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Understanding Mission Essential Competencies as a Work Analysis Method

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14. ABSTRACT

The United States Air Force Research Laboratory (AFRL), Human Effectiveness Directorate, Warfighter Readiness Research Division, in conjunction with the United States Air Force Major Command, Air Combat Command (ACC), has for a number of years pursued a program of research whose focus is the rational integration of networked flying, flying-related, and command and control simulators into current training via Distributed Mission Operations (DMO). The Mission Essential Competency (MEC) work analysis methodology was developed as one facet of this DMO initiative. The MEC approach addresses multiple AFRL/ACC DMO program needs. Among other purposes, MECs enable the determination of training requirements and the appropriate mix of live operation and virtual training media, allow ACC to identify the "value" of DMO and provide justification for funding, and directly enable the construction of air combat simulation scenarios for which validated measures can be developed. While much has already been written about the MECs, one particular unaddressed topic relates to the nature of this effort relative to other work analysis and competency methods. How are MECs different from other methods of work analysis? What outcomes does the MEC approach produce that are unique? Is the MEC process rigorous enough to be considered a work analysis method, as Industrial/Organizational Psychologists understand the terminology and process?

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Introduction

The United States Air Force Research Laboratory (AFRL), Human Effectiveness Directorate, Warfighter Readiness Research Division, in conjunction with the United States Air Force Major Command, Air Combat Command (ACC), has for a number of years pursued a program of research whose focus is the rational integration of networked flying, flying-related, and command and control simulators into current training via Distributed Mission Operations (DMO)[1]. The Mission Essential Competency (MEC) job analysis methodology was developed as one facet of this DMO initiative. The MEC approach addresses multiple AFRL/ACC DMO program needs. Among other purposes, MECs enable the determination of training requirements, and the appropriate mix of live operation and virtual training media, allow ACC to identify the "value" of DMO and provide justification for funding, and directly enable the construction of air combat simulation scenarios for which validated measures can be developed.

While much has already been written about the MECs, one particular unaddressed topic relates to the nature of this effort relative to other job analysis and competency methods. How are MECs different from other methods of work analysis? What outcomes does the MEC approach produce that are unique? Is the MEC process rigorous enough to be considered a job analysis method, as Industrial/Organizational Psychologists understand the term?

In order to address these questions, we take a historical-comparative approach. First, we consider the origin and nature of modern job analysis. Second, we do the same for the competency movement. Third, we review in some detail how MECs are developed and used. Fourth and finally, we discuss MECs as a job analytic technique, including some thoughts on the validity of the method.

I.   What is "Job Analysis"?

Everyday, "subjective" descriptions of work

We can think of the understanding of work as being approached from two standpoints: objective and subjective. It is true, of course, that it is precisely in a personal, subjective way that work is usually discussed in informal settings. Consider, how do people describe their work in everyday, casual situations? In what terms would a professor of linguistics discuss her job when asked by a stranger "What do you do?" while at a party, or while seated at a gate in an airport? Or, how would a sales representative of a company which makes heavy farm equipment talk about his work in a similarly informal situation? Obviously, how these individuals would describe their work depends on many things – but it is unlikely that they will make highly general statements about all linguistics professors or all sales representatives. Instead, they are likely to describe their jobs in highly personal terms – reflecting what they, as individuals, do.

In fact, one interesting aspect of personal work descriptions is that they will differ from person to person, even if the people are doing work which on the surface is very similar. Two secretaries in the same department may produce very different descriptions of what they do. This is because how they see their job is inextricably bound up in *who they are*. Are you calm, personable, and relaxed by nature? If so, it is likely that you will describe the work which you do in a way different from someone who is pessimistic, negative, or highly emotional. Similarly,

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if you have been raised in an environment where the job someone does is an important determinant of social status, then the way you perceive and describe your job may be influenced by this.

Even when asked to describe their jobs in a somewhat more formal way, people often describe jobs which may be thought to be very similar to an outside observer in very different ways. Research indicates, for example, that when people in apparently the same job (same organization, job title and level) are asked to list the tasks that make up their work, some of them will list many more tasks than will others (Taber & Alliger, 1995). In other words, they appear to "chunk" the activities which make up their job into tasks of different sizes. Taber & Alliger (1995) report that one clerical worker reported that her job was made up of more than 44 different tasks. Another clerical worker used only 12 tasks to describe a position which, from the view of an outsider, would be essentially identical to the first. So, if we were to adapt the old adage that "beauty is in the eye of the beholder," we might say that in the case of jobs, that "the job is in the eyes of the job incumbent." That is, each person in some sense "creates" his or her job through a) different perceptions of the job, b) different expressions of it, and even c) different ways of carrying out the tasks and duties of the job. The methodology of Vallacher and Wegner (1986), called "Action Identification," and which examines how people understand what they do, can be applied to this topic. Does a person filing a letter see himself as "storing information" or "clearing his desk," or "getting ready for the boss's arrival?" Research in psychology which examines these personal aspects of job experience is still relatively rare (Alliger, 1991; Dubin, Porter, Stone, & Champoux; 1974).

Objective descriptions of work: Job analysis

For many reasons a need developed around the turn of the 20th century to be able to describe work in an objective or scientific way. Hence, for a psychologist or work analyst, describing work usually does not mean listening to and transcribing personal narrative descriptions from job incumbents, as Studs Terkel, for example, did when he wrote his famous book *Working* (Terkel, 1974). Instead, it means determining just what activities are entailed in a particular job, or what knowledge, education, training, or talent is required to perform that job, *where "job" is considered independently from whoever is performing the job*. That is, psychologists usually want to describe jobs separately from the particular characteristics and uniquenesses of any one job holder. This is why job analysis involves obtaining the views, opinions, and attitudes from many job holders of a given job. In a sense, job analysis is thus largely inductive in nature – it draws general conclusions by building up a picture of a job from a myriad of observations by or about job incumbents.

Information about jobs which is "objective" in this way can help inform decisions about which job candidates could be expected to perform well on the job (or, via the extension of job analysis called job evaluation, how much a particular job is "worth"). The study of "objective" characteristics of work, as opposed to personal and subjective characteristics, can be thought of as the application of the scientific method to the study of work, and has a long history.

Early "science of work" research

The scientific study of work has a long history. In Europe, the second half of the 19th century saw the development of a discipline which can be termed the *science of work* (Rabinbach, 1990). The Europeans were particularly interested in understanding how the human body functioned when working under laboratory conditions. They developed sophisticated techniques, such as chronophotography (time lapse photography), to analyze the nature of the movement of the human body engaged in a task. Of particular interest was how and when fatigue set in during the course of work. There was a general interest among scientists at that time that workers could be told how to be more and more efficient in their actions, and learn to conserve energy and limit fatigue. The modern parallel to this interest in limiting fatigue is the concern about managing stress. Some of the early research on fatigue seems rather whimsical now: one European scientist diligently sought, and at one point believed that he had discovered, an anti-fatigue vaccine, for example. In any case, the Science of Work movement sought to study human labor using scientific methods. In most situations, they felt the laboratory was the best place to do this.

Taylorism

Also in the late 19th century, but in the United States, Frederick Taylor (Taylor, 1947) was developing what he would eventually call "Scientific Management," and what historians have often called "Taylorism." While European researchers studied labor in the laboratory, Taylor applied his techniques directly on the shop floor. Taylor was interested in determining the "one best way" to do a job. Using a stop watch, logic, and trial-and-error, Taylor and his co-workers examined each of the tools and tasks in many jobs with an eye toward maximizing the work output possible in each job. Once the "one best way" to do a job was found, workers could produce more and hence earn more. In addition, Taylor argued, the workers would be less exhausted under his system, while producing more. The Europeans criticized Taylor's system, suggesting that it focused on redesigning jobs with an eye toward *maximum*, not *optimal* work output. That is, the critics of Taylor's work (and these included many of the trade unions of the day), felt that Taylor, in creating a more efficient way to do the job, was exploiting workers. The evidence for this presumed exploitation is somewhat ambiguous, as detailed in the famous case of Schmidt, a steel worker whom Taylor used to showcase Scientific Management. Taylor convinced Schmidt to adopt a new way of working, and as a result, to get much more done than previously. Although it is clear that Taylor was in fact interested in redesigning Schmidt's job for greatly increased output, at the same time Taylor argued that Schmidt was satisfied with the new arrangements because he was also being paid more.

Besides finding the "one best way" to do a job, Taylor's Scientific Management had several other major facets. These included the redesign of tools and machines to maximize efficiency and ease of use (ergonomic redesign); linking amount of wages earned to amount of work output (performance-based compensation); and the logical coordination of production. The keynotes of Taylor's approach to work were *standardization* and *efficiency*. It can be seen from

this that the objectification of work, already occurring in Taylor's work, was sophisticated and thorough-going.

Positivism

One of the reasons that a "scientific" approach to work seemed to hold so much promise is that the late 19th and early 20th centuries were steeped in the philosophy of science called positivism. Postivism, of course, holds that scientific truth, through the discovery of facts, is completely objective and incontrovertible. There was "one best way" to do science, and if followed, humankind could fathom the world's mysteries.

So, the European science of work and Scientific Management, along with other industrial forces such as "Fordism"—Henry Ford's implementation of the assembly line—and the general atmosphere of scientific positivism, led to an increasing standardization of work. No longer would employers see first the person who worked for them; instead, they would see the job, and the person as someone who filled that job. That is, the evolution of production caused work to both appear, and to some extent actually become, increasingly objectified and independent of individual job holders. In a real sense, job analysis became possible at the same time that work became highly standardized. In fact, it may not be an exaggeration to say that the development of job analysis along Tayloristic lines was inevitable, given the nexus of social and scientific forces which characterized the late 19th and early 20th centuries.

Thus, in answer to our question, "what is job analysis?" we can answer: it is the broad body of techniques that developed to describe jobs objectively, that is, independent of any job holder. As such, job analysis is clearly different from subjective, everyday discussions of work. Job analysis has several typical outcomes and applications, discussed briefly below.

Immediate Outcomes of Job Analysis

Job analysis usually results in "job descriptions" and "job specifications." A job description is task-oriented. It often is little more than a list of the activities, or tasks, which typify a particular job. These are usually written in such a way that the sentences start with "doing" verbs. While job descriptions describe the tasks required for a job, job specifications are worker-oriented, and state the education, knowledge, skills, or the physical or mental abilities which a person must have in order to perform a job adequately. For example, job specifications would list the manual dexterity, ability to concentrate, attention to detail and other human abilities required of a worker.

As mentioned, one outstanding characteristic of scientific job analysis is that of objectivity. The job analyst attempts to be objective by not necessarily taking at face value workers' estimates such as those relating to task difficulties or job requirements. Every piece of information is checked with supervisors and/or with as many incumbents of the target job as possible. Job analysis is therefore objective in the general sense that the final job description should not be dependent on the perceptions, uniqueness, or even level of performance of any individual job holder (Harvey, 1991).

