Developing Expertise at the Operational-Level of Warfare

POC: Chad Tossell, 1Lt, USAF
Program Manager, C2 Training Research
Warfighter Readiness Research Division
6030 S Kent Street
Mesa, AZ 85212
Phone: 480-988-6561
E-Mail: chad.tossell@mesa.afmc.af.mil

Michael J. Garrity, Ph.D.
Team Lead: Performance Requirements & Assessment
Aptima, Inc.
12 Gill Street, Suite 1400
Woburn, MA 01801
www.aptima.com
Phone: 781.496.2451
Fax: 781.935.4385
Mobile: 339.227.7144
E-Mail: mgarrity@aptima.com

Kevin M. Gildea, Ph.D.
Human Factors Psychologist
Aptima, Inc.
12 Gill Street, Suite 1400
Woburn, MA 01801
Tel: 781.496.2400
Fax: 781.935.4385
kgildea@aptima.com

Developing Expertise at the Operational-Level of Warfare

Chad Tossell
Michael J. Garrity
Kevin Gildea

ABSTRACT

Though the Joint Force Air Component Commander (JFACC) is the senior leader responsible for planning, coordinating, and directing all theater air operations, there is a lack of systematic training at the operational-level of war. General John P. Jumper, Air Force Chief of Staff (CSAF), said of Kosovo: "LGen Michael Short, JFACC of Operation Allied Force, trained himself in the operational level of warfare... [Most of us in Air Force leadership] trained ourselves, because our system did not." (Tirpak, 2000). Below we describe a unique functional work analysis completed for the JFACC position to begin to specify training requirements and associated gaps. In addition, key experiences were identified that enable the development of proficiency in the requisite knowledge, skills, and abilities. Finally, we conclude with a discussion of how simulation-based technologies can be leveraged to provide these experiences in a way that drives training at the operational-level of warfighting and decision-making vice staff functions or tactical-level processes.

INTRODUCTION

The authority to plan, direct, and assess air and space theater operations for the United States (US) and coalition military resides with the individuals occupying the Joint Force Air Component Commander (JFACC) positions. Operations Desert Storm and Allied Force brought to light existing shortfalls in the training programs for senior leaders in critical command and control (C2) positions such as the JFACC. Traditionally, leaders transfer from rated positions to fill C2 leadership positions without attending much, if any, formal training programs for their specific role. While they may develop an understanding of the language, they likely have never had any real training in applying the operational art of war or conducting contingency planning. Without requisite training, senior leaders are required to learn on-the-job. Despite demonstrated leadership and performance capabilities at the tactical levels, senior personnel have been less prepared to take on the critical leadership roles that shape military operations. This problem is not unique to military leadership. In business, politics, and industry, leaders must often make "operational level" decisions without adequate, if any, formal training. Relying solely upon on-the-job training is slow and expensive for military and business leaders alike.

General John P. Jumper, CSAF, said of Kosovo: "LGen Michael Short, JFACC of Operation Allied Force, trained himself in the operational level of warfare... [Most of us in Air Force leadership] trained ourselves, because our system did not." (Tirpak, 2000). Six years later, flag officers still have limited training opportunities to prepare for the specific roles and responsibilities required. A JFACC course is offered to some flag officers and potential flag officers typically well before they become a JFACC. The Air Force Senior Mentors (former JFACCs) are part of an organization that provides up-and-coming JFACCs with mentorship. Even with the this extensive mentoring program, current JFACCs still spend the majority of their career developing expertise in tactical execution and are less prepared for applying operational art until late in their career. This change of job functions and level of responsibility necessitates a new look at air power and, subsequently, may require a new set of knowledge and skills. In addition, old habits developed during their career must be broken. This represents an important challenge for training research psychologists and training developers; namely, to provide military officers with operational-level experiences before they become JFACCs and to increase the overall proficiency of current JFACCs.

Below we discuss a training requirements identification methodology, Mission Essential Competencies (MECs), designed to provide the building blocks for (1) formalizing the readiness requirements for the JFACC role, (2) modifying/maintaining/reducing current training bases on these requirements and (3) the creation of new training capabilities for the JFACC. Specifically, we first identify JFACC training requirements & define expertise in terms of competencies, knowledge, and skills. Second, we introduce key developmental events, defined by former JFACCs, which allow novice JFACCs to develop the requisite competencies, knowledge, and skills. These events are called Experiences within the MEC framework. Third, we discuss the relationship of these constructs across operational environments for real-world implementation (i.e., which environments should a certain developmental experience be provided). Finally, we conclude with an example of training implementation via simulation and then encourage both and training developers and researchers to consider new methods for preparing JFACCs to develop operational-level decision making skills.

