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An Analysis of Factors that Influence the Success of Expeditionary Civil Engineer Hub-and-Spoke Organizations

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EXPEDITIONARY CIVIL ENGINEER HUB-AND-SPOKE ORGANIZATIONS

THESIS

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Abstract

Expeditionary Air Force Civil Engineer support to recent operations in southwest Asia created a unique organizational learning environment, particularly related supporting the general engineering requirements of geographically separated units in a manpower-constrained contingency environment. One of the direct results of this organizational learning was the hub-and-spoke expeditionary engineer unit featuring elements of both Rapid Engineer Deployable Heavy Operational Repair Squadron, Engineer and Prime Base Emergency Engineer Force capabilities operating with theater-wide visibility of infrastructure requirements. This study acquired insights from literature and a purposeful sample of subject matter experts about operational advantages this hub-and-spoke unit offered compared to those offered by strictly legacy organizational models. The research used a Delphi method of expert opinion elicitation to which of these may be applicable in future contingency environments with caveats, constraints, and conditions that CE force planners should consider for hub-and-spoke organizations. The expert panel demonstrated consensus on 20 advantages and associated success factors, including resource cross-leveling flexibility, optimized organizational proximity to key support functions like logistics and contracting, centralized core engineering functions, and better-defined command relationships in the Joint environment.

In Memory of
Servant...Leader...Grandpa
Salt...Light...Grandma
d. 2012

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AN ANALYSIS OF FACTORS THAT INFLUENCE THE SUCCESS OF EXPEDITIONARY CIVIL ENGINEER HUB-AND-SPOKE ORGANIZATIONS

I. Introduction

Background

Since the 1960s, expeditionary Air Force civil engineer (CE) capabilities have been presented to combatant commanders (COCOMs) primarily in the form of Prime Base Emergency Engineer Force (BEEF) and Rapid Engineer Deployable Heavy Operational Repair Squadron, Engineer (RED HORSE) teams (Marlin, 1987). While these teams are operationally controlled by various levels of an often complex command structure, local wing commanders have developed an expectation that at least one of these teams will be assigned to their installation to support their local mission.

Most recently, the Expeditionary Prime BEEF Group (EPBG), Expeditionary RED HORSE Group (ERHG), and Expeditionary Civil Engineer Group (ECEG) concepts have been utilized in Air Force Central Command's (AFCENT) area of responsibility (AOR) in Southwest Asia (SWA) to present expeditionary CE capability to supported operations. These units use a hub-and-spoke concept of operation (CONOP) to fulfill roles and responsibilities related to general contingency engineering. They primarily support project programming, design, troop labor, and contract construction management needs generated by Air Force and Joint tactical infrastructure requirements (Allen, 2009). This CONOP has become the basis for presenting Air Force CE contingency support capabilities to commanders in the Joint operational community prosecuting Operations IRAQI FREEDOM (OIF) and ENDURING FREEDOM (OEF).

The operational advantages this CONOP appears to offer to supported commanders have led CE planners to consider its use in contingency situations in other areas of responsibility (AORs).

One of the critical factors for success in most military operations is effectively addressing the challenge of applying the right people to the right place at the right time (Borofsky & Matecko, 1989). To address this challenge, CE force planners have primarily utilized two models to develop recommendations for how many and in what skills mix CE personnel will be required to support a given operation. For the first model, the Air Force personnel resources functional community maintains the Air Force Manpower Standard, which is based on expected personnel requirements at a permanent, enduring operating location. The Air Force Civil Engineer Unit Type Code (UTC) Guide and CE supplement to the War Mobilization Plan (WMP) form the second model. They are based on how many personnel may be required to fulfill Air Force infrastructure requirements in an expeditionary environment. The application of these two models in the situations for which they were developed has historically produced effective recommendations for manning levels (Winkler, 2011).

These models assume that Prime BEEF expeditionary CE capabilities remain primarily aligned with and controlled by local installation commanders. This paradigm stands in contrast to the one in which hub-and-spoke organized Air Force CE units found themselves operating in later phases of OEF and OIF. These units were aligned at the command echelon above wing (or Joint equivalent), often as part of a Joint task force, with AOR-wide visibility of infrastructure requirements. As of 2013, they featured Prime BEEF capabilities and the heavy repair and construction capabilities of RED HORSE

under one centralized command element. Anecdotal accounts and those summarized in available after action reports (AARs) suggest that this alignment made it possible to better manage the utilization of expeditionary CE capability in the AFCENT AOR by enabling functional commanders to allocate often-limited CE resources to the areas where these resources will have the greatest impact on the mission.

This research effort supports the CE contingency force planning community, who is seeking to develop a CE force planning model that capitalizes on operational advantages SWA hub-and-spoke CE units have appeared to offer supported commanders. Developing this model requires documenting current CE manpower planning knowledge developed in the course of applying the hub-and-spoke organizational model to CE units operating in SWA. Recommendations can then be made for application of appropriate facets of that knowledge to future operations plans in other AORs. Currently, only an ad hoc hub-and-spoke manpower model exists. It is limited in its ability to reflect human resources requirements for constructing, repairing, and maintaining expeditionary airfields. This research seeks to add to the existing force planning body of knowledge. Its outcome may act as the theoretical basis upon which further investigative efforts pertaining to contingency construction labor productivity, manpower planning tools, expeditionary airbase location optimization, knowledge transfer at deployment rotation turnover, exercises and evaluations, and others may be based.

Research Objective

This research's objective is to acquire insights and recommendations from literature and CE functional subject matter experts (SMEs) about factors that influence

CE hub-and-spoke units' successful delivery of operational advantages to supported commanders compared to those offered by strictly legacy expeditionary CE organizational models. It seeks to answer a research question formulated based on direction from the sponsor, previous research, published literature, and accounts of recent actions in OEF and OIF. Specifically:

> What are factors that influence successful delivery of operational advantages offered by hub-and-spoke organized expeditionary CE units?

Answering this question requires the consideration of a series of initial investigative questions:

1. What operational advantages have hub-and-spoke-organized expeditionary CE units offered for meeting theater-level objectives effectively in SWA?
2. Of the operational advantages determined in Question One, which might be potentially relevant or applicable to supporting the combined forces air component commander (CFACC) in another AOR?
3. Of the operational advantages determined in Question One, which might not be potentially relevant or applicable to supporting the CFACC in another AOR?
4. What factors should be present for CE hub-and-spoke units to successfully provide these operational advantages to a supported CFACC?

Air Force senior leadership responses to the need to codify the organizational learning the CE community has experienced in recent SWA operations, commander-in-chief-directed reevaluation of the national security strategy in the Pacific, and actual and anticipated personnel resource constraints serve as the impetus for this research objective. It seeks to codify the organizational knowledge gained through the course of hub-and-spoke

operations in SWA and offer recommendations about how this knowledge may be applied to how expeditionary CE capability is employed in other contexts. It is upon that basis that future research may be undertaken to develop tools that may more directly assist CE expeditionary manpower planners.

Methodology

Based on a grounded theory approach, two phases of analysis were used to meet the research objective. The first phase of analysis documented existing policies on agile combat support (ACS) force planning, organizational learning and innovation, Department of Defense (DoD) planning guidance, and available AARs of expeditionary CE actions in SWA. The goal of this historical analysis phase was to compile current theories supporting the two models currently used in expeditionary CE force planning. Gaps in published organizational knowledge were then identified so qualitative data gathering in the second phase could be appropriately focused.

The second phase of the research more closely examined identified gaps in published force hub-and-spoke force planning knowledge. This phase utilized a modified Delphi technique to elicit expert panel opinion. Panelists were queried on their opinions regarding the operational advantages obtained by organizing expeditionary CE capability in a hub-and-spoke fashion in SWA. The panel of experts' responses were iterated among the group to work towards agreement and consensus on an appropriate set of factors contributing to the success of CE hub-and-spoke units operating in SWA and their perceived applicability to other theaters. The goal of this phase was to document tacit

force planning knowledge and establish a theoretical basis upon which future research can be founded.

Scope, Assumptions, and Limitations

This research effort analyzed contingency CE force planning theories in the context of recent SWA deployment experiences. It sought to determine factors that made CE hub-and-spoke successful in SWA and which of them may be applicable to CE hub-and-spoke units supporting Air Force expeditionary infrastructure requirements in other AORs. During the course of this research effort, assumptions were required to maintain appropriate scope and increase the likelihood that meaningful results were produced. Specifically, the research was based on the following general assumptions:

- The material contained in AARs was communicated accurately and provided a comprehensive overview of the challenges met and issues addressed by CE hub-and-spoke-organized units
- Supported operational commanders in contingency environments will comply with published Air Force installation infrastructure standards and guidance
- That expeditionary CE capabilities will be primarily organized, trained, equipped, and employed in support of CFACC requirements, with support provided to Joint infrastructure requirements by exception

As with all expert opinion elicitations, data sourced from human recollection and communication comes with some bias that cannot be entirely eliminated through deliberate mitigation measures. Furthermore, potentially available data and informed opinion pertain to hub-and-spoke operations in SWA almost exclusively. An element of risk is introduced when attempting to generalize information to new contexts. Other AORs may introduce conditions or constraints that limit the potential success factors documented by this research and forecasted to be applicable elsewhere. The project was

also limited by the availability of adequate quantitative data to identify and validate other planning factors to be included in its recommendations.

A formative effort, this research was not without limitations. Data classification, availability, method of elicitation and analysis, and time constraints presented the greatest limitations to this research. Only unclassified data were examined in the course of this study. While additional insight may be gained if classified data is incorporated into subsequent research efforts, these data would not have necessarily enhanced the utility of findings at such an early stage of this research stream. Thus, this research explored general operational advantages and associated unclassified success factors exclusively.

While genuinely well-intentioned and having the prerequisite buy-in required for participation in the project, one of the primary sources of data - the SME panel - experienced ongoing challenges related to its collective ability to conform to the study's time constraints. Furthermore, applying the Delphi technique to the problem introduced its own constraints. Literature suggests that for as many projects that have achieved success conducting a Delphi study, there may be as many that have experienced unfavorable outcomes. Common reasons for failure often include a combination of the following (Linstone & Turoff, 2002):

- Imposing monitor views and preconceptions of a problem upon the respondent group by over-specifying the structure of the Delphi and not allowing for contribution of other perspectives related to the problem.
- Assuming that Delphi can be a surrogate for all other human communications in a given situation.
- Poor techniques of summarizing and presenting the group response and ensuring common interpretations of the evaluation scales utilized in the exercise.
- Ignoring and not exploring disagreement so that discouraged dissenters drop out and an artificial consensus is generated

- Understanding the demanding nature of a Delphi and the fact that the respondents should be recognized as consultants and properly compensated for their time if the Delphi is not an integral part of their job function

Literature suggests three additional limitations commonly associated with research using the Delphi technique to forecast solutions. First, the data produced from a Delphi study is exclusively qualitative, not evidence-based. Second, there are no universally recognized standards and guidelines for organizing and conducting a Delphi study (Keeney, Hasson, & McKenna, 2005). Myriad opinions exist for how to identify panel members, how many should be utilized given a population, how many phases of questioning to conduct, the appropriate definition of consensus, how data should be analyzed and reported, and indicators for appropriate conclusion of a study (Hsu & Sandford, 2007; Keeney, Hasson, & McKenna, 2005). Internal peer review of appropriate panel members and consultation with local statistical SMEs was accomplished to address potential validity concerns introduced by using descriptive statistical techniques.

External time factors introduced the ultimate constraint on how thorough an investigation could be accomplished. These time factors confirm the third primary limitation: conducting a Delphi study can be time-consuming. Appropriate time must be allotted to accomplish initial interviews and design, distribute, collect, analyze, and record questionnaires. Literature-recommended times to allocate for Delphi studies vary from 45 days to 16 months (Delbecq, Van de Ven, & Gustafson, 1975; Keeney, Hasson, & McKenna, 2005; Linstone & Turoff, 2002). While studies can be well planned and executed, researchers often underestimate the amount of time it takes to gain consensus (Keeney, Hasson, & McKenna, 2005). Lack of panel participation often requires follow-up contact by way of reminder e-mails and phone calls, thus adding to the overall time

required. Data gathering in this research effort was attempted over major holiday seasons, through rigorous class schedules, and at a time when the sample population was task saturated planning courses of action to address unprecedented federal fiscal challenges. Subsequent phases of follow-up questions or further research on the themes suggested by this study may be best left to future researchers.

The body of Delphi literature acknowledges the fact that Delphi studies typically possess limited internal validity (Lynch, 2012). To counter this limitation, Delphi studies are by their nature designed to utilize the concept of data triangulation inherent in grounded theory approaches to obtain inputs from multiple sources with the expectation of convergence. The tendency toward limited internal validity was addressed by intentionally designing the SME panel such that a representative group of opinions would be represented. Special consideration was also given to providing an adequate description of the intended outcomes of the research to the participants and using research colleagues to provide survey feedback.

Despite its relative advantages, utilizing a Likert scale to gauge a subjects' level of agreement with given statements introduces potential limitations. Use of the scale to gauge a respondent's level of agreement with a statement assumes that respondents' responses refer wholly to the attitude being measured. Participants may agree or disagree with a given statement for a host of reasons beside the attitude of interest. However, this research determined that given the formative nature of this topic, the potential advantages the Likert scale offered outweighed its potential pitfalls, thus making its use most appropriate.

Expert assessments of current and future scenarios are not always free of potential bias or perfectly objective. Only agile combat support (ACS) SME opinion was solicited regarding how to replicate the operational advantages that past and present hub-and-spoke expeditionary CE units offered to a supported CFACC. Supported commanders whose missions have the potential to be supported by CE capability organized in a hub-and-spoke fashion were not canvassed. Thus, an assumption of this research is that the sample surveyed possess the knowledge required to accurately determine the general engineering effects required to effectively support a given operation. The validity and future applicability of this research effort's findings relies on open and honest communication with supported stakeholders about synchronizing perceived requirements and resource realities.

Document Preview

This document presents this research effort in 5 main topics: literature review, research methodology, results, and conclusions. Chapter II presents a historical analysis and review of relevant literature including a brief history of Air Force CE capability utilization; a review of the problem and its evolution, statutory guidance, and constraints; discussion of the importance of knowledge management in high-performing organizations, and a case for the use of an adapted Delphi technique to elicit expert opinion. Chapter III presents the methodology used to meet the research objectives. Chapter IV discusses results and associated analysis used to arrive at them. Chapter V rounds out the main portion of the document by presenting conclusions and

recommendations. Appendices are included to provide additional supporting information and document information sources.

II. Literature Review

This historical analysis and literature review establishes the basis for how Air Force civil engineer (CE) capabilities interface with the Air Force's doctrinal core function of agile combat support (ACS). In doing so, gaps in published Air Force CE-related force planning knowledge are outlined to provide a basis for the execution of the research methodology presented in Chapter III. To more fully appreciate the force planning challenge Air Force CE faces as it prepares to support future operations, the research must discuss Air Force combat capability presentation and employment, expeditionary CE capabilities within that context, how CE has historically determined required manpower levels, how the concepts of organizational learning and knowledge management shaped CE expeditionary organizational innovation to produce the current hub-and-spoke concept of operation (CONOP), and the anecdotal suggestions of advantages realized as a result of its implementation. Finally, a discussion of subject matter expert (SME) opinion elicitation methods establishes the justification for use of the Delphi technique to address the identified knowledge management need at hand.

Airpower Presentation and Employment

Air Force force planning is rooted in operational doctrine and the policy documents, handbooks, and pamphlets that flow from that doctrine. Formulating the context in which this manpower planning problem exists requires understanding these publications and the overarching national security strategy directed by the commander-in-chief. Continued study of how to present and employ CE capabilities in support of combat operations more effectively is an operational imperative. Reductions in personnel

and budget resources as the Air Force continues to evaluate the use of Cold War-era theater-level, scenario-based force planning factors versus the capabilities-based factors that define the post-9/11 Department of Defense (DoD) introduce unique and often-dynamic manpower planning constraints.

Understanding the Air Force doctrine that developed from the statutory basis for its existence requires a brief review of United States defense policy in the past several decades. The Goldwater-Nichols DoD Reorganization Act formally indicated that each branch of service (Army, Air Force, Navy, and Marine Corps) is responsible for organizing, training, and equipping forces to support unified combatant commands. A senior general officer, typically from alternating branches of service, commands each unified combatant command. They are directly responsible for prosecuting military operations within its given area of responsibility (AOR). This command structure and associated responsibilities foster a joint approach to warfighting wherein capabilities from each branch of service are designed to be leveraged to fulfill missions most effectively (Goldwater & Nichols, 1986).

The Goldwater-Nichols Act drives current budgetary and resources request processes. Title 50, United States Code, Section 404a, requires the executive branch to issue the National Security Strategy (NSS) annually (Joint Chiefs of Staff, 2011b). Among other issues of national security concern, it ultimately communicates to COCOMs those major contingencies they must be prepared to execute to most effectively support United States foreign policy objectives. Policy documents that the NSS initiates, including the National Defense Strategy, the Quadrennial Defense Review (QDR), Unified Command Plan, and Guidance for the Employment of the Force, ultimately drive

expectations of troop numbers and equipment. The Joint Strategic Capabilities Plan (JSCP) formally communicates the capabilities that manpower and associated materiel are expected to provide. Each Service Chief of Staff, COCOM, and other Defense agencies use the JSCP to develop requirements to accomplish tasks and mission based on near-term military capabilities. Thus, JSCP implements deliberate planning guidance (Department of the Air Force, 2006b).

The Air Force developed the Air and Space Expeditionary Force (AEF) construct within this context. The AEF represents "the Air Force's methodology for organizing, training, equipping, and sustaining rapidly responsive air and space forces to meet defense strategy requirements" (Department of the Air Force, 2011b). In short, the Air Force presents its capabilities to COCOMs by means of the AEF. The doctrinal tenet of ACS, which is critical to the facilitation of combat airpower projection, is embedded within the AEF construct. CEs act as an integral part of the synergy that happens between the transportation, materiel logistics, installation security, maintenance, and human resources capabilities traditionally considered ACS components (Department of the Air Force, 2005).

Expeditionary CE Capabilities in Context

Air Force Doctrine Document 3-34, *Engineer Operations* (Department of the Air Force, 2011a), states that the CE functional community's primary ACS responsibility is to "provide, operate, maintain, and protect sustainable installations as weapon system platforms through engineering and emergency response services across the full mission spectrum." This allusion to the full mission spectrum includes a broad range of

contingencies that CE must be prepared to address. At one end, the potential exists for operations to be based from installations where the existing facilities are more than adequate for sustained operations. At the other extreme, supported commanders may require CE to be a part of the initial seizure of an airfield location and construct the base's infrastructure from scratch (Department of the Air Force, 2011a). The evolution of this unique range of capabilities drives how CE organized, trained, and equipped (Department of the Air Force, 1999).

Air Force expeditionary operations distinguish CE capability in two ways: Rapid Engineer, Deployable Heavy Repair Squadron, Engineer (RED HORSE) and Prime Base Emergency Engineer Force (BEEF) teams (Department of the Air Force, 2011a). The lines of specific task delineation are often blurred, but at their core, they fulfill unique portions of the CE mission. While so-called low density, high demand resources like pavement evaluation teams and major command (MAJCOM) staff augmentees also provide critical support to COCOMs, they make up a relatively small percentage of the overall number of Air Force CEs postured to support contingencies.

RED HORSE

RED HORSE organizes, trains, and equips its personnel to provide COCOMs with expeditionary base heavy construction and repair capabilities. These forces are capable of self-sustaining operations as they execute tasks related to water well drilling, demolition, quarry operations, concrete and asphalt batch plant operations, paving, and large expedient base construction. In contingency situations, the combined forces air component commander (CFACC) of the unified command's area of responsibility (AOR) to which the capability is attached controls overall RED HORSE direction. This

command and control (C2) relationship ensures the highest probability that their unique capabilities will be utilized in the most effective manner theater-wide. When not directly supporting an active contingency, these units fall under the command of a Numbered Air Force (NAF) and fulfill construction and repair projects not necessarily in direct support of expeditionary operations (Department of the Air Force, 2011a).

