

Development and Assessment of Battlefield Visualization Training for Battalion Commanders

Scott B. Shadrick
U.S. Army Research Institute
Fort Knox, KY 40121
Scott.shadrick@us.army.mil

Dennis K. Leedom
Evidence Based Research, Inc.
Vienna, VA 22182
dkl-texas@suddenlink.net

James Bell, David Manning
Dynamic Research Corporation, Inc.
Fort Knox, KY 40121
Jbell3@drc.com, dmanning@drc.com

Carl W. Lickteig
U.S. Army Research Institute
Fort Knox, KY 40121
Carl.Lickteig@us.army.mil

Keywords: Visualization, battle command, training, human performance

ABSTRACT

Visualization—the art and science of developing situational understanding, determining a desired end state, and envisioning how to move the force from its current state to the desired end state—is critical to successful battle command. Unfortunately, the most common method of training battle command in today’s Army is not the most effective method for developing expert visualization skills. Recent research on expertise indicates that experience alone, be it real or in simulated battle, is not adequate (Shadrick, Lussier, & Fultz, 2007). Instead, expertise is more likely to be attained through a combination of education, training, practice, and experience. For those reasons, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) initiated an analysis to better understand how expert battalion commanders visualize battlefields, and to develop a structured, theme-based training program. Results of that analysis revealed four distinct dimensions of visualization (Build, Synchronize, Assess, and Exploit) and seven associated skills. The dimensions and skills provide the framework for *End State: Commander Visualization at the Battalion Level*. *End State* is an interactive training program designed to provide field grade officers and battalion commanders with education, training, practice, and experience in battlefield visualization. The training uses 3-dimensional animated coaches to relay the knowledge and perspectives of expert commanders and to provide immediate performance evaluation and feedback. In this paper, we discuss an analysis that led to the visualization framework and skills, the development of *End State* training, and the results of initial tests of *End State* with battalion commanders.

ABOUT THE AUTHORS

Dr. Scott B. Shadrick is a Team Leader and Senior Research Psychologist for U.S. Army Research Institute at Fort Knox. He has conducted research on the acceleration of adaptive performance in tactical thinking skills, training/instructional systems design and evaluation, cognitive task analysis and knowledge elicitation techniques, performance assessment, and leader development. He is currently conducting research to understand and develop training for visualization skills at the battalion level. He received a B.A. degree in Psychology from the University of South Florida, a M.A. in Industrial/Organizational Psychology from Western Kentucky University, and a Ph.D. in Technology Management (Training) from Indiana State University.

Dr. Dennis K. Leedom is a Senior Scientist with Evidence Based Research (EBR). During his 36 year career with the U.S. Department of Defense, Dr. Leedom has led numerous research projects and organizations dealing with military command and control—including serving as the Senior Science advisor to the U.S. Army’s III Corps. Since joining EBR in 2001, his research on organizational sense making has focused on developing advanced knowledge management theories and analytic tools for collaboratively maintaining operational awareness and understanding of modern adversaries in a complex and emergent battlefield environment.

LTC (ret.) Jim Bell is a retired U.S. Army lieutenant colonel who served 22 years as an Armor Officer. He has conducted extensive research and analysis on collective and individual training requirements for U.S. Army units at

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 01 DEC 2008		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE Development and Assessment of Battlefield Visualization Training for Battalion Commanders				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) u.s. Army Research Institute Fort Knox, KV 40121				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 12	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

brigade and below. He has also conducted extensive research on developing cognitive skills for training visualization. He received his undergraduate degree from The Citadel and is a graduate of the Army's Command & General Staff College.

LTC (ret.) David Manning is a retired U.S. Army lieutenant colonel who served 22 years as an Armor Officer. He has conducted extensive research and analysis on collective and individual training requirements for U.S. Army units at brigade and below. He received his undergraduate degree from Texas A&M University and a Masters degree in Human Resources and Training Development from the University of Louisville.

Dr. Carl W. Lickteig is a Team Leader and Research Psychologist for U.S. Army Research Institute at Fort Knox. Since receiving a Ph.D. in Experimental Psychology from the University of Louisville in 1984, his work has focused on design, use, and application of digital technologies to complement human performance. His current work includes developing a companion training program on Company Commander's Visualization and a research program on unit training.

Development and Assessment of Battlefield Visualization Training for Battalion Commanders

Scott B. Shadrick
U.S. Army Research Institute
Fort Knox, KY 40121
Scott.shadrick@us.army.mil

James Bell, David Manning
Dynamic Research Corporation, Inc.
Fort Knox, KY 40121
Jbell3@drc.com, dmanning@drc.com

Dennis K. Leedom
Evidence Based Research, Inc.
Vienna, VA 22182
dkl-texas@suddenlink.net

Carl W. Lickteig
U.S. Army Research Institute
Fort Knox, KY 40121
Carl.Lickteig@us.army.mil

INTRODUCTION

U.S. Army doctrine describes battle command as the exercise of command in an operation against a hostile, thinking, and adaptive opponent (Department of the Army [DA], 2008). Battle command encompasses assigning missions; prioritizing and allocating resources; selecting the critical time and place to act; and knowing how and when to make adjustments in an on-going operation. In addition, battle command includes visualizing the current state and the desired end state, then formulating concepts of operation to get from the current state to the end state. Visualization results when commanders understand the higher commander's intent, their assigned mission, the operational environment, the enemy's intent and purpose, and the friendly force's capabilities and limitations. Battlefield visualization includes the commander's view of what his forces will do and the resources needed to accomplish the mission.

