Creating JFACC Aces: Utilizing Cognitive Requirements to Develop Effective Training Simulations

Holly C. Baxter, Ph.D.
Klein Associates Inc.
Fairborn, OH
holly@decisionmaking.com

James R. Lunsford
MÄK Technologies
Leavenworth, KS
lunsford@mak.com

ABSTRACT

New training simulations are being developed at an increasingly rapid rate to improve skills ranging from piloting and driving proficiency to learning tactical decision making and logistics. While these training simulations often have high physical fidelity (the landscape, buildings, vehicles, and people look real), they often lack cognitive fidelity (the decisions people are making are not realistic). Developers commonly have a clear picture of the “what” that needs to be accomplished such as what tasks need to be trained. However, developers rarely address the “why” (why is this decision challenging?) and “how” (what information do you need to make this decision?) components in their simulations. This study used Cognitive Task Analysis (CTA) and Decision Requirements Tables (DRTs) to fill this gap. Through CTA we identified several cognitive training requirements of Joint Force Air Component Commanders (JFACCs). The results of CTA interviews with experienced JFACCs were analyzed and the critical decisions they identified, such as managing and prioritizing their activities associated with the air tasking order (ATO) battle rhythm or ATO cycle, were evaluated. JFACCs will often engage in numerous ATO planning processes concurrently, and given the limited time they have, they must be able to prioritize these critical tasks. DRTs were then used by the developers to create a training simulation that realistically replicated the stressful decision-making environment within a Joint Air Operations Center. Additional benefits noted by the developers were that the DRTs eliminated the need for multiple versions of the tool and reduced the time needed for modifications and repetitive testing. Finally, not only did the DRTs lead to reduced development time, they also led to increased training effectiveness.

ABOUT THE AUTHORS

Holly C. Baxter, Ph.D., is a Research Associate specializing in instructional design, evaluation metrics, organizational development, and training. Her research interests include knowledge management and all phases of cognitively-based training including cognitive needs analysis, design, development, implementation, and development of cognitive metrics for evaluating training initiatives ranging from classroom training to simulations. As a member of Klein Associates she has served as the project manager and technical lead on projects that include developing effective training for enhancing situation awareness, designing embedded training solutions for damage control personnel, developing evaluation metrics for simulation based training, identifying cognitive training requirements for Future Force environments, and using knowledge management tools to capture tacit knowledge in the field and turn that knowledge into effective just-in-time training. Prior to joining Klein Associates, Dr. Baxter developed a corporate training program for a large company from ideation to implementation. In addition, she has seven years of experience teaching at the University of Dayton and Indiana University. Dr. Baxter holds a B.A. in Communication from the University of Dayton, an M.A. in Organizational Communication and Training from Indiana University, and a Ph.D. from Indiana University in Organizational Communication and Management with a focus on Training, Instructional Design, and Organizational Development.

James R. Lunsford is a Senior Simulations Designer with MÄK Technologies. He graduated from the Virginia Military Institute in 1980 with a Bachelor of Science degree in Civil Engineering and from the U.S. Army Command and General Staff College in 1993 with a Masters of Military Arts and Sciences. He is actively involved in all military-related trainer projects at MÄK and is the lead designer and project manager for several tactical trainer development efforts including a time-sensitive targeting trainer and JFACC cognitive skills trainer for the USAF. Before joining MÄK in April 2000, he served as a U.S. Army officer for twenty years. Mr. Lunsford’s military experience included command and staff positions within numerous infantry units, a tour as an exchange officer with the British Parachute Regiment, and an assignment as a tactics instructor at the U.S. Army Command and General Staff College (CGSC). He created *Decisive Action*, a PC-based simulation of division and corps-level warfare that was used in Army Experiments 5-7, *Solo Warrior*, a division combat simulation, *The Military Map and Symbology Tutor*, and *Credible Force*, a SASO training simulation. *Decisive Action* was showcased at the Association of the U.S. Army Convention in 1998 as part of the Army Experiment 5 exhibit and received positive reviews in several commercial computer gaming publications. *Credible Force* was used in the classroom at CGSC as part of the Army Transformation Exercise in 2000.