DEFINING JFACC EXPERTISE

The term “expertise” refers to performance in a particular field, such as sport, chess, or medicine, that is superior to the performance of others in that same field. Whereas the definition of expertise is quite clear, the representation of expertise in terms of knowledge, skills, and competencies that define expert performance is not. Especially considering the wide range of domains in which one could become an expert. While cognitive scientists have addressed this representation in other terms (Schvaneveldt, Durso, Goldsmith, Breen, and Cooke, 1985 & Chase & Simon, 1973), training developers may benefit from a contextualized, simplified approach to a competency-based definition of expertise (Tossell, Garrity, Morley, Rodriguez, 2004).

The Mission Essential Competency (MEC^{SM}) process is used by the United States Air Force (USAF) to provide guidelines for knowledge elicitation and validation techniques from Subject Matter Experts (SMEs) for the purpose of developing a hierarchical model of competencies, knowledge, and skills (Colegrove & Alliger, 2002; Alliger, Colegrove, & Bennett, 2003). These constructs are organized in three tiers to define levels of expertise for a team or position. At each level, the competencies, knowledge, and skills are couched in terms familiar to the warfighter. Though commonly used for training requirements in Air Force training programs, MECs do not target minimum standards of performance for certification. Instead, MEC definition, using a SME-centered, iterative process, identifies performance and decision-making components that represent a fully prepared operator or team. These elicited constructs are extensively validated across theaters and operators with varying levels of relevant experience. The focus on higher level competencies and responsibilities inform training and accurately capture the combat environment. Indeed, none of the MEC constructs are dependent on a certain system (e.g., Theater Battle Management Core System, Command and Control

Planning Capability). "Buttonology" is not the focus, only the core processes, decisions, and behaviors noticed in fully prepared experts within the domain. Finally, another interesting note on what makes the MEC process distinct from other work analyses is the customizable process given the position, division, or airframe. To date, the MEC process has been successfully applied across a multitude of weapon systems (i.e., Bombers, Fighters, Information Operations, and Command and Control Organizations, etc.) and missions (i.e., Air to Air, Air to Ground, etc.).

Below we briefly describe the MEC model for the JFACC. For a more thorough description of the finer details of the JFACC MEC process to include the structure of the workshops, attendees, and comparison to other domain-specific MEC efforts, the reader should review Alliger, Garrity, McCall, Tossell, See, 2003.

Mission Essential Competencies℠ (MECs) for the JFACC

Mission Essential Competencies, as a general construct, are at the highest level of abstraction. They are highly contextualized to the domain (mission), but contain general characteristics relevant to experts across fields at least within the military. Formally, MECs are defined as the higher-order individual, team, and inter-team competencies that a fully prepared pilot, crew or flight requires for successful mission completion under adverse conditions and in a non-permissive environment. See below (Table 1) for a list of the MECs for the JFACC position.

Table 1: JFACC MECs.

Blue Capability Integration:	Develops and maintains understanding of current internal and external joint and coalition resources and capabilities, limitations, Red and Blue CoGs (centers of gravity) and vulnerabilities. Develops plan that integrates, coordinates, and leverages resources to support Coalition/Joint Force Commander (C/JFC) guidance and intent supporting the campaign plan.

Blue Analysis of Red:	Understands Red's current internal and external resources and capabilities, limitations, and Red's view of Red and Blue CoGs (centers of gravity) and vulnerabilities. Attempts to model Red plan that integrates, coordinates, and leverages Red resources to achieve Red's assumed strategic and operational objectives
Personal Contribution:	Focuses personal contribution to AOC in planning, execution, and assessment by taking a proactive approach towards future strategy and planning. Maintains appropriate theater strategic understanding and operational focus without being preoccupied with current tactical operations. Able to anticipate, articulate, and respond to the changing nature of the campaign as it unfolds/develops.
Situational Awareness / Understanding:	Establishes and maintains broad, horizontal and vertical operational level situational awareness (SA). Translates this broad SA into situational understanding in order to put individual tasks in context by conveying how individual tasks (details) impact the mission.
Formal/Informal Means:	Exploits the strengths of formal and informal organizations, agencies, and hierarchies to achieve mission objectives.
Joint and Coalition Team:	Creates an environment that facilitates team building through open horizontal and vertical communication, feedback, education, and innovation. Uses walk-throughs, individual interactions with key personnel, scheduled and unscheduled briefs, and continuous training
Personal and Organizational Battle Rhythm:	Establishes personal and organizational battle rhythm integrated with C/JFC battle rhythm (BR) to support horizontal and vertical integration to ensure a coordinated campaign.

