired military. (Two additional participants had limited or no military experience – they were software designers for a component of the command and control system. As training time was limited, these experts used their product (the Web-based Temporal Analysis System, WebTAS) to interface between the staff intelligence officer and the database. Strictly speaking, WebTAS is not part of PAL, so it was determined during the planning for the event that these technicians would respond to the requests made of them to search the database.) Eleven of the 12 participants had retired from the army – 10 of them field grade officers and the eleventh, a retired senior non-commissioned officer. All 11 of these had 22 or more years of service – the

two brigade combat team commanders were both 30-year veterans who had previously commanded at the brigade level.  A twelfth participant was an active duty Army major with 12 years of service, who had just completed a combat tour in Iraq using CPOF in a division headquarters.  The 12 role players had an average of just under 24 years (23.83) in service.

Half of these participants had been out of the Army for seven or more years, which could be construed as having a lack of currency of the systems, tactics and procedures.  But because each of these participants works in the Battle Command Battle Lab, those concerns were ameliorated since they all work at a job requiring participation in multiple research events such as this using this scenario and the Command Post of the Future as the primary command and control tool.

Ten (83%) of the participants had a graduate degree and all the others had achieved at least a bachelor's degree.  All the military participants – which is to say all but the two WebTAS technicians – were staff college equivalent or higher graduates.

Each role player was assigned a specific function based on his experience in the military. Two teams were formed with a convenience sample based on this experience.  Each team had seven positions:  Commander, Operations Officer (S3), Battle Captain, Intelligence Officer (S2), WebTAS Technician, Fires Officer and Logistics Officer.  These functions represent primary staff functions at brigade level, and allowed construction of the database to facilitate collaboration and information sharing. The scenario database has been discussed in greater depth in the methodology chapter.

Where the cohorts showed less experience was in the use of the command and control systems themselves.  Prior to the training for the trials, half the participants rated their

proficiency on CPOF as "none" (14.3%) or "limited" (35.7%) and 64% ranked their PAL

proficiency in those terms.  Additionally, 83% of the role players had not experienced actual

stability operations in a deployed location, although all of them had participated in numerous

experiments that portrayed the complex environment of full spectrum operations while working

at the Battle lab.

To compensate for this shortcoming, each role player participated in several training

sessions in the lead-up to the experiment to ensure proficiency on the command and control

systems and familiarity with the scenario and tasks that would be expected of them.  All were

required to pass basic proficiency exams designed by the CPOF manufacturers/trainers.  A copy

of the proficiency exam is included at Appendix J.  This process is also more fully explained in

the methods section.

Data below is organized into separate tables for the self assessments (includes overall

scores and the six subscales) followed by two more tables containing data containing the quiz

scores, speed and quality, and allow comparisons across and within teams.  The tables consist of

the mean, standard deviation and significance and allow comparison of each team in the control

group (CPOF) and the treatment (PAL).

## Quantitative Results

The first research question asked: "Does the Personalized Assistant that Learns (PAL)

improve situational awareness when compared to the "Command Post of the Future" (CPoF) suite of

collaborative and visualization tools?"

To answer this question, first, the overall scores were gathered from the self assessment

surveys throughout the trials.  Since each team performed in one trial in the control group (using

CPOF) and the other trial in the treatment group (using PAL-Enhanced CPOF), each team's

scores while using the treatment were compared to its scores when in the control group. This method addresses the validity issues that could be associated with a convenience sample in which one team simply outperformed the other. In this construct, each team in the treatment condition (with PAL) is compared to itself and the other team in the control group. The most important comparison is that of the overall CPOF scores versus the overall PAL scores.

Although means were compared for both planning and execution activities, to determine if PAL was particularly beneficial during one phase of the trial, they are aggregated here, leaving that investigation for future study. "Trial 1" scores represent aggregate scores of the first trial's two phases (planning and execution). It is the first iteration of the test with Team "1" using CPOF and Team "2" using PAL-Enhanced CPOF. "Trial 2" scores represent aggregate scores of the second trial's two phases, this time with Team "1" using PAL and Team "2" using CPOF. With the self-assessment scales used, lower numbers indicate greater agreement, more favorable assessment of the command and control system being used. The scores for questions 25 and 26 (the Trust subscale) have been inverted as both these questions were posed in the negative.

Following the determination of means, a repeated measures analysis was done on all the self assessment data to determine any significance of relationships among and between data.

When the overall mean scores of the self assessments of the treatment groups are compared to the mean scores of the control groups, participants' overall scores indicate no significant difference (Table 4-1). These relationships will be explored further in the repeated measured testing. There are no statistically significant interactions or mean differences across teams.

Overall results for Team 1, Trial 1(CPOF) are $M = 2.13$, $SD = 0.51$. Team 1, Trial 2 (PAL) results were $M = 1.61$, $SD = 0.40$. Overall results for Team 2, Trial 1(PAL) were $M = 2.04$, $SD =$

0.59.  Team 2, Trial 2 (CPOF) results were $M = 1.98$, $SD = 0.55$.  Overall Mean for the first trial was $M = 2.09$, $SD = 0.53$, and for the second trial was $M = 1.80$, $SD = 0.50$.  This within subject effect of trial yielded a Wilks' $\lambda = .69$, $F(1,10) = 4.61$, $p = .057$, $\eta^2 = 0.315$, indicating no significant difference between average Trial 1 and Trial 2 scores at the .05 level.

The interaction between team and trial yielded a Wilks' $\lambda = .78$, $F(1,10) = 2.80$, $p = .125$, $\eta^2 = 0.219$.  The interaction between team and trial is not statistically significant, indicating there is no statistically significant difference in the performance of the teams by trial.

Tests of between subjects effects (between Team 1 and Team 2) indicated that there was not a difference in teams when averaging across the CPOF and PAL means ($F(1,10) = .27$, $p = .612$, $\eta^2 = 0.027$; Team 1 $M = 1.87$, $SE = .19$ and Team 2 $M = 2.01$, $SE = .23$).

*Table 4-1*
Table of Means (M), Standard Deviation (SD) and Significance (P): Self-assessment survey results

Team 1 (CPOF first, then PAL)

| Subscale/ Condition | Task Management | Info Management | Decision Support | Environment Appreciation | Visualization | Trust | Overall SA |
|---|---|---|---|---|---|---|---|
| PAL | **M=1.73** | **M=1.40** | **M=2.24** | **M=1.74** | **M=1.17** | **M=1.42** | **M=1.61** |
| | SD=0.49 | SD=0.53 | SD=0.55 | SD=0.73 | SD=0.41 | SD=0.65 | SD=0.40 |
| | **M=2.13** | **M=2.15** | **M=2.65** | **M=2.24** | **M=1.78** | **M=1.77** | **M=2.13** |
| CPOF | SD=0.33 | SD=0.95 | SD=0.36 | SD=0.75 | SD=0.54 | SD=0.69 | SD=0.51 |

Team 2 (PAL first, then CPOF)

| Subscale/ Condition | Task Management | Info Management | Decision Support | Environment Appreciation | Visualization | Trust | Overall SA |
|---|---|---|---|---|---|---|---|
| | **M=2.19** | **M=2.01** | **M=2.42** | **M=1.90** | **M=1.81** | **M=1.81** | **M=2.08** |
| PAL | SD=0.56 | SD=0.63 | SD=0.61 | SD=0.55 | SD=0.62 | SD=0.89 | SD=0.51 |
| | **M=2.16** | **M=2.06** | **M=2.19** | **M=2.01** | **M=1.66** | **M=1.56** | **M=1.96** |
| CPOF | SD=0.65 | SD=0.60 | SD=0.68 | SD=0.67 | SD=0.46 | SD=0.59 | SD=0.55 |

Lower scores indicate more favorable assessment

While Team 1 scores trend generally lower than Team 2, there is no significant difference between them. These two tables together allow comparison within and across the teams. Further tests

of repeated measures determined the significance of these mean scores between the treatment and control in the overall assessment. These results follow. First, the subscale scores will be discussed.

The second research question asked: "Does the Personalized Assistant that Learns (PAL) improve task management when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?" This research question is answered by questions 1, 2, and 4-7 on the self-assessment tools survey (only the CPOF version of the survey is listed here, but when using PAL, the questions reflected that as indicated in Appendix E, Survey A):

- CPoF made organizing routine tasks easy.

- CPoF made no difference in the quantity of tasks I was able to handle.

- CPoF was effective in assisting in planning tasks.

- CPoF was effective in assisting in execution.

- CPoF allowed me to complete tasks rapidly.

- CPoF allowed me to complete tasks without loss of accuracy.

Neither team experienced a significant difference between trials, nor was there a significant interaction between the trial and team for this variable. Team 1, Trial 1(CPOF) results for Task Management were $M = 2.13$, $SD = 0.33$. Team 1, Trial 2 (PAL) results were $M = 1.73$, $SD = 0.49$. Team 2, Trial 1(PAL) results for Task Management were $M = 2.19$, $SD = 0.56$. Team 2, Trial 2 (CPOF) results were $M = 2.16$, $SD = 0.65$. Overall Mean for task management in the first trial was $M = 2.16$, $SD = 0.44$, and for the second trial was $M = 2.21$, $SD = 0.59$. This within subject effect of trial yielded a Wilks' $\lambda = .73$, $F(1,10) = 3.67$, $p = .085$, $\eta^2 = 0.268$, indicating no significant difference between average Trial 1 and Trial 2 scores at the .05 level.

The interaction between team and trial yielded a Wilks' $\lambda = .80$, $F(1,10) = 2.51$, $p = .144$, $\eta^2 = 0.20$. The interaction between team and trial is not statistically significant, indicating there is no statistically significant difference in the performance of the teams by trial.

Tests of between subjects effects (between Team 1 and Team 2) indicated that there was not a difference in teams when averaging across the CPOF and PAL means ($F(1,10) = .78$, $p = .397$, $\eta^2 = 0.073$; Team 1 $M = 1.93$, $SE = .20$ and Team 2 $M = 2.18$, $SE = .20$).

Post-hoc interviews sought to identify if subjects experienced any differences, despite the lack of statistical significance. A common theme among interview comments regarding task management was the differences between the systems as volume increased. One subject recalled: "With one or two tasks [required] CPOF handles them no problem. But as you add more, the gap [between PAL and CPOF performance] will get bigger and bigger." Even though not statistically significant, users identified advantages managing tasks with PAL.

The third research question asked: "Does the Personalized Assistant that Learns (PAL) improve information management when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?" This research question is answered by questions 8, 9, 10, 13 and 14 on the self-assessment tools survey:

- I was always able to forward information to the right people with CPoF.

- CPoF assisted in collecting information rapidly.

- CPoF assisted in collecting information effectively.

- CPOF provided me the ability to get information from other sources.

- CPOF enabled me to focus on and understand key information

Neither team experienced a significant difference between trials, nor was there a significant interaction between trial and team for this variable. Team 1, Trial 1(CPOF) results for Information

Management were $M = 2.15$, $SD = 0.95$. Team 1, Trial 2 (PAL) results were $M = 1.40$, $SD = 0.53$.

Team 2, Trial 1(PAL) results for Information Management were $M = 2.01$, $SD = 0.63$. Team 2,

Trial 2 (CPOF) results were $M=2.06$, $SD= 0.60$. Overall Mean for information management in the

first trial was $M = 2.08$, $SD = 0.77$, and for the second trial was $M = 1.73$, $SD = 0.64$. This within

subject effect of trial yielded a Wilks' $\lambda = .74$, $F(1,10) = 3.59$, $p =.088$, $\eta^2 = 0.264$, indicating no

significant difference between average Trial 1 and Trial 2 scores at the .05 level.

The interaction between team and trial yielded a Wilks' $\lambda = .68$, $F(1,10) = 4.62$, $p =.057$, $\eta^2$

$= 0.316$. The interaction between team and trial is not statistically significant, indicating there is no

statistically significant difference in the performance of the teams by trial.

Tests of between subjects effects (between Team 1 and Team 2) indicated that there was not

a difference in teams when averaging across the CPOF and PAL means ($F(1,10) = 0.522$, $p= .487$,

$\eta^2 = 0.050$; Team 1 $M = 1.78$, $SE = 0.30$ and Team 2 $M = 2.04$, $SE = 0.25$). Again, despite the lack

of significant differences, one subject indicated, "[PAL is of] great value to combine and share

relevant information."

The fourth study question asked: "Does the Personalized Assistant that Learns (PAL)

improve decision support when compared to the "Command Post of the Future" (CPoF) suite of

collaborative and visualization tools?" This research question is answered by questions 15-18 on the

self-assessment tools survey:

- I gave the commander good staff recommendations when I used CPoF.

- The quality of my staff products was good when I used CPoF.

- CPoF made no difference in the quality of products I was responsible for creating.

- I made good decisions when I used CPoF

Neither team experienced a significant difference between trials, nor was there a significant interaction between trial and team for this variable.  Team 1, Trial 1(CPOF) results for Decision Support were $M = 2.65$, $SD = .36$.  Team 1, Trial 2 (PAL) results were $M = 2.24$, $SD = .55$.  Team 2, Trial 1 (PAL) results for Decision Support are $M = 2.42$, $SD = .61$.  Team 2, Trial 2 (CPOF) results were $M = 2.19$, $SD = .68$.  Overall Mean for decision support in the first trial was $M = 2.53$, $SD = .49$, and for the second trial was $M = 2.21$, $SD = .59$.  This within subject effect of trial yielded a Wilks' $\lambda = .66$, $F(1,10) = 5.06$, $p = .048$, $\eta^2 = 0.336$, indicating a significant difference between average Trial 1 and Trial 2 scores at the .05 level.  Decision support activities were rated significantly more favorably by both teams in the second trial.  This significance would seem to indicate that

The interaction between team and trial yielded a Wilks' $\lambda = .96$, $F(1,10) = 0.45$, $p = .52$, $\eta^2 = 0.043$.  The interaction between team and trial is not statistically significant, indicating there is no statistically significant difference in the performance of the teams by trial.

Tests of between subjects effects (between Team 1 and Team 2) indicated that there was not a difference in teams when averaging across the CPOF and PAL means ($F(1,10) = .215$, $p = .653$, $\eta^2 = 0.021$; Team 1 $M = 2.45$, $SE = 0.18$ and Team 2 $M = 2.31$, $SE = 0.27$).