"Whatever approach is chosen, the analyst should do the utmost to measure the job rather than the individual doing it. If he or she observes, observe with this in mind; if he or she

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interviews, tease out the idiosyncratic from the essential by careful questioning. Even if he or she uses a *worker-oriented* method, focus on those behaviors that any worker in that job would be expected to carry out." Howell and Dipboye, (1986; page 203).

Task Elements, Tasks, Functions

Any objective method of measurement must have units of measurement. Just as the English measurement system has inches within feet, and feet within yards, so (by rough analogy) job analysis sees the basic, or smallest, unit of the job as the task element. A task element is some action or set of actions which is part of a task. If "typing a letter" is a task, some task elements which comprise it might be: starting the PC session; loading the proper word processing software; reading an original handwritten letter or listening to dictation; typing the appropriate letters into the wordprocessor file, and so forth. Just as tasks are made up elements, job duties, or functions, are clusters of tasks—so, "managing correspondence" would be a job duty which includes many tasks. To sum up this point: a job is made up of several duties, or functions; functions are made up of tasks; tasks are made up of task elements. Later, we will map competency models onto this framework.

Applications of Job Analysis

Job analysis has many applications. Figure 1 shows the relationship between what we call the immediate, derived, and applied outcomes of job analysis. Job analysis first yields a job description and job specifications, as described above; job descriptions can be considered theoretically prior to job specifications, because the first logical step, even if hidden, in determining human capacities required for job performance is consideration of tasks performed in the job. The information in specifications may be examined to yield likely predictors of the job, which can be tested for effectiveness in selecting and placing employees successfully as well as contributing to training needs analysis. Job description information can help employers develop relevant measures of job performance, or criteria. Both criteria and predictors are derived outcomes, stemming from descriptions, on the one hand, and specifications, on the other. Job performance criteria will permit analysis of training needs, performance appraisal development, and job redesign.
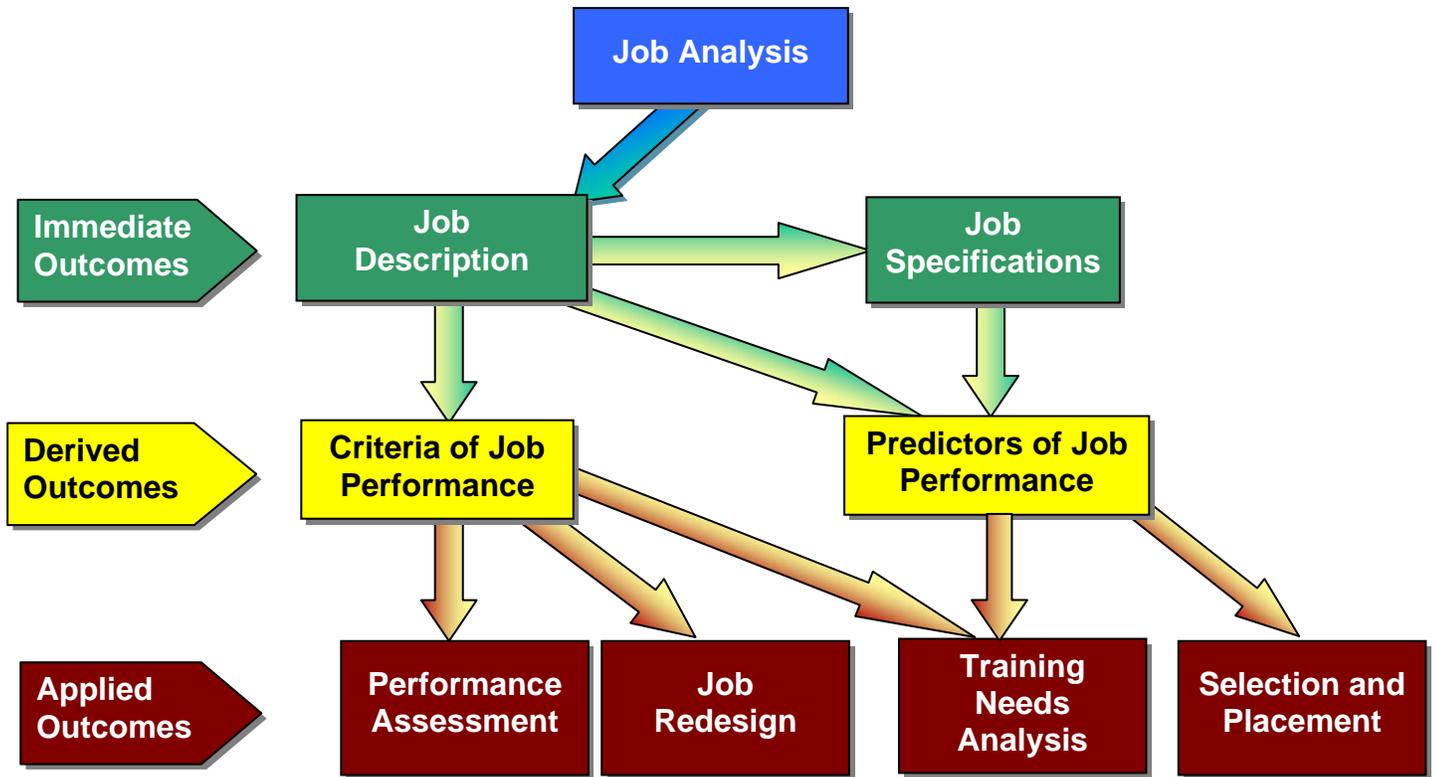
Figure 1. An illustration of the outcomes of job analysis
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Procedures for Collecting Job Analysis Information

There are a number of ways you could go about a job analysis, and these are described below. These procedures are not mutually exclusive, however and they may also be complementary (e.g., interviewing and surveying).

Observation

One way in which a job analysis may proceed is through simple observation. That is, a job analyst may station himself near someone a person at a workstation, and patiently watch and record all that the person is doing. Naturally, if the job is one where the person travels, the job analyst must travel too. For example, if the analyst were analyzing the job of airline flight attendant, he would need to fly with them, and follow them back to their workstation, watch them serve the passengers or give instructions.

To help record tasks which the analyst sees being performed, they would have a form on which they could list and describe tasks. The form might prompt the analyst to describe a given task in terms of a) exactly what was done, b) why it was done, c) how was it done, d) how difficult it appeared to be, and e) how often it was done.

Observation has some disadvantages as a technique to help us understand work. Tasks done infrequently or those done in response to an emergency may not be observed. Also, the analyst may not be able to perceive the cues to which a job incumbent is responding with certain actions. So, if certain important decisions are being made by the job incumbent about whether a cue or stimulus is present in the work environment, and whether to respond to it if it is present, the analyst may not be able to record these accurately. For example, it may appear that a worker is responding with certain actions to the cue of illumination of a light on a panel board, while in fact the actual cue is a sound or something else in the environment. Observation may also be weak in assessing the difficulty of performed tasks, or in resolving differences among how equivalent tasks are successfully performed by workers (Annett & Duncan, 1967). It is also a time consuming approach to gathering data and may require the observation of more than one individual. Further, it is actually possible for the analyst to interfere with job performance by her observation. Finally, like most job analysis techniques, observation tends to capture the status-quo—it leads us to understand how a job is done, not whether it might be done better.

Analyst performance of job

One rarely used technique is for the job analyst actually to perform the job. If you wished to understand the job of a roofer, you could learn a lot about it by actually joining a roofing crew. In doing the job itself, you could rely on your own experience rather than that of someone else in compiling a description of the tasks and demands of the job. This technique has some very obvious limitations. First, it would not be feasible for any job which is dangerous or takes very long to master, or requires apprenticeship or certification. That is, for only the most simple jobs could the analyst be expected to be able to perform in a way similar to an experienced job incumbent. Second, this method is time-consuming. Third, the analyst probably will not have a chance to perform rare but important job tasks.

Interviews

Interviews with job incumbents are an important method of job analysis. In this approach the job analyst asks questions of job incumbents, obtaining information about what tasks are performed on the job, how often each task is performed, how important each task is to the overall job, how much education is required for the job, what knowledge and skills are required, and so forth.

The interviews must be "structured," so the analyst will use an interview protocol or other written material which ensures that the same questions are asked of every incumbent, for every job analyzed. This provides consistency across interviews and allows easier interpretation of trends and commonalities across incumbents.

Any type of interviewing is part art, and this is as true of the job analysis interview as with other interviews. People can be suspicious of strangers asking them questions about their work. This is particularly true if they suspect that decisions regarding the rate of pay for their job may somehow be related to the questions they are being asked. And, pay can be related to job analysis results, because one important outcome of job analysis is information for job evaluation procedures, which in turn may affect compensation rates within an organization. Beyond establishing rapport with the job incumbent, the job analyst should also beware of "puffery": the tendency of the incumbent to inflate certain job characteristics, such as the

difficulty of tasks within the job or the level of education required for the job.

      For reasons like this, it is important that the analyst interview several job incumbents for each job, and, if possible, supervisors of those incumbents as well. In this way, the analyst should be able to counterbalance any inflated or inaccurate claims with realistic ones. Moreover, since the goal of job analysis is to describe a job independent of any particular incumbent, the analyst wants to capture the aggregate, or common, features of the job. For this reason too, it is important to get information from several sources often interviewing both novice and expert incumbents to obtain the full picture of the job.

Surveys

      One of the most common ways to perform a job analysis is via survey. The job analyst in this case provides each job incumbent with a series of questions about his or her job. Usually, these questions ask the incumbent for ratings of importance, frequency, applicability or difficulty regarding various aspects of the job. Surveys are most often categorized into two different classes: job-oriented or worker-oriented surveys.

      Job-oriented surveys. Job-oriented surveys, sometimes called task-oriented surveys, are carefully and specially constructed for a particular job, in the following way. Individuals who are experts in a particular job, for example entry-level programmer, are gathered together, and all possible tasks entailed in a particular job are listed. This list is then discussed in detail until a final agreed-upon list of job tasks is created. These tasks may be grouped into categories, such as "Communication with others," "Development tasks," or "Administration" to help respondents think about the tasks. Then, a survey is constructed which presents the final list of tasks, clustered by category, and all available entry-level programmers are asked to complete it. Often, this will mean rating each task for frequency of performance, task importance, and task difficulty. Generic task oriented surveys are also available, but provide less detailed information (simply asking for the level of applicability of a wide variety of generic tasks to the position).