Supporting Competencies are general aptitudes that enable successful performance of the MECs or Knowledge and Skills. Though more general in nature than MECs, they describe important capacities to carry out the JFACC job function. Typically, Supporting Competencies apply across jobs or job domains in the Air Force. In the case of the JFACC, however, atypical constructs were elicited by the subject matter experts that may not be seen in other MEC efforts or even other work analyses for civilian managerial positions. The specific nature may be due to the focus on a single position instead of a team or weapon system. More likely, the competencies learned through joint service experience and level of responsibility are partial factors. The following are examples of the distinct Supporting Competencies for the JFACC (Table 2):

Table 2: JFACC Supporting Competencies.

Projection:	Ability to conceptualize future actions and events based on relevant factors.
Concentration:	Ability to maintain focus and deal with uncertainty through the fog of war.
Negotiation:	Ability to tactfully resolve difficult situations when internal and external partners disagree due to contrasting opinions, goals, priorities, methods, and/or solutions.
Courage:	Ability to do the right thing at the right time in spite of pressure to do otherwise--includes the ability to talk about doubt, uncertainty, and bad news.
Acceptance of Risk:	Ability to make decisions in the absence of total certainty.
Objectivity:	Ability to clearly look at your situation and the enemy's situation as they unfold.

At the lowest level of the hierarchy are the Knowledge and Skill elements. These Knowledge and Skills encompass the totality of what a *fully-prepared* JFACC needs to know or be able to do in a stressful, non-permissive environment for successful mission completion. For the JFACC, eighty-three Knowledge and Skills were identified. In the MEC methodology, Knowledge is defined as *information or facts that can be accessed quickly under stress*. For our purposes, a Skill is defined as *a compiled sequence of actions that can be carried out successfully under stress*.

The list of eighty-three knowledge and skills were also rated by SMEs in terms of importance to the JFACC position (1 = Critical, 2 = Important, 3 = Nice to Have). See Table 3 for example.

Table 3. Knowledge and Skill requirements rated by the Senior Mentors as "Critical".

Workflow	Understands the 51 formal processes (team makeup, inputs, and outputs), the products for the major processes, and the nine which he/she is personally responsible for.	**1**

Interrelationships	Understands how Air and Space Operations Center (AOC) operations and timelines are affected by relationships among forces, systems, components, and headquarters and by policy constraints. Particularly important to understand the contributions of the other components to the joint fight.	**1**
Process Integration	Able to integrate personal JFACC command responsibilities with staff processes through an iterative commander-centric process.	**1**
Assessment Processes	Understands the multi-faceted assessment (campaign, operational, and tactical assessment) processes (e.g., who is responsible for what, where information/inputs come from, where information is archived, how to derive conclusions, and how to share assessment horizontally and vertically).	**1**
Personal Time	Able to schedule personal time for JFACC and subordinates.	**1**
The Opponent	Understands the interactions between PMESII factors (political, military, economic, social, information, infrastructure) (e.g., how economic warfare may have political consequences).	**1**

This taxonomy of Knowledge and Skills for the JFACC position formalizes key concepts that the subject matter experts and perhaps other Air Force leaders knew intuitively. For example, the reader will likely recognize the importance of planning and assessment even in the small examples of knowledge and skills above. One interesting observation from this analysis relates to the location within the Air and Space Operations Center (AOC) where the JFACC leads. A few previous JFACCs confess to spending most of their time on the Combat Operations Division floor where current operations are monitored and real-time command and control is executed. The Knowledge and Skills most critical to JFACC mission accomplishment seem to suggest that the JFACC must spend time in the Strategy Division or a strategy position where long-term strategy is made and operational assessment takes place. The reader should recognize that this brief exercise was done by research psychologists and not Air Force decision-makers. Though this brief analysis here is clearly incomplete and will not be expanded upon in this

paper, we hope the reader feels more informed of the MEC constructs. Namely, that the MECs are a way to represent those intuitive factors that make sense.