This variable provides the only statistically significant finding – the main effect of time for decision support.  Given this significant difference, it is not surprising that one of the trained subject matter expert observers noted the following:

> "With PAL, detailed intelligence was attained more quickly and this allowed the [intelligence officer] to put out intelligence that thwarted enemy actions.  For example, the BCT with PAL was able to stop the bomb attack on the mosque because they got inside the insurgents' planning process.  Insurgents performing reconnaissance on the mosque were detained which foiled the bombing plot.  In contrast, the CPOF role

players were not able to get inside the planning and execution cycle of the insurgents and the mosque was blown up."

The decision to interdict the insurgents was only possible because of the advantage provided by PAL. A comparable team, with access to all the same information and intelligence was not able to match the speed of decision making PAL afforded.

The fifth research question asked: "Does the Personalized Assistant that Learns (PAL) improve environment appreciation when compared to the "Command Post of the Future" (CPoF) suite of collaborative and visualization tools?" This research question is answered by questions 3, 19-21 on the self-assessment tools survey:

- I maintained good situational awareness when I used CPoF

- I was able to anticipate the threat's actions when I used CPoF.

- CPoF was effective in assisting in situational awareness tasks.

- CPOF enabled me to maintain situational awareness.

Neither team experienced a significant difference between trials, nor was there a significant interaction between trial and team for this variable. Team 1, Trial 1(CPOF) results for Environment Appreciation were $M = 2.24$, $SD = 0.75$. Team 1, Trial 2 (PAL) results were $M = 1.74$, $SD = 0.73$. Team 2, Trial 1(PAL) results for Environment Appreciation were M=1.90, SD = 0.55. Team 2, Trial 2 (CPOF) results were M=2.01, SD= 0.67. Overall Mean for environment appreciation in the first trial was $M = 2.07$, $SD = 0.65$, and for the second trial was $M = 1.88$, $SD = 0.68$. This within subject effect of trial yielded a Wilks' $\lambda = .89$, $F(1,10) = 1.23$, $p = .294$, $\eta^2 = 0.109$, indicating no significant difference between average Trial 1 and Trial 2 scoresat the .05 level.

The interaction between team and trial yielded a Wilks' $\lambda = .76$, $F(1,10) = 3.19$, $p = .104$, $\eta^2 = 0.242$. The interaction between team and trial is not statistically significant, indicating there is no statistically significant difference in the performance of the teams by trial.

Tests of between subjects effects (between Team 1 and Team 2) indicated that there was not a difference in teams when averaging across the CPOF and PAL means ($F(1,10) = 0.009$, $p = .927$, $\eta^2 = 0.001$; Team 1 $M = 1.99$, $SE = 0.30$ and Team 2 $M = 1.96$, $SE = 0.25$).

One observer noted that Team 1, while using CPOF, "On storyboards, the [Battle Captain and operations officer] are not adding much to any reports, just cut and paste [who, what, when where and why] from the initial report. No extra thought applied." He added, "The staff seems to be paying attention to [significant activities] and not the other reports that come in. But with the same team using PAL in the second trial, the observer noted, "The Staff and Commander seem to have a better control/ understanding of what the [battalions] are doing during the mission."

So, again, while there was no significant differences in the self-assessments, observers noted differences in appreciation of the environment while Team 1 used PAL.

The sixth research question asked: —Does the Personalized Assistant that Learns (PAL) improve visualization when compared to the —Command Post of the Future (CPoF) suite of collaborative and visualization tools? This research question is answered by questions 11, 12, 22-24 on the self-assessment tools survey:

- PAL-Enhanced CPoF assisted in displaying information rapidly.

- PAL- Enhanced CPoF assisted in displaying information effectively.

- PAL-Enhanced CPOF enabled me to set up work displays that represented the area of operations.

- PAL-Enhanced CPOF assisted in establishing battle boards rapidly for a complex set of operations.

- PAL-Enhanced CPOF assisted in establishing effective battle boards for a complex set of operations.

Neither team experienced a significant difference between trials, nor was there a significant interaction between trial and team for this variable. Team 1, Trial 1(CPOF) results for Visualization were $M = 1.78$, $SD = 0.54$. Team 1, Trial 2 (PAL) results were $M = 1.17$, $SD = 0.41$. Team 2, Trial 1(PAL) results for Visualization were M=1.81, SD = 0.62. Team 2, Trial 2 (CPOF) results were M=1.66, SD= 0.46. Overall Mean for Visualization in the first trial was $M = 1.80$, $SD = 0.55$, and for the second trial was $M = 1.41$, $SD = 0.49$. This within subject effect of trial yielded a Wilks' $\lambda = .69$, $F (1,10) = 4.51$, $p = .060$, $\eta^2 = 0.311$, indicating no significant difference at the .05 level.

The interaction between team and trial yielded a Wilks' $\lambda = .86$, $F(1,10) = 1.64$, $p = .229$, $\eta^2 = 0.141$. The interaction between team and trial is not statistically significant, indicating there is no statistically significant difference in the performance of the teams by trial.

Tests of between subjects effects (between Team 1 and Team 2) indicated that there is not a difference in teams when averaging across the CPOF and PAL means ($F(1,10) = 1.200$, $p= .299$, $\eta^2 = 0.107$; Team 1 $M = 1.48$, $SE = 0.20$ and Team 2 $M = 1.74$, $SE = 0.22$).

Despite the lack of significant differences, several subjects identified PAL's visualization tools as contributory to the highest levels of situation awareness.

The final research question asked: ―Do users of the Personalized Assistant that Learns (PAL) trust the cognitive assistant's autonomy when compared to the ―Command Post of the Future (CPoF) suite of collaborative and visualization tools? This research question is answered by questions 25 and 26 on the self-assessment tools survey:

- PAL-Enhanced CPOF performed function I did not want to happen.

- I had to manually undo or recall PAL-Enhanced CPOF did automatically.

Neither team experienced a significant difference between trials, nor was there a significant interaction between trial and team for this variable. Team 1, Trial 1(CPOF) results for Trust were $M = 1.77$, $SD = 0.69$. Team 1, Trial 2 (PAL) results were $M = 1.42$, $SD = 0.65$. Team 2, Trial 1(PAL) results for Trust were M=1.81, SD = 0.89. Team 2, Trial 2 (CPOF) results were M=1.56, SD= 0.59. Overall Mean for Trust in the first trial was $M = 1.79$, $SD = 0.76$, and for the second trial was $M = 1.49$, $SD = 0.60$. This within subject effect of trial yielded a Wilks' $\lambda = .77$, $F(1,10) = 3.07$, $p = .110$, $\eta^2 = 0.235$, indicating no significant difference between Trial 1 and Trial 2 scores at the .05 level.

The interaction between team and trial yielded a Wilks' $\lambda = .99$, $F(1,10) = 0.078$, $p = .786$, $\eta^2 = 0.008$. The interaction between team and trial is not statistically significant, indicating there is no statistically significant difference in the performance of the teams by trial.

Tests of between subjects effects (between Team 1 and Team 2) indicated that there was not a difference in teams when averaging across the CPOF and PAL means ($F(1,10) = 0.049$, $p= .814$, $\eta^2 = 0.006$; Team 1 $M = 1.55$, $SE = .27$ and Team 2 $M = 1.69$, $SE = .30$).

The next portion of this chapter addresses the three remaining variables that were assessed to determine objectively teams' situation awareness. Unlike all the previous data which were self-assessments, these scores reflect the results of external analysis. They are represented in Table 4-2 for Situation Awareness Quiz Scores and Table 4-3 as Speed and Quality. The scores are aggregated by team and by condition (CPOF or PAL). Note in Table 4-2 higher mean scores indicate greater awareness and in Table 4-3, higher mean scores for quality assessment

indicate greater situation awareness, and lower mean times equate to faster product submission. One of the seven situation awareness quizzes is at Appendix D.

Team 1's quiz scores rose nearly 10% (60 to 65.5) while Team 2's scores rose more than 20% from 59 points to 71. In both cases, scores improved, but for neither team was this difference significant (Table 4.2).

*Table 4-2*
Table of Means (M) and Standard Deviation (SD): Situation Awareness Quizzes

| Team/ Condition | Team 1 | Team 2 |
|---|---|---|
| PAL | **M=65.47** | **M=70.92** |
| | SD=5.52 | SD=11.23 |
| CPOF | **M=60.00** | **M=58.93** |
| | SD=16.63 | SD=4.87 |

*= Higher scores indicate greater situation awareness

Neither team experienced a significant difference between trials, nor was there a significant interaction between trial and team for this variable. Team 1, Trial 1(CPOF) results for Situational Awareness Quizzes were $M = 60.00$, $SD = 16.63$. Team 1, Trial 2 (PAL) results were $M = 65.47$, $SD = 5.52$. Team 2, Trial 1(PAL) results for Situational Awareness Quizzes were $M = 70.92$, $SD = 11.23$. Team 2, Trial 2 (CPOF) results were $M = 58.93$, $SD = 4.87$. Overall Mean for Situational Awareness Quizzes in the first trial was $M = 65.46$, $SD = 14.68$, and for the second trial was $M = 62.20$, $SD = 6.03$. This within subject effect of trial yielded a Wilks' $\lambda = .94$, $F (1,10) = 4.43$, $p = .45$, $\eta^2 = 0.058$, indicating no significant difference between average Trial 1 and Trial 2 scores at the .05 level.

The interaction between team and trial yielded a Wilks' $\lambda = .69$, $F (1,10) = 4.43$, $p = .062$, $\eta^2 = 0.307$. The interaction between team and trial is not statistically significant, indicating there is no statistically significant difference in the performance of the teams by trial.

Tests of between subjects effects (between Team 1 and Team 2) indicated that there was not a difference in teams when averaging across the CPOF and PAL means ($F(1,10) = 0.23$, $p= .642$, $\eta^2 = 0.022$; Team 1 $M = 62.74$, $SE = 4.52$ and Team 2 $M = 64.93$, $SE = 3.29$).

None of the improvements identified in Table 4-2 are significant. Yet both subjects and observers commented on improved appreciation of the situation while using PAL. This attitude was also reflected in the post-hoc survey detailed below.

In the ensuing table (Table 4-3), speed and quality scores are aggregated by Team. For this research, only the means will be compared – additional analysis will be left to future study. The significant value, as highlighted in Chapter 2, is the team or "shared" situation awareness scores and those are the ones compared here.

In all cases, the team in the treatment group fared better – in higher demonstrated quality of storyboards submitted (as determined by subject matter experts employing a vetted rating scale) – and in the lower time it took to submit storyboards for significant activities. Behaviorally Anchored Rating Scale grading sheets and the Scenario-based cognitive assessment tool – which were used to score the quality assessments – are at Appendix G.

Team 1 improved its time of submission for storyboards by about 26 seconds with PAL, or 4.3%, while Team 2 improved its time by more than one minute, 11.67%. These scores were also more consistent as evidenced by their standard deviation decreasing from M=6:16 to M=2:34 for Team 1 and from 5:27 to 3:55 for Team 2.

In the final measurement, quality of the submitted products, both teams benefitted from PAL, with Team 2 increasing quality of submitted products by 15.83% (from M=2.50 to M=3.00) and Team 1 increasing its quality of submissions by 8.59% M2.56 to M=2.78). (Table 4-16). Because

when measuring shared situation awareness in this study n=2, no further analysis was conducted

beyond comparing means.

*Table 4-3*

Table of Means: Results of the speed and quality of submitted products

| Dependent Variable | Speed 1# | Quality 1 | Speed 2 | Quality 2 |
|---|---|---|---|---|
| CPoF | M=10:00 | M=2.50 | M=10:01** | M=2.56* |
| | SD=5:27 | SD=0.69 | SD=6:16 | SD=0.96 |
| PAL | M=9:37 | M=2.78 | M=8:50 | M=3.00 |
| | SD=3:55 | SD=0.51 | SD=2:34 | SD=1.10 |

*= Higher scores indicate more favorable assessment
** = Lower time is favored, in minutes:seconds

**Additional Findings**

The last section of this chapter addresses results captured in the post hoc, comparative

survey in which role players chose between the two systems, feedback gathered from post-trial

discussions and written comments on survey instruments. These measures offer corroboration

and support to the data above.  These findings help amplify the data above, and in some cases,

highlight specific aspects of the research objective. The data analysis above provides some

evidence of the objective variables, and the key ideas evoked in discussion augment and refine

those findings.  This discussion is continued in Chapter 5.

The post hoc survey consisted of 24 questions with answers along a 5-point Likerd Scale,

similar to the tools self-assessment surveys discussed previously (Appendix E, Surveys A and

B).  It was constructed similarly to the preceding self-assessment surveys, but allowed for the

direct comparison between the two command and control systems (Survey C, Appendix E). For

example, in the self-assessment surveys during the trials, questions were worded like, "CPoF (or

PAL-Enhanced CPOF) made organizing routine tasks *easy*." In the survey administered after both teams had a chance to use both systems, questions read like this instead, "PAL Enhanced CPoF made organizing routine tasks *easier* than using CPOF alone." This survey was administered to offer the researcher a gauge of validity and reliability of the self-assessment surveys. Scores from the *self-assessment surveys* consistently indicated a preference for PAL in Team 1, but were not consistent for Team 2, and there were no significant differences between the teams. This post hoc survey was one more way – in addition to the three separate tests of situation analysis quizzes, quality and speed of submission – to provide insight to the self assessment numbers.

The post hoc survey results indicated users had considerably higher satisfaction in the treatment group. In fact, nearly 50% of all responses (143 of 288) agreed most strongly with the questions that PAL was favored in all aspects of operation, and fully 85% (244 of 288) strongly agreed or somewhat agreed that PAL was favored. This is clear confirmation that the users, given the opportunity to compare the two systems after experimenting for four days with a full spectrum operations scenario, chose PAL. Table 4-17 shows questions and mean scores across the 12 participants. For this survey, taken once by all 12 participants, $M = 1.73$ and $SD = 0.86$. This result reflects considerable satisfaction with PAL among the subjects. Apparent incongruities between this survey and the other self assessments will be discussed in the next Chapter.