      Worker-oriented surveys. Worker-oriented surveys are not designed to gather information about tasks which are specific to any one job, although the goal may still be the description of a single job. This approach would not have workers rate the frequency with which they perform a specific task (e.g., "Determine errors in programming code") since this is something that applies only to the job of a computer programmer. Instead, a worker-oriented survey might have a question on error-checking in general. For example, consider the following:

      Rate the extent to which the following is important in your job:

            Error-identification and fixing: Examining work output such as writing, programming code, financial records, tables or charts, physical objects, etc. for mistakes and using normal procedures to correct identified errors.

            ___very important
            ___important
            ___somewhat important
            ___slightly important
            ___not at all important

As you can see, such a question could be asked of almost any job. For this reason, worker-oriented surveys may be useful in comparing different jobs to each other. You could compare the importance of "error-checking," for example, for the job of entry-level programmer to its

importance for the job of manager or assembly-line worker.

Worker-oriented job-analysis surveys, as you may have noted, do not really ask questions about workers, but rather about what a job requires from a worker. But, these surveys permit inferences about the human requirements necessary for a job. For example, if a job is high in the degree of Relationships with Other Persons, then it can be assumed that the job is best filled by a person who is good in dealing with people. Or, if the survey identifies Mental Processes as a large job demand, then perhaps that job needs an incumbent who is intelligent and accustomed to the processes mentioned. So these and similar surveys are worker-oriented by inference: the demands of the job can be translated into job-relevant human characteristics.

Pre-existing sources of job analysis information

The job analyst should not overlook the fact that in many cases, materials already exist which can assist in the analysis of a given job. Company contracts, existing job descriptions, manuals, training material and other written or video sources can contain much useful information about jobs.

By reviewing this material, the analyst may get a "jump start" on identifying relevant job information. This can provide a foundation for the content used in other analysis procedures, such as customizing interview protocol questions or survey questions to the job. It also provides the analyst with background information on a job prior to interacting with incumbents. However, simply reviewing existing job materials is often not sufficient for a detailed job analysis depending on the level of detail that is provided in the materials.

Outcomes of Procedures

When all the data from a given process are collected and analyzed, a picture of the job emerges: the job analyst is able to draw up a job description and job specifications based on the information. Usually, this will then be checked for completeness and accuracy with job incumbent experts. So, the final result is an understanding of a job which is in some sense a complete, general picture. Of course, since we are typically aggregating or collapsing information across many incumbents, it is always possible that what one particular job incumbent does has not been captured well.

Comparison of Job Analysis Procedures

Each job analysis process has weaknesses and strengths. Some methods are convenient because they are quick to complete or inexpensive (such as a generic worker oriented survey), others are particularly useful for certain purposes such as job description or job classification (Levine, Ash, Hall, & Sistrunk, 1983). In fact, the choice of a job analysis method should be based on how the information obtained will be used (e.g., for selection, job redesign, training, and/or performance assessment). While some very convenient methods or some highly informative and reliable methods are good in many instances, for a particular purpose they may not provide the right information. A generic worker oriented survey may yield information about a job that is too global for training purposes, where detailed information on each task within a job is required. In such a case, a method that is designed particularly with training goals in mind may be best (such as interviews), rather than a multi-purpose job analysis approach.

Criticisms of Job Analysis

Job analysis has been critiqued on a number of different grounds. The central and most enduring complaint is that it is a management "tool," and assists organizations to generate maximum rather than optimal worker output; another way to put this is that there is a disconnect between the interests of the worker and the use of job analysis. This is a criticism long voiced by European "Science of Work" researchers, and has modern echoes in the disagreements about length of work day and week, hours of work per year, and so forth. It is fascinating to read Taylor today; although he argues that the redesign of work through time-and-motion studies benefits both workers and the organization they work for, it is easy to believe that work was perhaps more challenging after a job redesign (as in the aforementioned example of "Schmidt," who increased his work load from 12.5 to 47.5 tons of pig iron per day after Taylor's intervention). Do work psychologists side with management? Certainly, few if any are employed by unions, and in general unions are neglected by psychologists. Recently, Zickar (2004), has provided several explanations of this apparent indifference of psychologists to labor unions; he concludes that the two most important reasons are a reluctance on the part of psychologists to address the conflict between unions and management, and a lack of any early, pro-union psychologists.

One question that might be raised is whether job analysis is in fact "too objective." Does the focus on the job to the exclusion of the worker harm the endeavor in some way? It may be that in an effort to generate a picture of work apart from any individual worker, job analysis in effect tends to create the suspicion that the interests of those very workers are not important. Curiously, the competency movement may have evolved successfully precisely because it addresses this concern to some extent.

II. What are "Competencies"?

History and Definitions of Competencies

Compared to job analysis, competencies are a relatively recent development. They arose outside of the purview of job analysis in the sense that they did not originally represent an extension of any existing job analytic method. Rather, the term first appeared in one or more business books, after which it was increasingly adopted within organizations.

McClelland (1973) made the argument that intelligence tests and academic measures such as grades did not predict job performance and should be replaced by a measure of competence. One of his associates, Richard Boyatzis, in 1982 published *The Competent Manager: a Model for Effective Performance*. He defined a competency as an "underlying characteristic of a person which results in effective and/or superior performance in a job." Based on a large sample of managers from several organizations, Boyatzis suggested that there were a finite number of competencies that were related to job success. The reception to the concept of competencies in the business world was positive, and competencies seem to have increased in popularity since that point. It should be pointed out that not all authors attribute the beginnings of the popularity of competencies to Boyatzis. Brannick and Levine (2002), for example, suggest that it was the work of Prahalad and Hamel (1990) that was pivotal in this regard. However, the fact that Zemke was criticizing the concept of competencies and competency models as early as 1982 seems to suggest that 1990 is too late a date for the beginnings of the

surge of popularity which we are discussing.

In any case, it can be said with certainty that competencies have been defined in many ways over the past 20 years (e.g., Blancero, Boroski, & Dyer, 1996; Ulrich, Brockbank, Yeung, & Lake, 1995; Spencer & Spencer, 1993). However, perhaps three discernable central or consistent characteristics of competencies emerge from these definitions (Catano, 1998). First, competencies underlie successful performance; second, they should in some way distinguish superior from average performers; and third, competencies ought to be measurable and observable in some way.

One way to understand competency modeling is to compare it to the units employed by job analysis. In terms of Figure 1, competencies are the equivalent of job specifications – they are statements of human attributes required for job performance. As such, they can be thought of as at the same level (though different than) job tasks or functions. That is, they are human attributes that are required for successful performance at one of two levels of complexity, either functions or tasks; this is illustrated in Figure 2.
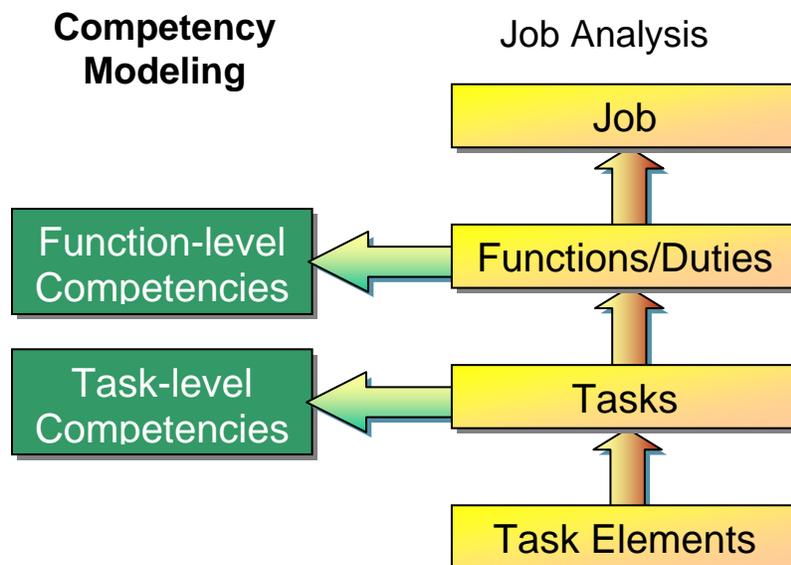
Figure 2: Levels of Analysis in Job Analysis and Competency Modeling

Criticisms of Competencies

Criticisms of competencies (e.g., Harvey, 1999) focus on their sometimes amorphous, broad character (e.g., Harvey, 1999), or a failure to include job analysis information in their development (Lievens, Sanchez, & De Corte, 2004). It is true that a general competency statement such as "Makes optimal decisions" or "Manages performance effectively" are insufficiently defined to serve much useful purpose. But in fact many competency models have behavioral descriptors that further elucidate the nature of the competencies. Good competency models are, just like job analysis, the result of systematic development (and may include job analysis as part of that development).

Why is Competency Modeling so Popular?

Competency models have found great acceptance in modern organizations. Somehow, the worker-threatening characteristics of job analysis have been ameliorated in competency modeling. That is, competencies manage to objectify jobs in a more acceptable way than job analysis. The reasons for this are presumably many; we discuss three. First, competency models tend to be used primarily for "white collar" working situations. It may be that such environments have a tendency to be less concerned about analytical approaches to jobs than more "blue collar," typically unionized, settings. There may simply be greater tolerance for management analysis of work in white collar settings, due to the traditionally closer relationship between management and the incumbents of these jobs. Unionized settings, on the other hand, as mentioned before, often regard work analysis as being a tool of management. A second reason for the popularity of competencies is that they tend to be more obviously connected to the goals and strategies of the organization. Pearlman (1977) found that job analysis was superior to competencies in methods, descriptors, reliability, content revision, and documentation; it was not better, however, in linkage to business strategies and goals. This tighter linkage to organizational strategy may cause competency modeling to be seen by management and employees both as more important in a wide-spread, lasting sense than job analysis. Indeed, to the extent that competencies are seen as critical to the accomplishment of organizational strategy, it may be seen as a feature of the organization that should be carefully developed, nurtured, and vigorously employed.

A third reason for the popularity of competencies relates to the earlier discussion of subjective and objective descriptions of work. It was pointed out that while most people naturally use a subjective, personal narrative when talking about their jobs, job analysis is a highly (and intentionally) objective method for describing jobs. To the extent that people see their jobs described in naturalistic terms familiar to them, and close to the way that they themselves would discuss them, they should, it would be reasonable to assume, be more comfortable and satisfied. That is, if it can be argued that competency models use a more day-to-day language in describing work than job analysis, then people should be happier and more inclined to credit the usefulness and validity of this approach. In fact, competency models tend to be couched in the language of the job holder rather than that of the job analyst, in part because the outcome of competency modeling is often a tool, measure, or other organizational initiative that will be used by the employees themselves. For example, a 360-degree feedback initiative often uses competencies, and in fact may be one major reason for competency modeling. But employees, not analysts, are the end users of a 360-degree feedback system.