Success in an operation can often be attributed to the commander who has a better mental "picture" of the terrain, enemy, and friendly forces. The U.S. Army is trying to enhance a commander's ability to visualize an increasingly more complex environment as it continues to pursue advanced technologies and operational concepts. Network-enabled battle command systems, for example, will give future commanders an information advantage critical to successful performance. The new systems, tools, and automation initiatives may enhance a commander's ability to visualize the battlefield. Systems will not, however, replace the need for the commander to clearly understand the situation and to visualize the operation. As General Wallace (2005) wrote, no matter how sophisticated the new network-enabled battle command systems of the future might be:

... there is no situational understanding until the commander applies his skilled judgment, and that of his staff, to interpreting the display in the context of

the mission and visualization of the end state of the operation. Because there are always gaps and inconsistencies in information, the commander must use his or her 'mind's eye' to determine what displays mean. Inevitably, even with net-centricity, there is less information than one would like to have. Filling in gaps is a function of command, enabling an experienced commander to navigate gaps using his or her experience to identify feasible solutions in a time-critical environment. (p. 4)

New battle command systems, therefore, will not greatly change the underlying cognitive behaviors a commander must perform to achieve mission success. The underlying human behaviors will remain relatively consistent. To improve a commander's ability to visualize, our Army must pursue training and leader development opportunities to improve the cognitive behaviors associated with visualization skills. To address the challenging visualization requirement, the U.S. Army Research Institute (ARI) initiated research to understand and train commander's visualization at the battalion level.¹

The paper begins with an overview of commander's visualization, and a review of military and behavioral literature. Next, practical guidance on commander's visualization is reported from commanders deployed to Afghanistan and Iraq who participated in a cognitive task analysis (CTA). The paper then examines how the results of the CTA—an identified set of visualization principles and skills—were structured and integrated into multi-media training products. Finally, an evaluation of the training is summarized.

Commander's Visualization

Commander's visualization is the guiding and indispensable force in military operations and the

¹ ARI is also developing training to support commander's visualization at the company level.

cornerstone of a commander's expertise. Visualization, the ability to think and create in mental images, is the core mental process commanders use to make decisions (DA, 2003a). It is the process by which commanders: develop a clear understanding of the current state; envision a desired end; and determine a sequence of activity to achieve the end state.

Army doctrine and command practice assert that the commander's vision is framed by the factors of Mission, Enemy, Terrain, Troops, Time, and Civilians (METT-TC). Commanders also draw on the principles of war, the tenets of Army operations, and particularly their own experience and judgment to form an understanding of the situation and to visualize the operations required. Commanders utilize other operational variables (political, military, economic, social, information, and infrastructure plus physical environment and time [PMESII-PT]), to develop an understanding of each METT-TC factor. But, that alone, is not sufficient for envisioning their interactions, in particular the interactions among friendly, enemy, and civilians within the environment.

Commander's visualization is a continuous process, which begins in planning and is repeatedly updated until the force accomplishes its mission. Visualization is the commander's essential means of assessing and adjusting operations. By continually confirming or modifying their vision, commanders determine when and where to make a decision, as well as what decisions are needed (DA, 2003b).

On a more personal level, the commander's vision helps lead and motivate the force. It convinces Soldiers their commander sees and understands the enemy in a manner that strengthens and secures their course of action. As the visualization forms and evolves during an operation, it is frequently described and shared to revise how ongoing actions and resources must be directed to accomplish the mission. It is the process of sharing and shaping visualizations that links collective thought to collective action.

Visualization Challenges

Caveats abound on the many potential problems in forming and communicating the commander's visualization (DA, 2003b). Commanders base their visualizations not only on facts, but also on their interpretation of them; not only on their observations, but also on the observations and interpretations of others. Invariably, the higher the commander's level, the more removed the commander is from the situation, from direct observation.

A related problem is that while high-technology displays extend the commander's vision far beyond line-of-sight, the information and images displayed may appear more reliable and timely than they are (Wallace, 2005). As the amount of information expands, and time to process it contracts, reports tend to lack significant details or contain hasty errors. More distortion and delay is added by the process of sharing information and visualizations across the many persons and echelons required for collective enterprise.

