Identifying Technical Competencies: A Delphi Approach

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ABSTRACT—*Tomorrow's joint operating environment demands U.S. Army FA49s to be ingenious, proactive, and multi-talented; proficient in their core competencies as military leaders as well as being proficient in their technical competencies as problem solvers in the operations research field.*

Guided by one primary and three secondary research questions, the purpose of this study was to identify the technical competencies and knowledge, skills, and abilities required for future U.S. Army FA49s to perform their duties within the joint operating environment of the next twenty-five years. To identify these technical competencies and KSAs, this study employed a qualitative research design with a quantitative component using a conventional, web-assisted Delphi methodology.

The Delphi study engaged 10 experts through a first round of data gathering through a web-based questionnaire. First round data was synthesized and sent to the experts, seeking consensus, during a subsequent second round. Expert consensus was achieved on the second round, precluding the need for subsequent rounds to reach consensus. Based upon the results derived from the two Delphi rounds, the experts' identified and reached consensus on 5 technical competencies, 21 areas of knowledge, 41 skills, and 22 abilities that are required for future U.S. Army FA49s to perform their duties within the joint operating environment of the next twenty-five years.

Additionally, this research made four contributions to the engineering management discipline. First, it has added to the existing body of knowledge in engineering management theory and methodology by presenting and substantiating that a Delphi process is capable of identifying future and/or forecasting requirements. Second, it contributed to the literature by providing a basis for the expansion of the domain of competencies and KSAs for operations research. Third, this research contributed to the identification of competencies and KSAs that are germane to the practical development of military FA49 educational curricula and may be germane to the practical development of engineering management curricula. Fourth, this research has suggested directions for future research to enhance understanding of the competencies, knowledge, skills, and abilities for the operations research field.

Keywords — competency, Delphi, operations research, technical competency

1. INTRODUCTION

U.S. Army Functional Area 49s (FA49, Operations Research/Systems Analysis (ORSA)) are uniquely competent and operationally experienced officers who are trained to think with a disciplined mind (FA49 Proponent Office, 2011). A U.S. Army FA49 is a problem solver and identifier of risk who by employing their technical competencies and requisite knowledge, skills, and abilities integrates military knowledge with science and management producing analyses and analytic products to enable decision makers and stakeholders within the DOD. Tomorrow's joint operating environment will demand U.S. Army FA49s who will be ingenious, proactive, and multi-talented; proficient in their core competencies as military leaders leading during times of intricacy and multidimensionality as well as being proficient in their technical analytical competencies as problem solvers. In order to adapt and be prepared for the joint operating environment of the next quarter century, U.S. Army FA49s will have to possess both core leadership and technical competencies in order to successfully perform their duties as officers and analysts. According to the current U.S. Army FA49 Proponent Office's Strategic Plan, "it is critical to identify what the OR[SA] of the future must look like … in order to grow the right skill set now" (FA49 Proponent Office, 2011). Developing the abstraction for what the future U.S. Army FA49 needs to look like to meet ever-evolving U.S. Army requirements so that the future U.S. Army FA49 is competent as both a leader and an analyst will be extremely challenging for the U.S. Army FA49 community. Of these two facets, leader and analyst, of a U.S. Army FA49, exploring the extent of future U.S. Army FA49 technical competencies and knowledge, skills, and abilities (KSAs) was the focus of this study. The leadership competencies and their associated components and actions required of all U.S. Army Officers are outlined in the U.S. Army's Field Manual 6-22, *Army Leadership – Competent, Confident, and Agile*; however, the technical competencies and KSAs for a U.S. Army FA49, following extensive review of the literature, have not been identified. Figure 1 below summarizes the framework guiding this study.

