Developing Command and Control Performance-Based Training Criteria in a Network Centric Environment

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To meet the evolving needs of 21st century combat, the United States Air Force (USAF) has advanced a competency-based approach to training by developing command and control (C2) metrics to (1) identify training requirements that focus on processes and collaboration rather than platform-specific "buttonology", (2) determine behaviorally-anchored performance measurement criteria, and (3) develop team training methods and systems. The Mission Essential Competency (MEC^{SM}) process was used as a foundation to achieve these three objectives. Below we describe the MEC^{SM} framework and its application for both Air and Space Operations Center (AOC) training and acquisition. Specifically, we show how the application of the MEC^{SM} analysis to the Senior Command and Control (C2) Node in the USAF has provided a framework for Distributed Mission Operations (DMO) integration, focused training scenario development, and a performance measurement capability for certification and after action review. Finally, we conclude with an analysis of the applicability of the MECs^{SM} and associated performance metrics to the development and integration of the AOC weapons system.

Developing Command and Control Performance-Based Training Criteria in a Network Centric Environment

Technology is evolving at a rapid pace making bringing the theory of Network Centricity closer to reality. Achieving effective team performance in a Network Centric Environment, however, remains a key challenge within Command and Control (C2). In this report, we describe recent advances in training that enable the development of proficiency in key skills necessary for effective decision-making and teamwork in this environment. We use the Air and Space Operations Center as a case study to illustrate these developments.

The Air and Space Operations Center (AOC) is undoubtedly the most multifaceted weapons system in the United States Air Force (USAF) inventory (Tossell, Garrity, Morley, & Rodriguez, 2004). Typically, an AOC employs well over three hundred personnel at a given time. Five divisions separate the numerous teams within an AOC, and each team carries out different command and control (C2) functions to execute common objectives spanning nearly every USAF Mission. Needless to say, training individuals in this complex environment to function as a war fighting whole is both challenging and important.

A highly contextualized competency-based approach was used to meet the aforementioned challenge of increasing training proficiency in war fighting organizations like the AOC. The Mission Essential Competency (MEC^{SM}) process (Alliger & Colegrove, 2002) is a unique method to define and validate training requirements for training development and competence assessment. Two new constructs, Experiences and Environments, not found in traditional competency models are introduced in this framework to provide Human Resource Managers (HRM) and Training Managers additional ways in which to develop competencies and

competency-based training. Additional unique characteristics of this methodology include the identification of competencies that are more contextualized than is typically found, the ability of the MEC^{SM} elements to scale across organizational levels (from an entire organization down to a position within an organization), and the validation of the constructs through an extensive survey process.

This competency-based approach has been adopted by multiple organizations in the USAF to serve as the basis for developing, managing, and assessing training. This paper will use the AOC as a case study to illustrate the benefits of the MEC^{SM} process. In this article, we first provide an overview of the AOC and its unique organizational structure, mission, and training requirements. Second, we briefly describe the MEC^{SM} framework and discuss the challenges associated with utilizing this competency-based approach on a large and complex organization. Third, we discuss the impact of the MEC^{SM} analysis on AOC training though the AOC is still in the initial stages of transitioning from a traditional training approach to a competency-based approach. We conclude with recommendations regarding the implementation of this type of approach for the larger command and control community.

Air and Space Operations Center (AOC)

The AOC is the senior command and control node in the USAF Theater Air Control System (for more on the AOC, the reader should review other literature, e.g., Alliger, G., Garrity, M. J, Tossell, C., McCall, M., Beer, L. 2004; Garcia, 1996). Consisting of five

divisions[1], each comprised of multiple teams, the AOC provides operational level command and control of air and space forces as the focal point for planning, directing, and assessing air and space operations. Personnel assigned to the AOC are responsible for managing hundreds of aircraft and ground assets every day of an operation. Individuals working in an AOC must be well-trained, versed in military doctrine, and have a "big-picture" viewpoint of the given operation. While the AOC has been in existence since the beginning of the USAF, lessons learned since Operation DESERT STORM, personnel policies which drive AOC manning, and the incorporation of evolving net-centric collaborative tools has created a high demand for improved training methods. The high work tempo of the military and lack of defined, formal continuation training (Tossell et al., 2004) has further exacerbated the need for focused training for AOC personnel.

Training Shortfalls in the AOC

Like most organizations in the USAF, individuals are trained to work in an AOC in three basic ways. First, classroom training is provided to most as an introduction to command and control, and to basic AOC operations and systems. Second, for select groups of AOC personnel from different locations, a large-scale exercise (Blue Flag) is conducted roughly once a year and part-task training events (Red Flag and Virtual Flag) are conducted twelve times a year. Third, on-the-job training is offered at every unit; because of the differences between theaters, training is tailored to the location of the AOC.

[1] The five divisions in the AOC are the Strategy Division, the Combat Plans Division (CPD), the Combat Operations Division (COD), the Intelligence, Surveillance, and Reconnaissance Division (ISRD), and the Air Mobility Division (AMD).

While in general AOCs have been historically successful (Clancy & Horner, 1999), serious training shortfalls have been identified (Tossell et al., 2004). For example, consider the aforementioned Blue Flag exercise provided to select members of the AOC community to practice the art of command and control in a simulated operation. Due to the large number of people at a given exercise and typical training objectives, not everyone in attendance receives optimal training. During Blue Flag exercise, strategists and planners participate in developing only a single executable plan. Once developed, that plan is executed by the AOC combat operations personnel. There may be little, if any, opportunity for the strategists and planners to revise and improve the plan based on feedback obtained during execution. Training, in these larger exercises, is focused at an organizational level. Thus, individual and team training requirements are not always considered in exercise planning or in post-exercise debriefing sessions. As the individual contributions of each position and team affect the ability of the entire AOC to successfully complete its mission, this lack of continuity from individual to team to organizational training requirements reflects a large gap in training development and execution.