In myriad ways, commanders must counter these and many additional problems in visualizing operations. In particular, expert commanders base their decisions on information from as many sources as possible. They exploit all available assets to proactively gather the information and intelligence needed to best determine what the enemy will do, when and where. However, despite all resources available, commanders must rely ultimately on their *own* visualization. Only the commander makes the decisive "read" through fog and friction that commits the force toward peril and the end state, as Wallace (2000) stated:

My notion is just sit down and think. I tell my folks that you must do that. The night before the fight, go sit in your vehicle with the map. Tell your driver to not let anyone bother you. Sit there with a cup of coffee, and just kind of map out to yourself. Think about how you expect the enemy will come, and importantly, what you are going to do about it. (p. 11)

Challenges to training visualization today only intensify due to: unpredictable threats, a multitude of interagency and multinational considerations, an endless stream of technology insertions that result in more complicated systems, and increased "turbulence" in personnel, organization, and doctrine. Unfortunately, current methods for training visualization skills are not sufficient. Too often "training" equates to placing commanders in a realistic situation and hoping they "figure it out."

The commander's ability to visualize is a human performance requirement. Yet, research on the development of expertise clearly indicates that "train as you fight" immersion in fully simulated and realistic battles is neither the most effective nor efficient method of developing expertise (Ericsson, 1996). In most domains, expertise is not a happenstance; nor the result of incidental, discovery, or experiential learning. The development of expertise generally requires highly structured and focused learning methods that progressively mold and hone performance to match expert models. To help train commander's

visualization, two key research issues were examined. How do experts visualize? How do you train visualization?

HOW DO EXPERTS VISUALIZE?

To understand how expert commanders visualize operations, we conducted a cognitive task analysis of visualization skills and expertise at the battalion level (Leedom, et al., 2007). Analysis included reviews of military and behavioral literature coupled with interviews of military experts. The goal of the analysis was to identify the underlying cognitive behaviors expert battle commanders exhibit during visualization of dynamic battlefield environments.

Military Literature

Doctrinal literature identifies several characteristics that can serve as a guide for identifying and articulating visualization skills at different tactical levels of command. These characteristics include:

- Visualization purposefully frames actions and links them with understanding and intent. Visualization serves to frame and identify actions that can be taken to move the battlefield toward a set of objectives, goals, or desired end states.
- Visualization is synchronized horizontally across the commander and staff who each contribute to its construction and maintenance.
- Visualization balances intuition with deliberate reasoning in response to operational constraints such as time and commander's experience.
- Visualization is structurally framed by Army doctrine to provide a common understanding that specifies and organizes the elements of knowledge that traditionally comprise an effective operational plan.
- Visualization is multifaceted and multilevel, matched to the dimensions of operational complexity faced in modern military operation that ranges from short-term combat and security operations to long-term stability and counterinsurgency operations with political, economic, and social dimensions.
- Visualization is collaborative to achieve unity of effort across the multitude of units, teams, and agencies that impact the operation.
- Visualization is continuously dynamic, adjusted in response to friendly actions, unforeseen civilian considerations, and unpredictable enemies.
- Visualization is part of a larger mental process; it supports a larger planning and execution process that combines visualization, description, direction, and assessment to translate understanding into action.

Taken together, these eight characteristics of visualization provide a basic framework for examining how visualization skills might be improved through training. However, these characteristics are general in nature and do not convey the complex challenges of visualization faced by tactical commanders in Afghanistan, Iraq, or other operational environments. To begin to understand these challenges at a deeper level, we must turn attention to the specifics of modern stability and counterinsurgency operations.

Military literature contends that visualizing and conducting stability operations requires the same general skills and processes as traditional offensive and defensive operations (DA, 2001). However, doctrine also stresses that there are unique characteristics of stability operations that commanders must envision. They include:

- Stability operations are political. Achieving the desired political end state is often more challenging than achieving the desired military end state.
- METT-TC applies differently in stability operations where the "enemy" is ambiguous and the "mission" may change rapidly from conducting lethal combat to non-lethal stability operations.
- Key "terrain" is often based on political and social factors, not physical features of the landscape.
- "Troops" may include host nation police and army elements, contracted interpreters and laborers, and multinational partners versus an integrated force.
- Achieving goals in stability operations requires perseverance, maybe years. Civilian considerations and organizations are critical to achieving the goals.

The increased complexity and ambiguity of stability and counterinsurgency operations taxes the commander's visualization process in countless ways. The commander may, for example, need to envision a three-block war that entails engaging insurgents in one block, quelling civilian protests in another, and conducting humanitarian assistance in a third (Krulak, 1997). In addition, the Contemporary Operational Environment (COE) is multidimensional (DA, 2003a). Threats may emerge suddenly (Kilcullen, 2006) and may come from any direction (on the ground, on top or within structures, underground, or from the air). These characteristics suggest the need for commanders to consider a number of additional factors in their planning and execution of stability operations.

Behavioral Literature

Behavioral literature examined the visualization process from cognitive, social, and ecological perspectives. The cognitive level focused on the internal mental structures and processes commanders

use to develop a framework of understanding; the social level, mechanisms by which commanders identify and use other sources of expertise to augment and refine their understanding; and the ecological level, ways in which thought and action mutually influence one another over time (Leedom, et al., 2007).