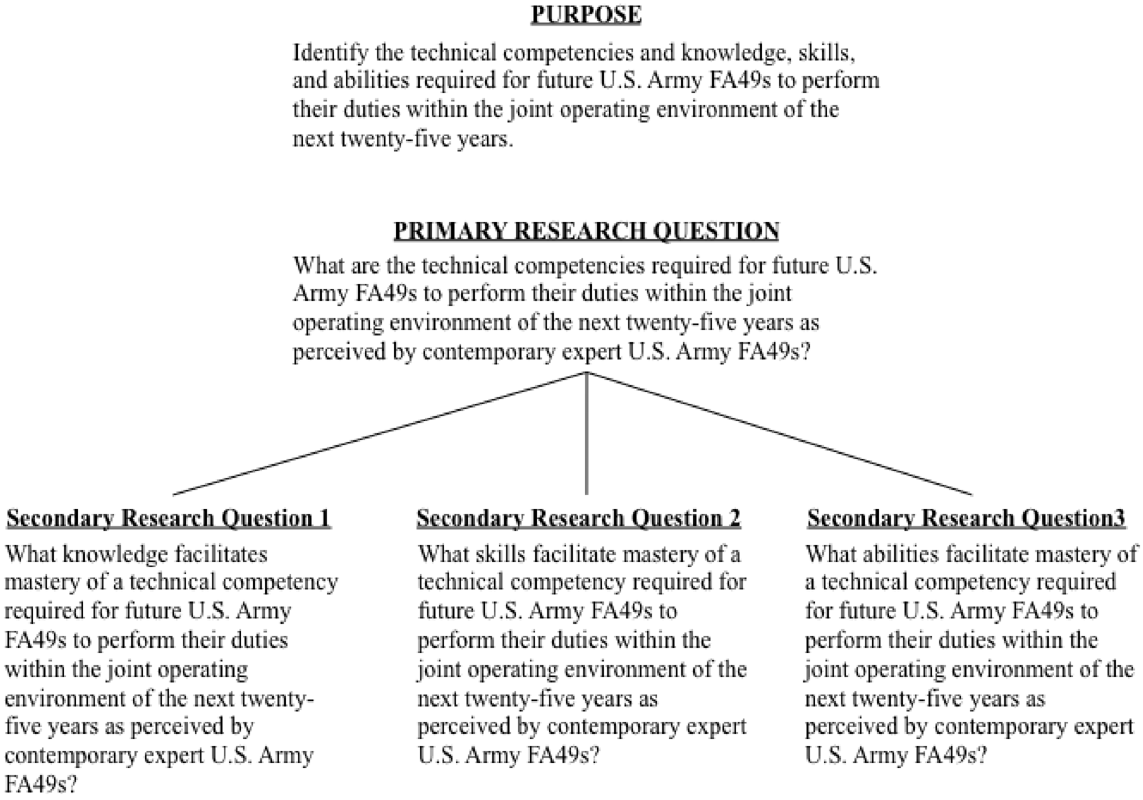

Figure 1 - Guiding Framework

There are primarily three group decision making processes used for creative or judgmental problem solving: Nominal Group Technique (NGT), Interacting Group Method (IGM), and Delphi (Delbecq *et al.*, 1975).

NGT is very similar in structure to Delphi; however, it uses a face-to-face forum. A group decision is made based upon a statistical criterion for aggregating the individual judgments (Rowe and Wright, 1999). NGT was not chosen because of its face-to-face forum requirement.

IGM is nothing more than a brainstorming exercise in which the individuals openly discuss their ideas with each other, provide feedback, and analyze each other's work. The process ends when the group arrives at a level of agreement (Clayton, 1997). As with NGT, IGM was not chosen because of the necessity to have all the individuals collectively gathered in one place.

Delphi is very similar in structure to NGT, but Delphi possesses two characteristics not found in either of the other two processes. First, exploration of the topic by members is conducted in isolation and under conditions of anonymity. Second, communication between members in Delphi is overseen remotely by a director and occurs via questionnaires and feedback reports. Both NGT and IGM group decision-making exercises require large groups of people to be brought together (Clayton, 1997). Delphi was chosen as the contributors to this study were geographically dispersed across the continental United States and only Delphi allowed for geographical dispersion.

This study employed a qualitative research design with a quantitative component using a conventional, web-assisted Delphi methodology in which the experts identified and reached consensus on 5 technical competencies, 21 areas of knowledge, 41 skills, and 22 abilities that are required for future U.S. Army FA49s to perform their duties within the joint operating environment of the next twenty-five years.

1.1 Key Definitions

Ability – An enduring cognitive or physical potential or capacity to successfully perform physical or mental tasks possessing a wide range of plausible results not necessarily involving tools, equipment, or machinery. This definition is a synthesis derived from definitions by Hoge, Tondora, & Marrelli (2005) and Lahti (1999).

Competency – Demonstrated and measurable capability comprised of knowledge, skills, or abilities that is causally related to superior performance in a given job or situation. This definition is a synthesis derived from definitions by Lahti (1999); Mirabile (1985); Spencer & Spencer (1993); and Ulrich, Brockbank, Yeung, & Lake (1995).

Core or General Competency – A competency that applies to everyone in an organization across a variety of occupations. This definition is a synthesis derived from definitions by Hoge, et al. (2005) and the U.S. Office of Personnel Management (2011).

Expert – An individual with extensive education or training, possessing acute and relevant knowledge, longevity, and has risen to the top in their domain or field of specialization. This definition is a synthesis derived from definitions by Ayyub (2001), Booker & McNamara (2003), Shanteau, Weiss, Thomas, & Pounds (2002), Adler & Ziglio (1996), and Jackson (1999).

Knowledge – A learned or acquired concrete or abstract awareness, understanding, or information that directly relates to the performance of a job. This definition is a synthesis derived from definitions by Hoge, et al. (2005), Lahti (1999), and Lucia and Lepsinger (1999).

Skill – A concrete or abstract potential or capacity to successfully perform physical or mental tasks using tools, equipment, or machinery. This definition is a synthesis derived from definitions by Hoge, et al. (2005), Lahti (1999), and Lucia and Lepsinger (1999).

Technical Competency – A competency tailored to particular knowledge, skills, or abilities that apply to everyone performing a specific type of service or job in an organization. This definition is a synthesis derived from definitions by Hoge, Tondora, & Marrelli (2005) and the U.S. Office of Personnel Management (2011).

U.S. Army FA49 Expert – An individual usually with twenty-one or more years of experience in the U.S. Army and who possesses a minimum of a master's degree. These individuals hold or have held the highest and key positions in the U.S. Army FA49 community. These officers hold the rank of Colonel or Lieutenant Colonel (Promotable). According to the U.S. Army, "Attaining the grade of colonel is realized by a select few and truly constitutes the elite of the officer corps" and "those promoted to colonel are truly the world-class specialists in their respective fields" (United States Department of the Army, 2010).