Prime BEEF

Personnel aligned with Prime BEEF teams are typically part of a stateside Civil Engineer Squadron (CES) whose primary responsibility is to maintain the installation to which they are permanently assigned. These craftspersons and engineers fulfill traditional home station installation support functions full time, with readiness exercises providing scenario-specific practice in contingency CE skills (Department of the Air Force, 2011a).

The Prime BEEF concept evolved out of an emerging expeditionary facilities requirement after World War II, through the Korean War, and into the Southeast Asia War. An Air Force CE study group meeting in the late 1960s noted the following (Marlin, 1987):

> Problems plaguing [Air Force CE] at this time included the following: 1) AFCE had no appreciable mobile response capability for contingencies, 2) AFCE lacked uniformity in the military/civilian mix from base to base, 3) AFCE provided inadequate career progression for military members, and 4) AFCE had shown itself improperly aligned to meet several pre-1964 crises.

To meet these challenges and provide COCOMs with more effective infrastructure support, a former director of Air Force CE noted "the Prime BEEF program was initiated to provide responsive, compact temporary duty (TDY) Civil Engineering forces of specific military skills for direct support of short-term combat operations" (Marlin, 1987). These teams primarily perform force beddown and war damage repair tasks at the

locations to which the flying squadrons they support in wartime deploy. Requirements for sizes of teams in these situations are typically based on the anticipated facility and infrastructure needs of all Air Force units – flying and non-flying – at a given deployed location (Cummings, 1997; Department of the Air Force, 2011b).

In contingency scenarios, an Expeditionary Civil Engineer Squadron (ECES) CONOP often drives how these teams are organized, commanded, and controlled. They are designed to provide on-going, general contingency engineering support directly to a supported wing commander or equivalent. While these units facilitate theater-level operational objectives through their support to the local operator, they are not traditionally directly commanded or controlled by the command echelon above the wing level.

Expeditionary Capabilities Applied

RED HORSE and Prime BEEF teams support four primary categories of expeditionary bases. The Forward Operating Location (FOL) is an airfield utilized for short-term contingencies like counter-drug or combat search and rescue (CSAR) missions. Operational constraints limit FOL infrastructure development to minimum standards. Forward Operating Bases (FOBs) airfields are primarily supporting tactical, CSAR, and reconnaissance operations without establishing full support facilities. FOBs may be used for an extended duration, but they require main operating base support to sustain combat operations. A Main Operating Base (MOB) is normally occupied by one or more wings, typically representing 550 or more personnel. These installations are continuously operated and possess in-place Air Expeditionary Wing (AEW) command structures, robust expeditionary combat support (ECS), and logistics supply functions.

Intermediate Staging Bases (ISBs) are locations or airfields used to stage forces prior to inserting combat forces into the forward theater of operations. These locations have large transient cargo and personnel requirements and normally require greater planning factors for cargo ramps and ECS to accommodate robust asset movement. A fifth type of base is often minimally operated by contracted labor for the purpose of maintaining prepositioned assets with initial beddown infrastructure. These so-called "warm" bases may be "heated up" to facilitate rapid deployment of personnel and weapons systems to a forward expeditionary location (Department of the Air Force, 2006a).

COCOMs issue construction standards for each type of installation as a surrogate measure of expected contingency operation duration. These standards in turn provide guidance to force planners calculating manpower recommendations,. These typically fall into four main categories. The Expeditionary Standard is meant to be in place for up to 90 days. This is the expected life-cycle of a FOL or FOB. The Initial Standard is designed to be used for up to 6 months and requires a minimum of specialized engineering effort to sustain operations. Bases to be utilized for up to 24 months are typically built to the Temporary Standard. Military Construction (MILCON) projects worth in excess of $750,000 are often programmed and executed to provide this level of infrastructure. When a base is planned to be utilized for longer than 2 years, it is considered "enduring" and thus benefits from MILCON-level construction of semi-permanent and permanent facilities (Department of the Air Force, 2006a).

Core tasks CE units are expected to execute in the course of making any installation operate at peak effectiveness are organized around in four main areas: 1) force beddown, 2) airfield damage repair, 3) facilities damage repair, and 4) general

contingency responsibilities (Department of the Air Force, 2011a). The combat engineering aspect of military engineering is associated with providing direct support to the maneuver of land forces. Clearing routes of improvised explosive devices (IEDs) and breaching obstacles are two examples of how combat engineering capability enables mobility, counter-mobility, and survivability (Joint Chiefs of Staff, 2011a). Air Force CE is not organized, trained, or equipped to provide combat engineering capabilities (Department of the Air Force, 2011a).

While not an all-inclusive list, the following tasks are expected in the course of force beddown situations (Department of the Air Force, 2011b):

- Revetment of unsheltered aircraft
- Expanding aircraft parking ramps by laying airfield matting
- Constructing earth berms and dikes for fuel bladders or unsheltered aircraft
- Modifying existing facilities for alternate use
- Erecting bare base facilities and equipment
- Installing power generation systems
- Installing airfield and installation perimeter lighting
- Providing all essential utilities
- Constructing earth berms and access roads for bomb dumps
- Constructing communication tower foundations
- Facility hardening, construction and maintenance of force protection enhancements
- Establishing and maintaining installation contaminated equipment storage, holding, or disposal areas

Depending on the persistence, abilities, and chance opportunities exploited by human and natural adversaries, airfield damage repair tasks can vary widely. While historically, U.S.-held airfields have not experienced catastrophic attack by a determined antagonist since World War II, Air Force CE maintains the ability to execute wide-ranging rapid

airfield damage repairs (Department of the Air Force, 2011b). These tasks include (Department of the Air Force, 2011b):

- Identifying unexploded ordnance (UXO) and coordinating disposal
- Determining minimum operating strip (MOS) dimensions
- Repairing craters and spalls
- Assembling and placing foreign object damage (FOD) covers
- Performing mechanized FOD sweeping operations
- Assembling and placing manufactured load bearing airfield surface matting
- Applying airfield markings
- Installing and maintaining airfield lighting systems

Facility damage repair tasks are expected to include the application of a wide variety of expedient construction and repair methods to keep mission-critical facilities operational. Tasks associated with base recovery after attack include (Department of the Air Force, 2011b):

- Assisting with search and rescue efforts
- Assessing facility systems damage
- Wrecking and demolition
- Reporting UXOs and coordinating safing operations
- Restoring functionality of facilities, utilities, and equipment

General contingency responsibilities fall into four primary areas: 1) anti-terrorism and force protection, 2) determination of facility requirements, 3) base master planning, and 4) contracted construction management (Department of the Air Force, 2011a). In addition to fulfilling these responsibilities in the active phases of contingencies, they are also applied to pre-conflict operations designed to assist building partner nation capacity in areas like the Asia-Pacific region (David, 2010; Hoyler, 2010; Rojas, 2011).

Determining CE Manpower Requirements

Periodically, functional area leaders at the Headquarters Air Force (HAF) level initiate a comprehensive evaluation to determine the total personnel required to execute the missions they may be called upon to carry out. This process is known colloquially as the "Blue Suit Review." SMEs determine their best recommendation for manpower levels based on the required CE capabilities given a certain set of scenarios (Department of the Air Force, 2006b). In the absence of directed guidance specifically outlining the level to which Air Force capabilities and manpower will be utilized by the Joint operational community, planners must make educated assumptions based on their own experiences and on feedback from the field about how many personnel it will take to sustain their assigned missions (Cummings, 2012).

Contingency CE manpower requirements are most heavily influenced by the following variables (Cummings, 2012; Department of the Air Force, 2011a; Department of the Air Force, 2011b):

- Wartime workload
- Wartime man-hour availability
- Continuing requirements (those tasks required to continue base operations)
- Climatic factors that may affect man-hour availability
- Anticipated tenant, COB, FOL, and/or bare base requirements
- The possibility of noncombatant evacuation
- How effectively manning/asset attrition is addressed by higher headquarters
- The availability of ongoing contracted services

By engaging in a continuous cycle of deliberate contingency planning during peacetime, COCOMs and supporting entities identify the capabilities required to support a wide range of operations based on scenarios and threats identified in the JSCP (Department of the Air Force, 2006a).

Currently, CE manpower planners use

Equation 1 to produce recommendations for the total CE operations and engineering personnel required at each installation to support sustainment phase operations:

$$Y = 61.42 + 0.05584x \quad (1)$$

where Y is total CE personnel require and x is weighted floor space.

The weighted floor space is equal to the total floor space located on the installation and any outlying areas with a similar standard of living measured in thousands of square feet (KSF) multiplied by the Base Square Footage Weighting Factor (BSFWF). The BSFWF is based on labor intensity weights established by real property codes. Three categories of labor requirements (high, 0.47; average, 0.33; and low, 0.20) are applied to derive base-specific factors (Department of the Air Force, 2011b).

Minimal published guidance currently exists to guide the determination of CE hub-and-spoke unit manning requirements. The calculations to determine the hub-and-spoke manning level required to present effective general engineering capability to the supported commander are typically ad hoc. As expected in dynamic contingency environments, situations unfold where increased manpower and floor space capacity must be provided on severely abbreviated timelines (Department of the Air Force, 1999). At these times, supported commanders need a revised method of employing readily surge-able CE capability to seize and hold the initiative. CE manpower planners require a method of determining whether adopting the use of a hub-and-spoke-type organization has the highest probability of providing the operational advantages realized in SWA operations, whether the current organizational model offers the highest probability of

effective support, or if the widespread implementation of a new hub-and-spoke organizational CONOP may best meet supported commander objectives.

Origin of the Prime BEEF Hub-and-spoke Organization

The military-political environment in which Operations ENDURING FREEDM (OEF) and IRAQI FREEDOM (OIF) were undertaken catalyzed a shift in senior military and Executive Branch civilian approach to Joint operations. A series of Army force utilization decisions created a severe deficit in its uniformed combat service support capability (Allen, 2009; Bosworth, 2012). Particularly affected was its general engineering capability, specifically in the tactical infrastructure planning, design, construction, maintenance and repair disciplines. When the on-the-ground consequences of this deficit began to emerge, leaders serving on Joint staffs were challenged to find an expedient solution. Employing expeditionary Air Force CE capability in direct support of Army infrastructure requirements was determined to be the ideal Joint warfighting solution (Bosworth, 2012). Formal requests for forces (RFFs) were issued and Air Force CE personnel aligned with Prime BEEF unit type codes (UTCs) were deployed on what initially became known as in-lieu-of (ILO) taskings and then Joint Expeditionary Taskings (JETs).

Prime BEEF personnel were initially placed under the tactical control (TACON) of fielded Army brigade combat team (BCT) commanders as one-for-one replacements in their imbedded utilities detachments (U-Det) and facility engineer teams (FET). Organizationally, the size and scope of operations characterized by BCTs make them a rough equivalent to an Air Force wing, typically commanded by a colonel or brigadier

general. Similarly, the infrastructure support these Air Force CE teams provided to BCT commanders was analogous to that which they provided Air Force wing commanders (Allen, 2009; Bosworth, 2012).

Feedback received from supported Army BCT commanders regarding the effectiveness of employing expeditionary Air Force CE capability in this way was generally outstanding. However, through several deployment rotations, manpower challenges associated with aligning Air Force CE capability directly under the control of an Army brigade commander became apparent. Furthermore, concerns related to potential undermining of Air Force CEs ability to provide beddown and sustainment of airpower were raised as Air Force CE capability was flexed to support Joint requirements (Allen, 2009).

Direct, end-of-tour interview, and after action report (AAR) feedback provided by Air Force teams attached to BCT command staffs suggested wide disparities in the workload experienced by teams attached to different BCTs (AFIT CES Faculty, 2010). No process existed to shift those personnel in one BCT who were not as busy with mission-critical work to provide workload relief to those teams in a separate BCT who were task saturated fulfilling mission-critical infrastructure requirements. The same challenge existed for shifting materials and expertise. Institutional differences in how supported commanders leverage engineer capability also meant that Air Force CE personnel were often called upon to perform tasks well outside the general engineering capabilities they were deployed to provide. Those institutional differences also created significant challenges and administrative and tactical control over fielded Air Force CE forces were separated between two branches of service (AFIT CES Faculty, 2010).

Furthermore, an effective system for providing feedback to pre-deployment training centers and to planners who might be able to tailor the requests for forces capabilities to those that met emerging requirements in-theater remained chronically elusive (Frey, 2009). These challenges appeared to compound as Air Force CE operations tempo (OPSTEMPO) levels increased to unsustainable levels, home station missions began to be affected, and personnel retention issues were identified (Allen, 2009).

Practitioners and researchers have long-understood that most innovations are the result of borrowing or building on previous innovation, rather than invention from scratch (Cohen & Levinthal, 1990; March & Simon, 1958). This was certainly the case as functional Air Force CE leaders more intentionally considered the application of knowledge gained as a result of supporting over 7 years of continuous overseas contingency operations to the problem of how to best present expeditionary CE capabilities to their Joint functional partners (Allen, 2009). By 2009, Air Force CE leadership had successfully made the case for realignment and consolidation of Air Force CE forces fulfilling general engineering responsibilities in direct support of the Army and Marines operating in Afghanistan. By design, the command echelon above the BCT level controlled the newly proposed Expeditionary Prime BEEF Group (EPBG) with the purpose of supporting regional engineer task forces. Bagram Airfield served as the headquarters for the EBPG, with squadron headquarters hubs at three major airfields located around Afghanistan. Spoke teams would then forward deploy to Army and Marine FOBs to perform general engineering tasks, including light vertical construction; surveying; life, health, and safety utilities inspections and repairs; base master planning; minor construction project programming; design; and construction management (Allen,

2009). Feedback from supported units has served as a proof of concept for the EPBG's hub-and-spoke style of organization also utilized by RED HORSE units for their service in SWA (Yolitz, 2009).

A new iteration of the hub-and-spoke-organized expeditionary CE unit concept emerged in late 2011. Statutory limits, most closely related to boots-on-ground (BOG) constraints in Afghanistan as part of the so-called surge recovery operations, drove planners to consider an over-the-horizon approach to providing expeditionary CE capability. This CONOP stipulated that with the exception of lean contingents of CE personnel at various installations, expeditionary CE capability would be centrally commanded and controlled from a major enduring location far to the rear of the primary action. Resources were provided such that CE personnel would fulfill both Air Force and Joint infrastructure requirements, often thousands of miles removed.

The newly-formed 1st Expeditionary Civil Engineer Group (ECEG) met this command and control (C2) and logistics challenge by providing "highly mobile, light and heavy construction and repair capability throughout the AFCENT area of responsibility when requirements or threat levels exceed normal civil engineer unit capabilities" (AFCENT, 2012). It thus unified Prime BEEF and RED HORSE capabilities under one commander, a colonel, and more closely controlled the prioritization and utilization of their capabilities. Headquartered at Al Udeid Air Base, Qatar, and reporting directly to the AFCENT CFACC, it maintained SWA-wide visibility of infrastructure requirements. The success experienced by the 1 ECEG suggests that this over-the-horizon hub-and-spoke innovation should be considered for implementation in support of contingencies in

other theaters. However, doing so first requires an examination of the factors contributing to this success.

Codifying and Applying Observations, Innovations, and Lessons Learned

Through guidance documents like the 2010 QDR and National Security Strategy of 2012, the current administration has directed active reevaluation of Pacific Command (PACOM) operations plans (OPLANs) (Gates, 2010; White House, 2012). This strategic guidance ultimately informs the organizational planning of the aggregate functional communities that support the execution of those OPLANs. Congressionally-mandated resource constraints further affect overall manpower authorizations DoD-wide, driving decision-makers to reevaluate the way in which remaining personnel resources are employed to support given OPLANs. These decision-makers often look to recent military organizational and process innovations to inform their recommendations about future organizing, training, and equipping actions. Characterizing and attempting to replicate the success factors that gave the supported CFACC the operational advantages that hub-and-spoke organized CE units did may provide future commanders with similar operational advantages. Being aware of the challenges posed by certain circumstances can also increase the likelihood that these challenges may be effectively identified and overcome in future contingencies.

Air Force policy regarding the creation and dissemination of new knowledge takes its formal cues from Department of Defense Instruction (DODI) 8260.01, *Support for Strategic Analysis,* and DODI 8260.2, *Implementation of Data Collection, Development, and Management for Strategic Analyses*. Air Force policy states that AARs

are one of the primary means by which observations of successes and challenges can be collected and lessons learned gleaned. These reports become the published products that reconstruct specific events or combat operations through the lens of the participants' firsthand knowledge and experience. One of their primary objectives is to assist Airmen in the incorporation of knowledge that facilitates more effective and efficient prosecution of assigned missions. To that end, these reports "describe how the mission could be/was improved, potential risks to mission degradation, and how to mitigate those risks" (Department of the Air Force, 2010).

While the successful application of the hub-and-spoke concept to expeditionary CE operations in SWA has catalyzed discussions of potential courses of action in the Air Force CE functional community, additional rigor must be applied to more fully distill lessons learned and their potential application to hub-and-spoke-organized CE units in future contingencies. Little in the way of published material has been produced documenting operational knowledge applicable to this problem. A theoretical basis for operational CE force planning tools required characterization. A knowledge gap existed that required collection and analysis of qualitative data about the challenges and successes SWA CE hub-and-spoke-organized units experienced. From these data, it would be possible to determine factors leading to the success of these units. Data of the types included in AARs prepared by unit commanders and gleaned from input by a panel of CE functional SMEs with first-hand experience working with the personnel and processes involved with the hub-and-spoke concept had to be collected and analyzed. From these data, a basis could be established for further research into operational tools to

assist manpower planners considering hub-and-spoke presentation of expeditionary CE surge capabilities in support of future contingencies.

The AARs produced by recent hub-and-spoke unit commanders capture observations, innovations, and lessons learned (OILs) developed as a result of Air Force expeditionary CE capability being organized in a hub-and-spoke fashion in SWA. They address primarily tactical challenges with some regard to how these may be overcome in contexts other than those in which the unit operated. Some of these OILs have broader applicability to hub-and-spoke organization manpower requirements generally. They may also apply to CE hub-and-spoke organizations supporting CFACCs in other AORs. Analysis of their content can yield valuable input into how to most effectively organize expeditionary CE capability. Further canvassing of organizational knowledge held by those senior leaders who had firsthand experience with both the SWA hub-and-spoke CE units and other contexts in which this CONOP may be applied has a higher probability of determining valid recommendations.

Nonaka (2007) argues that the ultimate competitive advantage against an adversary is knowledge, stating "where the only certainty is uncertainty, the one sure source of lasting competitive advantage is knowledge." Furthermore, the "secret [of] success is [a] unique approach to managing the creation of new knowledge" (Nonaka, 1991). Kogut and Zander (1992) present multiple cases where highly successful organizations whose operations transcend national borders rely on the effective codification and dissemination of the knowledge gained as a result of a process of organizational knowledge creation. On this view, effective organizations commit to this "process of making available and amplifying knowledge created by individuals as well as

crystallizing and connecting it to an organization's knowledge system" (Nonaka & von Krogh, 2009) . Nonaka and von Krogh (2009) further state that in highly dynamic operational contexts, those organizations who are most consistently successful are those that "create new knowledge, disseminate it widely throughout the organization, and quickly embody it" into new ways of executing their mission. Creating new knowledge often requires "tapping the tacit and often highly subjective insights, intuitions, and hunches of individual[s] and making those insights available for...use by the [organization] as a whole." Being highly personal and context-dependent, tacit knowledge can be difficult to formalize and communicate to others (Nonaka, 2007). Nevertheless, it is imperative that qualitative data and knowledge be solicited. Stakeholders must then use that knowledge to move from tacit applications to explicit ones by providing tools for others in the organization to utilize.