Thus, competencies appear to have accomplished, at least in some spheres, what job analysis has not: acceptance by employees. This fact has led to some perplexity among job analytic psychologists, given that job analysis (as illustrated in the results from Pearlman, 1997 mentioned earlier) is an exceedingly well-established, highly developed set of techniques. What then, are job analytical psychologists to make of competencies? To their credit, psychologists seem to recognize the usefulness of competency modeling; moreover, its success is not to be denied. So, there has been a tendency to accept the situation, and to say that competency modeling is good, but needs to be made better by applying the lessons of rigor derived from the history of job analysis. As Harvey (1999) has put it, perhaps psychologists ought to "declare victory" and move ahead by ensuring that competency modeling is captured as one additional job analytic approach.

III. What are Mission Essential Competencies?

The term "Mission Essential Competencies" (MEC) refers to more than simply competencies. It reflects a set of outcomes developed via a fairly time-intensive and specific process. The outcomes (which can be called "elements") comprise the full MEC "model." This MEC model is both an end product, and the input into a subsequent decision-making process (termed Comprehensive Mission Needs Analysis and Determination (COMMAND)). In order to be able to discuss the nature of MECs as a job analytic method, we discuss below a) the elements of the MEC model, b) the MEC development method, and c) the COMMAND decision-making process.

Elements of the MEC Model

The MEC process results in several outcomes: the MEC statements themselves – the Mission Essential Competencies, Supporting Competencies, statements of Knowledge and Skills, and Experiences. Depending on the system examined, there may be additional information (e.g., information about system-specific training programs) identified during the development process that is required to develop surveys capable of answering specific training needs questions.

Mission Essential Competencies

Mission Essential Competencies are high level functions, job-contextualized and less general in most cases than competencies found in typical business environments (Colegrove & Alliger, 2002). The term MEC has been formally defined as a "higher-order individual, team, and inter-team competency that a fully prepared pilot, crew, flight, operator, or team requires for successful mission completion under adverse conditions and in a non-permissive environment." Note the conditions of performance specified in this definition. The USAF has not previously used combat conditions to define standards of warfighter performance. Interestingly, the high standard explicit in this definition is in accord with one of the central characteristics of competencies as originally conceived; specifically, standards of "success," and that in adverse conditions, is inherent in the nature of the MECs.

Each MEC is a brief statement, with clarifying text as appropriate. It also has a stipulated start, end, and purpose statement. Example MECs, the first for Airborne Warning and Control System (AWACS), the second for Joint Terminal Attack Controller (JTAC), and the third from MCS/CRC (Modular Control System/Control and Reporting Center) are:

Detects entities in Area of Interest – Includes all air and surface tracks, and emitters of interest.

> Start: When systems operational
>
> Stop: When systems powered down
>
> Purpose: Assist in contributing entities to Single Integrated Operational Picture (SIOP) (e.g., using onboard and offboard sensors)

Pre-mission Planning – Receive mission; read, understand ATO/ACO/SPINS/OPORD; extract information (e.g., C2, ISR, all lethal and non-lethal capabilities, communications plans, and priorities of fire) from all sources. Identify end state objective. Recognize and address problems (e.g., information that is absent or incorrect). Determine mission

essential equipment and evaluate manpower requirements. Know supported unit's concept of operations.

> Start: On receipt of warning order
>
> Stop: Begin execution
>
> Purpose: Prepare to support mission requirements

Mobilization/deployment/set up – Site survey, pack equipment, deal with personnel readiness issues (e.g., weapons training, chem warfare, self aid and buddy care, CPR, RF/radiation training, vehicle training, EAPS); moving to site, airlift, convoy to permanent location and set up – unpack equipment and set up site: set up radar, set up satellite, data comms, housing, command post, medics tent, ops tent, complete equipment readiness checkout; notify higher headquarters that ready for operations; survive to operate

> Start: When mobilization order received
>
> Stop: When equipment ready for operation
>
> Purpose: To enable conducting of mission

Often, the entire set of MECs that are defined by subject matter experts for a given weapon system reflect a broad chronological order, arising from the nature of the mission in question. For example, from an analysis of the tasks carried out by fighter pilots, MECs such as Detect, Target, Engage, as well as others usually emerge – the roughly sequential nature of these functions is mirrored in the MECs, so that one MEC may have as its start the end of another. However, this is not always the case – some MECs may be temporally parallel, while others may be continuous or on-going throughout the course of the performance of a job.

Not all MECs will necessarily apply to all positions in a multi-person system. For example, consider the Modular Control System (or, as it is also called, the Control and Reporting Center). This ground-based multi-person command and control center has a number of positions similar in function to those of an AWACS. Table 1 provides a mapping of the MECs by MCS position, showing which MECs mapped onto which positions as primary duties, secondary duties, or not applicable.

Table 1: Mapping of MECs by Position for MCS

MEC	AST	ST	ASO	DST	EPT	WD	SD	MCC	ICT	BC	BSC	OC
1. Mobilization/deployment/set up	P	P	P	P	P	P	P	P	P	P	P	P
2. Plans and prepares for theater mission	P	S	P	P	P	S	P	P	P	P	P	P
3. Crew mission planning	P	S	P	S	S	P	P	P	S			P
4. Establishes, maintains and adjusts link and comm. Architecture	P	S	P	P	S	P	P	S	P			

MEC	AST	ST	ASO	DST	EPT	WD	SD	MCC	ICT	BC	BSC	OC
5. Establishes, maintains and adjusts radar picture	P	S	P	S	P		S	S				
6. Detects entities in Area of Interest	P	P	P		P	S	S	S				
7. Identifies entities in Area of Interest per ID matrix	P	P	P		S	S	S	S				
8. Updates/tracks entities in Area of Interest	P	P	P		P	S	S	S				
9. Conducts decentralized command and control	S	S	S			P	P	P		P	S	S

Note:
P = Primary duty
S = Secondary duty
Blank = Not applicable

AST = Air Surveillance Technician
ST = Surveillance Technician
ASO = Air Surveillance Officer
DST = Data Systems Technician
ICT = Interface Control Technician
BSC = Battle Staff Coordinator

EPT =Electronic Protection Technician
WD = Weapons Director
SD = Senior Director
MCC = Mission Crew Commander
BC = Battle Commander
OC = Operations Coordinator

Supporting Competencies

There are broad, high-level skills and knowledge that underlie the successful development and performance of the MECs. Termed "Supporting Competencies" (SCs), these may include classic organizationally relevant competencies such as Decision Making or Adaptability, as well as more USAF-specific competencies such as Situation Awareness. SCs tend to have a similar nature to competencies typically developed in industry (that is, high-level and more or less context-free), as opposed to the MECs, which are highly contextualized job functions. Typical SCs include Situational Awareness, Leadership, Adaptability/Flexibility, and Information Management.

A review of example SCs (these are from the MCS/CRC) will give the reader their flavor:

Situational Awareness – Builds, maintains, and when necessary regains situational awareness (SA) throughout the mission; communicates as necessary; active listening

Multi-Tasking – Handles the requirements of multiple tasks simultaneously

Internal Team Work – Establishes and executes contracts, requests assistance as needed, monitors indications of reduced performance in self and others, and provides timely assistance to others as needed

External Team Work – Knows when, how, and to whom to handoff tasks and accepts handoff of tasks

Leadership/Team Management: Establishes vision and objectives, sets tone and tempo, leads team by assigning tasks, delegates responsibilities, manages conflict, assesses performance and models correct behaviors and performance levels

Knowledge and Skills

At a "lower" level of analysis than either MECs or Supporting Competencies are Knowledge and Skills (KS). These are deliberately elicited at the level of natural language – they are couched in terms and at an interpreted level of action clustering that is usual or common among job holders. This is intentional, both because it is deemed desirable to use the level of KS "chunking" that is common among warfighters since this facilitates data collection and ensures comprehension by the warfighter community, and because the USAF already has Training Task Lists (TTLs) that are written at a more basic level of analysis. Research linking existing TTLs to KS developed in the MEC project has begun.

Knowledge is defined as "information or facts that can be accessed quickly under stress," and skill can be defined as "a compiled sequence of actions that can be carried out successfully under stress." Since the emphasis is on performing under combat conditions, the use of the word "stress" in defining K/S is highly important, and a baseline of initial training is assumed during the knowledge and skills elicitation process. Below are some example knowledge statements (from Close Air Support [A-10]):

- *Environment Effects* – Understands the effects of environmental factors on the mission (e.g. terrain, smoke, vegetation)

- *Systems/Weapons Capability* – Understands the capabilities of own and supporting aircraft and their weapons; knows penetration aids

- *Aircraft Characteristics* – Understands aircraft flying characteristics in both medium and low altitude regimes

- *JTAC/FAC-A Operations* – Knows how the ground forces and TACS typically operate

Some example Skills (also from Close Air Support [A-10]) are:

- *Identifies Targets/Threats* – Interprets the visual cues/system indicators that identify various targets/threats

- *Assesses Risk* – Identifies and assesses risks related to mission accomplishment

- *Weaponeering* – Matches assets to targets; selects weapons to achieve desired goal; limits collateral damage; avoids fratricide

- *Positions Assets/Weapon Systems* – Arranges assets for maximum impact and minimum threat exposure consistent with mission accomplishment

If MECs are being developed for a multi-person system or team, not every KS will apply to every position on that team. For example the AWACS skill "AWACS employment: Positions AWACS to optimally meet mission tasking," actually applies only to the Mission Crew Commander and those other positions that have the responsibility for obtaining the best possible radar picture, given constraints and objectives. Thus, a position-by-Knowledge and Skill matrix showing these dependencies is developed. Table 2 shows a partial example of such a matrix. In this table, a few KS are listed for the AOC Combat Plans Division. Note that there are four teams represented, each with a number of positions. The SME-stipulated required level of KS is shown

for each position, such that a given position may be required to have a Basic, Intermediate, or Advanced level for a given KS. In addition, some KS may be "not applicable" – that is, not required for that position.