Creating JFACC Aces: Utilizing Cognitive Requirements to Develop Effective Training Simulations

Holly C. Baxter
Klein Associates Inc.
Fairborn, OH
holly@decisionmaking.com

James R. Lunsford
MÄK Technologies
Leavenworth, KS
lunsford@mak.com

OVERVIEW

Currently, there is very little opportunity for Joint Forces Air Component Commanders (JFACCs) to learn their required skills prior to assuming command. Recent operations have demonstrated that most have to learn their skills on the job. Although only the best are selected to become JFACCs, few have the necessary depth of experience to assume their role without extensive preparation. The complexity of the JFACC's role exacerbates the problem because the JFACC usually wears more than one hat and has additional responsibilities beyond the scope of the JFACC role itself. Moreover, the JFACC has to interact with host nation leaders, joint and coalition partners, the Joint Force Commander (JFC), and other groups such as non-governmental organizations and relief agencies. A JFACC's job is very complex and involves a myriad of tasks, all competing for time. Although most JFACCs are comfortable with their warfighting tasks, few have experience in the other areas of responsibility.

Senior-level command and control (C2) leader training is currently accomplished through mentoring by senior leaders from prior warfighting operations. This type of approach is highly sensitive to scheduling and availability of mentors, is limited by their memory of specific actions and reactions during critical incidents, and is not always in context for the current conflict. A better, more uniform training approach is required.

Such an approach should include the use of a simulation training environment to enable JFACCs to learn and practice the skills they will need as well as the use of an efficient and effective Knowledge Management (KM) system that could provide appropriate archived data to support learning and decision-making. A simulation training environment is the most efficient way of providing appropriate challenges and expert scaffolding to improve cognitive skills. However, one downfall of many simulations is that they focus on physical fidelity while ignoring cognitive fidelity (Baxter, Ross, Phillips, Shafer, & Fowlkes, 2004). This means that while the physical environment may look realistic on the surface, it is missing the key cognitive cues needed to create a realistic decision environment. Another problem with simulations is that developers will usually have a clear picture of what needs to be trained, but rarely address the "why" (why is this decision challenging?) and "how" (what information do you need to make this decision?) components in their simulations. Being able to capture these types of cognitive components is vital to developing effective training (Baxter, Harris, & Phillips, 2004).

What JFACCs need in order to be prepared for their jobs is a simulation that trains them not only on the various skills they will need but also on what decisions will be challenging and how to successfully make them. The objective of this research was to identify the decision-making models associated with the JFACC and other senior leaders within the Joint Air Operations Center (JAOC) and to develop the framework for a senior leader cognitive training system and associated training simulation environment.

METHODS, ASSUMPTIONS, AND PROCEDURES

Our research was divided into three key parts:

- Develop initial high-level C2 cognitive requirements
- Determine training requirements and describe an instructional strategy
- Determine functional requirements for a training simulation

The first part of our research was to gain insight into the cognitive requirements of a JFACC. Cognitive requirements are the key cognitive decisions, in this case the decisions an effective JFACC needs to make during the critical 72-hour Air Tasking Order cycle (ATO) to be successful. Understanding the high-level cognitive requirements of an experienced JFACC is vital to understanding the training needs for the position. We used Cognitive Task Analysis (CTA) to do this.

Cognitive Task Analysis is the process of understanding the team or individual cognitive demands of a task. It provides a set of tools for eliciting and representing general and specific knowledge pertaining to a particular activity, in this case command decision making. The CTA leads the research beyond procedural knowledge and the behavioral aspects of the JFACC position into many of the cognitive aspects involved in the judgment, decision-making, and problem-solving skills that are so critical in JAOC environment. The purpose is to get inside the JFACC's head and try to understand the "cognitive map" that guides his or her decision-making processes. We must understand how both novice ("JFACCs of the future") and experienced JFACCs view their environments and also what critical cues, expectancies, and goals they require to make a quality decision in a specific context.

There are a number of specific knowledge elicitation tools with which to perform a CTA. We have found that no single method works well in all cases; the methods must be adapted to suit the needs of each domain based on the characteristics of the task, the characteristics of the operators, and the conditions under which they must perform the task. In this project, a Knowledge Audit (Klein, Calderwood, & MacGregor, 1989) was the primary method of CTA for eliciting expertise from former JFACCs.