2. METHODOLOGY

2.1 Research Technique

Delphi is an iterative decision support tool that enables anonymous, systematic honing of authoritative opinion with the aim of arriving at mutual synergy of judgments between expert panel members (Dalkey and Helmer, 1963; Brown et al., 1969; Dalkey, 1969; Dalkey et al., 1969; Martino, 1972; Delbecq et al., 1975; Helmer-Hirschberg and Quinton, 1976; Linstone and Turoff, 2002). Delphi was developed in the 1950s by the Rand Corporation as a means to obtain group consensus in forecasting the outcome of Russian nuclear bombings on munitions capabilities within the continental United States (Dalkey and Helmer, 1963). The technique derived its name from the ancient Greek myth of the Oracle of Delphi. The Oracle of Delphi was thought to have the power to foresee the future. Because of these semantic overtures, Delphi has been very closely associated with forecasting and prediction (Rowe and Wright, 1999).

Delphi consists of two sequential phases: exploration and evaluation (Ziglio, 1996). During exploration, the subject matter to be studied is identified and a purposively chosen panel of subject matter experts is recruited to be contributors in the study (Delbecq and Van De Ven, 1974; Skulmoski et al., 2007). Open-ended questions are presented to the expert panel members, enabling them to explore the problem in an anonymous manner. The exploration phase is referred to as Round 1. The evaluation phase, Rounds 2 and higher, is used to gather the contributor's opinions on the ideas identified by exploration from Round 1 (Murry and Hammons, 1995). In Round 2, information from Round 1 is reported back to the expert panel members and they are asked to reply with their concurrence or non-concurrence on the ideas. Likert scales are usually used in Rounds 2 and higher (Linstone and Turoff, 2002). The data from Round 2 are analyzed and summarized and then sent back to the expert panel members as Round 3. Round 3 data are analyzed to determine for consensus. If the expert panel has not reached consensus, additional rounds may be initiated. Delphis continue until consensus is reached.

2.2 Expert Panel

Careful selection of the panel of experts is crucial to a successful Delphi (Stitt-Gohdes and Crews, 2004) as the validity and quality of the results generated are directly related to the selection of the panel of experts (Hsu and Sandford, 2007). For, "If the panelists [experts] participating in the study can be shown to be representative of the group or area of knowledge under study then content validity can be assumed" (Goodman, 1987).

As such, the identification of experts is a major point of debate in the use of Delphi and the researcher had to closely examine and seriously consider the qualifications of panel members and the definition and use of the term expert (Williams and Webb, 1994). One of the key issues related to the use of experts in Delphi research is disagreement with respect to who is an expert (Sackman, 1975; Goodman, 1987). "Simply because individuals have knowledge of a particular topic does not necessarily mean that they are experts" (Keeney et al., 2001) and thus researchers must explicitly stipulate the criteria in their methodology as to how an expert is defined.

There are multiple viewpoints in the literature on the exact size of the expert panel for a Delphi study. Powell (2003) noted that there is little empirical evidence of the effect of the number of participants on the reliability or validity of the process. Linstone and Turoff (2002) and Ziglio (1996) both noted that the size of an expert panel would undoubtedly be variable. Okoli and Pawlowski (2004) posited group size does not depend on statistical power and suggested the optimum size to be 10-18 individuals. For focused studies, Stitt-Gohdes and Crews (2004) suggested 10-15 participants should be adequate. For homogeneous populations (all expert panel members come from the same discipline (Clayton, 1997)), Hsu & Sanford (2007), Skulmoski, Hartman, & Kran (2007), and Wilhelm (2001) suggested a panel of 10 to 15 experts; and for heterogeneous populations (all expert panel members possess expertise with the topic in question but come from varying professional stratifications (Clayton, 1997)) , Delbecq, Van de Ven & Gustafson (1975) suggested a panel of 5 to 10 experts.

The population of U.S. Army FA49s possessing the rank of COL or LTC(P) represented a homogeneous population, thus a 10-member, purposively chosen expert panel was chosen from among this group. Such a panel formation is consistent and within the guidance prescribed by the literature.

2.3 Data Collection & Instruments

This study was approached in phases. There were two broad phases to the approach: exploration and evaluation. These phases included: developing an open-ended questionnaire, conducting an initial review of the questionnaire, selecting the panel, submitting the open-ended questionnaire to the expert panel members, analyzing the results, and creating the next questionnaire(s). The process of questioning the panel, analyzing the results, and modifying the questionnaire would continue until consensus was achieved. Ideally and typically, Delphi studies conclude with an expert panel reaching consensus within three rounds of questioning. Figure 2 illustrates these phases.

2.4 Consensus

To confirm if a necessity existed for supplemental Delphi rounds, the researcher used the coefficient of variation to determine if a strong consensus had been reached. English and Kernan (1976) recommended calculating the coefficient of variance as a method to determine the measure of dispersion in answers. According to these researchers, a strong consensus is achieved when the coefficient of variance is less than or equal to 0.5. For this study, the researcher adhered to this interpretation for a strong consensus. If a strong consensus was reached, the Delphi process stopped and no further rounds would be necessary.