Cognitive Perspective

Visualization is the mental process of linking intent with action within a constructed problem space. As shown in Figure 1, visualization involves the selective retrieval of data elements from the environment, the activation of relevant tacit knowledge or mental models from the individual's experience, and the mental integration of these data and frameworks to form focal knowledge (Polanyi, 1962). Here, focal knowledge represents the "current understanding" of the problem space in terms of high-level objectives and operational realities. It is the framework used by the commander to envision and commit to specific actions.

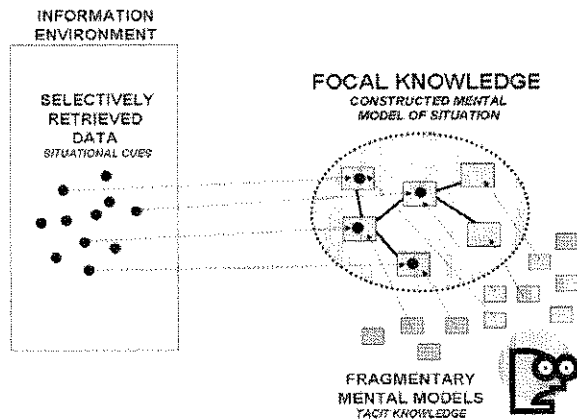


Figure 1. Visualization as the Construction of Focal Knowledge.

While Army doctrine can guide this mental process through mnemonics such as METT-TC and the elements of operational design, it cannot prescribe "cookbook" solutions for constructing and linking the set of mental constructs. Such devices merely serve to direct the commander's attention to different aspects of the problem space.

How the commander constructs this framework has been investigated by Sieck, Klein, Peluso, Smith, & Harris-Thompson (2004). Essentially, this process involves the activation of specific mental model fragments—based upon the commander's experience and expertise and the recognition of relevant triggering cues from the operational environment. Once activated, mental model fragments provide a basis for interpreting

other pieces of information about the commander's information environment. Available information is then used to validate the activated mental models, fill in missing features, or initiate a search for a more relevant model. Overall, this process is iterative in nature, with the goal being to find a set of mental model fragments and information elements that cohere—that are consistent and mutually reinforcing of one another. In a more formal manner, the so-called "data/frame" model of Seick et al., involves a number of different mental processes that serve to maintain a consistent understanding of the current situation.

The data/frame model primarily deals with familiar situations in which the individual possesses relevant experience and expertise to deal with the problem space. However, this is not always the case in many real world situations where a known problem calculus cannot be applied. To address this broader visualization challenge, the individual must first characterize the level and nature of disorder being faced. Then, depending upon the type of situation at hand, the individual adjusts the framing cycle. Based on the inherent degree of order, Kurtz and Snowden (2003) offer a quadratic classification system of Known, Knowable, Complex, and Chaos situations. A key tenet is that each situation requires, or is best understood, by employing different ways to form the commander's visualization.

Known situations, for example, might be often repeated Cordon and Searches against a suspected terrorist safe house. The process of visualizing the mission might be bound by a familiar set of tactics, techniques, and procedures (TTPs) with an emphasis on obtaining actionable intelligence. Complex or novel situations, however, might require a focus on detecting and interpreting meaningful patterns or links. The commander may need to probe the situation to discover patterns or links before being able to determine what actions are needed to disrupt undesirable patterns and foster favorable ones.

Arguably, military training and practice are not adequately geared toward more complex and chaotic situations (Kurtz & Snowden, 2003). Kurtz and Snowden relate a case in which a group of Marines went to the New York Mercantile Exchange and competed against professional traders in a simulated trading environment. Of course, the traders always won. But when the traders visited Quantico and competed in simulated war games against the Marines, they won again. One interpretation is that traders were skilled at spotting and shaping patterns amid disorder, while Marines were trained to collect and analyze data in order to make rational decisions in an orderly world.

Regardless of how it is accomplished, the mental goal of visualization is to develop a set of conceptual pathways that link intent with action. As the operational situation evolves, commanders are able to continually adjust execution decisions with reference to the current and end state. The visualization serves as a roadmap or guide for maintaining unity of purpose and synchronization across the various elements of the operation. If this visualization space is not explicitly expressed and maintained, the commander runs the risk of myopic attention on moment-to-moment actions while losing sight of the “bigger picture” involved in achieving mission success.

Social Perspective

Typically, visualization is regarded as a cognitive process occurring within an individual. However, battalion success hinges on its ability to achieve shared understanding and unity of purpose despite social structures, processes, and barriers that often curtail collaboration. The commander and supporting staff play unique and complementary roles in the visualization process. The commander establishes a framework for this process and articulates his or her vision through commander's intent, planning guidance, and critical information requirements. The staff elaborates and translates this vision into causal mechanisms and pathways to the end state through knowledge products such as Intelligence Preparation of the Battlefield (IPB), Intelligence, Surveillance, and Reconnaissance (ISR) Plan, Running Estimate, and Course of Action Briefings. This more detailed knowledge is developed through collaboration across the commander's personal, coordinating, and special staffs. Each focuses on specific aspects of the commander's visualization space. The effective ability of these groups to create shared understanding and unity of purpose minimizes barriers to collaboration across cognitive, social, organizational, and technical domains.