*Table 4-4*
Table of Means, Post Hoc Survey Results

| Question | Mean |
| --- | --- |
| -PAL made organizing routine tasks easier than using CPOF alone. | 1.50 |
| -Using PAL made no difference in the quantity of tasks I was able | |

| | |
|---|---|
| to handle than when I used CPOF alone (score inverted to remain consistent) | 1.75 |
| -PAL was more effective in assisting in planning tasks than using CPOF alone. | 2.08 |
| -PAL was more effective in assisting in execution tasks than using CPOF alone. | 1.33 |
| -PAL enabled me to complete <u>more</u> tasks than when I used CPOF alone. | 1.67 |
| -PAL enabled me to complete a <u>broader variety</u> of tasks than when I used CPOF alone. | 1.67 |
| -PAL e to complete a <u>more complex set of tasks</u> than when I used CPOF alone. | 1.67 |
| -PAL assisted in collecting information more rapidly than using CPOF alone. | 1.58 |
| -PAL assisted in collecting information more effectively than using CPOF alone. | 1.67 |
| -PAL assisted you in displaying information more rapidly than using CPOF alone. | 1.33 |
| -PAL assisted in displaying information more effectively than using CPOF alone. | 1.58 |
| -PAL improved my ability to get information from other sources better than using CPOF alone. | 1.83 |
| -PAL enabled me to focus on and understand key information better than using CPOF alone. | 1.58 |
| -I gave the commander better staff recommendations when I used PAL than using CPOF alone. | 1.75 |
| -The quality of my staff products was better when I used PAL than when I used CPOF alone. | 1.92 |
| -Using PAL made no difference in the quality of products I was responsible for than when I used CPOF alone (score inverted to remain consistent) | 2.33 |
| -I made better decisions when I used PAL than using CPOF alone. | 2.08 |
| -I was able to anticipate the threat's actions when I used PAL than when I used CPOF alone. | 2.17 |
| **-**I was able to more accurately anticipate the threat's actions when I used PAL than when I used CPOF alone. | 2.08 |
| - I had better situational awareness when I used PAL than when I used CPOF alone. | 1.92 |
| -PAL helped me maintain better situational awareness than using CPOF alone. | 1.67 |
| -PAL enabled me to set up work displays that represented the area of operations better than using CPOF alone. | 1.50 |
| -PAL assisted in establishing battle boards rapidly for a complex set of operations better than using CPOF alone. | 1.42 |
| -PAL assisted in establishing effective battle boards for a complex set of operations better than using CPOF alone. | 1.33 |
| | Mean = 1.73 |
| | SD= 0.8622 |

The researcher treats these results differently than the other surveys because the questions were directed propositions (questions asked users to agree or disagree with propositions that PAL made tasks easier, or more efficient, etc.).  But as a complementary source of input from the role players, it provides insight to the research.

## Discussion

The results of this research are mixed as to the improvements to situation awareness gained by incorporating an automated cognitive assistant into existing command and control systems.  Self assessment scores do not indicate a significant difference between the two systems, but written and oral feedback throughout the trials and post hoc responses suggest that teams are modestly faster, produce products and decisions of higher quality and sustain a

slightly, though not significantly, higher situational awareness. Additionally, when given a direct choice between the two systems, the subjects overwhelmingly opted for PAL. There is a positive effect on situational awareness as a result of integration of PAL with CPOF, albeit not one that is statistically significant. A more thorough discussion of these insights will continue in Chapter 5.

### Conclusions

The evaluation described in this study was designed to measure whether situation awareness – measured by six specific elements relating to command and control systems – is improved by adding an automated cognitive assistant to that existing command and control system. The self assessment survey results indicate that a cognitive assistant (the Personalized Assistant that Learns) did not improve situation awareness significantly for a representative brigade-level team operating in a complex, full-spectrum operations scenario. However, three separate, objective measurements of situational awareness, including multiple choice quizzes and the speed of submission of required products, and quality of decisions and decision making products, all indicated modest improvements to situational awareness across the teams, trials and conditions. This discussion will also continue in the ensuing chapter.

# CHAPTER 5
## CONCLUSIONS AND RECOMMENDATIONS

> At any time or place, executive judgment involves answering three sets of questions: What is going on?"; "So what?" (Or, "What difference does it make?"): and "What is to be done?" The better the process of executive judgment, the more it involves asking the questions again and again, not in set order, and testing the results until one finds a satisfactory answer to the third question....
>
> (May, 2000, p. 458)

This study investigated the effect that the Command Post of the Future (CPOF) command and control system enhanced with a Personalized Assistant that Learns (PAL) had on several dimensions of situational awareness. A 26-question self-assessment survey, administered to the 12 subjects at seven separate times during the four-day test, found no statistically significant difference between the team using CPOF and the team with PAL-enhanced CPOF. However, descriptive statistics suggest that leaders that used the PAL-enhanced CPOF were more efficient and provided decision makers with richer, more detailed reports. Objective measurement of descriptive statistics of situational awareness in the form of seven different quiz instruments found that this cohort of active and retired military officers using the PAL-enhanced CPOF had better overall situational awareness than officers who used CPOF alone.

This study had tested the hypothesis that the use of automated cognitive assistants in a brigade combat team command and control system could improve situational awareness.

The analysis of data in the previous chapter confirms this primary hypothesis, albeit in a qualified manner. In this chapter, the researcher presents overall study conclusions, suggestions for additional research and the implications of cognitive assistants on command and control. This chapter will revisit limitations of the study, initially outlined in the methods chapter, adjusted for the learning about them that took place during the trials.

This chapter contains the following sections: general recommendations; summary of the data collected and analyzed in the findings chapter regarding shared situational awareness of the two teams; recommendations for future study; and limitations of the study. Discussion is focused on answers to the research questions. The summary of the findings contains the conclusions and implications of the study.

This research helps illuminate a path toward the introduction to cognitive assistants, and perhaps even more complex artificial intelligence agents, into military command and control systems, as well as other activities that would benefit from a reduction in cognitive load. It should advance the idea that there is a place for this technology within headquarters, be they military, business, or other government agencies. In order for our military, and potentially, these other organizations and agencies, to succeed in the complex operating environments they all operate in today and will in the future, exploiting technologies that offer a promise of reducing complexity must be part of the strategy. We must indeed work smarter, not harder.

This research and these results do not portray PAL as a miracle cure or "silver bullet" for situation awareness, rather the modest improvements PAL exhibits over CPOF reflect the state-of-the-art – both in terms of current command and control systems in use throughout the Army and the introduction of automated cognitive assistants. PAL demonstrated clearly, if not overwhelmingly, there is a place for artificial intelligence agents in command and control, but as the following paragraphs will discuss, the integration of this technology will need to overcome some shortcomings, and should consider some additional features.

## General Recommendations

PAL is an effective assistant to brigade staff officers and non-commissioned officers. This is a technology that should be considered for implementation Army-wide. Considering the

prototype nature of this cognitive assistant, the handful of shortcomings identified should be remedied in short order, much the same as the product was modified over the course of the training process for the role players. Based on the data collected and analyzed in the previous chapter, and complemented by the comments offered by the subjects and expert observers brought forth in this chapter, PAL offers greater situation awareness at lower cognitive loads and should be integrated into the Army command and control acquisition process. However, there are several small issues that should be pursued to make the product more effective and easier to integrate into high operations tempo organizations.

While not highlighted by this report, PAL has some shortcomings that warrant mention in this section to lead to improvement of this cognitive assistant in this application. First, the training required to make a staff officer competent to use PAL is excessive. Battle Lab users spent weeks focused on PAL proficiency. While it should be noted that few of these participants were accomplished CPOF users prior to the beginning of training, most were at least familiar with the basic operation and approximately half assessed their familiarity with CPOF as average or above, and nearly 40% assessed their PAL familiarity similarly. If training on this technology is so tough that it takes average users weeks to become marginally proficient, this tool needs work on its user interface. Some features of PAL (e.g. an e-mail application), considered to be outside the scope of this research, would have been unlikely subjects of study given the additional time that would have been required to gain proficiency in those features as well. Consideration should be made to simplify the user interfaces to speed PAL's integration into organizations.

Secondly, the PAL to the Web-Based, Temporal Analysis System (WebTAS) interface must be improved to allow smoother sharing of products identified in the database. (As executed

during the trials, products found by searching the database through WebTAS were only available to the remainder of the staff by a painstaking process of converting files to a usable format, placing them within a presentation and transferring the presentation from the WebTAS analyst's station to the remainder of the staff.)  Since the remainder of the staff all operates on real time updates through CPOF, a "snapshot" briefing introduces information latency to the rest of the staff's information.

Given the complexity of the automated assistant and the thoroughness of the assessment conducted throughout the training and evaluation events, these two concerns warrant mention only to improve an already effective tool.  This study identified these shortcomings, but focused on the impact PAL had on situation awareness; the proceedings are summarized below, after a few suggestions for enhancements to PAL.

As a collaborative tool, CPOF relies on common voice over internet protocol (VOIP) communications and common displays that maintain a near-real time common operational picture.  Despite this impressive complement of features, new information or icons can get lost on a cluttered computer screen. There is no "inbox" on CPOF.  There are clearly times when a battle captain needs to ensure certain people or functions see new information immediately. When that individual is at his or her workstation and attention is undivided, the current system works adequately.  But neither call on the VOIP system nor the posting of a new icon on the common picture lingers were that recipient to be away from his/her workstation or engrossed in another activity.  During the train-up period for the trials, PAL technicians devised a clunky system that incorporated existing features of CPOF to facilitate an e-mail-like capability.  As development of this technology continues, creation of an e-mail system with the look and feel of

a common webmail program is a necessary improvement to ensure information can be directed to specific users or groups of users.

A second improvement is to develop an interface between the 3-dimensional view of CPOF and PAL. At the time of the testing, PAL was not compatible with the 3-D functions of CPOF. This would not be a significant issue except that the graphical drawing tools associated with the 3-D function are more powerful and easier to use than those that work on the 2-D screens. This should be a simple enhancement that would make PAL considerably easier to use with CPOF.

Additionally, the development of PAL should continue henceforth with greater feedback from fielded forces or those who have recently returned. Insights gained in combat and stability operations can assist the development of features this test did not investigate.

These few improvements are suggested as potential enhancements to PAL, based on the months of training and the tests themselves. As with the limitations of the software, these enhancements would merely make a very good system that much better. As this research focused on the system, it is worth the review of the research and findings.

Chapter 1 offered an introduction to the complexity of the environment faced by our deployed military forces today, and offered a glimpse into a specific technology solution that attempts to reduce the difficulty of compiling, visualizing and sharing large volumes of information in various forms. It would take little imagination to consider the application of cognitive assistants into other professions, from emergency management, to medicine, to education. In fact, any work involving significant redundant or monitoring tasks would be a good candidate for cognitive assistants that could reduce cognitive load among leaders and decision makers.

As discussed in Chapter 2, our short term memories can only juggle a limited number of bits of information at any one time, but that the bits themselves can be highly complex (Miller, 1956). One way to allow our minds to "chunk" these bits in our working memory is by reducing the complexity of the intrinsic load (Sweller, 1988). Among the ways to do this is to eliminate extraneous loads – those things that serve only to hinder learning. PAL offers a means of mitigating extraneous loads by automating processes that a human mind no longer has to keep in working memory. Ultimately, this research validates that using automated cognitive assistant such as PAL can indeed reduce that extraneous load.

But PAL must also facilitate sharing or collaboration within the staff to improve the shared situation awareness of the team (Nofi, 2000). And through its task management, information management and visualization aspects, it does. With these thoughts in mind, let us briefly review the findings of the last chapter.

### Summary of the data collected and analyzed in the findings chapter

Quantitative data collected from the self-assessments focused on six components of situation awareness: task management, information management, perception of environment appreciation, decision support, visualization, and user trust, as well as the overall self-assessment scores. Descriptive statistics suggest improvement in situational awareness, as well as improved speed, quality and objective situation awareness quiz scores on both teams.

Comments provided by the subjects bolster the descriptive statistical findings. The data from interviews and post hoc discussions has bolstered the quantitative findings with specific, effective aspects of PAL.

Supporting data is contained in the transcripts of interviews conducted after the trials and the written comments provided on surveys throughout the experiment. Discussions of the task management features elicited these comments from the role players:

- It automatically does multi-step procedures saving time and improving accuracy.

- I'm a big believer in CPOF, but as the [operations tempo] increases, I turn into more of an event processor than concerned with quality of the products.

- Accuracy, PAL allows all tasks to be done. Again, it's not the time thing but the accuracy.

These comments reinforce the assertion that PAL's ability to handle tasks quickly and accurately has measurable impacts on situation awareness. Additionally, users felt that the more complex the situation, the more PAL had to offer.

On the subject of information management, one role player shared comments on the specific value of how PAL's information management tools facilitated better situation awareness, "by collaboratively sharing information real time, situational awareness was increased making decision making much more rapid." One role player said, "[PAL is of] great value to combine and share relevant information." Another added, "Got reports on map and screens before voice reports, able to start analysis." And another, "Collaborative sharing information reduces forwarding time between headquarters." Finally, "…very powerful tool – excellent intelligence." In a few short comments, users describe the value for virtually all the subscales. Most significant is the union of "relevant information," "collaborative sharing," and [rapid] "decision making."

Regarding decision support, the quotation provided in the preceding chapter provides fidelity to the advantages of PAL in decision making. Made by one of the expert observers, the

quotation indicated that the PAL team gained appreciation of the environment quickly enough to thwart an enemy plot that was not interdicted by the CPOF team, despite having access to precisely the same information. Additionally, the observer continued, "With PAL, the [brigade combat team (BCT)] staff role players were able to draw more linkages between insurgents plotting to blow up the mosque compared to CPOF BCT staff role players."

In the area of environment appreciation, PAL also got high praise from the subjects:

- You can see more of the situation in every warfighting function

- Very great value to help assemble relevant information of events and personnel for analysis and situational awareness

- [Intel Officer and analyst] had time to do analysis during the execution of the mission.

- By collaboratively sharing information real time, situational awareness was increased making decision making much more rapid

Of significance is the appreciation of the need to analyze aspects of the environment for context even while executing operations. This supports Endsley (1995a) and Hjelmfelt and Pokrant (1998) regarding the volatile nature of situation awareness.

On the subject of visualization and the value of PAL's ability to assist setting up one's digital workspace one user wrote, "[PAL] Permitted me to achieve [situational understanding] quicker." Other comments included:

- Once I had it down where info was located it was very easy to get info to anticipate the next step/event.

- Started to make connections and pull them together for analysis.

- Great value as the battlefield picture is depicted and trends are identified.

- PAL can build products that are understood, familiar and acknowledged by all users.

- Great value to ensure extremely accurate situational understanding.

- Good for collaboration among staff sections and war gaming too.

These comments amplify the value of the visualization provided by PAL that created standardized battle boards quickly and accurately and to begin to reach into level three situation awareness, anticipation.

On the issue of trust, the results were essentially even. Overall the PAL team recorded slightly better trust scores than the CPOF team. Role players struggled at times with triggers that "fired" PAL procedures at incorrect or inopportune times. However, the overall trust scores were the most consistent, high scores of all the subscales, indicating that users largely trusted both systems. The comments regarding "trigger" firing should be considered for future experimentation with PAL.