Experiences

The last, and possibly the most relevant components of the MEC construct to training development, are the Experiences. An Experience is defined as *a developmental event during training and/or career necessary to learn a knowledge or skill, or practice a MEC or Supporting Competency under operational conditions.* Examples of experiences for the JFACC include:

- Dealing with friction vertically and horizontally between Joint Force Commander and components
- Managing different parts of your team across different time zones and different battle rhythms
- Participating in the complete assessment process coupled with horizontal and vertical assessment by other players
- Impact of collateral damage and losses of civilian life
- Participating in the Air Tasking Order cycle multiple times (every product and process)

In other words, the Experiences help to contextualize the learning or practice of knowledge and skills important to gain expertise. They bridge a gap for instructors/trainers between training requirements and concrete, formal training. Moreover, Experiences specify the events a JFACC must go through to develop proficiency in relevant knowledge and skills, and to practice a MEC or Supporting Competency.

Of course, some training events can only be experienced in real-world combat, especially for the JFACC. However, as retired Lieutenant General Steven Croker eloquently mentioned regarding the operational level of warfare during a MEC workshop, “Not everyone is good at this. There is a lot of artfulness involved. However, if you practice, you’ll likely get better.” Though this practice can be provided in different environments, such as the classroom, exercises, or other leadership positions, for the remainder of this paper, we will be focusing on simulation environment. Certainly, some developmental Experiences can be provided efficiently and

effectively in a virtual environment where an up-and-coming or current JFACC can learn via practice with feedback. One such capability, Multi-Player Operational Readiness Trainer for Advanced Leadership (M-PORTAL) described below, attempts to integrate the MECs with formal lessons learned to provide this experience.

Training Implementation (Lessons Learned and Simulation)

Lessons learned play a vital role in military operations and each branch of the military has established procedures to collect these lessons learned. The Air Force's Air Combat Command Center for Lessons Learned, the Army's Center for Army Lessons Learned, and the Navy Lessons Learned System provide the capability to centrally manage, access, and standardize lessons learned. Lessons learned have great potential to enhance operational readiness by providing access to operational reports and analysis. Specifically, senior leaders can use lessons learned for planning future operations/exercises or for guidance on current operations. Unfortunately, today's armed forces do not use lessons learned in a systematic and principled way to design formal training. Thus, employing these lessons to will help to ensure some mistakes are not repeated. Coupled with the MECs, the simulation capability implements a new way to train warfighters and shape operational performance.

The Role of Lessons Learned

Lessons learned may come from several sources or studies. An example of one such source of lessons learned is a report by the RAND institution, where researchers attempted to identify and document lessons learned from Operation Allied Force (OAF) that have implications for future coalition operations. Three such lessons learned are highlighted in Table 4. These lessons learned are being utilized in conjunction with the MECs to enhance training for

the JFACC. A database of operational lessons learned over the last two decades provides a foundation on which to structure training and provide signposts for those engaged in training.

Table 4: Lessons Learned from OAF (http://www.rand.org/publications/RB/RB72/)

Lesson Learned	***Description***
1. Although Alliance and U.S. media news releases during the operation recognized the contributions of all participating air forces, the United States was responsible for a disproportionately large share of the effort.	The Europeans certainly made some important contributions to combat operations. Germany and Italy played an important role in the campaign to suppress enemy air defenses, while the British and French joined the United States in delivering precision-guided munitions. However, the allies generally lacked the level of precision and all-weather capabilities that would allow them to carry out their missions by day and night while ensuring minimum civilian damage. The United States provided 700 of the 1055 aircraft deployed in the allied effort and flew by far the greatest number of sorties. The Europeans also lacked capabilities to deploy personnel and equipment to the field of operations and to sustain them as long as necessary. The United States provided more than 90 percent of aerial refueling aircraft, the bulk of airlift capabilities, and all tactical jamming capabilities.
2. Intra-Alliance politics made Operation Allied Force possible but also resulted in political and operational constraints that imposed limitations on warfare.	The conditions of coalition warfare produced a relatively slow, deliberate air campaign, in contrast to the U.S. preference for high-tempo, continuous operations and overwhelming levels of force. The slower style of campaign was necessary to accommodate the consultative and deliberative functions of the coalition and to secure domestic and international popular support for the operation. Public support depended in large part on assurances that the risk of civilian casualties and damage was low. To minimize this risk, the Alliance limited the size, pace, targets, and amount of force used in the campaign.
3. Despite years of multinational, cooperative planning within the Alliance, the allies found it difficult to agree on a common approach.	The consensus for action was fragile in the absence of an immediate threat to allied territory or traditional interests. Disputes within the Alliance centered on three issues: whether a "gradualist" approach to the air war would succeed, whether the United States had the right to keep some sensitive information in U.S.-only channels, and whether ground forces should be introduced. The last issue proved to be particularly contentious, even though none of the NATO members were eager to deploy ground forces. Ultimately, the discussion surrounding this issue may have helped sustain the consensus to continue the air campaign by reinforcing a shared belief that introducing ground forces would involve even more difficult and unpleasant issues.