For visualization skill development, we looked beyond the individual and address management skills needed to organize, maintain, and sustain this social process. Visualization synchronizes the knowledge elements and associations internally across different levels of thinking and assessment by the commander and staff. It synchronizes externally across different stakeholders and players relevant to the operation. Within the commander's immediate chain of command, this includes synchronization across warfighting functions. Beyond the immediate chain of command, this includes synchronization across the perspectives of other Joint/Coalition military forces, other government agencies, and key civilian political and administrative leaders with whom the commander must collaborate.

Ecological Perspective

Visualization is not the passive process of fitting available information into an experience-based framework of interpretation. Instead, organizations actively engage their operational environment to both (1) shape real world events and states in conformance with the organization's vision and (2) probe and reveal additional aspects of the operational environment for subsequent advantage. An organization's active engagement (*i.e.*, enactment) of the operational environment is a relevant strategy to pursue in the complex and chaotic disorder that permeates stability operations (Kurtz & Snowden, 2003).

Shaping actions serve to conform the commander's operational environment to the envisioned problem space. They also help reduce the number of unknowns and risks. Probing actions are particularly useful in complex operational environments where the commander is unable to apply a known battle calculus. Probing actions illuminate additional elements and linkages that can be exploited for an operational advantage. However, for probing actions to be effective and productive, they must be combined with deliberate analysis. Thus, the ecological aspects of visualization require the commander to establish meaningful measures of effectiveness (MOE) that focus on results and consequences of unit actions. Measures assist in determining if actions are appropriate, or if different or alternative actions are required. Measures also link the outcome of actions with the operational purpose, focus, and system effects established by the commander.

Battlefield visualization is typically associated with operational planning within the Military Decision Making Process (MDMP). However, visualization also serves an important role during execution. During execution, effective visualization enables the commander to track key problem elements and lines of effort over time to identify meaningful patterns or trends and to maintain unity of purpose for long-term mission objectives. This involves the development of a Running Estimate, the staff's continuous assessment of current and future operations to determine (1) if the current operation is proceeding according to the Commander's Intent and (2) if future operations are supportable. It allows the commander to identify key variances with respect to forecasted events, and to appropriately adjust actions to maintain unity of purpose. Without steady reference to the content and structure of the visualization space, the commander may become mentally absorbed in moment-to-moment operations and lose sight of the bigger picture.

Expert Interviews

We conducted Interviews with 25 brigade and battalion command and staff personnel followed by interviews with instructors from the Command and General Staff College and Fellows from the U.S. Army's School for Advanced Military Studies. The participants ranged from majors to colonels. All had recent experience in battalion command or battalion/brigade staffs in Afghanistan or Iraq. They could deliberately reflect on those experiences and their implications for leader development. Participants received a read-ahead package that prompted them to think about the types of skills required for battlefield visualization.

The "lessons learned" from the interviews focused on the great challenges commanders face in visualizing military operations in the COE. Almost unanimously, participants stated that understanding and visualizing stability and counterinsurgency operations in Afghanistan and Iraq was one of the most difficult tasks in their military careers. Some key challenges were:

- Civilians are the center of gravity and visualization must address the non-lethal lines of operation that influence civilians.
- Stability operations have immediate and long-term timelines that require commanders to visualize and reconcile often conflicting consequences.
- The prolonged nature of stability operations makes it difficult for commanders to maintain vigilance on the current state and progress toward the end state.
- The MDMP is often abandoned in counterinsurgency operations in favor of more ad hoc planning.
- The elements of operational design need to be extended down to the tactical level of visualization in stability operations (current doctrine associates these elements primarily with operational level visualization).

Similar lessons are increasingly documented in more recent counterinsurgency literature and doctrine (DA, 2007). However, many of the participants interviewed stated they did not have specific training on counterinsurgency issues. They arrived in theater without a solid mental model to visualize operations in their area of operation and, therefore, learned to cope with unfolding events through "on the job training." Participants also reported little use of some key conceptual frameworks in Army doctrine such as MDMP, PMESII-PT, and the elements of operational design.

HOW DO YOU TRAIN VISUALIZATION?

Based on the CTA findings, four skill domains and seven underlying visualization skills were identified, as shown in Figure 2. The four skill domains address the need to Build, Synchronize, Assess, and Exploit the commander's visualizations (Leedom, et al., 2007).

Build represents the ability to construct a coherent and comprehensive visualization in accord with doctrinal guidance (DA, 2003a). Synchronize reflects the ability to share and integrate visualizations internally and externally. Assess reflects the ability to effectively gauge execution progress and proactively refine the visualization. Exploit reflects the ability to maintain operational agility and momentum by advantaging emerging opportunities and deterring emerging threats. Each skill reflects the commander's ability to link intent to action.