Some of the most telling comments were in the area of how PAL improved the speed of handling the operations:

- Speed measurably increased

- [PAL is of] great value to reduce time required to access info and knowledge

- Speed gives time for greater and deeper understanding

- [PAL] allowed me to assess the meaning of the information faster

- [PAL] greatly reduced the time to access and share great volumes of information

- I was able to build boards in 20 seconds that would take 5 minutes from scratch. It automatically moved efforts, etc. that I would have had to take time to check.

- [PAL] rapidly developed needed products

Several trends emerged from the post hoc survey and discussions. Most notably, all role players remarked about the value of PAL in terms of automating routine tasks, freeing time to

allow one to focus on the most important information, and contributing to better decision making by improving situation awareness and reducing cognitive load.

*Overall Situation Awareness*

The experimental data collected supported the research hypotheses. Quantitative analysis supports a conclusion that when enabled with PAL, the brigade combat teams (BCT) were better postured to gain knowledge of current enemy and friendly operations significantly faster and more accurately than their non-PAL counterparts. Analysis of the descriptive statistics reflects that the teams believed they were processing more refined information when the BCT was using PAL. The subjects consistently indicated that PAL afforded them more time and easier access to existing information. The technological advantage of PAL enabled the staff to develop a deeper appreciation of the environment by linking (apparently unrelated) enemy activity. Additionally, the PAL team routinely enjoyed automatic notification of significant events that met the significant activity (SIGACT) criteria, speeding the process of responding on the ground and reporting to higher headquarters.

Furthermore, descriptive statistics support the conclusion that when enabled with PAL, the teams were able to achieve a higher level of situation awareness, specifically, Endsley's third level, "projection" (or "situational understanding" in Army manuals). Teams were better postured to analyze available data and make better decisions in mission planning and execution. Analysis of the survey mean scores reflects that the teams felt they had a better understanding of the operational picture and the enemy's objectives when their unit was using PAL. The technology of PAL enabled the staff to quickly make sense of and share friendly and enemy information between and among higher and lower echelons.

The descriptive statistics defining the results of the situation awareness quizzes also indicated improvements among the teams. Improvements were measured at 10-20% for the two teams. The quiz scores for situation awareness can be compared with the self-assessments to corroborate those scores objectively. There was, however, no significant difference for either team.

A quick review of conclusions regarding of the various aspects of situation awareness is warranted.

*Task Management*

Experimental data confirmed improvements to task management with the use of the cognitive assistant. Because PAL automated requirements from establishing "battle boards" (work spaces) to generating and sending reports to higher headquarters, teams functioned more efficiently and effectively while using PAL. As evidenced in the findings chapter, speed of report submission increased with PAL and the quality of the products submitted also improved. Role players attributed gains in both realms to how PAL allowed them to handle all tasks accurately.

Analysis of the descriptive statistics and post hoc interviews reflects that users felt they managed tasks better with PAL and with the burden of repetitive tasks lightened, they benefitted with greater situation awareness. PAL enabled the staff to be organized and focused on the most important information. One role player, who had recently returned from a tour in Iraq where CPOF was used exclusively for automated command and control offered, "PAL could be an incredibly powerful tool for Tactical Operations Center operations. It has the potential to save countless man-hours by performing routine, repetitive tasks... Those man-hours could then be

reallocated to other tasks … or even free up Soldiers to conduct combat operations." However, on the self-assessment, this difference was not significant for either team.

*Information Management*

Experimental data also identified improvements to information management with the use of the cognitive assistant. Role players spoke of knowing how to retrieve important information or having it at hand routinely with PAL. PAL was able to associate information in various databases that comparable users without PAL did not. The ability to share information and collaborate more quickly improved the teams' shared situation awareness. Subjects pointed to the rapid collaboration as a key component to improved situation awareness across the team.

Analysis of the descriptive statistics (including the post hoc survey means) reflects that the teams felt they managed information better with PAL and shared information more freely and timely. PAL enabled the staff to focus on, and share, the most important information. However, on the self-assessment, this difference was not significant for either team.

*Decision Support*

Experimental data collected confirmed that rich, detailed information was available for analysis more quickly with PAL, leading to better decisions. In both trials, the PAL team interdicted an enemy operation by making decisions faster than the enemy's ability to execute (Boyd, 1986). In the first trial, the PAL team located information regarding enemy capabilities at a proposed helicopter landing site. This discovery led to renewed planning for this "air assault" mission that would have been threatened by enemy air defense weapons on the objective. In the second trial, the PAL team connected individuals to a planned mosque bombing during a religious pilgrimage. In this instance, the bomb-plotters were apprehended before completing their mission. In both cases, friendly actions taken by the PAL teams mitigated or eliminated the threat. CPOF teams faced with the same information and missions were not able to identify the

threat and in each case suffered negative consequences; in each case, (simulated) friendly casualties were avoided because of decisions made plain by the PAL-assisted analysis.

PAL supports decision making by linking disparate bits of information itself as well as allowing users more time to reflect on and analyze the information before them by eliminating or reducing redundant requirements. Analysis of the descriptive statistics and other data reflects that the teams felt they supported decision making better with PAL. PAL enabled the staff to find, analyze and reflect upon information from multiple sources. However, these differences were not significant for either team.

*Visualization*

Experimental data collected indicted that PAL's capability to establish battle boards instantly led to faster achievement of situation awareness. Not only was the PAL team able to more quickly develop visual representations for a common operational picture, but also to form the basis of story boards to report significant activities to higher headquarters. PAL contributed to war gaming, an important step in the Military Decision making Process (Appendix F), by allowing staff officers to automate analysis and status tracking within their function. Several subjects identified PAL's visualization tools as contributory to the highest levels of situation awareness.

Analysis of the data reflects that the teams felt they could better visualize the operational environment with PAL. PAL enabled the staff to establish quickly and share visual information as well as track data to maintain a common operational picture and current appreciation of the situation. On the self-assessment, this difference was not significant for either team.

*User Trust*

Experimental data collected on user trust confirmed that users trusted both PAL and CPOF. Descriptive statistics across both teams reflected a high degree of confidence that

command and control systems would perform those tasks the user directed and only those tasks. In fact, both systems received consistently high marks for trust, indicating that both command and control systems generally perform as expected. This variable warrants further, more focused study in the future, perhaps using a broader range of questions.

*Speed of Product Submission*

Descriptive statistics collected validated that PAL team products were submitted more quickly than those generated in a CPOF team. The ability to complete more required staff actions was defined as submission of military decision making process products including Warning Orders (WARNOs), Fragmentary Orders (FRAGOs), planning boards and storyboards produced for significant activities. The overwhelming majority of products reviewed were the latter. Prior to the trials, higher headquarters orders products and predetermined scenario events were created by a separate team within the Battle Lab. These products were not seen by the subjects until they were issued to both teams simultaneously during the trials.

The teams' ability to produce the number of products expected was measured by an automatic tracking system programmed into the command and control system server. Observations of the teams while using CPOF indicated that the pace of routine tasks challenged the team to the point they rarely committed intellectual effort to ongoing and upcoming missions. Just keeping up with activities was much as they could handle. When enabled with PAL, the teams handled routine actions routinely, and had time to focus attention on issues that required commander and staff attention. The speed and efficiency that PAL facilitated left more time to analyze information, plan and make timely, sound decisions.

Analysis of the submission time descriptive statistics reflects that the teams produced products more quickly with PAL. Additionally, teams were more consistent (time-wise) producing the required products, evidenced by the lower standard deviation.

*Quality of Products Submitted*

The descriptive statistics collected validated that products submitted by the PAL teams were of higher quality than those submitted by the CPOF teams.  Although speed was measured separately, quality and speed are inextricably linked.  Fast products are of limited utility if not of a quality that facilitates good decision making and accurate status reporting.  And products of high quality are not helpful unless submitted rapidly enough to influence upcoming operations.  The Battle Lab used quality assessment tools that were based on behaviorally anchored rating scales and a scenario based cognitive assessment tool (Appendix G), which were used to measure the quality of all products produced.  The products submitted by the PAL teams – including planning boards and storyboards produced for significant activities – were deemed by a panel of experts to have consistently higher quality than those produced by the CPOF teams.  Furthermore, orders and guidance provided to subordinate units were more complete and contained more detail than the orders produced without PAL.

## Implications

The Army faces complex challenges daily, both as it fights wars in two separate theaters abroad and as it trains leaders to succeed.  To be prepared and effective for the future, it is wise for the Army to seek and adopt technologies that can reduce cognitive load, improve situation awareness or decrease the amount of time required to identify and act on emerging threats. It is important that thorough research be conducted on proposed technologies to test hypotheses and claims and to evolve these technologies into worthwhile and effective tools for soldiers.

Considering this discussion, it is important to derive the impacts and benefits of this research.  Clearly, the Army benefits from this research.  It contributes not only to the body of knowledge on shared situation awareness, but also on the impact of cognitive assistant technologies on it.  But cognitive assistant technologies will not only impact the Army or

military, it is believed that they can be generalized across diverse professions, including law enforcement, Homeland Security and potentially, education. Given the constructivist nature of situation awareness, and how cognitive assistants help build and maintain this awareness by reducing cognitive load, the disciplines that could benefit from this type of treatment are broad and varied.

Based on the trends observed in Chapter 4, PAL or a similar cognitive assistant could be used to enhance the capability of all Army command and control systems, as a method of decreasing cognitive load and improving staff performance. In Chapter 1, research questions focused on determining the impact of cognitive assistants on the situation awareness of representative brigade combat team staffs in a complex scenario, full of uncertainty, fast-tempo operations and reporting requirements. By allowing participants to focus on the most important information confronting them (the germane load), and alleviating the redundant, extraneous load, awareness increased and better decisions resulted.

Participant interviews confirmed the perceived improvements of PAL. By automating the redundant tasks, participants focused on deeper level inquiry, and it resulted in better performance in the areas measured in this research. Artman & Garbis (1998) suggest that measurement of team (shared) situation awareness is best done by assessing by more than one method and comparing results. This research did precisely that and the results favored the treatment group when all measures of analysis are included.

Although most of the implications of this research have been discussed, some questions remain, such as: What additional research should be done to further clarify or amplify the findings of this study? How can this research be generalized into other disciplines? What improvements to cognitive assistants will improve performance?

**Recommendations for Future Study**

This research focused on, and the research methodology was appropriate for, shared situation awareness within a brigade staff, and how that awareness is impacted by the application of an automated cognitive assistant. Since this test used replicated staffs, representing only a fraction of the members of an actual brigade staff, future study using more subjects would serve to inform these hypotheses more fully. Additionally, descriptive statistics consistently favor the treatment, but no statistical significance could be proven. Significance could conceivably be found in the larger sample sizes these additional subjects would represent.

Additionally, study of the introduction of cognitive assistants in other echelons of military command, particularly the division level, is appropriate to explore the differences in the application of these technologies at other, more diverse, organizations. Along those lines, the application of cognitive assistants should not be limited solely to military use; indeed, experimentation of these technologies in emergency response systems, and other government and civilian applications should be forthcoming. In order to apply these technologies in other milieus, the cognitive assessment tools would have to be amended to be appropriate in the new venues, as the extraneous loads presented in each discipline would likely vary. Yet PAL's ability to learn what situations to monitor or which tasks to conduct would make it a ready, useful tool for these excursions. Further refinement of these tools used in follow-on research could assist that effort.

Future study of cognitive assistants should parallel the improvements to the associated technologies, such as the Web-Based Temporal Analysis System (WebTAS) and the Command Post of the Future (CPOF) to ensure that as command and control technology advances, additional cognitive assistance is factored in. Additionally, use of these technologies in a real-world database, rather than a contrivance for experimentation, could more fully test the

capabilities of PAL. Several of the subjects stated that they expected that PAL's advantages over CPOF would be amplified in a higher complexity (near real world) scenario, as the number of activities required of the participants would increase exponentially.

The level of familiarity with the command and control tools among the staffs was inconsistent. This remained despite weeks of training and hours with them during the trials. Additional study might be warranted to determine if the use of cognitive assistants has a more or less pronounced effect on novice users. One of the subjects stated that he felt that PAL's advantages over CPOF would also be amplified in groups of expert CPOF (and PAL) users, as the individual's employing PAL would better appreciate the power of the tools and would devise methods to reduce redundant requirements by teaching PAL to execute those tasks.

Future research should focus on the order of the treatments as well. While there was not an order effect found in this research, using PAL after working with CPOF and vice versa, could affect outcomes. Additionally, there is some speculation that the transition from CPOF to the enhanced PAL is less difficult, or perhaps less frustrating than the reverse order, which might have led to mixed self-assessment scores on Team 2, the team that used PAL in the first trial.

Additional research could also focus on how cognitive assistants could be developed through a cooperative program within the Army experimentation community of practice, to ensure the various equities of each member of the community gets represented. The community would bring in new ideas and can draw from the experience of officers and developers alike.

Interesting data that has not been analyzed in this study includes the implications of cognitive assistants by job position within the headquarters, and the type of activities being conducted. Does a certain function (e.g. intelligence or logistics) benefit more or less from these technologies? Does PAL better support operations than planning? The answer to these

questions will help mold the future developments and integration of cognitive assistants into command and control systems.

## Limitations of the Study

The limitations of this study were addressed initially in the methods chapter and are only reiterated here as informed by the findings.

The Command Post of the Future, and the system enhanced with the automated cognitive assistant, PAL, received consistently high scores from all users throughout the trials. High user satisfaction with both tools likely contributed to the lack of significance found between the systems. Simply put, CPOF is a worthy opponent, a battle-tested system that has seen several iterations of improvements based on feedback from deployed forces since its deployment in 2004. It proved to be a highly trusted system as well, and might have limited the users' acceptance of the new application. CPOF is a reliable, effective collaborative and visualization tool itself. Comparing PAL to CPOF impacted the measurable difference between the two systems. As far as a rigorous examination was concerned, this was clearly a test of two capable systems, and this examination required much of the challenger.

Generalization is still considered a limitation given the many unique aspects of this experiment. The tactical focus of the problem and the significant military experience of the subjects would likely affect outcomes given other problem sets and participants. However, given the nature of this technology, it seems reasonable to expect that cognitive assistants for people in other types of work with those experiences and problem sets would offer similar benefits to efficiency. The limited number of subjects in this research could also limit its general application, and very likely contributed to the lack of statistically significant findings.