Mission Essential Competencies

A competency model is a set of competencies that have been identified as being required for successful performance in a job, job family, department, business unit, function, or organization. One major benefit of competency modeling is that, when done correctly, it can help align HR practices with the needs of the organization. However, competency modeling is often not as thorough as traditional job analyses, and Subject Matter Experts involved in competency development do not have job analysis information available to them (Lievens, Sanchez, & De Corte, 2004).

To retain the benefits and address limitations of traditional approaches, the MEC^{SM} process represents a "blended" approach that utilizes elements of both competency modeling and traditional job analyses. In addition, the MEC^{SM} model is distinctive (from both competency modeling and job analyses) in that it includes contextualized constructs that provide experiences for the development of the identified competencies. Table 1 briefly summarizes this comparative analysis among job analytic methods.

----------Insert Table 1 About Here----------

The nature of and rationale for MECs^{SM} have been explained elsewhere (Alliger, Colegrove, & Bennett (2003); Colegrove & Alliger, 2002), but a very brief description of the elements of the MEC^{SM} model and process is provided here. Included in the MEC^{SM} model are the Mission Essential Competencies (proper), Supporting Competencies, Knowledge, Skills, and Experiences. Each of these elements is a brief statement about required proficiency elements written at different levels of abstraction.

The AOC MEC^{SM} development process

The elements of the AOC MEC^{SM} model were developed via a Subject Matter Expert (SME)-centered process. Specifically, development involved a) detailed facilitated workshops with SMEs identified by the operational customers according to stipulated criteria, b) data gathering from the broader operational community via surveys, c) a detailed analysis and organization of the survey results, and d) facilitated workshops where SMEs view, interpret, and make recommendations based on the survey data. Thus, the initial set of draft MEC^{SM} s are developed following a workshop wherein SMEs provide information about work structure/tasks, Knowledge and Skill elements, and Supporting Competencies (SCs). All data gathered in the

first workshop is compiled and organized into a draft set of MECs[SM], SCs, and Knowledge and Skill elements. The second workshop provides an opportunity for SMEs to validate and refine the findings from the first workshop and allows the facilitators to delve deeper into the more detailed Knowledge, Skills, and elicit Experience components of the MEC[SM] model. Following the second workshop, an extensive database of expert knowledge about a career area exists. This information is organized into survey questionnaires which are presented to the broader operational community for that particular organization. After collecting and compiling the data, a comprehensive analysis of the organization and associated career field training status is performed, again via a facilitated, SME-centered workshop. As needed, other SME-centered work may occur (e.g., linking of knowledge and skills to experiences, Symons, France, Bell, & Bennett, 2003).

Mission Essential Competencies (Proper). Mission Essential Competencies are higher order functions, job-contextualized and hence, less general in most cases than competencies found in typical business environments (Colegrove & Alliger, 2002). The statements encapsulate expert performance indicators instead of a general description of observable behaviors showing moderate competence. Put another way, the MECs[SM] are carefully elicited from subject matter experts (SMEs) to capture characteristics of proficiency. The focus of the MECs[SM] is on those competencies that a *fully prepared* individual or team requires for successful mission completion under *adverse* conditions. The MEC[SM] process has been applied to a continuum of platforms, ranging from single-seat, single operator "systems" (e.g., F-15C, F-16, A-10, JTAC), to small, dyadic teams (e.g., F-15E, GR-4 "Tornado"), to larger platforms with multiple teams and operators (e.g., AWACS, Rivet Joint, JSTARS), to yet larger, multi-division,

multi-team ("team of teams") systems such as the Information Operations Center, Air Support Operations Center, and AOC, of which the AOC is the largest and most complex.

For the AOC, MECs[SM] were developed at the division level[2]. Examples of MECs[SM] from the Combat Operations Division include:

> Monitor the Battlespace: Maintain situational awareness of the battle plans and associated documents, TACS system, logistics, communications, weather, base/wing status, and friendly/adversary air, space, ground and naval force status and activity.
>
> Monitor Battle Plan Execution: Confirm taskings are carried out and that the JFACC objectives, in support of JFC's intent, are achieved. Ensure that tasked aircraft are packaged appropriately for maximum mission effectiveness and force protection.
>
> Assess and Integrate Information**:** Constantly assess and integrate information to identify potential ramifications to current operations.
>
> Dynamic Execution: Based on the ramifications of current information, make decisions regarding changes in plans, taskings, and execution. Work closely with units and component and allied liaisons for a coordinated application of capabilities and assets.

Analysis after workshop 1 typically results in five to seven MECs[SM] per organization to describe the higher-order competencies needed to carry out mission objectives.

Supporting Competencies. At a more broad and general level are the aptitudes that underlie the successful development and performance of the MECs[SM]. Supporting Competencies (SCs) are general aptitudes or competencies at a level more commonly seen in traditional competency models. Although the MEC[SM] model was developed to be highly contextualized, these low-context and broad-spectrum constructs are still noted as crucial to a comprehensive competency model. As the examples below from the AOC Combat Operations Division

[2] Currently, MECs[SM] have been developed for four out of the five divisions: Strategy Division, CPD, COD, and ISRD.

illustrate, Supporting Competencies can be typical of those found in public and private organizations (e.g., decisiveness) or more specific to the military (situational awareness).

Decisiveness: Ability and willingness to make timely decisions based on available information.

Adaptability: Identify and adjust to changes in the environment.

Multi-tasking: Ability to effectively perform multiple responsibilities simultaneously.

Situational Awareness: Ability to assimilate information to develop and maintain a perception of current operations scaled to individual responsibilities.