For each of the seven visualization skills, the CTA developed target performance criteria to assess skill acquisition during training. For instance, two of the six performance criteria for Skill 1, Identify tactical problems using the factors of METT-TC and Elements of Operational Design, are:

- Use factors of METT-TC and Elements of Operational Design to interpret and frame the problem elements across the unit's tactical and operational environment.
- Develop and communicate Commander's Intent and Planning Guidance.

As the CTA identified seven discrete skills, learning chunks tailored to each skill became a training design requirement. Other design requirements were to specify the tasks and learning objectives associated with each skill. Different kinds of skills often require different kinds of training. For example, for some perceptual tasks, the training might present very little theoretical background, but create lots of practice exercises where accuracy and speed of performance are essential (Fadede, 2006).

As tasks become more cognitive in nature, the instruction requires more complex cognitive challenges (Cooke, 1994). As such, the visualization process that is taught needs to help commanders learn and integrate higher-order cognitive skills. Therefore, exercises were developed that required learners to review a complex set of data, consider complex processes, and make decisions in complex situations.

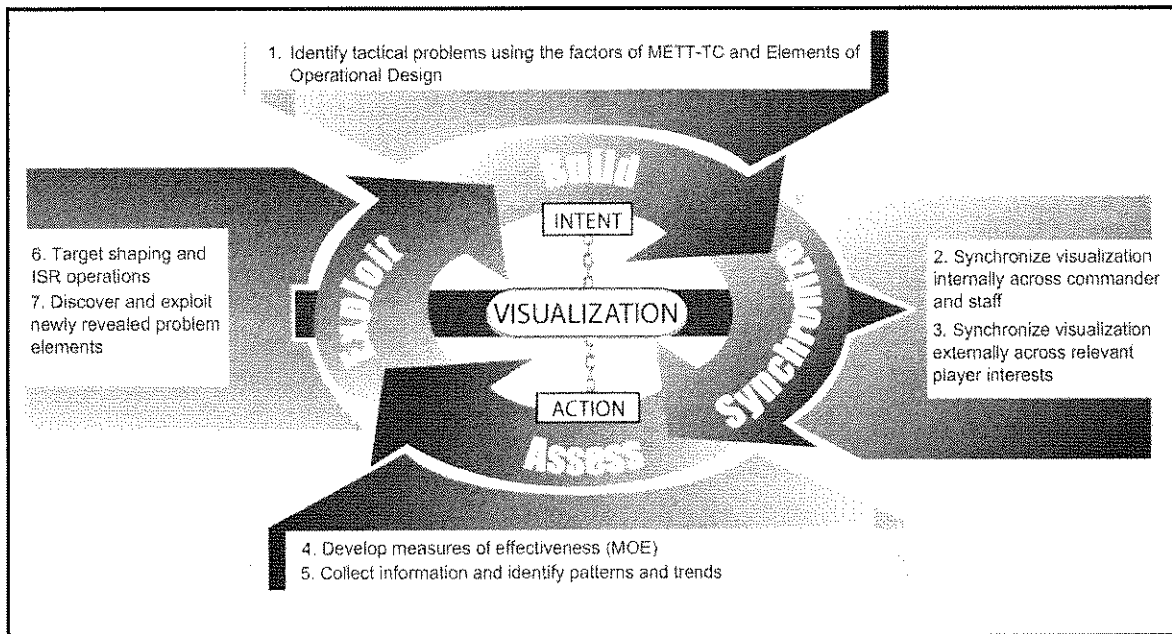


Figure 2. Visualization Framework and Associated Skills

For training complex cognitive skills across realistic situations, we used a set of instructional theories and approaches based on a common theoretical viewpoint. One of these instructional approaches was deliberate practice (Ericsson, Krampe, & Tesch-Roemer, 1993; Ericsson, 1996). In a separate example of deliberate practice training, learners were first provided the principles representing expert behaviors, and then given multiple practice opportunities to apply the behaviors (Lussier, Shadrick, & Prevou, 2003). Initially, the practice sessions were short and focused drills, with clear and immediate feedback, followed by more extended practice opportunities to overcome diagnosed skill deficiencies.

For *End State*, the instructional approach used the following deliberate practice components:

- Learners are provided the principles they need to apply; they are not left to discover the principles on their own.
- Learners apply the principles to real-life situations. Initially, the practice sessions are focused on isolated skills that are challenging but not overwhelming.
- Learners receive feedback, often by comparing the solutions they develop with more expert solutions.
- After learners solve a problem, the next problem is designed to further progress skill development.

END STATE TRAINING PROGRAM

End State: Commander's Visualization at the Battalion Level is a multi-media, interactive training program to

improve the visualization skills of field grade officers, battalion commanders and staffs. The training is situated in Iraq and provides supporting materials such as Introduction to Visualization, Road to War, Rules of Engagement, and a Battalion Update Brief. The actual training package includes 14 scenario-based training and practice exercises in vignette format. *End State* also includes a pre-test and post-test in vignette format. Throughout the training, learners observe exemplar performance of the seven expert visualization skills performed by 3-dimensional animated role models (see Figure 3) who convey the knowledge and perspective of expert commanders. Learners observe and then apply visualization skills across a spectrum of stability and counterinsurgency vignettes during which they receive immediate and instructorless performance feedback and evaluation.