In the case of this research study, consensus was reached after the second round; hence, Phase IIb was not necessary. Figure3 illustrates the revised phases of this study as executed.

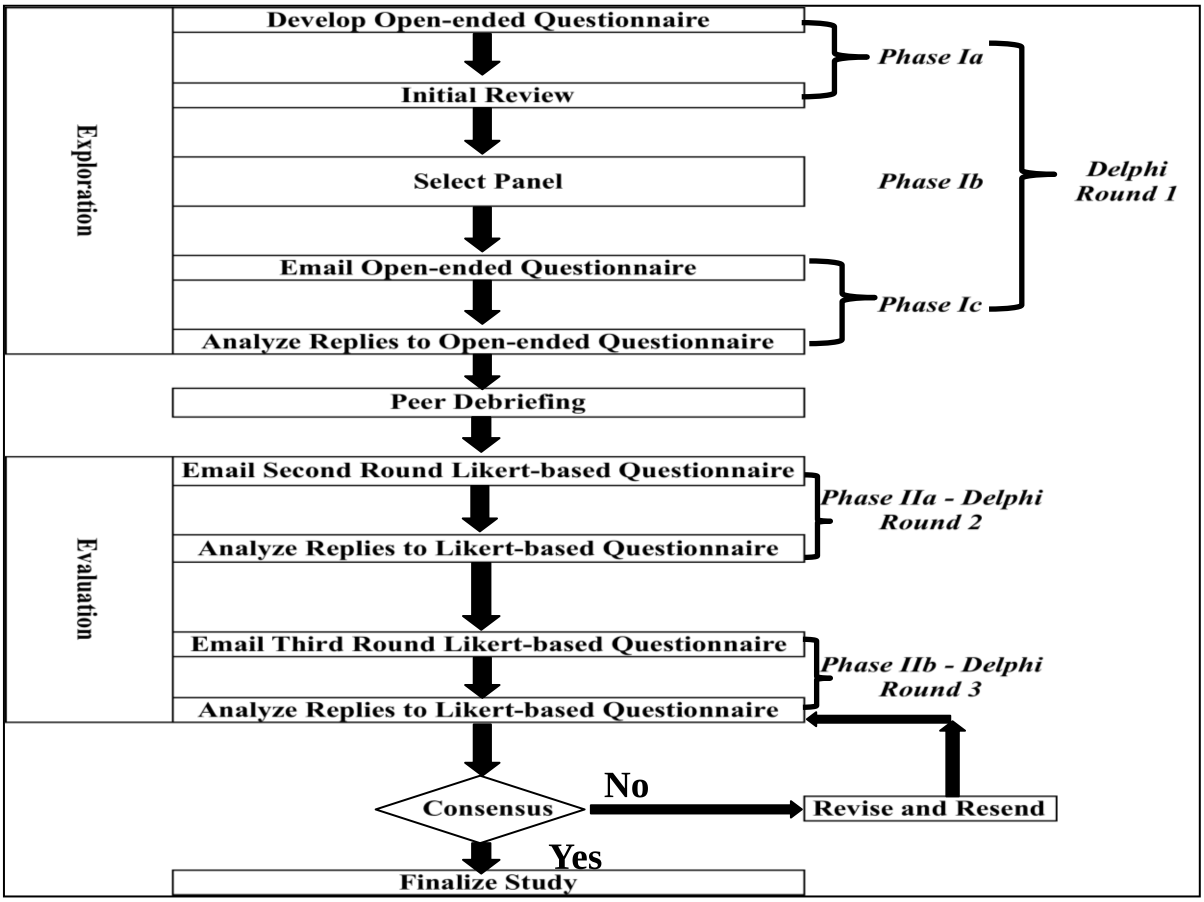

Figure 2 - Research phases

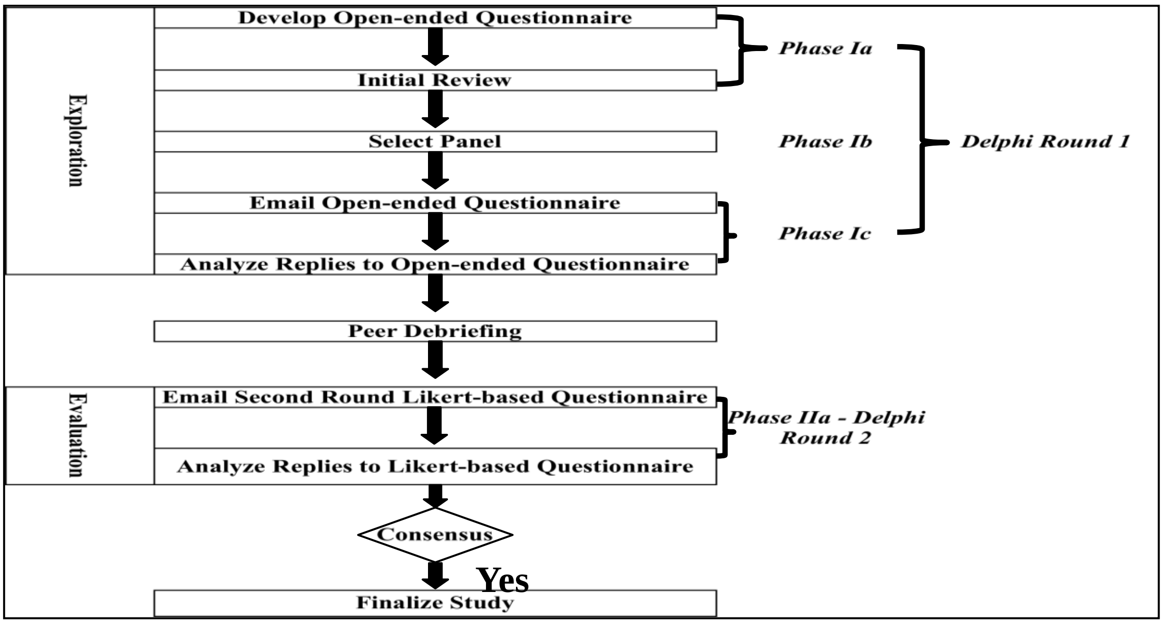

Figure 3 - Research phases, revised

3. RESULTS

3.1 First Delphi Round

The purpose of Round 1 was to have the expert panel members individually identify technical analytical competencies and KSAs required for future U.S. Army FA49s to perform their duties within the joint operating environment of the next twenty-five years. This phase began the process of seeking answers to the PRQ and SRQs 1-3. The replies to the open-ended questionnaire were analyzed, distilled, and synthesized using coding practices associated with grounded theory.

3.1.1 Results

For the answers to the open-ended questions, the researcher performed coding in two stages using elements associated with grounded theory methodology. During the first stage of coding for the open-ended questions, the researcher employed the elemental methods of initial/open and in vivo coding (Charmaz, 2006; Saldaña, 2011). The use of initial/open and in vivo coding allowed the researcher to break down the qualitative responses to the open-ended questions into distinct parts and compare them for similitudes (Miles and Huberman, 1994; Charmaz, 2006; Saldaña, 2011). The similitudes became the emerging categories that were taken forward to the second stage. During the second stage of coding for the open-ended questions, the researcher employed focused coding in an attempt to integrate the emergent categories (Charmaz, 2006; Saldaña, 2011). Focused coding allowed the researcher to insightfully and completely categorize the data (Charmaz, 2006). Given the terse nature to the overwhelming majority of the replies, in most cases first stage coding was all that was necessary to identify categories from the preponderance of the expert panel responses. When no new information appeared to emerge from the coding, the categories were considered saturated and the analysis concluded (Charmaz, 2006; Saldaña, 2011).

The expert panel members provided a total of 84 responses to the open-ended question concerning competencies. During the first stage of coding, 11 categories emerged that were further refined during the second stage of coding into the five categories shown in Table 1. These 5 categories were carried forward for inclusion in the Round 2 questionnaire as elements to be voted upon by the expert panel.