Cantwell and Mudambi (2011) argue that the best way for a large organization with global reach to maintain and extend its competitive edge is to find a way to effectively access those with possession of local knowledge. Their research suggests that the extent to which such a multi-national organization can effectively assimilate new competencies generated at a tactical level determines how effectively it can leverage competitive advantages by implementing these competencies more broadly. In their view, effective organizational knowledge creation paradigms must be established from the top down so that lessons may be effectively disseminated and applied.

However, Govindarajan and Ramamurti (2011) noted most recently "legacy internal organizational structure, legacy routines, and cognitive maps may act as barriers" to organizational knowledge creation and must be addressed in order for effective

learning to occur. Cohen and Levinthal (1990) argue that absorptive capacity (AC) is the ability of an organization to overcome those barriers to assimilate external information and apply it to beneficial use. AC becomes a function of prior related knowledge, which is often required to be intentionally documented and disseminated. Lack of early investment in expertise like force planning skills among Air Force CE officers may "foreclose the future development of capability in that area" (Cohen & Levinthal, 1990). Therefore, an evolving theoretical groundwork for force planning and organizational innovation must be set so the Air Force CE functional community maintains its edge into the future. A necessary method of laying this groundwork involves the solicitation of SME opinion and analysis of the content of their responses.

Eliciting Expert Opinion

Numerous non-experimental techniques are available to assist the researcher with soliciting and analyzing qualitative inputs from a group. The most widely used are surveys, interviews, and questionnaires. Each method possesses relative strengths and disadvantages when applied to various contexts.

Surveys are typically used to gather data from a randomly selected population sample. Researchers then take that sample's responses and attempt to make judgments about the characteristics or opinions of the population at-large (Krathwohl, 1998). Patton (2009) notes that participants "are interviewed, questioned, or otherwise observed so that their attitudes, beliefs, and behaviors as they exist without experimental intervention are determined." Respondent pools often number over one hundred, the volume of questions is relatively limited, and there is little opportunity for follow-up or clarifying questions

(Patten, 2009). While especially appropriate in contexts where questions can be appropriately designed to collect certain data, a survey of senior CE leader opinion did not appear appropriate.

Another often-utilized method of qualitative data gathering is the semi-structured interview. These interactions are typically face-to-face and recorded (Patten, 2009). Time commitment on the part of both the respondent and researcher is high, especially if follow-up interview sessions are required to clarify perspective based on subsequent data gathering (Krathwohl, 1998). While time constraints posed a serious challenge to the use of interviews for this study, the most significant challenge was the one presented by the geographical separation of participants.

Use of questionnaires through the application of a Delphi technique appeared to hold distinct advantages over all other methodologies. While variations exist, the main concept behind the Delphi technique centers on attempting to facilitate a group communication process that allows a group of individuals, taken as a whole, to address a complex problem. It starts with the distribution of an initial questionnaire to members of a group and inviting them to respond individually. The primary goal of a Delphi study is to define reality by facilitating interaction (Linstone & Turoff, 2002). It is among the handful of research methods based on grounded theory, which states that by its nature, qualitative research tends to apply inductive means of data analysis. Researchers collect and analyze qualitative inputs and develop theories grounded in those data (Patten, 2009).

Four distinctive features of a typical Delphi study make the definition of reality possible: anonymity among Delphi participants, iteration, controlled feedback, and statistical aggregation of group responses (Rowe & Wright, 1999). Whereas surveys tend

to answer "what is" questions, Delphi studies often attempt to determine "what could/should be" (Miller, 2001). These characteristics made the Delphi technique well-suited for the objectives of the SME opinion solicitation required by this research effort. Furthermore, while other distribution means were available, literature confirms that e-mail communication in the Delphi study can be highly effective. Sheehan and McMillan (2011) note one advantage on which this research effort sought to capitalize. Specifically, electronic mail messages tend to have higher response rates over traditional hardcopy mail. Additionally, they promote faster response times, and respondents typically appear more willing to reply to open-ended questions.

The Delphi Method

A growing body of research finds that the Delphi method of SME opinion elicitation can work well in helping investigate incomplete knowledge about a problem or phenomenon (Skulmoski, Hartman, & Krahn, 2007). It has the potential to focus group knowledge on an issue and structure that group's communication in a way that allows that knowledge to address it. The Delphi technique is also effective at meeting the double challenge of attempting to forecast requirements years into the future when quantitative data to do so is minimally existent (Linstone & Turoff, 2002).

After responses to an initial questionnaire have been received from a sample of participants, they are summarized and sent with a second questionnaire back to the respondents. This iterative process continues until responses demonstrate stability and consensus. Evidence from the literature that the Delphi technique can “seek out information which may generate a consensus on the part of the respondent group” and

"correlate informed judgments on a topic spanning a wide range of disciplines" confirms the appropriateness of its use in determining success factors and their potential applicability in other contexts (Delbecq, Van de Ven, & Gustafson, 1975). Similar time-sensitive, qualitative research efforts have confirmed the value of implementing variations of the Delphi technique to gather and analyze relevant SME opinion (Deason, 2009). Peer-reviewed precedent has been established for the use of the Delphi method of SME opinion solicitation in cases where a requirement exists to structure group communication to meet a stated research objective (Linstone & Turoff, 2002). Using the Delphi technique can be particularly effective at gathering and evaluating opinions held by heterogeneous groups of experts like those who maintain the largely tacit body of hub-and-spoke CE manpower planning knowledge (Rowe & Wright, 1999).

Use of a Delphi technique to solicit and analyze subject matter expert opinion presents the possibility of other, more practical advantages. Participants in a study guided by the Delphi technique are not required to be geographically co-located. The ability of panel members to be physically separated yet still provide meaningful inputs offers a particular advantage to this research since multiple time zones separate the SMEs most qualified to participate in this study. By utilizing iterative questionnaires, the Delphi technique makes it possible to elicit opinion that is relatively free from influence from other participants, thus protecting against bias and maximizing the probability that honest opinions will be shared. The time required for inputs to be received and analyzed can be abbreviated compared to focus groups and interviews by allowing participants to respond on their own time in a semi-asynchronous manner (Linstone & Turoff, 2002; Rowe & Wright, 2001).

Rowe and Wright (1999) first argue that an effective Delphi study must use experts who possess the appropriate domain knowledge. In addition to adequately informing the sharing of their opinions in the initial round of questions, having the appropriate expertise also ensures they are appropriately influenced, or not influenced, by other panelists' opinions. This study's intent was to follow four guidelines for selecting SME panel members. These included: 1) knowledge and experience with the issues under investigation, 2) capacity and willingness to participate, 3) sufficient time to participate, and 4) effective communication skills (Adler & Ziglio, 2002; Skulmoski, Hartman, & Krahn, 2007).

Reliance on qualitative expert opinion as the primary basis for establishing a theoretical framework has its drawbacks. However, when appropriate guidelines are followed, Delphi studies have a proven track record of producing meaningful results. Rowe and Wright (2001) outline several key principles to consider when designing and executing a Delphi study. Several specific Delphi technique considerations were addressed in the design of this study in an attempt to avoid common challenges experienced in similar research efforts. They were related to question formulation, sample size, number of rounds expected to reach consensus, and mode of interaction.

The first negative tendency of some efforts is to query the SME panel with questions that subsequently prove to be too broad. The knowledge characteristics that make certain SMEs good candidates for participation are the very reason these SMEs are often heavily saturated with regular work tasks. Thus, individual panel members may have only a limited amount of quality time to devote to responding to questionnaires. The task of analyzing the resulting glut of unfocused perspectives becomes time consuming

for the researcher as well and introduces a risk of overlooking critical insights (Skulmoski, Hartman, & Krahn, 2007). This challenge can be addressed by focusing the initial questions, limiting their number, and providing sufficient background information about the study's premise and potential benefits to motivate focused responses.

Consideration must also be given to sample size in the formation of the Delphi SME panel. Literature suggests a wide range of potentially valid opinion sample sizes, with a general increase in decision quality and reduction in error as sample sizes increase. However, large groups tend to compound challenges related to data collection, analytic complexity, reaching consensus, and verifying results (Linstone & Turoff, 2002; Skulmoski, Hartman, & Krahn, 2007). This dilemma was moderated by the fact that the participation commitment was obtained from a high percentage of those holding salient knowledge regarding recent expeditionary CE organizational innovations. It would be inappropriate to argue that this study is a census of all those who may have an informed opinion on the nature of past expeditionary CE hub-and-spoke operations and potential future innovation. However, a large enough segment of CE senior leaders was communicated with during the scoping phase of the research that it is probable that an appropriate number of participants were canvassed.

Literature Review Summary

This chapter provided the statutory and theoretical bases for this research effort. It outlined the laws and policies that direct the support relationships between the MAJCOMs and unified combatant commands. Following this strategic level overview was a discussion of how the Air Force organizes, trains, and equips its own forces to

support the COCOM, including how Air Force CE capabilities are employed within this context and how the CE functional community determines overall manpower requirements. The latest iteration of expeditionary CE capabilities presentation in the form of the ECEG hub-and-spoke was followed by an argument for how to best codify and apply applicable OILs to a hub-and-spoke model fulfilling future contingency requirements. Chapter III presents how the Delphi technique was adapted for use by this research.

III. Methodology

This research effort used grounded theory, specifically utilizing the Delphi method, to gather and analyze qualitative data regarding Air Force expeditionary CE manpower planning. This was accomplished by eliciting opinions of CE functional SMEs while considering two primary constraints: 1) the need for utilizing a systematic process featuring proven methods of qualitative data analysis and 2) accounting for the time constraints introduced by both the expert panel members and the research project itself. A two-phase qualitative investigation undertaken using the Delphi technique provided the most effective means of soliciting SME opinion by possessing the highest perceived likelihood of yielding meaningful data.

Delphi Study Design

A purposeful sample of SMEs was assembled before initiating the formal steps of the Delphi study. Selecting the appropriate mix of SME panel members is a critical component of the application of the Delphi technique since it is upon these panel members' expert opinions that the output of the research is based (Skulmoski, Hartman, & Krahn, 2007). Hsu and Sandford (2002) further argue "choosing the appropriate subjects is the most important step in the entire process because it directly relates to the quality of the results generated." While the literature suggests that successful panel selection is essential to generating valid Delphi study results, little in the way of standard criteria for SME selection has been published. However, a list proposed by Skulmoski et al. (2007) and augmented by Scheele (2002) appeared to offer an appropriate list of credentials for this effort. Specifically, participants should meet the following six

requirements to be considered a SME (Linstone & Turoff, 2002; Skulmoski, Hartman, & Krahn, 2007) :

- Knowledge and experience with the issue under investigation
- Capacity and willingness to participate
- Sufficient time to participate in the study
- Effective communication skills
- Those who are or will be directly affected
- Those who have skills in clarifying, organizing, synthesizing, stimulating

The research approached potential participants who had previously served or were currently serving in key CE manpower planning or command positions directly associated with both CE hub-and-spoke-organized units in SWA and those units whose organizational disposition represented more traditional, or legacy, organizational alignments. Additionally, those who possessed Headquarters Air Force-level operational perspectives were also desired. Only SMEs from within the CE functional community were sought out due to time constraints and the complexity of logistics associated with tracking down and eliciting the opinions of supported commanders.

The true population size of those holding the requisite perspective on expeditionary CE hub-and-spoke cannot be stated with absolute certainty. However, discussions with key research stakeholders indicated that approximately 20 individuals likely held the corporate knowledge required to produce meaningful research data. This population primarily consisted of Active Duty and Reserve commissioned officers in the grades of O-5 and O-6 each with over 20 years of military service, primarily in the CE career field. Also included in this population were select Active Duty senior non-commissioned officers and civilians who had recently retired. According to the latest guidance published by the Air Force Personnel Center, individuals in these grades have

typically served multiple tours in support of Joint and multinational military operations, at the local installation level, MAJCOM staffs, Air Force Headquarters, and others (Air Force Personnel Center, 2010). The panel thus acted as "stakeholders, those who are or will be directly affected; experts, those who have an applicable specialty or relevant experience; and facilitators, those who have skills in clarifying, organizing, synthesizing, stimulating" (Linstone & Turoff, 2002). Of these, a sample of nine was selected to participate in the study, primarily due to the availability of respondents, perceived level of commitment, and ability to respond within the requested timeframes. The Delphi study proceeded once this purposeful sample was established.

The literature suggests that two to ten iterations of questionnaire distribution, response, analysis, and verification may be necessary to assist a Delphi research panel in reaching consensus (Delbecq, Van de Ven, & Gustafson, 1975). During each phase, respondents are given the opportunity to see the distilled results, provide feedback, and rate their agreement with them. This research adapted the steps summarized in Table 1 from the work of Delbecq (1975) and Whittington (2012) and used them as the framework for the Delphi study. They assumed a three-questionnaire format while this research only used two.

Table 1. Delphi Study Steps

Step	Description
1	The researcher develops an initial questionnaire and distributes it to the panel.
2	Panelists independently generate answers for the questionnaire and electronically return it to the facilitator.
3	The researcher summarizes the responses to the Phase One questionnaire, and drafts and distributes a follow-up questionnaire for the SME panel.
4	Referencing the distributed questionnaire, panelists accomplish requested tasks
5	The facilitator summarizes the responses to the Phase Two questionnaire and develops a final summary report.

Step One initiates Phase One and begins with an open-ended questionnaire that seeks to solicit specific information about a content area from the SME panel (Hsu & Sandford, 2007). The initial questions for this research attempted to offer an opportunity to brainstorm without requiring more than 20 to 25 minutes of response time. This was accomplished by not initially requesting opinions about organizational success factors, but opinions about broader operational advantages that panelists perceived hub-and-spoke CE units operating in southwest Asia (SWA) offered to supported commanders. Panelists were also asked to offer their opinions about which of these advantages could be replicated in other operational environments and which could not. Justifications for their opinions were also requested. Follow-up queries would then offer an opportunity to explore each operational advantage and associated success factors.

The questions were then tested on AFIT student colleagues not involved in the questionnaire's design in an attempt to enhance their clarity and ensure responses would be appropriately focused. Once they were reviewed in this way internally, the questionnaire, researcher credentials, and proposed disclaimer documentation were reviewed by the AFIT Institutional Review Board (IRB). The IRB granted the Phase One

questionnaire an exemption from human experimentation requirements stipulated by 32 CFR 219, DoDD 3216.2, and AFI 40-402, on 19 November 2012. Appendix contains the exemption notice. This study qualified for an exemption since no sensitive data was collected and respondent anonymity was maintained. As outlined in Step Two, the questionnaire was distributed via e-mail to the SME panel members.

Step Three initiates Phase Two. Results of the Phase One questionnaire are analyzed within the context of the research question, associated literature review, and general knowledge of the SME backgrounds. Given the diverse perspectives each of the panel members offered and the small sample size itself, it was determined that all respondents' inputs would receive the same weight during the course of this analysis. The facilitator categorizes the inputs and requests that each panel member rate the degree to which they agree or disagree with the themes suggested by the panel's answers to the Phase One questionnaire. The panelists also review their Phase One responses to ensure their opinions were accurately captured, adjust answers upon review of other panel member responses, and provide additional feedback or qualifiers. In this analysis, they were asked to numerically rate the degree to which they agreed or disagreed with each theme using a five-point Likert-style scale where 5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, and 1 = Strongly Disagree. Precedent exists that proves the Likert scale's ease of producing data to which descriptive statistics may be applied to determine measures of central tendency (Carifio & Perla, 2007; Linstone & Turoff, 2002). Additionally, the scale is a "quick, easy to comprehend, and psychologically comforting" method of eliciting follow-up SME opinion (Linstone & Turoff, 2002). As presented in Step Four, panelists review initial panel responses and refine, retract, or expand their

previous answers based on their perception of the group's responses. Additionally, they typically "rate...items based off the responses to the first questionnaire in order to establish preliminary priorities among items" (Hsu & Sandford, 2007).

Step Five initiates the final phase of the Delphi study with the analysis of the follow-up questionnaire using descriptive statistics. For this study, the researcher determined consensus and stability by statistical analysis of the Likert scale responses. Hsu and Sandford (2007) provided a framework in which to accomplish this analysis by noting "the major statistics used in Delphi studies are measures of central tendency...and level of dispersion...in order to present information concerning the collective judgments of respondents." Inferential statistical techniques could not be used due to the unknown distribution of response values exhibited by such a small sample size and the grounded, inductive nature of the project.

Keeney et al. (2005) confirm that the Delphi body of literature does not present a standardized method for determining consensus. However, guidelines exist to assist in the determination of when consensus has been reached. Typically, the research must use descriptive statistical tools like histograms, mean, median, or mode, and qualitative descriptions of the response data to present outcomes (Kutner, Nachtsheim, Neter, & Wasserman, 1996). A significant body of literature suggests that the median is a favored measure of central tendency in Delphi studies utilizing a Likert Scale to measure degree of agreement (Eckman, 1983; Hill & Fowles, 1975; Hsu & Sandford, 2007). This is primarily due to the median's ability to moderate extreme answers. Depiction of the histogram produced by panel member responses also provides a means of gauging the level of consensus among the panelists. Neither standard deviation nor interquartile range

values were calculated due to the low sample size and subsequent inappropriateness of assuming any normality in response. It was thus determined that only the median scores and response histograms for each theme would be used to indicate degree of consensus.

Step Five concludes with the researcher summarizing the results and offering potential conclusions, thereby facilitating a sense of closure for the panelists and setting an expectation for potential future steps. The literature suggests that attempting to distribute more than three phases of questionnaires may fatigue participants, potentially diminishing both the quality and quantity of results (Sumison, 1998). Though consensus was reached on the majority of themes of primary interest, this research may have benefitted from an additional phase of queries to solidify consensus on items labeled "Special Interest" in Chapter IV. However, time constraints of both the research itself and panel members' personal schedules also made this temporally untenable.

Methodology Summary

This chapter provided the theoretical basis for gathering and analyzing the qualitative data required to explore the use of the hub-and-spoke organizational concept in SWA and its potential application to future contingencies. It discussed the appropriateness of Delphi Technique to solicit salient SME opinion on the nuances of how hub-and-spoke-organized units were designed and operated in OEF and OIF. Analysis and results of this methodology's effectiveness at meeting research objectives are summarized in Chapter Four.

IV. Analysis and Results

This chapter summarizes the data obtained by applying the methodology previously outlined and analyzing these data accordingly. Four primary areas are presented: how the Delphi technique was applied, the associated qualitative results of the Phase One questionnaire, the development of the Phase Two questionnaire, and statistical results of the follow-up questionnaire. Table 2 summarizes participation levels in each phase. It demonstrates that one of the limitations of this study is that it experienced both informed and latent attrition. Two of the invited participants from Phase One did not make themselves available for the follow-up questionnaire, reducing the total invited count by two. One of the panel members who had participated in Phase One simply became task saturated in the course of Phase Two and was unable to continue participation in the study.

Table 2. Summary of Participation

Phase	# Invited to Participate	# Participated	Participation Rate (%)
1	11	7	64%
2	9	6	67%
		Overall Participation:	65.5%

Delphi Study Application

Step One

The research questions were developed in consultation with the faculty research committee with the intent of providing an opportunity to present opinions about the operational advantages CE hub-and-spoke units provided in SWA. They further solicited

panel member opinion about how which of these advantages may be applicable in other AORs and which of them may not. While summarized here,

Appendix presents the full questionnaire:

1) What operational advantages do you perceive hub-and-spoke-organized expeditionary CE units offered for meeting theater-level objectives effectively in SWA?
2) For the advantages you would identify as potentially relevant/applicable to supporting the CFACC in another AOR, why would they be relevant?
3) For the advantages you would identify as NOT as potentially relevant/applicable to supporting the CFACC in another AOR, why would they not be relevant?

Upon confirmation from a panel of AFIT colleagues that it appeared appropriately clear, concise, and effective in soliciting initial panel responses, the initial questionnaire was distributed by e-mail to the SME panel.