Measurement is essential to training. Each training vignette provides training objectives and guidance, diagnoses performance difficulties and deficiencies, and assesses skill acquisition based on specified performance criteria. However, direct observation and objective measurement of performance is often difficult in military settings, especially commander's cognitive performance. The unpredictable and asymmetric COE along with the expanse of information and complexity in network-centric operations further complicates commander's visualization and its measurement. The training's approach to measurement helps to mitigate such challenges by exploiting the use of deliberate practice

methods situated in highly structured vignettes. The vignettes deliberately embed informational cues and triggers of varying utility—critical, useful, irrelevant, ambiguous, and misleading—and then ask participants to identify or assess the cues and triggers, or task participants to respond to problems posed in the vignette.

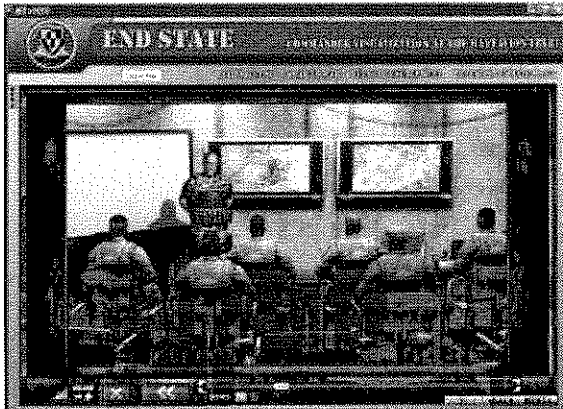


Figure 3. Screenshot from *End State Training*

The expert guidance and feedback needed for the training is drawn from: the expertise obtained in the CTA interviews; the U.S. Army's extraordinary ability to rapidly gather, structure, and distribute lessons learned (e.g., Center for Army Lessons Learned); and, in-stride counsel and review of all training design and development phases by active duty and reserve personnel and military instructors. The presentation formats used to convey expert guidance and feedback employ "authentic" mentors, instructors, and Soldier role models.

END STATE TRAINING

Formative assessment of the *End State* training program by military subject matter experts addressed the training approach, the visualization framework (Build, Synchronize, Assess, and Exploit), and the seven visualization skills. Training effectiveness assessment was conducted with an experienced group of battalion commanders.

Method

For formative assessment, the group consisted of four Majors from a brigade staff, three new battalion commanders, and one new brigade commander. The officers evaluating the training materials were informally interviewed before, during, and after the training to provide feedback on the different aspects of the training package.

For training effectiveness assessment, the group consisted of six battalion commanders and one brigade executive officer. Prior to accessing any of the training materials, participants completed a pre-training Visualization Confidence Inventory. The confidence inventory was part of a 360-degree assessment of the commander's ability to visualize the battlefield and was used to establish baseline performance measures. Next, the commanders completed the pre-test assessment vignette which addressed all seven visualization skills. After reviewing supporting materials, each participant completed at least four vignettes encompassing two of the four expert skill domains. For each visualization skill in the two domains, the first vignette provided a detailed *demonstration* of how to apply the skill in a representative situation. The second vignette required the commander to *apply* the skill in a new environment. Once all the training vignettes were completed, the participants were given a post-training vignette and visualization post-test. The tests also assessed the commanders on all seven skills even though they may have only completed training on two skill areas. Finally, participants completed a post-training Visualization Confidence Inventory and a post-training survey.

Results

Across assessments, Soldier comments, ratings, and visualization performance supported the potential of *End State* as a valuable tool for training visualization. Participants' comments in the formative assessment stressed three main themes:

- *End State* addresses an important Army training need and it warrants refinement and implementation.
- The visualization framework (Build, Synchronize, Assess, and Exploit) was supported and most participants understood the skill dimensions and agreed with the training principles.
- The Road to War was on target and in many ways represented the environment experienced in Iraq.

Participants' ratings and visualization performance in the training effectiveness assessment were encouraging and informative. A comparison of participants' percent correct on pre-test ($M = 79.6$, $SD = 4.6$) versus post-test ($M = 87.8$, $SD = 4.9$) scores showed significant improvement on visualization performance (Wilcoxon's $Z = 2.533$, $p < .05$). Further analysis found that the pre- to post-test gains were largely in the assigned skill domains and associated skills experienced during training. That is, performance tended to improve on the skill domains trained but remained about stable on skills domains not trained. The results are encouraging considering the

participants were *experienced* battalion commanders rather than individuals more in need of training prior to taking battalion command.

Results for the pre- and post-training Visualization Confidence Inventory mirrored test results. Participant ratings indicated more confidence in their visualization abilities after their training. Table 1 presents the overall means for the pre- and post-test confidence ratings by skill domain. All ratings were on a five point scale, with 1 = "Not confident" and 5 = "Extremely confident."