Table 1 - Competencies

Lead Analysis
Plan Analysis
Execute Analysis
Evaluate Analysis
Communicate Analysis

The expert panel members provided a total of 91 responses to the open-ended question concerning knowledge. During the first stage of coding, 18 categories emerged that were further refined during the second stage of coding into the 21 categories shown in Table 2. Normally during focused coding, one would expect the number of categories to decrease as one progresses from a lower level of abstraction to a higher level of abstraction; however, it was determined that too high a level of abstraction had actually been accomplished for two of the categories during the first stage of coding and that these resultant categories needed to be reevaluated and the abstraction level lowered. The final 21 categories were carried forward for inclusion in the Round 2 questionnaire as elements to be voted upon by the expert panel.

The expert panel members provided a total of 78 responses to the open-ended question concerning skills. During the first stage of coding, 28 categories emerged that were further refined during the second stage of coding into the 41 categories shown in Table 3. As with the analysis of items of knowledge, a higher level of abstraction had occurred during the first coding stage. The modeling, simulation, mathematics, and data analysis categories were at too high a level of abstraction and needed to have their abstraction level lowered. The resulting 41 categories were carried forward for inclusion in the Round 2 questionnaire as elements to be voted upon by the expert panel.

The expert panel members provided a total of 73 responses to the open-ended question concerning abilities. During the first stage of coding, 19 categories emerged that were further refined during the second stage of coding into first 18 and then 17 categories. During the review, it was determined that one of the final 17 categories (mathematical reasoning) may have been taken to too far a level of abstraction and subsequently this category and its 5 progenitors would need to be included in the final category listing. The final 22 categories are shown in Table 4. These 22 categories were carried forward for inclusion in the Round 2 questionnaire as elements to be voted upon by the expert panel.