The Knowledge Audit draws directly from the research literature on expert-novice differences (Chi, Feltovich, & Glaser, 1981; Dreyfus, 1972; Dreyfus & Dreyfus, 1986; Hoffman, 1992; Klein & Hoffman, 1993; Shanteau, 1985) and Critical Decision Method studies of expert decision making (Crandall & Getchell-Reiter, 1993; Kaempf, Klein, Thordsen, & Wolf, 1996; Klein et al., 1989; Klinger & Gomes, 1993; Militello & Lim, 1995). The Knowledge Audit has been developed as a means of capturing the most important aspects of expertise while streamlining the intensive data collection and analysis methods that typify studies of expertise. This elicitation technique is organized around knowledge categories that have been found to characterize expertise: diagnosing and predicting, situation awareness, perceptual skills, developing and knowing when to apply tricks of the trade, improvising, metacognition, recognizing anomalies, and compensating for system limitations. It employs a set of probes designed to describe types of domain knowledge or skill and elicit appropriate examples. The goal is not simply to find out whether each component is present in the task, but to find out the nature of these skills, specific events where they were required, strategies that have been used, and so forth. The list of probes is the starting point for conducting the interview. Then, the interviewer asks for specifics about the example in terms of critical cues and strategies of decision making. This is followed by a discussion of potential errors that a less-experienced person might have made in this situation. The examples elicited with the Knowledge Audit do not contain the extensive detail and sense of dynamics that those elicited with more labor-intensive methods such as the Critical Decision Method (Klein et al., 1989) incident accounts often do. However, they do provide enough detail to retain the appropriate context of the incident.

For this research effort, General Charles A. Horner, a retired JFACC, and General T. Michael Moseley, the current Air Force Vice Chief of Staff, participated as subject-matter experts (SMEs) and shared their experiences as JFACCs. General Horner was targeted to share his experiences as the master-architect of the air campaign against Iraq during Operations Desert Storm and Desert Shield. General Moseley's experiences as the Combined Forces Air Component Commander in Operations Southern Watch, Enduring Freedom, and Iraqi Freedom made him an invaluable asset to the goals of this project.

We analyzed the data collected from the Knowledge Audits of our SMEs using decision requirements analysis, a method for capturing the specific details of incidents gathered from SMEs. This analysis utilizes Decision Requirements Tables (DRTs), an organizing framework to categorize and highlight the key decisions or assessments in a given domain. Decision Requirements Tables incorporate features that show why a decision is difficult, factors that affect that decision, and strategies for improving how that decision is made. The individual decisions as well as the factors and strategies can be used in developing the training design behind a simulation. The process of creating DRTs began with analyzing notes from the SME interviews. Each key decision was identified along with what made it difficult, the factors that affected the decision, and the strategies the SMEs suggested using to make the decisions. (See Figure 1 for a sample DRT.) These DRTs allowed us to make the subsequent simulation reflective of natural cognitive processes.

Decisions/Assessments	Why Difficult?	Cues/Factors	Strategies
Determine which information sources to use.	• Trouble getting information from CIA due to red tape. • Information isn't always accessible/available. • Don't always know all the resources that are available.	• Information goes out of date rapidly, so you need to constantly be seeking information. • Information needed is situation dependent.	• JFACCs need to receive information, digest it, and act on it without asking for more information. • Need to get down and talk to people at all levels to get a sense of what is happening. • Don't just gather data; synthesize it and make sure you understand it. • Utilize all resources available to you when information can't be found elsewhere.

Figure 1. Sample DRT

The second part of our research was to determine training requirements and describe an instructional strategy. We reviewed the draft JFACC mission essential competencies (MECs) including the supporting competencies (SCs) provided by AFRL (Alliger, Garrity, McCall, & Rodriguez, 2003), other research materials such as the Air and Space Commander's Handbook for the JFACC, and we created a long list of critical JFACC decisions/ assessments.

It was very important early in our research to define the target audience and training objectives as specifically as possible. Once we had done so, we were able to examine how the JFACC receives information and communicates decisions. We were also able to define the training conditions in which a potential trainee would use the training simulation. This step was crucial in developing an instructional strategy.