Technical limitations – CPOFs in actual brigade combat teams in Iraq and Afghanistan are routinely in different locations throughout the BCT headquarters, not adjacent to one another as in the trials. Several of the interviewees indicated that a level of complexity would be introduced simply be separating participants physically. This better representation of a modern command post would also more fully tax the visualization and collaborative functions of the technologies. That said, participants were instructed to conduct all business through the collaborative tools and observers noted that most information did indeed pass among staff members via CPOF and PAL.

Using a contrived scenario, which is to say one that was not supported by real world data sets, limited the amount of data the subjects were required to analyze prior to making decisions. While this fact might have reduced the environment to a level of complexity much less than it is in actuality, there is still a feeling that the cognitive assistant would prove to be of more value as complexity increased. While the level of complexity had to be reduced to focus the scope of this research, experimenting with a more realistic database should be considered to incorporate additional and conflicting information to attempt to push the envelope of the capabilities of the assistant.

The limited numbers of staff and command representatives (six per team) grossly under represents actual brigade combat team staffing, and increasing the complexity for this test would have overwhelmed the participants. While all efforts were made to provide the appropriate complexity for the numbers of participants and to maintain within the scope of this research, it could be seen as a limitation.

One possible explanation for the lack of significant improvement is that the team became more comfortable and familiar with the scenario as the trials progressed, regardless of treatment

option.  The researcher does not believe this explanation since the team with PAL demonstrated

higher overall favorable ratings as measured through descriptive statistics and comments in the

follow-on interviews. The data recorded through surveys and observations reveal that the

treatment impacted positively on situation awareness, albeit not at a statistically significant level.

Regardless, the lack of significant difference is a limitation of the findings of this research.

Although these potential limitations existed, the researcher took numerous measures to

avoid any bias of the data.  Participants were randomly assigned; instruments were tested during a

pilot and adjusted after that event, prior to the trials.  The scenario was suitably rich to test the

subjects and the technologies.

Any time constraints or limitations are placed on a study, especially those that result in an

altered or less preferred research design, results could be distorted.  But this methodology

addressed limits as thoroughly and systematically as possible.

### Conclusion

In conclusion, quantitative measures and complementary insights indicate that the

Personalized Assistant that Learns, a cognitive assistant, improves the situation awareness of

teams as measured in terms of task management, information management, decision support,

environmental appreciation, visualization, trust, quality, speed and on situational awareness tests.

As soldiers in multiple theaters of war face ever more complex environments, cognitive

assistants can enable them to more fully focus on the germane tasks confronting them, and

ultimately relieve them of redundant tasks.  This advance in command and control technology

could have considerable value to fielded forces for years to come.

One explanation for the improvement of performance between control and treatment

groups is in the concept described as cognitive flexibility, which, defined, is the processing of

schema assemblies rather than intact schema (Spiro and Jehng, 1990). PAL assisted the subjects

develop much more complex mental models by simplifying or automating the germane load and

eliminating a considerable amount of the extraneous load (Sweller, Van Morriboer and Pass,

1988).

Because of the constructivist nature of situation awareness and the ways that PAL goes

about improving them, there appears to be great promise in the generalization of automated

cognitive assistants that reduce cognitive load for leaders and decision makers in a vast array of

other disciplines, from emergency management to education.

In this chapter, the findings of the data analysis have been documented and the meanings

of those data explored. These results provide the foundation to discuss the effectiveness of the

methods used to measure the research objective. Additionally, this chapter contributes to the

current discourse regarding technologies that could contribute to increasing situation awareness,

reducing cognitive loading within military headquarters, or both. It suggests that cognitive

assistants could be introduced to various non-military applications because of their constructivist

nature and their ability to reduce extraneous loads. Ultimately, based on all data collected and its

analysis, this research has determined that cognitive assistants in brigade combat team

headquarters can improve situational awareness. Further testing of these technologies in both

military and other applications should be pursued to generalize these findings and lead the way

to increasing performance through reducing cognitive load.

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**APPENDIX A, TECHNICAL DATA**
(All information in this appendix provided by SRI – developer of PAL)

**Personalized Assistant that Learns (PAL)**

The mission of the PAL program is to radically improve the way computers support humans by enabling systems that are cognitive, i.e., computer systems that can reason, learn from experience, be told what to do, explain what they are doing, reflect on their experience, and respond robustly to surprise. More specifically, PAL will develop a series of prototype cognitive systems that can act as an assistant for commanders and staff. Successful completion of this program will usher in a new era of computational support for a broad range of human activity.

Current software systems - in the military and elsewhere - are plagued by brittleness and the inability to deal with changing and novel situations - and must therefore be painstakingly programmed for every contingency. If PAL succeeds it could result in software systems that could learn on their own - that could adapt to changing situations without the need for constant reprogramming. PAL technology could drastically reduce the money spend by DoD on information systems of all kinds.

This is the first broad-based research program in cognitive systems since the Strategic Computing Initiative funded by DARPA in the 1980s. Since then, there have been significant developments in the technologies needed to enable cognitive systems, such as machine learning, reasoning, perception, and, multi-modal interaction. Improvements in processors, memory, sensors and networking have also dramatically changed the context of cognitive systems research. It is now time to encourage the various areas to come together again by focusing on by a common application problem: a Personalized Assistant that Learns.

Developing cognitive systems that learn to adapt to their user could dramatically improve a wide range of military operations. The development and application of intelligent systems to support military decision-making may provide dramatic advances for traditional military roles and missions. The technologies developed under the PAL program are intended to make military decision-making more efficient and more effective at all levels.

For example, today's command centers require hundreds of staff members to support a relatively small number of key decision-makers. If PAL succeeds, and develops a new capability for "cognitive assistants," those assistants could eliminate the need for large command staffs - enabling smaller, more mobile, less vulnerable command centers.

The strategy is to develop two system versions by separate independent research teams: CALO: Cognitive Assistant that Learns and Organizes, and RADAR: Reflective Agents with Distributed Adaptive Reasoning. To speed development, these first systems are being built as assistants in the office domain, allowing the developers to be the initial users.

PAL has capabilities in three main areas: Information Management, Task Management and Execution, and Meeting Assistance. Both the CALO and RADAR systems are tested each year to demonstrate that their performance improves each year, and that improvements are due to their ability to learn.

Technologies developed under the PAL program will make military decision making more efficient and more effective at all levels. For example, today's command centers require hundreds of staff members to support a relatively small number of key decision makers. As PAL

develops a new capability for "cognitive assistants," those assistants will reduce the need for large command staffs-enabling smaller, more mobile, less vulnerable command centers.

Several military transition efforts that incorporate PAL learning technology are under way. For example, CALO's ability to learn new tasks has been demonstrated in the context of the Command Post of the Future (CPoF), where it allows users to easily construct new procedures for displaying situation changes to commanders.

The PAL program is focused on developing technologies that:

- Enable machines to learn and improve their basic functionality through the accumulation of experience (and not through being explicitly programmed).
- Can represent purpose/goals, system structure, and behavior, in order to allow a computational system to reflect on its own capabilities and performance.
- Allow the software to be instructed and guided using natural human-oriented communications (e.g., natural language, pictures, gestures).
- Have the ability of the software to use visual and auditory sensors to understand the user's situation (who is in the meeting, who is speaking, etc).
- Are integrated and result in fully functioning systems.

**Command Post of the Future (CPOF)**

The latest trend in command and control technology is Command Post Of the Future (CPOF), a system currently deployed at division level, enabling division and brigade commanders to discuss and collaborate when processing information, share ideas, and attend virtual meetings without assembling at one place. As of October 2006 over 500 units are operational with US forces in Iraq.

CPOF runs on a commercial off-the-shelf computer workstation with three screens that provide a shared environment that distributes, manipulates and displays, current operational information about the locations of all friendly units, known enemy forces, and relevant operational plans. Information, including images and data, is seen in two and three dimensions across the distributed workspace. Commanders can be better informed and thus make better decisions, by sharing situational awareness and collaborating with headquarters.

Commanders attending the virtual meeting do not have to attend in the same location, or even the same country, to discuss and draw on the same map. CPOF was developed as a technology demonstration by DARPA. The prototype was deployed with the 1st Cavalry division and is currently operating in Baghdad, connecting the division HQ and five brigades. DARPA is expanding the system with the introduction of advanced visualization tools such as multi-screen video wall, video and audio conferencing and online collaboration tools, allowing brigade commanders to communicate, collaborate and share information. The first unit receiving the enhanced CPOF was the 3rd US Infantry Division. The program transitioned from DARPA to the Army in February 2006. CPOF is now managed by PM Battle Command at Ft. Monmouth, NJ, which directs the program's deployment, sustainment and feature development for the Army.

In May 2006, the U.S. Marine Corps launched an engineering design to determine how CPOF could be integrated into its Combat Operations Centers. CPOF was also used in the U.S. Air Force's Joint Expeditionary Force Experiment 06 (JFEX 06) at Langley AFB, Va., and the U.S. Joint Forces Command Urban Resolve 2015 series of experiments in October 2006.

CPOF enables forward command elements to reduced staff to operate C2 systems. In the distant future, advanced CPOF systems will eliminate parts of the brigade's Tactical Operations Centers (TOC) primarily the forward and assault TOC which could be transformed into virtual TOCs. CPOF relies on wideband data-communications links currently available to the Army, via military and commercial satellite communications services. The commander's battleboard is interfaced to the system supporting all communication, collaboration, and information feeds he needs.

The system is maintained as "liquid information" in database format, which separate the data from the viewing space. This method enables faster visualization and optimal maintenance of large volumes of constantly changing information. The system gathers real-time and near-real-time feeds from multiple C2 applications. Constant monitoring of the battlefield is provided, by tracking the combat elements on maps or satellite photos and video feeds from battlefield sensors, following enemy forces through intelligence reports, ground observations, forward units or UAVs. Commanders no longer have to call on the radio to check the status of each unit. CPOF support commercial presentation style briefings, including map, photos and video. The participants can respond, sketching out their comments on the shared "Battleboard" presented in each location and at the central CP's video wall. The Agile Commander program provided a scalable, reconfigurable operator environment which enabled commanders to access all

command post information and functions anywhere, anytime, utilizing advanced MOSAIC and Global Mobile networking.

## Enhanced CPOF with PAL

Incorporates the CPoF technologies with PAL technologies to create efficiencies in capabilities as a method to reduce workload, create better situational awareness, situational understanding and lead to better decisions.

## Web-Enabled Temporal Analysis System (WebTAS)

(All WebTAS and CIDNE information provided by ISS, lead developer of WebTAS)

An additional technology involved in this demonstration is the Web-Enabled Temporal Analysis System (WebTAS). WebTAS is a modular software toolset that supports fusion of large amounts of disparate data sets, visualization, project organization and management, pattern analysis and activity prediction, and various presentation aids. These tools have been successfully used by many Federal and regional government organizations, and are ideally suited to distributed networks and intranets.

WebTAS provides an integrated toolbox to users needing to make sense of large and diverse sets of data. The capabilities bundled in this environment include:

- Bringing together multiple sources of data into common, fused pictures.
- Sophisticated visualization components for viewing data
- Ad-HOC query of disparate data.
- Trend and pattern detection

- Dynamic web content generation based on these data sources

- Easily configured domain customization

WebTAS is ideally suited to distributed networks and intranets.  WebTAS  unique architecture provides a virtual file cabinet that can exploit a diverse set of information sources and formats. In addition to the local data services provided with the software, WebTAS can access external databases, real-time feeds, and provide links to multimedia such as imagery, video, and audio. This allows integrated access to all of this information from within a single application.

(WebTAS will be available to both teams at all times, but PAL technologies should impact ease of use, efficiency, effectiveness and speed of data searches in WebTAS.)

**Combined Information Data Network Exchange (CIDNE)**

CIDNE (Combined Information Data Network Exchange) is the Central Command (CENTCOM) directed reporting tool within Iraq and Afghanistan.  CIDNE serves as the primary bridge between disparate communities who might not otherwise share data by providing a standardized reporting framework across intelligence and operations disciplines.  This common framework allows structured operational and intelligence information to be shared vertically and horizontally as part of flexible, user-defined workflow processes that collect, correlate, aggregate and expose information as part of the end-user's individual information lifecycle requirements. CIDNE is interoperable with a number of Army Battle Command and Intelligence systems, including the Distributed Common Ground Station—Army (DCGS-A).  The information in CIDNE is collected across the battle space at all echelons.

(CIDNE will be available to both teams at all times, and there is no expectation that PAL technologies will have any effect on its utility.)

## APPENDIX B, ROLE PLAYER RESPONSIBILITIES

1. Play your role to the fullest extent.

   a. The Brigade Combat Team (BCT) Commander will provide guidance for planning and make decisions during execution based on the information the staff provides. He will provide brief updates to division when directed. It is NOT expected that the BCT commanders will remain in the Tactical Operations Center (TOC) at all times, but must be available at all times for consultation. Commanders also have assessment responsibilities.

   b. The Operations Officer, S3, must direct the staff in the absence of the commander and ensure each inject received by the battle captain is "handled" to completion. All planning timelines must be met – at the designated hour, the CPoF repository will be backed up and only the products (pasteboards) available at that point will "count" toward the post hoc grading.

   c. The Battle Captain must alert the staff each time a new inject arrives and maintain the Common Operational Picture (COP) battle board, projected within the TOC and the big screen.

   d. Intelligence Officer. The S2 MUST be the one working with the commander and staff on all intelligence issues – intelligence surveillance and reconnaissance (ISR), intelligence planning, Commander's Critical Information Requirements (CCIR) formulation/adjustment, intelligence preparation of the battlefield (IPB), Named/Target Areas of Interest (NAI/TAI), etc.

e. The Intelligence Analyst position will be the WebTAS technician – he will not be trained to do other intelligence tasks.  The WebTAS screen will be projected in each TOC, since only the two intelligence systems have WebTAS installed, and sharing must be done via other collaborative means.

f. Sustainment Officer. You are responsible for the spectrum from personnel (includes medical/medical evacuation), to all logistical functions – supply, transportation, ordnance, explosive ordnance disposal (EOD), humanitarian assistance, etc.  Since the sustainment position is also responsible for protection, all aspects of protection – air defense, engineer, military police, operations security and chemical, biological, radiological, nuclear and high explosive (CBRNE) are also part of your job.

g. Effects Officer. Consider all aspects of lethal and non-lethal effects available and desired in stability operations.  This includes wielding civil affairs (CA), information operations/engagement(IO/IE), psychological operations (PSYOP), humanitarian assistance, etc., as well as army artillery, mortar, and aviation fires and close air support.