Table 2: Example Stipulated Levels of Required Expertise by Position for Various Knowledge and Skills for the AOC Combat Plans Division

Knowledge or Skill	CCP	GAT				MAAP				ATO Production				C2 Planning					
		Chief	Planner	IW	ISR Element	Chief	Planner	IW Planner	ISR Planner	Chief	SPINS Officer	NCOIC	Tech	Chief	Air Defense Planner	C2 Arch. Planner/	Airspace Planner	Air Support Planner	Comm/Freq Planner
Able to convert targets and threat situation to plan of action	I	A	A	A	A	A	A	A	A	B	B	B	NA	B	B	NA	NA	NA	NA
Understands the offensive and defensive capabilities, limitations, and effects of weapons systems	I	I	I	A	A	A	A	A	A	B	NA	B	NA	B	A	B	B	B	B
Understands package development process & procedures	I	B	B	B	B	A	A	A	A	B	NA	NA	NA	NA	NA	NA	NA	NA	NA
Knows and understands current guidance (e.g., ROE, SPINS).	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Able to lead team (e.g., communication, delegation, performance monitoring)	A	A	NA	NA	NA	A	NA	NA	NA	A	NA	A	NA	A	A*	A*	A*	A*	A*
Able to ensure quality of MAAP	A	NA	NA	NA	NA	A	I	I	I	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Able to develop briefing and brief effectively (ops)	A	A	I	A	A	A	I	A	A	I	NA	NA	NA	A	A*	A*	A*	A*	A*

Experiences

An element that is unique to the MEC model is Experience. Experiences are captured during the MEC process as another measure related to the events in the life of warfighters that can be manipulated in training (either live or simulated). An Experience can be defined as a developmental event that occurs during training and at various times across the career of a Warfighter that facilitates learning a KS or practicing a MEC or SC under operational conditions. There are essentially three types of Experiences that are identified by SMEs: 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 thus 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 the first Experience category, **events** that occur to or a situation encountered by the subject (i.e., the pilot, crew, team, or flight), include (all examples from the MEC model for Air-to-Air [F-15C]):

- Flying where there are operating area restrictions (e.g., geographic, altitude, or political)
- Fatigue/time on task (e.g., long range force employment)
- Flying over mountainous terrain

Examples of the second category, **actions** performed by the subject, include:

- Using chaff/flare to deny/defeat enemy radar/weapons
- Live weapons employment (e.g., Weapon Systems Evaluation Program (WSEP), combat)
- Employing cross-cue (off board) sources to locate and ID targets

Examples of the third category of Experiences, **operation**s for a pilot, crew, team, or flight, include:

- Operations against air or ground adversary jamming
- Operations against a threat that uses chaff/flare
- Dynamic retasking/scramble operations

Experiences form the basis of most of the MEC surveys; they are crossed with MECs or training environments or mission types to answer particular questions (the surveys are discussed in more detail later).

The MEC Development Process

As mentioned earlier, SME involvement is a critical factor in the development of the elements of the MEC models, it is basically a SME-centered process. Specifically, development involves a) detailed facilitated workshops with SMEs identified by the operational customers

according to stipulated criteria, b) data gathered 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 MECs are developed following a workshop wherein SMEs provide information about the structure of their unit, missions and specific tasks performed, Knowledge and Skills, and Supporting Competencies. All data gathered in the first workshop is compiled and organized and the MECs are developed prior to the second workshop. The second workshop provides a validation of the findings from the first workshop (the MECs and SCs) and allows the facilitators to delve deeper into the more detailed Knowledge, Skills, and elicit Experience components of the MEC model. Following the second workshop, an extensive database of expert knowledge about a career area exists. This information is organized into surveys which are presented to the broader operational community for that particular weapon system. After collecting and compiling the data, a comprehensive analysis of the weapon system 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). Each workshop is described in more detail below.

MECs are developed for a given mission area, for example, Air-to-Air. There are several major weapon systems that perform the Air-to-Air mission: the MECs are the same for each. Conversely, multi-role weapon systems have several sets of MECs, a set for each mission, that apply to that community. Different MEC efforts target different major weapon and command and control systems (e.g., AWACS, F-15C, Air Operations Center [AOC], CRC).

Identification of SMEs. The MEC process is radically SME-centered, by which we mean that SMEs are involved in each step. SMEs are chosen based on their level of experience with the system under review. Generally, individuals with purely "academic" experience (e.g., course designers) are avoided in favor of operators (who may also have had instructional experience). The number of SMEs required for a workshop depends on the nature of the system. For example, a single-seat aircraft will require fewer SMEs than will a multi-position aircraft, for which each position should be represented by multiple individuals.

MEC Workshop 1: Mission Review, Task Identification, KS and SC Generation

It has been noted that one of the weaknesses of competency modeling is that 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 (e.g., Lievens, Sanchez, & De Corte, 2004). The first MEC workshop is in part a task analysis, so that although the task listings are not a formal MEC product, the SMEs have available to them a complete listing of tasks. The way this is done is to review and identify the tasks involved in a number of missions – one of simple, one of intermediate, and one of high, complexity. In most cases, the phases of the mission emerge, so that the tasks are elicited for each phase of each mission. For platforms with multiple positions, the tasks are identified by cycling through positions by phase by mission. In practice, because of the build from simple to complex missions, SMEs are often able simply to add additional tasks to the previously identified set of tasks as the mission difficulty increases. This is not always the case, however: sometimes equally difficult missions of rather different natures are identified. In this latter case, all relevant missions are reviewed and tasks identified.

After tasks are identified, KS required to perform those tasks are nominated by SMEs. SMEs also generate a list of potential Supporting Competencies.

It is important to point out that all of Workshop 1 is completed using flipcharts to record information. The facilitators write down verbal SME input onto flipchart paper, and the flip charts are posted in the room where the workshop is held. In this way, SMEs can at any time review any of the material previously generated, and refer to it (e.g., by pointing to it and discussing it). We have found that this visual "memory" of the workshop is important to participants and used by them extensively.

To clarify the nature of Workshop 1, we briefly review the results for MEC Workshop 1 USAF Air-to-Ground.

Mission Review. As an example of this kind of Workshop 1 task analysis, we briefly review the results for USAF Air-to-Ground. SMEs in this workshop identified a number of missions that they felt both reflected differences in complexity and character. A few of the missions they discussed included Basic Interdiction, Strategic Attack, and Destruction of Enemy Air Defenses (DEAD). Basic Interdiction is relatively simple. The focus is on taking out lines of communication, supply lines, command and control. The targets are operational and tactical (e.g., infrastructure, power, fielded forces); there is no immediate strategic goal specifically addressed. Strategic Attack, on the other hand, is a type of offensive mission that is inherently complicated. In this mission pilots must consider factors such as the nature and context of the target and the type of weapons that are likely to be most useful. DEAD involves destruction of enemy air forces, SAMS, and related communications and command and control systems. The phases common across missions that were identified included: Planning, Administration, Ingress, Time Over Target, Administration 2, Check-out, and Debriefing.

Task Identification. After gathering this mission-level information, the missions, and phases within mission, were then cycled through to produce a complete task list. The level of tasks elicited in this manner is meant to be at a level at which it is natural for SMEs (pilots, in this case) to speak. For example, for the phase of the mission the SMEs called Planning, the task list for the Basic Interdiction mission included:

- *Risk analysis* (e.g., analyzing weather, nature of threat(s), assets available); Game plan formulation (e.g., making maps, weapons engineering, communications with scheduler and SMO, obtaining all mission materials, determining timing, loading DTC)

- *Develop contingencies* (e.g., consider strengths, weaknesses in game plan, what could cause mission and individuals within mission to succeed/fail, develop backup plans for situations where failure is possible, Address failure to meet timing)

- *Brief Plan* (e.g., communicate game plan to all assets available, review flow of mission and planned mission roles, use phone/presentations as needed, since not all personnel necessarily co-located)

Thus, the mission framework and the task list are only intermediate outcomes, but are nonetheless fairly complete and substantive. Their role during the workshop, however, is simply to serve as stimulus for generation of KS.

KS Generation. After identifying tasks, the SMEs have available to them an outline of their missions (by phase, in most cases), and tasks within phase. With this in front of them, they are asked to generate knowledge and skills that are required to carry out the missions. The goal

is to obtain a list of knowledge and skills that is again (like the missions and the tasks) written at a level of language that is natural for the SMEs. In general, this results in KS that are of a moderate level of complexity (e.g., SMEs usually prefer to gather the various sub-skills for employing a particular weapons system – such as a bomb or rocket – under a single heading for that system). The SMEs are told that these are draft KS, which will be reviewed by them and/or similarly-qualified individuals.

Developing draft MECs

After the first workshop, the facilitators review all the material gathered from the SMEs in that workshop. Taking into account the missions, mission phases, tasks, and the draft KS, MECs are drafted. Guidelines for constructing the MECs include: a) they should be high-level, representing major functions or job responsibilities, b) they should represent combat-level performance, c) they should be in the SMEs own language and reflect functions understandable and usable by them, and d) they should not be abstract or general, but actual contextualized functions or responsibilities. Note that "a)" effectively limits the number of MECs. Usually they range from five to ten in number.

While the facilitators will look closely at mission phases as identified by SMEs when developing the MECs, the MECs have never been synonymous with mission phases. For example, the first MEC effort, F-15C Air-to-Air, included such MECs as "Force Orientation" and "Recognition of Trigger Points" – functions that may occur throughout various mission phases. F-16 Air-to-Ground offers other examples of MECs that do not match mission phases. "Threat Mitigation during Ingress/Egress," for example, covers two phases – the similarity in the two phases suggested that they could reasonably be combined. "Employ Air-Ground Weapons," another MEC, was derived from the SMEs discussion of events very close in time. Thus, what for Air-to-Air appeared as separate MECs (e.g., Detect, Target, Engage), seemed to be combined in Air-to-Ground. The complete MEC reads:

> *Employ Air-Ground Weapons*: Conduct airborne weaponeering; detect target(s); comply with ROE (e.g., PID/CDE/deconfliction); position forces for optimum weapons effects; effectively deal with environmental/platform contingencies (e.g., weather, thermal blooming, secondary explosions, DMPI destroyed previously or missing); release weapons on target; apply counter-measures as required; assess weapons effects visually and/or with sensors when able; coordinate, deconflict, and execute re-attack if able/required
>
> Start: Approaching release conditions or arrival in target area
>
> End: After weapons released, weapons impact, or effects assessed if able
>
> Purpose: Optimize endgame execution to attain desired weapons effects

Thus the SMEs innate clustering of responsibilities gives rise in this instance to a single MEC.

MEC Workshop 2: Confirmation/Revision of MECs and Workshop 1 Outcomes, Generation of Experiences

Workshop 2 further develops the MEC model by having SMEs review the MECs and KS and revise as needed. This is an important aspect of the content validation of the elements of the

MEC model. In addition, it is during Workshop 2 that the Experiences are generated. Guidelines have been developed over time to facilitate the process of elicitation of developmental experiences. Specifically, it is important for experiences to be worded in a way that permits them to be easily understood, without confusion or misinterpretation. There are two main rules that if followed will result in well-written experiences. First, in general, an experience should be single rather than compound. However, this is often an exercise in SME judgment, because fusing two or more potentially separable features into a single experience may seem reasonable to them. As an example, consider the Experience "Operations against air or ground adversary jamming," which could be rewritten as two separate experiences: "Operations against air adversary jamming" and "Operations against ground adversary jamming." Ordinarily it would be recommended to break such a compound experience into its component parts. However, SMEs may determine that for training/educational purposes, it is reasonable to combine ground and air adversary jamming into a single statement. Second, Experiences should be unambiguous and sufficiently clear to avoid misunderstanding. For example, the experience "Operations against a threat using chaff/flare" is ambiguous, because it could be interpreted as meaning either that the threat is using chaff/flare, or that the pilot is using chaff/flare to mitigate a threat. If the intended meaning is the former; it could be rewritten as "Operations against a threat which is using chaff/flare."