Once we defined the target audience, the desired training objectives, and the conditions for the trainer's use, it was much easier to determine the functional requirements for the training simulation itself. This included the nature of the simulation engine, the design of the graphical user interface (GUI), and the functional capabilities of visualization and after-action-review (AAR) tools.

RESULTS AND DISCUSSION

Develop Initial High Level C2 Cognitive Requirements

When all of the data was analyzed, several key cognitive demands came to light from the DRTs, including: how to plan for the enemy, how to determine which sources of information to use, how to plan for the ATO cycle, how to prioritize tasks, how to manage diplomacy within joint forces, how to manage diplomacy with coalition partners, how to manage diplomacy with the host nation, and how to decentralize execution of tasks. For each of these tasks, key strategies were identified to be incorporated into the training simulation environment. For example, when discussing the decision regarding which information sources to use, one strategy the SMEs identified was the need to get information from multiple sources at all levels of the hierarchy. Within the trainer, in order to be successful, the JFACC would need to seek out information from multiple sources including: military (all branches), media, non-governmental organizations, coalition partners, the host nation, the Central Intelligence Agency, etc. At the same time, he or she might be able to utilize another key strategy such as decentralizing execution by learning to delegate some of this information gathering rather than trying to accomplish it him- or herself.

Table 1 illustrates a sample of key decisions and strategies that could be incorporated into the training simulation environment.

Table 1. JFACC Decisions and Strategies

Decision	Key Strategy
Determine how to plan for the enemy.	Focus on what the enemy will do next and not what he has done in the past.
Determine how to decide which information sources to use.	Don't wait for information to come to you; seek it out at all levels.
Determine how to plan for an ATO cycle.	Don't set too many targets. Prioritize your targets, because you can't do everything you want to do.
Determine how to prioritize tasks.	You cannot always accomplish everything you need to. Delegate authority and prioritize key tasks that cannot be delegated.
Determine how to manage diplomacy within joint forces.	Understand that people have different personalities and that each service will see the priorities differently. You need to know what to communicate, when to communicate and to whom to communicate it.
Determine how to manage diplomacy with coalition partners.	Gain a deeper understanding of language and cultural customs. Know what each coalition partner's goals and motivations are.
Determine how to manage diplomacy with the host nation.	Get the host nation's input on what they think you ought to do. Don't assume that what you want is what they want or need.
Determine how to decentralize execution.	Build a strong staff you can rely on to hand out orders. If you issue all the orders, the system will come to a halt waiting for you to do so.

Determine Training Requirements and Describe an Instructional Strategy

In order to determine the JFACC's cognitive training requirements, we analyzed draft MECs and SCs and created a list of the major assessments and decisions JFACCs make. Using these and the results of our CTA research, we then created the JFACC critical decision/assessment list. This is by no means a complete list, but will evolve over time as more decisions/assessments are identified. The instructional strategy evolved from our analysis of the cognitive training requirements and the nature of the training audience.

JFACC Critical Decisions/Assessments List

Using our research material, we developed a list of 61 key JFACC decisions and assessments. The top 25 we identified were:

1. What are the theater campaign objectives?
2. Determine what constitutes victory.
3. How do we best implement the JFC's guidance for air and space operations?
4. Is the Joint Air Operations Plan still current and available to support the JFC phased campaign plan, its objective, and tasks?
5. Is our plan flexible?
6. What changes do we need to make to our plan?
7. Is my guidance clear and concise? Does it empower my subordinates to make the right decisions at the right time in my absence?
8. Do my guidance, mission and intent statements, and target priorities need to be changed to reflect campaign needs?
9. Determine how to plan for an ATO cycle.
10. How much time do I allocate for personal rest and fitness?
11. Determine how to prioritize tasks.
12. Determine how to decentralize execution.
13. What are the top five critical questions our intelligence must answer about enemy capabilities or intentions in the next 24/48/72 hours? What decisions will I need to make when these questions are answered?
14. How do I win the media war?
15. What pre-positioned resources are available?
16. Will force basing create operational issues?
17. Determine how to plan for the enemy.
18. What are the enemy Centers of Gravity (CoG)?
19. How do we attack the enemy CoG?
20. What are the Blue CoG?
21. What are the top five critical questions about friendly capabilities or problems that I need

answered in the next 24/48/72 hours? What decisions will I need to make when these questions are answered?