Training System Development

In order to effectively leverage Lessons Learned to create contextualized training, it is first necessary to create a database of Lessons Learned and relevant scenarios that defines the

relationship between these elements and provides easy access to their retrieval and utilization. As such, for this training effort, a database was designed to facilitate incorporation of scenarios from diverse sources into current training. The training system readily adapts to new training needs including assimilation of additional scenarios and adaptation to changing Political, Military, Economic, Social, Infrastructure, and Information (PMESII) factors in the world.

For JFACC training, it is essential that any system is based on sound training objectives. Developing the training objectives for the JFACC training system followed a systematic path. Starting with the competencies, knowledge, and skills that JFACCs need to acquire in order to successfully manage and lead; applicable knowledge and skills were linked to lessons learned from recent military operations. This linkage helps guide the training system by identifying which critical incidents or lessons learned are most appropriate to use for training specific knowledge and skills in the training simulation.

To ensure effective training, M-PORTAL was designed around those scenarios that are most likely to improve overall performance. In order to identify which scenarios were best suited to train specific knowledge and skills, a matrix was constructed in which the strength of the relationships between lessons learned, knowledge and skills, and scenarios were inserted. Subject matter experts rated the importance of each knowledge or skill during each critical incident. This provides the capability to determine what scenarios provide the most relevant context for training a specific lesson learned or knowledge and skill.

The mappings between the databases will be iterative and ongoing. When users add new lessons learned or scenarios, they will need to revisit the process of mapping and rating the importance of the relationships. The mapping of these relationships is aided by probabilistic Latent Semantic Analysis (pLSA), which is a statistical tool for determining the relative

relationship of various bodies of text to each other. Additionally, as M-PORTAL users interact with the tool they will be given opportunities to manually rate the relationships between small samples of the data to provide a check on the accuracy of the pLSA ratings. As multiple senior leaders add their ratings from their various perspectives and experience bases, the ratings will tend to become more stable and will backed by a growing library of experiences to support the conclusions. As the PMESII factors change, the ratings may shift as well. This adaptability is the major strength of the M-PORTAL system.

Simulation

The level of expertise possessed by a JFACC or other Air Force senior leader is their current high level of knowledge of their domain. An expert's deep understanding of the structure of a problem necessitates a very different approach to training than is appropriate for a novice who sees the problem at a superficial level (Newell & Simon, 1972). The expert is able to chunk data (Lachman, Lachman, & Butterfield, 1979; Miller, 1956) and is therefore able to process a higher volume of data than a novice (Norman & Bobrow, 1975; Navon & Gopher, 1979). Furthermore, experts are able to see relationships between chunks of information and are able to learn lessons from a situation that are not obvious to a novice (Shebilske, Goettl, & Regian, 1999). This creates a problem for designing a senior leadership trainer. However, some lessons from the training literature concerning Aptitude Treatment Interactions provided insight and direction (Ackerman, 1992; Corno & Snow, 1986).

Most trainers impart knowledge and develop skills from the perspective of the expert training the novice. Senior leaders, on the other hand, already possess a high level of expertise in most aspects of their field. Therefore, the best form of feedback for a senior leader is likely self-generated feedback, or feedback from other senior leaders. Experts typically have better

metacognition than novices (Smith, Ford, & Kozlowski, 1997) and, thus, are often aware of the mistakes they make.