Knowledge and Skills. At a somewhat finer level of granularity than MECs^{SM} or Supporting Competencies are Knowledge and Skill elements. The list of knowledge and skill elements, as one would expect, is more extensive than both the MECs^{SM} and SCs. The knowledge and skills are deliberately elicited at the level of natural language – they are couched in operational terms and at an interpreted level of action clustering that is common among job holders. This is intentional, as it is desirable to use the level of knowledge/skill "chunking" that is common among military personnel to facilitate data collection and ensure comprehension by the military community. This approach can cause jargon-based irregularities in the level of detail specified (Denning, 2004). Thus, it is critical that the knowledge elicitation sessions provide the researcher with an in-depth understanding of the scope of each knowledge and skill element. MEC^{SM} knowledge and skill elements are developed specifically with training utility as a primary consideration.

Knowledge is defined as "information or facts that can be accessed quickly under stress," while for our purposes, a skill can be defined as "a compiled sequence of actions that can be carried out successfully under stress." The addition of the word "stress" reflects the emphasis on performing under combat conditions. Knowledge and Skill elements, like the MECs^{SM} (proper),

are elicited to address what an expert knows or is able to do in these situations. Examples of Knowledge statements, again from the AOC Combat Operations Division, include:

- Understands Air Tasking Order (ATO) change processes and procedures
- Knows AOC battle rhythm
- Understands how offensive operations puts acceptable ordnance on the target in a timely manner

Examples of Skills include:

- Able to monitor ATO execution (missions/assets/resources)
- Able to recommend, coordinate and implement changes to the ATO
- Able to recommend and adjust assets to optimize C2, EW, and ISR coverage

This taxonomy of what an individual needs to know and accomplish for expert performance is further refined by a mapping of relevance for each Knowledge and Skill by position within the appropriate team and division.

Experiences. One of the toughest challenges for Human Resource Managers and Training Managers is to systematically transition from training requirements, like the MEC^{SM}, SC, and Knowledge and Skills, to the design of concrete, formal training. In our model, what we term "Experience" is elicited as one way to bridge this gap. Experience elements are tangible events in the life of, in this case, AOC military members that can be implemented in a training environment (either live or simulated) to increase proficiency in a MEC^{SM}, SC, Knowledge, or Skill. Put another way, an Experience can be defined as a event that creates conditions for competency or knowledge and skill development at various times across the career of a military member necessary to learn a Knowledge or Skill, or practice a MEC^{SM} or SC under operational conditions. An Experience in the MEC^{SM} model is thus 1) an **event** that occurs to or situation encountered by, 2) an **action** that is performed by, or 3) an **operation** for a pilot, crew, team, or

flight and that may be helpful in gaining the competencies required for successful mission completion under adverse conditions and in a non-permissive environment. An Experience is then an identifiable event that is a facilitator of combat mission readiness. An Experience can occur in any environment, training or actual combat operations. Examples of experiences from the AOC Combat Operations Division include:

- Senior level briefing
- Joint/Coalition operations
- Late completion of data inputs
- Poor target list

Not all of the experiences identified in the MEC^{SM} process are deemed desirable to encounter in "real-world" operations, but optimal to experience in a training environment to develop proficiency. Similar to the knowledge and skill elements, the Experiences are mapped to every position to highlight which positions would benefit most from each Experience.

Environments. In order to obtain optimally informative training needs analysis data from the field, Environments in which various Experiences can be obtained are identified. For the AOC, these included exercises, local training (such as on-line study), formal training (entry-level and advanced courses), and operational deployment (e.g., Operation Enduring Freedom).

Validation

Competency data is not typically examined closely to ensure validation. In most cases, it has been considered sufficient to assume that competencies are content valid – that is, possess validity based on the method by which they were constructed. Content validity is accepted as one way to demonstrate validity (Ebel, 1977; Lawshe, 1975). Due to the systematic method in

which MECs[SM] are constructed, they may be presumed to have content validity. However, because of the wide range of uses for the data collected via MEC[SM] surveys, and the importance of the decisions based on them, it is critical to look at these data more closely than is typical for competency models. To meet this goal, we report here two results: a) survey reliability and b) whether different teams within the same division make appropriate distinctions (Alliger, Beard, Bennett, Symons, & Colegrove, in preparation).

Reliability. We were interested in understanding whether individuals within the same team would demonstrate agreement when rating the relevance of a particular MEC[SM] to their job performance. Initial analyses indicate agreement among team members in their ratings (see figure 1). The data also show meaningful distinctions between MECs[SM] in terms of their relevance.

----------Insert Figure 1 About Here----------

Team distinctions. We asked whether teams within the same division would be distinguishable in terms of their expert ratings of proficiency. Initial indications are that this is the case. Figure 2 below shows the mean proficiency profiles for the Combat Plans Division teams within the AOC. Note that each of the teams is distinguished from one another, and the MECs[SM] are also distinguishable from one another in terms of mean ratings. AOC experts have concurred that the general pattern of proficiencies displayed in Figure 2 reflects those in the field.

----------Insert Figure 2 About Here----------

Impact of MEC[SM] Analysis on AOC Training

As discussed above, the MEC^{SM} analysis has impacted AOC training in several ways. First, MECs^{SM} are now used as the basis for formalized definitions of AOC training requirements (Air Force Instruction 13-1AOC Volume 1) used by AOC training managers worldwide. Second, AOC MECs^{SM} now feed the development of training scenarios implemented in the primary mission part-task trainer at every AOC unit. AOC MECs^{SM} are also used as the basis for the development of performance measures, used by trainer-observers and instructors, for assessing competence in AOC training. These examples, while not comprehensive, serve to illustrate the value of the MEC^{SM} process to AOC operators, trainers, and evaluators. A brief summary of each application is provided below.