The MEC Surveys

For each MEC effort, custom surveys are developed, so that surveys for each system differ in MECs, Knowledge and Skills, Supporting Competencies, and Experiences. In addition, there are other system differences, and the surveys are adapted accordingly. For example, different systems have different learning environments. Learning environments are defined as those locations or events where training and learning are accomplished. The learning environments form the basis of one of the surveys used in the MEC process and model. Beyond this, surveys may differ somewhat from system to system depending on the particular needs of the community, the missions that are performed, and the learning environments that are available. For example, The Ready Aircrew Program (RAP) is a training program to maintain readiness and proficiency among pilots. For systems that participate in RAP, there is a special survey that crosses Experiences with major elements in RAP. However, there are typically several categories of surveys which are similar system to system. Each is described briefly below in Table 3 according to type of survey, primary question(s) addressed, rationale, type of respondents, primary analysis goal(s), and scale(s) employed. In multi-role communities, surveys for each mission area are distributed according to the priority and frequency with which that community performs each mission.

Table 3: The MEC Surveys

Survey	Primary Question Addressed?	Rationale?	Respondents Experts or Non-Experts?	Primary Analysis Goals?	Scale
MEC Proficiency	How prepared are respondents to perform each MEC?	**Provide readiness assessment** Provide information about areas of MEC strength/ weakness in current USAF	Both	MECs rated by preparedness MECs ranked by preparedness	**Rate each MEC:** **1** = I am not ready to perform this area in a non-permissive environment. **2** = I'm ready to go, however I'd like to get a substantial amount of additional experience in this area. **3** = I'm ready to go, however I'd like to get a fair amount of additional experience in this area. **4** = I'm ready to go, however I'd like to get a little additional experience in this area. **5** = I'm ready to go, and I need no additional experience in this area **Rank each MEC:** Using numbers 1 to X, **rank** each of the X MECs in terms of your preparedness for performing each MEC in sustained combat operations. Use "1" for the MEC for which you have the highest level of preparedness, "2" for the MEC for which you have the next highest level of preparedness….
Experiences and MECs	How important is each Experience for the development of each MEC?	• Identify relative and absolute importance of each Experience for each MEC	Experts	• For each MEC, the most important Experiences to develop that MEC	Indicate how <u>important</u> each experience is in developing each MEC. **0** = Not Necessary/Does Not Apply **1** = Slightly Important **2** = Somewhat Important **3** = Very Important **4** = Mandatory
Experiences and Learning Environments – Ratings	To what extent is each Learning Environment reasonably appropriate for providing each Experience?	• Determine the extent to which Experiences can be provided within various Learning Environments	Experts	• The most appropriate Learning Environment(s) under which to provide Experiences	Rate to what extent it is <u>reasonably possible to provide</u> each experience in each environment. **0** = Not at all/Does Not Apply **1** = To a Slight Extent **2** = To a Moderate Extent **3** = To a Substantial Extent **4** = To a Great Extent

Survey	Primary Question Addressed?	Rationale?	Respondents Experts or Non-Experts?	Primary Analysis Goals?	Scale
Experiences and Learning Environments – Frequencies	How often is each Experience had in each Learning Environment?	• Identify the frequency of different Experiences in different Learning Environments	Non-Experts	• Determine whether Experiences are being provided at the right frequency in different Learning Environments	Indicate how often you have had each experience in each environment in the past X amount of time.
Experiences and Ready Aircrew Program (RAP)	How effective is each RAP mission in training pilots how to handle each Experience?	• Analyze utility of RAP mission types in providing varying learning Experiences	Experts	• The most effective RAP mission(s) for teaching pilots to handle each Experience	Rate how effectively a pilot is taught to handle each experience in each type of RAP mission. 0 = Not at All Effective 1 = Slightly Effective 2 = Somewhat Effective 3 = Quite Effective 4 = Very Effective N = Does Not Apply
Knowledge and Skills	What level of each Knowledge or Skill do respondents possess?	• Identify Knowledge and Skill levels compared to baseline	Both	• Identify opportunities to modify training (over- and under-training)	Please indicate **your** current level of expertise in the following knowledge and skills by circling "B", "I", "A" or "NA." Basic (**B**): Understands primary concepts and fundamental methods; is able to perform activity at a foundational level Intermediate (**I**): Understands main concepts and fundamental methods in some detail; performs activity above a basic level (e.g., could diagnose and solve some problems, could show someone with basic-level skill how to improve). Advanced (**A**): Understands concepts and methods in depth and detail; is able to perform activity at the expert level. Not Applicable (**N/A**): The knowledge or skill is not applicable for your position.

Note: Table adapted and expanded from Colegrove & Alliger (2002).

In the final workshop, the survey results are presented to a set of SMEs, who interpret the findings and identify training gaps. The data are formatted in a customized spreadsheet display, which is computer projected so that all SMEs can view it simultaneously.

Initial SME Review of Results. First, the SMEs study the demographics, in order to understand the nature of the survey sample. The demographics may show such breakouts as the number of survey responses by position or team (for a multi-position or multi-team system), the average number of years of service in the Air Force, the number of surveys collected per base, and so forth. Second, the SMEs review the results of the MEC proficiency survey, in order to get a general sense of proficiency reported by survey respondents for each of the MECs. Again, this may be broken down by position or team as appropriate. Third, the SMEs review the results for each of the surveys – these are not studied in depth, but a general sense of the number and nature of the surveys, and how data are displayed, is obtained. For example, several unique conventions of the data display are highlighted, such as color coding of mean responses by the value range of the mean. The KS survey are reviewed at this time as well as the other surveys, but are a special case in that the results of these KS surveys are not used in the COMMAND process itself, but rather are presented as a "take away" for further study by the customer of the particular MEC project targeted by the COMMAND. Indeed, the entire set of COMMAND worksheets is delivered to the customer for further deliberation and study.

COMMAND process. After the review of all of results from each of the separate surveys, the SMEs are presented with the COMMAND worksheet. This worksheet is formatted to present the results from each survey (except the proficiency and KS surveys), experience by experience. Specifically, the SMEs see, for each experience, results that permit them to answer the questions:
1. How important is the experience in developing the MECs?
2. How effectively are pilots taught to handle the experience in current RAP training?
3. In what environments (e.g., Flag, MTC) can the experience be provided?
4. How often in the past year are pilots receiving the experience in each environment?
5. What conclusions/gaps can we identify based on this process?

If the system does not have a RAP program, the second question in the list is not included in the COMMAND worksheet. Using these results, the SMEs work through one experience at a time, considering what the results say about each experience as reflected in the responses to each survey. They answer the five questions and their responses (after discussion and consensus) are recorded real-time into the COMMAND worksheet. In this way, each experience is reviewed and conclusions about it are recorded. Typically, to run a COMMAND session for a given system requires two days. Figure 3 shows a screenshot of a portion of this worksheet.

1 Operations in a robust low-tech IADS environment (e.g., Korean)

Step 1 - How important is the experience in developing the MECs? (0=Unnecessary, 1=Slightly Imp., 2=Somewhat Imp., 3/4=Very Imp/Mandatory)

Operations in a robust low-tech IADS environment (e.g., Korean)			Ratings for MECs					
			Plan/ Prepare	Organize/ Optimize	Threat Mitigation	Oriented to Mission	Employ Air-Ground Weapons	Post Mission Analysis and Comm
		n	m	m	m	m	m	m
F-15E	22 -	23	3.3	2.8	3.4	3.2	3.3	2.6
Conclusion:								

Step 2a - How effectively is this experience taught in each type of mission?   (0=Not at all, 1=Slightly, 2=Somewhat, 3/4=Quite/Very)

Operations in a robust low-tech IADS environment (e.g., Korean)			Ratings for Missions					
			BFM	ACM	BSA	DCA	SAT	CAS
		n	m	m	m	m	m	m
F-15E	22 -	22	1.3	1.4	2.0	2.1	3.2	2.6
Conclusion:								

Step 2b - To what extent can this experience be provided in each environment?   (0=Not at all, 1=Slight, 2=Moderate, 3/4=Substantial/Great)

Operations in a robust low-tech IADS environment (e.g., Korean)			Ratings for Environments										
			RAP Flying Events			MTC	UTD	WST	PCATD	MST	Post Combat Air Spt	Homeland Defense Ops	Sustained Combat Ops
			Not Flag/CFTR	Flag	CFTR								
		n	m	m	m	m	m	m	m	m	m	m	m
F-15E	1 -	22	2.4	3.5	3.0	2.0	2.0	2.1	0.7	1.0	1.4	0.1	2.7
Conclusion:													

Step 3 - How often have you had this experience in this environment in the past year?

Operations in a robust low-tech IADS environment (e.g., Korean)			Frequencies for Environments										
			RAP Flying Events			MTC	UTD	WST	PCATD	MST	Post Combat Air Spt	Homeland Defense Ops	Sustained Combat Ops
			Not Flag/CFTR	Flag	CFTR								
		n	median	median	median	median	median	median	median	median	median	median	median
F-15E	0 -	45	2.0	3.0	2.0		5.0	3.0	0.0	1.0	0.0	0.0	0.0
Response Rate			100%	51%	56%	0%	2%	78%	2%	13%	16%	7%	24%
Conclusion:													

Step 4 - What overall conclusions/gaps can we identify based on these results?   Gaps? Yes (Y) Potential (P) No (N)

Overall Conclusions:

Figure 3: Part of a COMMAND worksheet

COMMAND Summary. A final worksheet in the COMMAND spreadsheet is a summary that transfers overall conclusions from the COMMAND worksheet, and summarizes the data to show the number of gaps. It includes MEC proficiency data and permits the worksheet to be sorted by these data, by nature of the gap, and by experience. This COMMAND summary sheet, which brings the SME conclusions together in a single place, can be later used by decision makers. Figure 4 shows the format of this worksheet.

F-15E COMMAND SUMMARY

Mean MEC Rankings: 1= most prepared or [

Instructions:

Use the buttons to sort this spreadsheet by different columns. You can reset to original order by clicking the left button.