This tool takes a unique approach to training that incorporates self-generated and/or peer reviewed feedback in addition to providing information in a form that the expert is accustomed too. Typically, training systems parsed information into an easily digestible form targeted specifically at the desired task or subtask. However, experts often need a different type of information than novices (Kalyuga, Ayres, Chandler, & Sweller, 2003; Rasmussen, Pejtersen, & Goodstein, 1994). There is the potential that an overly structured information stream would be bereft of key chunks of information the expert would need. Furthermore, research indicates that training systems designed to reduce the working memory load for novices actually overload the working memory of experts because of the over specification of the information. This has been termed the Expertise Reversal Effect (Kalyuga et al , 2003). Senior leaders are required to receive information in briefings and make operationally significant decisions based on the briefing's content. Therefore, the M-PORTAL users will receive information in a similar format. The scenario begins with a briefing and from this information; the senior leader must generate his/her plan (Simon & Werner, 1996; Thiede & Dunlosky, 1999). They will be required to generate a documents, spreadsheets, and maps that organize and address the key issues involved in the problem space, generate a plan, and determine the repercussions of their actions.

After generating the document, the trainee will have the opportunity to see other SMEs' responses to the crisis. This will include the opportunity to view the lessons learned that have been associated with the scenario and the accompanying ratings. This will allow them to view other experts' perspectives thus providing immediate expert generated feedback. The trainee will also have the opportunity to provide a dissenting opinion to any of the other experts' inputs. The

trainee will upload their responses into a web log for other senior leaders to review, learn from, and comment on. A search option will allow the student to find lessons learned of a particular type and to read and embed comments in reference to other senior leaders' work. This will generate further opportunities for feedback and provide an ever-increasing repertoire of SME responses to study and analyze.

Therefore, the information presentation reflects the presentation in the operational setting; therefore, this tool will be ecologically valid (Gardner, 1992; Greeno, Moore, & Smith, 1993). Additionally, it will have cognitive fidelity because it will require the trainee to think and generate ideas in an unstructured problem space similar to the way they operate in the actual world. The ability to include new lessons learned and the ongoing input from senior leaders will provide a tool that is constantly evolving to meet the needs of the military as the operational world changes.

Training Delivery Method

The M-PORTAL provides the opportunity to train over a network. This allows the system users to upload content to a blog (web-log) for other system users to review and provide feedback. Senior leaders will be able to access the system worldwide and train when their schedule allows. The senior leaders input their ratings of the lessons learned to the MECs^{SM}, and the scenarios. Multiple reviews of the ratings of lessons learned and MECs^{SM} to scenarios will provide a form of interrater reliability to the system. Additionally, this provides the first iterations of the self-updating that the M-PORTAL tool will facilitate. After responding to each scenario, the senior leader views responses that are in the system and the ratings that other SMEs provide for the MECs^{SM}, lessons learned and scenarios. The senior leaders then critique and/or comment on existing input.

Conclusions/Future Directions

The roles and responsibilities that fall within the JFACC's purview are such that no current training program can provide in a comprehensive way. Only the life and death reality of combat can provide the complete training environment for the JFACC (i.e., the Skill: able to deal with death and destruction). Though the JFACC mentoring program provides opportunities for the development of future JFACCs, the mentoring process requires a great deal of time and resources to achieve the desired learning outcomes. The JFACC MEC effort, along with the development of JFACC desktop trainers (i.e., M-PORTAL), are initial attempts to augment current mentoring efforts. It is the authors' hope that the results from the MEC process will enable future training developers and researchers to assist current and future JFACCs in the development of sound decision-making skills necessary at the operations level of war.

REFERENCES

Ackerman, P. L. (1992). Predicting individual differences in complex skill acquisition: Dynamics of ability determinants. *Journal of Applied Psychology, 77,* 598-614.

Alliger, G., Garrity, M.J., McCall, Beer, L., and 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.

Alliger, G. M., Colegrove, C., & Bennett, W. Jr., (2003). Mission Essential Competencies: New Method for Defining Operational Readiness and Training Requirements. Paper presented at the 13th International Occupational Analyst Workshop, San Antonio, TX, April.

Chase, W.G., & Simon, H.A. (1973). Perception in chess. *Cognitive Psychology,* 4, 55-81.

Colegrove, C. M., & Alliger, G. M. (2002). *Mission Essential Competencies*^{SM}*: Defining Combat Mission Readiness in a Novel Way*. Paper presented at: NATO Research & Technology Organization, Studies, Analysis, and Simulation Panel, Conference on Mission Training via Distributed Simulation (SAS 38), Brussels, Belgium.

Corno, L. & Snow, R. E. (1986). Adapting teaching to individual differences among learners. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (pp. 605-629). New York, NY: Macmillan.