Uses of MECs^{SM} as AOC Training Requirements

As mentioned earlier, the MEC^{SM} model provides a set of competencies (both MECs^{SM} and Supporting Competencies) and related components (such as Knowledge and Skill statements) that can be used in various ways to build a competency-based training program. For the AOC, researchers have begun work to formally define the relationship between the various elements within the MEC^{SM} model (Tossell, in prep). Experiences are meant to provide opportunities to develop proficiency in Knowledge and/or Skills and, in turn, enable development of Supporting Competencies and MECs^{SM}. Formal modeling must include statistical weightings indicating differential relationships between components within element class (MECs^{SM}, SCs, KSs, Experiences, etc.). Below is an outline of three ways AOC training managers can use the linkage within this unique competency model to develop training.

MEC^{SM} -based training needs analysis, approach 1: Using MEC^{SM} proficiencies. Given the linkages discussed above, a potential implication for competency-based training needs

assessment becomes apparent: it may be possible to use a deductive approach, working backwards from the highest level, MECs[SM], to determine training needs. Specifically, an Assessment and Analysis approach could be used, as outlined below:

Assessment: First, assessment can determine which competencies require training. The MECs[SM] survey process typically gathers self-report information about the proficiency of individuals on each MECs[SM].

For example, initial data on the Combat Operations Division in the AOC indicates that the MEC[SM] ranked lowest in proficiency was Execution Feedback. Experts indicate that this MEC[SM] may be targeted for training through the use of vignettes (developed via the Experiences).

Analysis: Assuming a complete linkage among MEC[SM] elements, Experiences may be provided in a targeted way; that is, a "backward walk" from the appropriate MECs[SM], to the associated Knowledge and Skill(s), and from there to the associated Experience(s). The Experience may have one or many scenarios associated with it to engage the trainee.

MEC[SM] -based training needs analysis, approach 2: Using the COMMAND results. Yet another approach for identifying training needs is via the COMMAND (Comprehensive MECs[SM] Analysis and Needs Determination) process. Here, Experiences are reviewed in sequence, adhering to the following format: Within an AOC division, for each Experience, three questions are asked of SMEs, with survey data being presented for each:

1. How important is the experience in developing the MECs[SM]?
2. How useful would it be to provide this experience in specific environments?

3. How often have you had this experience in this environment over the last 2 years?

Experts on the AOC interpret the data and answer the questions above during a facilitated session. Conclusions for each question are captured, as well as overall conclusions for each experience. The result is that certain experiences are identified as requiring training – that is, training gaps are identified.

MECs^{SM} -based training needs analysis, approach 3: Knowledge and Skill Inventory. Yet a third approach to training needs analysis using MECs^{SM} is via the AOC Knowledge and Skills surveys for each major position within a team within a division (e.g., within the Targeting Effects Team (TET) within the Combat Plans Division). SMEs stipulated during the development of the MECs^{SM} the minimum level of Knowledge or Skill (Basic, Intermediate, or Advanced) required for proficient performance at that position. During surveys, each individual completes a Knowledge and Skill inventory in which he or she indicates their current proficiency level (Basic, Intermediate, or Advanced) in relation to the KS requirements. Thus, an assessment of current KS proficiency against the developed MEC^{SM} standard is obtained. These results are then analyzed to understand training needs in relation to specific KSs (e.g., if most operators at a given position for a particular Knowledge or Skill report a Basic level when an Intermediate level is required).

Below is an example of such an analysis conducted on data for the Offensive Operations team within the Combat Operations Division. This analysis (though on too small a sample as yet to draw conclusions for most of the positions) shows green where at least 75% of individuals reported having the minimum required level of Knowledge or Skill (indicated in each cell as B, I, or A for Basic, Intermediate, and Advanced); a hatched cell indicates at least 75% reported

exceeding the minimum level; yellow indicates a smaller majority than 75% reported meeting the minimum level; red indicates that less than half the sample indicated meeting the minimum level. The uses of such an analysis are straightforward, in that training needs are identified by the red and perhaps yellow cells, while potential areas for training savings may be indicated by the hatched cells.

----------Insert Table 2 About Here----------

Training to Meet Identified Needs

Once training needs for the AOC teams and positions have been formally defined, training can target those needs. If needs have been identified by the "backwards walk" approach from MEC^{SM} proficiencies, appropriate Experiences and/or Knowledge and Skills can be targeted for increased training. In addition, the COMMAND analysis identifies Experiences that can be provided to meet deficiencies with greatest impact for development. Finally, the Knowledge and Skill inventory approach provides specific information regarding Knowledge and Skill requirements in need of training attention. In each of the approaches, training managers must still bridge the gap between deficiencies and a training scenario in which to expose the trainees. COMMAND analysis experience inventories establish the closest solution to final form. With COMMAND experience sets, scenario development simplifies to threading experiences together into a rational flow. In the other approaches, there is still considerable work to be done by the trainers requiring extensive instructional knowledge and expertise.

Training Scenario Development for a Part-Task Trainer

Once select training needs have been identified, the principal challenge for training managers is to effectively transition from training requirements to the design of specific formal training. For the AOC, this challenge is compounded due to the sheer number of positions within the organization and the complexity of its mission. Air operations centers are responsible for all air operations planning, conduct, logistics support, and intelligence gathering within a theater of war. This creates a broad context for decisions across dimensions of time and space, making it difficult to create operational level training environments that provide the wide range of variables necessary to support learning. Hence, training managers must consider impacts of combinations of experiences and how they influence each other in the overall situation in which trainees are exposed.

Simulators, such as a part-task trainer, can provide focused training in the areas that the MEC^{SM} analysis highlights as most essential to facilitate improvement in a trainee's performance. In order to develop effective training for AOC personnel, we applied a systematic approach to link the training requirements identified throughout the MEC^{SM} process directly to developmental experiences, and tasks associated with these experiences, that can be used to build simulation scenarios (Figure 3).