Table 1. Visualization Confidence Ratings

Visualization Skill Domain	Mean Rating	
	Pre-Training	Post-Training
Build	3.89	3.92
Synchronize	3.96	4.05
Assess	3.37	3.76
Exploit	3.04	3.71

In the survey responses, the participant battalion commanders stressed that *End State* training has strong potential. One participant commented: "Scenarios were well done and realistic. I was deployed for a year in Kirkuk—you got it about right."

The training outcomes and participant feedback provide qualitative and quantitative support for the target performance criteria used to assess visualization skills during training. However, participants felt that the *End State* assessment questions could be improved by requiring the training participant to more directly apply each of the skills. Thus, while the performance criteria demonstrated face and content validity, the procedures used to assess performance could be improved.

CONCLUSIONS

U.S. Army doctrinal literature cites visualization as an essential part of battle command. Yet, despite the frequent reference to this skill, the concept of visualization lacked meaningful definition from either a cognitive, social, or ecological point of view. Lacking such a definition, it becomes difficult to characterize "good" visualization from that which is mediocre or inadequate. Without the ability to characterize specific performance goals, training or developing this skill in future commanders remains problematic.

What was missing was a structured way to deliberately train and measure the cognitive behaviors associated with commander's visualization skills. The results of the CTA made it clear that visualization by battalion commanders and their staff is a very complex cognitive process. Further, expert performance of battlefield visualization often involves very complex data with automatic processing that leads to quick analysis and decisions. The visualization process that is taught needs to help commanders learn and integrate higher order cognitive skills. Exercises must require that learners encounter a complex set of data, consider complex processes, and make decisions in complex situations.

The ability to visualize is an essential attribute that is critical to mission accomplishment. Currently, visualization is learned through a trial-and-error process with very few, if any, opportunities for formal training and instruction. That notion was confirmed in interviews with officers returning from Iraq and Afghanistan. Based on the results of the CTA, an instructional process and exemplar training products were developed. Results of the CTA underscore the need for improved training to visualize the increasingly complex and unpredictable operations our Soldiers face. Results of the training effectiveness assessment indicate that *End State's* visualization framework and training approach are a solid foundation for improving commander's visualization.

REFERENCES

- Cooke, N. J. (1994). Varieties of knowledge elicitation techniques. *International Journal of Human-Computer Studies*, 41, 801-849.
- DA. (2003a). *Mission Command: Command and Control of Army Forces*. (Field Manual 6-0). Washington, DC.
- DA. (2003b). *Urban Operations*. (FM 3-06). Washington, D.C.
- DA. (2007) *Counterinsurgency*. (Field Manual 3-24). Washington, DC.
- DA. (2008). *Operations*. (Field Manual 3-0). Washington, DC.
- Ericsson, K. A. (1996). The acquisition of expert performance. In K. A. Ericsson (Ed.), *The road to excellence* (pp. 1-50). Mahwah, NJ: Erlbaum Assoc.
- Ericsson, K. A., Krampe, R. T., & Tesch-Roemer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, 100, 363-406.
- Fadade, P. (2006, April). *Interactive video training of perceptual decision-making in the sport of baseball*. Presented at the meeting of the American

- Educational Research Association, San Francisco, CA.
- Krulak, C. C. (1997, December 15). The three block war: Fighting in urban areas. *Vital Speeches of the Day*, 64(5), 139.
- Kilcullen, D. (2006). Twenty eight articles: Fundamentals of company-level counterinsurgency. *Military Review*, 86(3), 103-109.
- Kurtz, C. F. & Snowden, D. J. (2003). The new dynamics of strategy: Sense-making in a complex and complicated world. *IBM Systems Journal*, 42(3), 462-424.
- Leedom, D. K., McElroy, W., Shadrick, S. B., Lickteig, C. W., Bell, J., Pokorny, R. A., Haynes, J., & Bell, J. (2007). *Cognitive task analysis of battalion level battlefield visualization process*. Arlington, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.
- Lussier, J. W., Shadrick, S. B., & Prevou, M. I. (2003). *Think Like a Commander prototype: Instructor's guide to adaptive thinking*. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.
- Polanyi, M. (1962). *Towards an Epistemology of Personal Knowledge*. Chicago, IL: University of Chicago Press.
- Shadrick, S. B., Lussier, J. W., & Fultz, C. (2007). *Accelerating the development of adaptive performance: Validating the Think Like a Commander Training*. Arlington, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.
- Sieck, W. R., Klein, G., Peluso, D. A., Smith, J.L., & Harris-Thompson, D. (2004). *FOCUS: A Model of Sense-making* (Technical Report No. 1435-01). Fort Knox, KY: United States Army Research Institute for the Behavioral and Social Sciences.
- Wallace, W. (2005). Network-enabled battle command. *Military Review*, May-June, 2-5.
- Wallace, W. (2000). Mentally preparing for the mission. In A. Frame & J. Lussier (Eds.), *66 Stories of Battle Command*, 11-13.