22. How will the Red commander attack Blue CoG?
23. What are the top five critical questions the Red commander will seek to answer about Blue capabilities or intentions in the next 24/48/72 hours? What decisions will I need to make to insure he will not get the correct answers?
24. How do we deceive our opponent?
25. How will we know when our deception is successful?

Instructional Strategy for Training JFACC

Officers selected to become JFACCs are very senior and possess a wealth of experience and skill. They are very busy people who have limited time for training. The average age of the primary training audience is expected to be 45-55 with most being 50-55. Since most, if not all, JFACCs are pilots, we can reasonably assume that most are technically comfortable using a personal computer for training and will not be intimidated by the use of technology. However, since they are very busy and might have to use the trainer in their spare time, all training must be very relevant and worth investing their time and energy. Moreover, the simulation trainer must be easy to use and require minimal time to learn. Otherwise, they will lose interest and not use it at all.

Our instructional strategy consists of five parts:

1. The use of a learning management system (LMS) or an LMS-like environment to maintain a record of student learning and provide access to online JFACC-related courseware, pertinent KM links, training scenarios, and the simulation training environment. Using this approach, a single office or command would be responsible for overall JFACC education and training. They would manage the LMS and its content. JFACCs would enroll through the LMS and gain access to the system through the internet using a user ID and password. Once entering the system, JFACCs could quickly access all pertinent information, enroll in any available courses, and review current information packaged for them in an efficient manner including updated links to current KM resources. Finally, they could select training scenarios designed to address specific cognitive skills. When ready, they could then enter the training simulation environment and practice that skill. Upon completion of the training they could exit the training simulation environment and return to the LMS.

2. The use of KM links created and updated by the JFACC course author to provide quick informational updates to the JFACC. Rather than trying to build a KM system specifically to support the JFACC, course authors or managers can create, organize, and update links to these sites within the LMS.

Example: If a current hot topic for JFACC is strategies for the integration of coalition forces, then all of the links to most relevant KM sites that address this topic can be created and posted to a single page.

3. The use of a Web-enabled simulation training tool to allow the JFACC to quickly practice their cognitive skills in an engaging, fast-paced, simulated environment. For the simulation trainer to be effective, it must be quick to learn and easy to use. Since the focus of training is cognitive skills development, the trainer cannot be a standard military simulation of air warfare. Although it needs to portray the conduct of an air campaign in order to replicate a realistic environment, all simulation interfaces and commands must be designed to provide the type of information and the correct levels of decisions/assessments made by the JFACC.

4. The interaction of senior mentors with the JFACC both during and after training in the simulated environment to insure the highest quality training takes place. Feedback will be the primary means for learning in the simulation training environment. Although we should ultimately create a full stand-alone trainer, initially it must rely on a senior mentor to observe and monitor student behavior in real time. Since the trainer will be Web-enabled, the trainee and the mentor do not have to be in the same location. As the student makes decisions and accesses information, the mentor should be able to record actions and introduce changes to the simulated environment in order to increase training rigor. The instructor must also be able to communicate with the trainee in order to coach performance throughout the training experience.

5. The use of the JFACC MECs and SCs as criteria to measure the JFACC's progress during training. In order to properly evaluate student learning, performance criteria must be established. The MECs and SCs are ideal for this purpose since they define those skills, knowledge, and attributes successful JFACCs must possess. However, if used alone, any kind of evaluation would lack a great deal of objectivity. To improve their use as performance

criteria, a complete CTA of each of the JFACC critical decisions/assessments must be accomplished. Then a linkage must be created from the results of the CTA to the JFACC critical decision/assessment and then to the MEC or SC. This would provide mentors a greater deal of objectivity in determining the MEC/SC proficiency of the JFACC.