Step Two

Ten duty days were allotted for the Phase One questionnaire to be completed by the panel. Of the questionnaires distributed, seven of eleven were ultimately returned, resulting in an 64% response rate. While this return rate was significantly less than anticipated, the sample of responsive panel members still represented a high percentage of the expected population. The low turnout did not change the underlying assumption that only descriptive statistical techniques could be used to present measures of central tendency and consensus. Furthermore, the literature review and pilot discussions with senior leaders possessing a depth of knowledge with CE hub-and-spoke organizations but who were not participating in the study acted as an informal validation data set for SME panel member responses. If questionnaire response data deviated significantly from the initial data gathered from literature and the others, the low response rate would have been

further addressed and an alternate course of research action pursued. Thus, the decision was made to proceed as initially planned.

Step Three

The content of the questionnaire responses was analyzed, major themes summarized, and the results incorporated into a follow-up Delphi questionnaire. The response data suggested that hub-and-spoke-organized CE units can offer three primary operational advantages to supported commanders compared to exclusively traditional organizational alignments. These advantages appeared to be most closely related to providing the supported combatant commander an improved ability to leverage general and geospatial engineering capability within the context of the core doctrinal tenets of unity of command, flexibility, versatility, and mass effects outlined in AFDD 3-34, *Engineer Operations*. These suggested advantages included enhancements in the following.

1. *Command and control effectiveness*, defined as effectively ensuring the right personnel are doing the right mission tasks fulfilling the requirements that most-impact the supported operational mission.
2. *Responsiveness to supported commander*, defined as providing a means of having appropriate flexibility to shift mass effects of CE capability as required to meet mission requirements and ensuring those effects are massed on the requirements that will have the greatest effect on the mission.
3. *Combat readiness of assigned personnel*, defined as personnel being appropriately trained and equipped to prosecute assigned duties/tasks effectively.

The SME responses also suggested various factors, the absence of which would likely have had a particularly negative effect on the delivery of the suggested operational advantages. Table 3, Table 4, and Table 5 present the three operational advantages suggested by the responses to Question One and associated potential factors for success. The total frequency of responses

supporting each suggested advantage is the sum of individual success factor themes associated with each suggested advantage.

Table 3. Potential Operational Advantage 1 and Supporting Responses

Advantage	Frequency
Enhanced command and control effectiveness	36
Factors for Success	
Ability to 'cross-level' personnel resources within group ensured appropriate concentration of mass at the most opportune locations	6
Ability to *cross-level* and tailor manpower, equipment, and material mixes to each specific requirement/task	6
Clearly communicated and utilized TACON, OPCON, and ADCON relationships	5
Adhere to centralized control/decentralized execution concept by establishing/preserving vital tactical-level relationships while ensuring tactical capability is surged in the most effective way to support theater-level operational objectives	4
Ensure local installation personnel footprint remains lean, facilitating effective boots-on-ground (BOG) numbers management - local unit sheds requirement to have a large or frequently expanding/contracting permanent party manpower numbers to support	3
Request-for-forces (RFF) personnel are not attached to the original requesting unit regardless of whether the need remains for them - reduces the need to augment local ECES organization directly with RFF or TDY forces	2
Blue-on-Blue ADCON ensures Airman are taken care of in a way that will best facilitate future career development	2
Maintain lean manpower and process overhead by centralizing core engineering functions (ie, planning, programming, design) - eliminates redundancy and facilitates more shovel-and-pick operations	2
Retain ability to communicate about and maintain accountability for RFF'd capabilities - ensures ability to rapidly vet emerging requirements that may require a supported unit to submit a RFF by determining if need can be met by simply standing up a spoke'd team to address the requirement	2
Centralize project tasking and command authority	1
Ensure support/supported force relationships are delineated (especially to Joint partners) - provides a clear organizational context in which to work	1
Increased flexibility in personnel waivers due to deeper 'bench' when hub-and-spoke unit is group-sized	1
Ability to communicate observations, innovations, and lessons learned across in-theater functional community through the use of various update tools - one O-6 commander improves the chances that lessons learned and other 'news' is synthesized and disseminated as appropriate	1

Table 4. Potential Operational Advantage 2 and Supporting Responses

Advantage	Frequency
Improved responsiveness to supported commander	28
Factor for Success	
Effective project prioritization through an 'asset management' approach to theater infrastructure requirements	5
Efficient materials handling and personnel movement logistics	4
Theater-wide visibility of requirements and ability to press the supported commander for his/her priorities - ensures the right capability is being applied in the right way at the right time (or as close to it as possible)	4
Theater-wide visibility of requirements and ability to press the supported commander for his/her priorities - ensures the right capability is being applied in the right way at the right time (or as close to it as possible)	3
Smooth interoperability with other higher echelons of agile combat support (ACS) functionals (ie, Contracting, Comm, Logistics, Finance, etc) - being a theater level asset, rather than a local CE squadron, enhances this potential	3
Contracting, finance, and supply personnel organic to the unit - provides another option for procurement of Class IV and others, potentially shortening lead times when local contracting and civil augmentation program (CAP) contracts are overwhelmed or are otherwise experiencing diminished effectiveness	3
Standardized/templated design/planning products and tactics, techniques and procedures (TTPs) for various core tasks - reduces delivery time, improves quality, and boosts safety	1
Provide ability to stand up and stand down a capability quickly - reduces requirement for local unit to have to vet a need through RFF process	1
Hub-managed material yards - provides potentially more expedient construction/repair material requirements and movement procurement option, reducing the need for local installations to work these issues	1
Theater-level visibility of requirements ensures theater-level prioritization of support as needed to fulfill strategic/operational objectives	1
Reduce wing (or Joint equivalent) level frivolous contention over infrastructure requirements and ownership of engineer capability	1
Optimized organizational proximity to CFACC air mobility division (AMD) - helps prioritize transportation	1

Table 5. Potential Operational Advantage 3 and Supporting Responses

Advantage	Frequency
Enhanced combat readiness	6
Factor for Success	
Train with those with whom personnel will 'fight'	2
Standardized pre-deployment training and equipping - a unified streamlined feedback voice, particularly in Joint training environments, helps focus training and equipping efforts on most relevant needs	2
Elements of self-sustainment - hub-and-spoke units do not have to rely solely on resources procured locally or from supported unit for work, movement, or force sustainment requirements	1
Some units had physician and religious support team (RST) support - provided timely personnel support as needed and ensured focus on mission	1

Content analysis of the responses to Questions Two and Three suggested that there may be general agreement that most of the operational advantages offered by SWA hub-and-spoke organized CE units may be replicated in other AORs. However, the responses suggested a number of caveats, conditions, and constraints that senior leaders and planning staffs should consider when making future CE hub-and-spoke force planning and organizational recommendations. Table 6 presents the number of responses that suggested that all or most of the operational advantages may be relevant in another AOR, along with the caveats, conditions and constraints offered simultaneously.

Table 6. Response Summary to Initial Questionnaire, Questions 2 and 3

Category	Frequency
All operational advantages previously suggested are potentially relevant to hub-and-spoke-organized CE units supporting the CFACC in another AOR	6
Caveats/Conditions/Constraints	13 (total)
There is limited evidence for a proof of concept for using hub-and-spoke-organized CE units in Phase 1/2 combat operations where active beddowns are on-going and infrastructure and materials procurement lines are not robust	2
The challenge of inter/intra-theater movement (air, ground, or sea-borne) must be addressed by planners determining required manning levels and associated equipment and materials requirements	2
It is critical that consideration be given to siting resources so that extreme distances or "islanding" of resources that could provide a means of self-sustainment, if co-located, is avoided	2
Consideration must be made for how the possibility of future coalition collaboration situations may affect hub-and-spoke manpower levels, disposition, and training requirements - prime power and other support equipment could introduce redundancies; falling in on foreign electrical infrastructure may impose serious operational constraints	1
Must have a pool of 'good' troop labor projects, especially when they are standing by to execute more appropriate emergency/surge tasks	1
Planners must be aware that the advantage of being able to flex personnel from one squadron to another can be tempered when some squadrons are TACON to another HHQ within the JTF	1
Planners must be aware that the advantage of being able to flex personnel from one squadron to another can be tempered when some squadrons are TACON to another HHQ within the JTF	1
Allowance must be given for loss in procurement effectiveness if policy dictates all procurement be accomplished centrally -consideration must be given to materials/equipment that can be more effectively/efficiently procured locally	1
Planners should fully consider for boots-on-ground (BOG) constraints as these may mitigate some of the potential operational advantages that hub-and-spoke organized units may offer	1
Air Force corporate culture challenge of local WG/CCs' expectation of owning their own robust CE capability (ie, "one base, one boss") must be addressed and the impact of no organic physician and/or RST support within a hub-and-spoke-organized CE group must be fully considered	1

Some respondents also offered additional comments related to potential future innovations of expeditionary CE hub-and-spoke organized units. The implication suggested was that CE decision-makers and planning staff personnel should consider

these additional recommendations when organizing future CE hub-and-spoke units. Table 7 summarizes these response data.

Table 7. Suggested Future Planning Considerations

Category	Frequency
Hub-and-spoke-organized CE units should be considered for support to contingency exercises and exercise-related construction requirements	1
When hub-and-spoke unit is leveraging both Prime BEEF and RED HORSE capabilities, it would be best to ensure the group commander (usually an O-6) has had operational RH experience prior to assuming command of the group	1

To provide formal feedback to the facilitator, participants were asked to review this summary and rate their level of agreement on the five-point Likert scale discussed in Chapter Three. The scale was as follows: 5=Strongly Agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly Disagree. Included at Appendix is the follow-up questionnaire distributed to the SME panel upon review and pretest by AFIT colleagues and the research committee.

Step Four

Thirteen working days were allotted for the Phase Two questionnaire to be completed by the panel. Two of the invited first round panelists were unresponsive so they did not receive the follow-up questionnaire. Thus nine follow-up questionnaires were distributed, six of which were returned, resulting in a 67% response rate. Despite the low response rate, similar rationale to that which was applied in Step Two's decision to continue the study applied in Step Four.

Step Five

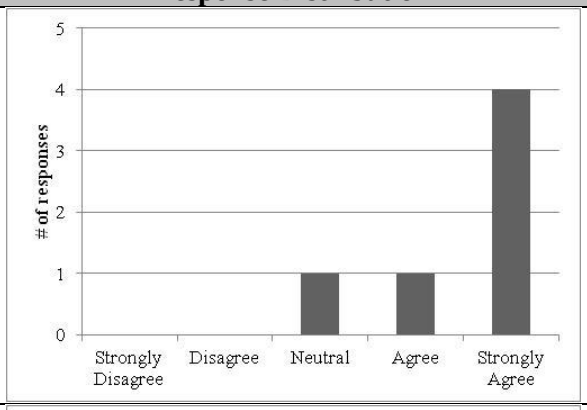
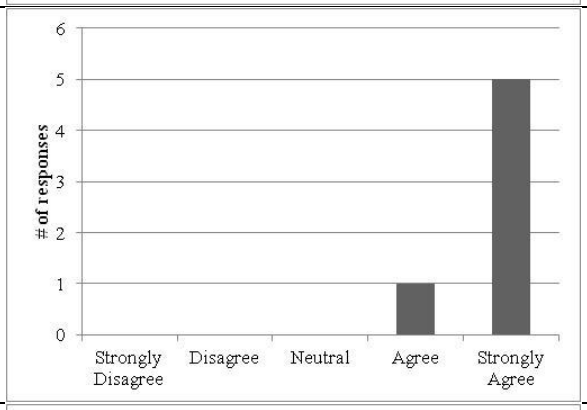
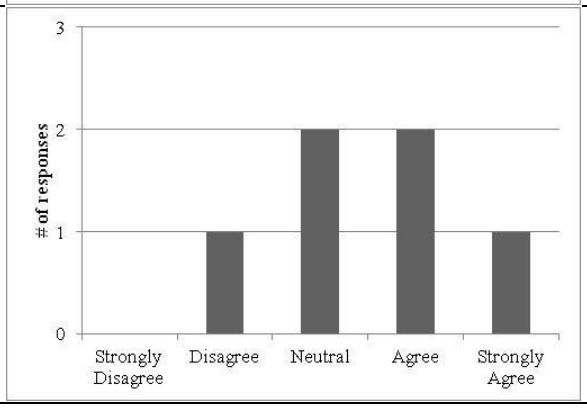
Using the framework outlined in Chapter III, content and statistical analyses were conducted on the Phase Two follow-up questionnaire responses. Statistical measures of

central tendency were calculated in Microsoft Excel using the median scores and histogram representation of each responses to each suggested theme. Table 8 -

Table 13 summarize these findings, with themes listed in the order in which responses were requested. Included at the top of each table are the original directions to respondents.

Table 8. Follow-up Questionnaire, Question One Response Data

Questionnaire Directions: Please review and rate your agreement with the following operational advantages that respondents perceived hub-and-spoke-organized expeditionary CE units offered for meeting theater-level objectives effectively in SWA.

Question and Statistical Information	Response Distribution
Enhanced command and control effectiveness • Number of respondents: 6 • Median: 5 • Overall group sense: Agree	
Improved responsiveness to supported commander • Number of respondents: 6 • Median: 5 • Overall group sense: Strongly Agree	
Enhanced combat readiness of assigned personnel • Number of respondents: 6 • Median: 3.5 • Overall group sense: Generally agree	

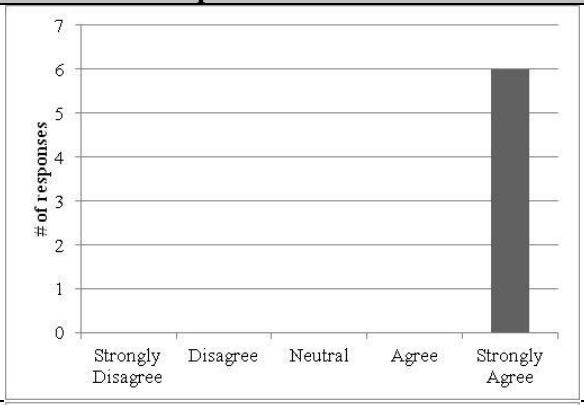
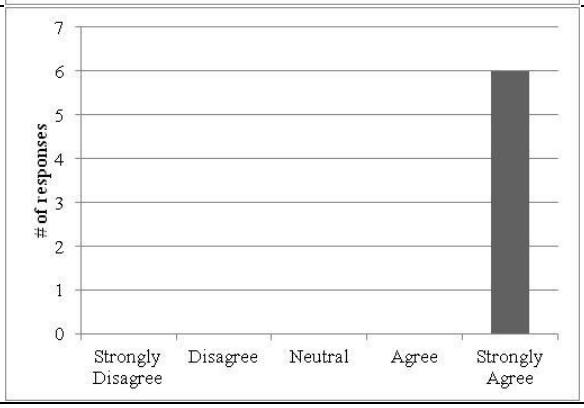
Question Two featured three sub-parts. The questionnaire noted that for each operational advantage suggested by responses to Question One, panel member responses indicated the potential for numerous success factors required for the existence of the

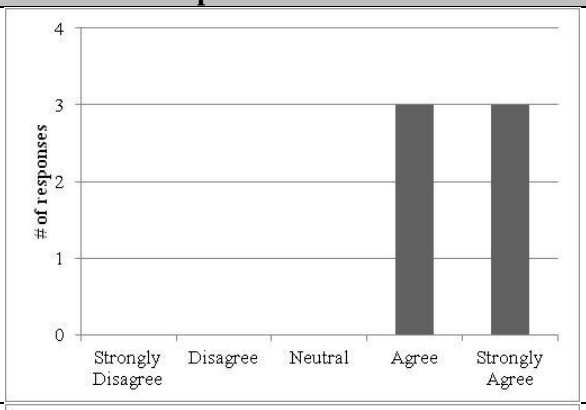
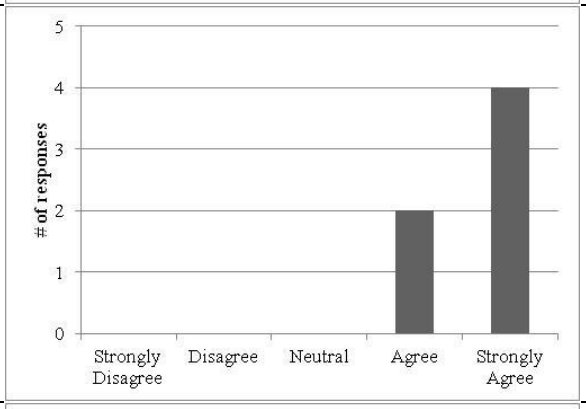
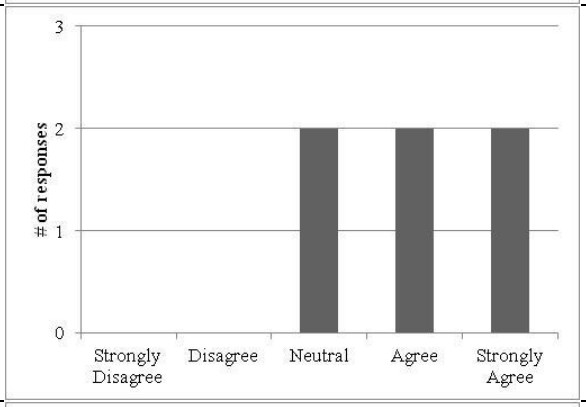
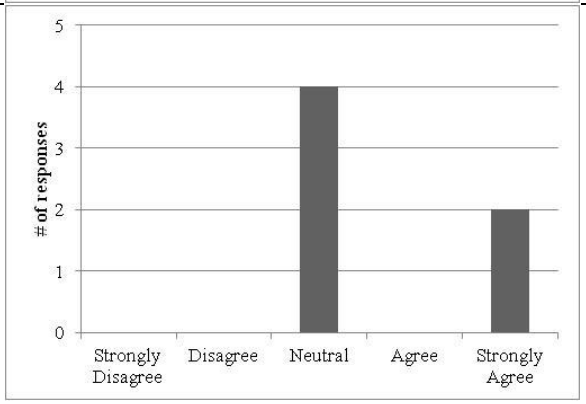
suggested operational advantages. They were then asked to review and rate the degree to which they agreed that the each factor contributed the successful deliver of each operational advantage. Table 9, Table 10, Table 11, Table 12, and

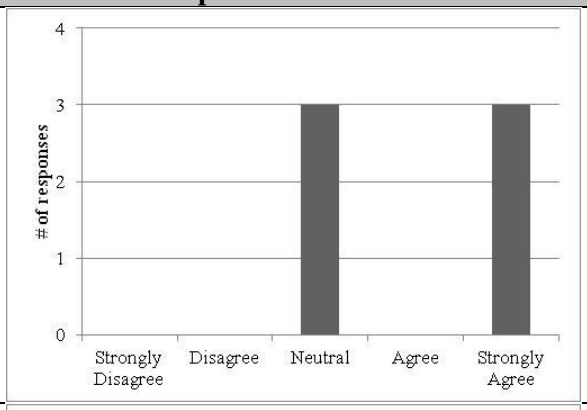
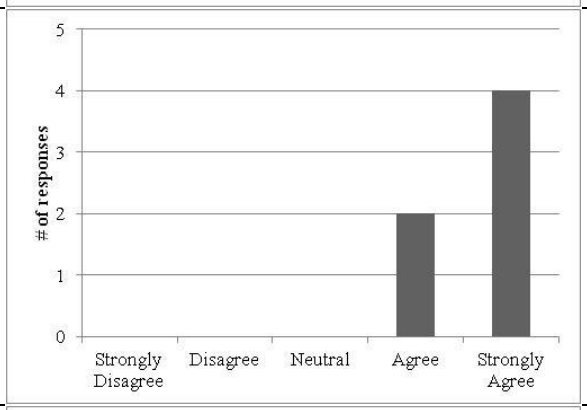
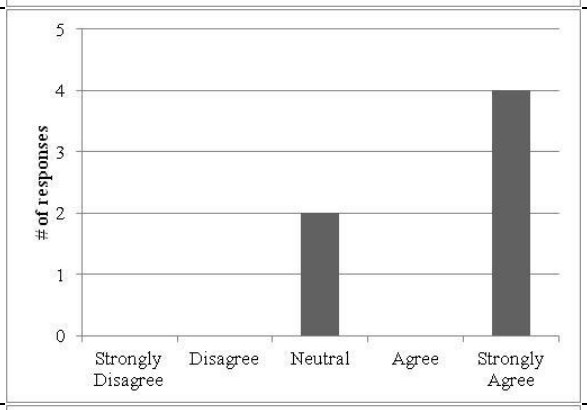
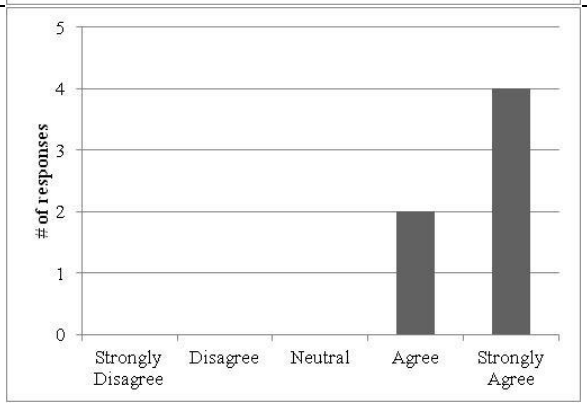
Table 13 summarize the resulting responses.