----------Insert Figure 3 About Here----------

Effective team-level training will be provided as we focus the simulation system around those scenario elements (Experiences) that are most likely to improve overall performance based on the MEC^{SM} framework. Thus, the linkage between knowledge and skills needed for mission success and developmental Experiences that are reasonably provided within a simulation environment are critical to the development of training scenarios for the part-task trainer.

Specifically, those Experiences that can develop the greatest number of knowledge and skill elements in a simulation environment are considered “rich” scenario events for training, providing many opportunities for learning. Successful performance throughout the scenario requires trainees to demonstrate proficiency in relevant knowledge and skill sets as well as SCs and MECs. These “rich” developmental experiences provide the context with which to build training scenarios, and by including these critical experiences in simulation systems, trainees can be engaged in situations which are known to develop competencies required for expert performance.

The use of the MECs^{SM} to develop shorter, more focused, scenarios can also allow trainees to face specific problem sets to overcome as well as offer opportunities to exercise branch and sequel events not always provided in larger scale training exercises. As such, MECs^{SM} enable the development of individual-level and team-level training scenarios for use in the Command and Control Weapons System Part Task Trainer (C2WSPTT). This smaller-scale and more focused training environment will mitigate the high resource requirements associated with large scale exercise while providing high-value training experiences in a live-constructive environment before these "warfighters" reach combat.

Competency-Based Assessment

Similar to other organizations in the military, the AOC has traditionally assessed readiness via time (e.g., pilot “hours”), relative ranking (e.g., comparison to normed peer performance), attendance (not performance) in a large-scale exercise, or completion of a series of courses. As the AOC adopts the competency-based approach to training, new criteria based on

the MECs[SM] are being identified for the USAF to determine mission readiness for AOC personnel. Research is underway to develop certification criteria for the AOC and, while not yet complete, we will introduce this process below.

Of primary importance to the development of this criterion for the AOC is the environment in which trainees demonstrate their performance. The assessment of individuals will primarily take place in a simulated combat situation. The technological capabilities that exists today in the USAF enables the simulated environment to interject conditions, cues, and feedback similar to the actual working environment (Colegrove & Alliger, 2002). Additionally, performance data can be more readily collected in simulated environments from data streams and from expert observers. This development in training environments provides additional training venues for individuals and teams without the cost of large exercises or the risk inherent in operational environments. The AOC part-task trainer discussed above is an example of such a simulated training environment. Thus, evaluators will be able to assess individual performance on targeted competencies in a "normal" environment in which combat processes are carried out in a training environment with engineered stress.

Assessment in competency-based programs must be criterion-referenced with the criteria being the competencies upon which the program is based (Foyster, 1990). Thus, the MEC[SM] constructs were elicited not only as training requirements for the AOC, but also as the competencies used to determine an individual's proficiency. These competencies are used as the basis for the development of Performance Indicators or observable behaviors associated with successful performance (Garrity, Entin, Morley, & MacMillan, 2004). These behaviorally-based performance indicators are captured during follow-on workshops and are mapped back to the

appropriate competencies and Knowledge and Skill elements (See Figure 3). Performance indicators are then used to create specific performance measurement criteria for observer/trainers and instructors to evaluate trainees' performance during a part-task training event, an exercise, or on-the-job training. The consideration of performance assessment, in addition to training requirements definition and training development, provides AOC human resource managers a comprehensive framework to effectively develop, manage, and assess training for their organization.

Discussion/Conclusion

The "blended" MEC^{SM} approach to training has multiple implications for the management of HR. Consider the Joint Force Air Component Commander (JFACC). This leader has the ultimate responsibility of human resource management in the AOC, and provides the guidance and intent that the AOC receives and builds into Air Tasking Orders designed to fulfill the strategic goals. From the JFACC's point of view, then, AOC members need to be selected and trained as effectively and efficiently as possible. Similarly, maintaining an appropriate number of skilled employees is not only desirable, but potentially critical to mission success. The MECs^{SM} provide value to the JFACC and other AOC leaders by giving them content and direction for recruitment, selection, training, and succession planning. Now that this framework has been built, work in developing a competency-based Learning Management System to house individuals' training history using the MEC^{SM} framework can be commenced. Research in this area is ongoing at the Air Force Research Laboratory.

Additionally, this approach can influence the development of future training system requirements. The identification of experiences and/or KSs that are critical to mission readiness but not currently provided or taught effectively can assist system acquisition personnel in identifying new avenues for development. For example, obtaining experience with "Joint/Coalition Operations" may currently lend itself to being obtained only in Blue Flag exercises and operational deployments. If the training gaps analysis were to find that this experience is very important in developing the MECs[SM] and it was not being experienced frequently enough, an Initial Capabilities Document (ICD) might be developed to explore alternative training venues for providing that experience. This can ultimately lead to the development of additional training platforms for AOC personnel.

This case study is meant to demonstrate the utilization of MECs[SM] in a broad, operational Air Force system. Several recommendations for the broader C2 community might be drawn from this work. First, we have found that SME involvement throughout the entire competency process is extremely useful, and in fact determinant of both the nature of the process and its success. For example, in a facilitated workshop, summary survey data is presented to SMEs, which they interpret (e.g., by identifying training gaps). This leads to a degree of realistic training need identification that we have not hitherto seen from, for example, a standard competency-based training needs survey. Part of the reason for its effectiveness may be precisely because it is SMEs, rather than training researchers, who are interpreting the data and ensuring the operational relevance of the findings. Second, the fundamentally job-oriented, non-general characteristics of the elements of the MEC[SM] model mean that requirements are not written or understood at the level of abstract skills. This eliminates an entire level of inference

between training needs and recommended ways of addressing those needs. Third, MEC[SM] efforts have been closely linked with immediate, recognized needs (e.g., the pressing need to develop training for AOC operators). This has resulted in quick prototyping of tools and methods to apply the constructs developed in the model (e.g., the smaller-scaled training events for a part-task trainer and other training venues mentioned earlier).