For example: "Determine How to Plan for the Enemy" is our JFACC Critical Decision/Assessment number fifty-three. This assessment supports the MEC, "Blue Analysis of Red." The eight successful strategies, identified, through CTA, for this assessment are:

- Model a thinking enemy.
- Maintain situation awareness through gathering intelligence from all available sources.
- Try to make the most obvious course of action the deception plan.
- Know what the enemy commander is thinking and never assume he is a mirror image of you.
- Fill in gaps with assumptions and make decisions with less than complete data.
- Focus on what the enemy is likely to do next and not what he has done in the past.
- Be able to anticipate cause-effect relationships and decide how effects are related to actions.
- Know what choices are left for the enemy and anticipate what they will do next.

If we use these strategies as performance measures, we can then evaluate how well the JFACC is able to "Determine How to Plan for the Enemy" by observing how many of these strategies the JFACC employs. If, in turn, this decision/assessment is one of several linked to the "Blue Analysis of Red" MEC, we will have a much stronger way to determine the student's overall mastery of that MEC.

Determine Functional Requirements for a Training Simulation

Simulation Engine
The training simulation environment should employ a simulation engine that abstractly models the conduct of an air campaign with only enough fidelity to support JFACC MEC and SC evaluation. It should also abstractly model key organizations the JFACC interacts with such as joint and collation partners, the JFC, and the JAOC staff. The simulation artificial intelligence, using a rules-based approach, should provide outcomes that provide reasonable feedback to the JFACC for each decision. The cognitive fidelity for this environment is derived from the key cues and factors identified in the DRTs.

GUI Design
Recognizing the capabilities of the current age, experience, and operational tempo of the target audience, the completed trainer must be easy to install and use. The GUI must be straightforward and simple. In order to achieve this objective, the training simulation environment should dynamically change the GUI to reflect the options that are available to the trainee at any given point during their training experience. This will reduce confusion and increase ease of use.

Scenario Design
The training simulation environment should use a common scenario to reduce the time required for trainees to familiarize themselves with the strategic-operational situation. The scenario, in keeping with the U.S. Air Force norm, should depict a fictional area of operations and situation. This scenario should be developed based on the CTA data in order to depict the most authentic and rich environment possible.

Internet Access
Most trainees should primarily use the training simulation environment by accessing data and information through the Internet or a network. However, it must also function as a stand-alone application to support training when the Internet or a network is not immediately available. When used as a stand-alone trainer, trainees will need to access the Web server at some time prior to and after training in order to access their training records, updated scenario information, and progress reports.

Single Player vs. Multiplayer
Initially, the training simulation environment should be developed as a limited multiplayer trainer that will allow a mentor/instructor to remotely connect and observe and/or shape the training experience of the JFACC trainee. In addition to this capability, it should also be a fully functional trainer in the single-trainee mode.

AAR Capabilities
The training simulation environment should log all significant simulated events and the corresponding trainee decision. Changes in trainee "scores" for each of the MECs generated by the trainee decision should be annotated so that the student, either alone or with

the assistance of a participating mentor, would be able to better understand what happened and why. Based on the outcome, particularly if significant shortcomings are apparent, expert recommendations, strategies, and support should be automatically triggered to further stimulate reflection and discussion.

CONCLUSIONS

We found our methods to be useful, efficient, and timely in unearthing the critical information needed to create a solution for JFACCs who are not being provided with the training they need. Using CTA to dissect selected JFACC decisions and assessments was very beneficial in understanding the full nature of each decision or assessment and will be critical in developing any kind of JFACC cognitive skills training program. The detailed analysis provides trainers with objective criteria for evaluating student performance (Baxter, Ross et al., 2004). Moreover, through its identification of successful strategies, it enables trainers to provide expert advice to the trainee on how to improve performance. This is important in coaching expert behaviors.

Although we clearly demonstrated the value of CTA, we were only able to conduct CTA for nine of the sixty decisions/assessments we identified. Any future effort must include a more comprehensive CTA of all decisions/assessments.

The DRTs served several purposes. First, by clearly identifying the decision requirements, along with what makes them cognitively challenging and the potential cues, factors, and strategies that are involved, we eliminated the need for multiple versions of the tool. Often a tool is created, and only during a test stage are you able to identify the types of contingencies that will require you to modify the system. The DRTs identified these contingencies upfront. As a result, overall development time was reduced by eliminating the need for repeated modifications and repetitive testing.