Table 9. Follow-up Questionnaire, Question 2a Response Data

Associated operational advantage: *Enhanced command and control effectiveness*, defined as effectively ensuring the right personnel are doing the right mission tasks fulfilling the requirements that most-impact the supported operational mission

Question and Statistical Information	Response Distribution
Empowerment to freely re-appropriate (or cross-level) CE resources within the group to ensure appropriate concentration of mass at the most opportune locations • Number of respondents: 6 • Median: 5 • Overall group sense: Strongly Agree	
Ability to cross-level and tailor manpower, equipment, and material mixes to each specific requirement/task • Number of respondents: 6 • Median: 5 • Overall group sense: Strongly Agree	

Question and Statistical Information	Response Distribution
Clearly communicated and utilized TACON, OPCON, and ADCON relationships • Number of respondents: 6 • Median: 4.5 • Overall group sense: Agree	
Adhere to centralized control-decentralized execution concept by establishing/preserving vital tactical-level relationships while ensuring tactical capability is surged most effectively to support theater operational objectives • Number of respondents: 6 • Median: 5 • Overall group sense: Agree	
Ensure local installation personnel footprint remains lean, facilitating effective boots-on-ground (BOG) numbers management - local unit sheds requirement to have frequently permanent party manpower to support • Number of respondents: 6 • Median: 4 • Overall group sense: Agree	
Request-for-forces (RFF) personnel are not attached to the original requesting unit regardless of whether the need remains for them - reduces the need to augment local ECES organization directly with RFF or TDY forces • Number of respondents: 6 • Median: 3 • Overall group sense: Inconclusive	

Question and Statistical Information	Response Distribution
Blue-on-Blue ADCON ensures Airman are taken care of in a way that will best facilitate future career development • Number of respondents: 6 • Median: 4 • Overall group sense: Bimodal/Agree	
Maintain lean manpower and process overhead by centralizing core engineering functions - eliminates redundancy and facilitates more shovel-and-pick operations • Number of respondents: 6 • Median: 5 • Overall group sense: Agree	
Retain ability to communicate about and maintain accountability for RFF'd capabilities - ensures ability to vet requirements that may require a supported unit to submit a RFF vs simply standing up a spoke'd team to address the requirement • Number of respondents: 6 • Median: 5 • Overall group sense: Agree	
Centralize project tasking and command authority • Number of respondents: 6 • Median: 5 • Overall group sense: Agree	

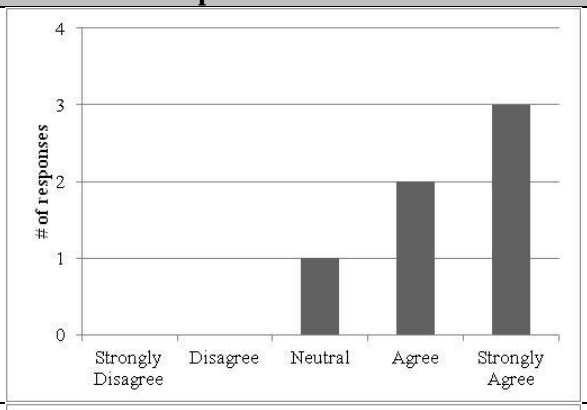
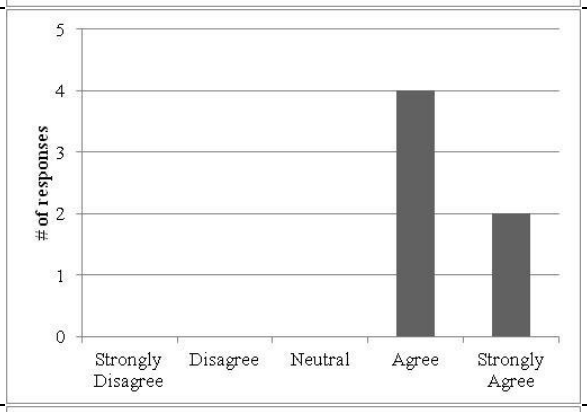
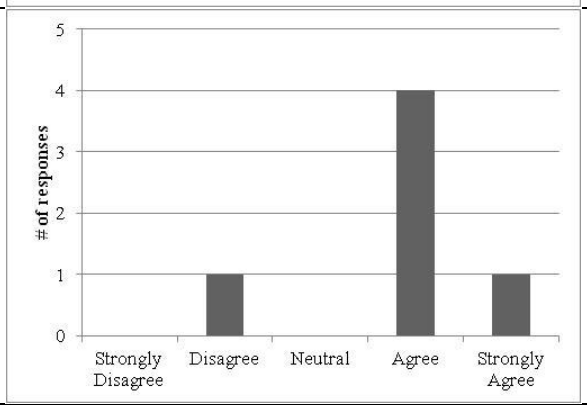
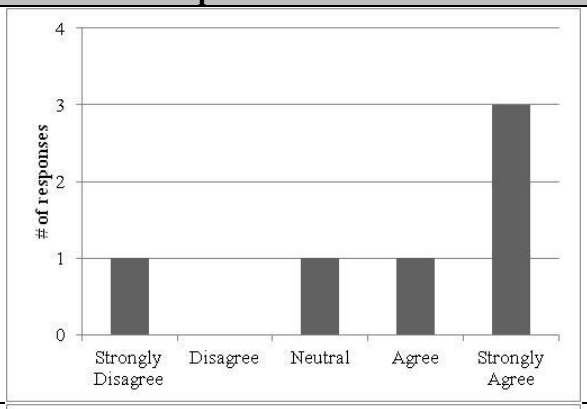
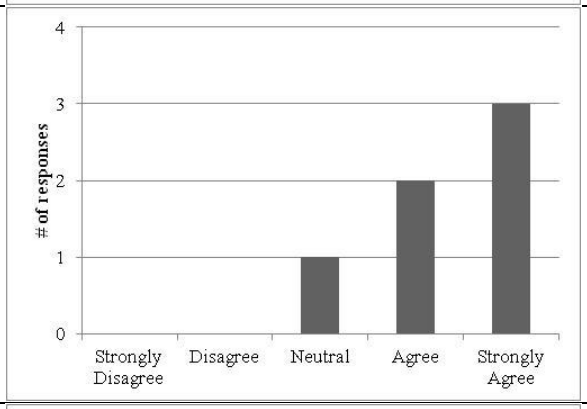
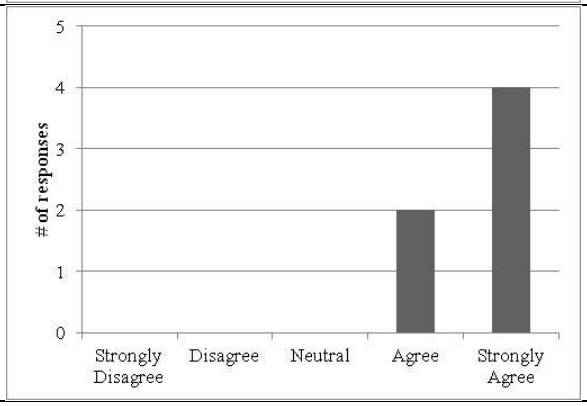
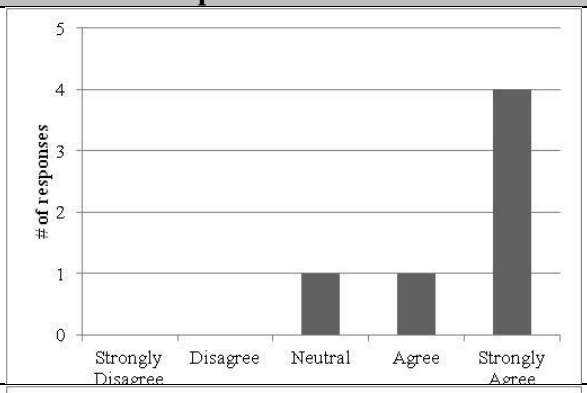
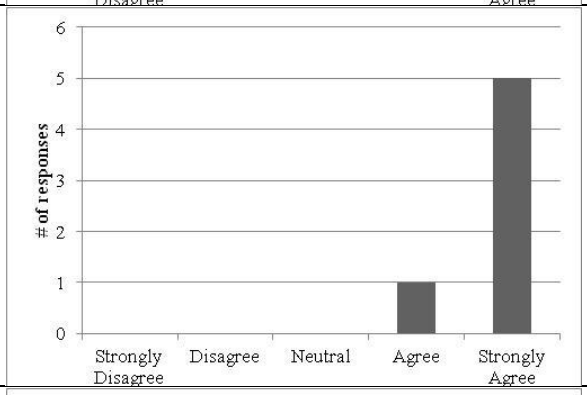
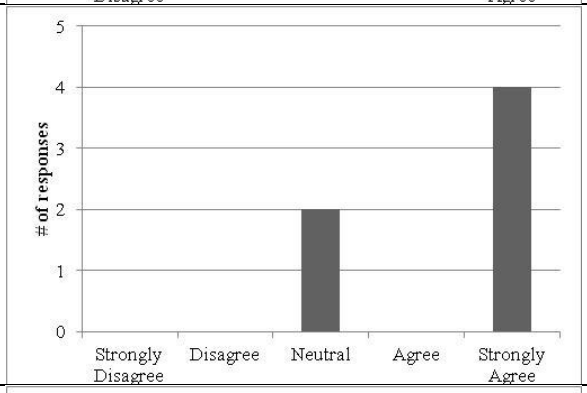
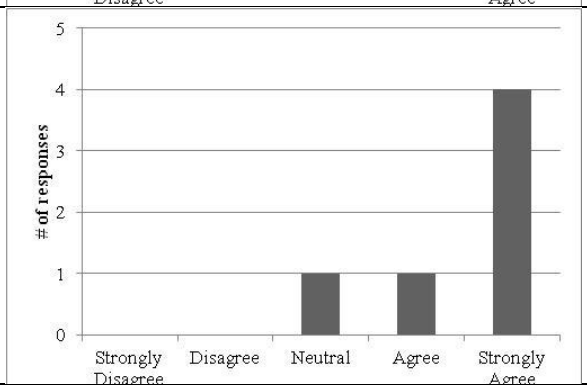
Question and Statistical Information	Response Distribution
Ensure support/supported force relationships are delineated (especially to Joint partners) - provides a clear organizational context in which to work • Number of respondents: 6 • Median: 4.5 • Overall group sense: Agree	
Increased flexibility in personnel waivers due to deeper 'bench' when hub-and-spoke unit is group-sized • Number of respondents: 6 • Median: 4 • Overall group sense: Agree	
Ability to communicate observations, innovations, and lessons learned across in-theater functional community through the use of various update tools - one O-6 commander improves the chances that lessons learned and other 'news' is synthesized and disseminated as appropriate • Number of respondents: 6 • Median: 4 • Overall group sense: Agree	

Table 10. Follow-up Questionnaire, Question 2b Response Data

Associated operational advantage: *Improved responsiveness to supported commander*, defined as providing a means of having appropriate flexibility to shift mass effects of CE capability as required to meet mission requirements and ensuring those effects are massed on the requirements that will have the greatest effect on the mission.

Question and Statistical Information	Response Distribution
Effective project prioritization through an 'asset management' approach to theater infrastructure requirements • Number of respondents: 6 • Median: 4.5 • Overall group sense: Agree	
Efficient materials handling and personnel movement logistics • Number of respondents: 6 • Median: 4.5 • Overall group sense: Agree	
Theater-wide visibility of requirements and ability to press the supported commander for his/her priorities - ensures the right capability is being applied in the right way at the right time (or as close to it as possible) • Number of respondents: 6 • Median: 5 • Overall group sense: Agree	

Question and Statistical Information	Response Distribution
Effectively address scope creep - when a spoke'd team comes in to address an infrastructure requirement, it is apparent they are not a permanent presence that can be tasked with additional work without appropriate vetting • Number of respondents: 6 • Median: 5 • Overall group sense: Agree	
Smooth interoperability with other higher echelons of agile combat support (ACS) functionals (ie, Contracting, Comm, Logistics, Finance, etc) - being a theater level asset, rather than a local CE squadron, enhances this potential • Number of respondents: 6 • Median: 5 • Overall group sense: Agree	
Contracting, finance, and supply personnel organic to the unit - provides another option for procurement of Class IV, potentially shortening lead times when local contracting and CAP) are experiencing diminished effectiveness • Number of respondents: 6 • Median: 5 • Overall group sense: Agree	
Standardized/templated design/planning products and tactics, techniques and procedures (TTPs) for various core tasks - reduces delivery time, improves quality, and boosts safety effectiveness • Number of respondents: 6 • Median: 5 • Overall group sense: Agree	

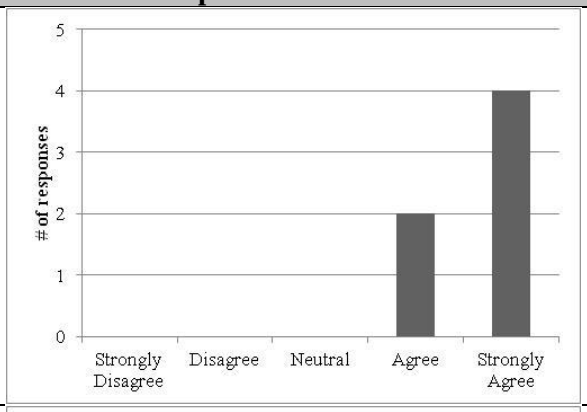
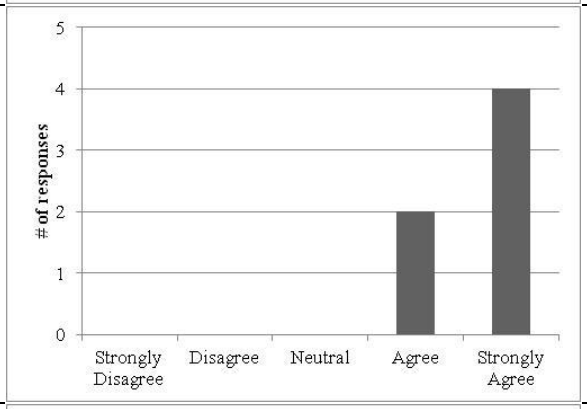
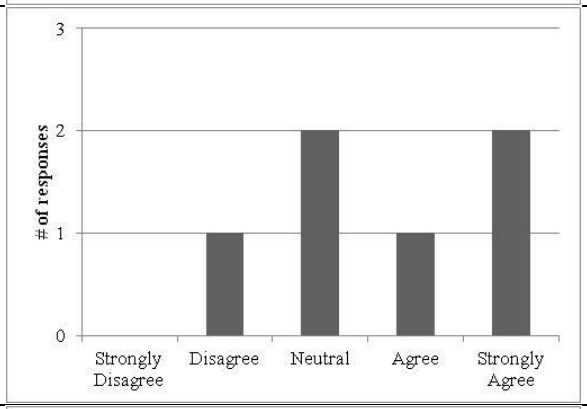
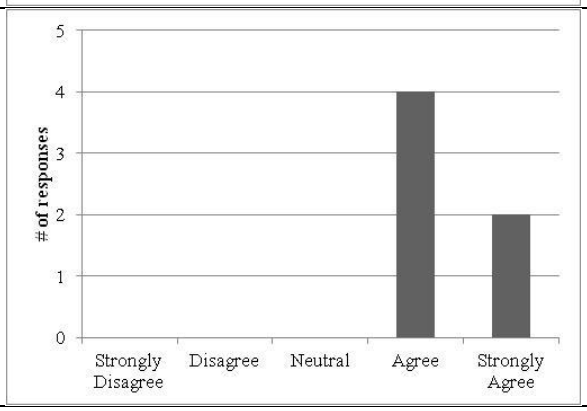
Question and Statistical Information	Response Distribution
Provide ability to stand up and stand down a capability quickly - reduces requirement for local unit to have to vet a need through RFF process • Number of respondents: 6 • Median: 5 • Overall group sense: Agree	
Hub-managed material yards - provides potentially more expedient construction/repair material requirements and movement procurement option, reducing the need for local installations to work these issues • Number of respondents: 6 • Median: 5 • Overall group sense: Agree	
Reduce wing (or Joint equivalent) level frivolous contention over infrastructure requirements and ownership of engineer capability • Number of respondents: 6 • Median: 3.5 • Overall group sense: Inconclusive	
Optimized organizational proximity to CFACC air mobility division (AMD) - helps prioritize transportation • Number of respondents: 6 • Median: 4 • Overall group sense: Agree	

Table 11. Follow-up Questionnaire, Question 2c Response Data

Associated operational advantage: *Enhanced combat readiness of assigned personnel*, defined as personnel being appropriately trained and equipped to prosecute assigned duties/tasks effectively