2. This is a demonstration experiment that is testing new software (PAL, Meeting Assistant and Task Assistant).  The surveys are intended to capture your performance and feelings about the test.  There will be a lot of them.  We will attempt to measure things including: situational awareness, situational understanding, task load, quality of your work, quantity of actions completed as well as your assessment of the tool suites.  Some of these surveys will be the same every time and others will change depending on the tools you are using that day (CPOF or PAL-Enhanced CPOF).  When you answer the surveys, please be

honest, thoughtful and thorough.  Your answers could affect the fate of this program, and are the reason the Battle Lab was asked to conduct this test.

3.  There are CPOF and PAL help desks available – use them!  They will also be available during the experiment in December.

4.  The event is broken down into manageable chunks of planning, execution and surveys. The intent is to make the two days with PAL-Enhanced CPOF as similar as possible to the two days with CPOF alone.

5.  The bottom line of this experiment is to determine whether or not the PAL suite makes a difference in the quality and quantity of staff work, and whether or not it aids in decision making and/or situational awareness.   The intent is to exercise the equipment in a stressful, (simulated) complex environment.

6.  After each iteration of planning or execution, we'll do surveys then have a short directed discussion as a hot wash.  Topics will vary from day to day, but your opinions about the day's activities are very important.  Please contribute.

# APPENDIX C, EVENT CALENDAR

## Proposed PAL "Challenge" 1 – 5 Dec 08

| | Monday | Tuesday | Wednesday | Thursday | Friday |
|---|---|---|---|---|---|
| 0800-0830 | Arrival/Sys Check | Arrival/Sys Check | Arrival/Sys Check | Arrival/Sys Check | AAR Build |
| 0830-0900 | Div Update to BCTs | BCT Prep for Execution | Div Update to BCTs | BCT Prep for Execution | |
| 0900-0930 | BCT Plan Prep | Execute FRAGO 1010/CONPLAN 1004 Injected Events | BCT Plan Prep | Execute FRAGO 1006 /CONPLAN 1001(HVT ) | AAR (0900-1000) |
| 0930-1200 | Planning FRAGO 1010/CONPLAN 1004 (Co Air Assault/Aircrew Recovery) | | Planning FRAGO 1006 (Religious Holiday) | | Way Ahead |
| 1200-1230 | CL and SA Surveys Pasteboard Capture Hotwash (CA) | CL and SA Surveys Pasteboard Capture Hotwash (CA) | CL and SA Surveys Pasteboard Capture Hotwash (CA) | CL and SA Surveys Pasteboard Capture Hotwash (CA) | |
| 1230-1330 | Lunch | Lunch | Lunch | Lunch | Lunch |
| 1330-1600 | Planning FRAGO 1010/CONPLAN 1004 (Co Air Assault/Aircrew Recovery) | Execute FRAGO 1010/CONPLAN 1004 Injected Events | Planning CONPLAN 1001 (HVT) | Execute FRAGO 1006 /CONPLAN 1001(HVT ) Injected Events | Way ahead Required training assessment |
| 1600-1630 | CL, SA, TA, SQ Surveys Pasteboard Capture | CL, SA, TA, SQ Surveys Pasteboard Capture | CL, SA, TA, SQ Surveys Pasteboard Capture | CL, SA, TA, SQ Surveys Pasteboard Capture | |
| 1630-1700 | Hotwash (CA, SQ) | Hotwash (CA, SQ) | Hotwash (CA, SQ) | Hotwash (CA, SQ) | |
| 1700-UTC | EXCON Meeting | EXCON Meeting | EXCON Meeting | EXCON Meeting | |

**Color Legend:**
**Green = Planning Event // Rose = Execution // Orange = Assessment //Gray = Admin**

**Survey Legend:**
**CA = Cdr's Assessment // CL = Cognitive Load**
**SA = Situational Awareness  // TA = Tools Assessment**
**SQ = Speed/Quality Self Assessment**
**Post hoc: Pasteboard Subjective  Evaluations by SME Board**

# APPENDIX D, SAMPLE SITUATIONAL AWARENESS TEST

1. What suspected activity caused division to order 1/3 to conduct the air assault? (Choose the best answer)
    a. Located a SAPA training camp
    b. Massing enemy formations
    c. Displaced civilian unrest
    d. High value target
    e. Weapons cache
2. The estimate of enemy at the objective is (roughly):
    a. A squad
    b. A platoon
    c. A company
    d. A battalion
    e. One HVT and his protection team
3. The enemy at the objective are (choose all that apply):
    a. SAPA
    b. Conventional AH left behind forces
    c. AH special forces
    d. None of these
4. Key tasks for this mission (choose all that apply):
    a. Minimize Civilian Casualties
    b. Coordinate with 2/3 BCT
    c. Plan for media and document exploitation
    d. Plan for MEDCAP and VETCAP
    e. All of the above
5. Known enemy threat(s) to the mission on or near the landing zones include (choose all that apply):
    a. Anti aircraft artillery weapons
    b. Shoulder fired weapons
    c. Small arms
    d. Mortars
    e. All of the above

6. This mission falls in which unit's area of operation?
    a. 1-22 IN
    b. 1-66 AR
    c. 7-10 CAV
    d. 2/3 BCT
7. The division has indicated the following assets would be available to 1/3 for the mission (select all that apply):
    a. AH-64
    b. Close air support (CAS) sorties
    c. CH-47
    d. UH-60
    e. Azeri forces
    f. All of the above

## APPENDIX E, TOOLS ASSESSMENT SURVEYS

*Survey A: PAL-Enhanced CPoF Tools Assessment.*

**Please respond to the questions using the following scale:**
**1 = Agree**     **2 = Somewhat Agree**       **3 = Neither Agree nor Disagree**
**4 = Somewhat Disagree**     **5 = Disagree   NA = Not Applicable**

1.  PAL-Enhanced CPoF made organizing routine tasks easy.
1_____          2_____          3_____          4_____          5_____          NA _____

2.  Using PAL-Enhanced CPoF made no difference in the quantity of tasks I was able to handle.
1_____          2_____          3_____          4_____          5_____          NA _____

3.  I maintained good situational awareness when I used PAL-Enhanced CPoF.
1_____          2_____          3_____          4_____          5_____          NA _____

4.  PAL-Enhanced CPoF was effective in assisting in planning tasks.
1_____          2_____          3_____          4_____          5_____          NA _____

5.  PAL-Enhanced CPoF was effective in assisting in execution.
1_____          2_____          3_____          4_____          5_____          NA _____

6.  PAL-Enhanced CPoF allowed me to complete tasks rapidly.
1_____          2_____          3_____          4_____          5_____          NA _____

7.  PAL-Enhanced CPoF allowed me to complete tasks without loss of accuracy.
1_____          2_____          3_____          4_____          5_____          NA _____

8.  I was always able to forward information to the right people with PAL-Enhanced CPoF.
1_____          2_____          3_____          4_____          5_____          NA _____

9.  PAL-Enhanced CPoF assisted in collecting information rapidly.
1_____          2_____          3_____          4_____          5_____          NA _____

10. PAL-Enhanced CPoF assisted in collecting information effectively.
1_____          2_____          3_____          4_____          5_____          NA _____

11. PAL-Enhanced CPoF assisted in displaying information rapidly.
1_____          2_____          3_____          4_____          5_____          NA _____

12. PAL-Enhanced CPoF assisted in displaying information effectively.
1_____          2_____          3_____          4_____          5_____          NA _____

**Please respond to the questions using the following scale:**
**1 = Agree     2 = Somewhat Agree       3 = Neither Agree nor Disagree**
**4 = Somewhat Disagree     5 = Disagree   NA = Not Applicable**

13. PAL-Enhanced CPOF provided me the ability to get information from other sources.
1_____        2_____        3_____        4_____        5_____        NA _____

14. PAL-Enhanced CPOF enabled me to focus on and understand key information.
     1_____        2_____        3_____        4_____        5_____        NA _____

15. I gave the commander good staff recommendations when I used PAL-Enhanced CPoF.
1_____        2_____        3_____        4_____        5_____        NA _____

16. The quality of my staff products was good when I used PAL-Enhanced CPoF.
1_____        2_____        3_____        4_____        5_____        NA _____

17. Using PAL-Enhanced CPoF made no difference in the quality of products I was responsible
    for creating.
1_____        2_____        3_____        4_____        5_____        NA _____

18. I made good decisions when I used PAL-Enhanced CPoF.
1_____        2_____        3_____        4_____        5_____        NA _____

19. I was able to anticipate the threat's actions when I used PAL-Enhanced CPoF.
1_____        2_____        3_____        4_____        5_____        NA _____

20. PAL-Enhanced CPoF was effective in assisting in situational awareness tasks.
1_____        2_____        3_____        4_____        5_____        NA _____

21. PAL-Enhanced CPOF enabled me to maintain situational awareness of the area of
    operations.
     1_____        2_____        3_____        4_____        5_____        NA _____

22. PAL-Enhanced CPOF enabled me to set up work displays that represented the area of
    operations.
1_____        2_____        3_____        4_____        5_____        NA _____

23. PAL-Enhanced CPOF assisted in establishing battle boards rapidly for a complex set of
    operations.
1_____        2_____        3_____        4_____        5_____        NA _____

**Please respond to the questions using the following scale:**
**1 = Agree    2 = Somewhat Agree      3 = Neither Agree nor Disagree**
**4 = Somewhat Disagree    5 = Disagree   NA = Not Applicable**

24. PAL-Enhanced CPOF assisted in establishing effective battle boards for a complex set of operations.
1_____      2_____      3_____      4_____      5_____      NA _____

25. PAL-Enhanced CPoF performed functions I didn't want to happen.
1_____      2_____      3_____      4_____      5_____      NA _____

26. I had to manually undo or recall of actions that PAL-Enhanced CPoF did automatically.
 1_____      2_____      3_____      4_____      5_____      NA _____

27.  I was able to communicate effectively using Meeting Assistant.
1_____      2_____      3_____      4_____      5_____      NA _____

**Please provide your insight to the questions below. Continue on back if more space is required:**

28. What was the value of PAL-Enhanced CPOF in assisting you in the identification of related items of information that would otherwise appear to be unrelated (PAL clustering and entity extraction in WebTAS)?
_____
_____
_____

29. What was the value of PAL-Enhanced CPoF to assemble relevant information (CPOF and WebTAS)
_____
_____
_____

30.  Specifically, what was the value of PAL-Enhanced CPoF in reducing time of information access?
_____
_____
_____

31. Specifically, what was the value of PAL-Enhanced CPoF in improving the anticipation of information needs?
_____
_____
_____

32. Specifically, what was the value of PAL-Enhanced CPoF in setting an appropriate presentation for user interpretation

_____
_____
_____

33. Specifically, what was the value of PAL-Enhanced CPoF in terms of accuracy of user interpretation of a situation

_____
_____
_____

34. Specifically, what was the value of PAL-Enhanced CPoF in terms of speed of access to information and knowledge products?

_____
_____
_____

35. Please provide additional comments on how you think the PAL technologies could be employed beyond those applications you have seen in this experiment

_____
_____
_____

36. The feature I found most useful with PAL-Enhanced CPoF is:

_____

37. The feature I found least useful with PAL-Enhanced CPoF is:

_____

38. The PAL feature that I would like to see developed further is: (please explain).

_____
_____

39. Specifically, what was the value of PAL-Enhanced Meeting Assistant in reviewing the information that was spoken?

_____
_____
_____

*Survey B:  CPoF Tools Assessment.*
**Please respond to the questions using the following scale:**

**1 = Agree     2 = Somewhat Agree       3 = Neither Agree nor Disagree**
**4 = Somewhat Disagree     5 = Disagree   NA = Not Applicable**

1.  CPoF made organizing routine tasks easy.
1_____          2_____          3_____          4_____          5_____          NA _____

2.  Using CPoF made no difference in the quantity of tasks I was able to handle.
1_____          2_____          3_____          4_____          5_____          NA _____

3.  I maintained good situational awareness when I used CPoF.
1_____          2_____          3_____          4_____          5_____          NA _____

4.  CPoF was effective in assisting in planning tasks.
1_____          2_____          3_____          4_____          5_____          NA _____

5.  CPoF was effective in assisting in execution.
1_____          2_____          3_____          4_____          5_____          NA _____

6.  CPoF allowed me to complete tasks rapidly.
1_____          2_____          3_____          4_____          5_____          NA _____

7.  CPoF allowed me to complete tasks without loss of accuracy.
1_____          2_____          3_____          4_____          5_____          NA _____

8.  I was always able to forward information to the right people with CPoF.
1_____          2_____          3_____          4_____          5_____          NA _____

9.  CPoF assisted in collecting information rapidly.
1_____          2_____          3_____          4_____          5_____          NA _____

10. CPoF assisted in collecting information effectively.
1_____          2_____          3_____          4_____          5_____          NA _____

11. CPoF assisted in displaying information rapidly.
1_____          2_____          3_____          4_____          5_____          NA _____

12. CPoF assisted in displaying information effectively.
1_____          2_____          3_____          4_____          5_____          NA _____

**Please respond to the questions using the following scale:**
**1 = Agree      2 = Somewhat Agree        3 = Neither Agree nor Disagree**
**4 = Somewhat Disagree      5 = Disagree   NA = Not Applicable**

13. CPoF provided me the ability to get information from other sources.
1\_\_\_\_\_          2\_\_\_\_\_          3\_\_\_\_\_          4\_\_\_\_\_          5\_\_\_\_\_          NA \_\_\_\_\_

14. CPoF enabled me to focus on and understand key information.
       1\_\_\_\_\_          2\_\_\_\_\_          3\_\_\_\_\_          4\_\_\_\_\_          5\_\_\_\_\_          NA \_\_\_\_\_

15. I gave the commander good staff recommendations when I used CPoF.
1\_\_\_\_\_          2\_\_\_\_\_          3\_\_\_\_\_          4\_\_\_\_\_          5\_\_\_\_\_          NA \_\_\_\_\_

16. The quality of my staff products was good when I used CPoF.
1\_\_\_\_\_          2\_\_\_\_\_          3\_\_\_\_\_          4\_\_\_\_\_          5\_\_\_\_\_          NA \_\_\_\_\_

17. Using CPoF made no difference in the quality of products I was responsible for creating.
1\_\_\_\_\_          2\_\_\_\_\_          3\_\_\_\_\_          4\_\_\_\_\_          5\_\_\_\_\_          NA \_\_\_\_\_

18. I made good decisions when I used CPoF.
1\_\_\_\_\_          2\_\_\_\_\_          3\_\_\_\_\_          4\_\_\_\_\_          5\_\_\_\_\_          NA \_\_\_\_\_