Developing a realistic, stressful simulation training environment to train JFACC cognitive skills is an important step in a sound instructional strategy to train JFACCs. It is one thing to study and discuss decision making, but to be able to practice decision making and receive expert feedback from former JFACCs is a completely different experience. Care must be exercised in the design and development of the training simulation environment to insure it meets the requirements without becoming too complex or difficult to use. Traditional methods of modeling air campaigns would be inadequate for the JFACC simulation training environment. Instead, the modeling must focus on providing appropriate feedback of the trainee's mastery of the MECs and SCs.

A need clearly exists to better train JFACCs for their important jobs. From our research, it is clear that a solution exists to provide the JFACC with this training. To be most successful, the instructional strategy must include the use of CTA to thoroughly document the JFACC's decision-making processes, the use of an appropriate training simulation environment to provide practice and feedback, and the successful integration of knowledge management resources to keep the JFACC abreast of current issues and successful strategies for dealing with these issues.

ACKNOWLEDGMENTS

The authors would like to acknowledge the support of Dr. Joseph L. Weeks of the Human Effectiveness Directorate, U.S. Air Force Research Laboratory, Mesa, AZ, during the research which was the basis for this paper. Dr. Weeks' guidance greatly facilitated the authors' work under contract # FA8650-04-M-6504, Enhancing Commanders' Cognitive Readiness at the Operational Level of War.

REFERENCES

Alliger, G., Garrity, M. J., McCall, B. L., & Rodriguez, D. (2003). *Competency-based definition of work and performance for command and control.* Paper presented at the 13th International Occupational Analyst Workshop, San Antonio, TX, April 2003.

Baxter, H. C., Harris, D., & Phillips, J. K. (2004, December 6-9, 2004). *Sensemaking: A cognitive approach to training situation awareness skills.* Paper presented at the Interservice/Industry Training, Simulation, and Education Conference, Orlando, FL.

Baxter, H. C., Ross, K. G., Phillips, J. K., Shafer, J., & Fowlkes, J. E. (2004, December 6-9, 2004). *Framework for assessment of tactical decision-making simulations.* Paper presented at the Interservice/Industry Training, Simulation, and Education Conference, Orlando, FL.

Chi, M. T. H., Feltovich, P. J., & Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science, 5*, 121-152.

Crandall, B., & Getchell-Reiter, K. (1993). Critical decision method: A technique for eliciting concrete assessment indicators from the "intuition" of NICU nurses. *Advances in Nursing Sciences, 16*(1), 42-51.

Dreyfus, H. L. (1972). *What computers can't do: A critique of artificial reason*. New York: Harper & Row.

Dreyfus, H. L., & Dreyfus, S. E. (1986). *Mind over machine: The power of human intuitive expertise in the era of the computer*. New York: The Free Press.

Hoffman, R. R. (Ed.). (1992). *The psychology of expertise: Cognitive research and empirical AI*. New York: Springer-Verlag.

Kaempf, G. L., Klein, G., Thordsen, M. L., & Wolf, S. (1996). Decision making in complex command-and-control environments. *Human Factors, 38*, 220-231.

Klein, G. A., Calderwood, R., & MacGregor, D. (1989). Critical decision method for eliciting knowledge. *IEEE Transactions on Systems, Man, and Cybernetics, 19*(3), 462-472.

Klein, G. A., & Hoffman, R. (1993). Seeing the invisible: Perceptual/cognitive aspects of expertise. In M. Rabinowitz (Ed.), *Cognitive science foundations of instruction* (pp. 203-226). Mahwah, NJ: Lawrence Erlbaum & Associates.

Klinger, D. W., & Gomes, M. G. (1993). A cognitive systems engineering application for interface design. *Proceedings of the Human Factors and Ergonomics Society 37th Annual Meeting*, 16-20.

Militello, L., & Lim, L. (1995). Patient assessment skills: Assessing early cues of necrotizing enterocolitis. *The Journal of Perinatal & Neonatal Nursing, 9*(2), 42-52.

Shanteau, J. (1985). *Psychological characteristics of expert decision makers* (Vol. 85). Manhattan, KS: Kansas State University.