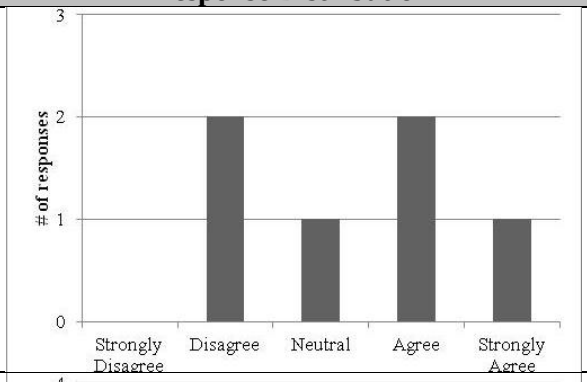
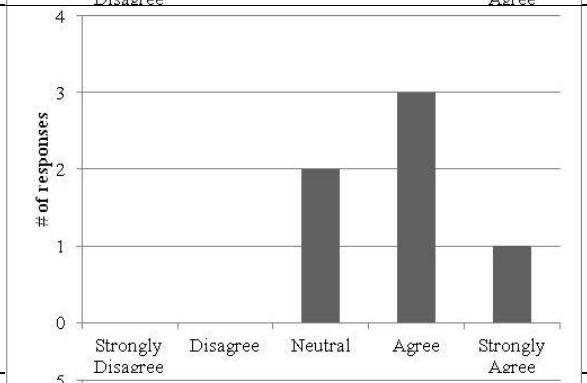
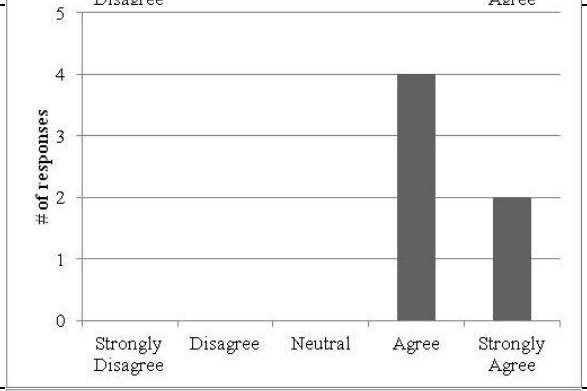
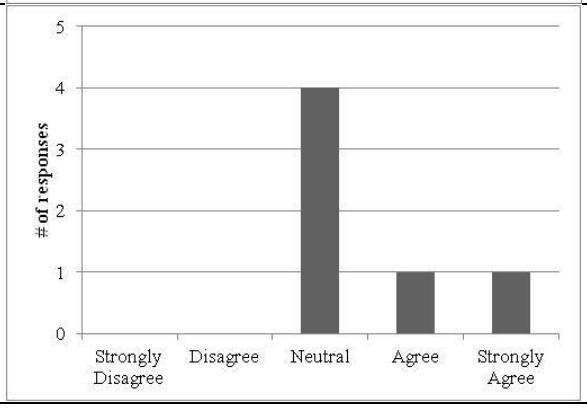
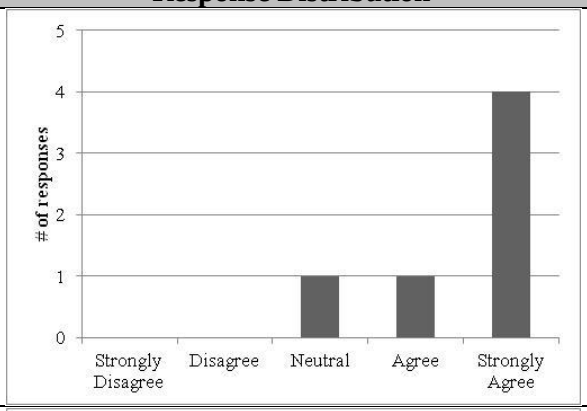
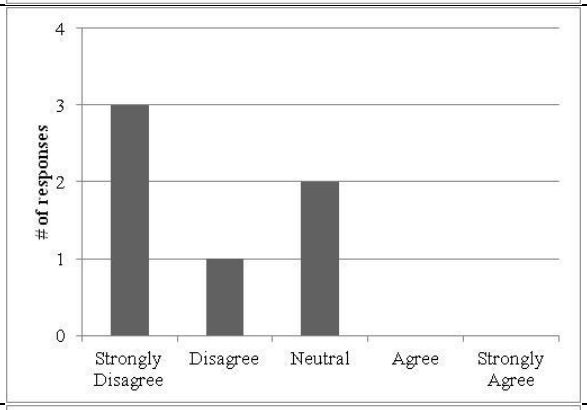
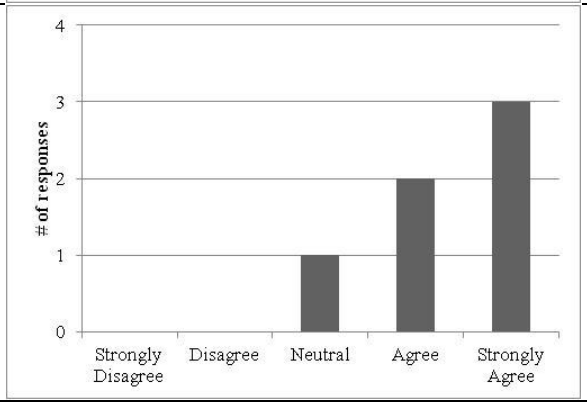
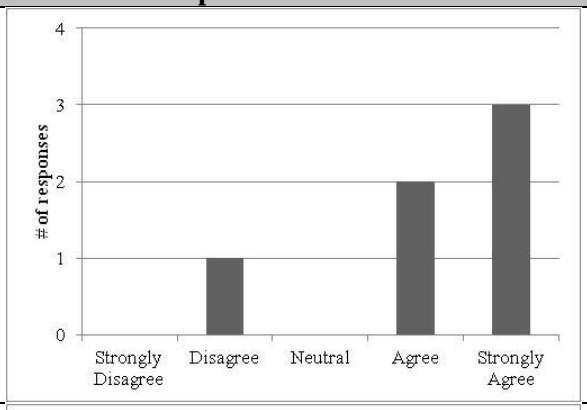
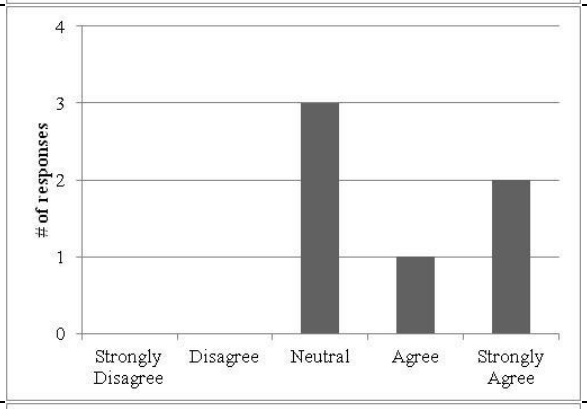
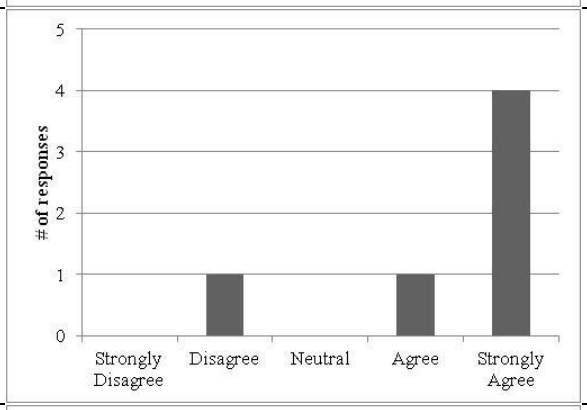
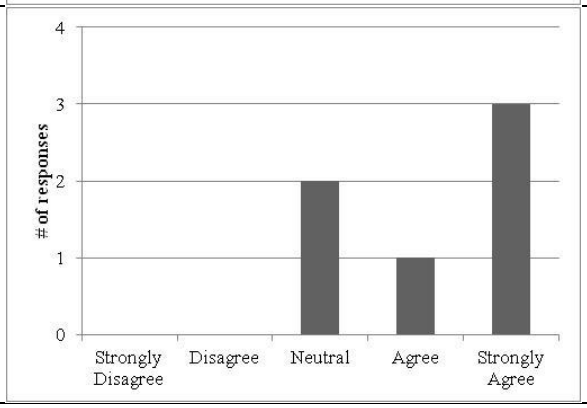
Question and Statistical Information	Response Distribution
Train with those with whom personnel will 'fight' • Number of respondents: 6 • Median: 3.5 • Overall group sense: Inconclusive	
Standardized pre-deployment training and equipping - a unified streamlined feedback voice, particularly in Joint training environments, helps focus training and equipping efforts on most relevant needs • Number of respondents: 6 • Median: 4 • Overall group sense: Agree	
Elements of self-sustainment - hub-and-spoke units do not have to rely solely on resources procured locally or from supported unit for work, movement, or force sustainment requirements • Number of respondents: 6 • Median: 4 • Overall group sense: Agree	
Some units had physician and religious support team (RST) support - provided timely personnel support as needed and ensured focus on mission • Number of respondents: 6 • Median: 3 • Overall group sense: Neutral	

Table 12. Follow-up Questionnaire, Question 3 Response Data

Questionnaire directions: Responses to Questionnaire #1, Questions 2 and 3 regarding applicability of the hub-and-spoke organizational concept in another AOR suggested the following themes. Please review and rate your agreement with the following statement about operational advantages and subsequent caveats, conditions, and/or constraints that respondents suggested may influence CE hub-and-spoke force planning and employment decisions.

Question and Statistical Information	Response Distribution
All operational advantages previously suggested are potentially relevant to hub-and-spoke-organized CE units supporting the CFACC in another AOR • Number of respondents: 6 • Median: 5 • Overall group sense: Agree	
There is limited evidence for a proof of concept for using hub-and-spoke-organized CE units in Phase 1/2 combat operations where active beddowns are on-going and infrastructure and materials procurement lines are not robust • Number of respondents: 6 • Median: 1.5 • Overall group sense: Disagree	
The challenge of inter/intra-theater movement (air, ground, or sea-borne) must be addressed by planners determining required manning levels and associated equipment and materials requirements • Number of respondents: 6 • Median: 4.5 • Overall group sense: Agree	

Question and Statistical Information	Response Distribution
It is critical that consideration be given to siting resources so that extreme distances or "islanding" of resources that could provide a means of self-sustainment, if co-located, is avoided • Number of respondents: 6 • Median: 4.5 • Overall group sense: Agree	
Consideration must be made for how the possibility of future coalition situations may affect H/S manpower, disposition, and training requirements - support equipment could introduce redundancies or falling in on foreign infrastructure may impose serious operational constraints • Number of respondents: 6 • Median: 3.5 • Overall group sense: Generally agree	
Must have a pool of 'good' troop labor projects, especially when they are standing by to execute more appropriate emergency/surge tasks • Number of respondents: 6 • Median: 5 • Overall group sense: Agree	
Planners must be aware that the advantage of being able to flex personnel from one squadron to another can be tempered when some squadrons are TACON to another HHQ within the JTF • Number of respondents: 6 • Median: 4.5 • Overall group sense: Agree	

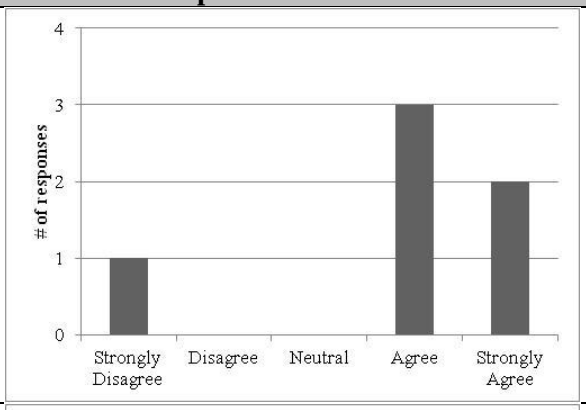
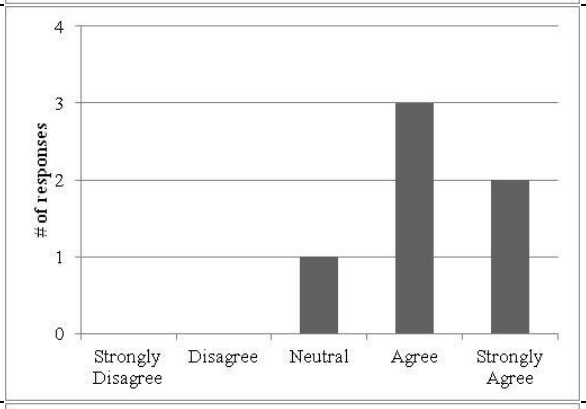
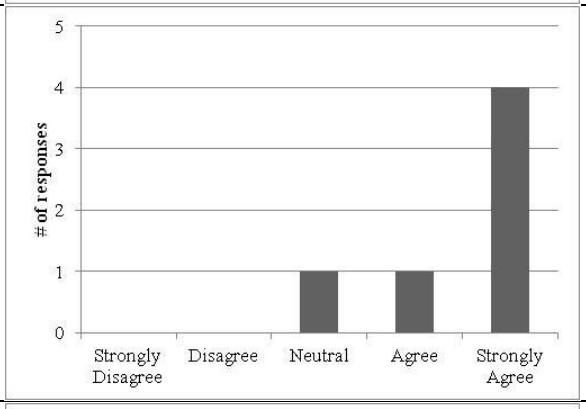
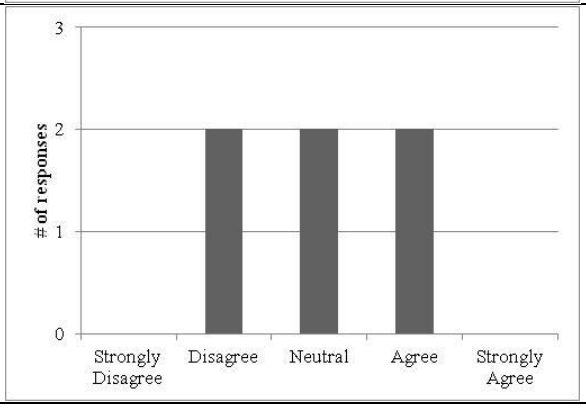
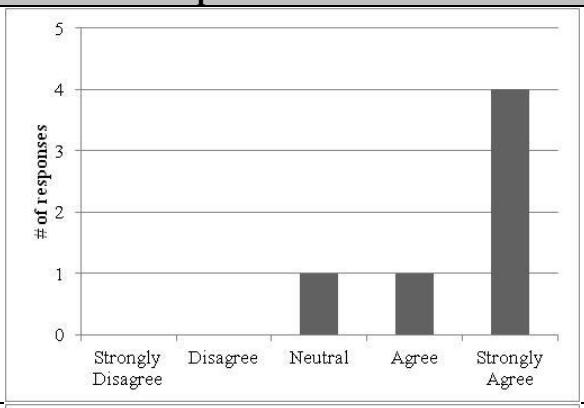
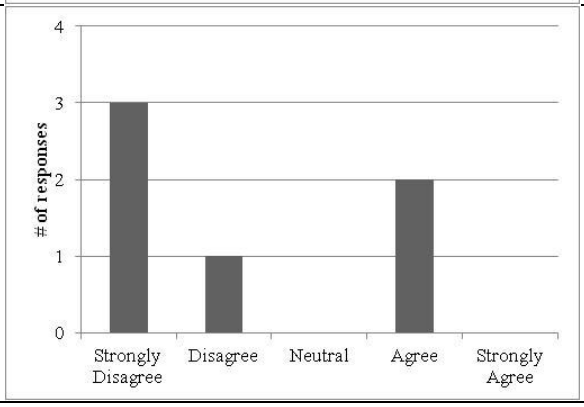
Question and Statistical Information	Response Distribution
Allowance must be given for loss in procurement effectiveness if policy dictates all procurement be accomplished centrally - consideration must be given to materials/equipment that can be more effectively/efficiently procured locally • Number of respondents: 6 • Median: 4 • Overall group sense: Agree	
Planners should fully consider for boots-on-ground (BOG) constraints as these may mitigate some of the potential operational advantages that hub-and-spoke organized units may offer • Number of respondents: 6 • Median: 4 • Overall group sense: Agree	
Air Force corporate culture challenge of local WG/CCs' expectation of owning their own robust CE capability (ie, "one base, one boss") must be addressed • Number of respondents: 6 • Median: 5 • Overall group sense: Agree	
The impact of no organic physician and/or RST support within a hub-and-spoke-organized CE group must be more fully considered • Number of respondents: 6 • Median: 3 • Overall group sense: Inconclusive	

Table 13. Follow-up Questionnaire, Question 4 Response Data

Questionnaire directions: The following are additional responses categorized as potential considerations for planning future expeditionary CE hub-and-spoke organized units. Please review and rate your agreement with these statements.

Question and Statistical Information	Response Distribution
Hub-and-spoke-organized CE units should be considered for support to contingency exercises and exercise-related construction requirements • Number of respondents: 6 • Median: 5 • Overall group sense: Agree	
When hub-and-spoke unit is leveraging both Prime BEEF and RED HORSE capabilities, it would be best to ensure the group commander (usually an O-6) has had operational RH experience prior to assuming command of the group • Number of respondents: 6 • Median: 1.5 • Overall group sense: Bimodal/Disagree	

Chapter Summary

This chapter presented the results of the application of the Delphi technique to the problem of determining success factors that influence successful delivery of operational advantages offered by hub-and-spoke organized expeditionary CE units. The statistical analysis provided a means to measure the degree to which the SME panel agreed or disagreed with each theme suggested by responses to the initial questionnaire. SME panel member responses suggested three operational advantages and associated critical success factors, some of which may require further research to develop operational tools to boost

the probability that they may be replicated in the future. However, based on review of the discussed measures of central tendency and visual inspection of the response histogram, consensus could not be claimed or the panel suggested general disagreement on ten themes. These themes and implications of the group's sentiment about them are discussed further in Chapter V.

V. Conclusions and Recommendations

Air Force expeditionary civil engineer (CE) support to contingency operations in southwest Asia (SWA) created a unique organizational learning environment related to how CE forces can better organize to support geographically separated units in a manpower-constrained environment and more effectively command and control those organizations and their capabilities in support of future contingency operations. This research acquired insights and recommendations into a formative theory on hub-and-spoke force planning of expeditionary engineers. It did so by utilizing grounded theory methods to determine factors required for SWA CE hub-and-spoke units' success and caveats, conditions, or constraints force planners may take into account when considering the concept's application to future contingencies. CE manpower planners will benefit from future research attempting to operationalize the success factors determined by this research by further exploring their roots and developing new planning tools to support decision-makers. To aid this effort, reviewed in this chapter are the themes upon which the panel agreed most strongly, caveats to the research in the form of a limitations discussion and special interest theme presentation, and potential future research topics.

High Consensus Themes

Twenty themes emerged upon which the group displayed a high degree of consensus and agreement as demonstrated by the associated median value of the Likert responses and visual inspection of the histograms. These factors represent the essence of what made it possible for expeditionary CE hub-and-spoke units in SWA to enhance general engineering functional command and control, increase CE capability

responsiveness to supported commanders, and ensure the continued combat readiness of assigned manpower. In their absence, mission capability would likely have been severely degraded. Manpower planners may be well-served if they account for these factors when considering future hub-and-spoke CONOPs and associated manpower planning tools. Table 14 provides a tabular summary of these themes in rank order of the degree to which the expert panel appeared to agree with each theme and relative response dispersion demonstrated by the response histogram. Accounts from literature, informal pilot discussions with non-participant stakeholders, and qualitative comments included on each questionnaire compelled inclusion of some themes in this list that did not necessarily achieve the highest possible Likert rating median score among participants. An expanded discussion follows the table.

Table 14. High Consensus Success Factor Summary

Median	Success Factor
5	Empowerment to freely re-appropriate (or cross-level) CE resources within the group to ensure appropriate concentration of mass at the most opportune locations
5	Ability to cross-level and tailor manpower, equipment, and material mixes to each specific requirement/task
5	Smooth interoperability with other higher echelons of agile combat support (ACS) functionals (ie, Contracting, Comm, Logistics, Finance, etc)
5	Adhere to centralized control-decentralized execution concept by establishing/preserving vital tactical-level relationships while ensuring tactical capability is surged most effectively to support theater operational objectives
5	Hub-managed material yards
5	Maintain lean manpower and process overhead by centralizing core engineering functions
5	Centralize project tasking and command authority
5	Theater-wide visibility of requirements and ability to press the supported commander for his/her priorities
5	Provide ability to stand up and stand down a capability quickly
5	Effectively address scope creep - when a spoke'd team comes in to address an infrastructure requirement, it is apparent they are not a permanent presence that can be tasked with additional work without appropriate vetting
5	Standardized/templated design/planning products and tactics, techniques and procedures (TTPs) for various core tasks
5	Retain ability to communicate about and maintain accountability for RFF'd capabilities
5	Having contracting, finance, and supply personnel organic to the unit - provides another option for procurement of Class IV and others, potentially shortening lead times when local contracting and CAP contracts are overwhelmed or are otherwise experiencing diminished effectiveness
4.5	Clearly communicated and utilized TACON, OPCON, and ADCON relationships
4.5	Ensure support/supported force relationships are clearly delineated (especially to Joint partners)
4.5	Efficient materials handling and personnel movement logistics
4.5	Effective project prioritization through an 'asset management' approach to theater infrastructure requirements
4	Increased flexibility in personnel waivers due to deeper 'bench' when hub-and-spoke unit is group-sized
4	Optimized organizational proximity to CFACC air mobility division (AMD)
4	Elements of self-sustainment - hub-and-spoke units do not have to rely solely on resources procured locally or from supported unit for work, movement, or force sustainment requirements

The supported commanders' enablement of CE hub-and-spoke units to freely re-appropriate, also referred to as *cross-level*, CE resources within the hub-and-spoke unit appeared to ensure appropriate concentration of engineering capability at the most

opportune locations. Furthermore, the panel felt that the ability to cross-level and tailor not just manpower, but also equipment and material, mixes to each specific task was also critical to the successful delivery of operational advantages to the supported commanders. When Prime BEEF teams comprise ECESs aligned in direct support of a single installation commander, this cross-leveling is often not possible. When operations are in protracted durations of transition between kinetic and sustainment phases, manpower requirements at the ECES level can vary widely. The hub-and-spoke organizational construct appears to offer a viable solution by being able to temporarily surge personnel and then quickly stand them down when the requirement no longer exists. Responsiveness is enhanced as a result of eliminating the requirement to go through the RFF vetting process every time a new manning requirement emerges. Furthermore, close organizational proximity to the CFACC and COCOM staff responsible for vetting RFFs made it possible to more effectively advocate for increases and decreases in personnel attached to the unit via RFF. Panel member qualitative responses suggested that this method of RFF accountability made possible by the CE hub-and-spoke directly addressed a perceived breakdown in the Joint RFF process. Thus, the perception was that personnel numbers were able to be more sustainably and effectively managed by the CE hub-and-spoke organization compared to the legacy Prime BEEF organizational alignment.