Enterprise efforts such as the intensive collaborative environment of an AOC are far more sensitive to competency of process than of supporting systems and applications. For example, failure of supporting systems is not grounds for ceasing activities. The AOC is still required to accomplish its processes by other means. In the event of partial or full system failure, teams and individuals must be fully conversant with the value added at each step of the overall process to be able to organize and adapt. The need for surety in mission accomplishment drives AOC training managers to focus on interactions between individual and team processes rather than systems operation at the individual level. A training system developed from mission essential competencies provides focus to knowledge and skill development on a higher plane of interactive processes enabling a vastly stronger mastery of the command and control mission.

Continued use of competencies to identify specific training needs and to guide solution development will effectively leverage MEC[SM] efforts and continue to benefit the USAF. The AOC has only begun transitioning from a more traditional training approach to the MEC[SM] - based approach. Few organizations have such an important and relentlessly detailed mission as the AOC. The AOC is responsible for command and control of every USAF asset in a given theater. One wrong coordinate on an Air Tasking Order could lead to a friendly-fire incident or

loss of innocent civilians' lives. The success of competency-based training in this dynamic and stressful environment is not an optional goal.

References

Alliger, G., Garrity, M. J., Morley, R., Rodriguez, D., Beer, L. & McCall, M. (2003). Competency-Based Definition of Work & Performance for Command and Control. Paper Presented at the *25th Interservice/Industry Training, Simulation & Education Conference*, Orlando, FL, December.

Alliger, G., Garrity, M. J, Tossell, C., McCall, M., Beer, L. (2004). Cross-Divisional Analysis of Competency-Based Training Requirements for the Air and Space Operations Center (AOC). In Proceedings of the *26th Interservice/Industry Training, Simulation & Education Conference*, Orlando, FL, December.

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

Alliger, G., Beard, R., Bennett, W., Symons, S., & Colegrove, C. (2005) A Psychometric Examination of Mission Essential Competency (MEC) Measures Used in Air Force Distributed Mission Operations Training Needs Analysis. *Manuscript in preparation.*

Clancy, T., & Horner, C. (1999). *Every man a Tiger*. New York: Penguin Putnam.

Colegrove, C. M. & Alliger, G. M. (2002). *Mission Essential Competencies: Defining Combat Mission Readiness in a Novel Way*. Paper presented at the *NATO RTO Studies, Analysis and Simulation Panel (SAS) Symposium*. Brussels, Belgium.

Denning, T., Bennett, W., Symons, S., France, M., Bell, J. (2004) *Performance Assessment in Ditributed Mission Operations: Mission Essential Competency Decomposition.* In

Proceedings of the *26th Interservice/Industry Training, Simulation & Education Conference*, Orlando, FL, December.

Garcia, P.F. (1996). Twelfth Air Force (12AF) Air Force Forces (AFFOR) Air Operations Center (AOC) Standard Operating Procedure (SOP). Retrieved February 23, 2005 from http://www.fas.org/man/dod-101/usaf/docs/aoc12af/index.html.

Garrity, M. J., Entin, E.B., Morley, R.M., & MacMillan, J. (2004). *A Streamlined Scenario-Based Methodology for Evaluating Distributed Performance.* AFRL Research Report AFRL-HE-AZ-TR-2004-0130. Mesa, AZ: United States Air Force Research Lab Human Effectiveness Directorate.

Foyster J. (1990). *Getting to Grips with Competency-Based Training and Assessment.* TAFE National Centre for Research and Development: Leabrook, Australia. ERIC: ED 317849

France, M. & Symons, S. (2003). Linking Knowledge and Skills to Mission Essential Competency-Based Syllabus Development for Distributed Mission Operations. Paper Presented at the *25th Interservice/Industry Training, Simulation & Education Conference*, Orlando, FL, December.

Lievens, F., Sanchez, J.I. & De Corte, W. (2004). Easing the inferential leap in competency modeling: The effects of task-related information and subject matter expertise. *Personnel Psychology, 57*, 881-904.

Smith, E. & Keating, J. (1997). *Making sense of training reform and competency-based training, Social Science Press*, Wentworth Falls.

Sullivan, R (1995). *The Competency-Based Approach to Training*. Retrieved from http://www.reproline.jhu.edu/english/6read/6training/cbt/cbt.htm

Tossell, C., Garrity, M. J. & Morley, R. Rodriguez, D. (2004). Promoting AOC Training Transformation by Quantifying and Refining AOC Training Scenarios. Paper Presented at the *26th Interservice/Industry Training, Simulation & Education Conference*, Orlando, FL, December.

Tossell, C. (2005). Developing A Mission Essential Competency Model For Command & Control Competency-Based Training. *Manuscript in preparation.*

Table 1. A Comparison of Various Job Analysis Methods

Job Analysis Method	Major Functions?	Detailed Tasks?	Human Requirements?		Develop-mental Experiences?	Training Require-ments?	Cognitions?	
			Knowledge/ Skill	General Abilities			Detailed Task or Decision Cognitions?	Overall Mental Model?
FJA	**Y**	**Y**	**Y**	**Y**	**N**	**Y**	**N**	**N**
CTA	**N**	**N**	**N**	**N**	**N**	**N**	**Y**	**Y**
Task Analysis	**N**	**Y**	**N**	**N**	**N**	**N**	**N**	**N**
WRO Analysis	**N**	**N**	**Y**	**Y**	**N**	**N**	**N**	**N**
MEC^{SM} Analysis	**Y**	**N**	**Y**	**Y**	**Y**	**Y**	**N**	**Y**

Key:
FJA = Functional Job Analysis
CTA = Cognitive Task Analysis
Task Analysis = Traditional task analysis (e.g., obtaining Frequency/Importance/Difficulty ratings)
WRO Analysis = Worker Requirements Oriented Analysis, yielding broad requirements by the job of a worker (e.g., Positional Analysis Questionnaire)
MEC^{SM} Analysis = Mission Essential Competency Analysis

Table adapted from Alliger, G.M., Colegrove, C. M., & Bennett W. (2003).