0 Experiences with Gaps
0 Experiences with Potential Gaps
0 Experiences with No Gaps

			Ranks	Plan/prepare for mission	Organize/Optimize Forces	Threat Mitigation during Ingress/Egress
			⇩			
			Preparedness	2	6	3
			Proficiency	1	6	3

Descending Sort · Descending Sort · Descending Sort · Descending Sort · Descending Sort · Descending Sort

	Experience	GAP?	COMMAND Conclusions	Importance	Plan/prepare for mission	Organize/Optimize Forces	Threat Mitigation during Ingress/Egress
							Importanc
1	Operations in a robust low-tech IADS environment (e.g., Korean)			3.09	3.26	2.83	3.39
2	Operations in a robust high-tech IADS environment (e.g., Chinese)			3.15	3.36	3.05	3.50
3	Performing Air to Air defensive maneuvering with Air to Ground loads			2.67	2.52	2.00	3.39
4	Employing a Maverick			1.94	2.00	1.46	1.77
5	Employing a GP bomb or CBU bomb			2.66	2.91	1.96	2.30
6	Employing a PW2 Laser-guided bomb			2.80	3.22	2.00	2.39
7	Employing a PW3 Laser-guided bomb			2.85	3.52	2.00	2.39
8	Employing a WCMD bomb			2.22	2.67	1.33	2.17
9	Employing a JDAM bomb			2.28	2.67	1.42	2.25
10	Employing a JSOW			2.18	2.67	1.25	2.00
11	Employing a AGM-130 or EGBU-15			2.96	3.39	2.00	2.87
12	Employing a SDB bomb			2.14	2.42	1.33	2.17
13	Strafing			2.66	2.82	2.00	2.50
14	Mixed loadouts			2.61	3.04	2.00	2.48
15	Employing weapons with			2.57	2.96	2.04	2.48

Figure 4: Part a COMMAND Summary spreadsheet

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IV. Mission Essential Competencies as a Job Analytic Method

MECs as a Type of Job Analysis

MECs in the context of other job analysis methods

We have noted that the first step in developing the MECs is task identification. Although those tasks are but a step in generating specific elements of the MEC model and not an end in themselves, nonetheless it can be stated that MECs are based on a task analysis. As such, the MEC approach can be categorized as a job analytic method. Probably it can be said that the MEC approach is a hybrid of a task-based job analysis approach and a worker-oriented approach. Its task-based characteristics can be discerned from the fact that it incorporates a task analysis. It is also worker-oriented in that it attends to the demands that the job places on the operators. This "blended" nature allows the MECs to be compared to a broad range of job analysis methods. Table 4 shows such a comparison, including Task Analysis, Worker-Oriented Analysis, Functional Job Analysis (FJA) and Cognitive Task Analysis (CTA).

Task analysis, as typified in the Management Position Description Questionnaire (MPDQ) focuses on identifying detailed tasks for a given position. In comparison, the MEC model does not focus on tasks as an outcome, but rather as a means to achieve other outcomes.

A comparison of the MECs can be made with the Worker Oriented Analysis. An example is the Position Analysis Survey (PAQ) uses such a worker-oriented approach, and its development is considered an important milestone in job analysis (Harvey, 1991). One problem that has been noted about the PAQ is that it requires a high school or higher reading ability of job incumbents. Harvey, Friedman, Hakel, & Cornelius (1988) have developed a survey called the Job Element Inventory, which is similar to the PAQ but has a substantially lower reading level. While the worker oriented analysis focuses on only the human requirements of a job, it has a much narrower focus than the MECs.

A comparison can certainly also be drawn between MECs and FJA (FJA Fine & Wiley, 1971). The MEC process is probably most similar to FJA than to other job analysis methods, because of the wide range of outcomes. However, it is also different from FJA in that specific developmental experiences are identified, where FJA specifies only some training requirements. Further, FJA may specify tasks at a detailed level, while the MEC process does not. However, for U. S. Air Force jobs, the Training Task Lists (TTLs) fulfill that function.

In another type of job analysis, Cognitive Task Analysis (CTA), the focus is on mental representations or processes of the worker. The MEC process is different than CTA, in that detailed understanding about decision factors and judgments, or the melding of perception level data to actions, is not addressed. However, to the degree that the MECs themselves somewhat capture the mental model commonly used by pilots (Find, Fix, Track, Target, Engage, Assess – the F2T2EA "kill-chain"), MECs and CTA would appear to overlap in terms of philosophy and outcomes.

Table 4: Comparison of Job Analysis Methods by Outcomes

| Job Analysis Method	Outcomes							
	Major Functions?	Detailed Tasks?	Human Requirements?		Developmental Experiences?	Training Requirements?	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
WO Analysis	N	N	Y	Y	N	N	N	N
MEC 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) WO Analysis = Worker Oriented Analysis, yielding broad requirements by the job of a worker (e.g., Positional Analysis Survey) MEC Analysis = Mission Essential Competency Analysis								

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

MECs in the Context of Competency Modeling

MECs enjoy not only some of the advantages of job analysis, but also those of competency models. Like any good competency model, they employ the language and phrasing of the community for which they are developed; moreover, they are clearly linked to an organizational goal (in this case strategic training realignment). Indeed, it may be said that the language and phrasing of the MECs are more intensely those of the user target group even than is true of most competency models. This is the case because they are not even slightly decontextualized, as many competency statements are. Another way to say this is that the MECs are not like "worker-oriented" job analysis statements, which are meant to be general and valid in a cross-job sense. Instead, MECs are high level functions particularly appropriate to the mission and platform under consideration. MECs for Air-to-Ground will not be the same as MECs for Air-to-Air. Air-to-Ground MECs for the RAF Jaguar are not the same as those for the F-16, because of the differences in the capabilities and tactics of these two aircraft. Thus, the extreme contextualization of MECs means that operators immediately recognize the language and stated functions as their own. Other aspects of the MEC model, such as Supporting Competencies, are general and decontextualized; Supporting Competencies are more like competencies found in traditional models. Figure 5 maps some of the major elements of the MEC model to the levels of analysis in job analysis. Note that Supporting Competencies are mapped at the duty/function level, KS at the tasks level; the thought here is that both are

"worker-oriented" outcomes detailing human characteristics required for successful job performance. MECs are, like supporting competencies, at the duty or function level (because they are, in fact, high-level functions), but also draw some of their character from specific tasks identified in the MEC process.

MEC Modeling	Job Analysis	MEC Modeling
	Job	
Supporting Competencies	Functions/Duties	Mission Essential Competencies
Knowledge and Skills	Tasks	
	Task Elements	
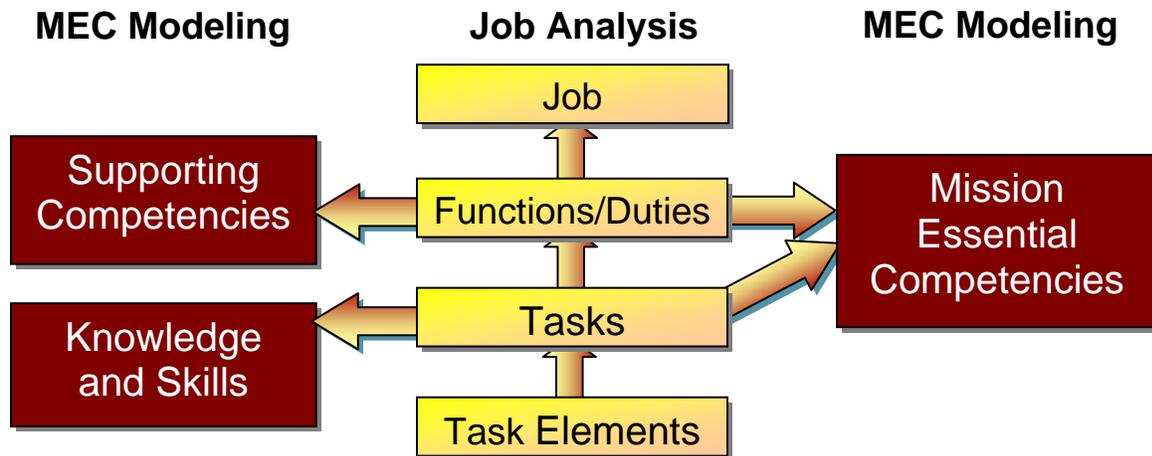
Figure 5: Levels of Analysis in Job Analysis and MEC Modeling

Evidence of the Validity of the MEC Process

The basis for the validity of job analysis is generally of two types: content and construct. Content validity is validity demonstrated on the basis of the methods employed: the domain of the job has been carefully depicted using rigorous techniques. Construct validity is validity demonstrated by the appropriate behavior of variables, such as raters agreeing with each other, or more experienced individuals scoring higher on job analytically derived measures. A third type of validity is the utility of the job analysis information: do job analytic results prove useful to the organization? Are good decisions made on the basis of the job analysis? We briefly discuss the MECs regarding each of these approaches to validity.

Content Validity

As detailed in section III., mission review and task identification are an initial and critical step in the MEC process, and other parts of the MEC model, including the MECs, are based on it. The first workshop thus grounds the MEC model in the nature of the job; inferences such as those made in the KS are therefore clearly focused. Careful selection of SMEs and a time-tested process for Workshop 1 also support the content validity of its outcomes.

The careful development of the model continues during the generation of the MECs, where all sources (e.g., outcomes from Workshop 1) are constantly kept in view. Workshop 2 operates as a further check on SME understanding of and agreement with the elements of the model. The MEC surveys draw on these elements in their entirety: that is, there is no room for content selection bias to operate, since every MEC, experience, and KS are to be found in the surveys.

As a result of this careful development, the MEC model can be appropriately presented as having content validity.

Construct Validity

　　If a job construct is valid, it is reasonable to expect appropriate convergence (e.g., among ratings for similar platforms with the same mission, or between years of service and proficiency), and also appropriate divergence (e.g., between experts and non-experts).