Theater-wide visibility of requirements was facilitated by close organizational proximity to the supported commander. Project tasking and command authority was centralized. This ensured the right capability was being applied in the right way at the right time, or as close to it as possible, to support theater-level objectives. However, CE units centered at secondary hubs were free to establish and maintain vital tactical-level

relationships with supported units, thereby maintaining appropriate situational awareness of ongoing and anticipated requirements.

Particularly in Joint operating environments, clearly communicated and utilized TACON, operational control (OPCON), and ADCON relationships are critical to the effective employment of CE capability. The advocacy phase preceding CE hub-and-spoke unit operations in SWA catalyzed necessary discussions regarding TACON, OPCON, and ADCON in Joint environments. Aligning and solidifying these relationships was a key factor in ensuring CE hub-and-spoke unit effectiveness and will likely ensure success of hub-and-spoke-organized CE units operating in support of future contingencies. Ensuring effective understanding of these relationships both within the hub-and-spoke organization and among the supported commanders - particularly in the Joint operational environment - made it possible to more effectively leverage CE capabilities.

Elements of core engineering functions like planning, programming, and design were centralized as much as practical to maintain a lean manpower and process overhead. This minimized redundancy and facilitated the use of more craftspersons on the front lines of repair and construction efforts. Reductions in base master plan and design delivery times, improvements in quality, and increases in occupational safety records boosts were realized as these products were standardized and templated. Standardized tactics, techniques, and procedures were more readily implemented across CE hub-and-spoke units and readily updated as scenarios unfolded. This agile responsiveness translated directly to improved organizational effectiveness.

CE hub-and-spoke units streamlined the behind-the-lines tasks associated with facilitating work in the field. Organizational and physical proximity at the hubs to other ACS functions like contracting, communications, logistics, and finance helped facilitate smooth interoperability with these functional communities. Being a theater-level asset rather than a local ECES appeared to provide a necessary boost in priority to keep resources flowing. The hub-managed materials yards that were subsequently populated also acted, in concept, as an effective method of ensuring consistent-as-possible flow of materials. This translated directly to efficient materials handling. Personnel movement logistics were also facilitated as well as could be expected by the hub-and-spoke units' organizational proximity to the theater air mobility division.

Once teams were dispatched to address identified and vetted infrastructure requirements, the hub-and-spoke organization was able to effectively address local scope creep. This appeared tenable for two primary reasons. Senior officers stationed at the teams' hub(s) enabled appropriate organizational top cover to reprioritize requirements offered locally by installation leaders at the locations to which the teams forward deployed. Additionally, when a spoke team would arrive to address an infrastructure requirement, it was apparent they were not a permanent presence that could be tasked with additional work without appropriate vetting. This kept the teams appropriately focused on the mission essential tasks of most interest to the supported theater commander. Furthermore, elements of self-sustainment meant forward deployed teams did not have to rely solely on resources procured locally or from supported unit for work, movement, or force sustainment requirements.

In addition to the success factors, the panel appeared to achieve consensus on six caveat, condition, or constraint themes. Table 15 summarizes these themes. Responses suggested general disagreement with the caveat that limited evidence exists for using hub-and-spoke CE units in the phases of large scale operations that are most kinetic. Most of those who disagreed offered qualitative comments to characterize their sentiment. They noted that, particularly in the heavy construction and repair aspects of the CE mission, hub-and-spoke operations provided the closest-to-ideal solution for flexibly massing general engineering effects at the most opportune times. They pointed to personal experiences in both Operations ENDURING FREEDOM (OEF) and IRAQI FREEDOM (OIF) as further evidence of success. Additional qualitative comments pertained to a perceived need to address the corporate Air Force's "one base, one boss" culture.

Table 15. High Consensus Caveat/Condition/Constraint Themes

Median	Caveat/Condition/Constraint Theme
5	Air Force corporate culture challenge of local WG/CCs' expectation of owning their own robust CE capability (ie, "one base, one boss") must be addressed
5	Must have a pool of 'good' troop labor projects, especially when they are standing by to execute more appropriate emergency/surge tasks
4.5	The challenge of inter/intra-theater movement (air, ground, or sea-borne) must be addressed by planners determining required manning levels and associated equipment and materials requirements
4.5	Planners must be aware that the advantage of being able to flex personnel from one squadron to another can be tempered when some squadrons are TACON to another HHQ within the JTF
4.5	It is critical that consideration be given to siting resources so that extreme distances or "islanding" of resources that could provide a means of self-sustainment, if co-located, is avoided
1.5	There is limited evidence for a proof of concept for using hub-and-spoke-organized CE units in Phase 1/2 combat operations where active beddowns are on-going and infrastructure and materials procurement lines are not robust

Special Interest Themes

Certain themes may be of special interest if additional questionnaires are contemplated as a part of a follow-up research effort. This interest may be due to their low consensus level, inconclusive response data, or outright rejection by the SME panel members. The SME panel did not appear to reach consensus on 11 items, as demonstrated by visual inspection of the histograms of Likert scale responses. Panel member responses to some themes also suggested only moderate levels of agreement or disagreement, suggesting lukewarm acceptance, response bias, or unclear questionnaire language. Finally, the panel disagreed with several of the themes suggested by one or more qualitative responses to the initial questionnaire. While subsequent questionnaires could catalyze consensus one way or the other, they could also serve as confirmation that multiple diverging opinions are currently held by CE SMEs.

The median and histogram of panel member responses suggested only moderate agreement with the operational advantage pertaining to the hub-and-spoke organization's potential to boost in-theater combat readiness of assigned personnel. An additional phase of inquiry may have clarified why this was the case or provided a means for the research team to clarify its impressions. Qualitative responses of the *disagree* and *neutral* responses suggested panel member confusion with how the advantage was communicated. They also suggested that qualifiers may have been needed to more appropriately narrow its focus. They noted that personnel readiness is primarily the responsibility of the MAJCOM to which personnel are permanently assigned. Perhaps stronger consensus for this item could have been attained if additional background verbiage had been included in the questionnaire.

A suggested success factor supporting the enhanced command and control operational advantage that received lukewarm support stated that RFF personnel were not attached to the original requesting unit regardless of whether the need remained for them, thus reducing the need to augment a local traditionally-aligned CE squadron directly with RFF or temporary duty (TDY) forces. Qualitative responses to this item suggested that its wording may have been unclear to the panelists. Based on qualitative comments provided by panelists, it appeared that neutral responses may have shifted towards *agree* if the wording had been clarified in a subsequent follow-up questionnaire. Based on these responses, a subsequent questionnaire may have catalyzed consensus in the *agree* range or confirmed the existence of two groups of thought within the panel.

Another suggested success factor supporting the enhanced command and control operational advantage that received subdued support stated that having ADCON aligned exclusively through Air Force channels ensures Airman are taken care of in a way that will best facilitate future professional military development. Qualitative responses to this item suggested that its wording may have been unclear to the panelists. Based on qualitative comments provided by panelists, it appeared that neutral responses may have shifted towards *agree* if the wording had been clarified in a subsequent follow-up questionnaire. Based on these responses, a subsequent questionnaire may have catalyzed consensus in the *agree* range or confirmed the existence of two groups of thought within the panel.

A suggested success factor supporting the presence of the improved responsiveness to supported commander advantage that did not achieve consensus stated that this advantage was achieved by reducing wing (or Joint equivalent) level perhaps-

frivolous tactical level contentions over infrastructure requirements and ownership of engineer capability. Panel members did not offer qualifying comments to aid in the interpretation of their responses. The response histogram was mound-shaped offset to the right of *neutral*, suggesting a potential *slightly agree* sentiment. However, half the respondents characterized their level of agreement as *neutral* or *disagree*. This suggests that the disagreements themselves were not resolved at all, that perhaps the presence of the CE hub-and-spoke was not the cause of a reduction of this functional dissonance, or that the statement itself was altogether unclear.

Another suggested factor that did not achieve consensus supported the premise that CE hub-and-spoke organizations in SWA improved combat readiness of assigned members. It stated that this advantage was delivered as a result of personnel training with those with whom they would serve in-theater immediately prior to the deployment. Panel members offered few qualitative comments to describe their ratings. However, one described the *disagree* rating by stating that the advantage could only be applicable to a future hub-and-spoke unit if the state-side squadron deployed its squadron en masse. Panelists responding to a follow-up questionnaire with additional clarifying information may have achieved consensus on this item.

A suggested factor that achieved only slightly *agree* consensus supported the premise that CE hub-and-spoke organizations in SWA improved combat readiness of assigned members. It stated that this advantage was delivered at least partially as a result of having physician and religious support team (RST) support directly attached to some hub-and-spoke units. While none of the panelists offered a *disagree* response, qualitative feedback suggested even less support for this factor than the numerical responses

indicated. While panelists appeared to support the premise that these support elements were certainly useful to those SWA hub-and-spoke CE units that had them, their presence was not an integral part of the ongoing or future success of the CE hub-and-spoke units. A follow-up questionnaire with additional background information requesting revised responses may have strengthened the consensus on this item.

The panel generally agreed with the condition that consideration should be made for how the possibility of situations where there is closer collaboration with coalition nation partners for infrastructure needs may affect hub-and-spoke manpower levels, disposition, and training requirements. However, a theme emerged from the qualitative response that tempered this sentiment. Specifically, it suggested that this situation may be present in most future operational contexts and must thus be taken regardless of how CE capability is presented.

Responses suggested that the group maintained no consensus in its sentiment about the caveat that the impact of having no organic physician or RST support in the latest iteration of the CE hub-and-spoke in SWA must be more fully investigated. Only those who disagreed offered qualitative comments to characterize their sentiment. They noted that they had specifically not seen this as a limiting factor in their personal experience within both the current ECEG and the EPBG before it. Perhaps another follow-up questionnaire may have catalyzed a shift in opinion one way or the other among those who were neutral on the subject.

The group appeared to reject the suggested innovation related to ensuring that future CE hub-and-spoke group commanders have operational RED HORSE experience in their duty history. Most of those who disagreed offered additional strongly-worded

qualitative justification. While one third of the group appeared to agree with the assertion, they provided no additional justification in support. This does not necessarily invalidate their input but having the chance to review their initial responses via another follow-up questionnaire may have provided a catalyst to justify or modify their responses.

Implications and Recommendations for Future Research

Summarized in Chapter II, the historical analysis phase of this research effort suffered from gaps in recent data and knowledge that perhaps should have been readily available through Air Force or Joint OIL databases. AARs, end of tour reports, and exit interviews canvassing the time periods of interest to this research were generally not available from previously established sources. Most of those obtained for use by this research were via personal contact with either the CE observations, innovations, and lessons learned (OIL) primary point of contact or the individuals responsible for their generation. Furthermore, even if the applicable theoretical basis for developing tools to apply the success factors documented by this research existed, the quantitative data required for such analysis are not readily available and conflicting expectations exist within the CE operational community about the existence of these data. The Air Force CE corporate knowledge management enterprise may benefit from research exploring how to more effectively codify applicable expeditionary knowledge and collect the data required to develop tools that help operationalize it. Perhaps simply tracking down manpower productivity and AAR data and populating OIL databases already present may be the best alternative.

The Air Force Civil Engineer Center's (AFCEC) Readiness Division (CEX) is well-positioned within the CE community to continue its record of facilitation of expeditionary knowledge transfer by partnering with the Center's renewed research focus. The professionals within the CEX expeditionary engineering section act as the SMEs for the Prime BEEF and RED HORSE issues within the Air Force and Joint environments. They also manage various inputs into war planning documents and act as a focal point for deliberate planning, which can benefit from further operational research and subsequent development of more quantitative planning tools. Their active input to research agents capable of operationalizing the advantages and success factors documented by this research is critical. Partnering with military research entities like the Air Force Institute of Technology to perform this research can also have the added benefit of facilitating the professional military education of company grade officers. While applying the necessary analytical rigor to these force planning problems, they also develop CE force planning knowledge they can then use to make informed decisions based on perspectives honed by exposure to operational doctrine within the context of addressing real world challenges. They can be thus better-equipped to act as effective advocates for Air Force CE's support to the Air Force and Joint operational communities.

In the scoping phase of this research, a CE senior leader reiterated one of the ultimate force planning goals he maintains for his planning staff. His intent is to operationalize the success factors distilled by this project so future hub-and-spoke organized CE capabilities can offer the supported commander with operational advantages analogous to those offered to the SWA combined forces air component commander (CFACC). Two primary areas may be worth considering as future research

goals to help operationalize the success factors documented by this research: the development of hub-and-spoke manpower optimization tools and geospatial beddown siting tools. Their success relies on several factors outlined in the next two sections.

Development of a Manpower Optimization Tool

Arguably the research outcome most readily useful to CE force planners may be the production of a hub-and-spoke unit manpower sizing tool. A goal programming optimization tool may be such a solution since presenting expeditionary CE surge capabilities in a hub-and-spoke fashion inherently introduces the possibility of tradeoffs. Engineer force planning is a problem of using finite manpower, supplies, and equipment to accomplish a seemingly-endless stream of engineer requirements. A wing commander may wish to upgrade base facilities to enhance the installation residents' quality of life or posture it for mission expansion later in the campaign but is unable to do so with the sustainment CE manpower level the installation is authorized. More generally, in the absence of a compulsory draft, it remains necessary to preserve the operations tempo (OPSTEMPO) of non-deployed personnel at a sustainable rate. If the maximum number of personnel were available for the duration of a campaign, the risk of longer term degradation of the CE functional community would become unacceptably high. For these reasons, the problem of creating a hub-and-spoke unit manpower recommendation for the supported combatant commander (COCOM) lends itself to having optimization analysis applied.

The possibility of multiple goals for the use of the wide spectrum of CE capability can be high. For this reason, it is possible that a new multi-criteria decision making (MCDM) tool could be of use to CE force planners. Given the sustainable mission

accomplishment objectives stated by senior leadership, the most relevant steps upon which to focus in the development of a MCDM tool may be the definition of model attributes and determining their objective weights. Proposing values for these may require a combination of further qualitative analysis of end-of-tour reports, elicitation of expert opinion, and quantitative analysis of productivity levels demonstrated by SWA CE hub-and-spoke units. Expert opinion may be required to determine the most appropriate constraints and objectives and their relative hierarchy. Man-hour productivity data may also provide the basis for the weighting or revision of historical, published productivity expectations.

As this research found, little in the way of CE hub-and-spoke unit manpower productivity data are readily available for analysis. Addressing this challenge may be the first step in the development of a MCDM manning tool. Additionally, consideration may need to be given to developing hybrid surrogate measures of CE manpower need and exploring the interaction between both the UTC and enduring location approaches. Research by Winkler (2011) and others began this exploration by evaluating recent evolutions of bases from austere expeditionary to enduring locations and associated impacts on CE manpower requirements. CE hub-and-spoke manpower planning effectiveness may be aided by similar analysis of hub-and-spoke manpower requirements as tactical infrastructure evolves. Once these data have been captured, more advanced statistical techniques than the simple descriptive ones used in this research could be applied to determine if official CE instructions should be revised to reflect the labor productivity demonstrated by CE hub-and-spoke units in SWA.

Another potential approach to developing an optimization model may be offered by the transportation and logistics operations research disciplines. Methods of gaining and maintaining operational and competitive advantages are continuously sought through the study of the hub-and-spoke network concept applied to logistics problems. Of particular interest to CE hub-and-spoke organizational planners may be logistics researchers' interest in the degree to which selective centralization of given functions offers systems-level operational advantages. Research into striking the optimal centralization-decentralization balance and finding methods of continuously evaluating that balance's ability to make an expeditionary CE organization effective may offer valuable insight to Air Force leaders and force planners. Additionally, treating CE capability as "packages" to be delivered and leveraged at a destination may yield useful perspectives.

Geospatial Tools

Developing geospatial tools may assist CE force planners' decision-making with regard to the physical disposition of CE hub-and-spoke capabilities. These tools may help answer a question like, "What is the optimal hub location for a hub-and-spoke-organized CE unit fulfilling expeditionary Air Force infrastructure requirements in a given contingency?" To answer this question, the researcher may consider potential variables for inclusion in a given CE hub-and-spoke physical disposition recommendation tool, assessing both significance of the variables to force disposition decision-making and practical aspects of data availability in the time available for the project. Perhaps available literature and discussions with SMEs in the CE functional community would confirm that analysis of primary variables would facilitate development of a geospatially-

derived recommendation for CE unit disposition. The researcher could enhance the validity of this type of project by eliciting SME opinion on objective weights or variable hierarchies for the variables. A preliminary list could include:

- Size/Length of Runway(s) at candidate airfields
- Type of aircraft expected to be utilized for routine mission-related transportation
- Range of those expected aircraft
- Relative location of candidate airfields to each other
- Relative location of candidate airfields to seaports
- Land area under coalition control in given phases of a major campaign/conflict
- Average annual precipitation at candidate beddown sites

Conclusion

This research offered insight into a formative theory on hub-and-spoke force planning for expeditionary engineers by documenting concepts and operational experiences previously held as tacit knowledge by SMEs. It documented factors that influenced the successful delivery of operational advantages offered by hub-and-spoke organized expeditionary CE units in SWA and made an initial determination about their applicability to CE hub-and-spoke units supporting future contingencies. It did so by first conducting an historical analysis of published CE history, manpower planning guidance, AARs, and the methods available to elicit SME knowledge in an effort to address published knowledge gaps. It then utilized a modified Delphi technique to elicit SME opinion about the operational advantages CE hub-and-spoke units offered to supported commanders in SWA and the factors that led to their successful delivery. It concluded by offering perspective on the findings' implications and recommendations for future research.

Appendix A. Delphi Study Phase One

CE Hub-and-spoke Delphi Study Questionnaire #1

Thank you for agreeing to participate in this Delphi Study. The purpose of this study is to perform research relating to AF civil engineer capability presentation in the PACAF AOR. The objective is to determine how operational advantages like those realized in southwest Asia when expeditionary CE capability was organized in a hub-and-spoke fashion may be replicated in PACAF. The sponsor for this research is Colonel Karl Bosworth, PACAF/A7, Joint Base Hickam-Pearl, HI.

Please note the following:

Benefits and risks: There are no personal benefits or risks for participating in this study. Your participation in completing this questionnaire should take 30-45 minutes per round.

Confidentiality: Your responses are completely confidential, and your identity will remain anonymous. No individual data will be reported; only data in aggregate will be made public. Data will be kept in a secure, locked cabinet to which only the researchers will have access. If you have any questions or concerns about your participation in this study, please contact:

JOSHUA A. HAGER, Captain, USAF GEM Student Graduate School of Engineering and Management Air Force Institute of Technology Wright-Patterson AFB, OH DSN 312-785-3636 Comm 937-255-3636	TAY W. JOHANNES, P.E., PhD, Lt Col, USAF Assistant Professor of Engineering Management Graduate School of Engineering and Management Air Force Institute of Technology Wright-Patterson AFB, OH DSN 312-785-3636 Comm 937-255-3636

Voluntary consent: Your participation is completely voluntary. You have the right to decline to answer any question, to refuse to participate, or to withdraw at any time. Your decision of whether or not to participate will not result in any penalty or loss of benefits to which you are otherwise entitled. Completion of the questionnaire implies your consent to participate.