Figure 1**: Mean Relevancy Ratings for the Defensive Operations Team within the AOC Combat Operations Division**

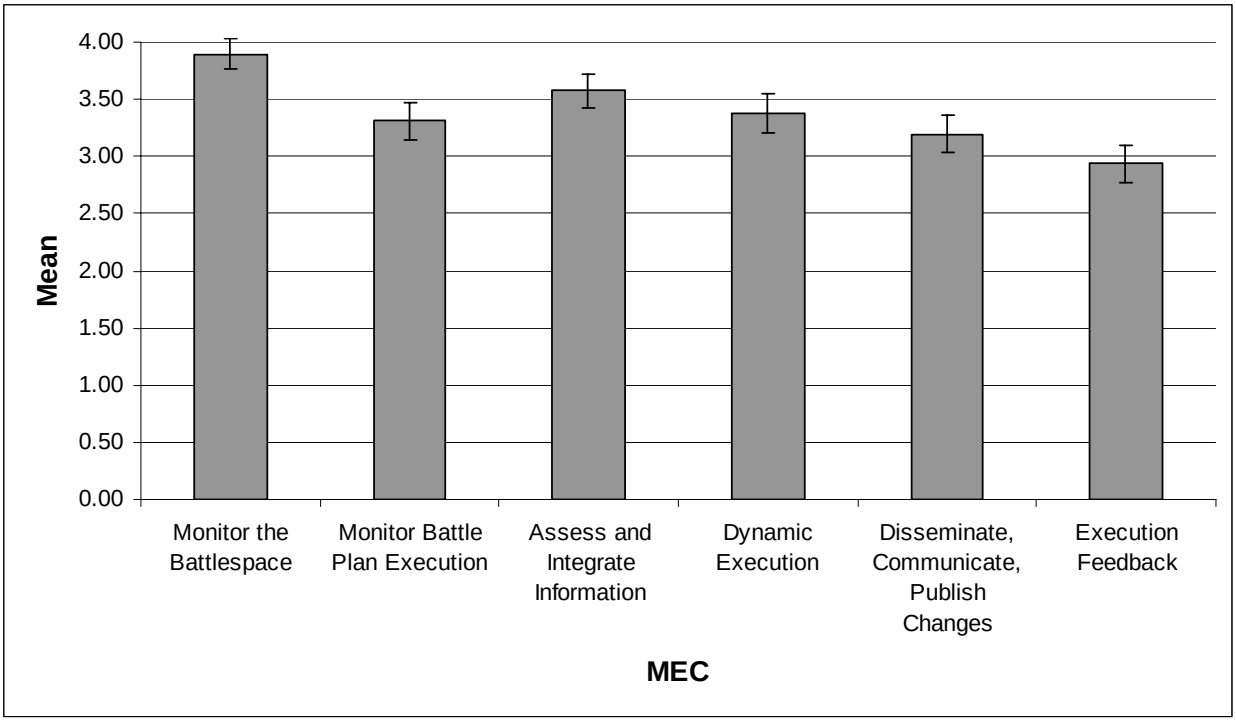
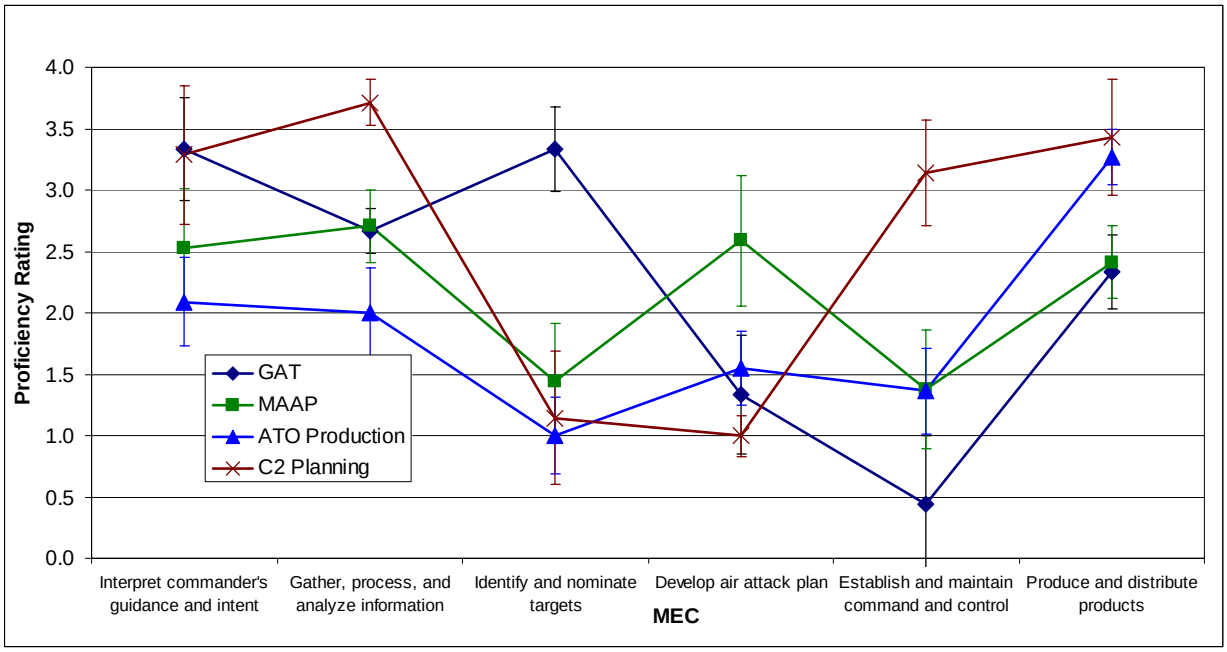