　　Convergence. Alliger, Beard, Bennett, and Colegrove (in press) provide evidence that inter-rater agreement, as indexed by intra-class correlations, is high for each of the MEC surveys found in Table 3. Two striking displays of agreement on average are shown in Figures 6 and 7. In these Figures, the average proficiency rankings are shown, comparing different platforms that perform the same mission (Air-to-Ground in Figure 6, Air-to-Air in Figure 7). It is intriguing that the average rankings are in such close agreement; while divergent average rankings might simply have reflected different levels of proficiency for each MEC, the convergent results should probably best be taken for evidence that the there is not a "main effect" for platform, but only mission. Such convergence is not likely by chance.
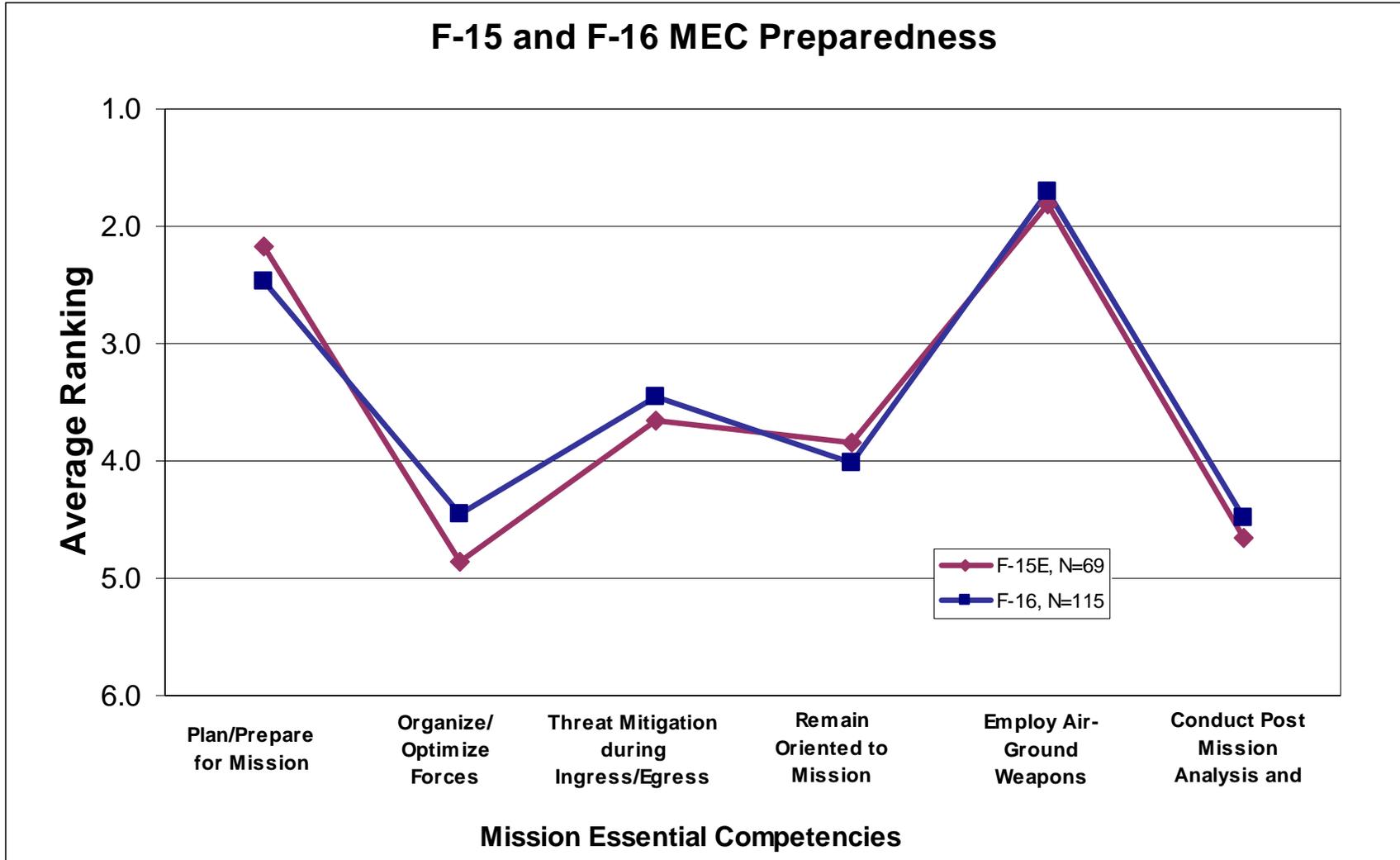
Figure 6: Average Preparedness Rankings for Two Platforms for the Air-to-Ground MECs
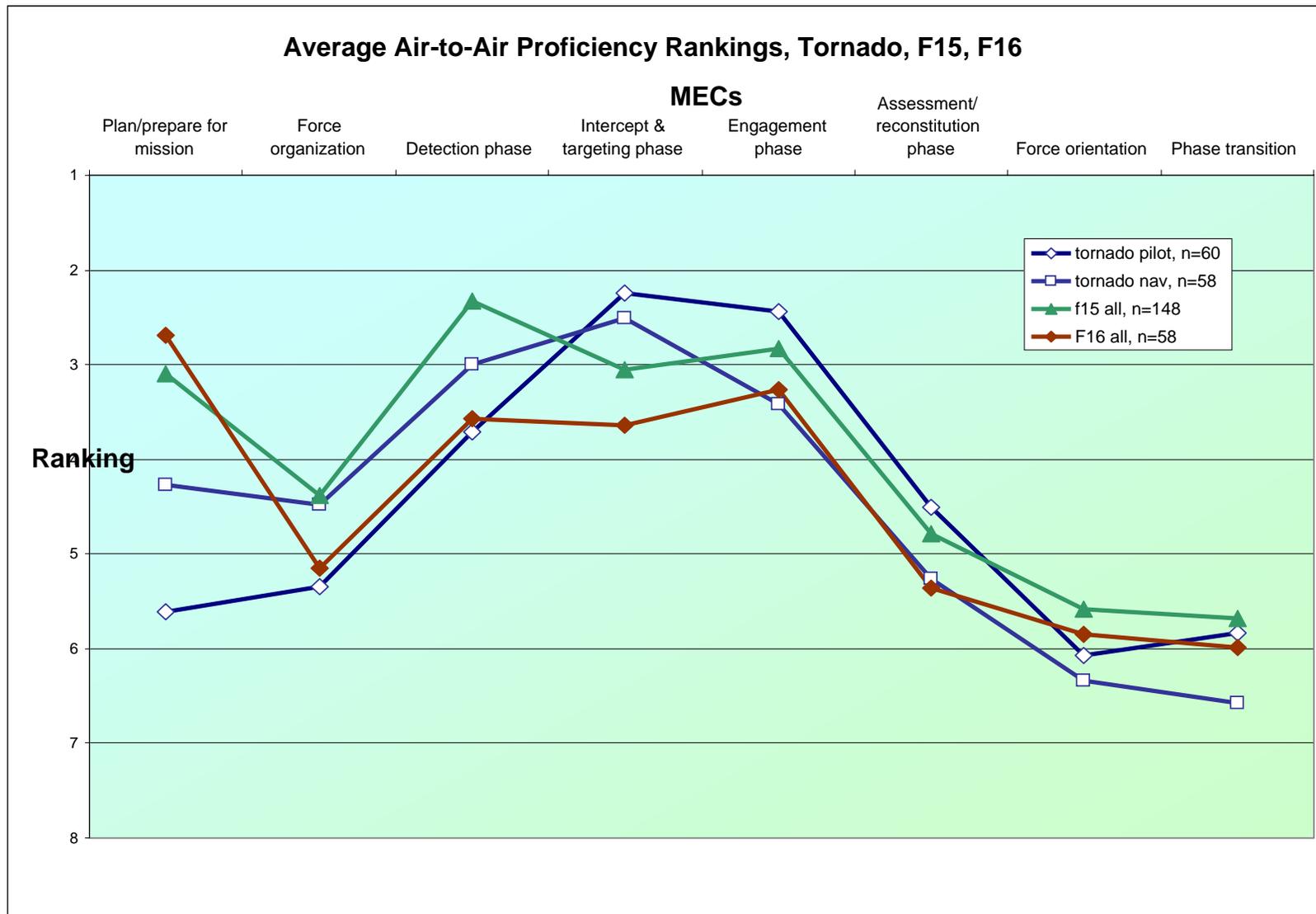
Figure 7: Average Preparedness Rankings for Three Platforms for the Air-to-Air

Another example of convergence can be found in the virtually universally positive, non-zero correlations found between years of service and KS ratings, also as reported in detail in Alliger, et al. (in press).

Utility Validity

Finally, the MEC models developed for various platforms, and the results of various COMMAND sessions, have proven useful to decision-makers. As Colegrove (2005) outlines, the MECs have been used to drive decisions regarding training. For example, the training for the F-15C has been altered using MEC inputs:

> As part of the MEC process we identified the developmental experiences that were most important to exercising knowledge and developing proficiency in those skills necessary to build back up to the MECs. Pilots at five F-15C bases were then surveyed to provide direct warfighter input and the results subsequently analyzed by experienced F-15C pilots. Comparisons of the ability to provide important experiences were made between live training and virtual events in the MTC. Defensive Counter Air (DCA) and Offensive Counter Air (OCA) were found to be credibly trained in the MTC and three missions of each type were added to the annual simulation requirement for each pilot. The total live sortie requirement did not decrease but was remixed – removing three each DCA and OCA but adding six additional sorties to the Commander's Option category thereby allowing the unit commander a greater opportunity to direct and target training done in the aircraft. The new simulation requirements target specific experiences and the time spent in the MTC during those missions counts toward the pilots' total time required (500 hours) to become "Experienced" – a point at which the pilot flies fewer sorties per training cycle. (Colegrove, 2005, p. 9.4)

Another example of the application of the MECs is found within the extensive work completed on automatic simulation measurement development documented by Schreiber and his colleagues (e.g., Portrey, Keck, & Schreiber (in press); Schreiber, Watz, & Bennett (2003)). Schreiber details how the MECs both suggest what to measure, and that they may in some cases be amenable to automatic measurement in a simulation environment.

Final Comments

While MECs can be seen, therefore, as a competency model that uses job analytic techniques, or perhaps as a job analytic method that generates competency-like outcomes, it is probably best be seen *in toto*, as a unique approach to work in the military setting that serves its designated purpose, that of training analysis, particularly well. The MEC development process is both task- and worker-oriented, representing therefore a "blended" job analysis approach. It is a rigorous approach, ultimately based in an understanding of the tasks of the job. Like other competency models, MECs are understood by their customers to address important strategic aspects of organizational needs – in this case, training in a DMO environment. MECs are highly contextualized, high level functions, in part successful because they capture the warfighter's job in a way that is deemed practical and accurate. The MEC model is unique, in that it includes developmental or learning experiences, which in fact form the basis for many

of the most influential aspects of the MECs (e.g., the COMMAND workshops and their outcomes). It is possible that the MECs retain a sufficient amount of the everyday, subjective descriptions of work that individuals are more comfortable with them than they might be with more technical, lower-level job analytic results.

The MEC process and model shows evidence of content, construct, and utility validity. MEC outcomes are being applied to different training-related situations, both applied settings (as in the determination of live-fly versus simulation training events) and settings that are more research-focused (as in the use of MECs to help guide development of simulator-based measures). In sum, it appears that the MEC model offers today's training researchers and training professionals a number of interesting points to consider. Whether and how MECs might generalize to a different, non-military setting remains to be seen.

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Footnotes

1. "DMO is a shared training environment comprised of live, virtual, and constructive simulations allowing warfighters to train individually or collectively at all levels of war. DMO allows multiple players at multiple sites to engage in training scenarios ranging from individual and team participation to full theater-level battles. It allows participation, using almost any type of networkable training device, from each weapon system and mission area. Additionally, computer-generated, or constructive, forces can be used to substantially enhance the scenario. This combination of live, virtual, and constructive environments allows nearly unlimited training opportunities for joint and combined forces from their own location or a deployed training site." (AFRL, 2005).