Background:

Contingency Air Force civil engineer (CE) capabilities have come to be presented to combatant commanders primarily in the form of Prime BEEF and RED HORSE teams. While these units have traditionally been controlled by various levels of an often-sprawling command structure, local wing commanders have developed a reasonable expectation that at least one Prime BEEF team will be assigned to a particular installation and controlled by that wing commander for the purpose of operating and maintaining local base infrastructure. And that RED HORSE resources will be commanded and controlled by the command echelon above wing. Most recently, the Expeditionary Prime BEEF Group (EPBG), Expeditionary RED HORSE Group (ERHG), and Expeditionary Civil Engineer Group (ECEG) have been utilized in the AFCENT AOR. These units use(d) a hub-and-spoke concept of operation to support infrastructure project programming, design, troop construction, and contract construction management requirements generated by SWA contingency operations. They have been aligned at the command echelon above wing (or Joint equivalent), typically as part of a Joint task force. Anecdotal data and those found in available end of tour reports suggest that this alignment, featuring traditional Prime BEEF capabilities and the heavy repair/construction capabilities of RED HORSE under one command element, has made it possible to better manage the utilization of expeditionary CE capability in the AFCENT AOR by enabling functional commanders to allocate often-limited CE resources to the areas where these resources will have the greatest impact on the mission.

This research effort is sponsored by the office of the PACAF/A7, who is seeking to ultimately develop a CE force planning model that captures operational advantages SWA hub-and-spoke-organized CE units have given to supported operations. Developing this model requires the distilling and codifying force planning knowledge developed in the course of applying the hub-and-spoke organizational model to CE units operating in OIF, OEF, and OND and applying appropriate facets of that knowledge to future

operations plans in other AORs. Currently, only an ad hoc hub-and-spoke manpower model exists; it is limited in its ability to reflect human resources requirements for constructing, repairing, and maintaining expeditionary airfields. NOTE: *This* study is undertaken with the assumption that expeditionary CE capability will be used primarily in direct support of the combined force air component commander (CFACC), with support to Joint infrastructure requirements provided by exception.

By responding, you have the opportunity to shape how the AF CE functional community takes advantage of lessons learned as a result of hub-and-spoke organizational innovations.. Thank you for participating in this study and helping apply those lessons and the perspective you have honed through years of CE service will to the next contingency. I appreciate your time and candid responses.

Process:

1. Please complete this questionnaire **electronically** and return it to: **joshua.hager@afit.edu** no later than **12 December 2012.** If you have questions, I can be reached at that e-mail or at DSN:.317-785-3636

2. This questionnaire is an instrument of a Delphi study. The Delphi method is an iterative, group communication process which is used to collect and distill the judgments of experts using a series of questionnaires interspersed with feedback. The questionnaires are designed to focus on problems, opportunities, solutions, or forecasts. Each questionnaire is developed based on the results of the previous questionnaire. The process continues until the research question is answered. For example, when consensus is reached, sufficient information has been exchanged. This usually takes, on average, 3-4 rounds.

3. There are three primary questions for this round. The survey is non-attribution, so **please elaborate fully on your answers** and feel free to provide additional insight, if you deem it relevant, even if it is not specifically requested by the questions. Once all interview responses are received and analyzed, you will be asked to review and revise your initial responses based on responses provided by the entire group. Subsequent rounds will be announced as needed and all research is scheduled to conclude by 6 February 2012.

Research questions:

Please answer the following questions as clearly and concisely as possible without omitting critical information or rationale required for the group to consider your opinions. Base your responses on your own personal experiences and perceptions.

1. What operational advantages do you perceive hub-and-spoke-organized expeditionary CE units offered for meeting theater-level objectives effectively in SWA?
2. For the advantages you would identify as potentially relevant/applicable to supporting the CFACC in another AOR, why would they be relevant?
3. For the advantages you would identify as NOT as potentially relevant/applicable to supporting the CFACC in another AOR, why would they not be relevant?

Appendix B. Delphi Study Phase Two

CE Hub-and-spoke Delphi Study Follow-up

Thank you for agreeing to participate in this Delphi Study. The purpose of this study is to perform research relating to AF civil engineer capability presentation in the PACAF AOR. The objective is to determine how operational advantages like those realized in southwest Asia when expeditionary CE capability was organized in a hub-and-spoke fashion may be replicated in future contingencies. The sponsor for this research is Colonel Karl Bosworth, PACAF/A7, Joint Base Hickam-Pearl, HI.

Please note the following:

Benefits and risks: There are no personal benefits or risks for participating in this study. Your participation in completing this questionnaire should take 15-20 minutes.

Confidentiality: Your responses are completely confidential, and your identity will remain anonymous. No individual data will be reported; only data in aggregate will be made public. Data will be kept in a secure, locked cabinet to which only the researchers will have access. If you have any questions or concerns about your participation in this study, please contact:

JOSHUA A. HAGER, Captain, USAF GEM Student Graduate School of Engineering and Management Air Force Institute of Technology Wright-Patterson AFB, OH DSN 312-785-3636 Comm 937-255-3636	TAY W. JOHANNES, P.E., PhD, Lt Col, USAF Assistant Professor of Engineering Management Graduate School of Engineering and Management Air Force Institute of Technology Wright-Patterson AFB, OH DSN 312-785-3636 Comm 937-255-3636

Voluntary consent: Your participation is completely voluntary. You have the right to decline to answer any question, to refuse to participate, or to withdraw at any time. Your decision of whether or not to participate will not result in any penalty or loss of benefits to which you are otherwise entitled. Completion of the questionnaire implies your consent to participate.

Background:

Your responses to the first round questionnaire spoke directly to the operational advantages that hub-and-spoke-organized CE units can offer to supported commanders. The question prompts were:

1) What operational advantages do you perceive hub-and-spoke-organized expeditionary CE units offered for meeting theater-level objectives effectively in SWA?
2) For the advantages you would identify as potentially relevant/applicable to supporting the CFACC in another AOR, why would they be relevant?
3) For the advantages you would identify as NOT as potentially relevant/applicable to supporting the CFACC in another AOR, why would they not be relevant?

The content of the responses was subsequently analyzed and major themes summarized. The response data suggest that hub-and-spoke-organized CE units can offer three primary operational advantages to supported commanders compared to legacy organizational alignment(s). These advantages appear to be most closely related to providing the supported combatant commander an improved ability to leverage general and geospatial engineering capability within the context of the core doctrinal tenets of unity of command, flexibility, versatility, and mass effects outlined in AFDD 3-34 *Engineer Operations*. These suggested advantages include enhancements in:

1) *Command and control effectiveness* , defined as effectively ensuring the right personnel are doing the right mission tasks fulfilling the requirements that most-impact the supported operational mission
2) *Responsiveness to supported commander*, defined as providing a means of having appropriate flexibility to shift mass effects of CE capability as required to meet mission requirements and ensuring those effects are massed on the requirements that will have the greatest effect on the mission.

3) *Combat readiness of assigned personnel*, defined as personnel being appropriately trained and equipped to prosecute assigned duties/tasks effectively

SME responses also suggest key factors, the absence of which would likely have had a particularly negative effect on the delivery of the suggested operational advantages. In addition, responses suggest a number of caveats, conditions, and/or constraints that senior leaders and planning staffs should consider when making future CE hub-and-spoke force planning and organizational recommendations. Finally, additional considerations were suggested for subsequent planning efforts. The following pages will guide your review of these suggested themes by presenting them systematically and requesting your evaluation in turn. I appreciate your time and candid responses.

Process:

1. The Delphi method is an iterative, group communication process used to elicit your expert opinion using a series of questionnaires interspersed with feedback. Questionnaires are designed to focus on problems, opportunities, solutions, or forecasts. Each follow-up questionnaire is developed based on the results of the previous questionnaire. The process continues until the research question is answered. This takes, on average, 3-4 rounds.

2. This follow-up questionnaire represents the second round of this study. Once all responses are received and analyzed, you may be asked to review and revise your initial responses based on those provided by the entire group. It is non-attribution, so **please elaborate fully on any qualitative comments you feel are necessary** and feel free to provide additional insight, if you deem it relevant, even if it is not specifically requested by the questions. Subsequent rounds will be announced as needed and all research is scheduled to conclude by 6 February 2012.

3. Please complete this questionnaire **electronically** and return it to: **joshua.hager@afit.edu** no later than **21 January 2013.** If you have questions, I can be reached at that e-mail or at DSN: 317-785-3636.

Directions:

Using the 5-point Likert Scale presented below, please rate your agreement with the themes suggested by the group's answers to the original research questions summarized in *Background*. Feel free to provide additional qualitative responses to any of the FOUR (4) questions, communicating as clearly and concisely as possible without omitting critical information or rationale required for the group to consider your opinions. Base your responses on your own personal experiences and perceptions.

Rating Scale:
5 - Strongly Agree
4 - Agree
3 - Neutral
2 - Disagree
1 - Strongly Disagree

1. Please review and rate your agreement with the following operational advantages that respondents perceived hub-and-spoke-organized expeditionary CE units offered for meeting theater-level objectives effectively in SWA.

Advantage	Rating	Comments
Enhanced command and control effectiveness		
Improved responsiveness to supported commander		
Enhanced combat readiness of assigned personnel		

Additional comments (if necessary):

2. For each operational advantage identified in Questionnaire #1, Question 1, panel member responses suggested the potential for numerous factors required for delivery of the suggested operational advantages. Please review and rate the degree to which you agree with the following factors for success suggested for each operational advantage provided by hub-and-spoke-organized CE units specifically.

a) *Enhanced command and control effectiveness* , defined as effectively ensuring the right personnel are doing the right mission tasks fulfilling the requirements that most-impact the supported operational mission

Factors for Success	Rating	Comments
Empowerment to freely re-appropriate (or *cross-level*) CE resources within the group to ensure appropriate concentration of mass at the most opportune locations		
Ability to *cross-level* and tailor manpower, equipment, and material mixes to each specific requirement/task		
Clearly communicated and utilized TACON, OPCON, and ADCON relationships		
Adhere to centralized control/decentralized execution concept by establishing/preserving vital tactical-level relationships while ensuring tactical capability is surged in the most effective way to support theater-level operational objectives		
Ensure local installation personnel footprint remains lean, facilitating effective boots-on-ground (BOG) numbers management - local unit sheds requirement to have a large or frequently expanding/contracting permanent party manpower numbers to support		
Request-for-forces (RFF) personnel are not attached to the original requesting unit regardless of whether the need remains for them - reduces the need to augment local ECES organization directly with RFF or TDY forces		
Blue-on-Blue ADCON ensures Airman are taken care of in a way that will best facilitate future career development		
Maintain lean manpower and process overhead by centralizing core engineering functions (ie, planning, programming, design) - eliminates redundancy and facilitates more shovel-and-pick operations		
Retain ability to communicate about and maintain accountability for RFF'd capabilities - ensures ability to rapidly vet emerging requirements that may require a supported unit to submit a RFF by determining if need can be met by simply standing up a spoke'd team to address the requirement		
Centralize project tasking and command authority		
Ensure support/supported force relationships are delineated (especially to Joint partners) - provides a clear organizational context in which to work		
Increased flexibility in personnel waivers due to deeper 'bench' when hub-and-spoke unit is group-sized		
Ability to communicate observations, innovations, and lessons learned across in-theater functional community through the use of various update tools - one O-6 commander improves the chances that		

lessons learned and other 'news' is synthesized and disseminated as appropriate		

b) *Improved responsiveness to supported commander*, defined as providing a means of having appropriate flexibility to shift mass effects of CE capability as required to meet mission requirements and ensuring those effects are massed on the requirements that will have the greatest effect on the mission.

Factors for Success	Rating	Comments
Effective project prioritization through an 'asset management' approach to theater infrastructure requirements		
Efficient materials handling and personnel movement logistics		
Theater-wide visibility of requirements and ability to press the supported commander for his/her priorities - ensures the right capability is being applied in the right way at the right time (or as close to it as possible)		
Effectively address scope creep - when a spoke'd team comes in to address an infrastructure requirement, it is apparent they are not a permanent presence that can be tasked with additional work without appropriate vetting		
Smooth interoperability with other higher echelons of agile combat support (ACS) functionals (ie, Contracting, Comm, Logistics, Finance, etc) - being a theater level asset, rather than a local CE squadron, enhances this potential		
Contracting, finance, and supply personnel organic to the unit - provides another option for procurement of Class IV and others, potentially shortening lead times when local contracting and civil augmentation program (CAP) contracts are overwhelmed or are otherwise experiencing diminished effectiveness		
Standardized/templated design/planning products and tactics, techniques and procedures (TTPs) for various core tasks - reduces delivery time, improves quality, and boosts safety		
Provide ability to stand up and stand down a capability quickly - reduces requirement for local unit to have to vet a need through RFF process		
Hub-managed material yards - provides potentially more expedient construction/repair material requirements and movement procurement option, reducing the need for local installations to work these issues		
Reduce wing (or Joint equivalent) level frivolous contention over infrastructure requirements and ownership of engineer capability		
Optimized organizational proximity to CFACC air mobility division (AMD) - helps prioritize transportation		

c) *Enhanced combat readiness of assigned personnel*, defined as personnel being appropriately trained and equipped to prosecute assigned duties/tasks effectively

Factors for Success	Rating	Comments
Train with those with whom personnel will 'fight'		
Standardized pre-deployment training and equipping - a unified streamlined feedback voice, particularly in Joint training environments, helps focus training and equipping efforts on most relevant needs		
Elements of self-sustainment - hub-and-spoke units do not have to rely solely on resources procured locally or from supported unit for work, movement, or force sustainment requirements		
Some units had physician and religious support team (RST) support - provided timely personnel support as needed and ensured focus on mission		

Additional comments (if necessary):

3. Responses to Questionnaire #1, Questions 2 and 3 regarding applicability of the hub-and-spoke organizational concept in another AOR suggested the following themes. Please review and rate your agreement with the following statement about operational advantages and subsequent caveats, conditions, and/or constraints that respondents suggested may influence CE hub-and-spoke force planning and employment decisions.

Category	Rating	Comments
All operational advantages previously suggested are potentially relevant to hub-and-spoke-organized CE units supporting the CFACC in another AOR		
Caveats/Conditions/Constraints		
There is limited evidence for a proof of concept for using hub-and-spoke-organized CE units in Phase 1/2 combat operations where active beddowns are on-going and infrastructure and materials procurement lines are not robust		
The challenge of inter/intra-theater movement (air, ground, or sea-borne) must be addressed by planners determining required manning levels and associated equipment and materials requirements		
It is critical that consideration be given to siting resources so that extreme distances or "islanding" of resources that could provide a means of self-sustainment, if co-located, is avoided		
Consideration must be made for how the possibility of future coalition collaboration situations may affect hub-and-spoke manpower levels, disposition, and training requirements - prime power and other support equipment could introduce redundancies; falling in on foreign electrical infrastructure may impose serious operational constraints		
Must have a pool of 'good' troop labor projects, especially when they are standing by to execute more appropriate emergency/surge tasks		
Planners must be aware that the advantage of being able to flex personnel from one squadron to another can be tempered when some squadrons are TACON to another HHQ within the JTF		
Allowance must be given for loss in procurement effectiveness if policy dictates all procurement be accomplished centrally -consideration must be given to materials/equipment that can be more effectively/efficiently procured locally		
Planners should fully consider for boots-on-ground (BOG) constraints as these may mitigate some of the potential operational advantages that hub-and-spoke organized units may offer		
Air Force corporate culture challenge of local WG/CCs' expectation of owning their own robust CE capability (ie, "one base, one boss") must be addressed		
The impact of no organic physician and/or RST support within a hub-and-spoke-organized CE		

group must be more fully considered		

Additional comments (if necessary):

4. The following are additional responses categorized as potential considerations for planning future expeditionary CE hub-and-spoke organized units. Please review and rate your agreement with these statements.

Future Considerations	Rating	Comments
Hub-and-spoke-organized CE units should be considered for support to contingency exercises and exercise-related construction requirements		
When hub-and-spoke unit is leveraging both Prime BEEF and RED HORSE capabilities, it would be best to ensure the group commander (usually an O-6) has had operational RH experience prior to assuming command of the group		

Additional comments (if necessary):

Appendix C. AFIT Human Subjects Exemption Approval (Phase One)

DEPARTMENT OF THE AIR FORCE
AIR FORCE INSTITUTE OF TECHNOLOGY
WRIGHT-PATTERSON AIR FORCE BASE OHIO

19 Nov 2012

MEMORANDUM FOR DR. TAY W. JOHANNES

FROM: Jeffrey A. Ogden, Ph.D.
AFIT IRB Research Reviewer
2950 Hobson Way
Wright-Patterson AFB, OH 45433-7765

SUBJECT: Approval for exemption request from human experimentation requirements (32 CFR 219, DoDD 3216.2 and AFI 40-402) for PACAF CE Hub and Spoke.

1. Your request was based on the Code of Federal Regulations, title 32, part 219, section 101, paragraph (b) (2) Research activities that involve the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior unless: (i) Information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) Any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

2. Your study qualifies for this exemption because you are not collecting sensitive data, which could reasonably damage the subjects' financial standing, employability, or reputation. Further, you are not collecting any demographic data which could realistically be expected to map a given response to a specific subject.

3. This determination pertains only to the Federal, Department of Defense, and Air Force regulations that govern the use of human subjects in research. Further, if a subject's future response reasonably places them at risk of criminal or civil liability or is damaging to their financial standing, employability, or reputation, you are required to file an adverse event report with this office immediately.

JEFFREY A. OGDEN, PH.D.
AFIT Research Reviewer

Appendix D. AFIT Human Subjects Exemption Approval (Phase Two)

DEPARTMENT OF THE AIR FORCE
AIR FORCE INSTITUTE OF TECHNOLOGY
WRIGHT-PATTERSON AIR FORCE BASE OHIO

25 January 2013

MEMORANDUM FOR LT COL TAY JOHANNES

FROM: William A. Cunningham, Ph.D.
AFIT IRB Research Reviewer
2950 Hobson Way
Wright-Patterson AFB, OH 45433-7765

SUBJECT: Approval for exemption request from human experimentation requirements (32 CFR 219, DoDD 3216.2 and AFI 40-402) for student research PACAF CE Hub and Spoke.

1. Your request was based on the Code of Federal Regulations, title 32, part 219, section 101, paragraph (b) (2) Research activities that involve the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior unless: (i) Information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) Any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

2. Your study qualifies for this exemption because you are not collecting sensitive data, which could reasonably damage the subjects' financial standing, employability, or reputation. Further, the demographic data you are collecting and the way that you plan to report it cannot realistically be expected to map a given response to a specific subject.

3. This determination pertains only to the Federal, Department of Defense, and Air Force regulations that govern the use of human subjects in research. Further, if a subject's future response reasonably places them at risk of criminal or civil liability or is damaging to their financial standing, employability, or reputation, you are required to file an adverse event report with this office immediately.

//signed//
WILLIAM A. CUNNINGHAM, PH.D.
AFIT Research Reviewer

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Vita

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14. ABSTRACT
Expeditionary Air Force Civil Engineer support to recent operations in southwest Asia created a unique organizational learning environment, particularly related supporting the general engineering requirements of geographically separated units in a manpower-constrained contingency environment. One of the direct results of this organizational learning was the hub-and-spoke expeditionary engineer unit featuring elements of both RED HORSE and Prime BEEF capabilities operating with theater-wide visibility of infrastructure requirements. This study acquired insights from literature and a purposeful sample of subject matter experts about operational advantages this hub-and-spoke unit offered compared to those offered by strictly legacy organizational models. The research used a Delphi method of expert opinion elicitation to which of these may be applicable in future contingency environments with caveats, constraints, and conditions that CE force planners should consider for hub-and-spoke organizations. The expert panel demonstrated consensus on 20 advantages and associated success factors, including resource cross-leveling flexibility, optimized organizational proximity to key support functions like logistics and contracting, centralized engineering functions, and better-defined command relationships in Joint environments.

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