Figure 2**: Mean Proficiency Ratings for Four AOC Plans Division Teams**



Note: TET Team: N=15; MAAP Team: N=20; ATO Production Team: N=15; C2 Planning Team: N=10

Refresh

Knowledge and Skills

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Key: Percent at Level or Above

>75	Level +
50-74	
<50	
N/A or no data	

1 = **Basic (B):** you have the basic minimum knowledge or skill expected by an augmentee or less experienced personnel.
2 = **Intermediate (I):** you are currently applying the knowledge or skill but still need to seek direction and guidance regularly.
3 = **Advanced (A):** you serve as a model and source of information for the particular knowledge or skill.
N/A: the knowledge or skill is obviously not applicable for your position.

	Knowledge or Skill	Offensive Operations					CCO
		SODO (n=2)	SODO Tech (n=5)	ODO(s) (n=7)	TST Chief (n=3)	ATO Change Tech (n=11)	CCO (n=4)
7	Understands how defensive operations puts assets on the target in a timely, effective, and efficient manner	A	B	B	B	B	A
8	Understands how to coordinate with TACS units	A	B	I	A	N/A	A
9	Understands the data link architecture	I	N/A	N/A	I	N/A	I
10	Understands how Defensive Operations provides information for SA	I	B	B	A	N/A	I
11	Understands how Defensive Operations coordinates for alert status	I	I	I	B	B	I
12	Knows AOC battle rhythm	A	A	A	A	B	A
13	Knows function of other AOC teams and divisions	I	B	I	I	B	I
14	Understands the offensive and defensive capabilities, limitations, and effects of weapons systems	A	I	I	A	N/A	I
15	Knows criteria for alerts and warnings	I	B	I	B	N/A	I

Table 2. Example of Knowledge and Skill COMMAND Analysis

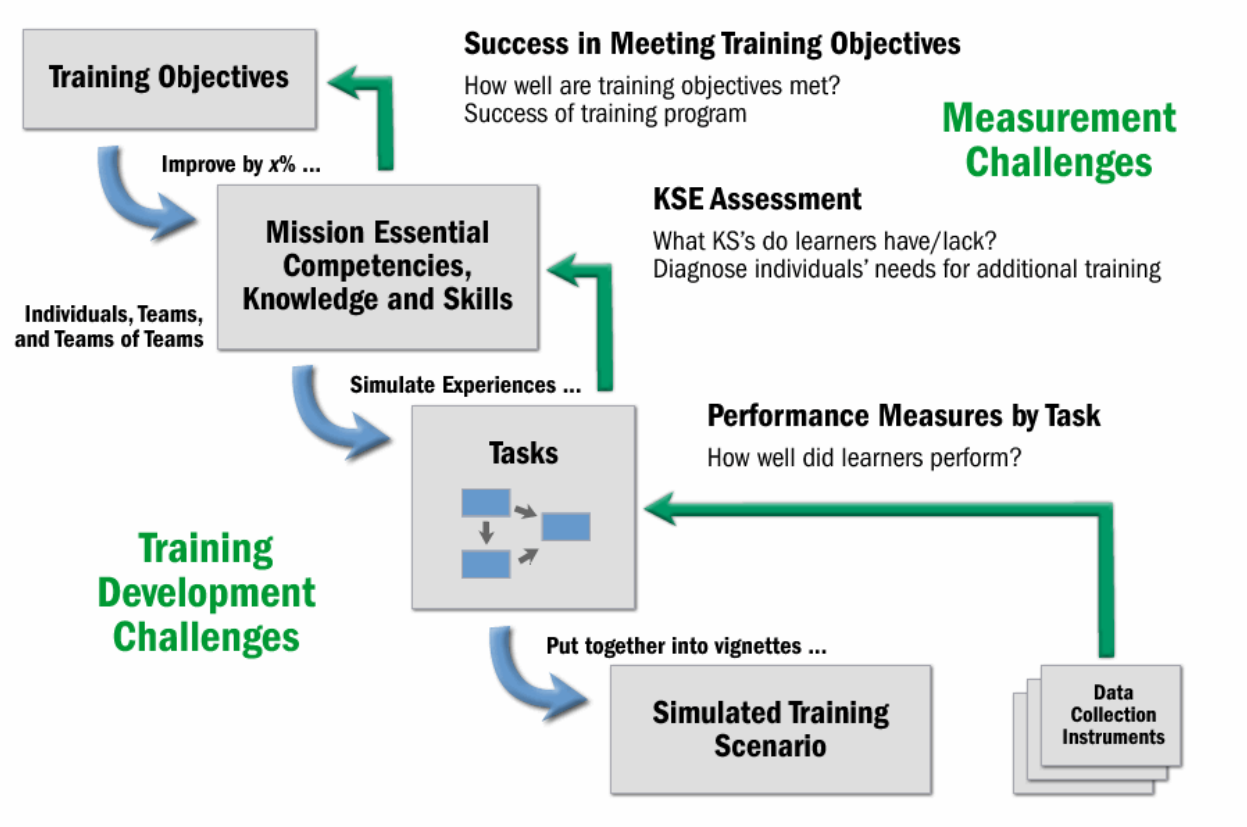

Figure 3. Systematic Approach to Transition from Training Objectives to Training Scenarios

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