19. I was able to anticipate the threat's actions when I used CPoF.
1\_\_\_\_\_          2\_\_\_\_\_          3\_\_\_\_\_          4\_\_\_\_\_          5\_\_\_\_\_          NA \_\_\_\_\_

20. CPoF was effective in assisting in situational awareness tasks.
1\_\_\_\_\_          2\_\_\_\_\_          3\_\_\_\_\_          4\_\_\_\_\_          5\_\_\_\_\_          NA \_\_\_\_\_

21. CPoF enabled me to maintain situational awareness of the area of operations.
       1\_\_\_\_\_          2\_\_\_\_\_          3\_\_\_\_\_          4\_\_\_\_\_          5\_\_\_\_\_          NA \_\_\_\_\_

22. CPoF enabled me to set up work displays that represented the area of operations.
1\_\_\_\_\_          2\_\_\_\_\_          3\_\_\_\_\_          4\_\_\_\_\_          5\_\_\_\_\_          NA \_\_\_\_\_

23. CPoF assisted in establishing battle boards rapidly for a complex set of operations.
1\_\_\_\_\_          2\_\_\_\_\_          3\_\_\_\_\_          4\_\_\_\_\_          5\_\_\_\_\_          NA \_\_\_\_\_

24. CPoF assisted in establishing effective battle boards for a complex set of operations.
1\_\_\_\_\_          2\_\_\_\_\_          3\_\_\_\_\_          4\_\_\_\_\_          5\_\_\_\_\_          NA \_\_\_\_\_

**Please respond to the questions using the following scale:**
**1 = Agree     2 = Somewhat Agree       3 = Neither Agree nor Disagree**
**4 = Somewhat Disagree     5 = Disagree  NA = Not Applicable**

25. CPoF performed functions I didn't want to happen.
1_____        2_____        3_____        4_____        5_____        NA _____

26. I had to manually undo or recall of actions that CPoF did automatically.
 1_____        2_____        3_____        4_____        5_____        NA _____

27. I was able to communicate effectively using Meeting Assistant.
1_____        2_____        3_____        4_____        5_____        NA _____

**Please provide your insight to the questions below. Continue on back if more space is required:**

28. What was the value of CPoF in assisting you in the identification of related items of information that would otherwise appear to be unrelated (PAL clustering and entity extraction in WebTAS)?

_____
_____
_____

29. What was the value of CPoF to assemble relevant information (CPOF and WebTAS)
_____
_____
_____

30.  Specifically, what was the value of CPoF in reducing time of information access?
_____
_____
_____

31. Specifically, what was the value of CPoF in improving the anticipation of information needs?
_____
_____
_____

32. Specifically, what was the value of CPoF in setting an appropriate presentation for user interpretation

_____
_____
_____

33. Specifically, what was the value of CPoF in terms of accuracy of user interpretation of a situation

_____
_____
_____

34. Specifically, what was the value of CPoF in terms of speed of access to information and knowledge products?

_____
_____
_____

35. Please provide additional comments on how you think the PAL technologies could be employed beyond those applications you have seen in this experiment

_____
_____
_____

36. The feature I found most useful with CPoF is:

_____

37. The feature I found least useful with CPoF is:

_____

38. The PAL feature that I would like to see developed further is: (please explain).

_____
_____

*Survey C:  Post-Hoc Tools Comparison*

## <u>PAL-CPOF 08 Post Hoc Questionnaire</u>

**Now that you have had an opportunity to plan and execute operations with PAL-Enhanced CPoF, please respond to the questions using the following scale:**

**Please respond to the questions using the following scale:**

**1 = Agree      2 = Somewhat Agree       3 = Neither Agree nor Disagree**
**4 = Somewhat Disagree     5 = Disagree            NA = Not Applicable**

1.  PAL Enhanced CPoF made organizing routine tasks easier than using CPOF alone.
1\_\_\_\_        2\_\_\_\_        3\_\_\_\_        4\_\_\_\_        5\_\_\_\_        NA \_\_\_\_

2.  Using PAL Enhanced CPoF made no difference in the quantity of tasks I was able to handle than when I used CPOF alone.
1\_\_\_\_        2\_\_\_\_        3\_\_\_\_        4\_\_\_\_        5\_\_\_\_        NA \_\_\_\_

3.  PAL Enhanced CPoF was more effective in assisting in planning tasks than using CPOF alone.
1\_\_\_\_        2\_\_\_\_        3\_\_\_\_        4\_\_\_\_        5\_\_\_\_        NA \_\_\_\_

4.  PAL Enhanced CPoF was more effective in assisting in execution tasks than using CPOF alone.
1\_\_\_\_        2\_\_\_\_        3\_\_\_\_        4\_\_\_\_        5\_\_\_\_        NA \_\_\_\_

5.  PAL Enhanced CPoF enabled me to complete <u>more</u> tasks than when I used CPOF alone.
1\_\_\_\_        2\_\_\_\_        3\_\_\_\_        4\_\_\_\_        5\_\_\_\_        NA \_\_\_\_

6.  PAL Enhanced CPoF enabled me to complete a <u>broader variety</u> of tasks than when I used CPOF alone.
1\_\_\_\_        2\_\_\_\_        3\_\_\_\_        4\_\_\_\_        5\_\_\_\_        NA \_\_\_\_

7.  PAL Enhanced CPoF enabled me to complete a <u>more complex set of tasks </u>than when I used CPOF alone.
1\_\_\_\_        2\_\_\_\_        3\_\_\_\_        4\_\_\_\_        5\_\_\_\_        NA \_\_\_\_

8.  PAL Enhanced CPoF assisted in collecting information more rapidly than using CPOF alone.
1\_\_\_\_        2\_\_\_\_        3\_\_\_\_        4\_\_\_\_        5\_\_\_\_        NA \_\_\_\_

**Please respond to the questions using the following scale:**

**1 = Agree      2 = Somewhat Agree      3 = Neither Agree nor Disagree**
**4 = Somewhat Disagree     5 = Disagree          NA = Not Applicable**

9.  PAL Enhanced CPoF assisted in collecting information more effectively than using CPOF alone.
1_____          2_____          3_____          4_____          5_____          NA _____

10. PAL Enhanced CPoF assisted you in displaying information more rapidly than using CPOF alone.
1_____          2_____          3_____          4_____          5_____          NA _____

11. PAL Enhanced CPoF assisted in displaying information more effectively than using CPOF alone.
1_____          2_____          3_____          4_____          5_____          NA _____

12. PAL-Enhanced CPOF improved my ability to get information from other sources better than using CPOF alone.
1_____          2_____          3_____          4_____          5_____          NA _____

13. PAL-Enhanced CPOF enabled me to focus on and understand key information better than using CPOF alone.
1_____          2_____          3_____          4_____          5_____          NA _____

14. I gave the commander better staff recommendations when I used PAL Enhanced CPoF than using CPOF alone.
1_____          2_____          3_____          4_____          5_____          NA _____

15. The quality of my staff products was better when I used PAL Enhanced CPoF than when I used CPOF alone.
1_____          2_____          3_____          4_____          5_____          NA _____

16. Using PAL Enhanced CPoF made no difference in the quality of products I was responsible for than when I used CPOF alone.
1_____          2_____          3_____          4_____          5_____          NA _____

17. I made better decisions when I used PAL-Enhanced CPOF than using CPOF alone.
1_____          2_____          3_____          4_____          5_____          NA _____

18. I was able to anticipate the threat's actions when I used PAL Enhanced CPoF than when I used CPOF alone.
1_____          2_____          3_____          4_____          5_____          NA _____

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**Please respond to the questions using the following scale:**

**1 = Agree      2 = Somewhat Agree        3 = Neither Agree nor Disagree**
**4 = Somewhat Disagree      5 = Disagree            NA = Not Applicable**

19. I was able to more accurately anticipate the threat's actions when I used PAL Enhanced CPoF than when I used CPOF alone.
1_____        2_____        3_____        4_____        5_____        NA _____

20.  I had better situational awareness when I used PAL Enhanced CPoF than when I used CPOF alone.
1_____        2_____        3_____        4_____        5_____        NA _____

21. PAL-Enhanced CPOF helped me maintain better situational awareness than using CPOF alone.
1_____        2_____        3_____        4_____        5_____        NA _____

22. PAL-Enhanced CPOF enabled me to set up work displays that represented the area of operations better than using CPOF alone.
1_____        2_____        3_____        4_____        5_____        NA _____

23. PAL-Enhanced CPOF assisted in establishing battle boards rapidly for a complex set of operations better than using CPOF alone.
1_____        2_____        3_____        4_____        5_____        NA _____

24. PAL-Enhanced CPOF assisted in establishing effective battle boards for a complex set of operations better than using CPOF alone.
1_____        2_____        3_____        4_____        5_____        NA _____

# APPENDIX F, THE MILITARY DECISION MAKING PROCESS[1]

1. Receipt of Mission
   a. Input:
      i. Mission received from higher HQs or deduced by commander and staff
   b. Issue:
      i. Commander's Initial Guidance
      ii. Warning Order (WARNO)

2. Mission Analysis
   a. Input:
      i. Higher HQs order/plan
      ii. Higher HQs Intelligence Preparation of the Battlefield (IPB)
      iii. Staff Estimates
   b. Issue:
      i. Restated mission
      ii. Initial Commander's intent, planning guidance
      iii. Initial Commander's Critical Information Requirements (CCIR)
      iv. Updated staff estimates
      v. Initial IPB products
      vi. Initial Intelligence Surveillance and Reconnaissance (ISR) plan
      vii. Preliminary movement (WARNO)

3. Course of Action (COA) Development
   a. Input:
      i. Restated mission
      ii. Initial Commander's intent, planning guidance, and CCIR
      iii. Updated staff estimates
      iv. Initial IPB products
   b. Issue:
      i. Updated staff estimates

4. Course of Action (COA) Analysis (War Game)

---

[1] Army Field Manual 5-0 Army Planning and Orders Production, Jan 2005, p. 3-3

    a. Input:
        i. Refined Commander's intent and planning guidance
        ii. Enemy COAs
        iii. COA Statements and sketches
    b. Issue:
        i. War-Game results
        ii. Decision support templates
        iii. Task Organization
        iv. Mission to subordinate units
        v. Recommended CCIR

5. Course of Action (COA) Comparison
    a. Input:
        i. War-Game results
        ii. Criteria for comparison
    b. Issue:
        i. Decision Matrix

6. Course of Action (COA) Approval
    a. Input:
        i. Decision Matrix
    b. Issue:
        i. Approved COA
        ii. Refined Commander's Intent
        iii. Refined CCIR
        iv. High payoff target list

7. Orders Production
    a. Input:
        i. Approved COA
        ii. Refined Commander's Intent and guidance
        iii. Refined CCIR
    b. Issue:
        i. Operations Order/Plan or Fragmentary Order

# APPENDIX G
## SME SCORING GUIDES FOR SCENARIO-BASED COGNITIVE ASSESSMENT
## REVISED SCENARIO-BASED COGNITIVE ASSESSMENT TOOL

Research has identified eight dimensions or themes of tactical thinking that characterize expert tacticians (Deckert, Entin, Entin, MacMillan, & Serfaty, 1994). The dimensions of tactical thinking provided the basis for post hoc assessments of situation awareness used in the qualitative evaluation.

| Dimension Theme | Description |
|---|---|
| T1: Focus on Mission and Higher's Intent | Commanders must never lose sight of the purpose and results they are directed to achieve—even when unusual and critical events may draw them in a different direction. |
| T2: Model a Thinking Enemy | Commanders must not forget that the adversary is a reasoning human being, intent on defeating them—it's tempting to simplify the battlefield by treating the enemy as static or simply reactive. |
| T3: Consider Effects of Terrain | Commanders must not lose sight of the operational effects of the terrain on which they must fight—every combination of terrain and weather has a significant effect on what can and should be done to accomplish the mission. |
| T4: Know and Use All Assets Available | Commanders must not lose sight of the synergistic effects of fighting their command as a combined arms team—this includes not only all assets under their command, but also those which higher headquarters might bring to bear to assist them. |
| T5: Consider Timing | Commanders must not lose sight of the time they have available to them to get things done—a good sense of how much time it takes to accomplish various battlefield tasks and the proper use of that sense is a vital combat multiplier. |
| T6: See the Big Picture | Commanders must remain aware of what is happening around them and how it might affect their operations and how what they do can affect others' operations—a narrow focus on your own fight can get you blind-sided. |
| T7: Consider Contingencies and Remain Flexible | Commanders must never lose sight of the old maxim that "no plan survives the first shot"—flexible plans and well thought out contingencies result in rapid, effective responses under fire. What if…How else can I.... |
| T8: Visualize the Battlefield | Commanders must be able to visualize a fluid and dynamic battlefield with some accuracy and use this visualization to their advantage—a commander who develops this difficult skill can reason proactively like no other. |

Scenario-based cognitive assessment
BARS Scoring Form—Instructor Scoring Guide
PAL Demonstration: Air assault, downed aircrew recovery planning, cordon and search, and pilgrimage to a holy site

The following is a description of BARS (Behaviorally Anchored Rating Scale) dimensions on which role player performance will be rated. The scales provide a range of behaviors from novice to expert for each of the four dimensions being measured. Each is assigned a numeric value (1= novice; 5= expert). Each dimension description includes a list of actions that reflect each level of expertise development. Following the dimension description, you will find a dimension summary that describes how it is relevant to the planning and execution efforts. In the scoring considerations section are example role player actions, recommendations on scoring behaviors, and any scoring restrictions.