Table 2 - Knowledge

Acquisition Management
Army Operations
Army Organization
Army Processes (e.g. PPBE)
DoD Organization
Economics
Historical Applications of OR
How the Army Runs
How the DoD Runs
How the Federal Government Runs
Interagency Operations
Joint Operations
Joint Processes (e.g. JCIDS (DOTMLPF-P))
Leadership
Mathematics
Methods/Tools
Military Planning Processes (MDMP, JOPP)
Multinational Operations
Operational Environment
Resource Management (includes HRM)
Role of ORSA

Table 3 - Skills

Active listening
Ad hoc (quick turn) modeling
Agent based modeling
Analyzing data with and/or without software
Combat Modeling
Common software packages (SPSS, Minitab, MS Office)
Computer modeling
Computer Programming (VBA, Java)
Conduct Research
Cost benefit analysis
Data analysis and interpretation
Data modeling
Database programming, development, analysis, mining
Decision analysis (to include multi-objective)
Design of Experiments
Discrete event simulation
Effective Communication (writing, speaking, presentation)
Forecasting
Goal Programming
Leadership
Linear Algebra
Math Programming
Mathematics (Probability, Statistics)
Metric development
Military planning processes (MDMP, JOPP)
Modeling (general)
Negotiation
Optimization
Prioritization
Problem solving
Process improvement analysis
Qualitative analysis
Quantitative analysis
Risk analysis
Simulation (general)
Spreadsheet modeling
Statistical analysis with and/or without Software
Survey analysis
Survey development
Trend analysis
Value modeling

Table 4 - Abilities

Analytical Thinking
Application of OR Techniques to Military Problems
Creative Thinking
Critical Thinking
Communicate (Written and Oral Expression)
Comprehension (Written and Oral)
Deductive Reasoning
Evaluating a Study
Inductive Reasoning
Information Ordering
Integrating Information and Data
Leadership
Making Projections Based on Data
Managing a Study
Mathematical Reasoning
Motivate/Inspire
Problem Sensitivity
Problem Solving
Synthesizing Information and Data
Teamwork (Form, Manage, Lead)
Value Focused Thinking
Visualization

3.2 Second Delphi Round

The purpose of this round was to begin discerning the level of agreement or disagreement among the expert panel members. The expert panel members were asked to annotate their opinion of the importance of each listed technical analytical competency and KSA on a four-point Likert scale: Strongly Agree = 4, Agree = 3, Disagree = 2, and Strongly Disagree = 1. An even numbered Likert scale with no neutral option prevented the expert panel members from gravitating toward an undecided response (Linstone and Turoff, 2002).

3.2.1 Results

Descriptive statistics: mean, median, mode, first and third interquartile ranges (IRQ 1 and 3 respectively), standard deviation, and the coefficient of variance (COV) were calculated for the responses from Round 2. The results for each category follow below:

Based on the results obtained from the second Delphi round with regard to competencies, consensus had been achieved at the conclusion of this round with all 5 of the competencies achieving a value for COV <= 0.5 (Table 5), indicating a strong consensus. Additionally, each competency achieved a median score that warranted its inclusion in the final listing of competencies required for future U.S. Army FA49s to perform their duties within the joint operating environment of the future.

Based on the results obtained from the second Delphi round with regard to knowledge, consensus had been achieved at the conclusion of this round with all 21 of the areas of knowledge achieving a value for COV <= 0.5 (Table 6), indicating a strong consensus. Additionally, each area of knowledge achieved a median score that warranted its inclusion in the final listing of knowledge required for future U.S. Army FA49s to perform their duties within the joint operating environment of the future.

Based on the results obtained from the second Delphi round with regard to skills, consensus had been achieved at the conclusion of this round with all 41 of the skills achieving a value for COV <= 0.5 (Table 7), indicating a strong consensus. Additionally, each skill achieved a median score that warranted its inclusion in the final listing skills required for future U.S. Army FA49s to perform their duties within the joint operating environment of the future.

Based on the results obtained from the second Delphi round with regard to abilities, consensus had been achieved at the conclusion of this round with all 22 of the abilities achieving a value for COV <= 0.5 (Table 8), indicating a strong consensus. Additionally, each ability achieved a median score that warranted its inclusion in the final listing of abilities required for future U.S. Army FA49s to perform their duties within the joint operating environment of the future.

Table 5 - Competency Descriptive Statistics

	Competency	Mean	Median	Mode	IRQ 1	IRQ 3	SD	COV
1	Communicating Analysis	3.8	4	4	4	4	0.42	0.11
2	Executing Analysis	3.6	4	4	3	4	0.52	0.14
3	Leading Analysis	3.6	4	4	3.25	4	0.70	0.19
4	Planning Analysis	3.5	4	4	3	4	0.71	0.20
5	Evaluating Analysis	3.4	3.5	4	3	4	0.70	0.21