Croker, S. (2003). *Operational Art in Theory and in Practice: Serbia and Beyond.* (Unpublished Presentation).

Gardner, H. (1992). Assessment in context: The alternative to standardized testing. In B. R. Gifford & M. C. O'Connor (Eds.), *Changing assessments: Alternative views of aptitude, achievement and instruction* (pp. 77-119). Norwell, MA: Kluwer.

Greeno, J. G., Moore, J. L., & Smith, D. R. (1993). Transfer of situated learning. In D. K. Detterman & R. J. Sternberg (Eds.), *Transfer on trial: Intelligence, cognition, and instruction* (pp. 99-167). Norwood, NJ: Ablex.

Kalyuga, S., Ayres, P., Chandler, P., & Sweller, J. (2003). The expertise reversal effect. *Educational Psychologist, 38,* 23-31.

Lachman, R, Lachman, J. L., & Butterfield, E. C. (1979). *Cognitive Psychology and Information Processing: An Introduction.* Hillsdale, NJ: Erlbaum.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63,* 81-97.Mooney, C. Z., & Duval, R. D. (1993). *Bootstrapping: A nonparametric approach to statistical inference.* Newbury Park, CA: Sage Publications.

Navon, D. & Gopher, D. (1979). On the economy of the human-processing system. *Psychological Review, 86,* 214-255.

Newell, A. & Simon, H. H. (1972). *Human problem solving.* Englewood Cliffs: NJ: Prentice-Hall.
Norman, D. A. & Bobrow, D. G. (1975). On data-limited and resource-limited processes. *Cognitive Psychology, 7,* 44-64.
Norman, D. A. & Bobrow, D. G. (1975). On data-limited and resource-limited processes. *Cognitive Psychology, 7,* 44-64.
Rasmussen, J., Pejtersen, A. M., & Goodstein, L. P. (1994). *Cognitive systems engineering.* New York, NY: John Wiley.

Schvaneveldt, R., Durso, F., Goldsmith, T., Breen, T., Cooke, N. (1985). Measuring the structure of expertise. *International Journal of Man-Machine Studies,* 23, 699-728.

Shebilske, W., Goettl, B., & Regian, J. W. (1999). Executive control and automatic processes as complex skills develop in laboratory and applied settings. In D. Gopher and A. Koriat (Eds.), *Attention and performance XVII: Cognitive regulation of performance: Interaction of theory and application* (pp. 401-432). Cambridge, MA: The MIT Press.

Simon, S. J. & Werner, J. M. (1996). Computer training through behavior modeling, self-paced, and instructional approaches: A field experiment. *Journal of Applied Psychology, 81,* 648-659.

Smith, E. M., Ford, J. K., & Kozlowski, S. W. J. (1997). Building adaptive expertise: Implications for training design strategies. In M. A. Quinones & A. Ehrenstein (Eds.), *Training for a rapidly changing workplace: Applications of psychological research* (pp. 89-118). Washington, DC: APA.

Tirpak, T. A. (2000). Kosovo Retrospective. *Air Force Magazine,* 83, 4. http://www.afa.org/magazine/april2000/0400koso.asp

Thiede, K. W. & Dunlosky, J. (1999). Toward a general model of self-regulated study: An analysis of selection of items for study and self-paced study time. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25,* 1024-1037.

Tossell, C., Garrity, M.J., Morley, and Rodriguez, D. (2004). Promoting Air and Space Operations Center (AOC) Training Transformation by Quantifying and Refining AOC Training Scenarios. In *Proceedings of the 26th Interservice/Industry Training, Simulation & Education Conference,* Orlando, FL, December, 2004.

ABOUT THE AUTHORS

Chad Tossell is a Behavioral Scientist for the Warfighter Readiness Research Division, Air Force Research Laboratory. Chad supports research and development (R&D) in training enhancement for the Air and Space Operations Center and Information Operations. He helps integrate R&D efforts with users, customers, decision makers, DoD, industry, and support contractors.

Michael J. Garrity is an Industrial-Organizational Psychologist and Team Lead for Performance Requirements and Assessment in the Human Performance Division at Aptima, Inc. Dr. Garrity has acted as a facilitator and analyst for several MEC[SM] efforts including recent efforts to define readiness requirements for the JFACC.

Kevin Gildea is a Human Factors Psychologist and Product Manager for the Distributed Dynamic Decision-making tool at Aptima, Inc. Dr. Gildea manages an effort to develop training for Air Force senior leaders.