# MODEL A THINKING ENEMY

Commanders must not forget that the adversary is a reasoning human being, intent on defeating them—it's tempting to simplify the battlefield by treating the enemy as static or simply reactive.

| Ignore Enemy | Use Enemy Template | Model a Thinking Enemy | Accurate Predictions | Deny Enemy Intent |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** |
| • Does not consider the enemy while developing a plan<br>• Thinks of the enemy as static and reactive<br>• Puts a friendly unit in a dangerous spot<br>• Does not consider the culture of potential adversaries<br>• Considers all parties as enemies | • Uses schoolhouse knowledge about enemies when developing a plan<br>• Uses theoretical or scholastic models (templates) to think about the enemy<br>• When referring to the enemy, uses phrases like, "traditionally this type of enemy would…"; "According to the Ahurastani model…"; "An enemy in the 3rd world model would…"; etc.<br>• Views the enemy as one big entity, instead of being comprised of being many subsystems | • Analyzes what the enemy might be doing<br>• Articulates ideas about what the enemy might be thinking<br>• Considers what the enemy's capabilities are, as well as their vulnerabilities<br>• Considers what the enemy's objective might be<br>• Considers things such as how the enemy might use the terrain, how they might employ their assets, avenues of approach, etc. | • Initiates planning for how to deny enemy intent<br>• Considers how own plan, use of terrain, employment of assets, etc. will inhibit the enemy from accomplishing their objective<br>• Predicts adversary's reactions to own actions | • Shows evidence that the role player took a particular course of action (COA) in order to deny enemy intent<br>• Carries out COA with rationale being enemy intent |

## CONSIDER EFFECTS OF TERRAIN

Commanders must not lose sight of the operational effects of the terrain on which they must fight—every combination of terrain and weather has a significant effect on what can and should be done to accomplish the mission.

| KOCOA | Recognize Important Aspects | Dynamic Friendly Terrain Model | Dynamic Enemy Terrain Model | Shape the Battlefield |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| • Goes through a checklist of **K**ey Terrain **O**bstacles **C**over and concealment **O**bservation and fields of fire **A**venues of Approach • | • Asks questions about aspects of terrain • Notes aspects of the terrain that might affect operations such as weather, sources of water, road networks, forests, hills, etc. • Considers infrastructure and physical characteristics | • Recognizes how to use terrain to own advantage • Considers specific ways to utilize the terrain to accomplish the mission • May consider things such as, "can I use the terrain to protect my forces from observations?" or "can I obscure the enemy's vision with the smoke?" • Incorporates possible obstacles (e.g. choke points, flooding, winds) into planning. | • Recognizes how the enemy may use the terrain to their advantage • Considers specific ways that the enemy may use the terrain to achieve their objective • For example, may consider things such as "the enemy may use that hill for observation…" ; "The enemy is likely to use this avenue of approach…" | • Integrates knowledge of how friendly forces can use the terrain and how enemy forces might use the terrain in order to most effectively accomplish the objective. For example" we could use that terrain to split the enemy force and this one to mass fires". • Frames terrain and infrastructure problem situation |

## KNOW AND USE ALL ASSETS AVAILABLE

Commanders must not lose sight of the synergistic effects of fighting their command as a combined arms team – this includes not only all assets under their command, but also those which higher headquarters might bring to bear to assist them.

| Know Data about Systems | Link systems to Mission Requirements | Dynamic Friendly Model | See Own Unit in Context of Larger Org Assets | Command the Force |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| • Asks questions about facts<br>• Understands what assets are available<br>• Understands the capabilities of the assets. | • Matches assets to a general mission. E.g. "the UAVs can be used for recon…", but doesn't consider how to utilize the assets to their fullest capabilities within this particular mission<br>• Give template answers to questions about how assets will be utilized.<br>• Does not use combat assets to recon or recon assets to direct fires. | • Focuses on how the available assets can be used to overcome enemy capabilities and accomplish the current mission<br>• Considers what other assets might be needed | • Recognizes the availability of other assets outside of those that are organic to one's unit<br>• Doesn't think about units in isolation, but sees them as a team.<br>• Requests assistance from higher while repositioning his own forces as needed. | • Leverages assets from the larger organization in addition to one's own<br>• Employees all the combat multipliers effectively. |

## CONSIDER TIMING

Commanders must not lose sight of the time they have available to them to get things done—a good sense of how much time it takes to accomplish various battlefield tasks and the proper use of that sense is a vital combat multiplier.

| Ignore Timing | Aware of Timing Constraints | Model Time Against Assets, Terrain, & Objective | Accurate Predictions | Bold Actions |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| • Makes plans without considering how long it takes to accomplish the tasks involved<br>• Ignores factors such as rate of movement<br>• Does not sequence or coordinate assets effectively | • Acknowledges timing constraints<br>• Articulates timing estimates (e.g., is able to estimate time required for movement), but does not incorporate that knowledge into plans. | • Keeps time in mind as a critical factor while developing the alternative COAs<br>• Incorporates knowledge of assets, terrain and timing into COA<br>• Calculates timing based upon factors such as available assets, terrain, obstacles, etc. | • Accurately visualizes how long it is going to take to accomplish specific tasks and what the battlefield will look like when all assets are in place<br>• Mentally simulates what is going to be accomplished and in what sequence | • Applies predictions about the enemy to command force within appropriate timing and sequence<br>• Creates a well-synchronized effort whereby units' actions are interdependent, and appropriately timed and sequenced<br>• |

## APPENDIX H, DEMOGRAPHIC SURVEY

PAL Demographics

| | |
|---|---|
| 1. Name | |
| 2. Organization/Duty Position | |
| 3. Experiment job title | |
| 4. What is/was your current/highest rank? | |
| 5. What is your basic branch/Other skill? | |
| 6. Years of service?  (If no longer in service, add how long you have been out of the military) | |
| 7.  How many months of command do you have at: | Company level? ____ months<br><br>Battalion level? ____ months<br><br>Brigade level?  ____ months |
| 8.  How many months of staff experience do you have at: (continue on the back if necessary) | Battalion level? ____ months    Position(s) S-__ , ____ , __<br><br>Brigade level? ____ months    Position(s) S-__ , ____ , __<br><br>Division level? ____ months    Position(s) G-__ , ____ , __<br><br>Corps level?     ____ months    Position(s) G-__ , ____ , __<br><br>Joint Level?     ____ months    Position(s) J-__ ,<br><br>(AO=action Officer) |
| 9. How many months of Stability Operations experience do you have? Where and when? (continue on the back if necessary) | Company level? ____ months   Where?<br><br>_____<br><br>Battalion level? ____ months   Where?<br><br>_____<br><br>Brigade level?  ____ months   Where?<br><br>_____ |

| | |
|---|---|
| | Division level? \_\_\_\_ months    Where? _____ <br><br> Corps level?    \_\_\_\_ months    Where? _____ <br><br> Joint Level?    \_\_\_\_ months    Where? _____ |
| 10.  Briefly describe your interest and experience in Future Force concepts and development. (continue on the back if necessary) | |
| 11. Rate your proficiency using the following scale: <br> 1 = None <br> 2 = Limited <br> 3 = Average <br> 4 = Above Average <br> 5 = Very High | Personal Computers    1    2    3    4    5 <br><br> CPoF    1    2    3    4    5 <br><br> PAL    1    2    3    4    5 <br><br> WebTAS    1    2    3    4    5 <br><br> Pre-CPOF (MCS/ABCS)    1    2    3    4    5 |
| 12. Education Level | Undergraduate Degree  //  Graduate Degree // Other |

## APPENDIX I, INFORMED CONSENT

## <u>Informed Consent Statement</u>

The Department of Curriculum and Teaching at the University of Kansas supports the practice of protection for human subjects participating in research. The following information is provided for you to decide whether you would like to participate in the present study. Even if you agree to participate, you are free to withdraw at anytime without penalty.

This study is designed to determine whether or not the Personalized Assistant that Learns (PAL) affects Situational Awareness, Situational Understanding, speed, task loading and/or quality in a full spectrum operations scenario. It is estimated that this will take approximately five days. Your participation will include role-playing on a Brigade Staff, completing surveys, being observed, and taking part in discussions ("hot washes") after each day.

Although participation may not directly benefit you, we believe that the data collected will be useful in assessing this product and could be instrumental in the determination to continue this prototyping effort.  Systems that increase situational awareness and situational understanding of complex situations and assist in improving their decision making skills are becoming increasingly important, not only in combat operations, but domestic support operations as well.

Your participation is solicited; however, it is strictly voluntary. Although the names and e-mail addresses of individuals that participate will be collected, they will not be used in any written reports reflecting the findings of this study. The information will be identified only by a code number.

If you would like additional information concerning this study or your participation, please do not hesitate to contact the principal investigator, Mr. Carl Fischer by phone: 913-684-7726 or e-mail: carl.fischer@us.army.mil or the faculty supervisor, Dr. Ron Aust, e-mail: aust@ku.edu. We appreciate your cooperation.  You can also contact the Human Subjects Committee representatives at Kansas University (Mary Denning (785-864-7385), David Hahn (785-864-7429), or Jan Butin (785-864-7996).

Sincerely,
Carl Fischer
PH.D Candidate, University of Kansas

_____**I agree to participate in the study.**
_____**I do not wish to participate in the study.**


Signature_____Date_____


E-mail address _____

# APPENDIX J, TRAINING CERTIFICATION

CPOF + PAL Certification

| No Go<br>(<50%) | Needs Reinforcement<br>(>50 - <70%) | Go<br>(70%+) |
|---|---|---|

CPOF SKILLS
(all participants should complete this part)

1.    Start up and shut down
- Use the green star to Start 2D, and Start Maps.
- Use the green star to Stop All

2.    Workspace Tools
Arrange these CPOF tools in my workspace
- Frame Dispenser
- Trash Can
- Tree Viewer (pointed to Shared Products)
- Item Palette
- Tool Bar

3.    Navigating and using Shared Products
- Use the Tree Viewer to find and view other battle staff's shared work products and shared data
  - Find the 1:3_BTLCPT's pasteboard and double-click to display it in your workspace.
  - Find the "Zones" and Ctrl-drag on the "bubble" icon to drag the box with the zones onto your workspace

4    Create a personal Pasteboard with nested work products and use layout controls.
- Create and name (with "Your name") a new personal Pasteboard and nest these work products (e.g., Map, a blank Table, two Stickies, and the Zones effort)) into it.
  - Set to manual layout with buttons instead of tabs    `
  - Set to Automatic Layout
  - Create a sub-pasteboard with the only a map and the Zones Effort on it.
  - Nest it within your pasteboard.

5.    Use Frame Controls
- Use the Frame controls on your pasteboard to :
  - view permissions on the pasteboard
  - iconify, and then de-iconify the pasteboard

6.    Trash
- Trash your pasteboard
- View trash and recover the pasteboard you just trashed.
- Trash the map within your pasteboard, then recover it from trash and re-nest it into the pasteboard

7.    Maps
- Use the map Navigator controls to:

150

- - zoom in/out,
  - pan in the various map directions using the compass rose,
  - center map on a location (by using alt-click) ,
  - zoom in and create a map reset
  - Hide and restore your Map's effort list and navigator

8. Ink, Text, Graphics and Marking
   - On your map, draw a General Area with an outline and fill of different colors.
   - Create a text label that appears within the General Area.
   - Create any other graphic on the map and demonstrate one way to remove the graphic from the map.

9. Mirrors, Clones, and Permissions
   - Create a mirror of my own pasteboard; create a mirror of my own map
   - Do same for someone else's shared battle board (in shared Products).
   - Create a clone of my own pasteboard; create a clone of my own map
   - Repeat above to get clone of someone else's pasteboard and map
   - Show where to set the default permissions for work products you create from now on.
   - Give collaboration privileges on your own map to "1:3_Intel"

10. Create and use data
    - Create these new data elements and set data attributes (event, unit, geo-Stickie)
      - Create a new IED Event; define its basic attributes and place it on your map.
      - Create a new BTN-sized Unit, define its basic attributes and place it on your map
      - Find the Effort that contains the Event and the Unit and place a mirror of the Effort on your sub-pasteboard
      - Place a mirror of the unit on your sub-pasteboard and Mark the Unit (any color)
      - Center the map on the Event's location.

11. Use Efforts
    - Find the Pushkino Infrastructure effort and add it to your map
    - Place a mirror of the Pushkino Infrastructure Effort on your sub-pasteboard.
    - Display the Pushkino Infrastructure sub-Efforts in your map's Effort List
    - Use the Monitor button to display the contents of the Power effort on your map
    - Hide all the Pushkino Infrastructure sub-efforts in your map's Effort List
    - Create a new Effort, name it "My Data" and place it on your sub-pasteboard.
    - Move your BTN-sized Unit and Event into the "My Data" Effort.

12. Associations and Hide/Show
    - Zoom out to the Caspian Sea so you can display the 3ID unit on your map.
    - Display all the BTNs 2-levels down within the 3ID unit.
    - Hide all the "children" of the 3ID unit.
    - Create a sub-unit within the unit you created earlier,
    - Display that unit on your map.

    Tasks and Schedules
    - Add a scratch schedule to your pasteboard
    - Place your BTN-sized unit into the resources column of the Scratch Schedule
    - Create a new maneuver task for a Cordon & Search and give it a geographical location on your map.
    - Mirror your new Task into the Scratch schedule and assign it to the unit in your scratch schedule; Make the task at least 4 hours long and plan it occur sometime in December.
    - Use ink to draw an area within which the Cordon & Search will take place. Move the ink into the "contains" region of the task. Display the ink on the map.

13. Events Table, Event Chart, and Data Analysis
    - Create two new Efforts named "IED" and "Mortar"
    - Pull out the Events Table from the Frame Dispenser.
    - Using the Events Table and select all the events of type "IED"
    - Ctrl-drag a mirror of these events into your "IED" effort.
    - Using the Events Table and select all the events of type "Mortar"
    - Ctrl-drag a mirror of these events into your "Mortar" effort.
    - Mirror these Efforts onto your map and turn their contents on using the green "Monitor" button
    - Pull out a new Event Chart from the Frame Dispenser and nest it into your pasteboard
    - Mirror the two efforts into the Event Chart and display all their contents on the timeline.

14.     Collaboration
- Place a mirror of your Pasteboard into the "Drop box" effort in Shared Products.
- Create a clone of the Battle Captain's battle board and view his tabbed work products without affecting him or others users views.
- Flashlight on the map on the Battle Captain's battle board.
- Give "1:3_CDR_T" Content permissions (privileges) to one of the Stickies on your Pasteboard

PAL Skills

(Only non-Commander participants should complete this part)

15.     PAL Tools
Create a new Pasteboard, name it "PAL Tools" and nest these objects into it:
- PAL tool, Activity Manager, Trigger Palette

16.     Simple Procedure
- Create a simple procedure that places a green Stickie titled with your CPOF username and the current DTG on your desktop. Name the procedure – "Simple Popup".

17.     Stepped Procedure
Create a procedure with steps (using the PAL Handout as a Reference):
- Create a simple procedure with 2 steps.
- Place a breakpoint at Step 2.
- Set the "global state' of your PAL tool to "Stop at Breakpoints"
- Test your procedure
- Demonstrate your procedure, to show that it stops at Step 2 and then run the procedure to completion

18.     Area Trigger
(Using the PAL Handout as a reference) Create an Area Trigger for the entire 1:3 BCT AO that watches the "Test SIGACTs" Effort (found within the Drop box Effort in Shared Products) for newly added items.
- Have your Trigger run the "Simple Popup" procedure, but change the procedure so that the Stickie displays the Name of the newly added item.
- Demonstrate the procedure