Table 6 - Knowledge Descriptive Statistics

	Knowledge	Mean	Median	Mode	IRQ 1	IRQ 3	SD	COV
1	Joint Operations	3.2	3	3	3	3	0.42	0.13
2	Joint Processes (e.g. JCIDS (DOTMLPF-P))	3.3	3	3	3	3.75	0.48	0.15
3	Multinational Operations	2.8	3	3	3	3	0.42	0.15
4	Resource Management (includes HRM)	2.8	3	3	3	3	0.42	0.15
5	Army Operations	3.4	3	3	3	4	0.52	0.15
6	Army Organization	3.4	3	3	3	4	0.52	0.15
7	DoD Organization	3	3	3	3	3	0.47	0.16
8	Acquisition Management	3.1	3	3	3	3	0.57	0.18
9	How the DoD Runs	3.1	3	3	3	3	0.57	0.18
10	Operational Environment	3.1	3	3	3	3	0.57	0.18
11	How the Federal Government Runs	2.9	3	3	3	3	0.57	0.20
12	Interagency Operations	2.9	3	3	3	3	0.57	0.20
13	Army Processes (e.g. PPBE)	3.5	4	4	3	4	0.71	0.20
14	Mathematics	3.3	3	3	3	4	0.67	0.20
15	Military Planning Processes (MDMP, JOPP)	3.3	3	3	3	4	0.67	0.20
16	How the Army Runs	3.4	3.5	4	3	4	0.70	0.21
17	Methods/Tools	3.4	3.5	4	3	4	0.70	0.21
18	Role of ORSA	3.4	4	4	3	4	0.84	0.25
19	Economics	2.9	3	3	2.25	3	0.74	0.25
20	Historical Applications of OR	2.6	2.5	2	2	3	0.70	0.27
21	Leadership	3	3	3	3	3.75	0.94	0.31

Table 7 - Skill Descriptive Statistics

	Skill	Mean	Median	Mode	IRQ 1	IRQ 3	SD	COV
1	Problem Solving	4	4	4	4	4	0.00	0.00
2	Quantitative Analysis	4	4	4	4	4	0.00	0.00
3	Effective Communication	3.9	4	4	4	4	0.32	0.08
4	Design of Experiments	3.1	3	3	3	3	0.32	0.10
5	Forecasting	3.1	3	3	3	3	0.32	0.10
6	Goal Programming	3.1	3	3	3	3	0.32	0.10
7	Data Analysis And Interpretation	3.7	4	4	3.25	4	0.48	0.13
8	Decision Analysis (To Include Multi-Objective)	3.7	4	4	3.25	4	0.48	0.13
9	Survey Analysis	3.2	3	3	3	3	0.42	0.13
10	Value Modeling	3.2	3	3	3	3	0.42	0.13
11	Analyzing Data With and/or Without Software	3.6	4	4	3	4	0.52	0.14
12	Qualitative Analysis	3.6	4	4	3	4	0.52	0.14
13	Spreadsheet Modeling	3.6	4	4	3	4	0.52	0.14
14	Optimization	3.3	3	3	3	3.75	0.48	0.15
15	Simulation (General)	3.3	3	3	3	3.75	0.48	0.15
16	Trend Analysis	3.3	3	3	3	3.75	0.48	0.15
17	Active Listening	3.5	3.5	3	3	4	0.53	0.15
18	Process Improvement Analysis	3.5	3.5	4	3	4	0.53	0.15
19	Risk Analysis	3.5	3.5	3	3	4	0.53	0.15
20	Statistical Analysis With and/or Without Software	3.5	3.5	4	3	4	0.53	0.15
21	Cost Benefit Analysis	3.4	3	3	3	4	0.52	0.15
22	Mathematics (Prob & Stat)	3.4	3	3	3	4	0.52	0.15
23	Metric Development	3.4	3	3	3	4	0.52	0.15
24	Combat Modeling	3	3	3	3	3	0.47	0.16
25	Discrete Event Simulation	3	3	3	3	3	0.47	0.16
26	Conduct Research	3.6	4	4	3.25	4	0.70	0.19
27	Common software packages (SPSS, Minitab, MS Office)	3.2	3	3	3	3.75	0.63	0.20
28	Data modeling	3.2	3	3	3	3.75	0.63	0.20
29	Modeling (general)	3.2	3	3	3	3.75	0.63	0.20
30	Computer modeling	2.6	3	3	2	3	0.52	0.20
31	Prioritization	3.5	4	4	3	4	0.71	0.20
32	Survey development	3	3	3	3	3	0.67	0.22
33	Negotiation	3.1	3	3	3	3.75	0.74	0.24
34	Agent based modeling	2.6	2.5	2	2	3	0.70	0.27
35	Computer Programming (VBA, Java)	2.6	2.5	2	2	3	0.70	0.27
36	Database programming, development, analysis, mining	2.9	3	3	3	3	0.88	0.30
37	Math Programming	2.9	3	2	2	3.75	0.88	0.30
38	Linear Algebra	3	3	3	3	3.75	0.94	0.31
39	Ad hoc (quick turn) modeling	3.1	3	4	3	4	0.99	0.32
40	Leadership	3.1	3	4	3	4	0.99	0.32
41	Military planning processes	3.1	3	4	3	4	0.99	0.32

Table 8 - Ability Descriptive Statistics

	Ability	Mean	Median	Mode	IRQ 1	IRQ 3	SD	COV
1	Analytical Thinking	4	4	4	4	4	0.00	0.00
2	Application of OR Techniques to Military Problems or Situations	4	4	4	4	4	0.00	0.00
3	Critical Thinking	3.9	4	4	4	4	0.32	0.08
4	Communicate (Written and Oral Expression)	3.8	4	4	4	4	0.42	0.11
5	Managing a Study	3.8	4	4	4	4	0.42	0.11
6	Problem Solving	3.8	4	4	4	4	0.42	0.11
7	Teamwork (Form, Manage, Lead)	3.7	4	4	3.25	4	0.48	0.13
8	Comprehension (Written and Oral)	3.6	4	4	3	4	0.52	0.14
9	Deductive Reasoning	3.6	4	4	3	4	0.52	0.14
10	Creative Thinking	3.5	3.5	3	3	4	0.53	0.15
11	Inductive Reasoning	3.4	3	3	3	4	0.52	0.15
12	Mathematical Reasoning	3.4	3	3	3	4	0.52	0.15
13	Leadership	3.3	3	3	3	4	0.67	0.20
14	Motivate/Inspire	3	3	3	3	3	0.67	0.22
15	Integrating Information and Data	3.1	3	3	3	3.75	0.88	0.28
16	Evaluating a Study	3.2	3	3	3	4	0.92	0.29
17	Synthesizing Information and Data	3.3	3.5	4	3	4	0.95	0.29
18	Visualization	3.3	3.5	4	3	4	0.95	0.29
19	Value Focused Thinking	3	3	3	3	3.75	0.94	0.31
20	Problem Sensitivity	2.8	3	3	2.25	3	0.92	0.33
21	Information Ordering	2.9	3	3	3	3.75	1.10	0.38
22	Making Projections Based on Data	2.9	3	3	3	3.75	1.10	0.38

3.2.2 Inclusion

Only those competencies and KSAs with median ratings equaling Agree or Strongly Agree were included in the final compilation. The value ranges for the levels of agreement were: Strongly Agree – 3.26 – 4.00, Agree – 2.50 – 3.25, Disagree – 1.75 – 2.49, and Strongly Disagree – 1.00 – 1.74. Based upon these predetermined levels, the researcher concluded that the 5 competencies, 21 items of knowledge, 41 skills, and 22 abilities rated by the expert panel members were to be included as being required for future U.S. Army FA49s to perform their duties within the joint operating environment of the next twenty-five years. Table 9 shows the distribution of agreement for competencies and KSAs.

Table 9 - Agreement Distribution

	Agree	Strongly Agree
Competency	0.0%	100.0%
Knowledge	81.0%	19.0%
Skill	65.9%	34.1%
Ability	45.5%	54.5%

4. CONCLUSIONS, IMPLICATIONS, & FUTURE RESEARCH RECOMMENDATIONS

4.1 Conclusions

Of singular importance to the conclusions drawn from this research study is whether or not the research purpose was met, and whether the primary and secondary research questions were answered. Based upon the results derived from the two Delphi rounds, the researcher has concluded that the research design did unequivocally accomplish its objective by producing the following outcomes, which supported the overall research purpose: identification of 5 technical competencies, 21 areas of knowledge, 41 skills, and 22 abilities that are required for future U.S. Army FA49s to perform their duties within the joint operating environment of the next twenty-five years as perceived by contemporary expert U.S. Army FA49s.

4.2 Implications

First, while the Delphi methodology may not be unknown to the engineering management community, its use and application to identify competencies and/or KSAs is limited to a relatively small number of studies, none of which focused on ORSA competencies or KSAs. This study has added to the existing body of knowledge in engineering management theory and methodology by presenting and substantiating that the Delphi process is capable of identifying pertinent issues and future and/or forecasting requirements with regard to the identification of ORSA competencies and KSAs. The rigorous use of Delphi in this study makes a significant contribution to the body of knowledge on qualitative research in engineering management. The increased use of qualitative methods, common in the domains of psychology and sociology, in engineering management research may be instrumental to the comprehension of a variety of issues within the field.

Second, it contributed to engineering management literature by providing a basis for the expansion of the domain of competencies and KSAs for the operations research field. Through the use of the Delphi technique, this research helped close a gap in the understanding of required competencies and KSAs for operations researchers. The operations research field and the concepts of competencies and KSAs have been established in the literature for quite a while; however, this rigorous study was the first to wed the two areas and attempt to provide insights. Additionally, since no studies have been conducted on competency and KSA identification this study and its results may be indicative of where operations research may be headed.

Third, being the first rigorous research study based on ORSA technical competencies and KSAs for the U.S. Army FA49 field, this research has provided areas for future research that suggest the conduct of additional studies that can be used to potentially extend the findings to the wider operations research community as a whole (i.e. beyond the military ORSA domain).

Finally, this research contributed to the identification of competencies and KSAs that may be germane to the development of engineering management (operations research focus) and military educational curricula. As such, development of these curricula may bring clarity and enhancements to human resource life-cycle developmental models that may assist with both human resource career management and career advancement issues.

4.3 Future Research Recommendations

Finally, recommendations for potential future research efforts stemming from this study include:

two philosophical issues, the first focusing on the positivistic versus naturalistic paradigm with regard to the identification of competencies and KSAs in operations research and military operations research and the second focusing on the possible differences between operations research and military operations research,

two theoretical issues, one being theory development for competency and KSAs with respect to operations research and military operations research and the second being identification of the theoretical roots for competency and KSA development with respect to operations research and military operations research,

one axiological issue, understanding the ethical considerations for operations research and military operations research,

one methodological issue, establishment of the methodological bases upon which operations research and military operations research lie, and

one practical effort, expansion of the study by providing a larger sample and/or by covering a broader scope of individuals.

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